PRECONCEPTION NUTRITION KNOWLEDGE, DIETARY INTAKES AND LIFESTYLE CHARACTERISTICS OF AUCKLAND WOMEN

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ABSTRACT

Introduction

Adequate nutritional status prior to conception and during early pregnancy is important in achieving a healthy pregnancy outcome. This study examined preconception nutrition knowledge, and dietary and lifestyle habits in Auckland women of childbearing age.

Methods

Women aged 18-45 years (n=115) were recruited and data collected using a detailed questionnaire, anthropometric measurements and a diet history to evaluate dietary intakes.

Results

18 women were attempting to conceive and 97 women indicated they were not currently planning pregnancy. The reproductive history of the women identified that 53 women had previously been pregnant but only 47% of these pregnancies had been planned.

Nearly all of the women (93.7%) had heard of folic acid and 65% were aware that folic acid was required for pregnancy. Although 53.9% of the women knew that folic acid prevents birth defects, only 31.3% of women had specific knowledge that folic acid use a month before conception can prevent neural tube defects. All of the women in the study who were currently planning a pregnancy had heard of folic acid and 13 (72%) were taking a folic acid supplement (≥400μg).

Although 80% of the women thought that dietary habits in the preconception period could affect pregnancy outcome few women thought preconception diet could influence risk of miscarriage, preterm delivery or maternal deficiencies. 83% of women used alcohol, 13.0% had a caffeine intake >300 mg/day, 8% smoked and 26.0% were overweight or obese.

Conclusions

Women recruited to the study demonstrated a lack of awareness of the importance of preconception nutrition and were not in an optimal physical state for pregnancy. The high rate of unplanned pregnancies in New Zealand is a significant obstacle to preconception care and efforts to increase the awareness of the importance of preconception nutrition are needed.

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LIST OF ABBREVIATIONS

ARND	Alcohol-Related Neurodevelopmental Disorders
BAC	Blood Alcohol Concentration
BMI	Body Mass Index
CA	Congenital Anomalies
CDC	Centers for Disease Control and Prevention
CHO	Carbohydrate
CI	Confidence Intervals
CNS	Central Nervous System
DRV	Dietary Reference Values
EAR	Estimated Average Requirement
FAS	Foetal Alcohol Syndrome
FFQ	Food Frequency Questionnaire
GI	Glycaemic Index
Hb	Haemoglobin
hCG	β-Human Chorionic Gonadotropin
IQ	Intellectual Quotient
IU	International Unit
IUGR	Intrauterine Growth Restriction
LBW	Low Birth Weight
MOH	Ministry of Health
MRC	Medical Research Council
n-3	Omega-3
n-6	Omega-6
NHS	National Health Survey
NNS	National Nutrition Survey
NIP	Nutrition Information Panel
NS	Non-Significant
NZSEI	New Zealand Socio-Economic Index
NTD	Neural Tube Defect
OR	Odds Ratio
PUFA	Polyunsaturated Fatty Acids
SAB	Spontaneous Abortion
SES	Socio-Economic Status
SGA	Small-for-Gestational Age
SPSS	Statistical Package for the Social Sciences
RDI	Recommended Daily Intake
RNI	Reference Nutrient Intake
RR	Relative Risk
TTP	Time to Pregnancy
UL	Tolerable Upper Limit
US	United States
WHO	World Health Organisation
WHR	Waist-to-Hip Ratio

1. BACKGROUND

1.1 Introduction

Pregnancy is recognised as a vulnerable period during which the health and well being of both the foetus and mother are at risk. Adverse pregnancy outcomes that can affect the foetus include miscarriages, stillbirths, premature delivery, intrauterine growth restriction (IUGR) and low birth weight (LBW). Other adverse outcomes at birth include mental retardation and congenital anomalies such as neural tube defects (NTDs). While adverse maternal outcomes include morbidity and mortality, often as a direct result of anaemia, haemorrhage, obstructed labour and hypertension (Ramakrishnan et al., 1999).

In recent years there has been increasing recognition of the importance of the role a woman's health status prior to conception plays in achieving a healthy pregnancy outcome (Korenbrot et al., 2002; Moos, 2002). The failure to observe reductions in congenital anomalies, premature delivery and LBW despite advancements in prenatal nutrition and care, suggests that prenatal care alone is not adequate to prevent adverse pregnancy outcomes (Korenbrot et al., 2002). This idea was recognised 20 years ago in a statement by the Institute of Medicine,

> 'Only causal attention has been given to the proposition that one of the best protections available against low birth weight and other poor pregnancy outcomes is to have a women actively plan for pregnancy, enter pregnancy in good health with as few risk factors as possible, and be fully informed about her reproductive and general health.' (Moos, 2002).

The failure of prenatal care to impact on pregnancy outcome relates to the critical period of cell differentiation and organogenesis which occurs between days 17 and 56 post-implantation (Allaire & Cefalo, 1998). Over half of all pregnancies in New Zealand are unplanned (Paterson et al., 2004; Schader & Corwin, 1999). The critical period in foetal development occurs before most women realise they are pregnant, therefore the developing foetus may potentially be exposed to risks such as poor maternal nutrition, alcohol and teratogenic medications (de Weerd et al., 2002). This means that the high rate

of unplanned pregnancy is a significant obstacle to preconception care in many parts of the world.

The concept of preconception care aims to ensure that women are in an optimal physical state at the start of pregnancy, thereby improving the chance of a healthy pregnancy outcome. Maternal nutrition is thought to be an underlying factor in a variety of pregnancy outcomes and therefore, is a key component to preconception care. This is highlighted by the prevention of NTDs with folic acid supplementation for at least one month prior to conception (MOH, 2003b).

The high rate of unplanned pregnancy emphasises the need for preconception care to be targeted towards all women who are capable of becoming pregnant and not just those women planning pregnancy. The American Dietetic Association recommends that all women of childbearing age should maintain a good nutritional status through a lifestyle that optimises maternal health and reduces the risk of birth defects and sub-optimal foetal growth and development (Kaiser et al., 2002).

1.2 Maternal Nutritional Status and Pregnancy Outcomes

Maternal nutrition is thought to be an underlying determinant of a variety of adverse pregnancy outcomes. An increasing body of evidence has established an association between maternal nutritional status and pregnancy complications (Coad, 2003; Keen et al., 1993; Kramer, 2003), with the most well established link that of folic acid and the prevention of NTDs (MOH, 2003b; Shaw et al., 1995; Thompson et al., 2003).

Most studies to date have evaluated maternal nutritional status during pregnancy, with few studies examining the effect of nutrition prior to conception on pregnancy outcomes. There are a number of difficulties in accurately assessing nutrient intakes in the preconception period. Prospective studies require the enrolment and follow-up of women planning pregnancy; these studies provide the most accurate dietary information as more accurate dietary assessment methods (i.e.: weighed food records) can be used to evaluate current intakes. However, few prospective studies have been carried out to date as the large amount of time and expensive involved are major disadvantages to prospective studies. Additionally, it is difficult to recruit a representative sample of women planning pregnancy, as women who plan pregnancy are more likely to be older, more educated and European (Hellerstedt et al., 1998). The loss of participants at follow-up can also be an issue in prospective studies.

The majority of studies on preconceptional intakes have been retrospective as these studies are less time consuming and less expensive to conduct. Women with planned and unplanned pregnancies can be included enabling a more representative sample of women to be obtained, however this is limited if participants are recruited from antenatal or postnatal clinics (Ray et al., 2004). Retrospective studies are prone to errors associated with recall bias and require the use of less robust dietary assessment methods (i.e. FFQs). A major limitation to retrospective studies on preconceptional intakes is the recall error arising from the misclassification of the timing of consumption, women are more likely to recall habits from the time of pregnancy recognition rather than the period before conception (da Costa Pereira et al., 1993). Differential recall bias between case and control mothers may be an issue in retrospective studies, as an adverse pregnancy outcome may trigger more intense recall of habits around the time of conception in case mothers compared to controls (Rasch, 2003).

This review will cover associations between preconception nutrition and pregnancy outcome, maternal nutritional status during early pregnancy will also be considered, as the period before pregnancy recognition is a vulnerable period in embryonic and foetal development. Although nutrient requirements during early pregnancy are comparatively small, specific nutritional deficiencies and toxicities in this period can have adverse effects on foetal development (Ashworth & Antipatis, 2001).

1.2.1 Macronutrients

Epidemiological studies indicate that the susceptibility of adults to hypertension, cardiovascular disease and diabetes may be induced by maternal undernutrition (Sallout & Walker, 2003). It is now widely accepted that foetal programming arising from undernutrition during foetal development permanently alters foetal growth characteristics and postnatal metabolism and physiology with long-term effects on adult health that include diabetes, obesity and cardiovascular disease (Barker, 1999; Harding, 2001).

Maternal undernutrition during early gestation is associated with a number of adverse effects on foetal development in animal studies (Bloomfield et al., 2003; Joshi et al., 2003; Kwong et al., 2000; Oliver et al., 2001). Moderate undernutrition during the periconceptional period has been found to induce premature delivery in sheep, as a result of accelerated maturation of the foetal adrenal gland (Bloomfield et al., 2003). Maternal undernutrition in the periconceptional period has also been shown to alter pancreatic function in sheep offspring, indicating that maternal nutrition around the time of conception may have important consequences for the regulation of insulin secretion in the offspring (Oliver et al., 2001).

Maternal protein restriction in rats has been shown to programme changes in foetal and postnatal growth, physiology and vital organs of the next generation (Joshi et al., 2003). Maternal protein restriction prior to conception that was followed by a normal protein diet during gestation, not only affected the growth and composition of vital organs but also resulted in increased blood glucose and cholesterol levels in the adult offspring (Joshi et al., 2003). Weight gain during pregnancy was also found to be significantly affected when protein restriction was limited to before conception and not during pregnancy. The results also indicated that protein undernutrition may affect the rate of conception (Joshi et al., 2003).

Protein restriction limited to during the pre-implantation phase was sufficient to programme significant changes in rat postnatal growth and physiology (Kwong et al., 2000). Maternal protein undernutrition in the pre-implantation phase resulted in reduced birth weight, over compensatory growth post-weaning, increased systolic blood pressure, disproportionate growth of specific body organs and blastocyst abnormalities. The findings from animal studies indicate that changes to adult metabolism and physiology induced by maternal undernutrition, particularly, that of protein around the time of conception might have far reaching consequences to adult disease in later life.

Evidence from human epidemiological studies is not sufficient to conclude that there is a direct relationship between low protein intake in early pregnancy and pregnancy outcomes (Table 1.2.1) (Metges, 2001). However, the Dutch famine during World War II provides information on the long-term effects of a brief period of undernutrition during early, mid and late pregnancy. Maternal undernutrition around the time of conception was associated with an increased risk of an atherogenic lipid profile, obesity, heart disease and schizophrenia in later life (Roseboom et al., 2001; Susser & Stein, 1994). The health effects in adults were predominately found when maternal undernutrition was around the time of conception rather than during mid or late pregnancy, indicating that the effects of undernutrition depend on the timing during gestation and the organs developing at the time. There was no reduction in birth weight with famine exposure around conception, as the abrupt end to the famine meant that mothers were well nourished in late pregnancy. This indicates that malnutrition around conception may permanently affect adult health without effecting birth weight and the effects cannot be overcome with good nutrition in later pregnancy.

More recent data from human populations shows that maternal nutrition can affect size at birth. Nutritional status prior to pregnancy, as measured by prepregnancy weight and body mass index (BMI), is associated with IUGR and LBW (Andersson & Bergstrom, 1997; Ehrenberg et al., 2003; Godfrey et al., 1997; Neggers et al., 1997; Thame et al., 1997; WHO, 1995). Provision of nutritious foods during the inter-pregnancy period to at risk women enrolled in the Women, Infant and Children program improved outcomes in subsequent pregnancies, including the incidence of LBW and preterm delivery (Abrams, 1993). Short inter-pregnancy intervals can lead to a compromised nutritional status at the time of conception and closely spaced pregnancies are associated with an increased risk of LBW and SGA infants (King, 2003).

Table 1.2.1: Summary of studies on macronutrient intakes and pregnancy outcome

Author	Study Design	Results
Oken et al. 2004	Prospective observational study of diet during the 1st trimester and pregnancy outcome (n=2109).	Increased 1st trimester intake of n-3 PUFA associated with lower birth weight (trend p=0.01) and lower foetal growth z value (trend p=0.001). Increased total seafood intake associated with lower birth weight (trend p=0.05) and lower foetal growth z value (trend p=0.02). No associations for preterm delivery or gestational age.
Mitchell et al. 2004	Case-controlled study of retrospective dietary intake at time of conception in women with a SGA infant (n=844) and controls (n=870).	Increased intake of fish (p=0.04) and CHO-rich foods (p=0.04) around conception were associated with a reduced risk of SGA
Scholl et al. 2004	Prospective observational study of diet during pregnancy and birth weight and foetal growth (n=1082).	Low dietary GI associated with a 116 g decrease in birth weight (95%, 50.0-182.5) and a 1.8 fold increase in risk of SGA birth (95%, 1.1-2.8).
Shaw et al. 2003	Case-controlled study of retrospective dietary intake in the 3 mths before conception in women with a previous NTD (n=454) and controls (n=462).	Adjusted OR for a NTD with highest quartile of sucrose intakes was 2.34 (95%, 1.39-3.96) and for dietary GI was 1.86 (95%, 1.29-2.70) compared to lowest quartile; risk ≥ 4-fold higher in obese women.
Olsen & Secher 2002	Prospective observational study of seafood consumption during early pregnancy and preterm delivery and low birth weight (n=8729).	Linear trend for decreased LBW (p<0.001), preterm birth (p=0.003) and IUGR (p=0.001), and increased birth weight (p=0.001) with increasing n-3 PUFA intake. Adjusted OR for preterm delivery was 2.7 (95%, 1.5-4.8) and LBW was 3.2 (95%, 4.7-6.0) for no intake compared to highest intake.
Rao et al. 2001	Prospective study on dietary intakes at 18 and 28 wks gestation and measure of birth size in India (n=797).	Energy, CHO and protein intakes not associated with birth size; higher fat intake associated with greater birth length (p<0.001).
Roseboom et al. 2001, Susser & Stein 1994	Birth cohort of the effect of timing of prenatal exposure to the 1944/45Dutch famine on birth outcomes and adult disease (n=2414).	Exposure to famine early in pregnancy associated with reduced fertility and increase in stillbirths and NTDs; increased risk of obesity, heart disease, atherogenic lipid profile and schizophrenia and anti-social personalities in adult life.
Mathews et al. 1999	Prospective observational study on dietary intakes during early pregnancy and placental and birth weights (n=693).	Macronutrient intakes not related to placental or birth weights.
Godfrey et al. 1996	Prospective observational study of diet during the 1st trimester and placental growth and foetal growth. (n=538).	Placental (p=0.03) and birth weights (p=0.03) inversely related to energy intake, largely dependent on association with CHO intake. Placental weight decreased 41g (p=0.01) and birth weight by 143 g (p=0.01) for each unit increase in CHO; stronger association for sugars (p<0.02) than for starch (P<0.1). Non-significant association for fat intake (p≤0.07). No association for protein.

Note: CHO: carbohydrate; GI: glycaemic index; IUGR: intrauterine growth restriction; LBW: low birth weight; PUFA: polyunsaturated fatty acid; NTD: neural tube defect; n-3: omega-3; SGA: small-for-gestational age.

To date most of the limited number of human studies have not found an association between maternal protein intake in early pregnancy and birth weight (Godfrey et al., 1996; Mathews et al., 1999; Mitchell et al., 2004). However, in some studies energy intake (Godfrey et al., 1996) and maternal protein at the onset of pregnancy have been strongly correlated with size at birth (Wynn & Wynn, 1988). Difficulties in accurately assessing dietary intakes in the periconceptional period may explain the lack of

consistency between studies. Most studies have assessed first trimester intakes, which are complicated by nausea in early pregnancy. However, retrospective intakes for the period around conception are subject to recall bias, as women may be more likely to recall the period since pregnancy recognition or from the onset of nausea (da Costa Pereira et al., 1993).

High intakes of carbohydrate, particularly from sugars, in early pregnancy have been associated with lower birth weight (Godfrey et al., 1996). In a recent study increased intakes of both carbohydrate and sugar during pregnancy were linearly correlated with a decline in glycaemic index (GI); a low dietary GI was associated with reduced birth weight and increased risk of a SGA birth (Scholl et al., 2004). Findings from this study indicate that the type of carbohydrate in the diet may influence foetal growth and infant birth weight. Mitchell et al. (2004) found that intake of carbohydrate-rich foods was associated with a reduced risk of a SGA infant ($p=0.04$), however, this study used a FFQ to recall dietary intakes the year before so is subject to considerable recall bias.

Recently, a retrospective study found that both a higher dietary GI and higher intakes of sucrose in the periconceptional period were found to be associated with an increased risk of NTDs (Shaw et al., 2003). Glycaemic control, namely the prevention of hyperglycaemia, before and during early pregnancy in diabetic women has been shown to reduce the rate of congenital anomalies to that of the non-diabetic population (Kitzmiller et al., 1991). This suggests that elevated blood glucose levels during embryogenesis and organogenesis may be teratogenic.

Animal studies have shown that essential fatty acid deficiency (Crawford, 1993; Uauy et al., 2001) and protein malnutrition (Morgane et al., 1993) in early pregnancy has a permanent effect on brain development and results in impaired performance in behavioural and learning tests. Fish intake during pregnancy has been found to correspond to cognitive development in infants (Daniels et al., 2004). A low birth weight in humans is a risk factor for neurological developmental disorders. Low habitual intakes of essential fatty acids (Crawford, 1993; Olsen & Secher, 2002) and decreased seafood consumption (Mitchell et al., 2004; Olsen & Secher, 2002) around conception have both been associated with lower birth weights in humans; though slightly reduced birth weight was seen with increased intake of n-3 polyunsaturated fatty acids (PUFA) in the first trimester in one study (Oken et al., 2004).

Table 1.2.2: Summary of studies on diet quality and pregnancy outcome

Author	Study Design	Results
Carmichael et al. 2003	Case-controlled study of diet quality score in the 3 mths before conception in women with a NTD (n=454) and controls (n=462).	Lower diet quality score associated with an OR for NTD of 1.6 (95%, 1.0-2.6) among non-supplement users or those not regularly eating cereals.
Di Cintio et al. 2001	Case-controlled study on dietary intakes in 1st trimester and SAB in cases (n=912) and controls (n=1769).	Risk of SAB inversely associated with green vegetables, fruit, milk, cheese, egg, and fish consumption ($p<0.0001$). Increased OR with higher intakes of butter (2.0; 95%, 1.1-3.6) and oil (1.6; 95%, 1.1-2.3).
Shaw et al. 1999	Case-controlled study of dietary intake in the 3 mths before conception in women with a NTD (n=409) and controls (n=420).	Risk of a NTD reduced with increased intake of grains by 0.6 (95%, 0.3-1.4) and 0.8 (95%, 0.5-1.1) and for dairy products by 0.5 (95%, 0.2-1.1) and 0.9 (95%, 0.6-1.2) in supplement and non-supplement users respectively.
Friel et al. 1995	Case-controlled study of dietary habits in women with a NTD (n=25) and controls (n=25).	Controls consumed more dairy and cereal products, fruits and vegetables, and fewer sweets (no statistics given). Cases had lower intakes of Fe, Ca, Thiamin, riboflavin, niacin, Vitamin A and C and total folate ($p<0.05$).
Laurence et al. 1980	Case series that assessed diet quality in the 1st trimester of the NTD affected and subsequent pregnancy and in the inter-pregnancy period (n=186).	NTD recurrence was 8/45 in women with poor 1st trimester diets compared to 0/141 for good or fair diets ($p<0.0001$).

Note: CHO: carbohydrate; LBW: low birth weight; NTD: neural tube defect; SAB: spontaneous abortion; SGA: small-for-gestational age.

Low fish consumption around the time of conception has also been identified as a risk factor for preterm delivery (Di Cintio et al., 2001; Olsen & Secher, 2002). However, the FFQ used by Olsen and Secher (2002) did not assess portion size or fish species to estimate n-3 PUFA, while Mitchell et al. (2004) and Di Cintio et al. (2001) both used retrospective FFQs.

In many societies overnutrition, particularly the excessive consumption of dietary fat, is fast becoming the most common nutritional imbalance during pregnancy (Buckley et al., 2005a). Animal studies have shown that exposure to maternal hyperglycaemia and impaired glucose intolerance induced by excessive food intake increase the risk of metabolic diseases in the offspring (Buckley et al., 2005a). A diet rich in saturated fatty acids permanently altered the structure of the pancreas and programmed glucose metabolism in rat offspring (Siemelink et al., 2002). Offspring from rats fed diets high in n-6 PUFA had elevated levels of total body fat, abdominal fat and liver triglycerides (Buckley et al., 2005b). The down-regulation of the expression of key proteins involved in the insulin-signalling cascade would indicate reduced hepatic insulin sensitivity in the offspring, suggesting that high fat diets predispose the offspring to metabolic perturbations (Buckley et al., 2005b).

A poor maternal diet around conception is associated with an increased risk of pregnancy complications (Table 1.2.2). However, the definitions of 'poor' diets are variable and it is often hard to dissociate the effects of a poor diet from other non-dietary factors. One study found that a diet low in vegetables and fruit, dairy products, eggs and fish but rich in fat was associated with an increased risk of miscarriage, however a retrospective FFQ was used and fat intake was assessed by self-reported subjective high/low intake of butter and oils (Di Cintio et al., 2001).

Another study used a retrospective FFQ to derive a diet quality score based on intakes of specific micronutrients and the percentage of energy from fats and sweets in the three months before conception (Carmichael et al., 2003b). A low diet quality score was associated with an increased risk of a NTD amongst non-supplement users and women who were not regular consumers of breakfast cereals. Another study found that mothers with a NTD-affected pregnancy tended to have a poorer overall diet that was characterised by low consumption of fruits and vegetables, dairy products, cereals and higher intakes of sweets and processed foods (Friel et al., 1995). However, this study used a current three-day weighed food record as a proxy for periconceptional intake one to four years earlier. An adequate diet before conception, as assessed by a prospective FFQ, was associated with a lower incidence and reoccurrence of NTD compared to women with diets low in protein, fruit and vegetables and with excessive intakes of carbohydrate and sweets (Laurence et al., 1980). These studies add to the evidence that suggests that a diet high in sugar may be a risk factor for having a NTD affected pregnancy (Shaw et al., 2003).

It appears that the balance of macronutrient intake, particularly protein and carbohydrate balance is important, with an imbalance being associated with lower birth weight, NTDs and long-term effects on adult health. While malnutrition may not be a problem in developed countries dieting or abnormal eating habits are common amongst women of childbearing age (Bellisle et al., 1995; Nunes et al., 2003). Twenty-two percent of Dunedin women aged 18-40 reported using strict dieting to control their weight during the previous year (Heath et al., 2000). It has been reported that nearly half of all college aged women in the US try to restrict their food intake (Hendricks & Herbold, 1998).

Many New Zealand women of childbearing age do not be meet the recommended energy intake of 8850 kJ for women aged 18-60 years set by the National Nutrition Taskforce

(MOH, 2003a). In the 1997 National Nutrition Survey (NNS) the median energy intake among women of childbearing age was 8783 kJ and 8175 kJ for women aged 19-24 years and 24-44 years respectively (Russell et al., 1999). A lower median energy intake of 7969 kJ was reported among a sample of predominately European Dunedin women aged 18-40 years (Gibson et al., 2001). These findings indicate that many New Zealand women of childbearing age are at risk of having low energy intakes. Given that over 50% of pregnancies are unplanned in New Zealand (Paterson et al., 2004; Schader & Corwin, 1999) a significant proportion of pregnancies may be exposed to low energy intakes during early foetal development, which may have far reaching consequences to adult health (Barker, 1999) .

While protein intake appears to be adequate among New Zealand women (Gibson et al., 2001; Russell et al., 1999), the balance of dietary fat and carbohydrate is unfavourable among many women of childbearing age. In the 1997 NNS over half of New Zealand women aged 19-44 years exceeded the recommended maximum contribution of dietary fat to energy, while 53-65% of women did not met the minimum recommendation for carbohydrate (Russell et al., 1999). Of particular concern is the finding that only 8-10% of women consumed six or more servings of cereals/grains per day. Also less than half of women ate the recommended servings of fruit, while 59-71% of women met the guidelines for the number of servings of vegetables (Russell et al., 1999). Given that poor diets characterised by low consumption of fruits, vegetables and cereals/grains have been associated with an increased risk of miscarriage (Di Cintio et al., 2001) and NTDs (Friel et al., 1995; Laurence et al., 1980; Shaw et al., 1999), a substantial proportion of New Zealand women of childbearing age are not consuming an optimal diet to minimize the risk of adverse pregnancy outcomes. The popularity of low carbohydrate diets in recent years means that the prevalence of sub-optimal dietary intakes among women of childbearing age may potentially be higher than that reported in the 1997 NNS (Carter et al., 2004).

1.2.2 Micronutrients

Micronutrients have essential roles in enzyme and transcription factors and in signal transduction pathways that regulate cell growth and differentiation; and are key components in many cell structures (Ashworth & Antipatis, 2001). The dietary requirement for micronutrients during development is small, however, adequate amounts

are essential for embryonic and foetal development and an imbalance in selected micronutrients has been shown to result in abnormal development (Ashworth & Antipatis, 2001; Keen et al., 2003).

The lack of association between size at birth and maternal energy or protein intake but strong associations with intakes of foods rich in vitamins and minerals, suggests that micronutrients may be important limiting factors for foetal growth (Rao et al., 2001). Micronutrient deficiency or excess around the time of conception is associated with a number of adverse pregnancy outcomes (Bendich, 2001; McArdle & Ashworth, 1999).

The possible occurrence of multiple micronutrient deficiencies in developing countries has made it difficult to evaluate the effects of single micronutrients on pregnancy outcomes in observational studies. This is further complicated by the numerous interactions between micronutrients that can influence absorption, metabolism or the function of other micronutrients; making it hard to interpret results in intervention studies (Black, 2001b).

The micronutrients that appear to be of particular importance for the prevention of adverse pregnancy outcomes are folate, vitamin B_{12}, zinc and iron (Bendich, 2001).

1.2.2.1 Folate

'Folate' is the generic term used to describe both synthetic folic acid and naturally occurring vitamins in foods that exhibit the biological activity of folic acid. 'Folic acid' refers to pteroylmonoglutamic acid; a synthetic compound used in dietary supplements and fortified foods (Gibson, 1990).

Folate is necessary to form the co-enzyme required for erythropoiesis, for methionine regulation and the synthesis of pyrimidines and purines essential for DNA synthesis (Ashworth & Antipatis, 2001). In rapidly dividing cells, such as during embryonic and foetal development, marginal folate status can impair cellular growth and replication (Scholl & Johnson, 2000). These important functions indicate a role for folate in foetal growth and development.

The prevention of NTDs with periconceptional folic acid is the best known example of the importance of preconception nutrition on pregnancy outcome. Observational studies

have found that increasing intakes of dietary folate are associated with a lower risk of NTDs (Bower & Stanley, 1989; Thompson et al., 2003; Werler et al., 1993), though not all studies (Shaw et al., 1999). However, retrospective FFQs were used to assess dietary folate; the recall times involved were considerable so these studies are subject to recall bias.

In the early 1990s two randomised controlled trials found that folic acid supplementation in the periconceptional period could prevent both the occurrence (Czeizel & Dudas, 1992) and reoccurrence of NTDs (MRC, 1991) by approximately 70%. Czeizel and Dudas (1992) found that the daily use of 800 μg of folic acid for one month before conception prevented the first occurrence of NTDs compared to a trace element supplement in well-nourished women. Women with a previous NTD-affected pregnancy have a higher risk of a NTD; the use of 4 mg folic acid was found to prevent the recurrence of NTDs (MRC, 1991). Since then observational studies have shown that supplementation with 400 μg of folic acid in the periconceptional period is effective in preventing NTDs (Berry et al., 1999; Werler et al., 1993).

It is unknown whether doses of folic acid lower than 400 μg are also effective in reducing the incidence of NTDs. Further trials to determine the minimum dose of folic acid required to prevent NTDs would be unethical because women given a lower dose may be placed at risk of having an infant with a NTD. Red-cell folate levels in early pregnancy are inversely associated with the risk of a NTD (Daly et al., 1995; Smithells et al., 1976); it appears that red-cell folate levels above 906 nmol/L are optimal for the prevention of NTDs (Daly et al., 1995). Studies have shown that increasing dietary folate alone is relatively ineffective as a method of achieving the folate levels required to prevent NTDs compared to consuming folic acid supplements or fortified foods (Brown et al., 1997; Cuskelly et al., 1996; Daly et al., 1995). This is because the bioavailability of dietary folate is approximately half that of synthetic folic acid (MOH, 2003b). Recent research indicates that daily folic acid supplementation may be required for between three to six months before peak serum folate levels are achieved (Venn et al., 2002).

As a result of these findings most countries have adopted the recommendation that all women of childbearing age consume 400 μg of folic acid daily to reduce the risk of NTDs. Women at risk of having a NTD-affected pregnancy are advised to take 4 mg of folic acid. The current recommendation in New Zealand is that women planning

pregnancy take 800 μg of folic acid daily for at least four weeks before conception until the end of the first trimester to reduce the risk of an NTD-affected pregnancy (MOH, 2003b). The higher dose of folic acid recommended in New Zealand reflects the dose that is available as a registered medicine. However, only 0-2% of New Zealand women of childbearing age reported using a folic acid supplement in the 1997 NNS (Russell et al., 1999). The prevalence of folic acid use in the preconception period among pregnant women is also low in New Zealand, 35% of Christchurch women with a planned pregnancy and 2% of women with an unplanned pregnancy reported taking folic acid before conception (Schader & Corwin, 1999).

Folic acid and increasing levels of dietary folate intake have also been linked to reduced incidence of other congenital anomalies (Scanlon et al., 1998; Shaw et al., 2000a; van Rooij et al., 2003). Though the results for particular anomalies are not ways consistent in part due to methodological issues. Czeizel and Dudas (1992) may have underestimated the reduction in congenital anomalies in the early part of their study as the original supplement contained a dose of vitamin A that was later found to be teratogenic. While van Rooji et al. (2002) assessed current folate intake using a FFQ as a proxy for periconceptional intake one year earlier.

During pregnancy low levels of dietary or circulating folate have also been associated with increased risk of preterm delivery (Scholl et al., 1996), infant birth weight (Neggers et al., 1997; Rao et al., 2001; Scholl et al., 1996; Tamura et al., 1992; Tamura et al., 1997) and IGUR (Neggers et al., 1997; Rolschau et al., 1979; Tamura et al., 1992; Tamura et al., 1997), though this link is still unconfirmed (Baker et al., 1977; Godfrey et al., 1996) (Table 1.2.3). Limited data suggests that folic acid supplementation during late pregnancy in developing countries may improve foetal growth and reduce the incidence of LBW (Iyengar & Rajalakshmi, 1975; Rolschau et al., 1979).

The early studies on folic acid supplementation were not designed to measure pregnancy outcomes other than NTDs and as a result only a few studies have examined either folate status or folic acid supplementation around the time of conception and foetal growth (Table 1.2.3). A recent retrospective study found that folic acid supplementation around the time of conception was associated with a significantly reduced risk of a SGA infant (Mitchell et al., 2004). Dietary folate intake in the first trimester was not associated with placental or birth weights in a prospective study (Godfrey et al., 1996). In a randomised-

controlled trial an excess of LBW was found in women receiving folic acid compared to a trace element supplement, however significance was lost when confined to singleton births (Czeizel, 1993). They suggest the higher rate of LBW may be attributed to the increase in multiple births and a non-significant increase in female births in the folic acid group.

Homocysteine levels are elevated during folate deficiency; increased serum homocysteine before conception has been associated with nearly a 4-fold higher risk of preterm delivery (OR: 3.6; 95%, 1.3-10.0, $p<0.05$) (Ronnenberg et al., 2002b). In this study serum folate was not associated with preterm delivery, though folate deficiency tended to be more prevalent in LBW and SGA cases ($p>0.05$). The risk of spontaneous abortion also tended to increase with decreasing serum folate ($p=0.07$) and with folate deficiency ($p=0.10$) (Ronnenberg et al., 2002a). However, red-cell folate is a better proxy for folate status than serum folate as it reflects folate turnover in the previous 120 days, whereas serum folate reflects recent intakes (Gibson, 1990). Recently, a prospective study reported no associated between either serum or red-cell folate before pregnancy and during the first trimester and miscarriage or birth weight (de Weerd et al., 2003b).

Supplementation of women with hyperhomocysteinemia with 5 mg of folic acid and 100 mg of vitamin B_6 between pregnancies increased subsequent birth weight from 1088±570 to 2867±648 g ($p<0.0001$) and gestation length from 29.5±3.7 to 36.7±2.2 weeks ($p>0.05$) compared to the previous pregnancy; though these results may primarily reflect the effect of being second pregnancies (Leeda et al., 1998).

The estimated prevalence of inadequate dietary folate intakes among New Zealand women in the 1997 NNS were 21.2% and 13.4% for women aged 19-24 years and 25-44 years respectively (Russell et al., 1999). While further research is needed into folate status during early pregnancy to clarify the role of folate in birth size, miscarriage and preterm delivery, the low rate of folic acid use in New Zealand means that a significant number of women may enter into pregnancy with a sub-optimal folate status.

Table 1.2.3: Summary of studies on folate and foetal growth, preterm birth and miscarriage

Author	Study Design	Results
Mathews et al. 2004	Prospective observational study on serum nutrient profiles at 16 and 28 wks and placental and birth weight (n=798).	Serum folate, B_{12}, Se, ferritin or Hb not associated with placental or birth weights; Hb at 28 wk associated with birth weight ($p<0.001$).
Mitchell et al. 2004	Case-controlled study of retrospective folic acid use at time conception in women with a SGA infant (n=844) and controls (n=870).	Folic acid supplementation associated with a reduced risk of SGA ($p=0.04$).
de Weerd et al. 2003b	Prospective study on periconceptional haematological parameters and vitamin profiles and miscarriage and birth weight (n=240).	Preconceptional or 1st trimester serum or red-cell folate not associated with miscarriage or birth weight.
Ronnenberg et al. 2002a, 2002b	Case-controlled study on serum homocysteine and B vitamins before conception and preterm birth (cases=29, controls=405), LBW (cases=33, controls=390), SGA (cases=65, controls=358) and SAB (cases=49, controls=409).	Elevated homocysteine associated with increased risk of preterm birth (OR: 3.6; 95%, 1.3-10.0). Serum folate not related to preterm birth; folate deficiency tended to be more prevalent in LBW and SGA cases ($p>0.05$). Lower risk of preterm birth with vitamin B_{12} deficiency (OR: 0.4; 95%, 0.2-0.9). Risk of SAB tended to increase with decreasing serum B_6 ($p=0.06$) and folate ($p=0.07$); adjusted risk 4-fold higher in women with both sub-optimal folate and B_6.
Rao et al. 2001	Prospective study on dietary intakes at 18 and 28 wks gestation and measure of birth size (n=797).	Red-cell folate at 28 wks positively associated with birth weight ($P<0.001$).
Leeda et al. 1998	Cases with history of preeclampsia and IUGR were evaluated for hyperhomocysteinemia at 10 wk postpartum (n=207); positive test treated with 5 mg folic acid +100 mg vitamin B6 and subsequent pregnancy evaluated (n=14).	Higher rate of hyperhomocysteinemia in women with a history of preeclampsia (17.7%) and IUGR (19.2%) than normal population (2-3%). Supplementation increased birth weight from 1088±570 to 2867±648 g ($p<0.0001$) compared to previous pregnancy.
Tamura et al. 1992, 1997, Neggers et al. 1997	Prospective observational study of dietary folate and serum folate in women with risk factors for IUGR (n=1200); most analyses involved a sub-sample (n=289) that assessed dietary folate and serum folate at 18 and 30 weeks.	Linear associations between serum folate at wk 30 and infant birth weight ($p=0.03$), lower prevalence of IUGR ($p=0.014$) and maternal infections ($p=0.007$). Birth weight was significantly higher among women whose folate intake was above the 90th percentile compared to those below the 10th percentile ($p=0.03$).
Godfrey et al. 1996	Prospective observational study of diet during the 1st trimester and placental and birth weights. (n=538).	Folate intake in 1st trimester not associated with placental or birth weights.
Scholl et al. 1996	Prospective observational study of folate from diet and supplements, and serum folate at 28 weeks (n=832).	Women with low folate intake (≤240 µg/d) had >3 times greater risk of preterm delivery and LBW infant than women with folate intake >240µg/d ($p<0.05$). Odds of preterm delivery increased 1.5% per unit decrease in serum folate ($p<0.05$).
Czeizel 1993	Randomised-controlled study of a vitamin supplement (containing 800 µg folic acid) (n=2420) and a trace element supplement (n=2333) from 1 month before conception until 2nd missed period.	Folic acid group had more multiple pregnancies (3.8% compared to 2.7%, $p<0.05$), a non-significant increase in female births and an increase in conception rate than trace element group. Higher rate of LBW in folic group compared to trace element group ($p<0.05$), non-significant among singleton births ($p=0.17$).
Rolschau et al. 1979	Paired trial with allocation (method not stated) to multi-vitamin containing 200mg iron and 5 mg folic acid (n=16) or multi-vitamin without folic acid (n=16) during the last trimester.	Birth weight was 12.7% higher among folic acid supplemented women ($p<0.001$). Red-cell folate at birth was correlated with birth weight ($r=0.53$, $p<0.001$). No association for gestational age.

Note: IUGR: intrauterine growth restriction; LBW: low birth weight; OR: odds ratio; SAB: Spontaneous abortion; SGA: small-for-gestational age.

1.2.2.2 Vitamin B_{12}

Vitamin B_{12} is an essential nutrient present only in animal products. It is involved in various metabolic functions and is critical for the synthesis of nucleotides and amino acids (Ramakrishnan et al., 1999). It has long been recognised that vitamin B_{12} deficiency seen in pernicious anaemia is associated with infertility (Reznikoff-Etievant et al., 2002).

Vitamin B_{12} is required as an enzyme cofactor in the conversion of homocysteine to methionine and deficiency leads to elevated levels of homocysteine (Refsum, 2001). It has been suggested that elevated homocysteine, either due to a genetic defect or poor diet is implicated in the development of congenital anomalies and pregnancy complications (Refsum, 2001; Shoob et al., 2001). As discussed earlier, elevated homocysteine has been associated with increased risk of NTDs (Steegers-Theunissen et al., 1994), preterm delivery (Ronnenberg et al., 2002b), IUGR and preeclampsia (Leeda et al., 1998). The predominately vegetarian Indian population has low dietary vitamin B_{12} intakes, which may help to explain the very high incidence of NTDs in India (Refsum, 2001).

Low vitamin B_{12} has been implicated in preterm delivery (Ronnenberg et al., 2002b), recurrent abortion (Reznikoff-Etievant et al., 2002) and NTDs (Shoob et al., 2001), however the findings to date are not consistent (de Weerd et al., 2003b; Krapels et al., 2004; Mathews et al., 2004) (Table 1.2.4). Serum vitamin B_{12} reflects short-term intakes, because of the day to day variation in dietary intake it only provides a snapshot of recent intake (Gibson, 1990). Most studies have either measured serum vitamin B_{12} (de Weerd et al., 2003b; Mathews et al., 2004; Ronnenberg et al., 2002b), have been retrospective (Shoob et al., 2001) or used postpartum diet as a proxy for periconceptional intakes (Krapels et al., 2004), which may explain the lack of consistent findings between vitamin B_{12} and pregnancy outcome.

While very few (0.2-0.6%) New Zealand women of childbearing age were estimated to have inadequate vitamin B_{12} intakes in the 1997 NNS (Russell et al., 1999), certain population groups such as vegetarian or vegan women are at increased risk of having a low vitamin B_{12} status (Alexander et al., 1994; Koebnick et al., 2004). The results from the 1997 NNS indicated that 5% of women aged 19-24 and 3% of women aged 25-44 followed a vegetarian or vegan diet (Russell et al., 1999), while 22% of Dunedin women excluded red meat from their diet (Gibson et al., 2001). Women planning pregnancy who

follow vegetarian diets may require either vitamin B_{12} supplementation or be advised to include some red meat into their diet to optimise vitamin B_{12} status before pregnancy.

Table 1.2.4: Summary of studies on vitamin B_{12} status and pregnancy outcome

Author	Study Design	Results
Mathews et al. 2004	Prospective observational study on serum nutrient profiles at 16 wks and placental and birth weight (n=798).	Serum folate, B_{12}, Se, ferritin or Hb not associated with placental or birth weights; Hb at 28 wk associated with birth weight ($p<0.001$).
Krapels et al. 2004	Case-controlled study of dietary B vitamin intake and orofacial cleft cases (n=182) and controls (n=173).	Trend for risk reduction with increasing intake of thiamin ($p=0.04$) and B_6 ($p=0.03$) only among folic acid users. No association for Vitamin B_{12} and orofacial clefts.
de Weerd et al. 2003b	Prospective study on periconceptional haematological parameters and vitamin profiles and miscarriage and birth weight (n=240).	No associations for serum vitamin B_{12}, B_6, ferritin, Hb or iron and miscarriage or birth weight.
Reznikoff-Etievant et al. 2002	Case-controlled study of serum B_{12} and folate in women with history of recurrent abortion (n=110) and controls (n=96); deficient women given 250-500 μg B_{12}.	B_{12} deficiency in 9% of cases and 1% of controls (OR: 9.5 (95%, 1-75). Subsequent pregnancies after supplementation 4/5 delivered full term and 1/5 aborted.
Shoob et al. 2001	Case-controlled study on dietary methionine in NTD cases (n=170) and controls (n=269).	Cases had higher intakes of methionine, protein, B_6, folate, iron and zinc ($p<0.05$) and B_{12} tended to be higher ($p=0.05$).
Smithells et al. 1976	Observational study of serum vitamin levels during the 1st trimester and occurrence of NTD (n=900).	White-blood cell vitamin C associated with NTD ($p<0.05$).

Note: Hb: haemoglobin; LBW: low birth weight; NTD: neural tube defect; OR: odds ratio.

1.2.2.3 Zinc

Zinc has an essential role in normal growth and development, cellular integrity and many biological functions, including protein synthesis and nucleic acid metabolism (Shah & Sachdev, 2001). Zinc deficiency has been implicated in adverse maternal outcomes such as placental abruption (Black, 2001b). Severe zinc deficiency during pregnancy, as seen in the rare condition acrodermatitis enteropathica, has been associated with spontaneous abortion and congenital anomalies, while milder deficiency has been linked to LBW, IUGR and preterm delivery (King, 2000). These effects are consistent with the findings from animal studies that have shown that zinc deficiency around conception is associated with IUGR and congenital anomalies (King, 2000; Shah & Sachdev, 2001). The effect of marginal zinc status on pregnancy outcome is a more relevant issue; however the findings from human studies to date are not consistent (King, 2000; Shah & Sachdev, 2001).

A major challenge to zinc trials is the lack of a suitable indicator of zinc status due to the variability in serum zinc with infection, exercise and food intake. This is complicated further during pregnancy due to the wide variability in plasma volume expansion between

individual pregnancies (King, 2000). There have been few well designed studies on zinc status and congenital anomalies to date; most studies have been retrospective or have used serum zinc to assess zinc nutriture (Shah & Sachdev, 2001) (Table 1.2.5). Three case-controlled studies found an association between dietary zinc and NTDs (Shaw et al., 1999; Shoob et al., 2001; Veile et al., 1999). The study by Veile et al. (1999) found that the risk of a NTD decreased with increasing dietary zinc (p=0.004); with a 66% reduction in risk with the highest quintile of dietary zinc compared to the lowest quintile (OR: 0.44 (95%, 0.28-0.71) after adjustment for folate intake. There was a non-significant trend for reduced risk with increased total zinc (p=0.09). Shoob et al. (2001) found that periconceptional zinc intake was lower in women with a NTD compared to the controls (12.9 mg vs. 15.2 mg, p=0.01).

However, the data from these studies needs to be interpreted with caution as FFQs were used to recall intakes 12 months earlier and it is not clear whether increased zinc, or increased intake of another single nutrient or a combination of nutrients was associated with the prevention of NTDs. A prospective case-controlled study failed to show an association between serum zinc at the beginning of pregnancy and the incidence of congenital anomalies (Stoll et al., 1999).

Many studies have investigated the relationship between zinc status and birth size, however from the current evidence the association is unclear (Black, 2001b; King, 2000; Shah & Sachdev, 2001). Both observational studies on serum zinc levels (Neggers et al., 1990; Neggers et al., 1997; Tamura et al., 2000) and randomised-controlled trials of zinc supplementation during pregnancy (Caulifield et al., 1999; Goldenberg et al., 1995) on measures of birth size have provided mixed results. Most of the studies have been carried out in zinc replete populations, and as such have not addressed the association between low zinc and birth outcome. However, findings in zinc deficient populations are also inconsistent (Caulifield et al., 1999; Goldenberg et al., 1995). Further research is needed to address the association between marginal zinc status and pregnancy outcome, particularly during the period of embryogenesis and organogenesis in early pregnancy.

Inadequate zinc intakes do not appear to be common among New Zealand women of childbearing age, the prevalence of zinc inadequacy was estimated to be 0.9-1.6% in the 1997 NNS (Russell et al., 1999). However, the prevalence of inadequate zinc intake among Dunedin women aged 18-40 years was estimated to be 6% (Gibson et al., 2001).

In this study 17% of women had mild zinc deficiency (serum zinc <10.71 μmol/L); more women that excluded red meat had mild zinc deficiency compared to women who ate red meat (19% vs. 9%). Numerous studies have shown that dietary zinc intake does not differ between vegetarian or vegan women compared to omnivorous women (Alexander et al., 1994; Barr & Broughton, 2000; Cade et al., 2004; Haddad et al., 1999; Waldmann et al., 2003), though the high phylate content of vegetarian or vegan diets means that the bioavailability of zinc is poor (Donovan & Gibson, 1995). Though the zinc status of vegetarian or vegan women has been found to be similar to non-vegetarians in other studies (Haddad et al., 1999). Another population group at risk of a sub-optimal zinc status is adolescent females (Gibson et al., 2002). Women who enter into pregnancy with a marginal zinc status are not in a nutritional state to optimise pregnancy outcome.

Table 1.2.5: Summary of studies on zinc and pregnancy outcome

Author	Study Design	Results
Shoob et al. 2001	Case-controlled study on periconceptional dietary intakes and NTD cases (n=170) and controls (n=269).	Cases had lower intakes of methionine, protein, B_6, folate, iron and zinc ($p<0.05$).
Tamura et al. 2000	Prospective observational study of serum zinc at 16 wks (range: 6-34 wk) in women with serum zinc above the 50th percentile (n=3448).	Serum zinc not associated with IUGR, preterm birth, birth weight or length of gestation.
Caulifield et al. 1999	Randomised-controlled trial of 15 mg zinc, 60 mg iron + 250 μg folic acid (n=521) or same supplement without zinc (n=495) from 10-24 wk in zinc deficient population.	No association with birth weight, preterm birth, LBW or length of gestation.
Shaw et al. 1999	Case-controlled study on periconceptional dietary intakes and NTD cases (n=409) and controls (n=420).	Reduced risk of a NTD with highest intakes of dietary zinc was 0.50 (95%, 0.1-3.2).
Stoll et al. 1999	Prospective case-controlled study on serum zinc at the start of pregnancy in CA cases (n=170) and controls (n not given).	Serum zinc not associated with CA.
Veile et al. 1999	Case-controlled study on dietary intakes in the 3mths before conception and NTD cases (n=430) and controls (n=429).	Adjusted OR for a NTD with highest intakes of dietary zinc was 0.44 (95%, 0.28-0.71), trend p=0.004); for total zinc adjusted for folate OR was 0.68 (95%, 0.4-1.34, p=0.09).
Tamura et al. 1992, 1997, Neggers et al. 1997	Prospective observational study of dietary zinc and serum zinc at 18 and 30 wks in women with risk factors for IUGR (n=289).	Serum or dietary zinc not associated with birth weight, IUGR or maternal infection.
Goldenberg et al. 1995	Randomised-controlled study of 25 mg of zinc (n=294) or placebo (n=286) during pregnancy in women with serum zinc below 50th percentile. Also contained 30 mg Fe, 50 mg Ca and 400μg folic acid.	Zinc supplementation associated with increased birth weight (p=0.03), head circumference (p=0.02) and decreased LBW (p>0.05).
Neggers et al. 1990	Retrospective observational study of serum zinc during pregnancy (6-31 wks) and birth weight (n=476).	Serum zinc associated with adjusted birth weight ($p<0.05$); prevalence of LBW was >8-fold higher in lowest quartile than highest quartile (p=0.001).

Note: CA: congenital anomalies; Hb: haemoglobin; IUGR: intrauterine growth restriction; LBW: low birth weight; NTD: neural tube defect; OR: odds ratio; SGA: small-for-gestational age.

1.2.2.4 Iron

Iron is required for haemoglobin (Hb) synthesis and as an enzyme co-factor has several other important functions in the body (Ramakrishnan et al., 1999). During pregnancy the foetal demand for iron increases substantially, with the maximal requirements occurring in the last trimester (Steer, 2000). Iron deficiency anaemia can develop during pregnancy if a woman's iron stores at the start of pregnancy are inadequate to meet the demands of the foetus, this is despite increased iron absorption during pregnancy (van den Broek, 2003).

Maternal anaemia (Hb <120 g/L) during pregnancy has been associated with lower birth weight, preterm delivery and neonatal or perinatal mortality (Allen, 2000; Rasmussen, 2001) (Table 1.2.6). This association appears to follow a U-shaped distribution for LBW and preterm delivery, with both low and high Hb values associated with increased risk (Murphy et al., 1986; Rasmussen, 2001; Steer et al., 1995). However, interpreting Hb and ferritin levels during pregnancy is complicated by the differential expansion of the plasma volume and red-cell mass volume resulting in the haemodilution of blood constituents (Picciano, 2003). Many studies have adjusted the definition of anaemia for gestational age to try to control for the decline in Hb during pregnancy (Scanlon et al., 2000; Scholl et al., 1992), however not all studies (Steer et al., 1995). Although randomised-controlled trials of iron supplementation during pregnancy have consistently shown to improve maternal iron status, they have failed to reduce the incidence of adverse pregnancy outcomes associated with anaemia (Allen, 2000; Rasmussen, 2001; Scholl & Reilly, 2000).

Until recently is was presumed that iron deficiency was the cause of most cases of maternal anaemia, however in some populations only a fraction of maternal anaemia is due to iron deficiency (Knudsen et al., 2004; Ronnenberg et al., 2004; Scholl et al., 1992). Maternal anaemia can also result from infection, inflammation, folic acid deficiency or vitamin B_{12} deficiency. The primary cause of anaemia is likely to be plasma volume expansion during pregnancy and this form of anaemia is not associated with adverse pregnancy outcome (Rasmussen, 2001; Scholl & Reilly, 2000). These factors may explain the lack of improvement in pregnancy outcomes with iron only supplementation trials.

Only a few studies to date have addressed the issue of iron deficiency anaemia versus anaemia and pregnancy outcomes. In a recent prospective study on iron status before

conception, the reduction in birth weight seen with iron deficiency anaemia (without vitamin B_{12} deficiency) was more pronounced than that found with either vitamin B_{12} deficiency anaemia or anaemia (Ronnenberg et al., 2004). Both low (<12 μg/L) and high (≥60 μg/L) ferritin levels were associated with decreased birth weight, but only high ferritin was associated with a significantly increased risk of LBW and IUGR ($p<0.006$). There was a non-significant 3-fold higher risk of preterm delivery with low ferritin ($p=0.12$). The association between elevated ferritin and pregnancy outcome is consistent with previous findings during pregnancy (Goldenberg et al., 1996; Rasmussen, 2001; Scholl & Reilly, 2000), which may reflect increased ferritin due to inflammation. However, since measurements were taken before conception elevated ferritin can not be attributed to pregnancy related infections or inadequate plasma volume expansion that are often cited as explanations for the association between elevated ferritin and pregnancy outcome (Ronnenberg et al., 2004).

An earlier study found that iron deficiency anaemia was associated with a 3-fold increased risk of LBW (OR: 3.10; 95%, 1.16-4.39) and more than a 2-fold higher risk of preterm delivery (OR: 2.66; 95%, 1.15-6.17), while anaemia without iron deficiency was not associated with the risk of LBW or preterm delivery (Scholl et al., 1992). The increase in LBW observed with iron deficiency was largely attributable to a higher number of preterm infants. A strength of this study was that different Hb levels were used to define anaemia at various stages of pregnancy, therefore controlling for the decline in Hb during pregnancy.

Recently, a small study showed that women with insufficient iron stores before conception developed anaemia earlier during pregnancy and that all of these women developed anaemia by term (Casanueva et al., 2003). Pre-gestational ferritin levels tended to be higher in women who did not develop anaemia than women with anaemia, though this did not reach significance ($p=0.06$). If women have low iron stores at the start of pregnancy it may be very difficult to replete iron stores during pregnancy, supplementation before conception may improve maternal iron stores and prevent iron depletion during pregnancy (Kaiser et al., 2002; Lynch, 2000). However, increased iron stores as a result of iron supplementation in non-iron deficient women have recently been associated with gestational diabetes and increased oxidative stress during pregnancy (Scholl, 2005). Therefore, while iron supplementation may benefit women who have iron

deficiency or iron deficiency anaemia, conversely supplementation may increase the risk of adverse pregnancy outcomes among iron replete women.

Table 1.2.6: Summary of studies on iron status and pregnancy outcome

Author	Study Design	Results
Ronnenberg et al. 2004	Prospective study on iron and B vitamin status 1-4 mths before pregnancy and pregnancy outcome (n=204). Mild anaemia: 95 ≤Hb< 120 g/L; moderate anaemia: Hb <95 g/L; Fe deficiency anaemia: Hb <120 g/L, ferritin < 12 µg/L. Low ferritin:<12 µg/L. Adjusted for gestational age.	Mild and moderate anaemia associated with lower birth weight (139 and 192g respectively, p=0.01); iron deficiency anaemia (without B_{12} deficiency) associated with 242 g lower birth weight (p=0.01); B_{12} deficiency anaemia (without Fe deficiency) associated with 141 g lower birth weight (p<0.05). Adjusted OR for LBW was 6.5 (95% 1.6-26.7, p=0.009) and for IUGR was 4.6 (95%, 1.5-3.5, p=0.006) for moderate anaemia compared to no anaemia. Low ferritin tended to have 3-fold higher risk of preterm (p=0.12); no association with LBW or IUGR.
Mathews et al. 2004	Prospective study on serum nutrient profiles at 16 and 28 wks, and placental and birth weights (n=798).	Serum ferritin, folate, vitamin B_{12} or Hb at 16 wks not associated with placental or birth weights; Hb at 28 wk associated with birth weight (p<0.001).
Casanueva et al. 2003	Prospective observational study on iron status 1-2 mths before pregnancy and anaemia during pregnancy (n=35).	Low serum ferritin (<20 µg/L) before conception associated with earlier development of anaemia (p=0.05). Ferritin tended to be lower in women who developed anaemia (p=0.06).
Cogswell et al. 2003	Randomised-controlled trial of 30 mg iron (n=146) or placebo (n=129) from <20 wks until 28 wks gestation in women with Hb≥110 g/L and ferritin ≥20 µg/L.	Iron supplementation associated with higher birth weight (206g, p=0.01), decreased LBW (4% vs. 17%, p=0.003) and SGA (7% vs. 18%, p=0.014) than placebo; no association with anaemia, iron deficiency anaemia or preterm delivery.
de Weerd et al. 2003b	Prospective study on periconceptional haematological parameters and vitamin profiles, and miscarriage and birth weight (n=240).	No associations between serum vitamin B_{12}, B_6, ferritin, Hb or iron and miscarriage or birth weight.
Scanlon et al. 2000	Observational study of Hb and pregnancy outcome (n=173031); Hb measured between 1-36 wks. Hb adjusted for gestational age.	Adjusted OR for preterm birth with moderate anaemia (Hb≤95 g/L) at 12 wks was 1.68 (95%, 1.29-2.21). Anaemia not associated with SGA. High Hb in 1st and 2nd trimesters associated with SGA.
Goldenberg et al. 1996	Prospective observational study of serum ferritin at 19, 26 and 36 wks, and birth weight and preterm delivery in African-American women with Hb≥110 g/L and ferritin ≥20 µg/L (n=580); women provided with prenatal supplement containing iron.	Ferritin in lowest quartile not associated with birth weight, preterm delivery or LBW at any gestational age compared to higher quartiles. At all stages ferritin in highest quartile associated with lower birth weight (p<0.009) and increased LBW (p<0.05); at 26 wks was associated with an increase in preterm birth (p=0.04); OR for LBW at 19 wks was 2.1 (95%, 1.1-3.9).
Steer et al. 1995	Observational study on lowest Hb entered in pregnancy records and birth weight and preterm delivery (n=157996).	U-shaped distribution between Hb and LBW, and Hb and preterm birth. OR for lowest Hb ≤85 g/L compared to Hb 96-105 g/l was 2.46 for preterm and 2.44 for LBW (CI not given).
Scholl et al. 1992	Prospective observational study on anaemia and iron deficiency anaemia (n=779); bloods at first prenatal visit (mean=16.7 wks).	Adjusted OR for LBW with iron deficiency anaemia was 3.10 (95%, 1.16-4.39), OR for preterm delivery was 2.66 (95%, 1.15-6.17). Anaemia without iron deficiency not associated with outcomes. No associations for SGA.
Murphy et al. 1986	Prospective observational study of Hb at <13 wks, 13-19 wks and 20-24 wks, and pregnancy outcome (n=54382).	U-shaped distribution between preterm delivery, LBW and perinatal mortality for all 3 gestational periods. High Hb associated with increased preterm delivery (p<0.05), LBW (p<0.01) and hypertension (p<0.001).

Note: CI: confidence intervals; Hb: haemoglobin; IUGR: intrauterine growth restriction; LBW: low birth weight; NTD: neural tube defect; OR: odds ratio; SGA: small-for-gestational age.

Further research is needed on preconceptional iron supplementation as a means of maintaining adequate iron stores throughout pregnancy to optimise pregnancy outcome, and needs to examine both the effectiveness and safety of supplementation in women with and without iron deficiency.

Inadequate iron intakes are prevalent among New Zealand women of childbearing age, 39-42% of women aged 19-44 were estimated to have inadequate iron intakes in the 1997 NNS (Russell et al., 1999). However, only 4-7% of women aged 19-44 years in the 1997 NNS had low iron stores (serum ferritin <12 g/L) and 3-5% of menstruating women had iron deficiency (serum ferritin <12 g/L and zinc protoporphyrin >60 μmol/mol) or iron deficiency anaemia (serum ferritin <12 g/L, zinc protoporphyrin >60 μmol/mol and Hb <120 g/L). Maori women aged 15-44 years appear to be at risk of sub-optimal iron stores compared to Pacific and European women, with a higher prevalence of low iron stores (11-14% vs. 2-7%) and iron deficiency/iron deficiency anaemia (13-22% vs. 2-4%) (Russell et al., 1999). Additionally, adolescent females were at higher risk of low iron stores (7%) and either iron deficiency or iron deficiency anaemia (12%) (Russell et al., 1999). Mild iron deficiency, defined as low iron stores (serum ferritin <20 μg/L and Hb ≥120 g/L) was prevalent in 26% of Dunedin women aged 18-40 years (Heath et al., 2000).

There is evidence to suggest that vegetarian women may have a higher risk of low iron stores (Alexander et al., 1994; Ball & Bartlett, 1999). While dietary intakes of iron between vegetarians and non-vegetarians are similar (Ball & Bartlett, 1999; Barr & Broughton, 2000; Cade et al., 2004) or higher among vegetarian women (Alexander et al., 1994; Harman & Parnell, 1998), vegetarians have lower intakes of haem iron compared to non-vegetarians (Alexander et al., 1994; Ball & Bartlett, 1999; Harman & Parnell, 1998). The poor bioavailability of iron in vegetarian diets means that vegetarians tend to have lower serum ferritin levels than non-vegetarian women (Alexander et al., 1994; Ball & Bartlett, 1999), though not all studies have found lower ferritin levels in vegetarian women (Haddad et al., 1999). However, a number of studies have found no difference in the proportion of women with serum ferritin levels below 12 μg/L (Alexander et al., 1994; Ball & Bartlett, 1999; Haddad et al., 1999; Harman & Parnell, 1998) or Hb below 120 g/L (Haddad et al., 1999) between vegetarian and non-vegetarian women. Possibly due to vitamin C intake, an enhancing factor for non-haem-iron absorption, being higher

in vegetarian women than non-vegetarian women (Ball & Bartlett, 1999; Haddad et al., 1999; Harman & Parnell, 1998). The Dunedin study found that women who avoided red meat were more likely to have mild iron deficiency than red meat-eaters (29.9% vs. 19.9%, p=0.05) (Heath et al., 2000). A significant proportion of New Zealand women may enter into pregnancy with low iron stores; therefore, efforts to optimise the iron status of New Zealand of childbearing age are needed.

1.2.2.5 Other micronutrients

Severe iodine deficiency during early pregnancy is associated with miscarriage, mental retardation and cretinism. Fortunately, the correction of iodine deficiency before conception or within the first trimester can prevent cretinism (Ramakrishnan et al., 1999). Iodine deficiency was endemic in New Zealand in the early part of last century as a result of the low iodine content of New Zealand soil. The iodisation of table salt in 1926 eradicated iodine deficiency in New Zealand, however the public health recommendation to reduce salt intake and the popularity of rock salt in recent years has lead to the possible re-emergence of iodine deficiency as a public health issue in New Zealand (Mann & Aitken, 2003).

Emerging evidence suggests that vitamin C deficiency may be associated with pregnancy outcomes, particularly preterm delivery due to premature rupture of membranes (Black, 2001b; Ramakrishnan et al., 1999). Increased dietary vitamin C during early pregnancy has been found to predict both placental and birth weight, each 1 mg increase in vitamin C was associated with a 3.2 g (95%, 0.4-6.1) and 50.8 g (95%, 4.6-97.0) increase in placental and birth weights respectively (Mathews et al., 1999). Interestingly vitamin C has been shown to enhance red-cell folate levels in both women receiving folic acid and women not receiving supplementation (Brown et al., 1997). While lower white-blood cell levels have been found in women with a NTD (Smithells et al., 1976). Recently, vitamin C supplementation in women receiving fertility treatment has been shown to increase the number of conceptions in non-smokers ($p<0.05$), however these results were not significant when smokers were included (Crha et al., 2003). The pregnancy rate was significantly higher in non-smokers than smokers ($p<0.01$), suggesting that reduced fertility in smokers is related to lower vitamin C levels found in smokers (Cogswell et al., 2003).

While routine preconceptional supplementation may benefit many women care needs to taken to avoid excessive micronutrient intakes; particularly that of vitamin A (Vahratian et al., 2004a). The intake of more than 10,000 IU a day of preformed vitamin A from supplements around the time of conception has been found to be associated with nearly a 5-fold increased risk of congenital anomalies (Rothman et al., 1995). The use of vitamin A supplements is not recommended during pregnancy or if attempting to conceive (MOH, 1995).

It likely that the aetiology of adverse pregnancy outcomes is not a result of a single micronutrient but that rather multiple micronutrients are involved. This is illustrated by the link between folate, vitamin B_{12} and elevated homocysteine, and the occurrence of NTDs (Ronnenberg et al., 2002a). The risk of spontaneous abortion is more pronounced with the occurrence of both sub-optimal preconception folate and vitamin B_{12} levels than the risk associated with either low folate or vitamin B_{12} alone (Ronnenberg et al., 2002a).

1.2.3 Body Composition

Body composition at the time of conception is associated with infertility and a number of adverse pregnancy outcomes including LBW, preterm delivery and pregnancy complications (Galtier-Dereure et al., 2000; Neggers & Goldenberg, 2003). Body mass index (BMI) is a simple, useful index for defining and measuring underweight, overweight and obesity in populations (Heyward & Wagner, 2004).

Women who are underweight or suffer from eating disorders are more likely to experience reproductive dysfunction due to menstrual irregularities (Crow et al., 2002; Frisch, 1994). Moderate weight loss, of between 10-15% of normal weight-for-height results in amenorrhoea and regular menstruation returns when body weight is restored to within 5% of normal weight (Bates et al., 1982; Frisch, 1994).

Both low and high BMI values have been associated with reduced fertility (Green et al., 1988; Grodstein et al., 1994b; Norman & Clark, 1998; Wang et al., 2000; Zaadstra et al., 1993). Studies have been carried out in both natural and assisted conception; however the cut-off points used in the definitions of body size often differ between studies.

A significant linear trend for reduced probability of conceiving with increasing BMI over 25 kg/m^2 was found in women undergoing fertility treatment (Wang et al., 2000). In a

case-controlled study Grodstein et al. (1994b) found that the relative of risk of ovulatory infertility was 3.1 (95%, 2.2-4.4) in obese women (BMI>27 kg/m^2) compared to normal weight women (20< BMI ≤24.9 kg/m^2). They also observed a reduced effect for moderately overweight women (25< BMI ≤ 26.9 kg/m^2) (RR: 1.7; 95%, 0.8-1.9) and for underweight women (BMI< 17 kg/m^2) (RR: 1.6; 95%, 0.7-3.9). Another study found that delayed conception among women no longer using contraception was strongly associated with a BMI over 30 kg/m^2 (OR: 11.54; 95%, 3.68-36.15) and also with a BMI under 20 kg/m^2 (OR: 1.70; 95%, 1.01-2.83), but only among smokers (Bolumar et al., 2000).

It also appears that body fat distribution may influence fertility in women. Waist-to-hip ratio (WHR) is used as a measure of body fat distribution; a WHR above 0.8 reflects increased storage of abdominal fat or central obesity (Heyward & Wagner, 2004). Among 542 women receiving artificial insemination treatment (due to infertility of their partner), a WHR of 0.80 or below was significantly associated with an increased rate of conception compared to a WHR above 0.80 (Zaadstra et al., 1993). Every 0.1 unit increase in WHR was associated with a 30% decrease in the probability of conception per cycle (RR: 0.71; 95%, 0.56-0.89). In this study underweight and obese women were less likely to conceive, though this difference was not significant ($p<0.10$). This indicates that the distribution of body fat may have more impact on fertility in women than body weight. Similar findings of either reduced fertility or menstrual irregularities have been found in women with central obesity in other studies (Norman & Clark, 1998). Central obesity is common among New Zealand women, 10.8% of women aged 19-24 years and 24.8% of women aged 25-44 years had a WHR greater than 0.80 in the 1997 NNS (Russell et al., 1999). Maori (34.1%) and Pacific women (53.5%) are more likely to be classified as centrally obese than European women (21.7%), with Pacific women most at risk of central obesity (Russell et al., 1999).

Obesity and being overweight is also associated with an increased risk of miscarriage (Norman & Clark, 1998). In women undergoing *in vitro* fertilisation a BMI of 25 kg/m^2 or more was associated with a higher rate of spontaneous abortion in the first six weeks compared to a BMI under 25 kg/m^2 (22% vs. 12%; $p=0.03$) (Fedorcsak et al., 2000). Being overweight was an independent risk factor for early pregnancy loss (RR: 1.77; 95%, 1.05-2.97). In another study obese women (BMI ≥30 kg/m^2) had a 4-fold higher risk

of spontaneous abortion compared to normal weight women (BMI 20.0-24.9 kg/m^2) (RR: 4.02;95%, 1.53-10.57, p=0.005) (Bellver et al., 2003).

Obesity has consistently been shown to be associated with the occurrence of congenital anomalies, particularly NTDs (Galtier-Dereure et al., 2000; Prentice, 1996). Additionally, folic acid seems to lose its protective effect in overweight women (Prentice, 1996). An early case-control study found a significantly higher risk of NTDs among obese (31< BMI ≤37 kg/m^2) and severely obese (BMI >38 kg/m^2) women, with adjusted odds ratios of 1.8 (95%, 1.0-3.2) and 3.0 (95%, 1.2-7.7) respectively (Waller et al., 1994). For all women with a BMI above 31 kg/m^2 the adjusted odds ratio was 1.8 (95%, 1.1-3.0). Similar findings of an approximately 2-fold increased risk of NTD among obese women (BMI >29 kg/m^2) have since been reported (Shaw et al., 1996; Watkins et al., 1996; Werler et al., 1996). In the study by Waller et al. (1994) obese women also had an increased risk of having an infant with selected non-NTD congenital anomalies, with risks between 2-fold and 6-fold for various anomalies. Other studies have also reported increased risks of congenital anomalies in sub-fertile overweight (BMI >25 kg/m^2) women (Honein et al., 2003) and in obese women (BMI >29 kg/m^2) (Shaw et al., 2000b).

Obese or overweight women have a higher risk of having pregnancy complications such as hypertension (Galtier-Dereure et al., 2000; Jensen et al., 2003), caesarean section (Jensen et al., 1998b; Rosenberg et al., 2003b; Sheiner et al., 2004), slow labour progression (Vahratian et al., 2004b), preeclampsia and gestational diabetes (Rosenberg et al., 2003b). Recently, prepregnancy weight was found to predict maternal insulin resistance at five year follow-up (Jeffery et al., 2004) and BMI before conception to be related to the risk of diminished intellectual ability in children at age five years (Neggers et al., 2003).

A substantial proportion of New Zealand women of childbearing age are either overweight or obese (MOH, 2004; Russell et al., 1999). The 1997 NNS indicated that 17.7-25.7% of New Zealand women of childbearing age were overweight and a further 17.1-17.2% were obese. Maori and Pacific women are more likely to overweight or obese than European women (Russell et al., 1999). More recent figures from the 2002/03 National Health Survey (NHS) showed that 27.4% of females over 15 years of age were overweight and 21.2% were obese (MOH, 2004).

Recently, the results from a case-control study suggest that dieting behaviours that involve the restriction of food intake during the first trimester may be associated with NTD risk (Carmichael et al., 2003b). The reporting of any weight loss diet, restriction of food intake or an eating disorder was associated with an odds ratio for a NTD of 2.1 (95%, 1.3-3.3). There was no association for dieting behaviours in the three months before conception, suggesting an acute effect of dietary restriction on early foetal development. Though known confounders were adjusted for, the relatively small numbers of women reporting dieting behaviours limited the detection of potential confounding variables so residual confounding can not be ruled out in this study. Further research into the impact of dieting behaviours before and during early pregnancy on NTDs is needed, though these results are in agreement with an earlier case series on weigh loss during the first month of pregnancy (Robert et al., 1995). Food restriction to control body weight is common among New Zealand women of childbearing age, nearly one in four women restrict their food intake (Heath et al., 2000).

A low prepregnancy BMI is one of the strongest predictors of adverse pregnancy outcomes such as preterm birth, LBW and IUGR (Neggers & Goldenberg, 2003). A Dunedin study among predominately European women found that 12.2% had a BMI under 20 kg/m^2 (Heath et al., 2000). Studies have shown that prepregnancy BMI (Doyle & Crawford, 1990; Johnson et al., 1994) and WHR (Brown et al., 1996) are correlated with infant birth weight. In data derived from a perinatal database, a prepregnancy BMI below 19.9 kg/m^2 was associated with an increased risk of IUGR (RR: 1.67; 95%, 1.2-2.39) and LBW (RR: 1.13; 95%, 1.0-1.27), while low prepregnancy weight was a risk factor for preterm delivery (RR: 2.45; 95%, 1.1-4.4) (Ehrenberg et al., 2003). In the zinc trial carried by Goldenberg et al (1995) the improvement in birth weight seen with zinc supplementation was restricted to normal weight women, with no effect observed in women whose BMI was above 26 kg/m^2.

Recently, a prospective Chinese study found that being severely underweight before conception (BMI $\leq$18.5 kg/m^2) was associated with a significantly lower birth weight (219 g, $p<0.0001$), increased risk of IUGR (OR: 1.8; 95%, 1.0-3.3, $p=0.05$) and a tendency towards an increased prevalence of LBW (OR: 2.0, 95%, 0.9-4.5, $p=0.08$) (Ronnenberg et al., 2003). Being moderately underweight (18.5< BMI <19.8 kg/m^2) was not associated with adverse outcome. While BMI was not associated with the risk of

preterm delivery in this study other studies have found an increased risk of preterm delivery with a low prepregnancy BMI and that this association is stronger in women with inadequate weight gain during pregnancy (Schieve et al., 2000; Spinillo et al., 1998). Women with a current eating disorder have been found to have a higher risk of LBW, an SGA infant (Conti et al., 1998; Sollid et al., 2004) and preterm delivery (Sollid et al., 2004). Two studies that did not find an association between BMI before conception and preterm delivery either did not obtain information on or control for weight gain during pregnancy (Ehrenberg et al., 2003; Ronnenberg et al., 2003).

A large proportion of New Zealand women of childbearing age do not have an ideal body weight that will optimise maternal health and pregnancy outcome, particularly Maori and Pacific women.

1.3 Lifestyle Habits and Pregnancy Outcome

1.3.1 Caffeine

Caffeine is one of the most commonly used pharmacologically active substances. Caffeine metabolism is reduced during the luteal phase of the menstrual cycle and during pregnancy, it can cross the placenta and caffeine metabolism is limited in the foetus. As a result, caffeine can accumulate in both the mother and the foetus during the pre-implantation phase and the period of embryonic development (Hinds et al., 1996).

A major limitation in the evaluation of the risks associated with caffeine is the accurate estimation of caffeine intake. The variability in caffeine content and serving sizes of beverages and foods makes determining caffeine intake difficult. Most studies fail to account for the caffeine content in chocolate or chocolate drinks by simply estimating the number of cups of coffee, tea and colas (Christian & Brent, 2001). A range of conversion factors have been used across studies to determine caffeine intake from different beverages, there are also differences in standard drink sizes between studies or drink size was not accounted for (Caan et al., 1998; Grodstein et al., 1993). Also the individual variation in caffeine metabolism leads to differences in tolerances for caffeine (Hinds et al., 1996). Evaluating the effects of caffeine is made more difficult by the association between high caffeine consumption and other negative confounding variables such as smoking and alcohol (Christian & Brent, 2001). Most studies have also included few women with moderate to high levels of caffeine use. These factors make it difficult to determine a threshold for caffeine exposure.

In animal studies mega doses of caffeine were consistently found to cause birth defects, however human studies have failed to find that caffeine is teratogenic (Christian & Brent, 2001; Hinds et al., 1996; McDonald et al., 1992). A limited number of studies have investigated the effect of caffeine on either infertility or sub-fecundity (defined as time to pregnancy (TTP) of over 12 months) (Table 1.3.1). It appears that caffeine intake over 300 mg per day (approximately three cups of coffee) is associated with a modest reduction in time to conception or fecundability, and that the effect may limited to non-smokers (Hatch & Bracken, 1993; Jensen et al., 1998b; Williams et al., 1990). However, a number of limitations in study design make it difficult to obtain consistent results. Some studies only measured coffee intake (Christianson et al., 1989; Williams et al., 1990),

while others did not include the use of cola drinks (Hassan & Killick, 2004) and only one study included chocolate consumption (Jensen et al., 1998a). Two of the studies relied on subjects to recall caffeine intake from over 10 years earlier (Bolumar et al., 1997; Stanton & Gray, 1995), while other studies based caffeine intake in early pregnancy as a proxy for intake before conception (Christianson et al., 1989; Hatch & Bracken, 1993; Williams et al., 1990). The later may underestimate caffeine intake as many women reduce their caffeine intake during pregnancy because of concerns for the health of the baby or as a result of the natural aversion to caffeine during pregnancy (Hinds et al., 1996). Only a few studies adjusted for coital frequency (Hassan & Killick, 2004; Joesoef et al., 1990; Wilcox et al., 1988), while others did not adjust for BMI as a confounder (Bolumar et al., 1997; Hatch & Bracken, 1993; Stanton & Gray, 1995; Wilcox et al., 1988).

Smokers are more likely to be high caffeine users (Christian & Brent, 2001), therefore it is difficult to determine the independent effect of caffeine on fertility. A few studies have examined the effect of caffeine among smokers and non-smokers (Jensen et al., 1998a; Jensen et al., 1998b; Stanton & Gray, 1995). In a prospective study Jensen et al. (1998) followed women attempting to conceive for six cycles, caffeine intake was measured by estimating weekly caffeinated beverage and chocolate consumption in women followed for six cycles. Among non-smokers with a caffeine intake between 300-700 mg/day the fecundity ratio was 0.88 (95%, 0.60-1.31) and was 0.63 (95%, 0.25-1.60) for more than 700 mg/day compared to less than 300 mg/day. Although these results did not reach significance, there was a significant dose-response relationship between caffeine intake and fecundity ($p<0.05$). No effect on fecundity was found among smokers, possibility due to the enhanced caffeine metabolism in smokers (Jensen et al., 1998a). These findings were consistent with an earlier study that found no effect in smokers, however non-smokers consuming more than 300 mg/day of caffeine had a significantly 2.7-fold increased risk of delayed conception and a 26% reduced probability of conceiving each cycle compared to those consuming 300 mg/day or less (Stanton & Gray, 1995).

While it appears that caffeine intake above 300 mg/day is associated with a modest reduction in fertility, further research is needed to establish a conclusive casual association between caffeine and infertility.

Table 1.3.1: Summary of studies on caffeine and infertility

Author	Study Design	Results
Hassan and Killick 2004	Observational study of retrospective lifestyle characteristics in women attending antenatal clinics (n=2112).	TTP longer with coffee and/or tea intake >6 cups/day (p=0.04). Heavy intake (≥7 cups/day) associated with relative risk of sub-fecundity of 1.7 (95%, 1.2-19.7, p=0.02).
Jensen et al. 1998a	Prospective study of weekly caffeine intake in women trying to conceive (n=430).	Among non-smokers fecundity ratio was 0.88 (95%, 0.60-1.31) with 300-700 mg/day of caffeine and was 0.63 (95%, 0.25-1.60) with >700 mg/day compared to <300 mg/day (trend p<0.05). No trend among smokers.
Caan et al. 1998	Prospective study of monthly caffeine intake in volunteers trying to conceive (n=210).	Caffeine intake not associated with fertility; highest level of intake was only >106.8 mg/day.
Boulmar et al. 1997	Multi-centre observational study of retrospective caffeine intake at the start of attempting to conceive in randomly selected women (n=3187); mean recall time of 12 years.	TTP increased with increasing caffeine (p=0.001); OR for delayed conception with ≥501 mg/day was 1.45 (95%; 1.03-2.04) compared to <100 mg/day after adjusting for smoking (p<0.05), effect stronger in smokers (OR: 1.45; 95%, 0.92-2.63) compared to non-smokers (OR: 1.38; 95%, 0.85-2.23).
Stanton and Gray 1995	Observational study of retrospective caffeine intake during the 1st mth of pregnancy among plant workers (n=1430); recall time up to 10 years.	Among non-smokers the OR for delayed conception was 2.65 (95%, 1.38-2.37) with caffeine ≥ 301 mg/day (trend p=0.02) and fecundability was decreased 26% (0.74; 95%, 0.59-0.92) compared to no caffeine. No effect intake in smokers.
Hatch and Bracken 1993	Cross-sectional study of caffeine intake during early pregnancy and delayed conception (n=1909).	Adjusted OR for 151-300 mg/d was 1.88 (95%, 1.13-3.11) and for >300mg/d was 2.25 (95%, 1.06-4.73) compared to no caffeine; fecundability ratio was 0.73 (95%, 0.61-0.88) with >300 mg/day.
Grodstein et al. 1993	Case-controlled study of caffeine intake prior to attempting to conceive among women with primary infertility (n=1050) and controls (n=3833).	Increased risk of infertility due to tubal disease (RR: 1.5; 95%, 1.1-2.0) with > 7g/mth; for endometriosis risk was 1.9 (95%, 1.2-2.9) with 5.1-7 g/mth and 1.6 (95%, 1.1-2.4) with > 7 g/mth (≈250 mg/day).
Joesoef et al. 1990	Observational study among volunteers with a planned live birth (n=2817) and primary infertility (n=1818).	Caffeine intake not associated with time to conception or fecundability, highest level of intake only 7 mg/mth, Trend for increasing TTP with increased cups of tea/day (p<0.01). Caffeine not a risk factor for primary infertility.
Christianson et al. 1989	Observational study of coffee intake before conception recalled early in pregnancy and subjective measure of difficulty in conceiving (n=6303).	>7 cups/day of coffee had a 2-fold increased risk of having difficulty conceiving compared to < 1 cup/day (CI not given).
Williams et al. 1990	Cross-sectional study of coffee intake during 1st trimester and time to conception (n=3010).	Fecundability ratio for ≥4 cups/day of coffee was 0.81 (95%, 0.67-0.970. Estimated relative risk of sub-fecundity was 1.8 (95%, 1.1-3.0) for ≥ 4 cups/day.
Wilcox et al. 1988	Observational study of caffeine intake in the 3 mths before conception in volunteers trying to conceive (n=104).	Fecundability ratio for caffeine >3150 mg/mth (≈112.5 mg/day) was 0.51 (95%, 0.35-0.75) compared to ≤ 3150 mg/mth, excluding smokers (n=11) did not effect results; risk of infertility was 4.7 (p<0.005) (CI not given).

Note: BMI: body mass index; CI: confidence intervals; OR: odds ratio; TTP: time to pregnancy. Fecundability defined as TTP >12 months.

Numerous studies have investigated the link between caffeine intake during early pregnancy and spontaneous abortion, while fewer studies have addressed caffeine intake prior to pregnancy (Table 1.3.2). However, the findings are inconsistent (Klebanoff et al., 1999; Mills et al., 1993; Tolstrup et al., 2003a), with the many of the studies suffering from additional methodological problems to those discussed earlier. Nausea during pregnancy is accepted as a symptom of a viable pregnancy (Signorello & McLaughlin,

2004). Therefore, women with a non-viable foetus are less likely to reduce their caffeine intake during pregnancy as result of nausea, which will tend to overestimate the association between caffeine and spontaneous abortion (Signorello & McLaughlin, 2004). It is difficult to account for all spontaneous abortions since a number occur before pregnancy is recognised, this is likely to underestimate any association with caffeine (Signorello & McLaughlin, 2004). Several studies also involved selection bias as controls were selected from antenatal clinics whereas cases were women presenting with a spontaneous abortion (Cnattingius et al., 2000; Giannelli et al., 2003; Rasch, 2003).

Table 1.3.2: Summary of studies on caffeine and spontaneous abortion

Author	Study Design	Results
Tolstrup et al. 2003b	Prospective case-controlled study of caffeine intake before conception in cases with SAB<28wks (n=303) and controls (n=1381).	Linear trend for increased risk with increasing caffeine (p=0.05). Adjusted OR for caffeine >900mg/day was 1.72 (95%, 1.00-2.96) compared to <75 mg/day.
Rasch et al. 2003	Case-controlled study of caffeine intake and SAB at 6-16 wk (n=330) and controls with live foetus at 6-16 wks (1168).	Adjusted OR for caffeine >375 mg/day was 2.21 (95%, 1.53-3.18) compared to < 200 mg/day; risk was higher in non-smokers (OR: 2.74 (95%, 1.89-3.99) than smokers (OR: 2.24 (95%, 0.99-5.04).
Giannelli et al. 2003	Case-controlled study of SAB (n=160) and controls attending antenatal clinics (n=314); usual caffeine intake before and during pregnancy. Adjusted for nausea, gestational age.	No association for intake before pregnancy. Linear trend for increasing risk with increased caffeine (p=0.0003). Adjusted OR was 1.94 (95%, 1.01-3.63) and 2.18 (95%, 1.08-4.40) for 300-500 mg/day and >500 mg/day respectively. Fewer cases reported nausea (trend p<0.0001).
Wen et al. 2001	Prospective study of monthly caffeine consumption before pregnancy and during the first trimester (live births n=575, SAB=75).	No association for caffeine intake before conception or in women without nausea. Caffeine ≥300 mg/d after start of nausea associated with increased risk of SAB (OR: 5.4; 95%, 2.0-14.6) compared with <20 mg/d.
Cnattingius et al. 2000	Case-controlled study of caffeine intake and SAB at 6-12 wks (n=562) and controls matched for gestational age (n=953).	Mean caffeine intake higher for SAB than controls (p<0.0001). Nausea more common in controls (p<0.0001). Among non-smokers adjusted OR with ≥500 mg/day was 2.2 (95%, 1.3-3.8) compared to <100mg/day (trend p=0.007). No effect in smokers.
Klebanoff et al. 1999	Case-controlled study of serum paraxanthine and SAB <20 wk (n=591) and controls matched for gestational age (n=2558).	Mean serum paraxanthine higher in cases (p<0.0001). When serum drawn within 17 days of SAB adjusted OR for levels above 95th percentile was 1.8 (95%,1.0-3.1).
Mills et al. 1993	Prospective study of first trimester caffeine intake in women enrolled within 21 days of conception (n=431) and SAB ≤20 wks. Ascertainment of pregnancy with hCG	No difference in mean intake between SAB and controls. Adjusted OR for any caffeine in 1st trimester was 1.15 (95%, 0.89-1.49) compared to no caffeine. No trend for increased risk with increasing caffeine
Infante-Rivard et al. 1993	Case-controlled study of retrospective caffeine in the mth before conception and during pregnancy in SAB cases (n=331) and controls matched for gestational age (n=993).	Adjusted OR for caffeine before conception >321 mg/day was 1.82 (95%, 1.18-2.89) compared to <48 mg/day (trend p=0.02); during pregnancy OR was 1.95 (95%, 1.29-2.93) for 163-321 mg/day and 2.62 (95%, 1.38-5.01) for >321 mg/day respectively (trend p<0.001).
Armstrong et al. 1992	Observational study of caffeine intake from coffee in the first trimester in 35, 848 pregnancies (SAB=7760).	Trend for increased risk with increasing coffee intake (p=0.01).

Note: hCG: β-human chorionic gonadotropin; OR: odds ratio; SAB: spontaneous abortion. Serum paraxanthine is a short-term marker for caffeine intake.

A recent review of the literature concluded that despite the fact the most epidemiological studies found a positive associated between caffeine during pregnancy and spontaneous abortion the potential bias would tend to overestimate any association, so the evidence must considered to be inconclusive (Signorello & McLaughlin, 2004). Since then three studies have reported a positive association between caffeine intake during pregnancy and spontaneous abortion, but these studies suffer from the same methodological problems as earlier studies (Giannelli et al., 2003; Rasch, 2003; Tolstrup et al., 2003b). A case-controlled study that matched controls for the gestational age of cases found that caffeine intake above 375 mg/day was associated with an adjusted odds ratio for a spontaneous abortion of 2.21 (95%, 1.53-3.18) compared to below 200 mg/day (Rasch, 2003).

A limited number of studies have examined the association between caffeine intake before conception and spontaneous abortion. An early retrospective study found a significant linear trend for an increased risk of spontaneous abortion with increasing caffeine intake in the month before conception (p=0.02) (Infante-Rivard et al., 1993). The adjusted odds ratio for caffeine intake above 321 mg/day was 1.82 (95%, 1.18-2.89) compared to intake below 48 mg/day, the risk was stronger for caffeine intake during pregnancy.

A prospective study that followed women every three months before conception and every month thereafter found that caffeine intake before pregnancy was not associated with spontaneous abortion (Wen et al., 2001), this was consistent with another study (Giannelli et al., 2003). Caffeine intake in the first trimester among woman who did not experience nausea was not associated with risk of spontaneous abortion (Wen et al., 2001). However, caffeine intake above 299 mg/day after the onset of nausea was strongly associated risk of spontaneous abortion compared to less than 20 mg/day (adjusted OR: 5.4; 95%, 2.0-14.6), though this findings is based on only four cases in the highest caffeine category (Wen et al., 2001). The absence of nausea is a risk factor for spontaneous abortion, therefore, the lack of association among women without nausea may result from it being harder to detect any additional risk in this group. More recently, high levels of caffeine consumption before pregnancy were found to be linearly correlated with spontaneous abortion (p=0.05) (Tolstrup et al., 2003b). Caffeine intake above 900 mg/day was significantly associated with an increased risk of spontaneous abortion compared to less than 75 mg/day (OR: 1.72; 95%, 1.00-2.96). This level of caffeine

intake is well above that of other studies, which may explain the lack of association in other studies with lower intakes. However, this study estimated caffeine intake from only coffee and tea consumption, and assigned 107 mg per cup to all methods of coffee preparation. Additionally, the mean length of time between prepregnancy exposure and conception was 9.3 months, it cannot be ruled out that women did not alter their caffeine intake over time.

Further research is needed to identify a casual link between caffeine and spontaneous abortion and the timing of exposure risk, until then it advisable for women to limit caffeine intake during pregnancy or if planning pregnancy to 300 mg/day (approximately three cups of coffee a day) in accordance with the current guidelines for pregnant women (MOH, 1995). An additional concern with the high consumption of caffeinated beverages is the presence of polyphenol compounds that inhibit iron absorption (Hurrell et al., 1999; Moreira et al., 2005; Zijp et al., 2000); increasing the risk of iron deficiency in instances where dietary intakes are already marginal. Coffee has also recently been found to contain a zinc-chelating compound that may reduce zinc absorption (Wen et al., 2005).

1.3.2 Alcohol

Alcohol is recognised as being the most common human teratogen. The teratogenic effects to the foetus include growth deficiency, central nervous system (CNS) dysfunction and craniofacial anomalies (Gladstone et al., 1996). The magnitude of the effects covers a wide continuum, with the most severe form being foetal alcohol syndrome (FAS) that involves profound mental retardation to more subtle effects on intellectual functioning (Weber et al., 2002). The foetal alcohol spectrum includes FAS, partial FAS, alcohol-related neurodevelopmental disorders (ARND) and alcohol-related birth defects. ARND involves CNS dysfunction without the characteristic facial abnormalities seen in FAS and manifests as developmental or intellectual impairment (O'Leary, 2004).

The expression of full FAS occurs with chronic alcohol consumption of six or more drinks per day or at least five drinks per occasion or 45 drinks per month (O'Leary, 2004). Moderate drinking during pregnancy is associated with less severe developmental problems, however, research has been unable to ascertain a safe level of alcohol intake during pregnancy (Jacobson & Jacobson, 1999). Several factors contribute to variations in the consequences of maternal drinking including drinking pattern, individual differences

in metabolism and genetic susceptibility and timing of alcohol exposure (Maier & West, 2001).

In recent years the focus of research has been on binge drinking, defined as five or more drinks per occasion, particularly in the period prior to pregnancy recognition. Animal studies have shown that a single or intermittent dose of alcohol given over a short interval is more teratogenic than when the same dose (or higher) is given continuously over a longer period (Gladstone et al., 1996; Maier & West, 2001). Clearly showing that the administration of alcohol in a pattern that resembles binge-drinking results in a high peak blood alcohol concentration (BAC) and that peak BAC predicts the teratogenic effects rather the total volume of alcohol administered. Additionally, studies in primates (Clarren et al., 1992) and mice (Livy et al., 2004) have shown that the deleterious effects of binge like alcohol exposure on brain development and foetal growth occur during early gestation or around the time of conception.

The information on binge drinking during pregnancy in humans is limited and the results are inconsistent. Earlier studies often measured the average or total amount of alcohol rather than the maximum amount in one sitting. As a result, averaging the total amount is likely to dilute the effect of binge drinking, for example one drink a day and seven drinks in a single day are both recorded as seven drinks per week. While other studies combined binge drinking into categorical data and the exposure is lost (Maier & West, 2001). Additionally, there are a number of inherent difficulties in measuring alcohol consumption that include difficulties in recall, variability in drinking patterns, variability in standard drink sizes, under-reporting due to misclassification of the timing of consumption and under-reporting of a socially undesirable response (da Costa Pereira et al., 1993). The reporting of alcohol use after pregnancy recognition rather than from the time of conception underestimates alcohol exposure as many women reduce their alcohol intake upon learning they are pregnant. Prospective studies that have enrolled women during pregnancy have not collected information on alcohol consumption in early gestation (Bailey et al., 2004).

Recently, a prospective study that followed-up children at age seven who were exposed to prenatal binge drinking at least once every two weeks were 1.7 times more likely to have sub-normal verbal IQ scores (41% vs. 24%, $p<0.01$) and 2.5 times more likely to have clinically significant levels of delinquent behaviour (17% vs. 7%, $p<0.01$) (Bailey et al.,

2004). No association was observed for the amount of alcohol per day. Another prospective study found that children whose mothers reported six or more alcoholic binges in the period before pregnancy recognition displayed a greater degree of disinhibited behaviour than controls (Nulman et al., 2004). First trimester exposure to one or more drinks per day predicted poorer teachers' ratings of overall school performance in children at age 10 in another study (β=-0.24, $p<0.01$) (Goldschmidt et al., 2004). An early study found that any alcohol consumption in the preconception period was associated with an increased risk of mental retardation (RR: 1.7; 95%, 1.2-2.3) and that the risk was higher in women who consumed three or more drinks/day once or twice per week (Roeleveld et al., 1992). The risk was more pronounced for alcohol use in the preconception period than for alcohol use during pregnancy.

In a recent case-controlled study, the consumption of 1-2 drinks per occasion sporadically during pregnancy was associated with an increased risk of eye anomalies (OR: 1.62, 0.97-2.62), though this did not quite reach significance (p=0.051) (Martinez-Frias et al., 2004). The sporadic consumption of nine or more drinks per occasion was associated with increased risk of various congenital anomalies, the type of defect depended on the timing when the exposure occurred. However, the number of cases was too small for the risk of most defects to reach significance. The risk for oral clefts was 3.49 (95%, 0.67-24.29, p=0.097), which was attributed to a high BAC during the critical period of embryogenesis. The risk of congenital defects also rose with increasing daily amounts of alcohol, the risk for facial anomalies with 1.5-5 drinks/day was 1.55 (95%, 1.17-206, p=0.0001).

The reporting of one or more binges per week in the periconceptional period was found to be associated with an increased risk of cleft lip with/without palate (OR: 3.4; 95% 1.1-9.7), multiple cleft lip with/without palate (OR: 4.6; 95% 1.2-18.8) and 'known syndrome' clefts (OR: 6.9; 95%, 1.9-28.6) compared to no binges, the adjustment for confounding variables did not alter the observed risks (Shaw & Lammer, 1999). The frequency with which alcohol was used (daily, weekly and less than weekly) was not associated with orofacial clefts. Another study found a weak association between one or more drinks per day during the first trimester and musculoskeletal defects (OR: 1.85; 95%, 1.0-3.3), though considerable recall times were involved and the overall reported alcohol intake was low (McDonald et al., 1992). Increased risk of ventricular septal

defects was found with the consumption of 10 or more drinks per week, though this lost significance after adjusting for confounding variables (OR: 2.1; 95%, 0.75-5.87) (Williams et al., 2004). This study also found that binge drinking two or more times per week was associated with a non-significant increased risk of ventricular septal defects compared to no binge drinking (OR: 95%, 1.87; 0.74-4.74).

Alcohol consumption has been associated with spontaneous abortion (Armstrong et al., 1992; Henriksen et al., 2004; Rasch, 2003), though the results are inconsistent (Tolstrup et al., 2003b). The inconsistencies are largely as a result of the same methodological problems in quantifying alcohol intake and timing of exposure. A recent study that followed women trying to conceive prospectively for six cycles was able to measure the weekly alcohol intake in the cycle of conception (Henriksen et al., 2004). A non-dose dependent relationship between increasing alcohol intake and increased risk of spontaneous abortion was observed; with a relative risk of 2.1 (95%, 1.0-4.3, $p<0.05$) for 1-4 drinks/week, 2.3 (95%, 1.0-5.1, $p<0.05$) for 5-9 drinks/week and 2.6 (95%, 1.2-5.9, $p<0.05$) for 10 or more drinks/week compared to no intake. However, after adjusting for confounding variables only 10 or more drinks/week was significantly associated with an increased risk of spontaneous abortion (RR 2.7; 95%, 1.0-7.3).

The consumption of three or more drinks per day in the first trimester has been associated with an increased risk of preterm delivery (OR: 2.0; 95%, 1.0-4.5), with the increased risk observed in preterm SGA births (OR: 3.6; 95%, 1.3-11.1) (Parazzini et al., 2003). Few human studies have examined the effect of binge drinking on foetal growth, one study found that the risk of an SGA infant was higher among binge drinkers than non-binge drinkers, but the difference was only significant among women who consumed four or more drinks/week and also binged compared to drinkers who did not binge (OR: 2.24; 95% 1.25-4.02) (Whitehead & Lipscomb, 2003).

Compounding the effects of binge drinking is the fact that women who binge drink are more likely to have an unplanned pregnancy (Naimi et al., 2003) and to have other negative characteristics such as poor dietary intakes and cigarette smoking (Gladstone et al., 1997; Naimi et al., 2003). Women who engage in binge drinking are also more likely to continue to consume alcohol and to binge drink during pregnancy (Naimi et al., 2003).

A number of studies have investigated the link between alcohol and infertility, however not all studies have found a positive association (Curtis et al., 1997; Hassan & Killick, 2004). A case-controlled study that collected retrospective data on alcohol consumption before the onset of primary infertility found that the consumption of one or more drinks/day was associated with a modest increased risk of ovulatory infertility and endometriosis (Grodstein et al., 1994a). In the same study population reported by Henriksen et al. (2004) the chance of conceiving decreased with increased alcohol consumption in the cycle of conception (Jensen et al., 1998b). Compared to no alcohol use the fecundity odds ratio decreased from 0.61 (95%, 0.40-0.93) with 1-5 drinks/week to 0.34 with more than 10 drinks/week. However, the odds ratio for more than 10 drinks/week was only significant for 11-15 drinks/week (OR: 0.34; 95%, 0.22-0.52) as few women consumed over 15 drinks/week (OR: 0.34; 95%, 0.11-1.07). Another prospective study that measured β-human chorionic gonadotropin levels to confirm conception found similar results of a dose-dependent relationship between one or more drinks/week and fecundity (Hakim et al., 1998). In women receiving *in vitro*-fertilisation treatment those who consumed one drink/day in the month prior to the treatment had a higher risk of not conceiving compared to women who drank less than one drink/day (OR: 2.86; 95%, 0.99-8.24, p=0.05) (Klonoff-Cohen et al., 2003). Alcohol consumption was not related to fecundity in women undergoing artificial insemination (Zaadstra et al., 1994).

A follow-up study found that the intake of more than one drink/week at baseline was associated with infertility five years later in women aged over 30 years but not in younger women (Tolstrup et al., 2003a). Alcohol consumption was not found to be associated with TTP in retrospective studies involving women receiving antenatal care (Hassan & Killick, 2004) or in women with a planned pregnancy (Curtis et al., 1997), however using TTP to assess sub-fecundity excludes women who fail to conceive or are no longer planning pregnancy.

It appears that alcohol consumption is related to decreases in fertility in women, though the threshold is not clear. However, given the adverse effects of alcohol consumption early in pregnancy, often before pregnancy is recognised, it is prudent to advise women to avoid alcohol if planning pregnancy or if capable of becoming pregnant (Kaiser et al., 2002). If total absence is not possible then alcohol consumption needs to be limited to no

more than seven drinks per week and no more than two drinks per occasion (O'Leary, 2004).

In New Zealand the majority of women consume alcohol, 80.3% of females aged over 15 years in the 2002/03 NHS (MOH, 2004) and 82.7% of women aged 18-45 years in the 2001 National Drug Survey (Wilkins et al., 2002) reported alcohol use in the previous year. One in five New Zealand women aged 15-45 years consume four or more drinks per occasion at least once per week (Wilkins et al., 2002). High rates of unplanned pregnancies mean that a number of pregnancies in New Zealand may be exposed to the risk of the detrimental effects of alcohol in early pregnancy (Paterson et al., 2004; Schader & Corwin, 1999). Recent studies have indicated that approximately a quarter of all pregnant women in New Zealand continue to drink after pregnancy recognition, with a significant number drinking at intoxicating levels (McLeod et al., 2002; Watson & McDonald, 1999). Women who engage in binge drinking during pregnancy are disproportionately Maori or Pacific, under 25 years and those with a lower SES status (Watson & McDonald, 1999).

1.3.3 Smoking

Smoking during pregnancy is one of the leading causes of preventable adverse pregnancy outcomes (Cnattingius, 2004). Smoking is causally associated with foetal growth restriction (Cnattingius, 2004), and a growing body of evidence suggests that smoking is casually linked to preterm birth (Burguet et al., 2004), still birth (Burguet et al., 2004; Tuthill et al., 1999), and placental abruption (Cnattingius, 2004; Tuthill et al., 1999). The majority of studies have found a dose-response relationship between smoking and increased risk for these outcomes, and smoking cessation reduces the risk (Cnattingius, 2004).

The literature strongly supports an association between smoking and delayed conception and infertility (PCASRM, 2004). Smokers experience longer TTP and are at increased risk of sub-fecundity and primary infertility (Hassan & Killick, 2004; Joesoef et al., 1993). There is also an association with sudden infant syndrome, although it is not clear whether this is as a result of prenatal smoking or postnatal passive exposure to smoking (Cnattingius, 2004). Smoking is considered to be a risk factor for spontaneous abortion (Armstrong et al., 1992; Chatenoud et al., 1998; Ness et al., 1999), however

methodological issues have meant not all studies have found an association (Rasch, 2003; Wisborg et al., 2003). No relationship is evident between smoking before conception and spontaneous abortion (Chatenoud et al., 1998; Wisborg et al., 2003).

Most studies have not found an association between smoking during pregnancy and congenital anomalies, except for orofacial clefts (Cnattingius, 2004; Tuthill et al., 1999). Limited research to date has related maternal smoking to several childhood behavioural disorders including attention-deficit/ hyperactivity disorder, but this area needs further research (Cnattingius, 2004). Studies suggest that vitamin C requirements may be higher among pregnant smokers (Cogswell et al., 2003). Smokers have been found to have lower serum levels of folate, vitamin B_{12}, vitamin B_6 and β-carotene, though it is not clear if this is due to increased requirements, lower dietary intakes or other factors (Cogswell et al., 2003).

Since 1997 the prevalence of smoking among New Zealand women has gradually declined (MOH, 1999). In a report conducted in 2001 by the MOH on national tobacco use 27.3%, 28.0% and 21.3% of females aged 15-24 years, 25-34 years and 35-54 years smoked respectively (MOH, 2002). Results from the 2002/03 NHS indicate that 22.1% of females over 15 years of age smoke and that Maori women are twice as likely to smoke than European women (50.5 vs. 18.8%), while a third of Pacific women smoke (MOH, 2004). Smoking rates at the onset of pregnancy are higher in Maori women (54.6% vs. 18.9% for non-Maori) (McLeod et al., 2003), which may explain the 40% higher prevalence of SGA infants in Maori compared to European women (Mantell et al., 2004). While women with a planned pregnancy are less likely to smoke at the onset of pregnancy (14.9% vs. 40.6% for unplanned pregnancy) (McLeod et al., 2003). Over two-thirds of women who smoke at the time of conception continue to smoke during pregnancy, with socio-economically deprived women and Maori women being more likely to continue to smoke during pregnancy (McLeod et al., 2003).

1.3.4 Recreational Drugs

Research on recreational drug use during pregnancy is limited and is subject to inherent reporting bias associated with the use of an illegal substance. Recreational drug use is also strongly correlated with a number of other negative characteristics making it difficult to separate the effects of recreational drugs from those of confounding factors (Fergusson et

al., 2002). The misreporting of drug use is highlighted in a study that found that cocaine detected in hair, a marker of long term use, was a risk factor for spontaneous abortion whereas self-reported cocaine use was not related to spontaneous abortion (Ness et al., 1999).

Cannabis use during pregnancy has been associated with reduced birth weight (Fergusson et al., 2002), LBW, premature delivery, IUGR and congenital anomalies (Park et al., 2004). Animal studies have shown that chronic cannabis exposure can increase the risk of spontaneous abortion, resportion and stillbirth, suggesting that the endogenous cannabinoid system may be critical in the maintenance and regulation of early pregnancy (Park et al., 2004). Women with a history of cannabis use have been shown to have an elevated risk of ovulatory infertility (Mueller et al., 1990), however the effect on fertility is inconclusive (Joesoef et al., 1993).

Cocaine use during pregnancy is associated with a number of adverse effects on the mother and foetus, including placental abruption, preterm labour, spontaneous abortion, IUGR, preterm delivery and still birth (Fajemirokun-Odudeyi & Lindow, 2004). Newborns with neonatal abstinence syndrome can also experience cocaine withdrawal (Fajemirokun-Odudeyi & Lindow, 2004). Cocaine use may also be a risk factor for tubal infertility (Mueller et al., 1990).

Little is known about the effects of methamphetamine exposure during pregnancy, limited data suggests an association between methamphetamines (McElhatton et al., 1999) or their precursor pseudo ephedrine (Bateman et al., 2004) and congenital anomalies. Prenatal methamphetamine exposure in rats has been shown to produce cognitive deficits, notably those involving spatial learning and memory tasks in the offspring (Williams et al., 2002).

Regular marijuana use (at least once a fortnight) was reported by 3.6% of New Zealand females aged over 15 years in the 2002/03 NHS (MOH, 2004), while 13.4% of women of childbearing age reported using marijuana during the past year in the 2001 National Drug Survey (Wilkins et al., 2002). The use of other recreational drugs is less common in New Zealand, with 2.3%, 1.8% and 0.5% of women aged 18-45 years using ecstasy, LSD and cocaine respectively in the previous year (Wilkins et al., 2002). The use of methamphetamines such as ecstasy is increasing in New Zealand women (Wilkins et al.,

2002). Maori women have the highest rates of recreational drug use in New Zealand (MOH, 2003c). While the prevalence of recreational drug use may be low among New Zealand women, drug use is associated with a number of other negative lifestyle characteristics such as smoking and heavy alcohol consumption (Fergusson et al., 2002) and these women have a high risk of unplanned pregnancies (Naimi et al., 2003).

1.4 Preconception Knowledge and Practices In Women of Childbearing Age

1.4.1 Folic Acid Knowledge

The overwhelming evidence of the reduction in NTDs with periconceptional folic acid supplementation lead to a number of countries adopting the recommendation that women of childbearing age consume 400 μg of synthetic folic acid daily. The US Public Health Service was the first to adopt the current folic acid policy back in 1992, the following year New Zealand recommended that women planning pregnancy should take folic acid daily (MOH, 2003b).

Knowledge of the benefits of folic acid, particularly specific knowledge that folic acid can prevent NTDs has consistently been shown to predict folic use in women (Amitai et al., 2004; Coll et al., 2004; De Jong-Van den Berg et al., 2005; Feldkamp et al., 2002). Therefore, information on folic acid knowledge is necessary to develop and to evaluate programs aimed at increasing periconceptional folic acid use.

Random studies conducted among women of childbearing age have shown that generally folic acid knowledge has increased since the introduction of the recommendations in the early 1990's, but has reached a plateau in recent years. The 1995 March of Dimes poll in the US found that 5% of women knew that folic acid prevents birth defects and 2% knew that folic acid should be taken before conception (Petrini et al., 1999). This increased to 21% aware that folic acid prevents NTDs and 10% aware of the critical time to take folic acid in 2003, and remained unchanged in 2004 at 24% and 12% respectively (Carter et al., 2004). Similar findings have been reported that 21-30% of women of childbearing age are aware that folic acid prevents birth defects, while comparatively less women know that folic acid needs be taken before pregnancy (8.5-17.0%) (Daltveit et al., 2004; French et al., 2003; Watson et al., 2001).

Higher knowledge of the relationship between folic acid and the prevention of birth defects was reported in a Utah study (Feldkamp et al., 2002). Forty-seven percent of women were aware of the relationship in 2000, with no significant increase in folic knowledge from 1998-2000. However, other studies have found women are more likely to have non-specific knowledge that folic acid is needed for pregnancy (Daltveit et al.,

2004). The Utah study asked women a multiple choice question on why women need to take folic acid, of which 'To prevent birth defects' was the only reason that involved pregnancy so is likely to overestimate the proportion of women with specific folic acid knowledge. A New Zealand survey carried out in 1998 found that 56% of women aged 25-44 years were aware of the relationship between folic acid and NTDs, while only 19.3% of females aged 15-24 years were aware of the relationship (Bourn & Newton, 2000).

Studied conducted among pregnant women or postpartum have generally reported higher proportions (25-77%) of women aware of folic acid and the prevention of birth defects, which may reflect knowledge gained since the preconception period (Amitai et al., 2004; Coll et al., 2004; De Jong-Van den Berg et al., 2005). A study conducted in 1999 among Christchurch women receiving antenatal care reported that 63% of women knew that folic acid prevents NTDs and 56% were aware of the need for folic acid in the preconception period (Schader & Corwin, 1999).

Women are more likely to be aware that folic acid prevents birth defects than to have specific knowledge of folic acid and NTDs, in one study 65% of pregnant women knew of the link to birth defects but only 25% knew that folic acid prevents NTDs (Kloeblen, 1999). Specific knowledge of the prevention of NTDs is important as women aware of the link between folic acid and NTD prevention are more likely to use folic acid in the preconception period than women with non-specific knowledge (De Jong-Van den Berg et al., 2005).

A number of factors are associated with increased folic acid knowledge including higher education, income and age (Daltveit et al., 2004; De Jong-Van den Berg et al., 2005; French et al., 2003). Women who have children are more likely to be folic acid aware (Chacko et al., 2003), particularly those with a child born since the introduction of the folic acid recommendations (French et al., 2003). In addition, pregnancy planning and preconception counselling is associated with higher folic acid knowledge than women with unplanned pregnancies and women without preconception care (De Jong-Van den Berg et al., 2005).

1.4.2 Folic Acid Use in the Preconception Period

Studies here in New Zealand have shown that only a small proportion (11-17%) of women take a folic acid supplement before pregnancy (MOH, 2003b; Schader & Corwin, 1999). Data from overseas suggests that while the use of folic acid before conception has increased since the 1990's only 7% to 40% of all pregnant women use folic acid before conception (Amitai et al., 2004; Coll et al., 2004; De Jong-Van den Berg et al., 2005; Knudsen et al., 2004).

The high rate of unplanned pregnancies is a substantial obstacle to increasing preconceptional folic acid use, however relatively few women with a planned pregnancy also report using folic acid before conception (Ray et al., 2004). The Christchurch study found that 35% of women who had planned their pregnancy used folic acid in the preconception period compared to 2% of women whose pregnancy was not planned (Schader & Corwin, 1999). Overseas studies have reported that between 10-52% of women with a planned pregnancy use folic acid in the preconception period (Amitai et al., 2004; Coll et al., 2004; De Jong-Van den Berg et al., 2005; Knudsen et al., 2004; Rosenberg et al., 2003a), while 0-14.8% of women with an unplanned pregnancy use folic acid before pregnancy (Coll et al., 2004; De Jong-Van den Berg et al., 2005; Knudsen et al., 2004; Rosenberg et al., 2003a).

In Denmark a folic acid campaign increased the proportion of women complying with the recommendations among women with a planned pregnancy, however following the campaign still only 22.3% of women used folic acid before conception (Knudsen et al., 2004). There was no effect on folic acid use among women who did not plan their pregnancy. Other folic acid promotions have increased preconceptional folic acid use, but in no study has the post-campaign folic acid use risen above 50% (Ray et al., 2004)

The reported daily use of folic acid among women of childbearing age in the US is between 22.7% to 48.4% (Cleves et al., 2004; Feldkamp et al., 2002; Petrini et al., 1999). The Utah study reported a significant increase in daily folic acid use from 39.9% in 1998 to 48.4% in 1999 ($p=0.017$), whereas no significant change was seen between 1999 and 2000 (46.1%) (Feldkamp et al., 2002). While on a national level in the US there was no substantial increase in daily folic acid use by women aged 18-45 years from 28% in 1995 to 32% in 2003, a substantial increase was seen in 2004, with 40% of women reporting

daily folic acid use (Carter et al., 2004). Other studies have reported daily folic acid use between 1.3-22.7% in women of childbearing age (Cleves et al., 2004; Daltveit et al., 2004).

In the 1997 NNS only 2% of New Zealand women aged 25-44 years had used a folic acid supplement in the previous year, while no females aged 15-24 years had taken folic acid (Russell et al., 1999). A survey in 1999 among a Dunedin cohort followed-up at age 26 found that 2.6% of females reported using folic acid (Allen et al., 2000).

Significant predictors of reduced periconceptional folic acid use include a low level of education, young age, lack of a partner and an unplanned pregnancy (Ray et al., 2004). Some studies have also reported increased folic acid use among women who received preconceptional counselling (Coll et al., 2004; De Jong-Van den Berg et al., 2005) or had heard about folic acid from a health care professional (Feldkamp et al., 2002).

1.4.3 Attitudes Towards Alcohol and Smoking

Currently there is no information available on women's knowledge or attitudes towards alcohol or cigarette use in the preconception period, though there is limited information on attitudes towards use during pregnancy. Most of the reports on attitudes towards alcohol use during pregnancy are from earlier studies and there are large differences in attitudes between studies. The advice to women on alcohol use can be conflicting, most countries advocate abstinence while some countries advise women to limit alcohol (O'Leary, 2004). Also within countries the advice given differs between individual health care professionals. Conflicting advice and the acceptability of alcohol in different cultures may explain the vast differences in opinions.

A survey in the late 1990's among Native American Indian women attending prenatal clinics reported that 90% of the women thought they should not drink any alcohol during pregnancy, however 6-10% continued to binge drink during pregnancy (May et al., 2004). Quite different results were reported in Norway in 1998 from a detailed assessment of attitudes towards alcohol use among women referred for routine antenatal care (Kesmodel & Schioler Kesmodel, 2002). Of the 439 women only 24.0% thought that women should abstain from alcohol during pregnancy, 46.2% thought that a woman could consume 1-6 drinks/week and 4.1% thought that one drink/day during pregnancy was acceptable. The

majority of women (85%) thought that binge drinking was potentially harmful to the foetus. Women who were binge drinkers were less likely to advocate abstinence and more likely to think that higher amounts of alcohol were acceptable during pregnancy. In this study only 6% of women abstained from alcohol before pregnancy and by 15-16 weeks gestation 30% of women were abstaining from alcohol. Only 21% of women were aware of the National Health Board recommendation to abstain from alcohol during pregnancy.

Earlier studies on attitudes towards alcohol use during pregnancy also report differing results. A French study in 1989 among women from prenatal clinics and postpartum wards reported that 83% of drinkers thought that alcohol was harmful to the baby's health; heavy drinkers were less likely to agree than light drinkers (Lelong et al., 1995). Only 6% advocated abstinence and 17% thought that three or more beers a day was reasonable, the more alcohol women consumed the more drinks they judged to be reasonable. A survey of women in Manitoba, Canada found that 52.5% of women thought that a safe amount of alcohol can be consumed during pregnancy (Williams & Gloster, 1999). A cross-sectional survey of the population of Norway in 1990 reported that 87% of women thought that women should abstain from alcohol during pregnancy, 9% thought alcohol needed to be reduced and 2% thought alcohol was acceptable (Ihlen et al., 1993).

The majority of women (87-99%) are aware that smoking can harm the unborn baby (Arnold et al., 2001; Lelong et al., 1995). Fewer women are aware of the health risks associated with smoking that are specific to women such as infertility (22%), spontaneous abortion (39%) and ectopic pregnancy (27%) (Roth & Taylor, 2001).

1.4.4 Preconception Practices in Women

Few studies have investigated the dietary intakes or lifestyle habits in women during the preconception period. The only prospective study to examine dietary and lifestyle habits before pregnancy was a small study among women planning pregnancy (n=46) and control women of reproductive age (n=23) (de Weerd et al., 2003a). Almost all (96%) of the women planning pregnancy reported consuming alcohol, 11% drank on average 7-10 drinks/week and 20% smoked. Women planning pregnancy did not meet the minimum guidelines for fruits, vegetables and grains and consequently had an excessive proportion of energy from fat and a low proportion of energy from carbohydrate. Less than halve of the women planning pregnancy were taking folic acid or a multivitamin and nearly three

quarters had an inadequate intake of iron. The women in this study were highly educated and motivated to participate; also reporting bias may be more prevalent in women planning pregnancy. As a result, negative habits are likely to have underestimated so the prevalence of unhealthy behaviours in the general population may be higher than reported.

Another study examined nutritional intakes retrospectively in the three months before pregnancy in a population of Latinas and non-Latinas (Schaffer et al., 1998). This study found that 58.7% of women consumed alcohol in the preconception period, 18.4% reported binge drinking and 26.4% smoked. The reported use of recreational drugs was 16.9%. Of those who drank before pregnancy, 40.7% stopped drinking in the first trimester or pregnancy. A similar finding to de Weerd et al (2003a) of an imbalance in macronutrient intake was reported, with less than halve of the women consuming five servings of fruit and vegetables per day and less than 10% met the recommendations for six servings of grains per day. Halve of the women had inadequate iron intakes and 75% did not meet the guidelines for total folate intake. Thirteen percent of the women reported to have been on a weight loss diet before the pregnancy.

Planning pregnancy is associated with a number of healthier lifestyle habits prior to pregnancy and during pregnancy (Hellerstedt et al., 1998; Naimi et al., 2003). Women with planned pregnancies are significantly less likely to smoke (Hellerstedt et al., 1998; McLeod et al., 2003; Naimi et al., 2003), less likely to consume caffeine and more likely to decrease caffeine intake during pregnancy (Hellerstedt et al., 1998) and less likely to binge drinking in the preconception period (Naimi et al., 2003). However, there appears to be no difference in the proportion of women reporting alcohol use in the preconception period according to planning pregnancy status, with nearly half of the women with a planned pregnancy consuming at least one alcoholic drink per week while trying to conceive in one study (Hellerstedt et al., 1998). An earlier study reported that 45% of women consumed alcohol prior to pregnancy recognition and 5% of women reported having six or more drinks per week in this period (Floyd et al., 1999).

1.5 Dietary Assessment Methods

The assessment of dietary intakes is central to studies on the relationship between diet and pregnancy outcome. It is important that the dietary assessment method chosen gives an appropriate measure of dietary intake. The accurate estimation of dietary intakes poses methodological problems due to the systematic errors associated with dietary assessment methods. Self-reporting of dietary intake is prone to errors, including those attributed to memory, estimation of portion size, under-reporting, over-reporting and socially desirable responses (Godwin et al., 2004; Jonnalagadda et al., 2000; Taren et al., 1999; Vuckovic et al., 2000). Accuracy is also limited due to errors associated with the conversion of foods into nutrients using food composition databases (Gibson, 1990; Schakel, 2001).

There is no ideal method for assessing dietary intakes; the choice of method needs to consider the objectives of the study, the target population and the available resources (Biro et al., 2002). Different methods are appropriate for characterising average intake, usual intake, or nutrient inadequacy at the individual or group level. The choice of method needs to be suitable for assessing the desired measure of intake. Generally, the more accurate methods are associated with higher costs, greater participant burden, and lower response rates. Often compromises have to be made between the collection of precise data on usual dietary intakes at the individual level and a high response rate (Gibson, 1990).

There are four basic categories of dietary assessment methods: weighed food records, diet recalls, diet histories and FFQs. Details of the common dietary methods are summarised in Table 1.5.1. None of the current methods are devoid of systematic errors, each method has inherent advantages and disadvantages (Gibson, 1990).

The weighed food record, considered the 'gold standard' for dietary assessment estimates current usual intake. It requires the participant to weigh all foods and beverages consumed during a specified time period. However, the participants must be motivated and literate, and may change their usual eating pattern to simplify food intake or to impress the investigator (Vuckovic et al., 2000). The number of recorded days depends on the nutrient being assessed and whether usual or average intakes are to be estimated. Records vary greatly in the detail given by participants on food items, including the amounts, brand names and food preparation methods. Participants may not record their diet as they consume items but instead may fill out the record once per day; therefore the accuracy of

the record is reduced. Accuracy also decreases with the number of recorded days due to reduced detail in recording and incomplete records (Biro et al., 2002).

Few studies have employed weighed food records to assess periconceptional dietary intakes (Friel et al., 1995; Mathews et al., 1999), as the expense and high participant burden limits the suitability of weighed food records in large scale prospective studies. The majority of studies have been retrospective, though current weighed food records have been used as a proxy for periconceptional intake four years earlier (Friel et al., 1995). The validity of the weighed food record to estimate intakes in the distant past is questionable, as it is based on the assumption that intakes have not changed over time.

A 24-hour recall provides a snapshot of a person's dietary intake. Intra-individual variation (the day to day variation in a person's diet) means that a single 24-hour recall can be used to characterise the average usual intake of a large group, but it can not be used to assess whether group intakes are inadequate (Gibson, 1990). Single 24-hour recalls have been used in large scale prospective studies to estimate habitual intakes in the preconception period or during pregnancy (Goldenberg et al., 1995; Rao et al., 2001; Scholl et al., 1996; Tamura et al., 1997). The 24-hour recall relies on the participant's memory of the previous days' food intake and estimation of portion sizes. It does, however, have a low respondent burden, is fast and inexpensive. A single 24-hour recall is valid for assessing habitual intakes in large scale prospective studies, whereas multiple 24-hour recalls are required to estimate usual mean intake of a smaller group.

A FFQ is suitable for describing food consumption patterns over a specified period and is often used in retrospective studies. Semi-quantitative FFQs include estimates on usual portion size and are useful for ranking individual intakes based on tertiles in epidemiological studies (Gibson, 1990). Each questionnaire must be specifically designed for the nutrient of interest and the target population (Black, 2001a). The majority of studies on periconceptional intakes have used retrospective FFQs to rank dietary intakes into quartiles in order to investigate associations with pregnancy outcomes (Di Cintio et al., 2001; Shaw et al., 2003; Thompson et al., 2003; Werler et al., 1993). FFQs are fast and can be self-administered with low burden to the participants, making them suitable for ranking dietary intakes in large scale observational studies. Portion size is usually estimated based on the use of standard serving sizes, therefore the considerable error in portion size reduces the accuracy of FFQs. Retrospective FFQs are prone to recall bias

due to errors associated with the recall of food intake. Many periconceptional studies have involved considerable recall times, therefore the validity of the FFQ is reduced (Mitchell et al., 2004; Shoob et al., 2001; Veile et al., 1999). A major limitation to retrospective periconceptional studies are recall errors arising from the misclassification of the timing of consumption, women are more likely to recall habits from the time of pregnancy recognition rather than the period before conception (da Costa Pereira et al., 1993). Differential recall bias between case and control mothers may be an issue in retrospective studies, as an adverse outcome may trigger more intense recall of habits around the time of conception in case mothers compared to controls (Rasch, 2003).

The diet history method attempts to construct a typical days eating pattern during a face-to-face interview. Diet histories provide a valid estimate of usual dietary intakes (Black, 2001a; Gibson, 1990). A 24-hour recall is first taken and then, each meal and snack is considered in turn to identify and quantify possible alternative foods or meal items (Black, 2001a). A FFQ is used as a checklist to identify missing items. If the previous days intake was not typical of the participant's usual food intake then a description of a usual days intake can be taken as the basis for the 24-hour recall (Tapsell et al., 2000). Information on usual intake for weekdays and weekends can be collected to account for the variation in intakes in the weekend. A weighted daily average intake can then be calculated using the following formula:

$$\text{Average Daily Intake} = \frac{(5 \times \text{weekday}) + \text{Saturday} + \text{Sunday}}{7}$$

The time period covered by the diet history can vary from one month to a year. When the specified period of the diet history is short (1-3 months) it can be used to assess inadequacy and the usual intake of an individual or group (Black, 2001a; Gibson, 1990). The major advantage of the diet history is that it can assess usual intake in a single interview. The accuracy of the diet history is improved by the interviews being conducted by a single interviewer, and the use of food models and standard household measures to estimate portion size (Black, 2001a; Gibson, 1990).

The diet history is time consuming, although the time commitment is restricted to the one occasion. It requires a trained interviewer who is knowledgeable about local foods, brand names and food preparation methods. The participant needs to be able to make subjective judgements on their usual intake and account for variability in their diet to provide an

estimate of usual intake, however they do not need to be literate (Black, 2001a). The usefulness of a diet history is limited in individuals with erratic eating patterns as it tends to underestimate irregularities in food intake because of the emphasis on regular eating patterns (Thompson & Byers, 1994).

Diet histories that cover a short time frame have been validated against 7-day and 16-day weighed food records. Generally, the diet history provides a higher estimate of energy and protein group intakes compared to weighed food records (Black et al., 2000; Gibson, 1990). Validation of a 16-day weighed food record and diet history against urinary nitrogen and doubly-labelled water in women suggests that the diet history produces a more valid estimate of group intakes for protein and energy intake than the food record, but the food record performs better at the individual level (Black et al., 2000). The diet history is not a valid method for characterising nutrients for which the day-to-day variation in a person's diet is notoriously high, notably vitamin A and C (Gibson, 1990).

Few studies have used diet histories to assess periconceptional intakes, as the need for a highly trained interviewer and the time involved makes this method impractical for use in large scale epidemiological studies. Diet histories have been used by small scale intervention studies to assess habitual intake in the periconceptional period (Cuskelly et al., 1996; Laurence et al., 1981).

Table 1.5.1: Uses and limitations of commonly used dietary assessment methods

Method	Description	Period of Food Intake	Uses	Advantages	Disadvantages
24-hour recall	Subjects recall foods consumed over the previous 24 hrs or on a 'typical day' in an interview. Quantities estimated using standard household measures. Widely used in epidemiological studies.	24 hours	Useful for assessing average usual intakes of a large population, provided sample is truly representative and days of the week are adequately represented.	Fast, easy and inexpensive. Low subject burden. Can be used with illiterate individuals. Less likely to modify food intake. Multiple 24-hr recalls can be used to estimate usual intake of individuals. Food models aid estimation of amounts.	Relies on subject's honesty, memory and food knowledge. Requires trained interviewer. Day chosen may not be typical of usual intake. Relies on subject's assessment of portion sizes.
Food Frequency Questionnaire	Uses comprehensive list or list of specific items to measure how often foods are eaten over a given period. Semi-quantitative questionnaires can include standard portion sizes.	From 24 hour period to open-ended.	Designed to obtain qualitative, descriptive data on usual intakes over a long time period. Useful in epidemiological studies for ranking subjects into broad categories of intakes of foods or nutrients. Identifies food patterns associated with inadequate intakes of specific nutrients.	Self-administered, fast and low subject burden. Can be used to cross check data obtained from other methods. Validated for ranking nutrient intakes. Validated against 7-day weighed food record. Can be modified to target certain nutrients or populations.	Validity dependent on the food list and the quantification method. Accuracy lower than other methods. Requires literate subjects.
Diet History	Open-ended interview that incorporates a 24-hr recall, alternative meal and snack options are obtained to construct a 'typical' days intake. Short FFQ used as checklist.	Open-ended or over a specified period.	Used to estimate usual nutrient intakes over a 1-3 month period; estimates prevalence of inadequate intakes. Identifies food patterns associated with inadequate intakes of specific nutrients.	Accounts for daily variation in food intake in a single interview. Can target contrasts between seasons, week-days/weekends etc. Food models aid estimation of amounts. Can be used with illiterate individuals. Validated against 7-day weighed food record for intake over 1-3 month period. Performs better at estimating group intakes than individual intakes.	Relies on subject's honesty, memory, food knowledge and ability to subjectively assess usual intake. Relies on subject's assessment of portion sizes. Labour intensive and time consuming. Requires trained interviewer; results depend on skill of the interviewer. Limited in subjects with wide variability in dietary habits.
Food Record	Written record of all food and drinks consumed over a defined period. Quantities weighed or estimated in household measures. Considered the gold standard for dietary assessment.	From 1 to 7 days. 3 days commonly used	Used to assess actual or usual intakes. Three or more days are needed to assess intakes of individuals. Estimates prevalence of inadequate intakes.	More accurate quantification of nutrient intakes; accuracy depends on conscientiousness of subjects.	Relies on subject's honesty, memory and food knowledge. Time consuming and high subject burden. Quality of recording decreases with the number of days. Requires literate, motivated and willing subjects. Subject may alter usual eating pattern to simplify or improve their diet. Expensive, requires electronic scales.

1.6 Methods of Estimating Body Composition

Both the amount and distribution of body fat have been identified as factors that may contribute to reproductive health or pregnancy outcomes. Anthropometric measurements are commonly used in studies as measures of nutritional status and body composition before or during pregnancy (Jensen et al., 2003; Neggers et al., 2003; Ronnenberg et al., 2003). For small clinical studies body composition can be estimated using specialized accurate laboratory based methods such as underwater densitometry, bioelectrical impedance or DEXA scans. However, these methods are expensive, time consuming and only available for use in a laboratory setting (Han & Lean, 2001; Heyward & Wagner, 2004).

Simple, cheap and portable anthropometric methods are suitable for large surveys. BMI, the ratio of weight divided by height squared, is widely used as an indicator of excess prepregnancy body fat in women (Jensen et al., 2003; Neggers et al., 2003; Ronnenberg et al., 2003). BMI has been found to correlate strongly with other more accurate laboratory measures of body fat (Heyward & Wagner, 2004). The main limitation with BMI is that it does not distinguish fat weight from muscle or bone weight, however it is cheap and highly practical for use in the field. International standards have been published for classifying BMI, additional criteria for New Zealand Maori and Pacific women have been developed due to the higher proportion of muscle mass in these population groups (Wilson et al., 2001).

The accumulation of abdominal fat is known as central obesity. Central obesity is associated with increased risk of disease and appears to be more strongly related to reduced fertility than overall obesity (Norman & Clark, 1998; Zaadstra et al., 1993). WHR uses waist and hip circumference measurements as an indirect indicator of both subcutaneous and visceral abdominal fat. WHR is used as a simple and reproducible estimate of central obesity in studies on pregnancy outcome (Brown et al., 1996; Zaadstra et al., 1993). However, waist circumference is gaining support as an alternative to WHR for assessing central obesity, as it provides a more accurate indirect measure of visceral fat and is not greatly influenced by age and the degree of overall adiposity (Han & Lean, 2001; Heyward & Wagner, 2004). The recommended waist circumference cut-off point indicative of central obesity in women is greater than 88 cm (Heyward & Wagner, 2004).

1.7 Rational

A woman's nutritional status and lifestyle habits in the periconceptional period are important in achieving a healthy pregnancy outcome and in the foetal programming of adult health. It appears that a balanced macronutrient intake, particularly protein and carbohydrate balance, and adequate levels of folate, vitamin B_{12}, zinc and iron is required around the time of conception to optimise pregnancy outcome. Women who are underweight, overweight or obese before conception have a higher risk of adverse pregnancy outcomes. Alcohol consumption early in pregnancy, particularly before pregnancy recognition can have immediate and long-term effects on the foetus and appears to be most pronounced with binge drinking. High levels of caffeine appear to be associated with reduced fertility and an increased risk of spontaneous abortion. Smoking is causally associated with foetal growth restriction and increasing evidence suggests a casual link to other adverse pregnancy outcomes.

In order to optimise maternal and infant health a broad health education campaign is needed to ensure that all women of childbearing age are aware of the importance of preconception care and being in a healthy physical state at the start of pregnancy. Prior to implementing any education campaign it is necessary to first assess the current knowledge and practices of women of childbearing age. This includes the need to assess the knowledge of women who plan pregnancy, as the potential to improve preconception care is greatest in these women. Women who plan pregnancy are more likely to be older, more highly educated and European (Hellerstedt et al., 1998). European women in New Zealand have the highest rates of planned pregnancies and begin childbearing at an older age than Maori or Pacific women (Craig et al., 2004). Given that European women also have the highest rate of NTDs in New Zealand they are most likely to experience the benefits of preconceptional folic acid supplementation (MOH, 2003b).

Currently there is no information available on women's knowledge and attitudes towards the role of preconception nutrition or alcohol and caffeine consumption in the preconception period in the outcome of pregnancy. Overseas studies have found that despite the introduction of the recommendation for daily folic acid use over 10 years ago there still appears to be a lack of awareness of the benefits of folic acid among women of childbearing age. While there is limited information available on the folic acid knowledge

of New Zealand women who are already pregnant, in New Zealand most pregnancies are unplanned therefore it is important to understand the knowledge of women of childbearing age before they enter into pregnancy. The knowledge of pregnant women or postnatal women is likely to reflect recent knowledge, therefore may not represent women's knowledge prior to conception. A prospective study conducted among women of childbearing age is able to examine the knowledge of women of childbearing age and of women planning pregnancy in the preconception period.

To date no study has examined the knowledge and attitudes towards preconception nutrition, dietary intakes and lifestyle practices in New Zealand women of childbearing age. This information in needed to identify women at risk of sub-optimal preconception practices and to identify strategies to increase the awareness of preconception care in order to improve the dietary and lifestyle practices of women of childbearing age in New Zealand. This is particularly important among women who plan pregnancy, as information on preconception care is most easily targeted towards women who already plan pregnancy.

2. AIMS OF THE STUDY

The broad aim of this study is to assess the knowledge and attitudes of women towards preconception nutrition and to assess the current dietary intakes and lifestyle practices in women of childbearing age in Auckland.

The specific aims of this research are:

- To determine the knowledge and attitudes towards preconception nutrition and general nutrition knowledge in Auckland women of childbearing age.
- To determine the knowledge of the benefits of preconceptional folic acid in the prevention of NTDs in Auckland women of childbearing age.
- To assess the current dietary intakes and lifestyle characteristics in Auckland women of childbearing age.
- To assess folic acid use, vitamin and/or mineral supplement use and attitudes towards folic acid fortification in Auckland women of childbearing age.
- To identify any differences in the knowledge and attitudes, dietary intakes, supplement use and lifestyle factors between women planning pregnancy and women not attempting to conceive.

3. METHODOLOGY

3.1 Study Design

This explorative study was designed to assess women's knowledge and attitudes towards preconception nutrition, dietary intakes and lifestyle practices. The study was designed to collect data using face-to-face interviews involving an interviewer-administered questionnaire, a diet history and anthropometric measurements.

3.2 Questionnaire Design

An interviewer-administered questionnaire (Appendix A) was developed to assess preconception nutrition knowledge, dietary habits and lifestyle characteristics in women of childbearing age. The questionnaire was divided into sections on dietary and lifestyle habits, general nutrition knowledge, preconception knowledge, pregnancy and medical history, demographics and a self-administered confidential section. The questionnaire consisted of both open-ended and categorical questions. A review of the current evidence and expert opinion was used to identify the components of preconception nutrition to be covered in the questionnaire. Expert consultation is thought to maximise the content validity of the questionnaire by ensuring that the questionnaire measures all relevant aspects of preconception nutrition (Parmeter & Wardle, 1999). Where possible questions were taken from existing questionnaires (Quigley & Watts, 1997). A review of the questionnaire was carried out by a panel of experts to determine face validity and to identify the best questions in terms of clarity (Parmeter & Wardle, 1999).

Dietary and Lifestyle Habits

Personal views on women's own dietary habits were assessed by the following questions: whether women considered their eating habits to be healthy (yes/no), what could be done to improve their diet (open-ended), whether they were satisfied with their body weight (yes/no) (de Weerd et al., 2003a) and why they used supplements (open-ended) (Conner et al., 2001). Dieting practices were assessed by the following questions: whether they tried to control their weight (yes/no) and what methods they used to control their weight (open-ended).

Information on current supplement use was collected using questions on the brand and frequency of vitamin and mineral supplement use taken directly from the 1997 NNS (Quigley & Watts, 1997). Caffeine intake was estimated by the average daily number of cups of coffee, tea, cola and energy drinks consumed, usual cup size and by the type of coffee consumed (e.g. filtered, instant) (Bolumar et al., 1997; Giannelli et al., 2003; Hatch & Bracken, 1993; Stanton & Gray, 1995). Visual aids of standard cup sizes were used to estimate usual cup size. Questions on alcohol use assessed whether they consumed any alcohol, frequency of use (categorical) and the average number of standard drinks consumed per week (categorical) (Henriksen et al., 2004; Williams et al., 2004). Information on the number of hours and type of physical activity per week, and smoking habits were also collected.

General Nutrition Knowledge

The questionnaire was designed to identify women's knowledge of the relationship between preconceptional folic acid use and the prevention of NTDs. Specific knowledge regarding the prevention of NTDs was assessed as it has been shown that this knowledge predicts folic acid use better than general knowledge on the prevention of birth defects (Amitai et al., 2004; Coll et al., 2004; De Jong-Van den Berg et al., 2005). The participants were asked, 'Have you ever heard of folate or folic acid? (yes/no)'; if the response was 'yes', they were then asked 'What do you know about folic acid?' (open-ended). This was followed by the prompt 'When is the best time to take folic acid?' (open-ended). The questions on folic acid knowledge were taken from previous studies (Habak et al., 2003; Kloeblen, 1999). Additional questions on the awareness of folic acid fortification (Watson et al., 2001) and whether women could identify sources of folate (French et al., 2003; Kloeblen, 1999), calcium and iron from food pictures (Appendix B) were included. The participants were asked whether they were aware if any foods/drinks can decrease iron absorption; if the response was 'yes', they were then asked to identify items from food pictures (Appendix B). Information on sources of nutrition knowledge (open-ended) and the best way to provide nutrition information (open-ended) was also collected.

Preconception Attitudes

Attitudes towards eating habits, body weight, alcohol consumption and caffeine use while planning pregnancy were assessed by a series open-ended questions and whether they

agreed or disagreed with several statements. Women were asked if they thought that a woman's eating habits while trying to conceive could affect pregnancy (yes/no); if the response was 'yes', they were then asked to identify how they thought preconception nutrition could affect pregnancy (open-ended). Women were asked if they were to try to conceive would they change their eating habits (yes/no); if the response was 'yes', they were then asked to identify how they would change their eating habits (open-ended). Attitudes towards alcohol and caffeine consumption while trying to conceive were assessed by whether they thought that women should change the amount they drink while trying to get pregnant (yes/no) and how they thought alcohol/caffeine intake should be modified (open-ended). Women were asked whether they thought that body weight could affect fertility (yes/no); if the response was 'yes', they were then asked to describe the type of body weight that can affect fertility. Women were also asked if they were to plan pregnancy whether they would seek any preconception advice (yes/no) and where they would go for advice (open-ended).

Pregnancy History

The questions on pregnancy history were designed to collect information on whether they had ever been pregnant (yes/no), the number of children (open-ended), whether they planned their last pregnancy (yes/no), the gestational period when their last pregnancy was confirmed (categorical) and when they first visited a doctor regarding their last pregnancy (categorical). Woman were also asked whether they had ever had a negative pregnancy test result either from a home pregnancy test or during a doctors appointment (yes/no), as these are potential opportunities for preconception advice (Jack et al., 1998).

Women were asked if they were currently trying to conceive (yes/no). Women who had been pregnant were asked if they had been pregnant within the last 10 years (yes/no) and whether they had had a planned pregnancy within the last 10 years (yes/no). Women whose pregnancy was within the last ten years were asked if they had taken folic acid during pregnancy (yes/no). Preconceptional folic acid use (yes/no) was assessed in women who had had a planned pregnancy within the last 10 years and in women attempting to conceive; as well as how long they had taken folic acid before conceiving or how long they had currently been taking folic acid for (open-ended). Information on the dose of folic acid was obtained for women attempting to conceive from the brand of supplement used.

Women who had had a planned pregnancy within the last 10 years and women attempting to conceive were also asked the following questions: whether they had changed their eating habits while planning pregnancy (yes/no), how they changed their eating habits (open-ended), whether they used any other supplements in the preconception period (open-ended), whether they had tried to lose or gain weight before trying to conceive (yes/no), whether they sought any preconception advice (yes/no) and the source of preconception advice (open-ended).

Medical History

Medical history questions assessed how often they visit a doctor (open-ended), use of prescribed medications (open-ended) and whether they had any of the following medical conditions: diabetes, hypertension, epilepsy or acne (yes/no).

Demographics

The demographic variables that were assessed included age (categorical), ethnicity (open-ended), the highest level of education (open-ended), employment status (categorical), occupation (open-ended), income (categorical) and whether they had a partner (yes/no).

Confidential Section

A self-administered confidential section contained questions on contraception use, current recreational drug use and whether woman had ever had a NTD, miscarriage, premature birth, still birth or abortion. This section also included questions on whether they had ever had or currently had either bulimia nervosa or anorexia nervosa.

3.2.1 Pre-Testing of the Questionnaire

The questionnaire was pre-tested on seven women from the target population with no formal nutrition training prior to the pilot testing. The pre-testing was necessary to test women's ability to understand the questions and terminology, questionnaire effectiveness and questionnaire acceptability. The participants involved in the pre-test were asked if they had any problems understanding or answering the questions and if they were offended in any way. As a result of the pre-testing standard prompts for open-ended questions based on feed back and the interviewers experiences from the pre-testing were added to generate sufficient information when the response was not detailed or specific enough. For example, if the participant was unsure how to answer to 'How do you try to

control your weight' then the prompts 'Do you exercise, try to eat healthy, by dieting, by following a strict diet or a combination of these?'

The pre-test was important in identifying changes that needed to be made to some of the terminology to reduce ambiguity and maximise the clarity of questions. The pre-test showed that some women had heard of either folic acid or folate but not both terms; so the question 'Have you ever heard of folic acid?' was changed to 'Have you ever heard of either folic acid or folate? The questions on the use of vitamin and mineral supplements were changed to include the statement 'That does not include the use of any herbal supplements such as Echinacea or evening primrose oil.' As the pre-testing showed that herbal supplements were mistakenly reported as vitamin and/or mineral supplements. The phrase 'dietary habits' was changed to 'eating habits' as the former term was confused with being on a weight loss diet.

Following the pre-testing questions were added to the pregnancy history section to identify women who had been pregnant and had had a planned pregnancy within the last ten years. In the original questionnaire the use of folic acid in the preconception period would have been underestimated by the inclusion of women who had planned a pregnancy before the introduction of the recommendation to take a preconceptional folic acid supplement. Also women who had planned a pregnancy over 10 years ago had difficulty recalling their preconception practices, asking recall questions within a bounded time has been shown to improve the reliability of the answer (Parmeter & Wardle, 1999). Another modification was the inclusion of the consumption of energy drinks to the caffeinated beverages used to estimate caffeine intake.

A series of questions on nutrition knowledge were judged to be too hard and as a result the women felt like they had very little knowledge, these questions were removed from the final questionnaire so that women did not leave feeling dejected about their nutritional knowledge. Maori and Pacific groups were consulted to ensure that the questionnaire was culturally sensitive. As a result of the consultation process examples of traditional foods such as kumara and taro were included in the serving size examples in the FFQ.

The questionnaire was tested for face validity and content validity but unfortunately the questionnaire was not able to undergo test/re-test reproducibility, internal consistency reliability or construct validity within the tight timeframe.

3.3 Pilot Study

The target population was Auckland women of childbearing age. The Auckland population has a higher proportion of Maori, Pacific and Asian women compared to the rest of New Zealand (Statistics New Zealand, 2003). A pilot study was carried out to test the recruitment of a randomly generated sample that was representative of Auckland women. The pilot study tested the recruitment of participants in June 2004 through the random selection of street names and start points based on a map of Auckland, eligible women residents were given details on the study and invited to take part in the study by the researcher in-person. This method was not effective as a means of recruiting participants for this study. The safety considerations with door-to-door recruitment meant that potential participants needed to be home during the day; this limited the number of potential participants and heavily biased the sample towards women not in the work force. This method of recruitment also proved to be too time consuming for a single researcher.

The length of the interviews during the pilot testing ranged between 60 and 90 minutes. Feedback from both the participants and women who declined to take part in the pilot study indicated that the length of the interview was a burden. Many women stated that if the interviews were shorter they would have taken part. As result of the pilot study the questionnaire was shortened to reduce the interview time to between 30 to 45 minutes. The sections that were not included in the final questionnaire covered questions on barriers to dietary change, additional information on supplement use and partners lifestyle habits. Questions on snack consumption, use of butter and oils and trimming fat from meat were taken out of the FFQ.

As a result of the pilot study it was decided that this explorative study would recruit women of childbearing age through advertisements in the Auckland region between the 1st of August 2004 and the 31st of November 2004.

Ethical approval was sought and given for both the pilot study and the study by the Massey University Human Ethics Committee (see Appendix C).

The study was funded by the New Horizons Trust for Women 10th Birthday Research Award.

3.4 Selection of Study Participants

Study participants were recruited through advertisements in local Auckland newspapers, at health clinics, libraries, day care centres, gymnasiums, public notice boards and Massey University (Appendix D), and by word of mouth. Women were invited to contact the researcher at Massey University for further information regarding the study.

For this explorative study it was considered that a sample size of 150 women would provide data that would identify trends and would be completed within the timeframe of a Master of Science degree. The final number of women who participated in the study was 115.

3.4.1 Selection Criteria

To be in the study participants had to be a female aged 18-45 years and live in the Auckland region. Women who were pregnant and women who had studied towards a nutrition or dietetic degree were excluded from the study. Pregnant women were excluded from the study as recent knowledge gained during pregnancy may not represent knowledge before conception and dietary intakes during pregnancy may not reflect those in the preconception period. Two women over 45 years of age and one woman who lived outside the Auckland area were excluded from the study.

3.5 Interview Protocol

Women who responded to the invitation to be in the study were screened for eligibility and given further information about the study either over the telephone or via email. Appointments were made for the interviews at a time and place of the participant's choosing. Interviews were conducted either at the participant's home or workplace, or at an interview room at Massey University. Most subjects living on Auckland's North Shore preferred to be interviewed at Massey University, whilst those living further away preferred to be visited in their own homes.

Participants were given a copy of the information sheet (Appendix E) and given the opportunity to ask any questions. Signed consent (Appendix F) was obtained before starting the interview. The participants were also given oral instructions regarding what

the interview involved, what they would be required to do and the structure of the interview. The participants were given the option to receive a summary of the study results and their own personal dietary intake. The women were reminded that all the information provided was confidential and they would only be identified using a code number. The participants were instructed to answer questions according to their own personal habits, attitudes or knowledge. Before starting the interview the participants were reminded that they had the option to decline to answer any question and that no explanation was required.

Data was collected during face-to-face interviews that were divided into three components: a questionnaire, a diet history and anthropometric measurements. All the interviews were conducted by the same interviewer and followed a standard interview schedule. The interview was conducted in the following standardised order: questionnaire, diet history and anthropometric measurements. The body measurements were done last to allow time for the interviewer to develop a rapport with the participant.

The time frame for the interviews ranged between 30 to 60 minutes, with the majority of interviews lasting 30 to 45 minutes. The wide variability in the length of the interviews was largely dependent on the amount of food eaten and the complexity of the foods in the diet history.

3.6 Data Collection

3.6.1 Questionnaire

The questionnaire (Appendix A) was administered by the sole interviewer, with the use of show cards (Appendix B) where necessary. The questionnaire was divided into 10 sections: dietary and lifestyle habits, supplement use, nutritional knowledge, medical history, attitudes towards preconception nutrition, pregnancy history, demographics and a confidential section.

During the interview if the response to an open-ended question was inadequate standard steps were taken to obtain an appropriate answer. If the response given failed to answer the question, then the question was repeated. If the response was unclear or the meaning was ambiguous probes such as 'What do you mean (by)?' were used to clarify the answer.

When the response was not detailed or specific enough standard prompts were used to obtain more information (printed in italics after the question). For instance, when asked, 'What do you know about folic acid?' and the response was 'It prevents NTDs', but no information on when folic acid should be taken was offered, they were then asked 'When is the most important time to take folic acid to prevent NTDs?'

The confidential section contained questions on contraceptive and recreational drug use, eating disorders and previous adverse pregnancy outcomes. The participants completed this section themselves, as it was believed that some women would feel more comfortable answering sensitive questions this way. If they wished this sheet could then be placed inside a sealed envelope to ensure anonymity. The participants were given instructions and reminded that all information was confidential and to use the 'Choose not to answer' option if they did not want to answer any question. This information was also printed on the confidential questionnaire.

3.6.2 Diet history

The diet history was chosen as the most appropriate method to assess usual dietary intake and nutrient adequacy for this explorative study. A diet history can take into account the variation between weekdays and weekends over a specified period and can assess usual intakes and nutrient adequacy during a single interview (Gibson, 1990). The in-person interview can ensure that an adequate description of foods is obtained, as for micronutrients such as folate the fortification of some products makes brand names important when assessing intake.

The focus of this study was on women's preconception knowledge and it was considered important to try to obtain close to 150 women to be able to identify trends to be investigated further. The sample size meant that it was not feasible to use weighed food records due to the cost of equipment and the high participant burden, which would have reduced the response rate (Gibson, 1990).

A single 24-hour recall can only be used to estimate the average usual intake of a large group and can not be used to estimate nutrient inadequacy; given that this study was designed to collect data on usual intakes during a one-off interview a 24-hour recall was not suitable. A FFQ provides qualitative information about food consumption patterns,

while semi-quantitative FFQs can be used to rank intakes into broad categories (Gibson, 1990). A FFQ is not a valid method of estimating usual group intake or nutrient inadequacy.

A diet history method attempts to construct a typical days eating pattern during a face-to-face interview to estimate a person's usual food intake. The diet history method in the present study used a structured protocol that incorporated a 24-hour recall (Appendix G) and a qualitative FFQ (Appendix H). Participants were asked to provide information based on their usual eating habits over the last month as this time frame is valid for assessing usual intakes (Black et al., 2000; Gibson, 1990).

A 24-hour recall was first taken to collect information on all the food and beverage items consumed in a 24-hour period and then, each meal, snack and beverage was considered in turn to identify and quantify possible alternative foods or meal items (Black, 2001a). The same process was then followed to collect information on usual intake during the weekends.

At the start of the diet history the participants were advised that a description of their usual eating pattern over the last month was required. It was suggested that they start at the beginning of the day and report items in the order they were consumed. The participants were asked whether what they had to eat the previous day was typical of their usual food intake; if the response was 'no', then they were asked to provide a description of their usual days intake to be taken as the basis for the 24-hour recall rather than the previous days intake (Tapsell et al., 2000).

The 24-hour recall was carried out using the multiple-pass procedure detailed below:

Step One: In the first pass or quick list the participant was asked to list in order all the foods and beverages eaten in a 24-hour period. If the participant stopped at intervals waiting for a response then support was given for them to continue, for example, 'was that all for breakfast', 'do you have anything after that?' or 'what would usually have next?' If explanations were offered for why certain foods were consumed these were acknowledged in a supportive, non-judgemental way (Tapsell et al., 2000). Participants were asked if they used alcohol or dietary supplements, and these items were added to the quick list.

They were then asked to provide alternative foods or beverages for meals and snacks for a weekday and the frequency with which these were consumed (Black, 2001a)

Step Two: The second pass involved obtaining a more detailed description of the foods and beverages in the quick list. This included brand names, cooking methods, detailed recipes for homemade foods, when eaten and the amount eaten. The amount eaten was estimated using standard household measures, food models, pictures of different shapes at graded sizes, photographs of different sizes of packaged foods, and photographs showing different spreads on bread at varying thicknesses. Dried beans were poured into standard sized bowls or onto plates to estimate the volume of amorphous foods (moulded), such as for cereal and rice (Godwin et al., 2004). Standard prompts were used to obtain information on forgotten items, such as, whether they used butter on toast, added anything to hot drinks or if they had anything between meals (Thompson & Byers, 1994)

Step Three: The third and final pass was the review. The foods listed by the participant and the amounts eaten were read out in the order that they were consumed and they were asked if there was anything else that needed to be added or clarified.

After finishing the 24-hour recall for during the week the participants were then asked whether their eating pattern was different during the weekend; if they answered 'yes', then the same multiple-pass procedure was repeated for the weekend. If they indicated that their diet only differed on one weekend day then information was only collected for that day, otherwise both weekends were included.

A short self-administered FFQ was then used as a checklist to identify any missing items or discrepancies. The participants were given oral and written instructions to answer the FFQ questions based on what they usually eat, and to ask for any help if needed. The questions used in the FFQ were selected from the FFQ used in the 1997 NNS that had been tested for reproducibility (Quigley & Watts, 1997), with an additional question on the number of servings of dairy products eaten per day. The participants were finally

asked whether there was anything they would like to add and if they thought that this was a true reflection of their usual eating pattern (Tapsell et al., 2000).

3.6.3 Anthropometric Measurements

Following the diet history the participants were reminded what the body composition measurements involved and the participants were asked for permission to take the body composition measurements. Anthropometric measurements were made by a trained observer according to the methods outlined by the Anthropometric Standardisation Reference Manual to standardise the collection of physical measurements (Heyward & Wagner, 2004). All anthropometric measurements were made in duplicate by the sole observer. When duplicate readings differed according to standard protocol a third reading was necessary and the average result used. For any measurements that were outside the standard reference values for New Zealand women (Wilson et al., 2001) a note was made in the margin that the measurement was correct and not attributed to mis-recording. The measurements were always taken in the following order: weight, height and waist circumference.

3.6.3.1 Weight

Weight was measured using Tanita digital scales (Model 1609N), with a maximum weight of 150 kg. The scales were calibrated every day with a known 5 kg weight. A masonite board was taken to each interview so that the scales could be placed on a hard level surface. The participants were asked to remove their shoes and any heavy items of clothing such as jackets and to then stand on the scales with their feet together, arms hanging loosely by their side and head facing forward (Heyward & Wagner, 2004). Measurements were made in duplicate to the nearest 0.1 kg; a third measurement was necessary when readings differed by more than 0.5 kg (Quigley & Watts, 1997).

3.6.3.2 Height

Height was measured on a level floor using a portable stadiometer designed by the Institute of Food, Nutrition and Human Health, Massey University. The participants were asked to remove their shoes and to stand against a door or wall with their feet flat on the floor, heels together and weight evenly distributed on both feet. Where necessary

participants were also asked to untie their hair. The participants were directed to stand with their back as straight as possible and their head positioned so that their line of sight was parallel to the floor. The participants were asked to breathe in deeply and stretch to their fullest height, without altering their head position (Heyward & Wagner, 2004). The stadiometer bar was lowered onto the participant's head with enough pressure to compress any hair. They were then asked to step away while the stadiometer was held in position and the measurement taken with the attached measuring tape. Measurements were taken in duplicate to nearest 0.1 cm; a third measurement was taken if readings differed by more than 0.5 cm (Quigley & Watts, 1997).

3.6.3.3 Waist Circumference

The waist circumference measurement was taken over one layer of light clothing using a standard Birch tailor's tape. The measurement was taken on the right hand side of the body with the tape in a horizontal position, pulled firmly but not to cause an indentation (Heyward & Wagner, 2004). The waist circumference measurement was taken at the level of the natural narrowing located approximately midway between the costal border and the iliac crest (Heyward & Wagner, 2004; Quigley & Watts, 1997). When no waist was apparent an arbitrary measurement was taken at this midpoint (Quigley & Watts, 1997). Measurements were taken at the end of a normal expiration. Readings were taken in duplicate to the nearest 0.1 cm; a third measurement was necessary when readings differed by more than 1.0 cm (Quigley & Watts, 1997).

3.7 Data Processing

3.7.1 Questionnaire Data

Data from the questionnaire and the FFQ was directly entered into SPSS for Windows version 11. The responses were coded using the coding manual and entered into SPSS by the sole interviewer to maximise consistency of interpretation. Responses to open-ended questions on attitudes were coded according to common answers obtained from both the pre-testing and pilot study. When a response did not fit with any of the options the 'Other' code was used, a new code was added if the same response was given three or more times.

Women who were attempting to conceive were classified as 'planning pregnancy' and women not trying to conceive acted as controls. Women who had had a planned pregnancy within the last 10 years were classified as 'previously planned pregnancy'. The term 'women who plan pregnancy' included both women planning pregnancy and women with a previously planned pregnancy.

Women were classified as having specific folic acid knowledge if they knew of the relationship between preconceptional folic acid and the prevention of NTDs. Knowledge that folic acid prevents birth defects or that folic acid use during pregnancy prevents NTDs were both coded as 'Prevents birth defects'. Knowledge that women need folic acid during pregnancy was coded as 'Required for pregnancy'. Any other responses were classified as 'No knowledge'.

Sources of nutrition information were coded as information from a medical professional (doctor, nutritionist, dietician, nurse, midwife or a specialist), the media (TV, magazines or radio), books, family or friends, internet, school or other training and other.

Estimates of daily caffeine intake were calculated from questions on the average daily consumption of caffeinated coffee, tea, colas and energy drinks. This was converted into the average daily intake of caffeine by estimating the caffeine content of brewed coffee as 115 mg per cup, filtered coffee as 80 mg per cup, instant coffee as 65 mg per cup, tea as 57 mg per cup, cola as 47 mg per can, and energy drinks as 91 mg per can (Giannelli et al., 2003; Hinds et al., 1996). Four categories of caffeine intake commonly used in studies on caffeine and pregnancy outcome were coded for: 0-150 mg/day, 151-300 mg/day, 301-500 mg/day, >500 mg/day (Bolumar et al., 1997; Giannelli et al., 2003; Hatch & Bracken, 1993; Stanton & Gray, 1995).

Types of physical activity were coded as light, moderate or vigorous based on metabolic equivalent (MET) values (Ainsworth et al., 1993). The categories used in the 1997 NNS were used to define physical activity levels as: 0 hours, < 2.5 hours, 2.5-4.9 hours, ≥5 hours for the number of hours spent on moderate to vigorous exercise per week . The categories used for alcohol consumption were taken from previous studies on lifestyle factors and pregnancy outcome (Henriksen et al., 2004; Williams et al., 2004).

Socio-economic status (SES) was coded using the New Zealand Socio-Economic Index 1996 (NZSEI) according to the NZSEI-96 Users' Guide (Galbraith et al., 2003). This method of classification has been used in previous studies to describe the SES of New Zealand women (Gibson et al., 2001). NZSEI uses scores produced for 97 occupations classified by the New Zealand Standard Classification of Occupations 1995, the NZSEI scores are split into six categories to provide discrete class divisions (Table 3.7.1).

Table 3.7.1: NZSEI score class divisions

Socio-Economic Group	NZSEI Score Range
1	66-90
2	56-65
3	42-55
4	32-41
5	24-31
6	10-23

Source: (Galbraith et al., 2003).

Participants were assigned a NZSEI score based on their reported occupation. Participants not in the workforce, such as homemakers or students, were classified according the NZSEI-96 guidelines for those with no occupational information using an imputed mean NZSEI-96 score based on age and educational level (Table 3.7.2). Unemployed women were classified as NZSEI class six. Women on maternity leave were classified according to their usual occupation.

Table 3.7.2: Imputed mean NZSEI scores for those not in the workforce.

Qualifications	Age		
	15-24	25-34	35-44
None	26	29	30
School Certificate	28	33	35
Higher School Qualification	29	37	39
Vocational Qualification	33	39	41
Bachelors Degree	44	51	52
Postgraduate Qualification	48	57	59

Source: (Galbraith et al., 2003).

3.7.2 Anthropometric Data

The average reading for each anthropometric measurement was calculated and entered directly into SPSS. Weight and height measurements were used to calculate BMI. Europeans were classified as being overweight or obese according the WHO classifications for BMI (Han & Lean, 2001), for Maori and Pacific women the specific

New Zealand criteria were used (Wilson et al., 2001). Central obesity was defined using the definition of a waist circumference greater than 88cm (Heyward & Wagner, 2004). Imputing of body composition measurements were checked for errors by ranking the results and rechecking outliers below the 10^{th} percentile and above the 90^{th} percentile.

Table 3.7.3: Classification of overweight and obesity in adults according to BMI

Classification	BMI (kg/m^2)	
	NZ European & Others	Maori & Pacific
Underweight	≤ 18.50	≤ 19.50
Normal range	18.50 – 24.99	19.50 – 25.99
Overweight	25.00 – 29.99	26.00 – 31.99
Obese	≥30.00	≥32.00

Source: Profiling New Zealanders: 1997 Anthropometric Norms (Wilson et al., 2001).

3.7.3 Nutrient Intakes

Data from the diet histories was analysed using the New Zealand Food Composition Database (NZFCD) using Foodworks Professional version 3. Nutrient intakes were imported into SPSS for statistical analysis.

Nutrient intake was determined from foods and supplements listed in the database. When a direct match from foods eaten to foods in the NZFCD was not available the food matching criteria (Appendix I) was followed. The license for the Australian Food Composition Database (AFCD) was not available; therefore unavailable foods could not be imported into the NZCFD. Substitutions had to be used for items not available in the NZFCD. Nutrition Information Panels (NIP) from packaged foods and information available from Fast Food restaurants were used to help match foods according to macronutrient content. NIP provide limited information on micronutrients, when nutrient levels for folate, iron and calcium were available these were also used to match substitutions. This was particularly important for new fortified products not available in the NZFCD, such as breakfast cereals and breads that are fortified with folic acid, iron or calcium. A record of the all the substitutions was kept to standardise the substitutions. When a direct match for a food item was not available in the NZFCD then the list of substitutions was checked for a standard substitution, if none was available the best match was made and recorded. Vitamin and mineral supplements not listed in the NZFCD were entered as new foods using the amounts of active ingredients given on the label. Recipes had been obtained for composite dished and these were entered into Foodworks.

Volumes of food were entered directly into the NZFCD for foods that had a volume option; otherwise volume was converted to weight using food density tables. Different muffins sizes were assigned weights based on data available from Starbucks, Muffin Break and Brumbies Bakeries on standard sizes, and from weighing different sized muffins on electronic scales. Muffins that were described as extra large were entered as 150g, large as 120g, medium as 100g and small as 80g. Weights of packaged foods were obtained from the labels and amounts were calculated from the proportion of the package eaten.

The data from the diet history provided a 24-hour recall that included alternative meal options and variations that occurred in the weekend. This data was then used to construct a weighted average days food intake by adjusting the reported intake according to the following formula:

$$\text{Average Daily Amount} = \text{Amount Eaten} \times \left(\frac{\text{Frequency eaten in the week}}{5} + \frac{\text{Frequency eaten in weekend)}}{2}\right)$$

Dietary intakes were analysed using SPSS and were checked for accuracy by ranking the results for energy, protein, fat, carbohydrate, folate, iron and calcium, and investigating outliers below the 10^{th} percentile and above the 90^{th} percentile. The outliers were rechecked in Foodworks, those attributed to mistyping were corrected. For example, 0.75 cups had been entered as 75 cups. A random selection of 10% of the diet histories were double entered and the mean difference in nutrient analysis was found to be 1.8%.

3.8 Statistical Analysis

Statistical analysis was conducted using SPSS for Windows version 11.0. Continuous variables were checked for normality using the Kolmogorov-Smirnov test. Dietary intakes were reported as a mean or median where appropriate. Body composition variables were reported as median values. Mann-Whitney U tests and Independent T tests were used to investigate differences between medians and means where appropriate. Categorical data was reported using descriptive statistics. Chi^2 tests and Fisher's Exact tests were used to identify associations between categorical variables. Logistic regression analysis was performed to investigate linear trends. For all analyses statistical significance was defined by two tailed $p \leq 0.05$. Statistical advice and assistance was given by Dr Barry McDonald (Massey University).

4. RESULTS

4.1 Participant Characteristics

4.1.1 Demographics

One-hundred and fifteen women aged 18-45 years of age participated in the study, 18 women were attempting to conceive and 97 women indicated they were not planning pregnancy. The demographic characteristics of the study participants are summarised in Table 4.1.1. Seventy-six percent of women reported having a partner.

Table 4.1.1: Demographic characteristics

Demographic	Women Planning Pregnancy		Controls		Total Group	
	n (18)	%	n (97)	%	n (115)	%
Age[1]						
18-25	1	5.6	31	32.6	32	28.3
26-30	2	11.1	22	23.2	24	21.2
31-35	6	33.3	9	9.5[2]	15	13.3
36-40	7	38.9	16	16.8	23	20.4
41-45	2	11.1	17	17.9	19	16.8
Ethnicity						
European	17	94.4	77	79.4	94	81.7
Maori	0	0	8	8.2	8	7.0
Pacific	0	0	2	2.1	2	1.7
Asian	1	5.6	10	10.3	11	9.6
Education						
Low	0	0.0	9	9.3	9	7.8
Medium	6	33.3	40	41.2	46	40.0
High	12	66.7	48	49.5	60	52.2
NZSEI Class						
1 - 2	4	22.2	17	17.5	21	18.3
3 - 4	14	77.8	54	55.7	68	59.1
5 - 6	0	0.0	26	26.8[3]	26	22.6

[1] Declined to answer means n=95 for controls and n=113 for total group.
[2] Fisher's Exact test; aged ≤30 years vs. >30 years, p=0.004.
[3] Fisher's Exact test; class 5-6 vs. not in class 5-6, p=0.011.

Women trying to conceive were significantly older than those not planning pregnancy, they were more likely to be aged over 30 years compared to those not attempting to conceive (83.3% vs. 44.2%, $p<0.004$). Women planning a pregnancy were less likely to be in NZSEI classes 5-6 than control women (0.0% vs. 26.0%, $p=0.011$) and tended to be in classes 3-4 (77.8% vs. 55.7%, $p>0.05$), though the small numbers meant that the later

was not significant. There was no difference in the highest level of education or ethnicity between the two groups.

4.1.2 Body Composition

The body composition of the participants is described in Table 4.1.2. The median BMI of the group was 23.5 kg/m^2 and ranged from 17.6-45.8 kg/m^2. Seventy-three percent of the women were in the healthy BMI range for New Zealanders; less than 1% were classified as being underweight, while 16.5% were overweight and 9.5% were obese (Table 4.1.3). The prevalence of central obesity, as defined by a waist circumference greater than 88cm was 14.3%. The body composition of women planning a pregnancy did not differ from those not trying to conceive for any measurements. Table 4.1.4 compares body composition to the results from the 1997 NNS, mean values were used for comparative purposes where appropriate. On average the women in the present study were lighter, had a lower BMI and fewer women were obese compared to the 1997 NNS (Russell et al., 1999).

Table 4.1.2: Body composition measurements

Measurement	Median[1]	SD	SEM	Minimum	Maximum
Weight (kg)	63.8	12.3	1.1	45.1	125.4
Height (m)	1.65	0.06	0.01	1.47	1.77
BMI (kg/m^2)	23.5	4.1	0.4	17.6	45.8
Waist Circumference (cm)	73.2	10.2	0.9	60.5	109.5

[1] Mann-Whitney U test; women planning pregnancy vs. controls, $p > 0.05$.

Table 4.1.3: Proportion of women classified as overweight and obese

Category	Women Planning Pregnancy		Controls		Total Group	
	n (18)	%	n (97)	%	n (115)	%
BMI (kg/m^2)[1]						
< 18.5	0	0.0	1	1.0	1	0.9
18.5-24.9	13	72.2	71	73.2	84	73.0
25.0-29.9	2	11.1	17	17.5	19	16.5
≥30	0	0.0	8	8.2	11	9.5
Waist Circumference[1]						
≤ 88 cm	14	77.8	84	86.6	98	85.2
> 88 cm	4	22.2	13	13.4	17	14.8

[1] χ^2 test; women planning pregnancy vs. controls, $p > 0.05$.

Table 4.1.4: Comparison of body composition variables to the 1997 NNS

Body Composition	Present Study	1997 NNS[1]	
		19-24 years	24-44 years
Weight (kg) (mean)	65.6	67.8	68.6
Height (cm) (mean)	1.65	1.65	1.64
BMI (kg/m^2) (mean)	24.1	25.0	25.7
Overweight[2] (%)	16.5	17.7	25.7
Obesity[3] (%)	9.5	17.2	17.1
Overweight/ obese (%)	26.0	34.9	42.8

[1] Source: (Russell et al., 1999).
[2] NZ Maori and Pacific women with 26 $kg/m^2 \leq BMI < 32$ kg/m^2, European & others with 26 $kg/m^2 \leq BMI < 30$ kg/m^2.
[3] NZ Maori and Pacific women with $BMI \geq 32$ kg/m^2, European & others with $BMI \geq 30$ kg/m^2.

4.1.3 Reproductive and Medical History

The reproductive history of the participants is summarised in Table 4.1.5, 46.1% of women had ever been pregnant and 37.4% of women had at least one child. Forty-seven percent of women had planned their last pregnancy. The majority of women had their last pregnancy confirmed after 4 weeks of gestation (82.2%); nearly one-quarter of women had their pregnancy confirmed after 7 weeks of gestation. Sixty-nine percent of women who had been pregnant within the last 10 years had taken folic acid during pregnancy. Women attempting to conceive were significantly more likely to have ever been pregnant than control women (72.2% vs. 41.2%, p=0.015). Twenty-five women in the control group had had a planned pregnancy within the 10 last years.

Only one woman had had a pregnancy affected by a NTD and two women had previously had a preterm birth. Twenty-eight percent of women who had been pregnant had experienced a miscarriage and 8.7% of all women had had a pregnancy terminated. Over half of the women had ever had a negative home pregnancy test (51.3%) and a third had had a negative pregnancy test during an appointment with their physician (33.9%).

The majority of women visited a doctor at least once a year (84.3%); 55.6% and 22.6% of women saw a doctor every six months or every three months respectively. Among women who were sexually active 74.0% reported using contraception, with the oral contraceptive being the most popular method (34.0%). Infertility was reported by 3.1% of women. Thirteen women (11.3%) reported a history of eating disorders; eight women (7.0%) reported a history of anorexia nervosa and nine women (7.8%) had a history of bulimia

nervosa. None of the women had diabetes, three women (2.6%) had a history of hypertension and three women (2.6%) had epilepsy.

Table 4.1.5: Reproductive history

Characteristic	Women Planning Pregnancy		Controls		Total Group	
	n (18)	%	n (97)	%	n (115)	%
Ever been pregnant	13	72.2	40	41.2[1]	53	46.1
Parity						
Nulliparous	9	50.0	63	64.9	72	62.6
Primiparous	8	44.4	15	15.5	23	20.0
Multiparous	1	5.6	19	19.6	20	17.4
Planned their last pregnancy[2]	7	53.8	17	42.5	25	47.2
Number of missed periods before pregnancy test[3]						
0	1	12.5	7	19.4	8	18.6
1	7	87.5	26	72.2	32	74.4
2	0	0.0	3	8.3	3	7.0
Gestational period when pregnancy confirmed[3]						
< 4 weeks	0	0.0	8	21.6	8	17.8
4-6 weeks	7	87.5	18	48.6	25	55.6
7-9 weeks	1	12.5	9	24.3	10	22.2
10-12 weeks	0	0.0	1	2.7	1	2.2
Folic acid use during pregnancy (if within last 10 years)[4]						
Yes	7	87.5	20	64.5	27	69.2
No	1	12.5	11	35.5	12	30.8
Previously has had:[5]						
NTD	0	0.0	1	1.0	1	0.02
Miscarriage	6	33.3	9	9.3	15	28.3
Premature delivery	1	5.6	1	1.0	2	3.8
Induced abortion	1	5.6	9	9.3	10	8.7

[1] χ^2 test; women planning pregnancy vs. controls, p=0.015.
[2] Among the women who had ever been pregnant
[3] "Not sure" means n=8 for women planning pregnancy, n=36 for controls and n=44 for total group.
[4] Among 39 women with a pregnancy within the last 10 years; women planning pregnancy n=8, controls n=21.
[5] Among all women (including never pregnant and ever pregnant).

4.2 General Nutrition Knowledge

The general nutrition knowledge of the participants is summarised in Table 4.2.1. Less than half of the women could identify any source of dietary folate from food pictures. Only 19.1% knew that bread was a source of folate, 26.6% could identify cereals and 37.4% could identify green vegetables. The ability to identify any source of dietary folate was significantly higher among women who were attempting to conceive compared to control women (77.8% vs. 42.7%, p=0.027). Specifically, women planning a pregnancy were more likely to know that cereals (55.6% vs. 24.7%, p=0.009) and green vegetables (66.7% vs. 32.0%, p=0.005) were sources of folate than controls. Women planning a pregnancy also tended to recognise bread was a source of folate more often than control women, though this was not significant (33.3% vs. 16.5%, p=0.095).

Table 4.2.1: General nutrition knowledge

Nutrition Knowledge	Women Planning Pregnancy		Controls		Total Group	
	n(18)	%	n(97)	%	n(115)	%
Can identify any source of dietary folate	14	77.8	41	42.7[1]	55	48.2
Knowledge of sources of dietary folate:						
Cereals	10	55.6	24	24.7[2]	34	29.6
Bread	6	33.3	16	16.5[3]	22	19.1
Green vegetables	12	66.7	31	32.0[2]	43	37.4
Legumes	4	22.2	8	8.2[4]	12	10.4
Can identify any source of dietary iron	18	100	97	100	115	100
Knowledge of sources of dietary iron:						
Red meat	15	83.3	95	97.9[5]	110	95.7
Chicken	4	22.2	18	18.6	22	19.1
Fish	3	16.7	17	17.7	20	17.5
Green vegetables	14	77.8	66	68.0	80	69.6
Legumes	7	38.9	29	29.9	36	31.3
Knowledge of foods/beverages that decrease iron absorption						
Coffee/tea	11	61.1	52	53.6	63	54.8
Red wine	8	44.4	25	25.8	33	28.7
Dairy products	0	0.0	6	6.2	6	5.2
Aware that dairy products are a source of calcium	18	100	93	95.9	111	96.5

[1] Fisher's Exact test; women planning pregnancy vs. controls, p=0.009.
[2] χ^2 test; women planning pregnancy vs. controls, p≤0.009.
[3] χ^2 test; women planning pregnancy vs. controls, p=0.0.95.
[4] Fisher's Exact test; women planning pregnancy vs. controls, p=0.093.
[5] Fisher's Exact test; women planning pregnancy vs. controls, p=0.027.

All of the women could identify at least one source of dietary iron. While 95.7% of women knew that red meat was a good source of iron, surprisingly few women could

identify chicken (19.1%) and fish (17.5%) as sources of iron. Green vegetables and legumes were identified as sources of iron by 69.6% and 31.3% of women respectively. Fewer women who were attempting to conceive could identify red meat as a source of iron compared to controls (83.3% vs. 97.9%, p=0.027). When asked about foods that can decrease iron absorption, 54.8% of women were aware that coffee/tea decreases iron absorption and this was 28.7% for red wine. Few women were aware that dairy products inhibit iron absorption (5.2%).

Sources of nutrition information are shown in Table 4.2.2; the most common sources of information were the media (60.0%), family or friends (37.4%), medical professionals (27.8%) and books (27.0%). The media was most often cited as the main source of nutrition information (29.6%) (Figure 4.2.1). Using the χ^2 test, nutrition information from books (76.7% vs. 38.1%, p=0.000) and books as the main source of information (82.4% vs. 42.3%, p=0.003) were both associated with the ability to identify any source of folate.

Table 4.2.2: Sources of nutrition information

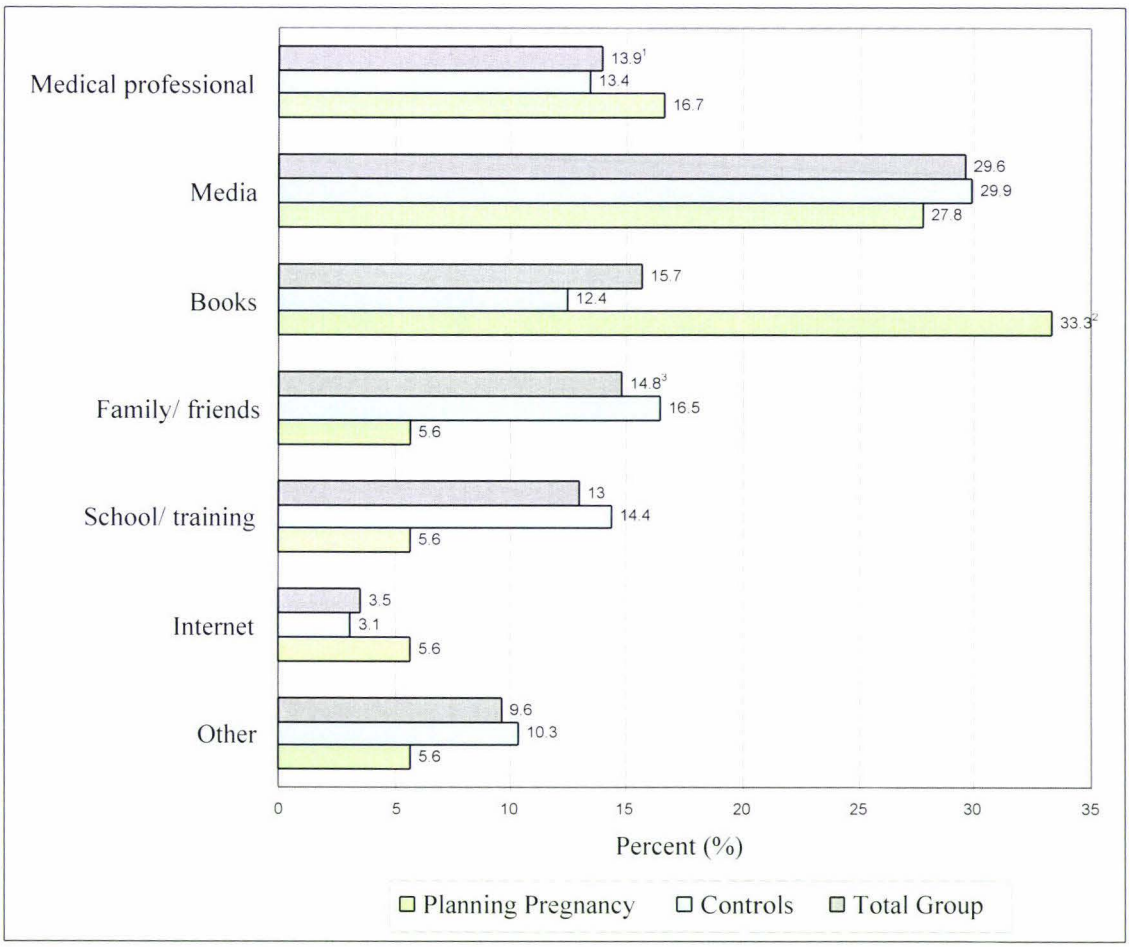
Sources of information	Women Planning Pregnancy		Controls		Total Group	
	n (18)	%	n (97)	%	n (115)	%
Medical professional	10	55.6	22	22.7[1]	32	27.8[2]
Media	11	61.1	58	59.8	69	60.0
Books	7	38.9	24	24.7	31	27.0[3]
Family/friends	7	22.2	39	40.2	43	37.4[4]
School/ other training	2	11.1	23	23.7	25	21.7
Internet	4	22.2	9	9.3	13	11.3
Other	3	16.7	33	34.0	36	31.3

[1] χ^2 test; women planning pregnancy vs. controls, p=0.004.
[2] χ^2 test; women who plan pregnancy vs. never planned pregnancy, (46.5% vs. 16.7%), p=0.001.
[3] χ^2 test; women who plan pregnancy vs. never planned pregnancy, (32.6% vs. 23.6%), p>0.05.
[4] χ^2 test; women who plan pregnancy vs. never planned pregnancy, (25.6% vs. 44.4%), p=0.043.

Women planning a pregnancy were twice as likely to have received information from a medical professional (55.6% vs. 22.7%, p=0.004) and to cite books as the main source of information (33.3% vs. 12.4%, p=0.025) than control women. Women who plan pregnancy were more likely to have received nutrition information from a medical professional (46.5% vs. 16.7%, p=0.0001) and for a medical professional to be the main source of information (25.6% vs. 6.9%, p=0.008) than women who have never planned pregnancy. There was also a non-significant tendency for women who plan pregnancy to

obtain information from books compared to women who have never planned pregnancy (32.6% vs. 23.6%, p>0.05). Women who plan pregnancy were less likely to cite family or friends as a source of nutritional information than women who have never planned pregnancy (25.6% vs. 44.4%, p=0.043).

Figure 4.2.1: Main source of nutrition information



[1] χ^2 test: medical professional, women who plan pregnancy vs. never planned pregnancy (25.6% vs. 16.7%), p=0.008.
[2] χ^2 test: books, women planning pregnancy vs. controls (33.3% vs. 12.4%), p=0.025.
[3] χ^2 test: family/friends, women who plan pregnancy vs. never planned pregnancy (7.0% vs. 19.4%), p=0.068.

The most effective form of media for a public health nutrition promotion is shown in Figure 4.2.2. Most women referred to television (37.4%) and magazines (24.3%) as the best way to influence their dietary habits. Around a third of the women were aware of the MOH guidelines for healthy eating during pregnancy (37.4%); women who were planning pregnancy (61.1% vs. 33.0%, p=0.024) or who had ever been pregnant (49.1% vs. 27.4%, p=0.017) were significantly more likely to aware of the MOH guidelines (Figure 4.2.3).

Figure 4.2.2: Most effective form of media for a public health nutrition campaign

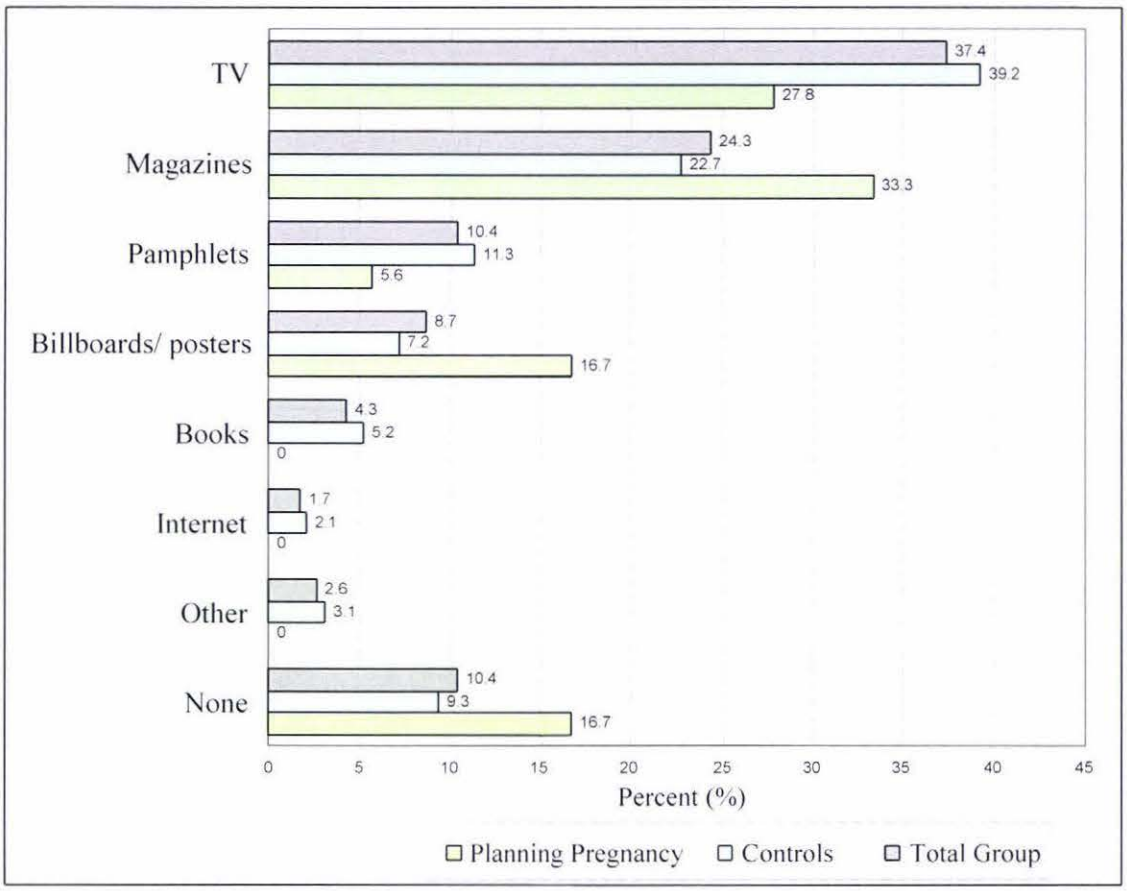
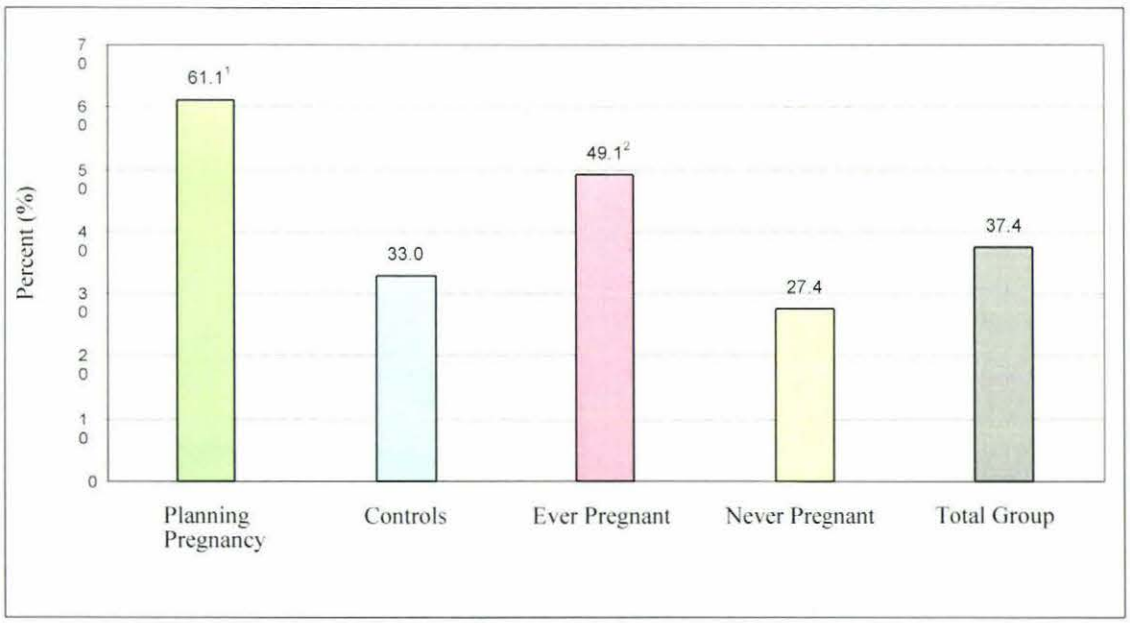


Figure 4.2.3: Proportion of women aware of the MOH guidelines for healthy eating for pregnancy



[1] χ^2 test; women planning pregnancy vs. controls (61.1% vs. 33.0%), p=0.024.
[2] χ^2 test; ever pregnant vs. never pregnant (49.1% vs. 27.4%), p=0.017.

4.3 Folate Awareness and Knowledge

Table 4.3.1 summarises the knowledge and awareness of folate among the participants. Nearly all of the women had heard of folate or folic acid (93.7%). Sixty-five percent of women knew that folic acid was required for pregnancy, 53.9% knew that folic acid prevents birth defects and only 31.3% of women had specific knowledge that folic acid use a month before conception can prevent NTDs.

Approximately half of the women were aware of folic acid fortification (54.8%). Fifty-one percent of women stated that they would prefer to take a folic acid supplement in order to increase their folic acid intake, only 9.6% would prefer to use folic acid fortified products. Women who were planning a pregnancy were more likely to prefer to take a folic acid supplement than control women (100.0% vs. 42.3%, p=0.000).

Table 4.3.1: Folate awareness and knowledge

Folate Knowledge	Women Planning Pregnancy		Controls		Total Group	
	n (18)	%	n (97)	%	n (115)	%
Heard of folate or folic acid	18	100	89	91.8	107	93.0
Folic acid knowledge						
Specific knowledge	12	66.7	24	24.7[1]	36	31.3
Prevents birth defects	5	27.8	21	21.6	26	22.6
Required for pregnancy	0	0.0	13	13.4	13	11.3
No knowledge	1	5.6	39	40.2	40	34.8
Aware of folic acid fortification	12	66.7	51	52.6	63	54.8
Preferred method of increasing folic acid intake						
Folic acid supplement	18	100.0	41	42.3[2]	59	51.3
Folic acid fortified products	0	0.0	11	11.3	11	9.6
Natural dietary intake	0	0.0	40	41.2	40	34.8
None	0	0.0	1	1.0	1	0.9
Not sure	0	0.0	4	4.1	4	3.5

[1] χ^2 test; women planning pregnancy vs. controls, p=0.000.
[2] Fisher's Exact test; women planning pregnancy vs. controls, p=0.000.

Variables associated with specific folic acid knowledge are shown in Table 4.3.2. Pregnancy planning, either in women attempting to conceive (66.7% vs. 24.7%, p=0.000) or women who plan pregnancy (53.5% vs. 18.1%, p=0.000) were both associated with specific folic acid knowledge. Specific folic acid knowledge was higher in women attempting to conceive than in women with a previously planned pregnancy (66.7% vs. 44.0%, p=0.010).

Table 4.3.2: Variables associated with specific folic acid knowledge

Variable	Specific Knowledge		
	n (total)	%	p-value[1]
Planning pregnancy			
Yes	12 (18)	66.7	0.000
No	24 (97)	24.7	
Previous planned pregnancy			
Yes	11 (25)	44.0	0.012
No	13 (72)	18.1	
Women who plan pregnancy			
Yes	23 (43)	53.5	0.000
No	13 (72)	18.1	
Ever pregnant			
Yes	21 (53)	39.6	0.075
No	15 (62)	24.2	
Parous			
Yes	18 (43)	41.9	0.059
No	18 (72)	25.0	
Age >30 years			
Yes	24 (57)	42.1	0.010
No	11 (56)	19.6	
NZSEI			
Class 1 & 2	9 (21)	42.9	
Class 3 & 4	22 (68)	32.4	
Class 5 & 6	5 (26)	19.2	0.083[2]
Highest level of education			
Low	3(9)	33.3	
Middle	13 (46)	28.3	
High	20 (60)	33.3	0.848[2]
Information from books			
Yes	20 (31)	64.5	0.000
No	16 (84)	19.0	
Information from a medical professional			
Yes	11 (32)	34.4	0.659
No	25 (83)	30.1	
Main source of information from books			
Yes	12 (18)	66.7	0.000
No	24 (97)	24.7	
Aware of MOH guidelines for pregnancy			
Yes	24 (43)	55.8	0.000
No	12 (71)	16.7	

Note: Planning pregnancy: defined as women attempting to conceive. Previously planned pregnancy: defined as women with a planned pregnancy within the last 10 years who were not currently trying to conceive. Women who plan pregnancy: defined as women attempting to conceive and women with a planned pregnancy with in the last 10 years.

[1] χ^2 test.

[2] Logistic regression; p for trend.

Both a previous pregnancy (39.6% vs. 24.2%, p=0.075) and parity (41.9% vs. 25.0%, p=0.059) tended to be associated with specific folic acid knowledge, though neither reached significance. Women aged over 30 years were significantly more likely to have

specific folic acid knowledge than younger women (42.1% vs. 19.6%, p=0.010). Specific folic acid knowledge remained significantly higher in women who plan pregnancy after univariate adjustment for age over 30 years, having ever been pregnant and parity using logistic regression ($p \leq 0.006$).

Using logistic regression there was a linear trend for specific folic acid knowledge to decrease with increasing NZSEI, though this did not reach significance (p=0.083). Education was not related with specific folic acid knowledge using logistics regression (trend $p > 0.05$).

Nutrition information from books was the only source of information positively associated with specific folic acid knowledge (64.5% vs. 19.0%, p=0.000). Family/friends as the main source of information was associated with reduced specific folic acid knowledge (5.6% vs. 19.0%, p=0.088), though this was not significant. Women aware of the MOH pregnancy guidelines were more than three times as likely to have specific folic acid knowledge than women not aware of the guidelines (55.8% vs. 16.7%,p=0.000).

4.4 Preconception Nutrition Knowledge and Attitudes

Attitudes towards preconception nutrition are summarised in Table 4.4.1. Eighty percent of women thought that dietary habits in the preconception period could affect pregnancy outcome. However, fewer women were able to specify how diet in the preconception period may influence pregnancy. Responses given to how preconception diet may affect pregnancy included fertility (39.1%), health or development of the baby (21.7%) and health of the mother (13.0%). Few women thought that preconception diet could influence risk of miscarriage (5.2%), preterm delivery (0.9%) or maternal deficiencies (2.6%). Women planning a pregnancy were more likely to think that preconception dietary habits can affect the health or development of the baby (50.0% vs. 16.5%, p=0.0002) and the health of the mother (33.3% vs. 9.3%, p=0.0005) than control women.

Table 4.4.1: Attitudes towards preconception nutrition

Attitudes	Women Planning Pregnancy		Controls		Total Group	
	n(18)	%	n(97)	%	n(115)	%
Dietary habits in the preconception period can affect pregnancy outcome	14	77.8	78	80.4	92	80.0
Responses to how women thought preconception diet may affect pregnancy						
Fertility	7	38.9	38	39.2	45	39.1
Health or development of the baby	9	50.0	16	16.5[1]	25	21.7
Health of the mother	6	33.3	9	9.3[1]	15	13.0
Risk of miscarriage	1	5.6	5	5.2	6	5.2
Risk of preterm delivery	0	0.0	1	1.0	1	0.9
Maternal deficiencies	0	0.0	3	3.1	3	2.6
Would change dietary habits if trying to conceive	15	83.3	71	74.0	86	75.4
Responses to how women would change their diet if trying conceive						
Eat a more healthy or balanced diet	4	22.2	20	20.6	24	20.9
Eat more fruit and vegetables	4	22.2	13	13.4	17	14.8
Eat more dairy products	1	5.6	7	7.2	8	7.0
Less processed foods or refined sugar	0	0.0	4	4.1	4	3.5
Avoid foods associated with risk of listeria	2	11.1	2	2.1	4	3.5
Less caffeine	11	61.1	9	9.3[1]	20	17.4
Less alcohol	10	55.6	27	27.8[2]	37	32.2

[1] χ^2 test: women planning pregnancy vs. controls, $p \leq 0.005$.
[2] χ^2 test: women planning pregnancy vs. controls, $p=0.021$.

Three-quarters of the women indicated that they would change their dietary habits if they were to plan a pregnancy; 32.2% responded they would consume less alcohol and 17.4% would consume less caffeine. Only 7.0% responded they would increase their intake of

dairy products and 3.5% would avoid foods associated with risk of listeria poisoning. Women attempting to conceive were more likely to respond that they would reduce their caffeine intake (61.1% vs. 9.3%, p=0.000) and alcohol intake (55.6% vs. 27.8%, p=0.021) while trying to conceive than control.

Table 4.4.2 summarises the participants' attitudes towards alcohol and caffeine consumption, and body weight while trying to conceive. Abstaining from alcohol while attempting conception was advocated by 57.4% of the women, 36.5% thought that alcohol intake should limited and 6.1% thought that there was no need to change alcohol intake while trying to conceive. Women planning pregnancy were less likely to advocate alcohol abstinence (33.3% vs. 61.9%, p=0.025) and more likely to support limiting alcohol (66.7% vs. 30.9%, p=0.004) than controls. Sixty-two percent of women supported limiting caffeine consumption while trying to conceive and 20.9% advocated avoiding caffeine. Women attempting to conceive tended to be more likely to advocate limiting caffeine intake while attempting conception compared to control women (77.7% vs. 58.8%, p=0.127), though this was not significant. Ninety-one percent of women thought that body weight could affect fertility. Though only 60.9% of women were aware that being both underweight and overweight can affect fertility; this was significantly higher in women planning pregnancy than control women (83.3% vs. 56.7%, p=0.033).

Table 4.4.2: Attitudes towards alcohol, caffeine, smoking and body weight before pregnancy

Attitudes	Women Planning Pregnancy		Controls		Total Group	
	n(18)	%	n(97)	%	n(115)	%
Alcohol consumption in preconception period						
Abstain from drinking alcohol	6	33.3	60	61.9[1]	66	57.4
Limit alcohol intake	12	66.7	30	30.9[2]	42	36.5
No need to change alcohol intake	0	0.0	7	7.2	7	6.1
Caffeine consumption in preconception period						
Abstain from drinking caffeinated beverages	2	11.1	22	22.7	24	20.9
Limit caffeine intake	17	77.8	57	58.8[3]	71	61.7
No need to change caffeine intake	2	11.1	14	14.4	16	13.9
Not sure	0	0.0	4	4.1	4	3.5
Body weight can affect fertility	17	94.4	86	88.7	104	90.4
Type body weight that may affect fertility						
Underweight and underweight	18	83.3	55	56.7[1]	70	60.9
Underweight	1	5.6	22	22.7	23	20.0
Not sure	1	5.6	10	10.3	11	10.0
Smoking reduces fertility in women	17	94.4	77	79.4	94	81.7

[1] χ^2 test: women planning pregnancy vs. controls, p≤0.033.
[2] χ^2 test: women planning pregnancy vs. controls, p=0.004.
[3] χ^2 test: women planning pregnancy vs. controls, p=0.033.

4.5 Preconception Practices in Women who Plan Pregnancy

The preconception practices of women planning a pregnancy and women with a planned pregnancy within the last 10 years are summarised in Table 4.5.1. Sixty-one percent of women who plan pregnancy reported that they changed their dietary habits while trying to conceive; 53.6% decreased their alcohol consumption, 42.9% reduced their caffeine intake, 21.4% increased their intake of fruit and vegetables and 10.7% ate more dairy products. Preconception advice was sought by only 35.7% of women who plan pregnancy, with the majority of these women seeking advice from a medical professional (85.7%). Women attempting to conceive were more likely to report having reduced their caffeine intake (66.7% vs. 15.4%, p=0.009) and to have sought preconception advice (61.1% vs. 16.7%, p=0.004) compared to women who had previously planned a pregnancy.

Table 4.5.1: Preconception dietary practices among women who plan pregnancy

Preconception Practice	Women Planning Pregnancy		Previous Planned Pregnancy		Total Women Who Plan Pregnancy	
	n (18)	%	n (25)	%	n (43)	%
Changed dietary habits while trying to conceive.	15	83.3	11	44.0[1]	26	60.5
Changes to diet in preconception period:						
Ate a more healthy or balanced diet	5	27.8	5	20.0	10	23.3
Ate more fruit and vegetables	4	22.2	2	8.0	6	14.0
Ate more dairy products	1	37.2	2	8.0	3	7.0
Avoided foods with risk of listeria	3	16.7	1	4.0	4	9.1
Less caffeine	10	55.5	2	8.0[1]	12	28.0
Less alcohol	10	55.5	5	20.0	15	34.9
Multi-vitamin and/mineral use	2	11.1	0	0.0	2	4.7
Tried to lose weight before trying to conceive	5	27.8	1	4.0[2]	6	14.0
Tried to gain weight before trying to conceive	0	0.0	1	4.0	1	2.4
Preconception advice	11	61.1	4	16.0	15	34.9
Preconception advice from a medical professional	10	55.6	2	8.0[1]	12	27.9

[1] Fisher's Exact test; women planning pregnancy vs. previous planned pregnancy, p≤0.013.
[2] Fisher's Exact test; women planning pregnancy vs. previous planned pregnancy, p=0.068.

Table 4.5.2 describes supplement use in the preconception period among women who plan pregnancy. Seventy-five percent of women who plan pregnancy reporting taking a folic acid supplement in the preconception period, but only 53.5% of women who plan pregnancy had taken folic acid for at least one month before conception or before attempting to conceive. All of the women trying to conceive reported taking folic acid;

this was significantly higher than women with a previously planned pregnancy (100.0% vs. 54.5%, p=0.001). Women attempting to conceive were also more likely to report using a multi-vitamin and/or mineral supplement in the preconception period than women with a previous planned pregnancy (67.1% vs. 16.7%, p=0.004).

Variables associated with preconceptional folic acid use among women who plan pregnancy are given in Table 4.5.3. Specific folic acid knowledge was positively associated with preconceptional folic acid use (95.7% vs. 47.1%, p=0.001), as was nutrition information from books (100.0% vs. 63.0 5, p=0.016) and preconception advice (100.0% vs. 60.0%, p=0.006). Using logistic regression, there was a linear trend for increased use of preconceptional folic acid with a higher level of education, though this did not quite reach significance (p=0.054). Fewer women with a low level of education used folic acid in the preconception period compared to women with a medium or high level of education (25.0% vs. 80.6%, p=0.042).

Information on the dose of folic acid was only available for women planning a pregnancy, 31.3% of women currently trying to conceive were taking a folic acid supplement with a dose below 400 μg. Of these women all were taking a multi-vitamin and/or mineral supplement containing 300 μg of folic acid. Two women were taking a dose of folic acid above the tolerable upper limit (UL) for folate of 1000 μg.

Table 4.5.2: Preconceptional supplement use among women who plan pregnancy

Supplement Use	Women Planning Pregnancy		Previous Planned Pregnancy		Total Women Who Plan Pregnancy	
	n (18)	%	n (25)	%	n (43)	%
Preconception folic acid use	18	100	12	54.5[1]	30	75.0
Length of preconception folic acid use						
< 1 month	0	0.0	2	16.7	2	6.7
1-3 months	3	16.7	2	16.7	5	16.7
> 3 months	15	83.3	8	66.7	23	76.7
Dose of folic acid						
< 400 μg	5	31.3	-	-	-	-
≥ 400 μg	13	72.2	-	-	-	-
Other preconception supplements used						
Iron	0	0.0	1	4.2	1	2.4
Calcium	3	16.7	2	8.3	5	11.9
Multi-vitamin &/ mineral	11	61.1	4	16.7[1]	15	35.7
Other supplement	2	11.1	0	0.0	2	4.8

[1] Fisher's Exact test; women planning pregnancy vs. previous planned pregnancy, p≤0.009.

Table 4.5.3: Variables associated with preconceptional folic acid use

Variable	Preconception Folic Acid Use		
	n (30)	%	p-value[1]
Specific folic acid knowledge			
Yes	22	95.7	
No	8	47.1	0.001
Information form books			
Yes	13	100.0	
No	17	63.0	0.016
Preconception advice			
Yes	15	100.0	
No	15	60.0	0.006
Education			
Low	1 (4)	25.0	0.042[2]
Medium	10 (13)	76.9	
High	19 (23)	82.6	0.054[3]

[1] Fisher's Exact test.
[2] Fisher's Exact test: low education vs. medium/high education.
[3] Logistic regression. p for trend.

4.6 Dietary Intakes

4.6.1 Dietary Habits

Eighty-three percent (n=95) of women ate a regular diet that included animal products. The most prevalent food restriction was a semi-vegetarian diet (avoids eating red meat) at 8.8% (n=10), followed by a vegetarian diet (avoids all meat) at 6.1% (n=7). Only two women followed a vegan diet (1.8%). Sixty-three percent of women met the National Nutrition Taskforce guidelines to consume at least two servings of fruit per day, 52.3% ate at least three servings of vegetables per day and 54.4% ate two or more servings of dairy products per day (Table 4.6.1.1). Very few women ate six servings of cereals/grains per day (5.3%); the majority of women consumed only 2-3 servings of cereals/grains per day (71.9%). There was no difference in the proportion of women meeting the guidelines for servings per day between women planning pregnancy and controls. Compared to the 1997 NNS more women in the present study met the guidelines for fruit intake (63% vs. 48-49%), while fewer women met the guidelines for vegetables (53% vs. 59-71%) and cereals/grains (5% vs. 8-10%) (Table 4.6.1.2) (Russell et al., 1999).

Table 4.6.1.1: Proportion of women meeting the guidelines for food servings per day

Servings Per Day	Women Planning Pregnancy		Controls[1]		Total Group	
	n (18)	%	n (96)[2]	%	n (114)[2]	%
Fruit per day ≥ 2	12	66.7	60	62.5	72	63.2
Vegetables per day ≥ 3	9	50.0	51	53.1	60	52.6
Cereals/grains per day ≥ 6	0	0.0	6	6.3[3]	6	5.3
Dairy products per day ≥ 2	9	50.0	53	55.2	62	54.4

[1] χ^2 test; women planning pregnancy vs. controls, p>0.05.
[2] Missing data means n=96 for controls and n=114 for total group.
[3] Fisher's Exact test; women planning pregnancy vs. controls, p>0.05.

Table 4.6.1.2: Proportion of women meeting the guidelines for servings compared to the 1997 NNS

Servings Per Day	Present Study		1997 NNS[1]	
			19-24 years	25-44 years
	n (114)[2]	%	%	%
Fruit per day ≥ 2	72	63.2	48	49
Vegetables per day ≥ 3	60	52.6	59	71
Cereals/grains per day ≥ 6	6	5.3	8	10
Dairy products per day ≥ 2	62	54.4	-	-

[1] Source: (Russell et al., 1999).
[2] Missing data means n=114.

The frequencies of the number of servings of foods are shown in Figure 4.6.1.1- Figure 4.6.1.6. Regular use of breakfast cereals was reported by 72.6% (n=82) of women compared to 52-60% of women of childbearing age in the 1997 NNS (Russell et al., 1999). Thirty-one percent of women reported skipping breakfast at least once per week, 11.5% skipped breakfast 3-6 times per week and 8.0% skipped breakfast daily (Table 4.6.1.3).

Table 4.6.1.3: Number of times breakfast skipped per week

Skip Breakfast	Women Planning Pregnancy		Controls[1]		Total Group	
	n (18)	%	n (95)	%	n (113)[2]	%
Never	15	83.3	63	66.3[3]	78	69.0
1-2 times per week	1	5.6	12	12.6	13	11.5
3-4 times per week	0	0.0	8	8.4	8	7.1
5-6 times per week	0	0.0	5	5.3	5	4.4
Daily	2	11.1	7	7.4	9	8.0

[1] Fisher's Exact test; women planning pregnancy vs. controls, $p>0.05$.
[2] Missing data means n=95 for controls and n=113 for total group.
[3] χ^2 test; women planning pregnancy vs. controls, $p>0.05$.

Supplement use is summarised in Table 4.6.1.4. Eight-two percent of women reported having used a supplement in the past year, 58.3% were currently taking a supplement on a regular basis (at least once per week). The most common type of supplement was a multi-vitamin and/or mineral (42.6%). All of the 11.3% of women taking folic acid were attempting to conceive. Sixteen percent of women were taking another type of supplement, these included vitamin B complexes, single vitamins or single minerals. None of the women were taking a vitamin A supplement.

Table 4.6.1.4: Current vitamin and /or mineral supplement use[1]

Supplement	Women Planning Pregnancy		Controls		Total Group	
	n (18)	%	n (97)	%	n (115)	%
Multi-vitamin and/or mineral	11	61.1	38	39.2[2]	49	42.6
Folic acid	13	72.2	0	0.0[3]	13	11.3
Iron	0	0.0	5	5.2	5	4.3
Calcium	3	16.7	2	2.1[4]	5	4.3
Other type of supplement	2	11.1	16	16.5	18	15.7

[1] Regular use includes those taking a supplement at least once/week as defined in the 1997 NNS (Russell et al., 1999).
[2] χ^2 test; women planning pregnancy vs. controls, $p\leq0.025$.
[3] Fisher's Exact test; women planning pregnancy vs. controls, $p\leq0.025$.
[3] Fisher's Exact test; women planning pregnancy vs. controls, $p>0.05$.

Figure 4.6.1.1: Servings of fruit per day

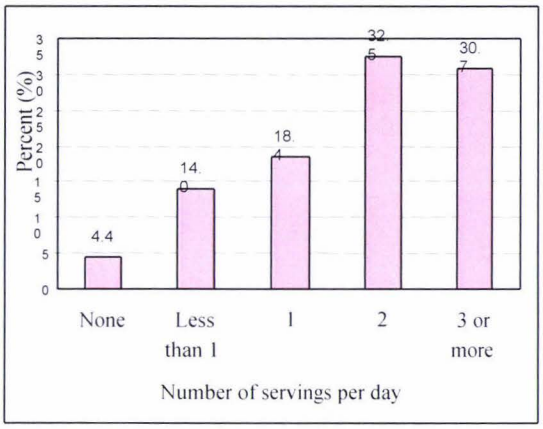


Figure 4.6.1.2: Servings of vegetables per day

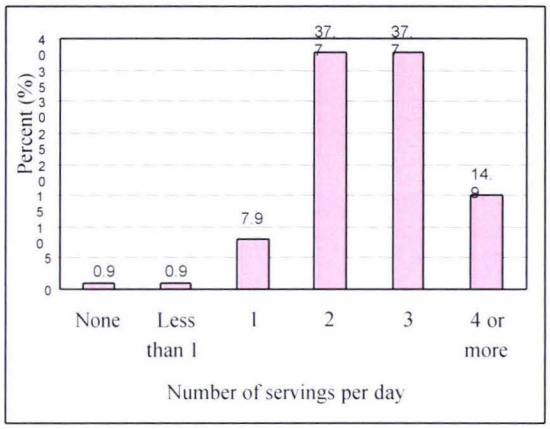


Figure 4.6.1.3: Servings of cereals* per week

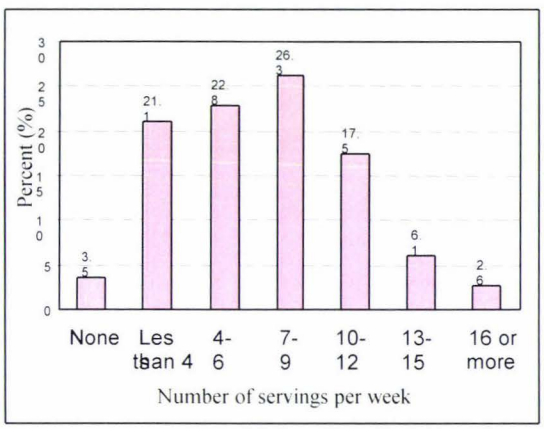
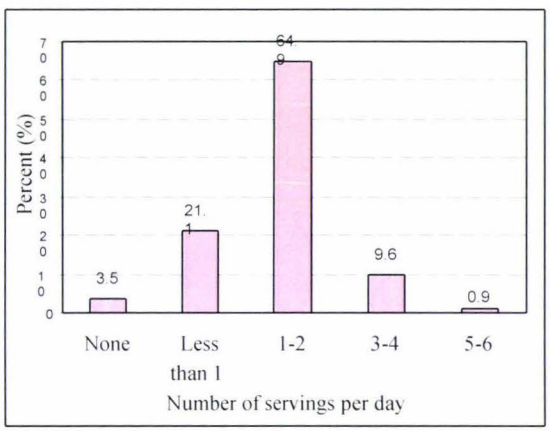


Figure 4.6.1.4: Servings of bread per day



* Cereals include rice, pasta and breakfast cereals.

Figure 4.6.1.5: Servings of dairy products per day

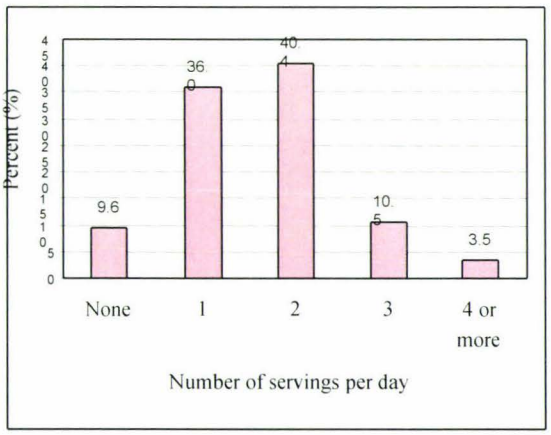
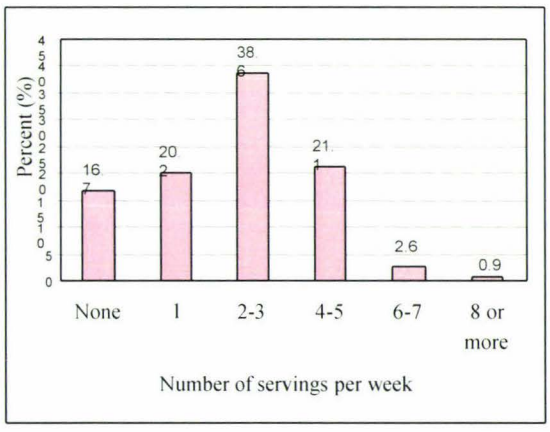


Figure 4.6.1.6: Servings of red meat per week



4.6.2 Nutrient Intakes

4.6.2.1 Macronutrient Intakes

Macronutrient intakes are summarised in Table 4.6.2.1. The mean energy intake was 8086 kJ. The mean proportions of energy from protein, fat carbohydrate and total sugars were 19.5%, 28.9%, 49.1% and 24.9% respectively.

Table 4.6.2.1: Macronutrient intake

Macronutrient	Mean[1,2]	SD	Minimum	Maximum	LQ	UQ
Energy (kJ)	8086	2297	4123	14911	6301	9417
Protein (g)	92.3	31.6	31.8	207.6	69.9	109.8
Fat (g)	65.0	31.0	15.8	201.6	42.7	81.3
Carbohydrate (g)	234	74	60	417	177	292
Total sugars (g)	119	50.3	17.8	244	85.6	154
Dietary fibre (g)	24.8	9.6	5.7	55.1	17.9	30.3
Energy from protein (%)	19.5	5.2	8.4	38.0	15.9	22.4
Energy from fat (%)	28.9	9.0	11.0	57.2	22.7	33.6
Energy from CHO (%)	49.1	10.1	21.4	73.2	43.4	55.5
Energy from sugars (%)	24.9	8.7	6.2	48.7	19.0	30.2
Energy from alcohol (%)	2.5	4.7	0.0	26.7	0.0	3.0

Note: SD: standard deviation; LQ: lower quartile; UQ: upper quartile.
[1] Independent T test; women planning pregnancy vs. controls, $p>0.05$.
[2] Independent T test; supplement users vs. non-supplement users, $p>0.05$.

The US (Institute of Medicine, 2002) and New Zealand (MOH, 1995) dietary guidelines were used for comparative purposes to estimate the proportion of women meeting the dietary guidelines, as the New Zealand RNI were under review at the time of writing this thesis (Table 4.6.2.2). Nearly all of the women met the recommendations for protein (96.5%). Twenty-eight percent of women exceeded the New Zealand guideline for the maximum contribution of dietary fat to energy, while 16.5% did not reach the minimum requirement of 20% of energy from fat. Less than half of the women met the New Zealand guideline for carbohydrates to contribute at least 50% of energy. Using the New Zealand guidelines, 87.0% of women exceeded the recommended maximum ratio of energy from total sugars, while using the US recommendations 48.7% of women exceeded the guidelines. Less than halve of the women met the guidelines for dietary fibre 944.3%)

Using the Independent T test, the mean energy intake in women with a BMI above the normal BMI cut-off point of 24.9 kg/m^2 was not significantly different from women below the normal BMI cut-off point (7937 kJ vs. 8138 kJ, p=0.683). Energy intake in women above the obese BMI cut-off point (>29.9 kg/m^2) tended to be lower than non-obese women (7572 kJ vs. 8140 kJ, p=0.437), though this was not significant.

Table 4.6.2.2: Proportion of women meeting the dietary guidelines for macronutrient intake

Macronutrient	NZ Dietary Guidelines[1]	> Dietary Guidelines		US Dietary Guidelines[2]	> Dietary Guidelines	
		n (115)	%		n (115)	%
Energy (kJ)	7200-10,500	38	33.0[3]	8100[4]	56	48.7
Dietary fibre (g)	25-30	51	44.3	25	51	44.3
Protein (g)	45	111	96.5	46	111	96.5
Energy from protein (%)	11-15	111	96.5	10-35	113	98.3
Energy from fat (%)	20-33	32	27.8	20-35	25	21.7
Energy from CHO (%)	50-55	56	48.7	45-65	80	69.6
Energy from sugars (%)	≤15	100	87.0	≤25%	56	48.7

[1] Source: (MOH, 2003a).
[2] Source: (Institute of Medicine, 2002).
[3] % above the medium recommend energy intake (8850 kJ) for women aged 18-60 with height between 150-180 cm.
[4] Estimated average requirement for females aged 18-50 from 1991 UK Dietary Reference Values (MOH, 2003a).

Table 4.6.2.3: Comparison of mean macronutrient intake to the 1997 NNS

Macronutrient	Present Study	1997 NNS[1]	
		19-24 years	24-44 years
	Mean	Mean	Mean
Energy (kJ)	8086	9102	8417
Protein (g)	92.3	78	77
Fat (g)	65	84	80
Carbohydrate (g)	234	255	229
Total sugars (g)	119	131	106
Dietary fibre (g)	24.8	17	18
Alcohol (g)	7.6	13	11
Energy from protein (%)	19.5	15	16
Energy from fat (%)	28.9	34	35
Energy from CHO (%)	49.1	38	46
Energy from alcohol (%)	2.5	4	3

[1] 1997 NNS results obtained using a 24-hour recall (Russell et al. 1999).

Macronutrient intakes did not differ between women planning a pregnancy and controls or between supplement users and non-supplement users using the Independent T test.

There was also no difference in the proportion of women meeting the dietary guidelines between these groups using the χ^2 or Fisher's Exact tests. Table 4.6.2.3 compares macronutrient intakes to the results from the 1997 NNS; mean values are used for comparative purposes.

4.6.2.2 Micronutrient Intakes

Table 4.6.2.4 summarises the micronutrient intakes from dietary sources, not including supplements. The median dietary intakes of vitamins were 362 μg, 3.4 μg and 2.0 mg for folate, vitamin B_{12} and vitamin B_6 respectively. The median dietary intakes of minerals were 13.8 mg, 11.3 mg and 938 mg for iron, zinc and calcium respectively. Using the Mann-Whitney U test, dietary micronutrient intakes did not differ between women attempting to conceive and control women or between supplement users and non-supplement users.

Table 4.6.2.4: Dietary micronutrient intake

Micronutrient	Median[1,2]	SD	Minimum	Maximum	LQ	UQ
Folate (μg)	362	218	107	1181	258	506
Vitamin B_{12} (μg)	3.4	2.4	0.1	11.1	2.38	5.4
Vitamin B_6 (mg)	2.0	1.4	0.4	10.	1.4	2.8
Iron (mg)	13.8	6.4	3.9	35.2	10.3	17.3
Zinc (mg)	11.3	4.7	4.1	25.5	8.3	14.5
Calcium (mg)	938	405	100.5	2120	721	1154

Note: SD: standard deviation; LQ: lower quartile; UQ: upper quartile.
[1] Mann-Whitney U test; women planning pregnancy vs. controls, $p>0.05$.
[2] Mann-Whitney U test; supplement users vs. non-supplement users, $p>0.05$.

The 1997 NNS reported micronutrient intakes from all food sources and did not include contributions from supplements (Russell et al., 1999). Table 4.6.2.5 compares dietary intakes in the present study to the results from the 1997 NNS; median values from the 1997 NNS were used for comparative purposes. Dietary micronutrient intakes were higher in the present study compared to the 1997 NNS, except for vitamin B_{12}. Dietary folate was considerably higher in the present study than in the 1997 NNS, largely due to the consumption of fortified breakfast cereals and wholegrain breads. Calcium fortified milk was also commonly used in the present study.

Table 4.6.2.6 summarises the total micronutrient intakes combined from dietary sources and intake from supplements. The median total intake of folate, vitamin B_{12} and vitamin B_6 was 442 μg, 4.9 μg and 2.7 mg respectively, and 15.4 mg, 12.9 mg and 987 mg for iron, zinc and calcium respectively. Women attempting to conceive had significantly higher intakes of total folate (940 vs. 406 μg, p=0.000), total vitamin B_{12} (9.2 vs. 4.6 μg, p=0.021) and total calcium (1112 vs. 955 mg, p=0.039), and tended to have higher total zinc intake (16.3 vs. 12.4 mg, p=0.095) than control women. These differences were due to increased supplement use in women attempting to conceive (see Table 4.6.2.9).

Table 4.6.2.5: Comparison of median dietary micronutrient intake to the 1997 NNS

Micronutrient	Present Study	1997 NNS[1]	
		19-24 years	24-44 years
	Median	Median	Median
Folate (μg)	362	195	213
Vitamin B_{12} (μg)	3.4	4.3	3.5
Vitamin B_6 (mg)	2.0	1.3	1.3
Iron (mg)	13.8	10.4	10.1
Zinc (mg)	11.3	10.3	10.1
Calcium (mg)	938	713	714

[1]1997 NNS results obtained using a 24-hour recall (Russell et al., 1999).

Table 4.6.2.6: Total micronutrient intake combined from diet and supplements

Micronutrient	Median	SD	Minimum	Maximum	LQ	UQ
Folate (μg)	442[1]	329	107	1821	285	662
Vitamin B_{12} (μg)	4.9[1]	21.8	0.2	150.1	3.0	9.8
Vitamin B_6 (mg)	2.7	20.6	0.4	105.6	1.7	5.8
Iron (mg)	15.4	18.3	3.9	153.0	11.5	21.5
Zinc (mg)	12.9[2]	7.9	4.1	50.3	9.0	18.0
Calcium (mg)	987[1]	431	100	2148	724	1202

Note: SD: standard deviation; LQ: lower quartile; UQ: upper quartile.
[1] Mann-Whitney U test; women planning pregnancy vs. controls, p≤0.039.
[2] Mann-Whitney U test; women planning pregnancy vs. controls, p=0.095.

The current New Zealand recommendations for nutrient intakes are taken from the Australian RDIs. RDIs are based on the levels required to prevent nutrient deficiency, whereas the Recommended Nutrient Intakes (RNIs) used in the Dietary Reference Values (DRVs) consider the levels required to prevent or reduce the risk of disease. The US DRVs provide the most up to date RNIs at the time of writing this thesis; therefore they were used along with the New Zealand RDI to estimate the risk of inadequate intakes.

The arbitrary cut-off level of two-thirds of the recommended intake was used to define the proportion of women at risk of inadequate intakes (Gibson, 1990). Table 4.6.2.7 shows the proportion of study participants at risk of inadequate micronutrient intakes.

DRVs also include a tolerable upper limit (UL), the maximum level of daily intake that is likely to pose no risk of adverse affects. The proportion of women at risk of potentially toxic intakes is shown in Table 4.6.2.7. Fourteen women (12.2%) consumed more than the UL for folate, women with intakes above 1000 μg were significantly more likely to be supplements users (38.7% vs. 2.4%, p=0.040). All of the women with total intakes above the UL for vitamin B_6, iron and zinc were supplement users, though the small numbers meant that significance was not reached. Eight women attempting to conceive (44.4%) had intakes above the UL for folate, one woman was above the UL for vitamin B_6 and one woman was above the UL for iron.

Table 4.6.2.7: Proportion of women at risk of inadequate total micronutrient intake

Micronutrient	RDI[1]	< 2/3 RDI		US RNI[#]	< 2/3 RNI		Tolerable Upper Limit[2]	> UL	
		n	%		n	%		n	%
Folate (μg)	200	4	3.5	400	23	20.0	1000	14	12.2
Vitamin B_{12} (μg)	2.0	6	5.2	2.4	8	7.0	-	-	-
Vitamin B_6 (mg)	0.9-1.4	3	2.6	1.3	7	6.1	100	2	1.7
Iron (mg)	12-16	12	10.4	18	34	29.6	45	4	3.5
Zinc (mg)	12	22	19.1	8	3	2.6	40	1	0.9
Calcium (mg)	800	13	11.3	1000	25	21.7	2500	0	0.0

[1] Source: (MOH, 2003a).
[2] Source: (Institute of Medicine, 1997; Institute of Medicine, 1998; Institute of Medicine, 2000).

Using the Mann-Whitney U test the median dietary folate intake did not differ according to whether women had specific folic acid knowledge (391 μg vs. 353 μg, p=0.402). There was, however, a tendency for the median total folate intake to be higher among women with specific folic acid knowledge compared those without specific knowledge (493 μg vs. 407 μg, p=0.073 using the Mann-Whitney U test).

4.6.2.3 Micronutrient Intakes from Supplements

Table 4.6.2.8 summarises the proportion of participants taking a supplement containing folic acid, vitamin B_{12}, vitamin B_6, iron, zinc or calcium. Twenty-seven percent of women were taking a supplement containing folic acid, the median dose was 300 μg and the dose

ranged from 42-1200 μg. Women attempting to conceive were significantly more likely to be taking a supplemental form of all the micronutrients (Table 4.6.2.9). The total micronutrient intakes in supplement users and non-supplement users are shown in Table 4.6.2.10, supplement users had significantly higher total intakes of folate, vitamin B_{12}, vitamin B_6, iron and zinc (p=0.000). Total calcium intake did not differ significantly between supplement users and non-supplement users (p=0.067).

Table 4.6.2.8: Proportion of women taking supplemental forms of micronutrients and dose taken

Micronutrient	% Taking Supplement Containing Specified Micronutrient		Dose	
	n (115)	%	Median	Range
Folic acid (μg)	31	27.0	300	42-1200
Vitamin B_{12} (μg)	30	26.1	25.0	0.2-11.1
Vitamin B_6 (mg)	35	30.4	30.0	0.4-100
Iron (mg)	24	20.9	10.0	1.9-135
Zinc (mg)	27	23.5	10.0	4.1-25.5
Calcium (mg)	26	22.6	79	8.4-1500

Table 4.6.2.9: Differences in supplement use among women planning pregnancy and controls

Taking Supplement Containing	Women Planning Pregnancy		Controls		
	n (18)	%	n (97)	%	p-value[1]
Folic acid	18	100.0	15	15.5	0.000
Vitamin B_{12}	10	55.6	20	20.6	0.002
Vitamin B_6	10	55.6	25	25.8	0.012
Iron	7	38.9	17	17.5	0.041
Zinc	10	55.6	17	17.5	0.000
Calcium	11	61.1	15	15.5	0.000

[1] χ^2 test.

Table 4.6.2.10: Median total micronutrient intake in supplement users and non- users

Micronutrient	Non-Supplement Users	Supplement Users[1]	
	Median	Median	p-value[2]
Folic acid (μg)	365	756	0.000
Vitamin B_{12} (μg)	3.6	29.7	0.000
Vitamin B_6 (mg)	2.0	31.2	0.000
Iron (mg)	13.7	23.1	0.000
Zinc (mg)	10.9	19.2	0.000
Calcium (mg)	953	1008	0.067

[1] Taking a supplement containing the specified micronutrient
[2] Mann-Whitney U test.

4.6.2.4 Relationship between food servings and dietary intakes

Differences in micronutrient intakes between women meeting the guidelines for servings of foods compared to those not meeting the guidelines were investigated. The only significant differences were for dietary folate and dietary iron (Table 4.6.2.11). Dietary folate was significantly higher in women meeting the guidelines for servings of fruit, vegetables and dairy products; however the difference for servings of grains was not significant due to the small numbers in this group. Dietary iron was significantly higher among women who met the guidelines for fruit, vegetables, grains and dairy products.

Table 4.6.2.11: Relationship between recommended servings and dietary intakes of folate and iron

Number of servings	Dietary Folate		Dietary Iron	
	Median (μg)	p-value[1]	Median (mg)	p-value[1]
Fruit per day ≥ 2				
Yes	398		15.0	
No	311	0.003	11.7	0.007
Vegetables per day ≥ 3				
Yes	405		14.8	
No	313	0.002	11.6	0.003
Cereals/ Grains per day ≥ 6				
Yes	645		21.1	
No	357	0.068	13.6	0.022
Dairy products per day ≥ 2				
Yes	398		15.1	
No	329	0.021	12.2	0.004

[1] Mann-Whitney U test.

4.6.3 Personal Views

The personal views of the women regarding their own dietary habits and body weight are summarised in Table 4.6.3.1. Seventy-nine percent of women considered their dietary habits to be healthy. In order to improve their diet 21.7% of women thought they needed eat more whole grains, 15.7% thought they should eat more dairy products, 10.4% thought they should eat less takeaways or junk food and 12.2% thought they should eat less sugar or sweet products. Only 3.5% thought they needed to increase their vegetable or fruit intake.

Nearly half of the women wanted to lose weight (47.8%). Over three-quarters of the women reported that they try to control their body weight. The combination of exercise and healthy eating was the most popular method reported to control weight (44.9%),

followed by exercise (32.6%). The use of a weight loss diet was reported by 15.7% of women who try to control their weight; the overall prevalence of dieting in the study population was 12.2% (n=14).

Reasons given for using vitamin/and or mineral supplements included that women believed they did not get enough vitamins and/or minerals in their diet (19.1%), use supplements when feeling run down or tired (20.9%), to boost energy (15.7%) and to prevent or treat illness (15.7%).

Table 4.6.3.1: Personal views regarding dietary habits and body weight

Personal View[1]	Women Planning Pregnancy		Controls		Total Group	
	n (18)	%	n (97)	%	n (115)	%
Consider eating habits to be healthy	14	77.8	77	79.4	91	79.1
Satisfied with body weight	9	50.0	48	49.5	57	49.6
Want to lose weight	9	50.0	46	47.4	55	47.8
Try to control body weight	15	83.3	74	76.3	89	77.4
Method used to control body weight						
Healthy eating and exercise	6	40.0	34	45.9	40	44.9
Healthy eating	2	13.3	3	4.1	5	5.6
Exercise	5	33.3	24	32.4	29	32.6
Dieting and exercise	2	13.3	6	8.1	8	9.0
Dieting	0	0.0	5	6.8	5	5.6
Strict dieting	0	0.0	1	1.4	1	1.1
Other	0	0.0	1	1.4	1	1.1

[1] χ^2 test: women planning pregnancy vs. controls, $p>0.05$.

4.7 Lifestyle Characteristics

The lifestyle characteristics of the participants are summarised in Table 4.7.1, 40.8% of women were physically inactive (<2.5 hours/week) compared to 34-38% of New Zealand women aged 18-49 years (van Aalst et al., 2002). The average number of hours spent on physical activity in the present study was less than half of the national average of 8.4 hours per week (Table 4.7.2) (van Aalst et al., 2002).

Only 7.8% of women smoked, nearly a third of the national rates for females in similar age groups (MOH, 2002; MOH, 2004). Twelve percent of women reported current recreational drug use, 7.8% reported marijuana use and 5.2% used ecstasy. The results are within the range of the national figures on marijuana use, while the use of ecstasy is higher than the 2.3% of females aged 18-45 years that reported ecstasy use in the past year in the 2001 National Drug Survey (Wilkins et al., 2002).

Table 4.7.1: Lifestyle characteristics

Characteristic	Women Planning Pregnancy		Controls		Total Group	
	n (18)	%	n (97)	%	n (115)	%
Physical activity (hours per week)[1]						
0	2	11.1	13	13.4	15	13.0
<2.5	4	22.2	28	28.9	32	27.8
2.5-4.9	8	44.4	27	27.8	35	30.4
≥5.0	4	22.2	29	29.9	33	28.7
Hours of activity/week (median)[2] (range)	2.8 (0-11.3)		3.0 (0-15.8)		2.9 (0-15.8)	
Smoker[3]						
Yes	1	5.6	8	8.2	9	7.8
No	17	94.4	89	91.8	106	92.2
Recreational drug use[3]						
Yes	0	0.0	14	14.4	14	12.2
No	18	100	83	85.6	101	87.8

[1] χ^2 test; women planning pregnancy vs. controls, $p>0.05$.
[2] Mann-Whitney U test; women planning pregnancy vs. controls, $p>0.05$.
[3] Fisher's Exact test; women planning pregnancy vs. controls, $p>0.05$.

Table 4.7.2: Comparison of physical activity levels to adult New Zealand women

Hours of Physical Activity per Week	Present Study (%)	NZ Females Over 18 years (%)[1]
0	13.0	10
<2.5	27.8	23
2.5-4.9	30.4	17
≥5.0	28.7	49
Mean	3.8	8.4

[1] Source: (van Aalst et al., 2002).

Physical activity levels and smoking prevalence did not differ significantly with pregnancy planning status. None of the women planning pregnancy reported recreational drug use compared to 14.4% of women not attempting to conceive, however the small numbers meant this was not significant.

Caffeine and alcohol consumption is shown in Table 4.7.3. The median caffeine intake was 102.8 mg/day and ranged from 0.0-660.5 mg/day. Fifteen percent of women reported that they did not consume caffeinated beverages; few women consumed over 300 mg/day (equivalent to approximately three cups of coffee) (13.0%). While the median caffeine intake did not differ between women planning pregnancy and control women using the Mann-Whitney U test; there was a tendency for women planning pregnancy to avoid using caffeinated beverages (27.8% vs. 12.4%, p=0.140) and to consume less than 301 mg of caffeine per day compared to control women (94.4% vs. 85.5%, p>0.05), although this did not reach significance. None of the women planning pregnancy consumed more than 500 mg of caffeine per day.

Table 4.7.3: Caffeine and alcohol consumption

Characteristic	Women Planning Pregnancy		Controls		Total Group	
	n (18)	%	n (97)	%	n (115)	%
Caffeine intake (mg/day)[1]						
0	5	27.8	12	12.4	17	14.8
< 150	5	27.8	37	38.1	42	36.5
151-300	7	38.9	34	35.1	41	35.7
301-500	1	5.6	9	9.3	10	8.7
≥ 501	0	0.0	5	5.2	5	4.3
Median Caffeine intake (mg/day)(range)[2]	102.8 (0-407.0)		143.4 (0-660.5)		138.8 (0-660.5)	
Alcohol use[1]	13	72.2	82	84.5	95	82.6
Alcohol consumption[1]						
Never	5	27.8	16	16.5	21	18.3
Less than once per month	0	0.0	6	6.2	6	5.2
1-3 times per month	3	16.7	22	22.7	25	21.7
1-2 times per week	5	22.2	13	27.8	18	27.0
3-6 times per week	5	27.8	18	18.6	23	20.0
Everyday	1	5.6	8	8.2	9	7.8
Average number of standard drinks/ week[1]						
< 1	7	38.9	30	30.9	37	32.2
1-5	6	33.3	32	33.0	38	33.0
6-10	5	27.8	22	22.7	27	23.5
>10	0	0.0	13	13.4	13	11.3

[1] χ^2 test or Fisher's exact test; women planning pregnancy vs. controls, p>0.05
[2] Mann-Whitney U test; women planning pregnancy vs. controls, p>0.05

Eighty-three percent of women reported drinking alcohol, over half (54.8%) reported consuming alcohol at least once per week and 7.8% reported using alcohol everyday. Most women (62.5%) reported drinking on average five or less standard drinks per week, 23.5% reported consuming 6-10 drinks per week and 11.3% reported more than 10 drinks per week.

The frequency of alcohol consumption in women attempting to conceive did not differ significantly from the control women. However, none of the women planning pregnancy consumed more than 10 drinks per week compared to 13.4% of the control women, though was not significant.

5. DISCUSSION

5.1 Participant Characteristics

This study was designed to assess the knowledge and attitudes of women regarding preconception nutrition and the current dietary and lifestyle practices in Auckland women of childbearing age. Additionally, this study intended to identify any differences in knowledge and practices among women planning a pregnancy and women not attempting to conceive.

Eight-two percent of the participants were European, 7.0% were Maori, 1.7% were Pacific, and 9.5% were Asian compared to 61.9%, 11.4%, 12.9% and 15.6% respectively in the general Auckland population of women aged between 20-44 years (Statistics New Zealand, 2003). Half of the participants were aged under 30 years, whereas 37.0% of Auckland women aged 20-44 years are reported to be under 30 years (Statistics New Zealand, 2003). The distribution of the study population across NZSEI class was 18.3%, 59.1% and 22.6% for classes 1-2, 3-4 and 5-6 respectively, this is compared to the national distribution of 12.9%, 48.0% and 38.9% respectively (Galbraith et al., 2003). Nearly three times as many in women in the present study had a university qualification compared to that reported for women of childbearing age in the general Auckland population (52.2% vs. 17.5%) (Statistics New Zealand, 2003). Although the study population was highly educated and predominately European compared to the general population, they are representative of women who plan pregnancy (Hellerstedt et al., 1998; MOH, 2001).

The present study had tried to recruit a representative sample of women, however the method used in the pilot study to generate a random sample of women proved not to be feasible for the scope of this study. Instead this study had to rely on active recruitment through advertisements for participants for a study on women's nutrition and health. It cannot be ruled out that highly educated women are more concerned about their nutritional habits and were therefore more willing to participate. The fact that the majority of the participants wanted to be provided with an evaluation of their diet indicated that the women were highly motivated to participate and interested about their own nutrition. Therefore, selection bias limits the degree to which the present findings can be applied to

the general population. The present study may overestimate healthy habits and underestimate undesirable habits in women of childbearing age or overestimate nutrition knowledge. An attempt was made to include a sample that was as representative as possible of Auckland women by placing advertisements throughout the Auckland area. However, the present group of women are representative of women who plan pregnancy, who are more likely to be highly educated and European (Craig et al., 2004; Hellerstedt et al., 1998). Even though the current group of women are not representative of the general population, they do represent women who are likely to plan pregnancy (Craig et al., 2004; Hellerstedt et al., 1998). It is valid to study highly educated and European women to see if the preconception knowledge and practices among women who are more likely to plan pregnancy is optimum. Additionally, this is also a group of women that is likely to welcome advice and change to their habits.

Obesity and being overweight are both risk factors for a variety of adverse pregnancy outcomes (Galtier-Dereure et al., 2000; Neggers & Goldenberg, 2003) and reduced fertility (Grodstein et al., 1994b; Wang et al., 2000). The majority of participants were in the normal BMI range for New Zealand women (18.5-24.9 kg/m^2 for European and 19.5-25.9 kg/m^2 for Maori/Pacific women). Seventeen percent of women were classified as being overweight (BMI 25.0-29.9 kg/m^2 for European women and BMI 26.0-31.9 kg/m^2 for Maori/Pacific women) and 10% as obese (BMI $\geq$30kg/m^2 for European women and BMI $\geq$32kg/m^2 for Maori/Pacific women). Compared to the results from the 1997 NNS, where 18-26% of women of childbearing age were overweight and 17% were obese, fewer women in the present study were overweight or obese (Russell et al., 1999). The mean BMI of 24.1 kg/m^2 in the present study was lower compared to 25.0-25.7 kg/m^2 in the 1997 NNS (Russell et al., 1999). The lower prevalence of overweight and obesity in the present study are to be expected given the low energy intakes in the current group of women. The lower BMI values in the present study are likely to reflect that the study population was predominately European, as Maori and Pacific women have a higher BMI than European women and are more likely to be overweight and obese (Russell et al., 1999).

Waist circumference is gaining support as a more accurate indicator of central obesity than WHR, as it is influenced to lesser extent by age and overall adiposity (Han & Lean, 2001; Heyward & Wagner, 2004). Waist circumference provides a suitable measure of

central obesity for this target group, as it is simple to use and less time consuming than WHR for identifying those women who may be at risk of adverse pregnancy outcomes if they conceived. In the present study 14.8% of women had a waist circumference indicating central obesity. Whereas 10.8-24.8% of women were defined as being centrally obese using WHR in the 1997 NNS (Russell et al., 1999).

The women were asked whether they had ever been pregnant and nearly half of the women had had a previous pregnancy, although not necessarily resulting in a live birth. The unplanned pregnancy rate was 53%, which is consistent with previous findings in New Zealand (Paterson et al., 2004; Schader & Corwin, 1999). The rate of unplanned pregnancies may differ across ethnic groups. In a study of Pacific women 60% of pregnancies were unplanned (Paterson et al., 2004) compared to 56% among European women (Schader & Corwin, 1999).

Within the study group only a small number of women were attempting to conceive (n=18). Women planning a pregnancy were significantly less likely to have a high SES status and tended to be in the medium SES class, though the small numbers limited the significance of this finding. The women planning pregnancy were more likely to already have a child than women not trying conceive. It is of interest whether women understand the need to plan pregnancy if they already have a child or if practical reasons arising from having children explain the difference in parity between women planning pregnancy and those not trying to conceive.

Women who were attempting to conceive tended to be older than the control women, though the only significant difference was for these women to be more likely to be aged over 30 years. Age was assessed by a series of five categories as it was felt that women would be more comfortable choosing an age range rather than specifying their exact age. However, the study population was not large enough to allow sufficient numbers in each age category to be able to determine significant associations between knowledge/practices and age. This was especially apparent among the small number of women planning pregnancy. Age should have been measured as continuous variable. It would have been interesting to determine whether age was a significant variable affecting women planning pregnancy as more women are leaving starting a family until later in life (MOH, 2001).

5.2 Preconception Nutrition Knowledge and Practices in the Preconception Period

5.2.1 Folic Acid and General Knowledge

Despite the existence of overwhelming scientific evidence on the effectiveness of folic acid in the preconception period in the prevention of NTDs, only 31% of the women in the study were aware that folic acid prior to conception prevents NTDs. While a higher proportion of women were aware that folic acid is needed during pregnancy (65%) or that folic acid prevents birth defects (54%), these results show the overwhelming majority of women lack the knowledge in order to optimise pregnancy outcome.

Fewer women in the present study had specific folic acid knowledge compared to 56% of Christchurch women receiving antenatal care (Schader & Corwin, 1999), however the knowledge of women who are already pregnant is likely to overestimate the knowledge of women of childbearing age due to information received during antenatal care. A random survey conducted in 1998 found that 46.6% of New Zealand women aged 15-44 years were aware of the relationship between folic acid and NTDs, though this study did not assess the knowledge of the critical time to take folic acid (Bourn & Newton, 2000).

A larger proportion of women in this study were aware of the critical time to take folic acid to prevent NTDs compared with findings among women of childbearing age in other countries (12-17.%) (Carter et al., 2004; Daltveit et al., 2004; Watson et al., 2001). However, the selection bias in the present study is likely to overestimate knowledge compared to the general population. The finding that a higher proportion of women have non-specific folic acid knowledge is consistent with other studies that have found that 51-65% of pregnant women or postpartum women were aware that folic acid prevents birth defects but only 14-25% knew that folic acid specifically prevents NTDs (Coll et al., 2004; Kloeblen, 1999).

The study population was highly educated compared to the general population and numerous studies have shown that education is positively associated with folic acid knowledge (Chacko et al., 2003; Daltveit et al., 2004; De Jong-Van den Berg et al., 2005; Feldkamp et al., 2002; Unusan, 2004). While education was not associated with specific

knowledge in the present study few women had a low level of education, which limited the ability to observe any difference in knowledge across education level.

Specific folic acid knowledge was strongly associated with pregnancy planning, information from books and being aware of the MOH nutrition guidelines for pregnancy. Women who were attempting to conceive were more likely to have specific folic acid knowledge than women who had previously planned a pregnancy, though current knowledge in women with a previous planned pregnancy does not necessarily reflect knowledge in the preconception period in the distant past. Folic acid awareness was also higher among women aged over 30 years and tended to be higher in women who had children, though parity did not quite reach significance ($p=0.059$). In contrast with an earlier study information from a medical professional was not associated with folic acid knowledge (French et al., 2003), though the present study collected information on sources of nutrition information rather than specific sources of folic acid information. The lack of specific data on the sources of folic acid and preconception nutrition information is a limitation in the questionnaire design, as it is this information that is important if planning an education based health promotion.

The findings that pregnancy planning (De Jong-Van den Berg et al., 2005), parity (Chacko et al., 2003; French et al., 2003) and age (Daltveit et al., 2004; De Jong-Van den Berg et al., 2005; Feldkamp et al., 2002; Unusan, 2004) were associated with higher folic acid awareness are consistent with previous studies. Contrary with other studies (De Jong-Van den Berg et al., 2005; Feldkamp et al., 2002) folic acid knowledge tended to be higher among women with a lower SES status. However, this finding may reflect that the method used to classify SES for homemakers/mothers did not take into account their partners occupation, which is suggested to be a better indicator of SES for homemakers/mothers (Galbraith et al., 2003). Using the imputed mean based on age and education many homemakers/mothers were categorised as having a low SES status, which is likely to have underestimated SES status for some women. If information on the partners occupation was available it could have been used to derive a NZSEI score for homemakers, which may be more likely to reflect their actual SES status than the imputed mean (Galbraith et al., 2003).

Consistent with other studies there appears to be a disparity between the awareness of the benefits of folic acid and folic acid use (De Jong-Van den Berg et al., 2005; Schader &

Corwin, 1999). In the present study 31% of women were aware of the effectiveness of preconceptional folic acid supplementation in preventing NTDs, however only 11% of women reported taking a folic acid supplement and all of these women were planning a pregnancy. A higher proportion of women were taking a form of supplemental folic acid but still only 27% of women of childbearing age were receiving folic acid from a supplement. However, since dietary supplements can currently only contain up to 300 μg of folic acid only the 11% of women using a specific folic supplement were receiving a dose above the recommended 400 μg (MOH, 2003b). None of the women who were not trying to conceive were taking a folic acid supplement in the present study and only 16% were taking a supplemental form of folic acid from a multi-vitamin and/or mineral supplement. This is consistent with the finding that only 2% of Christchurch women whose pregnancy was unplanned reported using folic acid in the preconception period (Schader & Corwin, 1999). Given that 53% of pregnancies were unplanned in the present study, a finding consistent with reported rates of unplanned pregnancies in New Zealand (Paterson et al., 2004; Schader & Corwin, 1999), the low rate of folic use among women of childbearing age is a significant obstacle to the prevention of NTDs in unplanned pregnancies.

The prevalence of folic acid use in the present study was higher than the results from the 1997 NNS, where no females aged 15-24 and only 2% of females aged 25-44 reported taking a folic acid supplement (MOH, 2003b). Folic acid use in the 1997 NNS was higher among European women compared to Maori and Pacific women (MOH, 2003b). Though folic acid use was higher than in the 1997 NNS, the present study indicates that folic acid use remains low even among highly educated European women. Given that folic acid use is higher among European and highly educated women (Ray et al., 2004), the prevalence of folic acid use in the present study is likely to have been overestimated compared to women of childbearing age in the general population.

Seventy-five percent of women who plan pregnancy reported folic acid use in the preconception period. All of the women who were attempting to conceive were taking folic acid compared to 55% of the women who had had a planned pregnancy within the last 10 years. The apparent increase in folic acid use may reflect the higher folic acid awareness among women attempting to conceive, though current knowledge in women who had previously planned pregnancy does not necessarily reflect their knowledge in the

distant past. Considerable recall times were involved among the women who had previously planned a pregnancy, therefore folic acid use in these women is subject to recall bias. Whereas women attempting to conceive reported current practices. Folic acid use in the present study was higher than that reported by Christchurch women receiving antenatal care in 1998, in the Christchurch study only 35% of women who had planned their pregnancy took folic acid before conception (Schader & Corwin, 1999).

Information on the dose of folic acid was only available for women currently trying to conceive as it was considered that women who had previously planned a pregnancy would be unlikely to remember the exact brand of supplement taken. All of the women attempting to conceive had been taking folic acid for more than one month, however, nearly one-third were taking a dose below the recommended 400 μg of folic acid. Of these women all were taking a multi-vitamin and/or mineral containing 300 μg. However, due to the small sample size in the subgroup of women attempting to conceive caution should be exercised when interpreting the present data on folic acid use. Though these results do highlight the need for women to be fully informed about the benefits of folic acid, including the recommended dose of folic acid.

It cannot be ruled out that women attempting to conceive who had an interest in nutrition may have been more likely to take part in the study. Women who were attempting to conceive were significantly more likely to cite books as their main source of nutrition information, which would indicate that these women had an interest in nutrition. Information from books was associated with increased folic acid awareness, which has been shown to predict folic acid use (Amitai et al., 2004; Coll et al., 2004; De Jong-Van den Berg et al., 2005; Feldkamp et al., 2002). As a result of the possible selection bias folic acid use among women attempting to conceive may have been overestimated in this study.

A number of variables were associated with preconceptional folic acid use among women who plan pregnancy. The strongest associated was found for specific folic acid knowledge, nearly all of the women who were aware of the benefit of folic acid in the preconception period reported taking folic acid before conception compared to less than halve of the women without specific knowledge. Knowledge of the benefits of folic acid has consistently been shown to predict folic use in other studies (Amitai et al., 2004; Coll

et al., 2004; De Jong-Van den Berg et al., 2005; Feldkamp et al., 2002). Preconception advice and information from books were also strongly related to preconception folic acid use. There tended to be linear trend for increased use of preconception folic acid with a higher education, though this did not quite reach significance due to the small number of women with a low education ($p=0.054$). However, preconception folic acid use was significantly lower among women who had a low level of education compared to women with a medium or high level of education. The use of folic acid in the preconception period has been found to be strongly related to the highest level of education in overseas studies (Ray et al., 2004) and among Christchurch women (Schader & Corwin, 1999), and has been associated with preconception advice in other countries (Coll et al., 2004; De Jong-Van den Berg et al., 2005).

While current folic acid use was assessed in the whole study group, the prevalence of folic acid use in the preconception period was only assessed among women with planned pregnancies. Considering that most pregnancies are unplanned information on folic acid use prior to conception among women with unplanned pregnancies also needed to be collected. This would have allowed a comparison between the prevalence of folic acid use in the preconception period among women with planned and unplanned pregnancies. Only 16% of the women who were not planning pregnancy were taking a folic acid supplement, this is compared to 100% among the small group of women trying to conceive. The low rate of folic acid use among women not planning pregnancy is a significant obstacle to optimising pregnancy outcome should they conceive.

Women were asked how they would choose to increase their folate intake. Folic acid supplementation was identified as the preferred method of increasing folic acid intake. This implies that with better education regarding folic acid use women may understand the need for supplementation, potentially leading to more women taking folic acid during the childbearing years. Few women stated they would prefer to use fortified products as a means of increasing folic acid intake, though only around halve of the women were aware of folic acid fortification. Over a third of women would prefer to increase their natural dietary intake of folate, though without fortification it would be difficult to increase dietary folate intake to a level that would result in a significant reduction in the incidence of NTDs. Studies in other countries have also found that women prefer to take a folic acid

supplement and that fortification is not a popular option (French et al., 2003; Watson et al., 2001).

Importantly, the results show that women of childbearing age lack the knowledge to be able to increase their dietary folate intake. Less than halve of the women could identify any dietary source of folate; green vegetables were the most commonly recognised source of folate but was only identified by 37% of the women. Few women could identify bread or legumes as being folate-rich. Also, of concern was the poor knowledge of iron-rich foods. While the majority of women could identify red meat as a good source of iron surprisingly few women could identify chicken and fish as being iron-rich. This deficit in basic nutrition knowledge is despite the study group being highly educated and perhaps interested in nutrition due to the selection bias. There appears to be a lack of general nutrition knowledge among women of childbearing age (Daltveit et al., 2004; French et al., 2003; Kloeblen, 1999; Schader & Corwin, 1999), highlighting the fact that women do not have the basic skills to be able to make dietary changes to improve their nutritional status.

5.2.2 Preconception Nutrition Knowledge and Attitudes

At the time of writing this thesis there is currently insufficient research which has examined the attitudes of women towards alcohol, caffeine and dietary habits in the preconception period. The present findings show that women's awareness of the importance of diet in the preconception period appears to be low. Most women thought that dietary habits in the preconception period could affect pregnancy outcome, however only a small proportion of women were able to specify how diet may influence pregnancy. Very few women were aware that diet around the time of conception is associated with the risk of miscarriage, preterm delivery or a LBW infant. While around a third of the women thought that diet could impact on fertility.

Extremes in body composition, either being underweight or overweight are both associated with reduced fertility (Green et al., 1988; Grodstein et al., 1994b; Norman & Clark, 1998; Wang et al., 2000; Zaadstra et al., 1993). Less than two-thirds of the women were aware that being both underweight or overweight could affect fertility, while 20% of women were only aware that being underweight could affect fertility.

Given the adverse effects of alcohol consumption in early pregnancy (Maier & West, 2001), often before pregnancy recognition and that there is no safe level of intake, it is prudent to advise women to avoid alcohol if planning pregnancy. However, only around half of the participants thought that women needed to abstain from consuming alcohol if attempting to conceive, while 37% advocated limiting alcohol intake. Also, it is concerning that women who were attempting to conceive were less likely to promote abstinence and more likely to advocate limiting alcohol consumption in the preconception period. Caffeine intake around the time of conception has been linked to spontaneous abortion (Giannelli et al., 2003; Infante-Rivard et al., 1993; Wen et al., 2001), therefore, it is advisable for women to limit caffeine intake if attempting to conceive to 300 mg/day. In the present study under two-thirds of the women thought that caffeine consumption should be limited if planning a pregnancy.

Three-quarters of the women stated that they would make changes to their dietary habits if attempting to conceive. However, few women stated they would increase their consumption of fruit, vegetables and dairy products, and none stated they would increase their intake of cereals/grains. Even fewer women were aware of the need to be careful of foods that are associated with listeria poisoning if attempting to conceive, such as soft cheeses, deli meats and shellfish that are associated with an increased risk of miscarriage, stillbirth, premature delivery or serious illness in the infant (Torvaldsen et al., 1999).

5.2.3 Preconception Practices in Women Who Plan Pregnancy

Overall, pregnancy planning appears not to significantly affect nutritional intake, alcohol use, caffeine consumption or smoking habits. However, the small sample size in this subgroup means that caution should be exercised when interpreting the present data. Estimated dietary intakes did not differ between women attempting to conceive and women not planning pregnancy. Though women who were attempting to conceive were more likely to be using dietary supplements, leading to higher total intakes of folate, vitamin B_{12} and calcium among women planning pregnancy. However, the diet history method performs better at characterizing group intakes rather than at the individual level, since only 18 women were trying to conceive the validity is reduced in such a small sample (Black et al., 2000; Gibson, 1990). However, because this was an explorative

study that aimed to identify trends to be investigated further in a larger study any difference or lack of difference were reported.

It is important that women planning pregnancy avoid excessive or inappropriate supplementation while trying to conceive. High doses of vitamin A are teratogenic, while interactions between nutrients can interfere with the absorption of iron and zinc (McArdle & Ashworth, 1999). Two women who were attempting to conceive were taking a dose of folic acid above the tolerable upper limit for folate as a result of taking multiple supplements. This highlights the need for women to receive guidance from a medical professional regarding supplementation, especially when trying to conceive (Kaiser et al., 2002).

Among the women attempting to conceive 83% stated they had made changes to their dietary habits, though there were no apparent differences in dietary habits between women planning pregnancy and those not planning pregnancy. Two-thirds of the women stated they had reduced their alcohol intake; however 72% of women planning pregnancy were still consuming alcohol while trying to conceive. There was no significant difference in weekly alcohol consumption between women attempting to conceive and women not planning pregnancy, though none of the women planning pregnancy consumed more than 10 drinks per week. A New Zealand study on alcohol consumption during pregnancy found no difference in the proportion of women consuming any alcohol at 20-24 weeks gestation according to whether the pregnancy was planned or unplanned (McLeod et al., 2002). However, women with planned pregnancies have been found to be less likely to engage in binge drinking in the preconception period (Naimi et al., 2003).

Two-thirds of the women planning pregnancy had reduced their caffeine consumption since trying to conceive; only one woman had a caffeine intake above the recommended 300 mg/day for pregnancy. Women attempting to conceive tended to be more likely not to consume caffeinated beverages compared to women not planning pregnancy, though the small numbers limited the statistical power. In an earlier study among women receiving antenatal care it was found that in comparison to women with unintended pregnancies, women whose pregnancies were intended were less likely to consume at one or more alcoholic drinks per week and to report daily caffeine use, and more likely to take a daily supplement in the preconception period (Hellerstedt et al., 1998). However, the definition

of an intended pregnancy used in this study is not as clear as a planned pregnancy and the categories used for the variables were very general.

Studies have shown that women with planned pregnancies are less likely to smoke (Hellerstedt et al., 1998; McLeod et al., 2003; Naimi et al., 2003). In the present study the prevalence of smoking did not appear to differ according to pregnancy planning status, though overall very few women smoked in the present study. None of the women trying to conceive reported current use of any recreational drugs compared to 14% of women not planning pregnancy, though again this did not reach significance. Physical activity levels also did not differ according to whether or not women were planning pregnancy.

The finding that pregnancy planning appears to have little affect on dietary and lifestyle habits is consistent with a recent study on habits among women attempting to conceive and women not planning pregnancy (de Weerd et al., 2003a). However, a number of limitations in both the former study and the present study reduce the ability to extrapolate the findings to the general population.

This explorative study had hoped to generate a study population that included a subgroup of women who were planning pregnancy. However, relatively few participants were attempting to conceive which limited the ability to identify significant differences between women planning pregnancy and women not trying to conceive. The small number of women attempting to conceive means that caution should be exercised when interpreting this data. Additionally, women planning pregnancy may be more likely to be subject to reporting bias in an attempt to impress the interviewer (de Weerd et al., 2003a). However, the research was promoted as a study on women's health and nutrition rather than a study on preconception habits in an attempt to minimise reporting bias among women planning pregnancy. The women trying to conceive were representative of women who plan pregnancy (Hellerstedt et al., 1998), however the control women also tended to be highly educated and predominately European compared to the general population. Therefore, the finding that planning pregnancy does not affect nutritional intake, alcohol use, caffeine consumption or smoking habits may underestimate any differences between women planning and not planning pregnancy.

Most of the women in the present study were consuming alcohol while trying to conceive despite over half of them having received preconception advice from a medical

professional. Additionally, not all of the women who had received preconception advice from a medical professional were taking the correct dose of folic acid. These results indicate that not only is there a need to educate women about preconception nutrition but there is also a need for medical professionals to be updated on the benefits of preconception care. Given the high rates of unplanned pregnancies medical professionals need to be encouraged to discuss preconception care with all women of childbearing age, not just women planning pregnancy. Every consultation with a woman with the potential to become pregnant should be viewed as an opportunity to promote preconception care, especially the benefits of preconceptional folic acid.

The subgroup of women who plan pregnancy included women attempting to conceive and women who had planned a pregnancy within the last 10 years. Sixty percent of these women stated that they had made changes to their dietary habits while trying to conceive. However, again very few women stated they had increased their intake of fruit, vegetables or dairy products and none of the women said they had tried to eat more cereals/grains while trying to conceive, all of which are important sources micronutrients. Of particular concern was the finding that only 35% of women stated they had reduced their alcohol intake while trying to conceive. Also less than a third of the women limited their caffeine intake. Women attempting to conceive were significantly more likely to state that they had changed their dietary habits and to have reduced their caffeine consumption while trying to conceive than women who had previously planned a pregnancy. They were also more likely to have used a multi-vitamin and/ mineral supplement in the preconception period.

Overall, less than a third of the women who plan pregnancy had sought preconception counseling from a medical professional. More women who were trying to conceive had sought preconception advice from a medical professional than the women who had previously planned a pregnancy. This may reflect that increasing numbers of women are seeing their general practitioner for preconception advice or just a heightened interest among the women trying to conceive due to the selection bias.

The validity of the data on preconception practices in the group of women who had previously planned a pregnancy is limited, as the recall time for these women was up to 10 years. Additionally, women who had previously planned a pregnancy were required to recall distant practices whereas women planning pregnancy reported current habits;

therefore the two groups are subject to differential reporting bias. However, in order to increase the sample size of this subgroup women attempting to conceive and women who had previously planned a pregnancy were grouped together.

Reporting bias associated with the under-reporting of socially undesirable responses and over-reporting of socially desirable responses in order to impress the interviewer cannot be ruled out. Though the interviewer attempted to develop rapport with the participants and conducted the interview in a non-judgemental manner to try to make the participants comfortable in an attempt to minimise reporting bias. Also sensitive questions were contained in a confidential section that was completed anonymously by the participants to reduce under-reporting of undesirable responses.

Unfortunately the questionnaire was not tested for construct validity prior to being used in the study. However, where possible questions were taken from validated questionnaires that have been used in previous studies (Habak et al., 2003; Kloeblen, 1999), while other questions were generated from the current evidence on preconception nutrition with expert advice to maximise the content validity of the questionnaire (Parmeter & Wardle, 1999). The questionnaire was pre-tested to test the clarity of the questions and terminology, questionnaire effectiveness and questionnaire acceptability. However, this did not identify all of the questions that needed to be modified, this was partly due to that fact that only one of the seven women in the pre-test had been pregnant and she had planned her pregnancy.

5.3 Dietary Intakes and Lifestyle Characteristics of Women of Childbearing age

5.3.1 Dietary Habits

The majority of women in the study followed a regular diet that included animal products. The most common food restriction was the elimination of red meat by 9% of the women. A higher proportion of women in the present study avoided red meat compared to 2-3% of women aged 19-44 years in the 1997 NNS (Russell et al., 1999). However, in a Dunedin study that was predominately European 22% of women aged 18-40 years reported to avoid red meat (Gibson et al., 2001). Two percent of women in the present study were vegan, a result similar to the 1997 NNS. Women following vegetarian diets,

particularly vegan diets, may be at risk of inadequate intakes of iron and vitamin B_{12} and these women may require supplementation if planning pregnancy (Kaiser et al., 2002). However, the small number of vegetarian/vegan women did not allow the the risk of adequate intakes to be assessed in the present study.

The present study shows that many women of childbearing age do not met the National Nutrition Taskforce guidelines for servings of fruit, vegetables, dairy products and cereals/grains. Less than two-thirds of the women ate at least two servings of fruit per day, while just over half ate the recommended servings of vegetables or dairy products per day. Compared to the 1997 NNS more women in the present study met the guidelines for fruit, however fewer women met the recommendations for vegetables. Maori and pacific women are less likely to eat the recommended servings of vegetables and more likely to eat less than one serving of fruit per day than European women (Russell et al., 1999), meaning that fruit and vegetable consumption in this predominately European group of women may overestimate consumption compared to the general population.

Of most concern was the finding that only 5% of women of childbearing age were consuming the recommended serving of cereals/grains per day, as these foods are important sources of folate and other B vitamins. Similarly the consumption of cereals/grains was low in the 1997 NNS with 8-10% of women meeting the guidelines (Russell et al., 1999). Maori and Pacific women are more likely to eat six or more servings of cereals/grains per day than European women (Russell et al., 1999), therefore the proportion of women meeting the guidelines for cereals/grains is likely to be underestimated in this study compared to the general population. One in four women ate less than one serving of bread per day, this is three times as high as the results from the 1997 NNS (Russell et al., 1999).

Breakfast cereal manufacturers are the only industry group to have widely taken up voluntary folic acid fortification, therefore it is important that that these products are being consumed by the target population. In the present study nearly three-quarters of the women reported regular consumption of breakfast cereals, which is higher than in the 1997 NNS where 52-60% of females aged 19-44 regularly used breakfast cereals (Russell et al., 1999).

Considering the poor compliance with the national dietary guidelines women appeared to overrate the adequacy of their diets, as few women thought that they needed to increase their consumption of fruit and vegetables, dairy products or cereals/grains. Similarly, women in a study from the Netherlands did not met the dietary guidelines, though few women acknowledged they should eat more fruit and vegetables and eat less fat (de Weerd et al., 2003a).

Food restriction around the time of conception has been related to a higher risk of a NTD-affected pregnancy (Carmichael et al., 2003a), LBW, an SGA infant (Conti et al., 1998; Sollid et al., 2004) and preterm delivery (Sollid et al., 2004). In this group of Auckland women 12% reported dieting behaviour. This figure is lower than the prevalence of strict dieting reported by 22% of Dunedin women (Carter et al., 2004) and the restriction of food intake by 42% of young women in the US (Hendricks & Herbold, 1998). It appears that dieting behaviours are common among women of childbearing age and are not appropriate for women who are trying to conceive.

Though not apparent in this study, low-carbohydrate diets are popular among women of childbearing age (Carter et al., 2004). Given the low intake of cereals/grains and that a quarter of the women consumed less than one serving of bread per day, it possible that diets to limit carbohydrate intake were underreported in this study. Considering nearly half of the women wanted to lose weight it cannot be ruled out that women were reluctant to report being on a low-carbohydrate diet or other restrictive diets in an interview situation due to self-conscious or in attempt to impress the investigator. Therefore, the prevalence of dieting behaviours, especially restrictive diets may have been underestimated in this study. In hindsight it would have been more appropriate to include questions on dieting behaviours as multiple-choice questions in the self-administered confidential section to reduce reporting bias.

5.3.2 Nutrient Intakes

The results from the present study have been compared to the most recent data available on national dietary intakes from the 1997 NNS. However, caution should be exercised when comparing the current results with the 1997 NNS. Specific differences in the methodology used to collect dietary information limit the ability to make direct comparisons; a single 24-hour recall was used in the 1997 NNS whereas a diet history

was used in this study to assess usual intakes. Additionally, the study population was predominately European compared to the 1997 NNS, which over sampled Maori and Pacific people. Therefore, only limited comparisons have been presented in this report.

5.3.2.1 Macronutrient Intake

Given that low energy intakes around the time of conception have been linked to reduced birth size in humans (Godfrey et al., 1996) and appears to be associated with a number of adverse effects on foetal development in animal studies (Bloomfield et al., 2003; Joshi et al., 2003; Kwong et al., 2000; Oliver et al., 2001), the low energy intakes in this group of women of childbearing age is a concern. Only one-third of the women met the New Zealand recommended energy intake for women aged 18-60 and less than half met the UK EAR for females aged 18-50. The mean energy intake in the present study was 8086 kJ, which was lower than 9102 kJ for women aged 19-24 and 8417 kJ for women aged 25-44 reported in the 1997 NNS (Russell et al., 1999). The estimated energy intake in this largely European group of women was similar to the lower energy intake reported among predominately European Dunedin women (7969 kJ) (Gibson et al., 2001) and for European women in the 1997 NNS (8317 kJ) (Russell et al., 1999).

Under-reporting of energy intake is common among women (Scagliusi et al., 2003), especially in women who are obese (Johansson et al., 2001), practice dietary restraint (Asbeck et al., 2002) or women who want to lose weight (Johansson et al., 1998; Taren et al., 1999). The extent of under-reporting cannot be evaluated or controlled for in the present study as detailed physical activity records, which were not collected, are needed to estimate total energy expenditure. There was no difference in the estimated energy intakes between women above or below the normal BMI cut-off point. However, women with a BMI above the obese BMI cut-off point tended to have lower estimated energy intakes than non-obese women (7572 kJ vs. 8140 kJ, p=0.437), though the small number of obese women limited the significance of this finding. This suggests that obese women may have underreported food intake in this study.

Given that nearly half of the women wanted to lose weight under-reporting of energy intake cannot be ruled out in the present study, however highly educated (Scagliusi et al., 2003) and normal weight women (Johansson et al., 2001; Johansson et al., 1998) are less likely to underreport energy intake. The energy intake in the present study was

comparable to that found among European women in Dunedin (Gibson et al., 2001) and to European women in the 1997 NNS (Russell et al., 1999) so under-reporting does not appeared to have distorted the current results.

Estimated protein intakes were high in this study; very few women were at risk of an inadequate protein intake. The mean protein intake was 92 g, which is twice the RDI for protein and was higher than the protein intake found in women of childbearing age in the 1997 NNS (77-78 g) (Russell et al., 1999). Protein intake was also higher than that reported in the Dunedin study (Gibson et al., 2001).

Typically high protein diets are also high in fat, however just over a quarter of the women exceeded the recommended maximum ratio of energy from fat. In the present study the mean fat intake was 65 g and the ratio of energy from fat was 28.9%, which was lower than 80-84 g of dietary fat and 34-35% of energy from fat among women of childbearing age in the 1997 NNS (Russell et al., 1999). The proportion of women who met the guidelines for the maximum ratio of energy from fat was substantially higher in this study, nearly three-quarters of women met the guideline compared to less than 50% of women in the 1997 NNS (Russell et al., 1999). Of concern, one in six women in the present study did not meet the minimum requirement of 20% of energy from fat.

While socially desirable foods are not underreported to the same extent as socially undesirable foods (Johansson et al., 2001; Johansson et al., 1998; Taren et al., 1999), under-reporting has little affect on the proportions of macronutrients from energy so is unlikely to explain the lower contribution of fat to energy in the present study (Hirvonen et al., 1997). Rather the fact that the participants were predominately European is likely to explain the lower fat intake in this study, as Maori women have higher fat intakes and fewer Maori women met the guidelines for dietary fat (Russell et al., 1999).

Carbohydrate intake was similar to the results from the 1997 NNS and similarly reflects that carbohydrate intakes are lower than recommended among women of childbearing age (Russell et al., 1999). In the present study the mean ratio of energy from carbohydrate was 49.1%, while approximately half of the women did not met the minimum recommended contribution of carbohydrate to energy from the New Zealand dietary guidelines. A similar result was found for women aged 19-24 in the 1997 NNS, though only 35% of

women aged 25-44 consumed at least 50% of energy from carbohydrates (Russell et al., 1999).

Intake of total sugar was similar to the 1997 NNS (Russell et al., 1999). Most women exceeded the New Zealand recommendation for sugars to contribute no more than 15% of energy, however using the US dietary guidelines less than half were above the recommended 25% (Institute of Medicine, 2002). Dietary fibre intake was higher than in the 1997 NNS (Russell et al., 1999), however still less than half of the women were meeting the minimum requirement for dietary fibre. Emerging evidence suggest that elevated blood glucose levels during the period of embryogenesis and organogenesis are associated with an increased risk of congenital anomalies and that the type of carbohydrate in the diet may influence foetal growth and infant birth weight (Scholl et al., 2004). Diets around the time of conception that are low in grains (Shaw et al., 1999) and high in sugar (Friel et al., 1995) or characterized by a high dietary GI and high sucrose intake have been associated with an increased risk of NTDs (Shaw et al., 2003). Given theses findings it is concerning that many women of childbearing age appear to consume diets that are characterized by a low intake of cereals/grains and high intakes of sugar.

Overall, the differences in macronutrient intakes found between this study and the 1997 NNS can be largely explained by the difference in the ethnic distribution between the two studies.

5.3.2.2 Micronutrient Intakes

The estimated dietary intakes for all the micronutrients, except for vitamin B_{12} were higher than the 1997 NNS (Russell et al., 1999). The median dietary folate intake was 362 μg; this was considerably higher than 195-213 μg reported among women of childbearing age in the 1997 NNS (Russell et al., 1999). At the time of the 1997 NNS few products were fortified with folic acid, since then there has been an increase in the availability of fortified products, particularly fortified breakfast cereals (MOH, 2003b). The increase in dietary folate intake seen in the present study may be explained by the higher use of breakfast cereals compared to in the 1997 NNS and that the majority of women were consuming breakfast cereals that were fortified with folic acid. Additionally, most women in the present study were using wholegrain bread, which is much higher in folate than white bread. Regular use of fortified breakfast cereals may also explain the higher dietary

iron found in the present study. Most of the women were also using calcium fortified milk which resulted in the dietary calcium intake being over 200 mg higher than in the 1997 NNS (Russell et al., 1999). This was despite that only 55% of women consumed more than two servings of dairy products per day. However, in light of the low energy intakes and that the possibility of under-reporting cannot be excluded dietary micronutrient intakes may have been distorted in the present study. Under-reporting has been shown to cause significant bias in micronutrient intakes (Hirvonen et al., 1997).

The total micronutrient intake combined from dietary sources and intake from supplements was 442 μg for folate, 15.4 mg for iron, 12.9 mg for zinc and 987 mg for calcium. The arbitrary cut-off point of two-thirds of the RDI was used to define the proportion of women at risk of inadequate intakes, this method was used rather than the proportion of women below the RDI as the later tends to overestimate the proportion at risk of inadequate intakes (Gibson, 1990). The intakes of vitamin B_{12} and vitamin B_6 appeared to be adequate in the present group of women of childbearing age.

Few women were at risk of having an inadequate intake of total folate, though the prevalence of inadequate folate intake was higher among Maori women in the 1997 NNS, therefore the current study is likely to underestimate inadequate folate intakes among women of childbearing age. However, the New Zealand RDI of 200 μg is not based on the requirement to prevent NTDs. To achieve the optimal level of red-cell folate needed to prevent NTDs women need to consume 200 μg of dietary folate plus an extra 400 μg of synthetic folic acid from either supplements or fortified products (MOH, 2003b). Unfortunately the NZFCD is not able to separately report the intake of dietary folate and synthetic folic acid, rather total folate is reported. It is unlikely that many women in this study would have achieved the recommended total folate intake for women of childbearing age, as only 25% had a total folate intake above 662 μg and the median intake of folic acid from supplements was only 80 μg.

If women have insufficient iron stores before conception it may be very difficult to replete iron stores during pregnancy (Kaiser et al., 2002). Maternal anaemia is associated with LBW, preterm delivery (Scholl et al., 1992) and perinatal mortality (Rasmussen, 2001). Ten percent of women were at risk of inadequate iron intakes using the current New Zealand RDI, however using the US RNI three times as many women were at risk of iron

deficiency. The 2000 US RNI provides the most up to date guidelines for iron and takes into account the adverse effects of iron deficiency to the mother and foetus (Institute of Medicine, 2000), whereas the current New Zealand RDIs devised in 1990 do not. Therefore, among women of childbearing age it is wise to use the US RNI, this means that 30% of women in the present study were at risk of inadequate iron intakes. The 1997 NNS evaluated the adequacy of selected micronutrients using probability analysis based on the UK EAR, the prevalence of inadequate iron intakes was 21% in females aged 19-24 and 13% in females aged 25-44 (Russell et al., 1999).

Around 10% of New Zealand women of childbearing age in the 1997 NNS had a sub-optimal iron status (ferritin <12 μg/L), which was most prevalent in Maori and Pacific women (Russell et al., 1999). The prevalence of mild iron deficiency, defined as serum ferritin <20 μg/L and Hb >120 g/L, was high among Dunedin women; with 26% of women aged 18-40 years having mild iron deficiency (Heath et al., 2000). Vegetarian women and adolescent females may be at increased risk of having a low iron status (Alexander et al., 1994; Ball & Bartlett, 1999; Gibson et al., 2002). A significant proportion of New Zealand women of childbearing age may be at risk of entering into pregnancy with less than optimal iron stores, which increases the risk of preterm delivery, LBW and maternal complications associated with maternal anaemia (Scholl, 2005).

Zinc is essential for normal growth and development (Shah & Sachdev, 2001) and zinc deficiency has been implicated in the aetiology of NTDs (Shoob et al., 2001; Veile et al., 1999), LBW and preterm delivery (King, 2000). Nearly one in five women were at risk of an inadequate zinc intake based on the current New Zealand RDI of 12 mg. However, using the more recent US RNI of 8 mg less than 3% of women were at risk of zinc deficiency (Institute of Medicine, 2000). The 1997 NNS indicated that inadequate zinc intakes are not common among New Zealand women of childbearing age; the prevalence of zinc inadequacy was only 0.9-1.6% (Russell et al., 1999). The prevalence of zinc inadequacy was higher in the Dunedin study, however only 6% of women were estimated to have inadequate zinc intakes (Gibson et al., 2001). This study also found that 17% of women had mild zinc deficiency (serum zinc <10.71 μmol/L), which was more prevalent in women who did not eat red meat. The higher rate of mild zinc deficiency compared to the rate of inadequate zinc intake was thought to be due to a high intake of dietary phylate. Certain population groups such as vegetarians, vegans (Gibson et al., 2001) and

adolescent females (Gibson et al., 2002) may be at risk of having a compromised zinc status at the onset of pregnancy.

Calcium is required for the development of the foetal skeleton and also has an important role in neuromuscular function and blood coagulation (Ramakrishnan et al., 1999). A deficiency of calcium can adversely affect pregnancy outcome by impairing foetal growth and development, and because of its role in smooth muscle contraction increases the risk of pregnancy induced hypertension and preeclampsia (Ramakrishnan et al., 1999). In addition, an adequate calcium intake is essential for women's health to reduce the risk of osteoporosis in later life (Bendich, 2001). The estimated risk of calcium inadequacy using the current New Zealand RDI of 800 mg was 11%, whereas using the US RNI that also considers the levels required to prevent osteoporosis 22% of women were at risk of having an inadequate intake of calcium (Institute of Medicine, 1997). The prevalence of inadequate calcium intakes in the 1997 NNS among women of childbearing age was estimated to be 21-22% (Russell et al., 1999).

Interestingly, there was no difference in macronutrient or dietary micronutrient intakes between supplement users and non-users. Other studies have also found similar dietary takes between supplement users and non-users (Beitz et al., 2002; Troppmann et al., 2002), though supplement users have also been found to have more adequate dietary intakes (Kirk et al., 1999). Given the high median micronutrient intakes in the present study it is unlikely that many women using dietary supplements would have gained any nutritional benefit from these supplements, apart from the increase in folic acid. Instead supplement users were at risk of having intakes above the UL, a finding similar to a recent study on supplement use (Troppmann et al., 2002). Women above the UL for folate were significantly more likely to be taking a supplement containing folic acid. All of the women above the UL for vitamin B_6, iron and zinc were supplement users, though the small numbers limited the significance of these findings. Given that the nearly half of the women reported regular use of multi-vitamin and/or mineral supplements potentially large numbers of women may be at risk of excessive micronutrient intakes.

Again, these results highlight the importance of the need for guidance from a medical professional before initiating dietary supplement use. Though none of the women in the present study were taking a vitamin A supplement, particular care needs to be exercised among women of childbearing age when using supplements containing preformed

vitamin A to avoid birth defects associated with intakes above 10,000 IU (Rothman et al., 1995). Women who could potentially become pregnant should not use supplements containing preformed vitamin A (MOH, 1995).

A diet history is a valid method to estimate usual intake among women (Black et al., 2000). However, as with any dietary assessment method there are limitations to the accuracy of the diet history. The diet history requires participants to be able to make subjective judgements about their usual intake and to account for variability in their diet (Black, 2001a). However, few participants appeared to have difficulty describing their usual intake and given that the study participants were highly educated this is not likely to have been a problem in this study. The emphasis on regular eating patterns can limit the usefulness of the diet history in individuals with erratic eating habits, as it tends to underestimate irregularities in food intake (Thompson & Byers, 1994). Although few women appeared to eat erratically, it cannot be ruled out that irregularities in food intake may have limited the validity of the diet history in some participants. It is important to avoid teratogenic doses of vitamin A around the time of conception, unfortunately a diet history is not a valid method for estimating the intake of vitamin A due to the notoriously high day-to-day variation in intake (Gibson, 1990).

One major source of error in the assessement of dietary intakes using a diet history is the estimation of portion size (Black, 2001a). Participants were required to estimate portion size using food models and standard household measures, while this improves the accuracy compared to when visual aids are not used, misestimation of portion size by more than 20% is still common (Godwin et al., 2004). Misestimation of portion size is related to the perceived healthfulness of the food, with smaller estimates of portion size given for high-fat foods and larger estimates for healthy foods such vegetables and wholegrain products (Johansson et al., 2001). Overestimation of portion size tends to more prevalent among individuals who eat smaller portions and underestimated by those who eat larger portions (Biro et al., 2002).

In this study some participants were reluctant to use the dried beans to estimate amounts of amorphous foods such as cereals and rice, which would have increased the error in the estimates of portion size. A booklet containing different shapes at graded sizes was used along with a 3D thickness measure where appropriate to estimate the volume of certain items, such as a slice of cake or lasagne. However, the different sizes shown did not

always represent the size of the food eaten. In this instance the participant was asked to pick the option that best fitted the amount consumed, which would have underestimated or overestimated portion size. Detailed information on brand names was collected; this improved the accuracy of the estimate of portion size of processed foods by being able to use the package weight. For example, the package weight for a particular brand of muesli bar could be used. However, the package weight represents the minimum weight of processed foods; the weight of packaged items is often more than the stated amount.

While the estimate of portion size is prone to errors the major source of under-reporting in dietary assessment appears to be the failure to report foods, especially between-meal snacks (Godwin et al., 2004). The multiple-pass method used in this study gives cues and probes for frequently forgotten foods such as snacks and condiments, therefore, minimising under-reporting simply due to forgotten food items (Godwin et al., 2004). Non-judgemental probes were also made for socially undesirable foods such as alcohol and takeaways to try to minimise under-reporting due to the exclusion of socially undesirable foods (Tapsell et al., 2000). However, since energy expenditure was not measured the extent of under-reporting in the present study cannot be determined.

Additional errors associated with the use of a food composition database also limits the accuracy of dietary intakes (Gibson, 1990; Greenfield & Southgate, 1992). The NZFCD is limited in the range of foods and brands of products available; therefore direct matches from foods eaten to foods listed in the NZFCD are not always possible. To minimize errors standardized substitutions were made with help from NIPs to match macronutrient content and where available folate, iron and calcium levels of packaged foods. Errors also arise from the natural variation in the nutrient levels of foods and variations in the actual nutrient content of fortified products compared to the claimed level (Greenfield & Southgate, 1992). It must be remembered that the nutrient levels derived from food composition databases represent the maximum amount available to the body and not the amount absorbed. Reduced bioavailability of nutrients, particularly for non-animal sources of iron and zinc means that the estimated intake may overestimate the amount available to the body (Greenfield & Southgate, 1992). Food composition databases do not take into account the combinations in which foods are eaten, which also affects the bioavailability of nutrients.

Errors in nutrient intakes may have also arisen from the incorrect recall of the brand of supplement used. While the brands of supplements could be verified for women interviewed in their own homes, this was not possible for women interviewed outside their homes. Though all of the women who could not remember the brand of supplement notified the researcher regarding the correct brand used, however it is possible that other women may have recalled the brand of supplement incorrectly.

5.3.3 Lifestyle Characteristics

The adverse effects of alcohol consumption are most pronounced with alcohol use during the critical period of organogenesis and embryogenesis (Maier & West, 2001). Given that this period occurs before pregnancy recognition the potential harmful affects of alcohol to the foetus can occur before women realise they are pregnant, particularly if the pregnancy was not planned. Although a significant number of women may abstain from drinking alcohol as soon as they become aware that they are pregnant, in this study only 18% of pregnancies were confirmed before four weeks of gestation. Even low levels of alcohol consumption during the early stages of foetal development have been linked to an increased risk of mental retardation (Roeleveld et al., 1992).

The majority of women in this study consumed alcohol, a finding similar to the national statistics on alcohol consumption (Wilkins et al., 2002). The consumption of more than 10 drinks per week before conception is associated with an increased risk of spontaneous abortion (Henriksen et al., 2004); in this study 11% of women reported consuming more than 10 drinks per week.

The risk of the teratogenic effects associated with alcohol is greatest with binge drinking that results in a high peak blood alcohol concentration (Maier & West, 2001). Additionally, women who binge drink are more likely to have an unplanned pregnancy, to continue to drink during pregnancy and to have other negative lifestyle characteristics (Gladstone et al., 1997; Naimi et al., 2003). Unfortunately information on binge drinking was not collected in this study, though 34% of the women had the potential to drink in a binge-like pattern as they consumed six or more drinks per week. Interestingly this is higher than the national figures that indicate that one in five women aged 15-45 years consume four or more drinks per occasion at least once per week (Wilkins et al., 2002). Given that just over 50% of pregnancies are unplanned in New Zealand (Paterson et al.,

2004; Schader & Corwin, 1999), a significant number of women may potentially expose their unborn child to the devastating effects of alcohol in early pregnancy (Paterson et al., 2004; Schader & Corwin, 1999). It is also a concern that recent studies have indicated that approximately a quarter of all pregnant women in New Zealand continue to drink after pregnancy recognition, with a significant number of women drinking to levels of intoxication (McLeod et al., 2002; Watson & McDonald, 1999). Women who continue to binge drink during pregnancy are disproportionately Maori or Pacific, under 25 years and those with a lower SES status (Watson & McDonald, 1999).

A limitation to this study is that information on the number of drinks per occasion was not collected, instead the total number of standard drinks per week was measured which is likely to dilute the effect of binge drinking (Maier & West, 2001). Also the alcohol categories used were not appropriate for determining the number of women who consume seven or more drinks per week, the recommended limit if alcohol can not be avoided (MOH, 1995). Therefore, the present study does not estimate the proportion of women with a drinking pattern that is a high risk factor for the adverse affects of alcohol during pregnancy.

There are a number of inherent errors in measuring alcohol intake that include difficulties in recall, variability in drinking behaviour, variability in standard drink sizes and under-reporting of a socially undesirable response (Gladstone et al., 1996). The participants in this study were required to estimate their usual alcohol intake for the past year as this time period is thought to reflect current drinking patterns (Dawson, 2003). This reference period is recommended for assessing drinking behaviour as it is sufficient to include the variability in alcohol consumption, particularly that influenced by holidays or social events (Dawson, 2003). The overall frequency of alcohol consumption and the usual number of standard drinks per week was assessed in this study as information about usual consumption has been shown to best represent harmful drinking patterns (Dawson, 2003). However, this required the participants to make a subjective judgement about their usual intake and to account for the variability in their alcohol intake.

The use of standard drink sizes improves the accuracy of information about alcohol consumption, however not all participants attempt to convert their number of actual drinks to standard drinks and some are incapable of doing so because they are not able to accurately estimate their actual drink size (Dawson, 2003). In this study pictures with the

volumes of standard drink sizes were used to help participants convert the number of actual drinks to the number of standard drinks consumed per week to reduce reporting error (Dawson, 2003). The order of the response categories can influence participants answers, ordering the highest category first makes higher alcohol intakes appear more normal and participants are less embarrassed responding to high levels of alcohol consumption (Dawson, 2003). In the present study the categories were ordered from lowest to highest intake, therefore high levels of alcohol intake might have been underestimated.

Caffeine consumption was low in the present study, few women consumed over 300 mg/day which is a risk factor for spontaneous abortion (Giannelli et al., 2003; Infante-Rivard et al., 1993; Wen et al., 2001). Polyphenols found in caffeinated beverages are also known to inhibit iron absorption (Hurrell et al., 1999; Moreira et al., 2005; Zijp et al., 2000); a high caffeine intake can increase the risk of iron deficiency if dietary intakes are already marginal. Coffee has recently been found to contain a zinc-chelating compound that may reduce zinc absorption (Wen et al., 2005).

However, it is difficult to accurately assess caffeine intake due to the variability in caffeine content and serving size of different beverages (Christian & Brent, 2001). Even though accuracy was improved in this study by the use of different conversion factors for the various types of coffee and visual aids to estimate the usual size of caffeinated drinks, caffeine intake from chocolate or chocolate drinks was not assessed so is likely to underestimate caffeine intake (Christian & Brent, 2001). Additionally, the estimation of caffeine intake required participants to be able to make a subjective judgement about their usual intake and to account for variability in their caffeine intake. To the researchers knowledge there is no data available on caffeine intakes among New Zealand women of childbearing age.

Smoking during pregnancy is one of the leading causes of preventable adverse pregnancy outcomes (Cnattingius, 2004). The prevalence of smoking in the present study was well under the national rates for females of similar age groups in New Zealand (MOH, 2002; MOH, 2004). Eight percent of women reported regular marijuana use which is linked to a higher risk of ovulatory infertility (Mueller et al., 1990). The use of methamphetamines is increasing among women of childbearing age in New Zealand (Wilkins et al., 2002), with 2% of females aged 18-45 reporting ecstasy use in the past year in the 2001 National

Drug Survey (Wilkins et al., 2002). Five percent of women in the present study reported current use of ecstasy. Little is known on the effects of methamphetamines on pregnancy, though there is some data to suggest that it is associated with an increased risk of congenital anomalies (Bateman et al., 2004; McElhatton et al., 1999). Additional to the affects of recreational drug use prior to conception on pregnancy outcome, is whether or not women who partake in recreational drug use can abstain from their use during pregnancy.

The American Dietetic Association recommends that women of childbearing years should be physically active to optimize nutritional status and to confer the health benefits of exercise (Kaiser et al., 2002). The level of physical inactivity in the present study was similar to that reported by Sport and Recreation New Zealand (van Aalst et al., 2002), with 41% of women considered to inactive. While more women in the present study were relatively active, around half as many women were considered to be highly active compared to the national figures (van Aalst et al., 2002). Overall, the average time spent on physical activity per week was less than half of the national average for females over 18 years (van Aalst et al., 2002).

5.4 Implications

The prevalence of NTDs in New Zealand including livebirths, stillbirths and abortions is 9.1 per 10,000 (MOH, 2003b). Any strategy to decrease the incidence of NTDs in New Zealand needs to ensure that the majority of women of childbearing age are reached. To date there has been no publicly funded awareness campaign on the benefits of folic acid supplementation in New Zealand. Overseas evidence suggests that educational campaigns can increase the rate of folic acid use in the preconception period among women planning pregnancy, however still fewer than 50% of women comply with the recommendations (Ray et al., 2004). Campaigns have little or no effect on the prevalence of folic acid intake among women with unplanned pregnancies (Knudsen et al., 2004; Ray et al., 2004). The effectiveness of campaigns is limited among less educated women, who may have a higher risk of having a NTD-affected pregnancy (van der Pal-de Bruin et al., 2003). Considering over half of all pregnancies in New Zealand are unplanned the current supplementation policy, on its own, will not be effective in reducing the rate of NTDs in New Zealand (Paterson et al., 2004; Schader & Corwin, 1999).

Voluntary fortification of bread products, pasta, breakfast cereals, drinks and juices was introduced in 1996. However, the uptake of voluntary fortification has been low among food manufacturers (Egan, 2004). Breakfast cereal manufacturers are the only industry group to have widely taken up voluntary folic acid fortification. It has been estimated that less than 4% of New Zealand women are receiving more than 400 μg of folic acid under the current voluntary fortification policy (MOH, 2003b), however this estimate is based on data derived from the 1997 NNS. Unless the food industry takes up voluntary fortification more widely than at present it is unlikely that maintaining the status quo would reduce the incidence of NTDs in New Zealand, particularly for unplanned pregnancies (MOH, 2003b).

The US (Honein et al., 2001) and Canadian (Gucciardi et al., 2002; Persad et al., 2002) experience has shown that the rate of NTDs decreased by 19% and 53%, respectively, following the introduction of mandatory folic acid fortification. However, the incidence of NTDs is higher in Canada compared to New Zealand so it is unlikely that New Zealand would experience the same decline in NTDs with mandatory fortification. The prevalence of NTDs in the US is similar to that in New Zealand, mandatory fortification of flour could lead to the prevention of approximately 13-16 NTDs per year in New Zealand (MOH, 2003b). Though the US data is based on the prevalence of NTDs reported on birth certificates, therefore the reduction in NTDs following fortification could partially be a result of increased prenatal screening and termination.

Mandatory folic acid fortification, if it is added to a staple food, has the potential to increase folic acid intakes among women of childbearing age regardless of SES and ethnicity, and does not depend on knowledge or motivation. As a result population groups who are less likely to use folic acid supplements such as Maori and Pacific women (Russell et al., 1999), women with a low education (Schader & Corwin, 1999) and low-income women (Cleves et al., 2004) are exposed to increased amounts of folic acid. Folic acid fortification also has the potential to reduce the incidence of NTDs among women with unplanned pregnancies.

However, it is difficult to fortify food at a level that will ensure that the majority of women of childbearing age consume more than 400 μg of folic acid per day without exposing other population groups to folic acid intakes above the UL (Green et al., 2003).

Modelling conducted by the University of Otago estimated that under the proposed levels of mandatory folic acid fortification only 6-14% of women of childbearing age would receive the recommended 400 μg of folic acid per day (Green et al., 2003).

One of the major concerns with mandatory fortification is the masking of vitamin B_{12} deficiency in the elderly. Based on modelling of different levels of fortification only a very small proportion of the elderly population would be at risk of excessive folic acid levels with the fortification of bread or flour at the proposed levels (Green et al., 2003). High intakes of folate have been associated with reduced risk of breast cancer (Bailey, 2003), however some evidence suggests that alcohol and high folate intakes interact to increase the risk of breast cancer in post-menopausal women (Freudenheim et al., 2004).

As neither voluntary nor mandatory fortification is likely to result in the majority of women of childbearing age consuming more than 400 μg of folic acid per day, the current recommendation for folic acid supplementation needs to continue regardless of which fortification policy is adopted. It is recommended that the MOH make a 400 μg folic acid supplement available as a registered medicine in light of recent evidence on folic acid and NTDs (Berry et al., 1999), this will ensure that folic acid supplementation remains affordable for low-income women and reduce the risk of folate intakes exceeding the UL.

An on-going public health education strategy needs to be implemented in New Zealand to raise the awareness of the benefit of folic acid supplementation in the preconception period. Any campaign also needs to promote increasing dietary folate, sources of dietary folate and the role of fortified foods in achieving increased folate intakes among women of childbearing age. Potentially one of the most effective ways to increase the awareness of the benefits of folic acid is to incorporate folic acid education into schools to improve folic acid use in the next generation of mothers (Wild et al., 1996).

An unplanned pregnancy is also a major determinant of poor antenatal care in general (Ray et al., 2004), therefore a national program to encourage the concept of planning pregnancy needs to be implemented. The development of national guidelines for healthy eating for planning pregnancy would mean that a folic acid promotion could then be part of a larger campaign to promote preconception care among New Zealand women of childbearing age. Information would need to be made available from free clinics such as Family Planning so as not to disadvantage low-income women. Any health promotion

strategy will also need education to be targeted at health professionals, who should be encouraged to discuss preconception care with all women who have the potential to become pregnant.

Health professionals would need to be educated about preconception guidelines covering alcohol use, caffeine consumption, folic acid and a healthy diet for women planning pregnancy, which could then be discussed during routine health care. The oral contraceptive needs to be re-prescribed every three to six months, this provides the ideal opportunity to discuss or provide a pamphlet on preconception care to a large number of women of childbearing age. In the Netherlands a sticker about folic acid is placed on oral contraceptive packages (De Jong-Van den Berg et al., 2005), this is potentially a way to target preconception care to a large proportion of women of childbearing age. A negative pregnancy test provides another opportunity to address preconception care (Jack et al., 1998); a third of women in the present study had received a negative pregnancy test during a visit with their physician. It has also been suggested that information on preconception care could be included in home pregnancy tests (Jack et al., 1998); over half of the women in the present study had received a negative test from a home pregnancy kit. Addressing preconception care at the time of a negative pregnancy test may be a useful way of targeting women who are at risk of becoming pregnant.

The development of guidelines on preconception nutrition has the potential to optimise pregnancy outcome among women who plan pregnancy. In this study women who were aware of the MOH guidelines on healthy eating for pregnancy were over three times as likely to know that folic acid prior to conception prevents NTDs. A MOH pamphlet on preconception care available from places such as medical waiting rooms, pharmacies, family planning and plunket would have the potential to target women of childbearing potential. Any intervention strategy should aim to encourage women to plan for pregnancy to ensure that they are in the optimal physical state at the start of pregnancy, thereby reducing the risk of an adverse pregnancy outcome. In order to optimise women's health efforts to increase the general nutrition knowledge of New Zealand women are needed, as currently women lack the knowledge to make positive changes to their dietary habits.

6. RECOMMENDATIONS

The results of this study show that there is a need for further research into the dietary intakes, preconception practices and preconception knowledge among a representative sample of New Zealand women of childbearing age. An up to date national nutrition survey is needed to identify current dietary intakes among a nationally representative sample of New Zealand women. In particular information on current dietary intakes is needed to evaluate the dietary and total folate intakes among women of childbearing age to account for the increased availability of fortified products and any changes in food consumption patterns since the 1997 NNS. This will allow a more accurate estimate of the proportion of women receiving 400 μg of folic acid and the risk of intakes above the UL under the proposed levels of mandatory fortification to be evaluated. The implementation of another national nutrition survey would provide national data on the prevalence of folic acid use among New Zealand women of childbearing age. This information would be useful in deciding on the best folic acid policy option for New Zealand.

Further research is needed into the preconception knowledge of women of childbearing age in the general population in New Zealand and needs to assess knowledge in women planning pregnancy and women not planning pregnancy. A large scale study into the preconception practices of women with planned and unplanned pregnancies is needed to identify population groups at risk of sub-optimal preconception practices. Particular population groups that need to be targeted for further research include women who are of Maori, Pacific and Asian descent, women with a low education and low-income women.

Particular areas that need to be investigated further include folic acid use in the preconception period among women with unplanned pregnancies, the prevalence of binge drinking, sources of information on preconception nutrition and the best way to target preconception information to women. Information on preconception knowledge and preconception practices among diabetic and epileptic women is needed as these women require specialised preconception care, also whether women taking potentially harmful medications are aware of the need to seek advice regarding their use if planning pregnancy.

The identification of population groups that need to be specifically targeted will help to plan an education based campaign aimed at increasing the awareness of preconception care. Research is also needed to identify the current awareness of preconception care and the practice of proving preconception advice among health professionals before any health campaign can be implemented.

7. CONCLUSIONS

This study showed that even among highly educated and predominately European women less than one-third of women of childbearing age were aware of the effectiveness of preconceptional folic acid in the prevention of NTDs. Folic acid knowledge was significantly associated with planning pregnancy, being aged over 30 years, information from books and being aware of the MOH guidelines for pregnancy. The prevalence of folic acid use was low among women of childbearing age, particularly among women not planning pregnancy. Given that 53% pf pregnancies were unplanned the low rate of folic use among women of childbearing age is a significant obstacle to the prevention of NTDs in New Zealand. Folic acid supplementation was the preferred method of increasing folic acid intake, with half of the women stating they would prefer to use a supplement. Only a small proportion of women would prefer to use fortified products as a means of increasing their folate intake, though many women were not aware of folic acid fortification.

Women of childbearing age appear to have little awareness of the importance of diet in the preconception period. Less than 6% of women were aware that an inadequate diet around the time of conception could increase the risk of miscarriage, preterm delivery or maternal deficiencies. Over half of the women thought that alcohol should be avoided if planning pregnancy, however of concern women attempting to conceive were significantly more likely to advocate limiting alcohol than those not planning pregnancy. There also appears to be a lack of general nutrition knowledge among women of childbearing age, with the women demonstrating poor knowledge of folate-rich and iron-rich foods.

Overall, pregnancy planning appears not to significantly affect nutritional intake, alcohol use, caffeine consumption or smoking habits. However, only 18 women were attempting to conceive so caution should be exercised when interpreting this data. Women attempting to conceive were significantly more likely to use a vitamin and/or mineral supplement than women not planning pregnancy. All of the women planning pregnancy were taking a folic acid supplement, however nearly a third were taking a dose of folic acid below 400 μg.

Preconceptional folic acid use in women attempting to conceive and women with a previous planned pregnancy were significantly associated with folic acid knowledge, information from books and preconception counselling. Women with a low education level were less likely to use a folic acid before conception among women who plan pregnancy.

Many women of childbearing age appear to not meet the National Nutrition Taskforce guidelines for daily servings of fruit, vegetables, cereals/grains and dairy products. Of particular concern was the finding that only 5% of women consumed the recommended servings of cereals/grains per day. Additionally, the women in this study appeared to overrate the adequacy of their diets, as few women thought that they needed to increase their consumption of fruit and vegetables, dairy products or cereals/grains.

Dietary intakes in this group of highly educated and predominately European women were characterized by low energy intakes with an imbalance in protein and carbohydrate. Two-thirds of the women did not meet the recommended minimum energy intake for New Zealand women. Nearly half of the women did not meet the guideline for dietary carbohydrate. Low carbohydrate intakes were characterized by low intakes of dietary fibre and high intakes of sugar. Protein intakes were well above the required level. A quarter of the women exceeded the guideline for the maximum ratio of energy from dietary fat, while one in six women did not consume the minimum amount of fat needed for women of childbearing age.

The regular use of fortified breakfast cereals, fortified milk and wholegrain breads meant that the median dietary intakes of folate, vitamin B_{12}, vitamin B_6, iron, zinc and calcium were high in this study. Based on the recent US DRV few women were estimated to be at risk of inadequate intakes of vitamin B_{12}, vitamin B_6 and zinc. However, the proportion of women at risk of inadequate intakes was 30% for iron, 22% for calcium and 20% for folate. It is unlikely that many women would have achieved the recommendation for women of childbearing age to receive 200 μg of dietary folate and an extra 400 μg from synthetic folic acid.

In summary, the awareness of the benefits of preconceptional folic acid and the prevalence of folic acid use appears to be low among women of childbearing age. Additionally, women demonstrate little awareness of the importance of preconception

nutrition and a lack of basic nutrition knowledge. Planning pregnancy is associated with increased folic acid knowledge. Among women who plan pregnancy those with folic acid knowledge or who had received preconception counselling were more likely to a use a preconception folic acid supplement, whereas women with a low level education were less likely to use folic acid. Many women of childbearing potential do not appear to be in the optimal nutritional state to minimise the risk of adverse pregnancy outcomes. Efforts to increase the awareness of the importance of preconception nutrition and to encourage women to plan pregnancy are needed in New Zealand to optimise pregnancy outcomes.

REFERENCES

Abrams, B. (1993). Preventing low birth weight: does WIC work? A review of evaluations of the special supplemental food program for women, infants, and children. *Annals of the New York Academy of Sciences*, **678,** 306-316.

Ainsworth, B.E., Haskell, W.L., Leon, A.S., Jacobs, D.R., Montoye, H.J., Sallis, J.F. & Paffenbarger, R.S. (1993). Compendium of physical activities: classification of energy costs of human physical activities. *Medicine and Science in Sports and Exercise*, **25,** 71-80.

Alexander, D., Ball, M.J. & Mann, J. (1994). Nutrient intake and haematological status of vegetarians and age-sex matched omnivores. *European Journal of Clinical Nutrition*, **48,** 538-546.

Allaire, A.D. & Cefalo, R.C. (1998). Preconceptional health care model. *European Journal of Obstetrics and Gynecology and Reproductive Biology*, **78,** 163-168.

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

Allen, T., Thomson, W.M., Emmerton, L.M. & Poulton, R. (2000). Nutritional supplement use among 26-year-olds. *New Zealand Medical Journal*, **113,** 274-277.

Amitai, Y., Fisher, N., Haringman, M., Meiraz, H., Baram, N. & Leventhal, A. (2004). Increased awareness, knowledge and utilization of preconceptional folic acid in Israel following a national campaign. *Preventive Medicine*, **39,** 731-737.

Andersson, R. & Bergstrom, S. (1997). Maternal nutrition and socio-economic status as determinants of birthweight in chronically malnourished African women. *Tropical Medicine and International Health*, **2,** 1080-1087.

Armstrong, B.G., McDonald, A.D. & Sloan, M. (1992). Cigarette, alcohol, and coffee consumption and spontaneous abortion. *American Journal of Public Health*, **82,** 85-87.

Arnold, C.L., Davis, T.C., Berkel, H.J., Jackson, R.H., Nandy, I. & London, S. (2001). Smoking status, reading level, and knowledge of tobacco effects among low-income pregnant women. *Preventive Medicine*, **32,** 313-320.

Asbeck, I., Mast, M., Bierwag, A., Westenhofer, J., Acheson, K.J. & Muller, M.J. (2002). Severe underreporting of energy intake in normal weight subjects: use of an appropriate standard and relation to restrained eating. *Public Health Nutrition*, **5,** 683-690.

Ashworth, C.J. & Antipatis, C. (2001). Micronutrient programming of development throughout gestation. *Reproduction*, **122,** 527-535.

Bailey, B.N., Delaney-Black, V., Covington, C.Y., Ager, J., Janisse, J., Hannigan, J.H. & Sokol, R.J. (2004). Prenatal exposure to binge drinking and cognitive and behavioral outcomes at age 7 years. *American Journal of Obstetrics and Gynecology*, **191,** 1037-1043.

Bailey, L.B. (2003). Folate, methyl-related nutrients, alcohol, and the MTHFR 677CT polymorphism affect cancer risk: intake recommendations. *Journal of Nutrition*, **133,** 3748S-3753S.

Baker, H., Thind, I.S., Frank, O., DeAngelis, B., Caterini, H. & Louria, D.B. (1977). Vitamin levels in low-birth-weight newborn infants and their mothers. *American Journal of Obstetrics and Gynecology*, **129,** 521-524.

Ball, M.J. & Bartlett, M.A. (1999). Dietary intake and iron status of Australian vegetarian women. *American Journal of Clinical Nutrition*, **70,** 353-358.

Barker, D.J. (1999). Fetal origins of cardiovascular disease. *Annals Of Medicine*, **31,** 3-6.

Barr, S.I. & Broughton, T.M. (2000). Relative weight, weight loss efforts and nutrient intakes among health-conscious vegetarian, past vegetarian and nonvegetarian women ages 18 to 50. *Journal of the American College of Nutrition*, **19,** 781-788.

Bateman, D.N., McElhatton, P.R., Dickinson, D., Wren, C., Matthews, J.N.S., O'keeffe, M. & Thomas, S.H.L. (2004). A case control study to examine the pharmacological factors underlying ventricular septal defects in the North of England. *European Journal of Clinical Pharmacology*, **60,** 635-641.

Bates, G.W., Bates, S.R. & Whitworth, N.S. (1982). Reproductive failure in women who practise weight control. *Fertility and Sterility*, **50,** 721-726.

Beitz, R., Mensink, G.B.M. & Thamm, M. (2002). Vitamins - dietary intake and intake from dietary supplements in Germany. *European Journal of Clinical Nutrition*, **56,** 539-545.

Bellisle, F., Monneuse, M.O., Steptoe, A. & Wardle, J. (1995). Weight concerns and eating patterns: a survey of university students in Europe. *International Journal of Obesity and Related Metabolic Disorders*, **19,** 723-730.

Bellver, J., Rossal, L.P., Bosch, E., Zuniga, A., Corona, J.T., Melendez, F., Gomez, E., Simon, C., Remohi, J. & Pellicer et, a. (2003). Obesity and the risk of spontaneous abortion after oocyte donation. *Fertility and Sterility*, **79,** 1136-1140.

Bendich, A. (2001). Micronutrients in women's health and immune function. *Nutrition*, **17,** 858-867.

Berry, R.J., Li, Z., Erickson, J.D., Li, S., Moore, C.A., Wang, H., Mulinare, J., Zhao, P., Wong, L.Y., J, G., Hong, S.X. & Correa, A. (1999). Prevention of neural-tube defects with folic acid in China. China-U.S. Collaborative Project for Neural Tube Defect Prevention. *New England Journal of Medicine*, **341,** 1485-1490.

Biro, G., Hulshof, K.F.A.M., Ovesen, L., Amorim Cruz, J.A. & EFCOSUM Group. (2002). Selection of methodology to assess food intake. *European Journal of Clinical Nutrition*, **56,** 25S-32S.

Black, A.E. (2001a). Dietary assessment for sports dietetics. *Nutrition Bulletin*, **26,** 29-42.

Black, A.E., Welch, A.A. & Bingham, S.A. (2000). Validation of dietary intakes measured by diet history against 24 h urinary nitrogen excretion and energy expenditure measured by the doubly-labelled water method in middle-aged women. *British Journal of Nutrition*, **83,** 341-354.

Black, R.E. (2001b). Micronutrients in pregnancy. *British Journal of Nutrition*, **85,** 193-197.

Bloomfield, F.H., Oliver, M.H., Hawkins, P., Campbell, M., Phillips, D.J., Gluckman, P.D., Challis, J.R.G. & Harding, J.E. (2003). A periconceptional nutritional origin for noninfectious preterm birth. *Science*, **300,** 606.

Bolumar, F., Olsen, J., Rebagliato, M. & Bisdanti, L. (1997). Caffeine intake and delayed conception: a European Multicenter Study on Infertility and Subfecundity. *American Journal of Epidemiology*, **145,** 324-334.

Bolumar, F., Olsen, J., Rebagliato, M., Saez-Lloret, I. & Bisdanti, L. (2000). Body mass index and delayed conception: a European Multicenter Study on Infertility and Subfecundity. *American Journal of Epidemiology*, **151,** 1072-1079.

Bourn, D.M. & Newton, R. (2000). Estimated dietary folate intakes and consumer attitudes to folate fortification of cereal products in New Zealand. *Australian Journal of Nutrition and Dietetics*, **57,** 10.

Bower, C. & Stanley, F.J. (1989). Dietary folate as a risk factor for neural-tube defects: evidence from a case-control study in Western Australia. *Medical Journal of Australia*, **150,** 613-619.

Brown, J.E., Jacobs, D.R., Jr, Hartman, T.J., Barosso, G.M., Stang, J.S., Gross, M.D. & Zeuske, M.A. (1997). Predictors of red cell folate level in women attempting pregnancy. *Journal of the American Medical Association*, **277,** 548-552.

Brown, J.E., Potter, J.D., Jacobs, D.R., Jr, Kopher, R.A., Rourke, M.J., Barosso, G.M., Hannan, P.J. & Schmid, L.A. (1996). Maternal waist-to-hip ratio as a predictor of newborn size: results of the Diana Project. *Epidemiology*, **7,** 62-66.

Buckley, A.J., Jaquiery, A.L. & Harding, J.E. (2005a). Nutritional programming of adult disease. *Cell and Tissue Research*, **Epub ahead of print,** 22 April 2005.

Buckley, A.J., Keseru, B., Briody, J., Thompson, M., Ozanne, S.E. & Thompson, C.H. (2005b). Altered body composition and metabolism in the male offspring of high fat-fed rats. *Metabolism: Clinical and Experimental*, **54,** 500-507.

Burguet, A., Kaminski, M., Abraham-Lerat, L., Schaal, J.-P., Cambonie, G., Fresson, J., Grandjean, H., Truffert, P., Marpeau, L., Voyer, M., Roze, J.-C., Treisser, A. & Larroque, B. (2004). The complex relationship between smoking in pregnancy and very preterm delivery. Results of the Epipage study. *British Journal of Obstetrics and Gynaecology*, **111,** 258-265.

Caan, B., Quesenberry, C.P. & Coates, A.O. (1998). Differences in fertility associated with caffeinated beverage consumption. *American Journal of Public Health*, **88,** 270-274.

Cade, J.E., Burley, V.J., Greenwood, D.C. & UK Women's Cohort Study Steering Group. (2004). The UK Women's Cohort Study: comparison of vegetarians, fish-eaters and meat-eaters. *Public Health Nutrition*, **7,** 871-878.

Carmichael, S.L., Shaw, G.M., Schaffer, D.M., Laurent, C. & Selvin, S. (2003a). Dieting behaviors and risk of neural tube defects. *American Journal of Epidemiology*, **158,** 1127-1131.

Carmichael, S.L., Shaw, G.M., Selvin, S. & Schaffer, D.M. (2003b). Diet quality and risk of neural tube defects. *Medical Hypotheses*, **60,** 351-355.

Carter, H., Lindsey, L.L.M., Petrini, J.R. & Prue, C. (2004). Use of vitamins containing folic acid among women of childbearing age-United States, 2004. *Morbidity and Mortality Weekly Report*, **53,** 847-850.

Casanueva, E., Pfeffer, F., Drijanski, A., Fernandez-Gaxiola, A.C., Gutierrez-Valenzuela, V. & Rothenberg, S.J. (2003). Iron and folate status before pregnancy and anemia during pregnancy. *Annals of Nutrition and Metabolism*, **47,** 60-63.

Caulifield, L.E., Zavaleta, N., Figueroa, A. & Leon, Z. (1999). Maternal zinc supplementation does not affect size at birth or pregnancy duration. *Journal of Nutrition*, **129,** 1563-1568.

Chacko, M.R., Anding, R., Kozinetz, C.A., Grover, J.L. & Smith, P.B. (2003). Neural tube defects: knowledge and preconceptional prevention practices in minority young women. *Pediatrics*, **112,** 536-542.

Chatenoud, L., Parazzini, F., di Cintio, E., Zanconato, G., Benzi, G., Bortolus, R. & La Vecchia, C. (1998). Paternal and maternal smoking habits before conception and during the first trimester: relation to spontaneous abortion. *Annals of Epidemiology*, **8,** 520-526.

Christian, M.S. & Brent, R.L. (2001). Teratogen update: evaluation of reproductive and developmental risks of caffeine. *Teratology*, **64,** 51-78.

Christianson, R.E., Oechsli, F.W. & van den Berg, B.J. (1989). Caffeinated beverages and decreased fertility. *Lancet*, **1,** 378.

Clarren, S.K., Astley, S.J., Gunderson, V.M. & Spellman, D. (1992). Cognitive and behavioral deficits in nonhuman primates associated with very early embryonic binge exposures to ethanol. *Journal of Pediatrics*, **121,** 789-796.

Cleves, M.A., Hobbs, C.A., Collins, H.B., Andrews, N., Smith, L.N. & Robbins, J.M. (2004). Folic acid use by women receiving routine gynecologic care. *Obstetrics and Gynecology*, **103,** 746-753.

Cnattingius, S. (2004). The epidemiology of smoking during pregnancy: smoking prevalence, maternal characteristics, and pregnancy outcomes. *Nicotine and Tobacco Research*, **6,** S125-S140.

Cnattingius, S., Signorello, L.B., Anneren, G., Clausson, B., Ekbom, A., Ljunger, E., Blot, W.J., McLaughlin, J.K., Petersson, G., Rane, A. & Granath, F. (2000). Caffeine intake and the risk of first-trimester spontaneous abortion. *New England Journal of Medicine*, **343,** 1839-1845.

Coad, J. (2003). Pre- and periconceptual nutrition. In *Nutrition in early life*, Morgan, J. & Dickerson, J. (eds) pp. 39-63. John Wiley & Sons Ltd: Chichester, West Sussex.

Cogswell, M.E., Weisberg, P. & Spong, C. (2003). Cigarette smoking, alcohol use and adverse pregnancy outcomes: implications for micronutrient supplementation. *Journal of Nutrition*, **133,** 1722S-1731S.

Coll, O., Pisa, S., Palacio, M., Quinto, L. & Cararach, V. (2004). Awareness of the use of folic acid to prevent neural tube defects in a Mediterranean area. *European Journal of Obstetrics, Gynecology, and Reproductive Biology*, **115,** 173-177.

Conner, M., Kirk, S.F., Cade, J.E. & Barrett, J.H. (2001). Why do women use dietary supplements? The use of the theory of planned behaviour to explore beliefs about their use. *Social Science and Medicine*, **52,** 621-633.

Conti, J., Abraham, S. & Taylor, A. (1998). Eating behaviour and pregnancy outcome. *Journal of Psychosomatic Research*, **44,** 465-477.

Craig, E.D., Mantell, C.D., Ekeroma, A.J., Stewart, A.W. & Mitchell, E.A. (2004). Ethnicity and birth outcome: New Zealand trends 1980-2001. Part 1. Introduction, methods, results and overview. *Australian and New Zealand Journal of Obstetrics and Gynaecology*, **44,** 530-536.

Crawford, M.A. (1993). The role of essential fatty acids in neural development: implications for perinatal nutrition. *American Journal of Clinical Nutrition*, **57,** 703S-709S.

Crha, I., Hruba, D., Ventruba, P., Fiala, J., Totusek, J. & Visnova, H. (2003). Ascorbic acid and infertility treatment. *Central European Journal of Public Health*, **11,** 63-67.

Crow, S.J., Thuras, P.T., Keel, P.K. & Mitchell, J.E. (2002). Long-term menstrual and reproductive function in patients with bulimia nervosa. *American Journal of Psychiatry*, **159,** 1048-1050.

Curtis, K.M., Savitz, D.A. & Arbuckle, T.E. (1997). Effects of cigarette smoking, caffeine consumption, and alcohol intake on fecundability. *American Journal of Epidemiology*, **146,** 32-41.

Cuskelly, G.J., McNulty, H. & Scott, J.M. (1996). Effect of increasing dietary folate on red-cell folate: implications for prevention of neural tube defects. *Lancet*, **347,** 657-659.

Czeizel, A.E. (1993). Controlled studies of multivitamin supplementation on pregnancy outcomes. *Annals of the New York Academy of Sciences*, **678,** 266-275.

Czeizel, A.E. & Dudas, I. (1992). Prevention of the first occurrence of neural-tube defects by periconceptional vitamin supplementation. *New England Journal of Medicine*, **327,** 1832-1835.

da Costa Pereira, A., Olsen, J. & Ogston, S. (1993). Variability of self reported measures of alcohol consumption: implications for the association between drinking in pregnancy and birth weight. *Journal of Epidemiology and Community Health*, **47,** 326-330.

Daltveit, A.K., Vollset, S.E., Lande, B. & Olen, H. (2004). Changes in knowledge and attitudes of folate, and use of dietary supplements among women of reproductive age in Norway 1998-2000. *Scandinavian Journal of Public Health*, **32,** 264-271.

Daly, L.E., Kirke, P.N., Molloy, A., Weir, D.G. & Scott, J.M. (1995). Folate levels and neural tube defects: implications for prevention. *Journal of the American Medical Association*, **274,** 169-1702.

Daniels, J.L., Longnecker, M.P., Rowland, A.S., Golding, J. & ALSPAC Study Team. (2004). Fish intake during pregnancy and early cognitive development of offspring. *Epidemiology*, **15,** 394-402.

Dawson, D.A. (2003). Methodological issues in measuring alcohol use. *Alcohol Research and Health*, **27,** 18-29.

De Jong-Van den Berg, L.T.W., Hernandez-Diaz, S., Werler, M.M., Louik, C. & Mitchell, A.A. (2005). Trends and predictors of folic acid awareness and periconceptional use in pregnant women. *American Journal of Obstetrics and Gynecology*, **192,** 121-128.

de Weerd, S., Steegers, E.A.P., Heinen, M.M., van den Eertwegh, S., Vehof, R.M.E.J. & Steegers-Theunissen, R.P.M. (2003a). Preconception nutritional intake and lifestyle factors: first results of an explorative study. *European Journal of Obstetrics and Gynecology and Reproductive Biology*, **111,** 167-172.

de Weerd, S., Steegers-Theunissen, R.P., de Boo, T.M. & Steegers, E.A. (2003b). Maternal periconceptional biochemical and hematological parameters, vitamin profiles and pregnancy outcome. *European Journal of Clinical Nutrition*, **57,** 1128-1134.

de Weerd, S., van der Bij, A.K., Cikot, R.J.L.M., Braspenning, J.C.C., Braat, D.D.M. & Steegers, E.A.P. (2002). Preconception Care: A screening tool for health assessment and risk detection. *Preventive Medicine*, **34,** 505-511.

Di Cintio, E., Parazzini, F., Chatenoud, L., Surace, M., Benzi, G., Zanconato, G. & La Vecchia, C. (2001). Dietary factors and risk of spontaneous abortion. *European Journal of Obstetrics, Gynecology, and Reproductive Biology*, **95,** 132-136.

Donovan, U.M. & Gibson, R.S. (1995). Iron and zinc status of young women aged 14 to 19 years consuming vegetarian and omnivorous diets. *Journal of the American College of Nutrition*, **14,** 463-472.

Doyle, W. & Crawford, M.A. (1990). The association between maternal diet and birth dimensions. *Journal of Nutritional Medicine*, **1,** 9-10.

Egan, U. (2004). Proposal P295: Consideration of mandatory fortification with folic acid inital assessment report. New Zealand Food Safety Authority: Wellington.

Ehrenberg, H.M., Dierker, L., Milluzzi, C. & Mercer, B.M. (2003). Low maternal weight, failure to thrive in pregnancy, and adverse pregnancy outcomes. *American Journal of Obstetrics and Gynecology*, **189,** 1726-1730.

Fajemirokun-Odudeyi, O. & Lindow, S.W. (2004). Obstetric implications of cocaine use in pregnancy: a literature review. *European Journal of Obstetrics, Gynecology, and Reproductive Biology*, **112,** 2-8.

Fedorcsak, P., Storeng, R., Dale, P.O., Tanbo, T. & Abyholm, T. (2000). Obesity is a risk factor for early pregnancy loss after IVF or ICSI. *Acta Obstetricia et Gynecologica Scandinavica*, **79,** 43-48.

Feldkamp, M., Friedrichs, M. & Marti, K. (2002). Folic acid awareness, knowledge, and consumption among women of childbearing age in Utah, 1998-2000. *American Journal of Medical Genetics*, **107,** 67-69.

Fergusson, D.M., Horwood, L.J., Northstone, K. & ALSPAC Study Team. (2002). Maternal use of cannabis and pregnancy outcome. *British Journal of Obstetrics and Gynaecology*, **109,** 21-27.

Floyd, R.L., Decoufle, P. & Hungerford, D.W. (1999). Alcohol use prior to pregnancy recognition. *American Journal of Preventive Medicine*, **17,** 101-107.

French, M.R., Barr, S.I. & Levy-Milne, R. (2003). Folate intakes and awareness of folate to prevent neural tube defects: a survey of women living in Vancouver, Canada. *Journal of the American Dietetic Association*, **103,** 181-185.

Freudenheim, J.L., Bonner, M., Krishnan, S., Ambrosone, C.B., Graham, S., McCann, S.E., Moysich, K.B., Bowman, E., Nemoto, T. & Shields, P.G. (2004). Diet and alcohol consumption in relation to p53 mutations in breast tumors. *Carcinogenesis*, **25,** 931-939.

Friel, J.K., Frecker, M. & Fraser, F.C. (1995). Nutritional patterns of mothers of children with neural tube defects in Newfoundland. *American Journal of Medical Genetics*, **55,** 195-199.

Frisch, R.E. (1994). The right weight: body fat, menarche and fertility. *Proceedings of the Nutrition Society*, **53,** 113-129.

Galbraith, C., Jenkin, G., Davis, P. & Coope, P. (2003). New Zealand Socio-Economic Index 1996: Users' Guide. Statistics New Zealand: Wellington.

Galtier-Dereure, F., Boegner, C. & Bringer, J. (2000). Obesity and pregnancy: complications and cost. *American Journal of Clinical Nutrition*, **71,** 1242S-1248S.

Giannelli, M., Doyle, P., Roman, E., Pelerin, M. & Hermon, C. (2003). The effect of caffeine consumption and nausea on the risk of miscarriage. *Paediatric and Perinatal Epidemiology*, **17,** 316-323.

Gibson, R.S. (1990). *Principles of nutritional assessment*. Oxford University Press: New York.

Gibson, R.S., Heath, A.L., Limbaga, M.L., Prosser, N. & Skeaff, C.M. (2001). Are changes in food consumption patterns associated with lower biochemical zinc status among women from Dunedin, New Zealand? *British Journal of Nutrition*, **86,** 71-80.

Gibson, R.S., Heath, A.-L.M. & Ferguson, E.L. (2002). Risk of suboptimal iron and zinc nutriture among adolescent girls in Australia and New Zealand: causes, consequences, and solutions. *Asia Pacific Journal of Clinical Nutrition*, **11,** 543S-552S.

Gladstone, J., Levy, M., Nulman, I. & Koren, G. (1997). Characteristics of pregnant women who engage in binge alcohol consumption. *Canadian Medical Association Journal*, **156,** 789-794.

Gladstone, J., Nulman, I. & Koren, G. (1996). Reproductive risks of binge drinking during pregnancy. *Reproductive Toxicology*, **10,** 3-13.

Godfrey, K.M., Barker, D.J., Robinson, S. & Osmond, C. (1997). Maternal birthweight and diet in pregnancy in relation to the infant's thinness at birth. *British Journal of Obstetrics and Gynaecology*, **104,** 663-667.

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

Godwin, S.L., Chambers IV, E. & Cleveland, L. (2004). Accuracy of reporting dietary intake using various portion-size aids in-person and via telephone. *Journal of the American Dietetic Association*, **104,** 585-594.

Goldenberg, R.L., Tamura, T., DuBard, M., Johnston, K.E., Copper, R.L. & Neggers, Y. (1996). Plasma ferritin and pregnancy outcome. *American Journal of Obstetrics and Gynecology*, **175,** 1356-1359.

Goldenberg, R.L., Tamura, T., Neggers, Y.H., Cooper, R., Johnston, K.E., DuBard, M. & Hauth, J. (1995). The effect of zinc supplementation on pregnancy outcome. *Journal of the American Medical Association*, **274**.

Goldschmidt, L., Richardson, G.A., Cornelius, M.D. & Day, N.L. (2004). Prenatal marijuana and alcohol exposure and academic achievement at age 10. *Neurotoxicology and Teratology*, **26,** 521-532.

Green, B.B., Weiss, N.S. & Daling, J.R. (1988). Risk of ovulatory infertility in relation to body weight. *Fertility and Sterility*, **50,** 721-726.

Green, T., Newton, R. & Bourn, D. (2003). Estimated folic acid intakes from simulated fortification of the New Zealand food supply. *New Zealand Medical Journal*, **116,** 294-302.

Greenfield, H. & Southgate, D.A.T. (1992). Guidelines for the use of food composition data. In *Food composition data, production, management and use* pp. 163-169. Elsevier Applied Science: London.

Grodstein, F., Goldman, M. & Cramer, D. (1994a). Infertility in women and moderate alcohol use. *American Journal of Public Health*, **84,** 1429-1432.

Grodstein, F., Goldman, M., Ryan, L. & Cramer, D. (1993). Relation of female infertility to consumption of caffeinated beverages. *American Journal of Epidemiology*, **137,** 1353-1360.

Grodstein, F., Goldman, M.B. & Cramer, D.W. (1994b). Body mass index and ovulatory infertility. *Epidemiology*, **5,** 247-250.

Gucciardi, E., Pietrusiak, M.A., Reynolds, D.L. & Rouleau, J. (2002). Incidence of neural tube defects in Ontario, 1986-1999. *Canadian Medical Association Journal*, **167,** 237-240.

Habak, P.J., Coonrod, D.V., Brady, M.J., Bay, R.C. & Mills, T.E. (2003). Knowledge regarding preconceptional folic acid use in a Mexican-American patient population. *Primary Care Update*, **10,** 274-277.

Haddad, E.H., Berk, L.S., Kettering, J.D., Hubbard, R.W. & Peters, W.R. (1999). Dietary intake and biochemical, hematologic, and immune status of vegans compared with nonvegetarians. *American Journal of Clinical Nutrition*, **70,** 586S-593S.

Hakim, R.B., Gray, R.H. & Zacur, H. (1998). Alcohol and caffeine consumption and decreased fertility. *Fertility and Sterility*, **70,** 632-637.

Han, T.S. & Lean, M.E.J. (2001). Anthropometric indices of obesity and regional distribution of fat depots. In *International Textbook of Obesity*, Bjorntorp, P. (ed) pp. 51-66. John Wiley & Sons Ltd.: Chichester, West Sussex.

Harding, J. (2001). The nutritional basis of the fetal origins of adult disease. *International Journal of Epidemiology*, **30,** 15-23.

Harman, S.K. & Parnell, W.R. (1998). The nutritional health of New Zealand vegetarian and non-vegetarian Seventh-day Adventists: selected vitamin, mineral and lipid levels. *New Zealand Medical Journal*, **111,** 91-94.

Hassan, M.A.M. & Killick, S.R. (2004). Negative lifestyle is associated with a significant reduction in fecundity. *Fertility and Sterility*, **81,** 384-392.

Hatch, E.E. & Bracken, M.B. (1993). Association of delayed conception with caffeine consumption. *American Journal of Epidemiology*, **138,** 1082-1092.

Heath, A., Skeaff, C.M., Williams, S. & Gibson, R.S. (2000). The role of blood loss and diet in the aetiology of mild iron deficiency in premenopausal adult New Zealand women. *Public Health Nutrition*, **4,** 197-206.

Hellerstedt, W.L., Pirie, P.L., Lando, H.A., Curry, S.J., McBride, C.M., Grothaus, L.C. & Nelson, J.C. (1998). Differences in preconceptional and prenatal behaviours in women with intended and unintended pregnancies. *American Journal of Public Health*, **88,** 663-666.

Hendricks, K.M. & Herbold, N.H. (1998). Diet, activity, and other health-related behaviors in college-age women. *Nutrition Reviews*, **56,** 65-75.

Henriksen, T.B., Hjollund, N.H., Jensen, T.K., Bonde, J.P., Andersson, A.-M., Kolstad, H., Ernst, E., Giwercman, A., Skakkebaek, N.E. & Olsen, J. (2004). Alcohol consumption at the time of conception and spontaneous abortion. *American Journal of Epidemiology*, **160,** 661-667.

Heyward, V.H. & Wagner, D.R. (2004). *Applied Body Composition Assesment*. Human Kinetics: Champaign, IL.

Hinds, T.S., West, W.L., Knight, E.M. & Harland, B.F. (1996). The effect of caffeine on pregnancy outcome variables. *Nutrition Reviews*, **54,** 203-207.

Hirvonen, T., Mannisto, S., Roos, E. & Pietinen, P. (1997). Increasing prevalence of underreporting does not necessarily distort dietary surveys. *European Journal of Clinical Nutrition*, **51,** 297-301.

Honein, M.A., Moore, C.A. & Watkins, M.L. (2003). Subfertility and prepregnancy overweight/obesity: possible interaction between these risk factors in the etiology of congenital renal anomalies. *Birth Defects Research. Part A, Clinical and Molecular Teratology*, **67,** 572-577.

Honein, M.A., Paulozzi, L.J., Mathews, T.J., Erickson, J.D. & Wong, L.Y. (2001). Impact of folic acid fortification of the US food supply on the occurrence of neural tube defects. *Journal of the American Medical Association*, **285,** 2981-2986.

Hurrell, R.F., Reddy, M. & Cook, J.D. (1999). Inhibition of non-haem iron absorption in man by polyphenolic-containing beverages. *British Journal Of Nutrition*, **81,** 289-295.

Ihlen, B.M., Amundsen, A. & Tronnes, L. (1993). Reduced alcohol use in pregnancy and changed attitudes in the population. *Addiction*, **88,** 389-394.

Infante-Rivard, C., Fernandez, A., Gauthier, R., David, M. & Rivard, G.E. (1993). Fetal loss associated with caffeine intake before and during pregnancy. *Journal of the American Medical Association*, **270,** 2940-2943.

Institute of Medicine. (1997). *Dietary reference intakes for calcium, phosphorus, magnesium, vitamin D, and fluoride*. National Academy Press: Washington, DC.

Institute of Medicine. (1998). *Dietary reference intakes for thiamin, riboflavin, niacin, vitamin B_6, folate, vitamin B_{12}, pantothenic acid, biotin, and choline*. National Academy Press: Washington, DC.

Institute of Medicine. (2000). *Dietary reference intakes for vitamin A, vitamin K, arsenic, boron, chromium, copper, iodine, iron, manganese, molybdenium, nickel, silicon, vanadium, and zinc*. National Academy Press: Washington, DC.

Institute of Medicine. (2002). *Dietary reference intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein and amino acids (Macronutrients)*. National Academy Press: Washington, DC.

Iyengar, L. & Rajalakshmi, K. (1975). Effect of folic acid supplement on birth weights of infants. *American Journal of Obstetrics and Gynecology*, **122,** 332-336.

Jack, B.W., Culpepepr, L., Babcock, J., Kogan, M.D. & Weismiller, D. (1998). Addressing preconception risks identified at the time of a negative pregnancy test: a randomized trial. *Journal of Family Practice*, **47,** 33-39.

Jacobson, J.L. & Jacobson, S.W. (1999). Drinking moderately and pregnancy. Effects on child development. *Alcohol Research and Health*, **23,** 25-30.

Jeffery, A.N., Voss, L.D., Metcalf, B.S. & Wilkin, T.J. (2004). The impact of pregnancy weight and glucose on the metabolic health of mother and child in the south west of the UK. *Midwifery*, **20,** 281-289.

Jensen, D.M., Damm, P., Sorensen, B., Molsted-Pedersen, L., Westergaard, J.G., Ovesen, P. & Beck-Nielsen, H. (2003). Pregnancy outcome and prepregnancy body mass index in 2459 glucose-tolerant Danish women. *American Journal of Obstetrics and Gynecology*, **189,** 239-244.

Jensen, T.K., Henriksen, T.B., Hjollund, N.H., Scheike, T., Kolstad, H., Giwercman, A., Ernst, E., Bonde, J.P., Skakkebaek, N.E. & Olsen, J. (1998a). Caffeine intake and fecundability: a follow-up study among 430 Danish couples planning their first pregnancy. *Reproductive Toxicology*, **12,** 289-295.

Jensen, T.K., Hjollund, N.H.I., Henriksen, T.B., Scheike, T., Kolstad, H., Giwercman, A., Ernst, E., Bonde, J.P., Skakkebak, N.E. & Olsen, J. (1998b). Does moderate alcohol consumption affect fertility? Follow up study among couples planning first pregnancy. *British Medical Journal*, **317,** 505-510.

Joesoef, M.R., Beral, V., Aral, S.O., Rolfs, R.T. & Cramer, D.W. (1993). Fertility and use of cigarettes, alcohol, marijuana, and cocaine. *Annals of Epidemiology*, **3,** 592-594.

Joesoef, M.R., Beral, V., Rolfs, R.T., Aral, S.O. & Cramer, D.W. (1990). Are caffeinated beverages risk factors for delayed conception? *Lancet*, **335,** 136-137.

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

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

Johnson, A.A., Knight, E.M., Edwards, C.H., Oyemade, U.J., Cole, O.J., Westney, O.E., Westney, L.S., Laryea, H. & Jones, S. (1994). Dietary intakes, anthropometric measurements and pregnancy outcome. *Journal of Nutrition*, **124,** 936S-942S.

Jonnalagadda, S.S., Mitchell, D.C., Smiciklas-Wright, H., Meaker, K.B., Van Heel, N., Karmally, W., Ershow, A.G. & Kris-Etherton, P.M. (2000). Accuracy of energy intake data estimated by a multiple-pass, 24-hour dietary recall technique. *Journal of the American Dietetic Association*, **100,** 303-308.

Joshi, S., Garole, V., Daware, M., Girigosavi, S. & Rao, S. (2003). Maternal protein restriction before pregnancy affects vital organs of offspring in Wistar rats. *Metabolism: Clinical and Experimental*, **52,** 13-18.

Kaiser, L.L., Allen, L. & American Dietetic, A. (2002). Position of the American Dietetic Association: nutrition and lifestyle for a healthy pregnancy outcome. *Journal of the American Dietetic Association*, **102,** 1479-1490.

Keen, C.L., Bendich, A. & Willhite, C.C. (1993). Maternal nutrition and pregnancy outcome. *Annals of the New York Academy of Sciences*, **678,** 1-367.

Keen, C.L., Clegg, M.S., Hanna, L.A., Lanoue, L., Rogers, J.M., Daston, G.P., Oteiza, P. & Uriu-Adams, J.Y. (2003). The plausibility of micronutrient deficiencies being a

significant contributing factor to the occurrence of pregnancy complications. *Journal of Nutrition*, **133,** 1597S-1605S.

Kesmodel, U. & Schioler Kesmodel, P. (2002). Drinking during pregnancy: attitudes and knowledge among pregnant Danish women, 1998. *Alcoholism, Clinical and Experimental Research*, **26,** 1553-1560.

King, J.C. (2000). Determinants of maternal zinc status during pregnancy. *American Journal of Clinical Nutrition*, **7,** 1334S-1343S.

King, J.C. (2003). The risk of maternal nutritional depletion and poor outcomes increases in early or closely spaced pregnancies. *Journal of Nutrition*, **133,** 1732S-1736S.

Kirk, S.F., Cade, J.E., Barrett, J.H. & Conner, M. (1999). Diet and lifestyle characteristics associated with dietary supplement use in women. *Public Health Nutrition*, **2,** 69-73.

Kitzmiller, J.L., Gavin, L.A., Gin, G.D., Jovanovic-Peterson, L., Main, E.K. & Zigrang, W.D. (1991). Preconception care of diabetes. Glycemic control prevents congenital anomalies. *Journal of the American Medical Association*, **265,** 731-736.

Klebanoff, M.A., Levine, R.J., DerSimonian, R., Clemens, J.D. & Wilkins, D.G. (1999). Maternal serum paraxanthine, a caffeine metabolite, and the risk of spontaneous abortion. *New England Journal of Medicine*, **341,** 1639-1644.

Kloeblen, A.S. (1999). Folate knowledge, intake from fortified grain products, and periconceptional supplementation patterns of a sample of low-income pregnant women according to the Health Belief Model. *Journal of the American Dietetic Association*, **99,** 33-38.

Klonoff-Cohen, H., Lam-Kruglick, P. & Gonzalez, C. (2003). Effects of maternal and paternal alcohol consumption on the success rates of in vitro fertilization and gamete intrafallopian transfer. *Fertility and Sterility*, **79,** 330-339.

Knudsen, V.K., Orozova-Bekkevold, I., Rasmussen, L.B., Mikkelsen, T.B., Michaelsen, K.F. & Olsen, S.F. (2004). Low compliance with recommendations on folic acid use in relation to pregnancy: is there a need for fortification? *Public Health Nutrition*, **7,** 843-850.

Koebnick, C., Hoffmann, I., Dagnelie, P.C., Heins, U.A., Wickramasinghe, S.N., Ratnayaka, I.D., Gruendel, S., Lindemans, J. & Leitzmann, C. (2004). Long-term ovo-lacto vegetarian diet impairs vitamin B_{12} status in pregnant women. *Journal of Nutrition*, **134,** 3319-3326.

Korenbrot, C.C., Steinberg, A., Bender, C. & Newberry, S. (2002). Preconception care: a systematic review. *Maternal and Child Health Journal*, **6,** 75-88.

Kramer, M.S. (2003). The epidemiology of adverse pregnancy outcomes: an overview. *Journal of Nutrition*, **133,** 1592S-1596.

Krapels, I.P.C., van Rooij, I.A.L.M., Ocke, M.C., van Cleef, B.A.G.L., Kuijpers-Jagtman, A.-M.M. & Steegers-Theunissen, R.P.M. (2004). Maternal dietary B vitamin intake, other than folate, and the association with orofacial cleft in the offspring. *European Journal of Nutrition*, **43,** 7-14.

Kwong, W.Y., Wild, A.E., Roberts, P., Willis, A.C. & Fleming, T.P. (2000). Maternal undernutrition during the preimplantation period of rat development causes blastocyst abnormalities and programming of postnatal hypertension. *Development*, **127,** 4195-4202.

Laurence, K., James, N., Miller, M., Tennant, G. & Campbell, H. (1981). Double-blind randomised controlled trial of folate treatment before conception to prevent recurrenece of neural-tube defects. *British Medical Journal*, **282,** 1509-1511.

Laurence, K.M., James, N., Miller, M. & Campbell, H. (1980). Increased risk of recurrence of pregnancies complicated by fetal neural tube defects in mothers receiving poor diets, and possible benefit of dietary counselling. *British Medical Journal*, **281,** 1592-1594.

Leeda, M., Riyazi, N., de Vries, J., Jakobs, C., van Geijn, H. & Dekker, G. (1998). Effects of folic acid and vitamin B_6 supplementation on women with hyperhomocysteinemia and a history of preeclampsia or fetal growth restriction. *American Journal of Obstetrics and Gynecology*, **179,** 135-139.

Lelong, N., Kaminski, M., Chwalow, J., Bean, K. & Subtil, D. (1995). Attitudes and behavior of pregnant women and health professionals towards alcohol and tobacco consumption. *Patient Education and Counseling*, **25,** 39-49.

Livy, D.J., Maier, S.E. & West, J.R. (2004). Long-term alcohol exposure prior to conception results in lower fetal body weights. *Birth Defects Research. Part B, Developmental and Reproductive Toxicology*, **71,** 135-141.

Lynch, S.R. (2000). The potential impact of iron supplementation during adolescence on iron status in pregnancy. *Journal of Nutrition*, **130,** 448-.

Maier, S.E. & West, J.R. (2001). Drinking patterns and alcohol-related birth defects. *Alcohol Research and Health*, **25,** 168-174.

Mann, J.I. & Aitken, E. (2003). The re-emergence of iodine deficiency in New Zealand? *New Zealand Medical Journal*, **116,** U351.

Mantell, C.D., Craig, E.D., Stewart, A.W., Ekeroma, A.J. & Mitchell, E.A. (2004). Ethnicity and birth outcome: New Zealand trends 1980-2001: Part 2. Pregnancy outcomes for Maori women. *Australian and New Zealand Journal of Obstetrics and Gynaecology*, **44,** 537-540.

Martinez-Frias, M.L., Bermejo, E., Rodriguez-Pinilla, E. & Frias, J.L. (2004). Risk for congenital anomalies associated with different sporadic and daily doses of alcohol consumption during pregnancy: a case-control study. *Birth Defects Research. Part A, Clinical and Molecular Teratology*, **70,** 194-200.

Mathews, F., Youngman, L. & Neil, A. (2004). Maternal circulating nutrient concentrations in pregnancy: implications for birth and placental weights of term infants. *American Journal of Clinical Nutrition*, **79,** 103-110.

Mathews, F., Yudkin, P. & Neil, A. (1999). Influence of maternal nutrition on outcome of pregnancy: prospective cohort study. *British Medical Journal. Clinical Research Edition*, **319,** 339-343.

May, P.A., Gossage, J.P., White-Country, M., Goodhart, K., Decoteau, S., Trujillo, P.M., Kalberg, W.O., Viljoen, D.L. & Hoyme, H.E. (2004). Alcohol consumption and other maternal risk factors for fetal alcohol syndrome among three distinct samples of women before, during, and after pregnancy: the risk is relative. *American Journal of Medical Genetics. Part C, Seminars in Medical Genetics*, **127,** 10-20.

McArdle, H.J. & Ashworth, C.J. (1999). Micronutrients in fetal growth and development. *British Medical Bulletin*, **55,** 499-510.

McDonald, A.D., Armstrong, B.G. & Sloan, M. (1992). Cigarette, alcohol, and coffee consumption and congenital defects. *American Journal of Public Health*, **82,** 91-93.

McElhatton, P.R., Bateman, D.N., Evans, C., Pughe, K.R. & Thomas, S.H. (1999). Congenital anomalies after prenatal ecstasy exposure. *Lancet*, **354,** 1441-1442.

McLeod, D., Pullon, S. & Cookson, T. (2003). Factors that influence changes in smoking behaviour during pregnancy. *New Zealand Medical Journal*, **116,** 418-425.

McLeod, D., Pullon, S., Cookson, T. & Cornford, E. (2002). Factors influencing alcohol consumption during pregnancy and after giving birth. *New Zealand Medical Journal*, **115,** 29-35.

Metges, C.C. (2001). Does dietary protein in early life affect the development of adiposity in mammals? *Journal of Nutrition*, **131,** 2062-2066.

Mills, J.L., Holmes, L.B., Aarons, J.H., Simpson, J.L., Brown, Z.A., Jovanovic-Peterson, L.G., Conley, M.R., Graubard, B.I., Knopp, R.H. & Metzger, B.E. (1993). Moderate caffeine use and the risk of spontaneous abortion and intrauterine growth retardation. *Journal of the American Medical Association*, **269,** 593-597.

Mitchell, E.A., Robinson, E., Clark, P.M., Becroft, D.M.O., Glavish, N., Pattison, N.S., Pryor, J.E., Thompson, J.M.D. & Wild, C.J. (2004). Maternal nutritional risk factors for small for gestational age babies in a developed country: a case-control study. *Archives of Disease in Childhood. Fetal and Neonatal Edition*, **89,** 431-435.

MOH. (1995). Food and nutrition guidelines for healthy pregnancy in women: a background paper. Ministry of Health: Wellington.

MOH. (1999). Tobacco Facts 1999. Ministry of Health: Wellington.

MOH. (2001). Sexual and reproductive health strategy. Phase one. Ministry of Health: Wellington.

MOH. (2002). Tobacco Facts 2002: Public Health Intelligence Occasional Bulletin Report No 2. Ministry of Health: Wellington.

MOH. (2003a). Food and nutrition guidelines for adult New Zealanders: a background paper. Ministry of Health: Wellington.

MOH. (2003b). Improving folate intake in New Zealand: Policy implications. Ministry of Health: Wellington.

MOH. (2003c). A snapshot of health: Provisional results of the 2002/03 New Zealand Health Survey. Ministry of Health: Wellington.

MOH. (2004). A portrait of health: Key results of the 2002/03 New Zealand Health Survey. Ministry of Health: Wellington.

Moos, M. (2002). Preconceptional health promotion: opportunities abound. *Maternal and Child Health Journal*, **6,** 71-73.

Moreira, D.P., Monteiro, M.C., Ribeiro-Alves, M., Donangelo, C.M. & Trugo, L.C. (2005). Contribution of chlorogenic acids to the iron-reducing activity of coffee beverages. *Journal Of Agricultural And Food Chemistry*, **53,** 1399-1402.

Morgane, P.J., Austin-LaFrance, R., Bronzino, J., Tonkiss, J., Diaz-Cintra, S., Cintra, L., Kemper, T. & Galler, J.R. (1993). Prenatal malnutrition and development of the brain. *Neuroscience and Biobehavioral Reviews*, **17,** 91-128.

MRC. (1991). Prevention of neural tube defects: results of the Medical Research Council Vitamin Study. MRC Vitamin Study Research Group. *Lancet*, **338,** 131-137.

Mueller, B.A., Daling, J.R., Weiss, N.S. & Moore, D.E. (1990). Recreational drug use and the risk of primary infertility. *Epidemiology*, **1,** 195-200.

Murphy, J.F., Newcombe, R.G., O'Riordan, J., Coles, E.C. & Pearson, J.F. (1986). Relation of haemoglobin levels in first and second trimesters to outcome of pregnancy. *Lancet*, **327,** 992-995.

Naimi, T.S., Lipscomb, L.E., Brewer, R.D. & Gilbert, B.C. (2003). Binge drinking in the preconception period and the risk of unintended pregnancy: implications for women and their children. *Pediatrics*, **111,** 1136-1141.

Neggers, Y. & Goldenberg, R.L. (2003). Some thoughts on body mass index, micronutrient intakes and pregnancy outcome. *Journal of Nutrition*, **133,** 1737S-1740S.

Neggers, Y.H., Cutter, G., Acton, R. & Tamura, T. (1990). A positive association bewteen maternal serum zinc concentration and birth weight. *American Journal of Clinical Nutrition*, **51,** 678-694.

Neggers, Y.H., Goldenberg, R.L., Ramey, S.L. & Cliver, S.P. (2003). Maternal prepregnancy body mass index and psychomotor development in children. *Acta Obstetricia et Gynecologica Scandinavica*, **82,** 235-240.

Neggers, Y.H., Goldenberg, R.L., Tamura, T., Cliver, S.P. & Hoffman, H.J. (1997). The relationship between maternal dietary intake and infant birth weight. *Acta Obstetricia et Gynecologica Scandinavica. Supplement*, **165,** 71-75.

Ness, R.B., Grisso, J.A., Hirschinger, N., Markovic, N., Shaw, L.M., Day, N.L. & Kline, J. (1999). Cocaine and tobacco use and the risk of spontaneous abortion. *New England Journal of Medicine*, **340,** 333-339.

Norman, R.J. & Clark, A. (1998). Obesity and reproductive disorders: a review. *Reproduction, Fertility and Development*, **10,** 55-63.

Nulman, I., Rovet, J., Kennedy, D., Wasson, C., Gladstone, J., Fried, S. & Koren, G. (2004). Binge alcohol consumption by non-alcohol-dependent women during pregnancy affects child behaviour, but not general intellectual functioning; a prospective controlled study. *Archives of Women's Mental Health*, **7,** 173-181.

Nunes, M.A., Barros, F.C., Anselmo Olinto, M.T., Camey, S. & Mari, J.D.J. (2003). Prevalence of abnormal eating behaviours and inappropriate methods of weight control in young women from Brazil: a population-based study. *Eating and Weight Disorders*, **8,** 100-106.

Oken, E., Kleinman, K.P., Olsen, S.F., Rich-Edwards, J.W. & Gillman, M.W. (2004). Associations of seafood and elongated n-3 fatty acid intake with fetal growth and length of gestation: results from a US pregnancy cohort. *American Journal of Epidemiology*, **160,** 774-783.

O'Leary, C.M. (2004). Fetal alcohol syndrome: diagnosis, epidemiology, and developmental outcomes. *Journal of Paediatrics and Child Health*, **40,** 2-7.

Oliver, M.H., Hawkins, P., Breier, B.H., Van Zijl, P.L., Sargison, S.A. & Harding, J.E. (2001). Maternal undernutrition during the periconceptual period increases plasma taurine levels and insulin response to glucose but not arginine in the late gestational fetal sheep. *Endocrinology*, **142,** 4576-4579.

Olsen, S.F. & Secher, N.J. (2002). Low consumption of seafood in early pregnancy as a risk factor for preterm delivery: prospective cohort study. *British Medical Journal. Clinical Research Edition*, **324,** 447.

Parazzini, F., Chatenoud, L., Surace, M., Tozzi, L., Salerio, B., Bettoni, G. & Benzi, G. (2003). Moderate alcohol drinking and risk of preterm birth. *European Journal of Clinical Nutrition*, **57,** 1345-1349.

Park, B., McPartland, J.M. & Glass, M. (2004). Cannabis, cannabinoids and reproduction. *Prostaglandins, Leukotrienes, and Essential Fatty Acids*, **70,** 189-197.

Parmeter, K. & Wardle, J. (1999). Development of a general nutrition knowledge questionnaire for adults. *European Journal of Clinical Nutrition*, **53,** 298-308.

Paterson, J., Cowley, E.T., Percival, T. & Williams, M. (2004). Pregnancy planning by mothers of Pacific infants recently delivered at Middlemore Hospital. *New Zealand Medical Journal*, **117,** 744-750.

PCASRM. (2004). Smoking and infertility. *Fertility and Sterility*, **81,** 1181-1186.

Persad, V.L., Van den Hof, M.C., Dube, J.M. & Zimmer, P. (2002). Incidence of open neural tube defects in Nova Scotia after folic acid fortification. *Canadian Medical Association Journal*, **167,** 241-245.

Petrini, J.R., Damus, K., Johnston, R.B., Mattison, D.R. & CDC. (1999). Knowledge and use of folic acid by women of childbearing age-United States, 1995 and 1998. *Morbidity and Mortality Weekly Report*, **48,** 325-327.

Picciano, M.F. (2003). Pregnancy and lactation: physiological adjustments, nutritional requirements and the role of dietary supplements. *Journal of Nutrition*, **133,** 1997S-2002S.

Prentice, P. (1996). Maternal obesity increses congenital malformations. *Nutrition Reviews*, **54,** 146-152.

Quigley, R. & Watts, C. (1997). Food comes first: Methodologies for the National Nutrition Survey of New Zealand. Ministry of Health: Wellington.

Ramakrishnan, U., Manjrekar, R., Rivera, J., Gonzales-Cossio, T. & Martorell, R. (1999). Micronutrients and pregnancy outcome: A review of the literature. *Nutrition Research*, **19,** 103-159.

Rao, S., Yajnik, C.S., Kanade, A., Fall, C.H., Margetts, B.M., Jackson, A.A., Shier, R., Joshi, S., Rege, S., Lubree, H. & Desai, B. (2001). Intake of micronutrient-rich foods in rural Indian mothers is associated with the size of their babies at birth: Pune Maternal Nutrition Study. *Journal of Nutrition*, **131,** 1217-1224.

Rasch, V. (2003). Cigarette, alcohol, and caffeine consumption: risk factors for spontaneous abortion. *Acta Obstetricia et Gynecologica Scandinavica*, **82,** 182-188.

Rasmussen, K.M. (2001). Is there a causal relationship between iron deficiency or iron-deficiency anemia and weight at birth, length of gestation and perinatal mortality? *Journal of Nutrition*, **131,** 590S-603.

Ray, J.G., Singh, G. & Burrows, R.F. (2004). Evidence for suboptimal use of periconceptional folic acid supplements globally. *British Journal of Obstetrics and Gynaecology*, **111,** 399-408.

Refsum, H. (2001). Folate, vitamin B_{12} and homocysteine in relation to birth defects and pregnancy outcome. *British Journal of Nutrition*, **85,** 109-113.

Reznikoff-Etievant, M.F., Zittoun, J., Vaylet, C., Pernet, P. & Milliez, J. (2002). Low vitamin B_{12} level as a risk factor for very early recurrent abortion. *European Journal of Obstetrics, Gynecology, and Reproductive Biology*, **104,** 152-159.

Robert, E., Francannet, C. & Shaw, G.M. (1995). Neural tube defects and maternal weight reduction in early pregnancy. *Reproductive Toxicology*, **9,** 57-59.

Roeleveld, N., Vingerhoets, E., Zielhuis, G.A. & Gabreels, F. (1992). Mental retardation associated with parental smoking and alcohol consumption before, during and after pregnancy. *Preventive Medicine*, **21,** 110-119.

Rolschau, J., Date, J. & Kristoffersen, K. (1979). Folic acid supplement and intrauterine growth. *Acta Obstetricia et Gynecologica Scandinavica*, **58,** 343-346.

Ronnenberg, A.G., Goldman, M.B., Chen, D., Aitken, I.W., Willett, W.C., Selhub, J. & Xu, X. (2002a). Preconception folate and vitamin B_6 status and clinical spontaneous abortion in Chinese women. *Obstetrics and Gynecology*, **100,** 107-113.

Ronnenberg, A.G., Goldman, M.B., Chen, D., Aitken, I.W., Willett, W.C., Selhub, J. & Xu, X. (2002b). Preconception homocysteine and B vitamin status and birth outcomes in Chinese women. *American Journal of Clinical Nutrition*, **76,** 1385-1391.

Ronnenberg, A.G., Wang, X., Xing, H., Chen, C., Chen, D., Guang, W., Guang, A., Wang, L., Ryan, L. & Xu, X. (2003). Low preconception body mass index is associated with birth outcome in a prospective cohort of Chinese women. *Journal of Nutrition*, **133,** 3449-3455.

Ronnenberg, A.G., Wood, R.J., Wang, X., Xing, H., Chen, C., Chen, D., Guang, W., Huang, A., Wang, L. & Xu, X. (2004). Preconception hemoglobin and ferritin concentrations are associated with pregnancy outcome in a prospective cohort of Chinese women. *Journal of Nutrition*, **134,** 2586-2591.

Roseboom, T.J., van der Meulen, J.H., Ravelli, A.C., Osmond, C., Barker, D.J. & Bleker, O.P. (2001). Effects of prenatal exposure to the Dutch famine on adult disease in later life: an overview. *Molecular and Cellular Endocrinology*, **185,** 93-98.

Rosenberg, K.D., Gelow, J.M. & Sandoval, A.P. (2003a). Pregnancy intendedness and the use of periconceptional folic acid. *Pediatrics*, **111,** 1142-1145.

Rosenberg, T.J., Garbers, S., Chavkin, W. & Chiasson, M.A. (2003b). Prepregnancy weight and adverse perinatal outcomes in an ethnically diverse population. *Obstetrics and Gynecology*, **102,** 1022-1027.

Roth, L.K. & Taylor, H.S. (2001). Risks of smoking to reproductive health: assessment of women's knowledge. *American Journal of Obstetrics and Gynecology*, **184,** 934-939.

Rothman, K.J., Moore, L.L., Singer M.R, Nquyen, U.S., Mannino, S. & Milunsky, A. (1995). Teratogenicity of high vitamin A intake. *New England Journal of Medicine*, **333**.

Russell, D., Parnell, W. & Wilson, N. (1999). NZ Food: NZ People. Key results of the 1997 National Nutrition Survey. Ministry of Health: Wellington.

Sallout, B. & Walker, M. (2003). The fetal origin of adult diseases. *Journal of Obstetrics and Gynaecology*, **23,** 555-560.

Scagliusi, F.B., Polacow, V.O., Artioli, G.G., Benatti, F.B. & Lancha, A.H., Jr. (2003). Selective underreporting of energy intake in women: magnitude, determinants, and effect of training. *Journal of the American Dietetic Association*, **103,** 1306-1313.

Scanlon, K.S., Ferencz, C., Loffredo, C.A., Wilson, P.D., Correa-Villasenor, A., Khoury, M.J. & Willett, W.C. (1998). Preconceptional folate intake and malformations of the cardiac outflow tract. Baltimore-Washington Infant Study Group. *Epidemiology*, **9,** 95-98.

Scanlon, K.S., Yip, R., Schieve, L.A. & Cogswell, M.E. (2000). High and low hemoglobin levels during pregnancy: differential risks for preterm birth and small for gestational age. *Obstetrics and Gynecology*, **96,** 741-748.

Schader, I. & Corwin, P. (1999). How many pregnant women in Christchurch are using folic acid supplements in early pregnancy? *New Zealand Medical Journal*, **112,** 463-465.

Schaffer, D.M., Velie, E.M., Shaw, G.M. & Todoroff, K.P. (1998). Energy and nutrient intakes and health practices of Latinas and white non-Latinas in the 3 months before pregnancy. *Journal of the American Dietetic Association*, **98,** 876-884.

Schakel, S.F. (2001). Maintaining a nutrient database in a changing marketplace: keeping pace with changing food products-a research perspective. *Journal of Food Composition and Analysis*, **14,** 315-322.

Schieve, L.A., Cogswell, M.E., Scanlon, K.S., Perry, G., Ferre, C., Blackmore-Prince, C., Yu, S.M. & Rosenberg, D. (2000). Prepregnancy body mass index and pregnancy weight gain: associations with preterm delivery. The NMIHS Collaborative Study Group. *Obstetrics and Gynecology*, **96,** 194-200.

Scholl, T.O. (2005). Iron status during pregnancy: setting the stage for mother and infant. *American Journal of Clinical Nutrition*, **81,** 1218S-1222S.

Scholl, T.O., Chen, X., Khoo, C.S. & Lenders, C. (2004). The dietary glycemic index during pregnancy: influence on infant birth weight, fetal growth, and biomarkers of carbohydrate metabolism. *American Journal of Epidemiology*, **159,** 467-474.

Scholl, T.O., Hediger, M.L., Fischer, R.L. & Shearer, J. (1992). Anemia vs iron deficiency: increased risk of preterm delivery in a prospective study. *American Journal of Clinical Nutrition*, **55,** 985-988.

Scholl, T.O., Hediger, M.L., Schall, J.I., Khoo, C.S. & Fischer, R.L. (1996). Dietary and serum folate: their influence on the outcome of pregnancy. *American Journal of Clinical Nutrition*, **63,** 520-525.

Scholl, T.O. & Johnson, W.G. (2000). Folic acid: influence on the outcome of pregnancy. *American Journal of Clinical Nutrition*, **71,** 1295S-1303S.

Scholl, T.O. & Reilly, T. (2000). Anemia, iron and pregnancy outcome. *Journal of Nutrition*, **130,** 443S-447S.

Shah, D. & Sachdev, H.P. (2001). Effect of gestational zinc deficiency on pregnancy outcomes: summary of observation studies and zinc supplementation trials. *British Journal of Nutrition*, **85,** 101S-108S.

Shaw, G.M., Croen, L.A., Todoroff, K. & Tolarova, M.M. (2000a). Periconceptional intake of vitamin supplements and risk of multiple congenital anomalies. *American Journal of Medical Genetics*, **93,** 188-193.

Shaw, G.M. & Lammer, E.J. (1999). Maternal periconceptional alcohol consumption and risk for orofacial clefts. *Journal of Pediatrics*, **134,** 298-303.

Shaw, G.M., Quach, T., Nelson, V., Carmichael, S.L., Schaffer, D.M., Selvin, S. & Yang, W. (2003). Neural tube defects associated with maternal periconceptional dietary intake of simple sugars and glycemic index. *American Journal of Clinical Nutrition*, **78,** 972-978.

Shaw, G.M., Schaffer, D., Velie, E.M., Morland, K. & Harris, J.A. (1995). Periconceptional vitamin use, dietary folate, and the occurrence of neural tube defects. *Epidemiology*, **6,** 219-226.

Shaw, G.M., Todoroff, K., Schaffer, D.M. & Selvin, S. (1999). Periconceptional nutrient intake and risk for neural tube defect-affected pregnancies. *Epidemiology*, **10,** 711-716.

Shaw, G.M., Todoroff, K., Schaffer, D.M. & Selvin, S. (2000b). Maternal height and prepregnancy body mass index as risk factors for selected congenital anomalies. *Paediatric and Perinatal Epidemiology*, **14,** 234-239.

Shaw, G.M., Velie, E.M. & Schaffer, D. (1996). Risk of neural tube defect-affected pregnancies among obese women. *Journal of the American Medical Association*, **275,** 1093-1096.

Sheiner, E., Levy, A., Menes, T.S., Silverberg, D., Katz, M. & Mazor, M. (2004). Maternal obesity as an independent risk factor for caesarean delivery. *Paediatric and Perinatal Epidemiology*, **18,** 196-201.

Shoob, H.D., Sargent, R.G., Thompson, S.J., Best, R.G., Drane, J.W. & Tocharoen, A. (2001). Dietary methionine is involved in the etiology of neural tube defect-affected pregnancies in humans. *Journal of Nutrition*, **131,** 2653-2658.

Siemelink, M., Verhoef, A., Dormans, J.A.M.A., Span, P.N. & Piersma, A.H. (2002). Dietary fatty acid composition during pregnancy and lactation in the rat programs growth and glucose metabolism in the offspring. *Diabetologia*, **45,** 1397-1403.

Signorello, L.B. & McLaughlin, J.K. (2004). Maternal caffeine consumption and spontaneous abortion: a review of the epidemiologic evidence. *Epidemiology*, **15,** 229-239.

Smithells, R.W., Sheppard, S. & Schorah, C.J. (1976). Vitamin deficiencies and neural tube defects. *Archives of Disease in Childhood*, **51,** 944-950.

Sollid, C.P., Wisborg, K., Hjort, J. & Secher, N.J. (2004). Eating disorder that was diagnosed before pregnancy and pregnancy outcome. *American Journal of Obstetrics and Gynecology*, **190,** 206-210.

Spinillo, A., Capuzzo, E., Piazzi, G., Ferrari, A., Morales, V. & Di Mario, M. (1998). Risk of spontaneous preterm delivery by combined body mass index and gestational weight gain patterns. *Acta Obstetricia et Gynecologica Scandinavica*, **77,** 32-36.

Stanton, C.K. & Gray, R.H. (1995). Effects of caffeine consumption on delayed conception. *American Journal of Epidemiology*, **142,** 1322-1329.

Statistics New Zealand. (2003). Auckland Community Profile-Census 2001. Accessed 7 June 2005. www.stats.govt.nz.

Steegers-Theunissen, R.P.M., Boers, G.H.J., Trijbels, F.J.M., Finkelstein, J.D., Blom, H.J., Thomas, C.M.G., Borm, G.F., Wouters, M.G.A.J. & Eskes, T.K.A.B. (1994). Maternal hyperhomocysteinemia: a risk factor for neural-tube defects? *Metabolism*, **43,** 1475-1480.

Steer, P., Alam, M.A., Wadsworth, J. & Welch, A. (1995). Relation between maternal haemoglobin concentration and birth weight in different ethnic groups. *British Medical Journal*, **310,** 489-491.

Steer, P.J. (2000). Maternal hemogolobin concentration and birth weight. *American Journal of Clinical Nutrition*, **71,** 1285S-1287S.

Stoll, C., Dott, B., Alembik, Y. & Koehl, C. (1999). Maternal trace elements, vitamin B_{12}, vitamin A, folic acid, and fetal malformations. *Reproductive Toxicology*, **13,** 53-57.

Susser, M. & Stein, Z. (1994). Timing in prenatal nutrition: a reprise of the Dutch Famine Study. *Nutrition Reviews*, **52,** 84-94.

Tamura, T., Goldenberg, R.L., Freeberg, L.E., Cliver, S.P., Cutter, G.R. & Hoffman, H.J. (1992). Maternal serum folate and zinc concentrations and their relationships to pregnancy outcome. *American Journal of Clinical Nutrition*, **56,** 365-370.

Tamura, T., Goldenberg, R.L., Johnston, K.E., Cliver, S.P. & Hoffman, H.J. (1997). Serum concentrations of zinc, folate, vitamins A and E, and proteins, and their relationships to pregnancy outcome. *Acta Obstetricia et Gynecologica Scandinavica. Supplement*, **165,** 63-70.

Tamura, T., Goldenberg, R.L., Johnston, K.E. & DuBard, M. (2000). Maternal plasma zinc concentrations and pregnancy outcome. *American Journal of Clinical Nutrition*, **71,** 109-113.

Tapsell, L.C., Brenninger, V. & Barnard, J. (2000). Applying conversation analysis to foster accurate reporting in the diet history interview. *Journal of the American Dietetic Association*, **100,** 818-824.

Taren, D.L., Tobar, M., Hill, A., Howell, W., Shisslak, C., Bell, I. & Ritenbaugh, C. (1999). The association of energy intake bias with psychological scores of women. *European Journal of Clinical Nutrition*, **53,** 570-578.

Thame, M., Wilks, R.J., McFarlane-Anderson, N., Bennett, F.I. & Forrester, T.E. (1997). Relationship between maternal nutritional status and infant's weight and body proportions at birth. *European Journal of Clinical Nutrition*, **51,** 134-138.

Thompson, F.E. & Byers, T. (1994). Dietary assessment resource manual. *Journal of Nutrition*, **124,** 2245S-2317S.

Thompson, S.J., Torres, M.E., Stevenson, R.E., Dean, J.H. & Best, R.G. (2003). Periconceptional multivitamin folic acid use, dietary folate, total folate and risk of neural tube defects in South Carolina. *Annals of Epidemiology*, **13,** 412-418.

Tolstrup, J.S., Kjaer, S.K., Holst, C., Sharif, H., Munk, C., Osler, M., Schmidt, L., Andersen, A.-M.N. & GrOnbAEk, M. (2003a). Alcohol use as predictor for infertility in a representative population of Danish women. *Acta Obstetricia et Gynecologica Scandinavica*, **82,** 744-749.

Tolstrup, J.S., Kjaer, S.K., Munk, C., Madsen, L.B., Ottesen, B., Bergholt, T. & Gronbaek, M. (2003b). Does caffeine and alcohol intake before pregnancy predict the occurrence of spontaneous abortion? *Human Reproduction*, **18,** 2704-2710.

Torvaldsen, S., Kurinczuk, J.J., Bower, C., Parsons, D.E. & Roberts, C.L. (1999). Listeria awareness among new mothers in Western Australia. *Australian and New Zealand Journal of Public Health*, **23,** 362-367.

Troppmann, L., Gray-Donald, K. & Johns, T. (2002). Supplement use: is there any nutritional benefit? *Journal of the American Dietetic Association*, **102,** 818-825.

Tuthill, D.P., Stewart, J.H., Coles, E.C., Andrews, J. & Cartlidge, P.H. (1999). Maternal cigarette smoking and pregnancy outcome. *Paediatric and Perinatal Epidemiology*, **13,** 245-253.

Uauy, R., Hoffman, D.R., Peirano, P., Birch, D.G. & Birch, E.E. (2001). Essential fatty acids in visual and brain development. *Lipids*, **36,** 885-895.

Unusan, N. (2004). Assessment of Turkish women's knowledge concerning folic acid and prevention of birth defects. *Public Health Nutrition*, **7,** 851-855.

Vahratian, A., Siega-Riz, A.M., Savitz, D.A. & Thorp, J. (2004a). Multivitamin use and the risk of preterm birth. *American Journal of Epidemiology*, **160,** 886-892.

Vahratian, A., Zhang, J., Troendle, J.F., Savitz, D.A. & Siega-Riz, A.M. (2004b). Maternal prepregnancy overweight and obesity and the pattern of labor progression in term nulliparous women. *Obstetrics and Gynecology*, **104,** 943-951.

van Aalst, I., Kazakov, D. & Mclean, G. (2002). SPARC fact series 1997-2001. Sport and Recreation New Zealand: Wellington.

van den Broek, N. (2003). Anaemia and micronutrient deficiencies. *British Medical Bulletin*, **67,** 149-160.

van der Pal-de Bruin, K.M., de Walle, H.E.K., de Rover, C.M., Jeeninga, W., Cornel, M.C., de Jong-van den Berg, L.T.W., Buitendijk, S.E. & Paulussen, T.G.W.M. (2003). Influence of educational level on determinants of folic acid use. *Paediatric and Perinatal Epidemiology*, **17,** 256-263.

van Rooij, I.A.L.M., Vermeij-Keers, C., Kluijtmans, L.A.J., Ocke, M.C., Zielhuis, G.A., Goorhuis-Brouwer, S.M., van der Biezen, J.-J., Kuijpers-Jagtman, A.-M. & Steegers-Theunissen, R.P.M. (2003). Does the interaction between maternal folate intake and the methylenetetrahydrofolate reductase polymorphisms affect the risk of cleft lip with or without cleft palate? *American Journal of Epidemiology*, **157,** 583-591.

Veile, E.M., Block, G., Shaw, G.M., Samuels, S.J., Schaffer, D.M. & Kulldorff, M. (1999). Maternal supplemental and dietary zinc intake and the occurrence of neural tube defects in California. *American Journal of Epidemiology*, **150,** 605-616.

Venn, B.J., Green, T.J., Moser, R., McKenzie, J.E., Skeaff, C.M. & Mann, J. (2002). Increases in blood folate indices are similar in women of childbearing age supplemented with [6S]-5-methyltetrahydrofolate and folic acid. *Journal of Nutrition*, **132,** 3353-3355.

Vuckovic, N., Ritenbaugh, C., Taren, D.L. & Tobar, M. (2000). A qualitative study of participants' experiences with dietary assessment. *Journal of the American Dietetic Association*, **100,** 1023-1028.

Waldmann, A., Koschizke, J.W., Leitzmann, C. & Hahn, A. (2003). Dietary intakes and lifestyle factors of a vegan population in Germany: results from the German Vegan Study. *European Journal of Clinical Nutrition*, **57,** 947-955.

Waller, K.D., Mills, J.L., Simpson, J.L., Cunningham, G.C., Conley, M.R., Lassman, M.R. & Rhoads, G.G. (1994). Are obese women at higher risk for producing malformed offspring? *Obstetrics and Gynecology*, **170,** 541-548.

Wang, J.X., Davies, M. & Norman, R.J. (2000). Body mass and probability of pregnancy during assisted reproduction treatment: retrospective study. *British Medical Journal*, **321,** 1320-1321.

Watkins, M.L., Scanlon, K., Mulinare, J. & Khoury, M.J. (1996). Is maternal obesity a risk factor for ancencephaly and spina bifida? *Epidemiology*, **7,** 507-512.

Watson, M., Watson, L., Bell, R. & Halliday, J. (2001). The increasing knowledge of the role of periconceptional folate in Victorian women of child-bearing age: follow-up of a randomised community intervention trial. *Australian and New Zealand Journal of Public Health*, **25,** 389-395.

Watson, P. & McDonald, B. (1999). Nutrition during pregnancy: report to the Ministry of Health. Massey University: Auckland.

Weber, M.K., Floyd, R.L., Riley, E.P. & Snider, D.E., Jr. (2002). National Task Force on Fetal Alcohol Syndrome and Fetal Alcohol Effect: defining the national agenda for fetal alcohol syndrome and other prenatal alcohol-related effects. *Morbidity and Mortality Weekly Report. Recommendations and Reports*, **51,** 9-12.

Wen, W., Shu, X.O., Jacobs, D.R., Jr & Brown, J.E. (2001). The associations of maternal caffeine consumption and nausea with spontaneous abortion. *Epidemiology*, **12,** 38-42.

Wen, X., Enokizo, A., Hattori, H., Kobayashi, S., Murata, M. & Homma, S. (2005). Effect of roasting on properties of the zinc-chelating substance in coffee brews. *Journal Of Agricultural And Food Chemistry*, **53,** 2684-2689.

Werler, M.M., Louik, C., Shapiro, S. & Mitchell, A.A. (1996). Prepregnant weight in relation to risk of neural tube defects. *Journal of the American Medical Association*, **275,** 1089-1092.

Werler, M.M., Shapiro, S. & Mitchell, A.A. (1993). Periconceptional folic acid exposure and risk of occurrent neural tube defects. *Journal of the American Medical Association*, **269,** 1257-1261.

Whitehead, N. & Lipscomb, L. (2003). Patterns of alcohol use before and during pregnancy and the risk of small-for-gestational-age birth. *American Journal of Epidemiology*, **158,** 654-662.

WHO. (1995). Maternal anthropometry and pregnancy outcomes : a WHO collaborative study. *Bulletin of the World Health Organisation*, **73,** 1S-98S.

Wilcox, A., Weinberg, C. & Baird, D. (1988). Caffeinated beverages and decreased fertility. *Lancet*, **2,** 1453-1456.

Wild, J., Schorah, C.J., Maude, K. & Levene, M.I. (1996). Girls should be taught at school about importance of folic acid. *British Medical Journal*, **312,** 974-.

Wilkins, C., Casswell, S., Bhatta, K. & Pledger, M. (2002). Drug use in New Zealand: National Surveys comparison 1998 and 2001. Alcohol and Public Health Research Unit, University Of Auckland: Auckland.

Williams, L.J., Correa, A. & Rasmussen, S. (2004). Maternal lifestyle factors and risk for ventricular septal defects. *Birth Defects Research. Part A, Clinical and Molecular Teratology*, **70,** 59-64.

Williams, M.A., Monson, R.R., Goldman, M.B., Mittendorf, R. & Ryan, K.J. (1990). Coffee and delayed conception. *Lancet*, **335,** 1603.

Williams, M.T., Vorhees, C.V., Boon, F., Saber, A.J. & Cain, D.P. (2002). Methamphetamine exposure from postnatal day 11 to 20 causes impairments in both behavioral strategies and spatial learning in adult rats. *Brain Research*, **958,** 312-321.

Williams, R.J. & Gloster, S.P. (1999). Knowledge of fetal alcohol syndrome (FAS) among natives in Northern Manitoba. *Journal of Studies on Alcohol*, **60,** 833-836.

Wilson, N.C., Russell, D.G. & Wilson, B.D. (2001). *Profiling New Zealanders: 1997 anthropometric norms*. LINZ Activity and Health Research Unit, University of Otago: Dunedin.

Wisborg, K., Kesmodel, U., Henriksen, T.B., Hedegaard, M. & Secher, N.J. (2003). A prospective study of maternal smoking and spontaneous abortion. *Acta Obstetricia et Gynecologica Scandinavica*, **82,** 936-941.

Wynn, M. & Wynn, A. (1988). Nutrition around conception and the prevention of low birthweight. *Nutrition and Health*, **6,** 37-52.

Zaadstra, B.M., Looman, C.W., te Velde, E.R., Habbema, J.D. & Karbaat, J. (1994). Moderate drinking: no impact on female fecundity. *Fertility and Sterility*, **62,** 948-954.

Zaadstra, B.M., Seidell, J.C., Van Noord, P.A., te Velde, E.R., Habbema, J.D., Vrieswijk, B. & Karbaat, J. (1993). Fat and female fecundity: prospective study of effect of body fat distribution on conception rates. *British Medical Journal. Clinical Research Edition*, **306,** 484-487.

Zijp, I.M., Korver, O. & Tijburg, L.B. (2000). Effect of tea and other dietary factors on iron absorption. *Critical Reviews in Food Science And Nutrition*, **40,** 371-398.

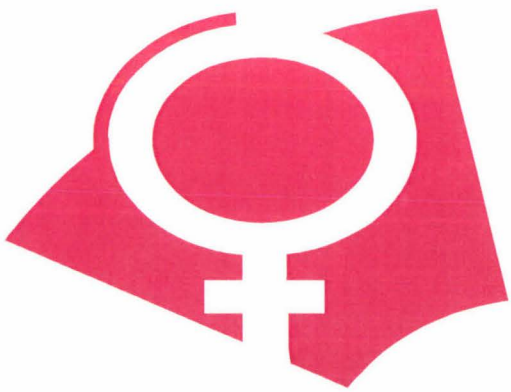
Appendices

APPENDIX A

Questionnaire

Massey University
COLLEGE OF SCIENCES

Women's Health and Nutrition Survey



Participant has met the selection criteria:

☐ **Yes**
☐ **No**

Section A: Dietary Habits

1. Do you consider your eating habits to be healthy? A1

☐ Yes =1 ☐ No =2 ☐ Not sure=3 ☐ Choose not to answer=0

2. Is there anything that could be done to improve your eating habits? A2

☐ Yes =1 ☐ No =2 ☐ Not sure=3 ☐ Choose not to answer=0

3. What could be done to improve your diet?_____ A3

_____

_____

_____

_____

_____

_____

4. Do you try to control your weight? A4

☐ Yes =1 ☐ No =2 ☐ Not sure=3 ☐ Choose not to answer=0

5. If, yes. How? *(Do you follow exercise, a diet, try to eat healthy, follow a strict diet or a combination?)*_____ A5

_____

_____

_____

_____

_____

_____

6. Are you currently satisfied with your body weight? A6

☐ Yes =1 ☐ No =2 ☐ Not sure=3 ☐ Choose not to answer=0

7. What would you like to change about your body weight?_____ A7

_____

8. Do you drink alcohol? A8

☐ Yes =1 ☐ No =2 ☐ Not sure=3 ☐ Choose not to answer=0

9. On average, how often do you drink alcohol per week or per month? *(eg. 1-3 times/mth, 1-2 days/wk, 3-4 /wk,5-6/wk, everyday)*_____

_____ A10

10. On average, how many standard alcoholic drinks do you have per week? Show card 1. *(eg. 1-5/wk, 5-10/wk, 11-15/wk, >15/wk)*_____

_____ A12

11. Do you usually drink beer, wine or spirits?_____ A13

9. Do you drink tea, coffee, cola or energy drinks?

☐ Yes =1 ☐ No =2 ☐ Not sure=3 ☐ Choose not to answer=0

13. Which do you drink?

Coffee		Cola	
Tea		Energy drinks	

14. **How many cups or cans of tea/ coffee/ cola do you drink a day? And what size cup? Use standard cup aids.** A14

01	Coffee		03	Cola	
02	Tea		04	Energy drinks	

15. **What type of coffee do you <u>most often</u> drink?** *(eg. instant, filtered, espresso brewed)*_____ A15

Section B: Lifestyle Characteristics

1. **What types of exercise do you do?**_____ B1

2. **For how long and how many times a week do you spend on each type of exercise?** B2

3. **Would you describe the intensity as light, moderate or vigorous?** *Light- easily carry out conservation, moderate-puffing and difficulty carrying out conservation, vigorous- very heavy puffing and can not talk.*_____

4. **Do you currently smoke?** B4
☐ Yes =1 ☐ No =2 ☐ Not sure=3 ☐ Choose not to answer=0

5. **How many cigarettes do you smoke a day?** *(eg 1-5, 6-10, 11-15, 16-20, > 20)* B5

6. **How long have you currently smoked for?** (< 6mth, 6-12 mth, 1-4 yrs, 5-9 yrs, 10-19 yrs, >20 yrs)_____ B6

7. **Did you use to smoke?** B7
☐ Yes =1 ☐ No =2 ☐ Not sure=3 ☐ Choose not to answer=0

8. **How long ago did you give up?** (eg. < 1 mth, 2-3 mth, 4-6 mth, 7-12 mth, 1-4 yrs, 5-9 yrs, 10-19 yrs, > 20yrs)_____ B8

9. **How stressful would you rate your life on a scale of 0 to 10? (10 very stressful)** B9

Section C: Dietary Supplements

1. **Did you take any vitamin and/ or mineral supplements during the last year?** C1
☐ Yes =1 ☐ No =2 ☐ Not sure=3 ☐ Choose not to answer=0

2. **Are you currently taking any vitamin and/or mineral supplements?** C2
☐ Yes =1 ☐ No =2 ☐ Not sure=3 ☐ Choose not to answer=0

3. **What vitamin and /or mineral supplements are you currently taking? Use show card 2. Fill out Supplement table.**

C3	

4. **Why do you take supplements?**_____

C4	

5. **Is it safe for everybody to use supplements in unlimited amounts?**
☐ Yes [=1] ☐ No [=2] ☐ Not sure [=3] ☐ Choose not to answer [=0]

C5	

C3. What vitamin and/or mineral supplements are you currently taking?

	Type	Brand	Frequency						
			Less than once a month	1-3 times per month	Once per week	More than once per week	Daily	Episodic	Not sure
01	Multi/vitamins or mineral								
02	Multi/vitamins with iron								
03	Multi/vitamins + other minerals								
04	Vitamin A or Carotenoids								
05	Thiamin (B1)								
06	Riboflavin (B2)								
07	Niacin (B3)								
08	Vitamin B6								
09	Vitamin B12								
10	B complex Vitamins								
11	Vitamin C								
121	Vitamin D								
13	Vitamin E								
14	Anti-oxidant Vitamin								
15	Calcium								
16	Iron								
17	Potassium								
18	Folic Acid								
19	Other (specify)								

Section D: Nutritional Knowledge

1. **Have you ever heard of folic acid? This is sometimes also called folate.** D1
   ☐ Yes =1 ☐ No =2 ☐ Not sure=3 ☐ Choose not to answer=0

2. **What do you know about folic acid?** *What is it? Why is it needed? Who needs it? When is it needed?* D2

3. **Are you aware that some food products have extra folic acid added to them?** D3
   ☐ Yes =1 ☐ No =2 ☐ Not sure=3 ☐ Choose not to answer=0

4. **If you where advised to increase your folic acid intake would you rather do this by: (read)** D4

1=	Folic acid supplements	
2=	Products fortified (extra folic acid added) with folic acid	
3=	Increase your natural dietary intake	
4=	You would not want to increase folic acid intake	
5=	Not sure	
6=	Other (specify)	

5. **Which of the following foods are high in folic acid? Use show card 3.** D5

6. **Which of the following foods are high in calcium? Use show card 3.** D6

7. **Which of the following foods are high in iron? Use show card 3.** D7

8. **Are you aware if any foods can decrease the absorption of iron from foods?** D8
   ☐ Yes =1 ☐ No =2 ☐ Not sure=3 ☐ Choose not to answer=0

9. **If so, which of these foods? Choose as many as necessary. Use show card 4.** D9

10. **Where have you received information about nutrition from?** D10

11. **Which was your main source of information?** D11

12. **What form of media do you think is the most effective for influencing your eating habits?** (eg. TV, magazines, books, billboards, pamphlets) D12

Section E: Medical History

1. **Do you have a family doctor that you visit?**
☐ Yes =1 ☐ No =2 ☐ Not sure=3 ☐ Choose not to answer=0 | E1

2. **How often do you visit a doctor?**_____ | E2

3. **Are you on any prescribed medications?**
☐ Yes =1 ☐ No =2 ☐ Not sure=3 ☐ Choose not to answer=0 | E3

4. **What prescribed medications are you on?** _____ | E4

5. **Have you been diagnosed with any of these medical conditions? Show card 5.**
(Diabetes, hypertension, epilepsy, acne, deep vein thrombosis) _____ | E5

6. **How would you describe your menstrual cycle?**
*(eg. Regular/ irregular AND heavy/ moderate/ light OR post-menopausal)*_____ | E6

Section F: Preconception Attitudes

All the following questions are related to when a woman is trying to get pregnant and not while she is actually pregnant. It is the time just before getting pregnant.

1. **Do you think that a woman's eating habits while trying to get pregnant can have an affect on the pregnancy?**
☐ Yes =1 ☐ No =2 ☐ Not sure=3 ☐ Choose not to answer=0 | F1

2. **If so, how?**_____ | F2

3. **If you were to try to get pregnant would you change your eating habits while trying to conceive?**
☐ Yes =1 ☐ No =2 ☐ Not sure=3 ☐ Choose not to answer=0 | F3

4. **How would you change your diet?**_____ | F4

5. **Do you think that women should change the amount of alcohol they drink while trying to get pregnant?** F5
☐ Yes =1 ☐ No =2 ☐ Not sure=3 ☐ Choose not to answer=0

6. **Change how?**_____ F6
_____

7. **Do you think that women should change the amount of caffeine they drink while trying to get pregnant?** F7
☐ Yes =1 ☐ No =2 ☐ Not sure=3 ☐ Choose not to answer=0

8. **Change how?**_____ F8
_____

9. **Are you aware of any foods that a women should avoid if trying to get pregnant?** F9
☐ Yes =1 ☐ No =2 ☐ Not sure=3 ☐ Choose not to answer=0

10. **What are these foods?**_____ F10
_____
_____
_____

If on any prescribed medications:

11. **Are you aware if any of your medications need to be avoided if trying to get pregnant?** F11
☐ Yes =1 ☐ No =2 ☐ Not sure=3 ☐ Choose not to answer=0

12. **What medications?**_____ F12
_____
_____
_____

13. **Where did you receive this advice?**_____ F13
_____
_____

If they have one of the earlier medical conditions:

14. **Have you been advised of any requirements that are specific to your <u>(state medical the medical condition)</u> that should be followed before attempting to get pregnant?** F14
☐ Yes =1 ☐ No =2 ☐ Not sure=3 ☐ Choose not to answer=0

15. **What is required?** _____ F15
_____
_____
_____
_____

16. **Where did you receive this advice?**_____ F16
_____
_____

17. **Do you think that a woman's body weight can affect fertility?** F17
☐ Yes =1 ☐ No =2 ☐ Not sure=3 ☐ Choose not to answer=0

18. **How?** (eg. being under weight or overweight)_____ F18
_____

19. **If you were to try to get pregnant would you seek any nutritional advice?** F19
☐ Yes =1 ☐ No =2 ☐ Not sure=3 ☐ Choose not to answer=0

20. Where would you go?_____

_____

21. The following statements relate to while trying to conceive or while pregnant. Do you agree, disagree or are not sure? *Agree* [1] *Disagree* [2] *Not sure* [3]

01	Women should avoid alcohol while trying to conceive.	
02	Women should avoid alcohol while pregnant.	
03	Women should limit caffeine while trying to conceive.	
04	Women should limit caffeine while pregnant.	
05	An overweight woman should try to lose weight before getting pregnant.	
06	An underweight woman should try to gain weight before getting pregnant.	
07	Smoking reduces fertility in women.	
08	The foods that I eat may affect my ability to conceive.	
09	The foods that my partner eats may affect our ability to conceive.	
10	Pregnant women are at risk of developing anemia.	

22. Are you aware that the New Zealand Ministry of Health has put out guidelines on healthy eating for pregnant women?

☐ Yes [1] ☐ No [2] ☐ Not sure [3] ☐ Choose not to answer [0]

Section G: Pregnancy history

1. Have you ever had a negative pregnancy test done at the doctors?

☐ Yes [1] ☐ No [2] ☐ Not sure [3] ☐ Choose not to answer [0]

2. Have you ever had a negative pregnancy test done at home?

☐ Yes [1] ☐ No [2] ☐ Not sure [3] ☐ Choose not to answer [0]

3. Have you ever been pregnant? *If No, Go to Question E10*

☐ Yes [1] ☐ No [2] ☐ Not sure [3] ☐ Choose not to answer [0]

4. How many children do you have?_____

5. For your last pregnancy, how many periods had you missed before you did a pregnancy test?*(eg. none, 1, 2, > 3)*_____

6. For your last pregnancy, when did you first see a doctor about the pregnancy? *(eg. before conception, immediately after positive test, 1st trimester, 2nd trimester)*___

_____

7. For your last pregnancy, how did you have your pregnancy confirmed? *(eg. if second positive test at doctors, blood tests, second positive test done at home)*_____

_____

8. For your last pregnancy, how many weeks were you when you had your pregnancy confirmed? (eg. <4 wks, 4-6 wks, 7-9 wks, 10-12 wks, >12 wks)_____

_____

9. If your last pregnancy was within the past 10 years did you take a folic acid supplement during that pregnancy? _____

10. Did you plan your last pregnancy?

☐ Yes [1] ☐ No [2] ☐ Not sure [3] ☐ Choose not to answer [0]

10a. Was your planned pregnancy within the last 10 years?

☐ Yes [1] ☐ No [2] ☐ Not sure [3] ☐ Choose not to answer [0]

11. Are you currently trying to get pregnant? *If No and No to Question E9 Go to E22*

☐ Yes [1] ☐ No [2] ☐ Not sure [3] ☐ Choose not to answer [0]

F20	
F21	
01	
02	
03	
04	
05	
06	
07	
08	
09	
10	
F22	
G1	
G2	
G3	
G4	
G5	
G6	
G7	
G8	
G9	
G10	
G10a	
G11	

12. **While trying to conceive did you change your eating habits?** G12
☐ Yes =1 ☐ No =2 ☐ Not sure =3 ☐ Choose not to answer =0

13. **What did you change?** G13
_____
_____
_____
_____
_____

14. **While trying to get pregnant did you take a folic acid supplement?** G14
☐ Yes =1 ☐ No =2 ☐ Not sure =3 ☐ Choose not to answer =0

15. **For how long before conception?** *(eg. >3 mth, 3 mth, 1 mth)* G15
_____

16. **While trying to get pregnant did you take any other vitamin or mineral supplements?** G16
☐ Yes =1 ☐ No =2 ☐ Not sure =3 ☐ Choose not to answer =0

17. **What were you taking?** G17
_____
_____
_____
_____

18. **Before trying to get pregnant did you try to change your body weight?** G18
☐ Yes =1 ☐ No =2 ☐ Not sure =3 ☐ Choose not to answer =0

19. **What did you try to change about your weight?** G19
_____
_____

20. **Did you seek and nutritional advice before trying to get pregnant?** G20
☐ Yes =1 ☐ No =2 ☐ Not sure =3 ☐ Choose not to answer =0

21. **Where from?** G21
_____

Section H Demographics

1. **What is your age? (Show card 6)** H1

1=	18 – 25 years	
2=	26 – 30 years	
3=	31 – 35 years	
4=	36 – 40 years	
5=	41 – 45 years	
0=	Choose not to answer	

2. **Which ethnic group or groups do you belong to?** H2
_____

If more than one ethnic group:

3. **You picked more than one ethnic group. Is there a group which you feel you belong to the most? If yes which group would that be?** H3

4. **What is the highest level of education that you have completed?** H4
_____

5. **What best describes your main employment status?**

Full-time mother		Unemployed not on benefit	
Full-time paid employment		Student	
Part-time paid employment		Not sure	
Receiving a benefit		Choose not answer	

H5

6. **What is your occupation?**_____

H6

7. **What is the <u>total annual or weekly</u> combined income for the <u>household</u> from all sources (including wages and benefits), before tax in the last 12 months?**

H7

	Yearly		Weekly
Loss/ zero		Loss, zero	
$1000 – $10,000		< $200	
$10,001 - $20,000		$201 - $400	
$20,001 - $30,000		$401 - $600	
$30,001 - $40,000		$601 - $800	
$40,001 - $50,000		$801 - $1000	
$50,001 - $60,000		$1001 - $1200	
$60,001 - $70,000		$12001 - $1400	
$70,001-$100,000		$14001 - $1600	
$100,001 or more		$1600 or more	
Not sure			
Choose not answer			

Section I: Partner Details

1. **Do you have partner?**
☐ Yes =1 ☐ No =2 ☐ Not sure=3 ☐ Choose not to answer=0

I1

2. **If you have had a planned pregnancy or are currently trying to get pregnant, did your partner change his eating habits while trying to conceive?**
☐ Yes =1 ☐ No =2 ☐ Not sure=3 ☐ Choose not to answer=0

I2

3. **How did he change his diet?**_____

I3

Section J: Body Assessment

1. **Weight (kg)** _____

2. **Height (m)** _____

3. **Waist (cm)** _____

4. **Hip (cm)** _____

Section K

The answers to these questions are anonymous; you will only be identified by your code number and your answers can be placed in sealed envelope.
Remember that any information you give me is confidential and you do not have to answer any questions that you are not comfortable with.

Please do not write in the gray panel.

1. What type of contraception are you currently using?

- ☐ Not sexually active
- ☐ Oral contraceptive (The pill).
- ☐ Condoms
- ☐ IUD
- ☐ Emergency contraceptive pill
- ☐ Contraceptive injection
- ☐ Rhythm Method
- ☐ Vasectomy
- ☐ Hysterectomy
- ☐ Tubes Tied
- ☐ Infertile
- ☐ None
- ☐ Choose not answer
- ☐ Other (please specify)_____

K1

2. Have you ever had a baby with a neural tube defect (e.g. spina bifida, anencephaly)?

- ☐ Yes
- ☐ No
- ☐ Not sure
- ☐ Choose not answer

K2

3. Have you ever had any of the following:

- ☐ Miscarriage
- ☐ Abortion
- ☐ Still born baby
- ☐ Premature baby
- ☐ None of these
- ☐ Not sure
- ☐ Choose not answer

K3

4. Have you ever had any of the following, either currently or in the past?

	Currently	Previously	Not Ever
Anorexia nervosa	☐	☐	☐
Bulimia nervosa	☐	☐	☐
Depression	☐	☐	☐
Anxiety disorders	☐	☐	☐
Choose not answer	☐	☐	☐

K4

Please Turn Over Page

5. Are you currently using any of the following illegal drugs?

K5	

- ☐ Marijuana
- ☐ Ecstasy
- ☐ LSD
- ☐ Cocaine
- ☐ Heroine
- ☐ P
- ☐ No
- ☐ Choose not answer
- ☐ Other (please specify)_____

6. Does your partner currently use any of the following illegal drugs?

K6	

- ☐ Marijuana
- ☐ Ecstasy
- ☐ LSD
- ☐ Cocaine
- ☐ Heroine
- ☐ P
- ☐ No
- ☐ Choose not answer
- ☐ Other (please specify)_____

Thank you for your time and effort for answering the questions this far.
It is much appreciated.

APPENDIX B

Show Cards

30mlstraight spirits = 1

330 ml can of beer = 1

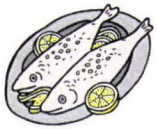
1 glass (100 ml) of table wine = 1

Handle of beer = 2

70 ml fortified wine = 1

Bottle of wine = 7.5

Chicken



Fish

Red Meat

Bread

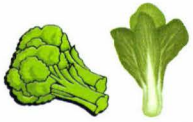
Cereals

Eggs

Legumes

Milk, yoghurt, cheese

Potatoes



Green vegetables

Fruit

Red/orange vegetables

Diabetes

Deep vein thrombosis (DVT)

Hypertension

Epilepsy

Depression

Acne

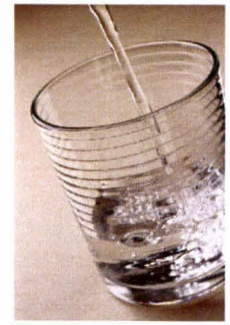
Fruit

Vegetables

Dairy products

Red wine

Coffee



Water

Multi/vitamins or mineral
Multi/vitamins with iron
Multi/ vitamins with other minerals
Vitamin A or Carotenoids
Thiamin (B1)
Riboflavin (B2)
Niacin (B3)
Vitamin B6
Vitamin B12
B complex Vitamins
Vitamin C
Vitamin D
Vitamin E
Anti-oxidant Vitamin
Calcium
Iron
Potassium
Folic Acid

18 - 25 years

26 - 30 years

31 - 35 years

36 - 40 years

41 - 45 years

APPENDIX C

Ethical Approval

Massey University
AUCKLAND

OFFICE OF THE
DEPUTY VICE-CHANCELLOR - AUCKLAND
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North Shore MSC
Auckland
New Zealand
T Deputy Vice-Chancellor - Auckland
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Regional Registrar - Auckland
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4 June 2004

Jaynie-Lee Proctor
C/- Cath Conlon
College of Science
Massey University
Albany

Dear Jaynie-Lee

HUMAN ETHICS APPROVAL APPLICATION – MUAHEC 04/041
"Women's Health and Nutrition Survey."

Thank you for your application. It has been fully considered, and approved by the Massey University, Albany Campus, Human Ethics Committee.

If you make any significant departure from the Application as approved then you should return this project to the Human Ethics Committee, Albany Campus, for further consideration and approval.

Approval is for three years. If this project has not been completed within three years from the date of this letter, a new application must be submitted at that time.

Yours sincerely

Associate-Professor Kerry Chamberlain
Chairperson,
Human Ethics Committee
Albany Campus

cc. Cath Conlon
College of Science

APPENDIX D

Advertisement

Massey University
COLLEGE OF SCIENCES

Women's Health and Nutrition Survey

I am looking for women aged 18-45 years to take part in a study on women's knowledge and attitudes towards the role of nutrition in women's health issues, and women's eating habits.

You need to be:

- A woman aged between 18-45 years.
- You are not currently pregnant.

What you would need to do:

- Answer a survey during a face-to-face interview containing questions on eating and lifestyle habits and nutritional knowledge.
- Provide a description of what you usually eat.
- Have your weight, height and waist/hip measurements taken.
- This should take about 30 minutes.

For your help I will provide you with a copy of your individual dietary assessment that includes your intake of energy, fat, carbohydrate, sugar, protein and vitamins & minerals and a comparison with the recommended daily intakes.

If you are interested in being in this study or would like more information please contact:

Janie Proctor
Institute of Food, Nutrition and Human Health
j.l.proctor@massey.ac.nz
443 9770

APPENDIX E

Information Sheet

Institute of Food, Nutrition & Human Health
22 Oteha Rohe
Massey University
Albany

Massey University
COLLEGE OF SCIENCES

Women's Health and Nutrition Survey

Who is carrying this study and what is it about?

My name is Janie Proctor. I am carrying out a thesis research project as part of my Masters of Science in Nutritional Science at Massey University. This study aims to measure the knowledge and attitudes of women aged 18-45 years in Auckland about nutrition and lifestyle factors involved with aspects of women's health and to see what the eating and lifestyle habits are in this group of women. This information will be useful to identify areas related to women's health that may need to be promoted to improve the health of New Zealand women. This study will gather information using a face-to face interview that involves a survey and a description of foods eaten during a day. The data will be used to assess the knowledge and attitudes towards nutrition and lifestyle factors associated with women health and to assess the current eating and lifestyle practices in women aged 18 – 45 years in Auckland. Women will be recruited to be in this study from posters placed throughout Auckland. I aim to recruit 150 women representative of the Auckland population to be in this study. I would like to invite you to be part of this study.

You need to be:

To be in this study you need to be a woman aged between 18 – 45 years and live in Auckland.

What you will need to do.

If you choose to be involved in this study you will need to answer a survey and to give details on what you usually eat over a day in an interview conducted in person. The survey contains questions on eating habits, lifestyle characteristics, dietary supplement use, nutritional knowledge, medical and pregnancy history and demographics. I will also collect weight, height and waist/ hip measurements. This should take no more than 30 minutes of your time.

Who will have access to the information you provide?

All information collected during this project is confidential and will be stored in a locked filling cabinet at Massey University and can only be assessed by my supervisor and myself. You will be given a unique code number and will not be identified at any stage as an individual. The identification codes will be kept locked away separate from any data. All information collected during this project will be shredded 5 years after the completion of the project. A summary of the findings will be given on request by contacting the researcher.

You are under no obligation to accept this invitation. If you decide to participate, you have the right to:

- decline to answer any particular question or not to have measurements taken;
- withdraw from the study by the 1st November 2004:
- ask any questions about the study at any time;
- provide information on the understanding that your name will not be used unless you give permission to the researcher;
- be given access to a summary of the project findings when it is concluded.

If you have any questions about this project please fell free to contact either my supervisor or myself.

Janie Proctor (Researcher)
j.l.proctor@.massey.ac.nz
4439770

Cath Conlon (Supervisor)
c.conlon@massey.ac.nz
4439748

This project has been reviewed and approved by the Massey University Human Ethics Committee, ALB Application 04/041. If you have any concerns about the conduct of this research, please contact Associate Professor Kerry Chamberlain, Chair, Massey University Campus Human Ethics Committee: Albany, telephone 09 414 0800 x9078, email humanethicsalb@massey.ac.nz.

APPENDIX F

Consent Form

Institute of Food, Nutrition & Human Health
22 Oteha Rohe
Massey University
Albany

Massey University
COLLEGE OF SCIENCES

Women's Health and Nutrition Survey

PARTICIPANT CONSENT FORM

This consent form will be held for a period of five (5) years

I have read the Information Sheet for the Women's Health and Nutrition Survey and have had the details of the study explained to me. My questions have been answered to my satisfaction, and I understand that I may ask further questions at any time.

I agree to participate in this study under the conditions set out in the Information Sheet.

Signature: ..... **Date:** .....

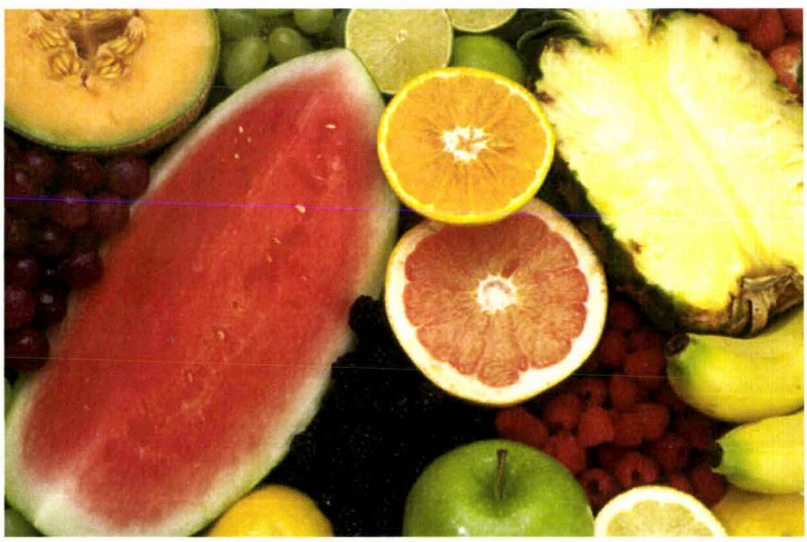
Full Name - printed .....

APPENDIX G

Diet History

Massey University
COLLEGE OF SCIENCES

DIET HISTORY



Eating Time	**Type of Food or Drink** (bread-white/wholemeal/ multi-grain)	**Brand Name (if any)** (eg: Maggi, Yoplait, Uncle Bens, Watties)	**Amount of Food or Drink** (eg: cup, mL, slice)	**Cooking Method** (e.g. boiling, frying, microwave, recipe)

Is your diet different in the weekend?____ If yes, please describe your usual food intake for the weekend.

Eating Time	**Type of Food or Drink** (bread-white/wholemeal/ multi-grain)	**Brand Name (if any)** (eg: Maggi, Yoplait, Uncle Bens, Watties)	**Amount of Food or Drink** (eg: cup, mL, slice)	**Cooking Method** (e.g. boiling, frying, microwave, recipe)

APPENDIX H

Food Frequency Questionnaire

Massey University
COLLEGE OF SCIENCES

Food Frequency Questionnaire

These questions are about what you usually eat.
Please answer by ticking the box which best describes how often you eat or drink a particular food.
Tick only one box for each question. Please do not write in the gray panel.

1. How would you describe your eating pattern?
- □ Eat a variety of all foods, including animal products.
- □ Eat eggs, dairy products, fish and chicken but avoid other meats.
- □ Eat eggs and dairy products but avoid all meats and fish.
- □ Eat dairy products but avoid eggs, all meats and fish.
- □ Eat no animal products
- □ Other (specify)_____

2. On average, how many servings of fruit (fresh, frozen, canned or stewed) do you eat per day?
(a serving = 1 med piece or 2 small pieces of fruit or ½ cup stewed fruit)

Per Day
- □ I don't eat fruit.
- □ Less than 1 per day.
- □ 1 serving a day.
- □ 2 servings a day.
- □ 3 or more servings a day.

3. On average, how many servings of vegetables (fresh, frozen, canned) do you eat per day?
(a serving = 1 med potato or kumara or 1 cup cooked taro or ½ cup cooked green vegetables or 1 cup of salad vegetables)

Per Day
- □ I don' t eat vegetables
- □ Less than 1 per day
- □ 1 serving a day
- □ 2 servings a day
- □ 3 servings a day
- □ 4 or more servings a day

4. On average, how many servings of red meat, including pork, beef, corned beef, mince, mutton, hogget or lamb do you eat per week?
(a serving = 1 steak or 1 cup cooked mince or 6 slices of corned beef or 4 slices of roast meat or 2 sausages)

Per Week
- □ I don't eat these meats
- □ 1 serving per week
- □ 2 – 3 servings per week
- □ 4 – 5 serving per week
- □ 6 –7 servings per week
- □ 7 or more servings per week

5. On average, how many servings of chicken do you eat per week?
(a serving = 1 breast or 1 cup cooked chicken or 2 drumsticks or 1 leg or 2 chicken wings)

Per Week
- □ I don't eat chicken
- □ 1 serving per week
- □ 2 – 3 servings per week
- □ 4 – 5 serving per week
- □ 6 –7 servings per week
- □ 7 or more servings per week

6. On average, how many servings of <u>dairy products</u> do you eat <u>per day</u>? (a serving = 1 cup of milk or ice cream or 1 pottle (150 g) yoghurt or 2 slices of cheese)

6

Per Day

- □ I don' t eat dairy products ⇒ Go To Question 8
- □ 1 serving a day
- □ 2 servings a day
- □ 3 servings a day
- □ 4 or more servings a day

7. Do you drink or use any type of milk? Including soymilk.

7

- □ No ⇒ Go To Question 8
- □ Yes ⇒ **What type(s) do you use <u>most often</u>?**

7a

  - □ Whole fat (Dark blue)
  - □ Reduced fat (Light blue)
  - □ Trim milk (Green)
  - □ Heartwise milk
  - □ Calci-trim (Yellow)
  - □ Full fat (Silver)
  - □ Soymilk
  - □ Other_____

8. On average, how many <u>servings</u> of <u>bread</u> (or toast), including rolls do you eat <u>per day</u>? (a serving = 1 slice of bread or 1 roll)

8

Per Day

- □ I don't eat bread or toast
- □ Less than 1 per day
- □ 1-2 servings a day
- □ 3-4 servings a day
- □ 5-6 servings a day
- □ 7 or more servings a day

9. On average, how many <u>servings</u> of foods such as <u>pasta, rice, muesli, porridge or breakfast cereals</u> do you eat <u>per week</u>? (a serving = 1 cup cooked rice/ pasta or porridge or cornflakes or ½ cup muesli or 2 weetbix)

9

Per Week

- □ I don't eat these foods
- □ Less than 4 per week
- □ 4-6 servings a week
- □ 7-9 servings a week
- □ 10-12 servings a week
- □ 13-15 servings per week
- □ 16 or more servings a week

10. Do you usually eat breakfast cereal?

- □ No ⇒ Go To Question 14
- □ Yes ⇒ **What breakfast cereal(s) do you eat <u>most often</u>?**

10

10a

  - □ Weetbix
  - □ Cornflakes or rice bubbles
  - □ Toasted muesli
  - □ Porridge
  - □ Just Right, Light 'N' Tasty or Good Morning
  - □ Nutragrain, Coco Pops or Honey Puffs
  - □ Puffed wheat or Mini-Wheats
  - □ Other (specify)_____

11. How often do you eat takeaways per week or per month?
_____Per week/month (Please circle)

11	

12. On average, how many times <u>a week</u> do you have breakfast?

- □ I don't have breakfast
- □ 1 – 2 times a week
- □ 3 – 4 times a week
- □ 5 – 6 times a week
- □ Daily

12	

13. On average, how many times <u>a week</u> do you miss <u>2 or more</u> meals a day?

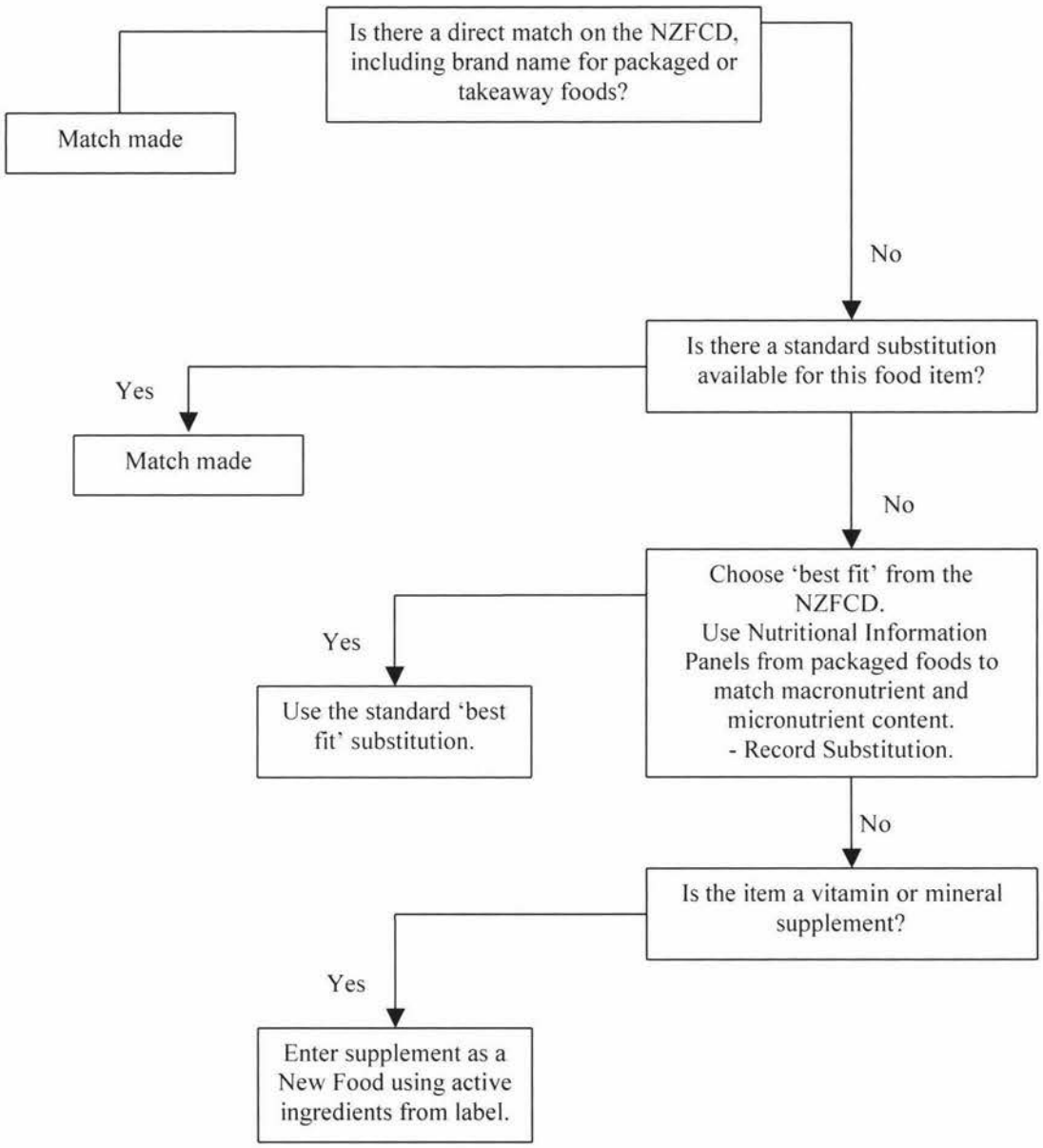
- □ Never
- □ Once a week
- □ 2 – 3 times a week
- □ 4 – 5 times a week
- □ 6 or more times a week

13	

APPENDIX I

Food Matching Criteria

Food Matching Criteria



KEY
NZFCD = New Zealand Food Composition Database
FC = Food Composition