DIETARY INTAKE AND PREGNANCY OUTCOME OF PREGNANT WOMEN IN AN OUTPATIENT CLINIC

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B.Sc. (Dietetics)

Mini-dissertation submitted in partial fulfillment of the requirements for the degree Magister Scientiae in Dietetics at the North-West University (Potchefstroom Campus)

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2005
Potchefstroom

ACKNOWLEDGEMENT

To the Almighty Lord:

" 'No eye has seen,
no ear has heard,
no mind has conceived
what God has prepared
for those who love him.'
But God has revealed it to us by his Spirit. The spirit searches all things, even the deep things of God. For who among men knows the thoughts of a man except the man's spirit within him? In the same way no one knows the thoughts of God except the Spirit of God. We have not received the spirit of the world but the Spirit who is from God, then we may understand what God has freely given us "

1 Corinthians 2:9-12

Aan die Almagtige Vader:

" 'Wat die oog nie gesien
en die oor nie gehoor het nie
en wat in die hart van 'n mens
nie opgekom het nie,
dit het God gereed gemaak
vir dié wat Hom liefhet.'
Aan ons dan het God dit deur die Gees bekend gemaak, want die Gees deursoek alle dinge, ook die diepste geheimenisse van God. Watter mens ken die verborge dinge van 'n mens behalwe die gees van die mens wat in hom is? So ook ken niemand die verborge dinge van God nie, behalwe die Gees van God. Die Gees wat ons ontvang het, is nie die gees van die wêreld nie, maar die Gees wat van God kom. So weet ons wat God ons uit genade geskenk het."

1Korintiërs 2:9 -12

PREFACE AND ACKNOWLEDGEMENTS

The author acknowledges the following persons and institutions:

- *The Primary Health Care Clinic in Potchefstroom, the clinic personnel, their supervisors and management form the Department of Health and Local Authority for the opportunity and assistance.*
- *The participants who prolonged their clinic visits, for their willingness and positive attitudes, to complete numerous forms and answer so many questions.*
- *To the personnel of the Maternity Ward in the Potchefstroom Hospital as well as the hospital dietician, Ms. R. Olckers, who assisted us in the congregation of the birth data and tracing of the mothers.*
- *The trained fieldworkers, who visited the mothers at home and assisted us in the translation process and completion of the Food Frequency Questionnaires*
- *The final year Dietetics students from the Potchefstroom University, who also assisted with the interviews with participants and their anthropometric assessments.*
- *Ms Elbie Rheeder, who assisted with all the capturing of the data*
- *Ms. E. Uren who read my dissertation for language editing.*
- *My promoter Prof H.S. Kruger for the opportunity to do my destination, who shared with me her nutrition knowledge, wisdom, passion and valuable time.*
- *My parents, not only for providing a solid foundation on which to build, but also most of the bricks and mortar*
- *My sisters, Adéle and Lindi for the time belonging to them that I have borrowed to complete this study, for all the support, love and prayers.*
- *Riaan for his patience, love, prayers and encouragement, which build my character and carried me.*

ABSTRACT

TITLE

OBJECTIVE

METHODS

RESULTS AND DISCUSSION

CONCLUSION

TITLE

Dietary intake during pregnancy and pregnancy outcomes.

OBJECTIVE

To evaluate the association between the dietary intake during pregnancy and the pregnancy outcomes.

METHODS

In the Thusa Mama study, 98 pregnant black women were included. Of these 98 women, two women had miscarriages and five women were lost during the follow-up visits. The total number of women of whom data could have been analysed were 91. They were a sub-sample of a total of 478 pregnant women who attended the midtown antenatal clinic in Potchefstroom during a period of one year. Demographic data, haemoglobin concentrations and food frequency questionnaires were used (during the visits of the women in the study at the antenatal clinic) to collect the data. During the pregnancy, weight and height were used as anthropometric measurements to monitor bodily changes. The mothers gave birth at the Potchefstroom hospital and this is where the babies' birth data were obtained.

RESULTS AND DISCUSSION

The subjects were divided into three categories according to their pre-pregnancy body mass index (BMI):

- BMI<19.8 (underweight)
- BMI 19.8 – 26 (normal weight)
- BMI > 26 (overweight).

With reference to the Institute of Medicine's recommendations for weight gain during pregnancy, the Thusa Mama study showed that most of the women in all three categories tended to gain excessive weight.

The study also showed that the lower the animal protein was, the lower the total protein intake were. The women with a prepregnancy BMI lower than 19.8 were significantly younger than the women with a BMI higher than 26.

The women are grouped in three nutrient index groups accordingly to their mean micronutrient intake during pregnancy:

- A mean micronutrient intake of less than 66% of the RDA (Poor diet group),
- A mean micronutrient intake between 67% en 100% of the RDA (Adequate diet)
- A mean micronutrient intake more than 100% van die RDA (Good diet).

The outcomes of the three groups showed that the average pregnant women had adequate intake of macronutrients, but the intake of the micronutrients such as iron and folic acid were in all three groups lower than 50% of the DRI. There were no adverse outcomes due to the fact that if a mother was at risk for poor pregnancy outcomes they received assistance from dieticians and the clinic staff. There was no significant difference between the babies' outcomes of the three diet groups, although there was a slightly lower birth head circumference in the poor diet group.

Number of previous pregnancies had significantly negative correlations with animal protein intake, fat intake and vitamin A intake of pregnant women. There was also a significant negative correlation between the number of previous pregnancies and the haemoglobin concentrations.

The baby birth weight had a significant positive correlation with the dietary iron intake of the mother. There were no adverse outcomes due to good standard clinic care.

CONCLUSION

In conclusion, it is essential for pregnant women to have a good balanced diet (with a adequate micronutrient density), but if the pregnant woman is from a low socio-economic group, good clinical care is crucial, where these women can receive iron and folic acid supplementation and outstanding help with education on healthy eating during pregnancy. It is also important that the mothers should be educated on the weight gain regarding the IOM's recommendation, to prevent excessive weight gain and to minimize the adverse outcomes during pregnancy.

SAMEVATTING

TITEL

Dieetinname tydens swangerskap en swangerskap-uitkomste

DOEL

Om die verband tussen dieetinname tydens swangerskap en swangerskap-uitkomste te evalueer.

METODE

Die Thusa Mama-studie het aanvanklik 98 swanger swart vroue ingesluit. Van hierdie 98 vroue het twee miskrame gehad en vyf het tydens die opvolgbesoeke nie weer opgedaag nie. Die data van 'n totaal van 91 vroue kon dus bespreek word. Die groep vrywilligers was 'n steekproef van 478 swanger vroue wat maandeliks oor 'n tydperk van een jaar besoeke by die voorgeboorteklinieke in Potchefstroom afgelê het. Die data is ingesamel deur middel van demografiese en voedselfrekwensie-vraelyste, en hemoglobienkonsentrasie is tydens die besoeke gemeet. Antropometriese metings is gebruik om die verandering in liggaammassa te moniteer. Die Potchefstoom Hospitaal, waar die moeders geboorte geskenk het, het die babas se geboortedata verstrek.

RESULTATE EN BESPREKING

Die groep swanger vroue is in drie kategorieë verdeel volgens hul liggaamsmassa-indeks (LMI) voor swangerskap:

- LMI<19.8 (ondergewig)
- LMI 19.8 – 26 (normale gewig)
- LMI > 26 (oorgewig).

Vergeleke met die riglyne van die "Institute of Medicine" vir massatoename tydens swangerskap is gevind dat al drie kategorieë vroue wat by die Thusa Mama-studie betrek is, geneig was om oormatige gewigstoename te toon. Die studie het ook aangedui dat hoe laer die

dierlikeproteïene-inname was, hoe laer die totale proteïene-inname. Die vroue met 'n voorgeboorte-LMI kleiner as 19.8 was betekenisvol jonger as die vroue met 'n LMI groter as 26.

Die vroue is in drie nutriëntindeks-groepe verdeel ooreenkomstig hulle gemiddelde mikronutriënt-inname tydens swangerskap:

- 'n gemiddelde mikronutriënt-inname kleiner as 66% van die "RDA" (Swakindeks-dieetgroep),
- 'n gemiddelde mikronutriënt-inname tussen 67% en 100% van die "RDA" (Voldoende-indeks-dieet)
- 'n gemiddelde mikronutriënt-inname groter as 100% van die "RDA" (Goeie-indeks-dieet).

Die uitkomste van die drie voedingindeks-groepe het aangedui dat die makronutriënt-inname van die gemiddelde swanger vrou voldoende was, maar dat die inname van die mikronutriënte soos yster en foliensuur van al drie groepe kleiner was as 50% van die Aanbevole Daaglikse Inname (ADI). Daar was geen nadelige uitkomste nie weens die bystand van die dieetkundiges en kliniekpersoneel in gevalle waar moeders die risiko van 'n ongunstige swangerskap geloop het. Daar was geen betekenisvolle verskille tussen die uitkomste van die drie groepe nie, alhoewel 'n effens kleiner kopomtrek by die swakindeks-dieetgroep voorgekom het.

Die aantal vorige swangerskappe van die swanger vroue het 'n betekenisvol negatiewe korrelasie getoon met dierlikeproteïen-inname, vetinname en vitamien A-inname. 'n Betekenisvol negatiewe korrelasie het ook tussen die aantal vorige swangerskappe en die hemoglobienkonsentrasie van die swanger vroue voorgekom.

Die babas se geboortegewig het 'n betekenisvol positiewe korrelasie met die dieet ysterinname van die swanger moeders getoon. Daar was geen ongunstige swangerskapuitkomste nie, weereens as gevolg van die hoë standaard van die klinieksorg.

GEVOLGTREKKING

Ten slotte kan daarop gewys word dat 'n goeie gebalanseerde dieet (met 'n toereikende mikronutriënt-digtheid) noodsaaklik is, maar as die swanger vrou uit 'n lae sosio-ekonomiese groep kom, is goeie klinieksorg deur middel waarvan sy yster- en foliensuur-aanvullings en uitstekende sorg ten opsigte van voedingopleiding rakende gesonde eetgewoontes tydens swangerskap kan ontvang, van kardinale belang. Dit is ook belangrik dat die moeders voorligting moet ontvang met betrekking tot die gewigstoename ooreenkomstig IOM-riglyne om so te voorkom dat hulle oorgewig raak en sodat die nadelige uitkomste tydens swangerskap geminimaliseer word.

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LIST OF ABBREVIATIONS

ADA	American Dietetic Association
AI	Adequate Intake
AIDS	Acquired Immunodeficiency Syndrome
alpha-TE	Alpha Tocopherol
ATP	adenosine triphosphate
BEE	basal energy expenditure
BMI	body mass index
BMR	basal metabolic rate
Ca	calcium
CDC	Centers of Disease Control
cm	centimeters
EAR	estimated average requirement
Fe	Iron
FDA	Food and Drug Administration
FFQ	Food Frequency Questionnaire
FNB	Food and Nutrition Board
g	gram
GA	gestational age
GDM	gestational diabetes
Hb	haemoglobin
HIV	human immunodeficiency virus
ID	iron deficiency
IOM	Institute of Medicine
IUGR	intrauterine growth retardation
kcal	kilocalories
kJ	kilojoules
kg	kilogram
kg/m^2	kilogram per meter square
LBW	low birth weight
m	metre
max	maximum
mg	milligram
min	minimum
MUAC	mid-upper arm circumference
n	number

NE	niacin equivalents
n-3	oméga 3
n-6	omega 6
ORs	odds ratios
PEM	Protein and energy Malnutrition Programme
RDA	Recommended Dietary Allowance
RE	retinal equivalents
SD	standard deviation
SGA	Small for gestational age
SOGC	Society of Obstetricians and Gynecologists of Canada
UL	Upper Intake Level
Vit A	vitamin A
Vit B_{12}	vitamin B_{12}
Vit B_6	vitamin B_6
Vit C	vitamin C
Vit D	vitamin D
Vit E	vitamin E
Vit K	vitamin K
WHO	World Health Organization
WIC	Women, Infants and Children
Zn	Zinc
µg	microgram

CHAPTER 1

INTRODUCTION AND AIM OF THE STUDY

1.1 INTRODUCTION

The mortality and morbidity data in South Africa are inadequate. Nevertheless, the available data provide sufficient evidence of the inequalities between different races and of the disadvantaged situation of many African children, especially rural, poor African children. The mortality rate for South Africa has been declining over time, leading to an increase in the expectation of life at birth. The crude death rate (CDR) is estimated at 9.4 per 1000 persons in 1994, down from 14 per 1000 persons in 1970. The infant mortality rate (IMR), an important indicator of the quality of life and level of development of a population, was estimated at 41 per 1000 live-births (1994), which is less than half the rate of 89 per 1000 live-births in 1960. The maternal mortality rate, an important indicator of the reproductive health and socio-economic status of women, was estimated at a high of 230 per 100 000 deliveries in 1993. The infant mortality rate of 49 per 1000 live births among the African population is six times the rates of 8.3 and 9 among the white and Asian populations respectively, and double the rate for coloureds at 23. A high perinatal mortality rate (PNMR) provides an indication of the quality and availability of antenatal care, as well as adverse health, nutrition and social conditions of childbearing women. Children born to rural women whose pregnancies are not regularly monitored and who give birth at home are significantly more at risk of perinatal deaths. Perinatal mortality is not routinely reported in South Africa. Available statistics reveal that the perinatal mortality rate increased between 1986 and 1989. In 1989 it was estimated at 23.3 per 1 000 births, which may only be applicable to the white population. A more recent estimate is higher at 45-55 per 1 000 births, and even higher in the former homelands (Ministry for Welfare & Population Development, 1997). The reason why the Thusa Mama study was done was to determine the effect of the dietary intakes and pregnancy weight gain of pregnant women on the pregnancy outcomes.

1.2 PROBLEM STATEMENT

Numerous factors interact to determine the progress and outcomes of pregnancy. Although much remains to be learned about the role of the nutrition modifying process, it is well accepted that the nutrition status of the pregnant women affects the outcome of her pregnancy (Barker, 1995). Across the world there is a high prevalence of adverse outcomes of pregnancy, which can be life threatening for both the mother and her baby. For the mother, poor nutrition status,

infection, stresses at home and at work all contribute separately or together, to increasing her risk of ill health and limiting her ability to provide an adequate supply of nutrients to the developing fetus. Sub-optimal growth is associated with higher fetal mortality (Jackson *et al.*, 2003). The evidence for contribution of micronutrient deficiencies to perinatal mortality and duration of gestation is limited and the evidence base for individual micronutrients on neonatal mortality and morbidity is unpredictable (Costello & Osrin, 2003). According to King (1994), a maternal nutrient depletion, due to closely spacing of pregnancies, may contribute to the increased incidence of pre-term births and fetal growth retardation, as well as the increased risk of maternal mortality and morbidity. Inappropriate nutrition could lead to a low pregnancy body mass index, which is one of the strongest predictors of adverse pregnancy outcomes.

Perinatal mortality rates point to the inadequacy of antenatal care, since a significant number of deaths in this age category are preventable. Antenatal care is important to ensure that complications are detected and dealt with promptly. The availability of antenatal facilities differs widely according to race, socio-economic standing and locality. The risk to mother and child are increased with home deliveries, especially when complications arise. Only 22% of all pregnant women attend antenatal clinics. Furthermore, some women only attend antenatal clinics once, late in their pregnancy (Ministry for Welfare & Population Development, 1997).

1.3 AIMS OF THE STUDY

The aim of this part of the Thusa Mama Study was to evaluate the association between pregnancy outcome in pregnant women, who visited a clinic on a regular basis and their dietary intakes. Factors such as socio-demographic background, blood concentration of haemoglobin, the macronutrient dietary intake (especially energy and protein) and micronutrient dietary intake (especially iron, folic acid, calcium, zinc, vitamin A and vitamin C), were investigated in this study. These factors could have an impact on dietary intake, or could have been affected by dietary intake. The outcomes that were investigated were mainly the outcomes of the infant's birth weight, birth length, head circumference and gestational age. The project was called the Thusa Mama Study, because 'Thusa' is the Tswana word for help and it was the aim of the study to eventually help mothers.

1.4 STRUCTURE OF DISSERTATION

This mini-dissertation begins with a preface and acknowledgements, to thank all the people involved in the study and acknowledge their contribution. An abstract in English and Afrikaans is given, followed by a list of tables, figures and abbreviations.

The researcher's contribution was to complete some of the food frequency questionnaires, analyze all food frequency questionnaires and present the data of the diets into results. She also did anthropometric measurements on few of the participants.

Chapter 1 acts as an introduction and explains the aims of the Thusa Mama study. Chapter 2 gives a review of the literature in relation to nutrition, dietary intake and pregnancy outcomes. The influence of behavioural factors, maternal age, environmental factors, maternal physical health, multiple pregnancy, pregnancy weight gain, the use of antropometry of pregnant women, macronutrient status and micronutrient status of pregnant women on the pregnancy outcomes, are discussed. Chapter 3 describes the study in the format of an article. A short introduction, which includes the aim of the study, is given, followed by the methodology, results, discussion, conclusion and recommendations. Chapter 4 acts as a closing chapter, in which a short summary of the most important aspects of the study is given.

All forms and questionnaires used during the study are attached as Appendix A – F. The references used for all the chapters are listed at the end of the mini-dissertation, according to the guidelines of the North-West University.

CHAPTER 2

LITERATURE STUDY

2.1 FACTORS ASSOCIATED WITH PREGNANCY OUTCOME

2.1.1 Behavioral factors

2.1.1.1 Smoking

The American Dietetic Association (ADA) (2002) cites that smoking during pregnancy reduces birth weight by an average of 200g and may increase the risk of pre-term delivery and perinatal mortality. Passive exposure to tobacco smoke may reduce infant growth. Low-income pregnant adolescents smoke to counter the anxiety and this can influence the gestational age (GA) or the birth weight (Rondó *et al.*, 2003). By increasing the energy intake alone, the negative effect of smoking on fetal growth cannot be mitigated. Smoking during pregnancy is also associated with other adverse long-term outcomes, including mental retardation, as well as nicotine addiction in the fetus (Drews *et al.*, 1996). Shu *et al.* (1995) are of opinion that before conception women should be advised about the dangerous effects of smoking during pregnancy. This is due to the fact that the fetal growth can be limited even when pregnant women quit smoking in the early stage of their pregnancy.

2.1.1.2 Alcohol intake

Women who are or may become pregnant should not drink alcoholic beverages at all. Heavy drinking during pregnancy increases the risk of mental retardation, learning disabilities and major birth defects, such as those included in fetal alcohol syndrome. Moderate alcohol intake, defined as no more than one drink per day for women, has been linked to impaired fetal growth and lower Apgar scores and may reduce fertility in women (ADA, 2002).

2.1.1.3 Caffeine intake

ADA (2002) cites that caffeine can readily cross the placenta and affect the fetal heart rate and breathing. A meta-analysis by Fernandes *et al.* (1998) showed an increased risk of spontaneous abortion and low birth weight in pregnant women who consumed more than 150 mg/day of

caffeine. According to ADA (2002), some evidence suggests that high levels of caffeine intake (>500mg/day) may also delay conception.

2.1.1.4 *Psychosocial factors, psychological stress and distress*

The World Health Organization (WHO) (1995) cites that low birth weight (LBW), prematurity and intrauterine growth retardation (IUGR) remain the leading causes of perinatal morbidity, mortality, neurodevelopment impairments and disabilities among newborn babies. A direct relationship between maternal psychological stress/distress and LBW, prematurity and IUGR may be related to the release of catecholamines, which result in placental hypoperfusion and consequent restriction of oxygen and nutrients to the fetus, leading to fetal growth impairment and /or precipitation of pre-term delivery (Omer, 1986; Copper *et al.*, 1996). Exposure to stressful conditions might also influence GA or birth weight by promoting specific behaviours in human beings such as smoking, alcohol and coffee intake, which may be independently associated with poor pregnancy outcomes (Rondó *et al.*, 2003). According to the results of a large study carried out by Edwards *et al.* (1994), women with a positive self attitude and higher self esteem were more likely to deliver infants at term. Rondó *et al.* (2003) cites that in a large study in Norway, parental education, maternal body proportion and lifestyle were the risk factors for IUGR.

2.1.2 *Maternal age*

A maternal age less than 16 years or more than 35 years, associated with low socioeconomic status and malnutrition can also be associated with triggers of pre-term deliveries (Harrison et al, 2001). Fagen (2000) is of the opinion of that about one million U.S. adolescents become pregnant every year. Hack *et al.* (2003) states that educational disadvantages associated with very low birth weight persist into early adulthood and that teenagers have a higher rate of bearing LBW infants, which is the greatest determinant of infant death and disability.

Figure 2.1 shows the significant medical and nutritional risks in pregnant adolescents.

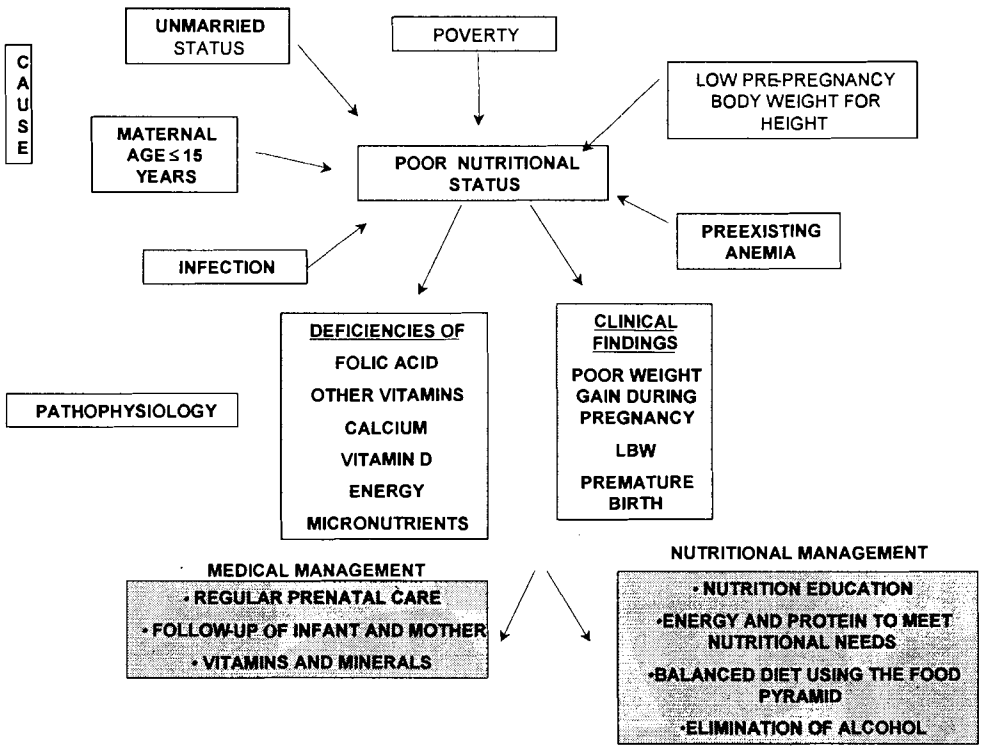


FIGURE 2. 1 The causes of poor nutritional status and the pathophysiology and management of pregnancy in adolescence (Shabert, 2004).

2.1.3 Physical activity

The Society of Obstetricians and Gynecologists of Canada (SOGC) suggests that if pregnant women do not exercise during pregnancy it may be associated with some risks. These risks include excessive maternal weight gain, higher risk of gestational diabetes or pregnancy-induced hypertension, development of varicose veins and deep vein thrombosis, a higher incidence of physical complaints such as dispnea or low back pain and poor psychological adjustment to the physical changes, loss of muscular and cardiovascular fitness (Johnson, 2003).

There is also a warning in the guidelines of exercising during pregnancy to not exceed more than 30 minutes or more of moderate exercise a day on most of the days of the week (Johnson, 2003). This is due to fact that excessive maternal activity during pregnancy is associated with smaller fetal sizes (Rao *et al.*, 2003).

Activities at a low to moderate intensity level are generally safe and may include walking, swimming, running, aerobic dancing and riding on a stationary bicycle. Activities that may not be

safe include ball games that increase risk of abdominal trauma, weight lifting, scuba diving, martial arts, anaerobic exercise, exercise above 2.500 metres of altitude and any exercise with a high risk of falling or requiring balance, especially in late pregnancy. Exercise is contra-indicated for women with pregnancy-induced hypertension, toxemia, preeclampsia, pre-term rupture of membranes, history of pre-term labour, persistent second or third trimester bleeding, incompetent cervix or any sign of intrauterine growth retardation (ADA, 2002).

Shaw (2003) states that the data available are insufficient to draw firm inferences that strenuous work, in either a developing country or a developed country, alters a pregnant woman's nutritional status and, therefore, affects her risk of an adverse pregnancy outcome. The effects on the nutritional status (micronutrients in particular) of pregnant women of strenuous physical activities at work or in other lifestyle events require further study in developing countries.

2.1.4 Maternal physical health

Petridou *et al.* (2001) state that factors associated with pre-term infants differ in nature, some affect the process of gestation, notably antenatal bleeding, chronic urinary tract infection and structural or functional uterine abnormalities.

2.1.4.1 Diabetes mellitus

Pre-existing diabetes (type 1 or 2) is associated with increased risk of congenital abnormalities, miscarriage and neonatal death. Gestational diabetes (GDM) increases the risk of macrosomia, difficult labour, infant shoulder dystocia (dislocation) and cesarean delivery (ADA, 2002). Petry *et al.* (1992), state that infants of mothers with poorly controlled diabetes have severely depleted stores of iron in the liver (6.6% of normal) and other organs. A possible mechanism is that elevated levels of insulin and glucose in the fetus may increase cellular oxygen consumption and erythropoiesis, which place demands on storage iron in the fetus.

2.1.4.2 The effect of Human Immunodeficiency Virus (HIV) and Acquired Immunodeficiency Syndrome (AIDS) on pregnancy outcome

Maternal HIV infection also contributes to LBW resulting from pre-term delivery and IUGR. This is due to the fact that the progression of HIV disease is usually accompanied by opportunistic infections, diminished dietary intake, nutrient malabsorption and metabolic and hormonal alterations that lead to depletion of both body fat and fat-free compartments, resulting in weight

loss. A part of the adverse effect of HIV diseases on pregnancy outcomes is most likely mediated through the changes in maternal body composition and the weight loss induced by the infection (Villamor *et al.*, 2002).

Poor gestational weight gain among HIV infected women could be explained by an HIV-related impairment of fetal and placental growth or by an effect of the infection on maternal body composition. However, the magnitude and determinants of these changes remain virtually unknown (Villamor *et al.*, 2002). Castetbon *et al.*'s (1999) cohort study of HIV-positive and HIV-negative pregnant women in Rwanda showed that the weight in infected women was lower than in uninfected pregnant women.

The presence of HIV infection may also influence the effect of malaria on intrauterine growth by increasing the susceptibility of pregnant women to heavier malaria loads and increased placental infection. In two studies in Malawi, HIV infection was significantly associated with increased malaria prevalence and parasite density. Parasite density and infection of the placenta have a negative effect on fetal growth. Due to this, malaria is an important determinant of LBW in HIV-infected women (Dreyfuss *et al.*, 2001).

2.1.4.3 The effect of weight gain on pregnancy outcomes

Maternal nutritional status before and during gestation is one of the strongest determinants of pregnancy outcomes. The Institute of Medicine (IOM) (1990) published recommended weight gains by pre-pregnancy body mass index (BMI) as shown in Table 2. 1. An overall weight gain during pregnancy of 11.5 to 16kg is considered appropriate for women in the normal weight BMI category. Feig and Naylor (1998) critiqued the IOM recommendations and recommended a weight–gain range of 7-15kg for women with a normal pre-pregnancy BMI. They stated that weight gains within the IOM recommendations would produce obese mothers and overgrown babies, necessitating caesarean deliveries. According to Theron and Thompson (1993), although weight gain alone is not a good screening tool, weight gain outside the IOM's recommendations are associated with twice as many poor pregnancy outcomes than are weight gains within the recommended range (IOM, 1990). Suitor (2000), cites that when maternal weight gain is within the IOM recommended range, the incidence of small-for-gestational-age and/or LBW birth is reduced. Figure 2.2 presents curves of desirable weight gain during pregnancy, as recommended by the subcommittee on Nutritional Status and Weight Gain During Pregnancy (IOM, 1990). Figure 2. 3 illustrates the potential consequences and effect which could influence the maternal weight gain. Pre-pregnancy BMI, net maternal weight gain and weight gain above the IOM recommendations may increase the risk of caesarean delivery (IOM, 1980).

TABLE 2. 1

RECOMMENDED WEIGHT GAINS FOR PREGNANT WOMEN BASED ON BODY MASS INDEX

WEIGHT CATEGORY BASED ON BMI	TOTAL WEIGHT GAIN *		1ST TRIMENSTER GAIN		2ND AND 3RD TRIMESTER WEEKLY GAIN	
	lb	kg	lb	kg	lb	kg
UNDERWEIGHT (BMI < 19.8)	28 - 40	**12.5 - 18**	5	**2.3**	1.07	**0.49**
NORMAL WEIGHT (BMI= 19.8 – 26)	25 - 35	**11.5 - 16**	3.5	**1.6**	0.97	**0.44**
OVERWEIGHT (BMI >26-29)	15 - 25	**7 - 11.5**	2	**0.9**	0.67	**0.3**
OBESE (BMI > 29)	At least 15	**6**	-	-	-	-

* YOUNG ADOLESCENTS AND BLACK WOMEN SHOULD STRIVE FOR GAINS AT THE UPPER END OF THE REOMMENDED RANGE. SHORT WOMEN (< 62 IN. OR < 157CM) SHOULD STRIVE FOR GAIN AT THE LOWER END OF THE RANGE

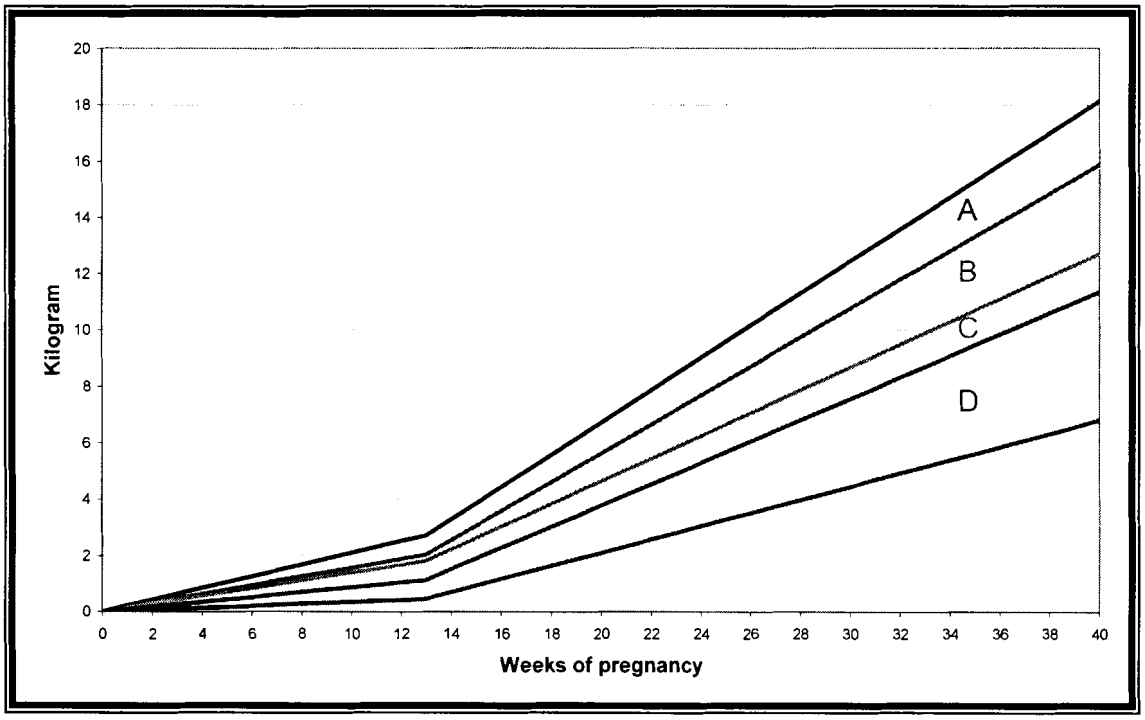


FIGURE 2. 2 DESIRABLE WEIGHT GAIN DURING PREGNANCY (FAGEN, 2000)

WOMEN WHO ARE OF NORMAL WEIGHT PRIOR TO PREGNANCY SHOULD AIM FOR A WEIGHT GAIN IN THE B – C RANGE (11.34KG – 15.88KG) DURING PREGNANCY. UNDERWEIGHT WOMEN SHOULD GAIN IN THE A – B RANGE (12.70KG – 18.14KG). WOMEN WHO ARE OVERWEIGHT PRIOR TO PREGNANCY GIN IN THE D RANGE (6.80KG – 11.34KG).

The normal distribution of weight gain is that less than half of the total weight gain resides in the fetus, placenta and amniotic fluid. The remainder is found in maternal reproductive tissues, fluid, blood and "maternal stores", a component composed largely of body fat (Fagen, 2000).

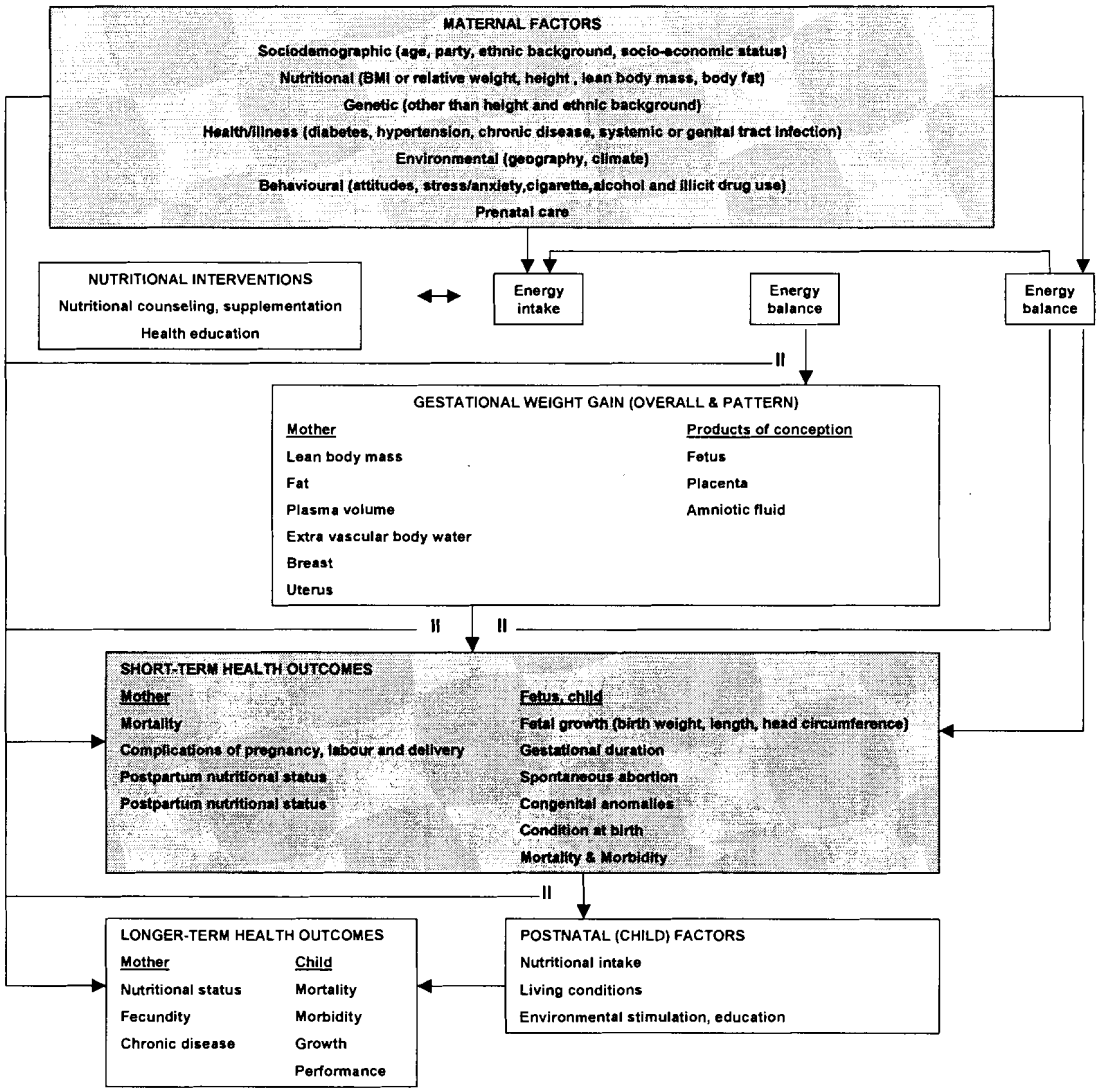


FIGURE 2. 3 SCHEMATIC SUMMARY OF POTENTIAL DETERMINANTS, CONSEQUENCES AND EFFECT MODIFIERS FOR MATERNAL WEIGHT GAIN (IOM, 1980)

Widga and Lewis (1999) are of the opinion that maternal weight gain and dietary behaviours can be influenced by prenatal nutrition intervention to promote more favourable pregnancy outcomes. Prenatal nutrition intervention may decrease the rate of LBW births. Due to this, nutrition counseling to improve the dietary intake of fat and the increase in maternal weight gain should be an essential part of all prenatal care.

2.1.4.4 *Obesity and pregnancy outcome*

Maternal morbid obesity in early pregnancy is strongly associated with a number of pregnancy complications of perinatal conditions. IOM (1990) cites that very high gestational weight gain is associated with an increased rate of birth weight, which in turn is associated with some increase in the risk of fetopelvic disproportion, operative delivery (forceps or caesarean delivery), birth trauma and asphyxia and mortality. These associations appear to be more pronounced in short women (length < 157cm). Due to this, a lower ceiling on weight gain may be more preferable in short women at any given BMI. Infants of obese women are at risk of macrosomia, low Apgar scores, shoulder dystocia and childhood obesity. Maternal obesity increases the risk of neural tube defects in the infants, independently of folate intakes (ADA, 2002).

Obese women are at a greater risk of hypertension, gestational diabetes, induced labour and caesarean sections (ADA, 2002). Cedergran & KäLLéN. (2003), large prospective study of Swedish medical health registries showed that maternal obesity (BMI > 29kg/m^2) was associated with an increased risk of overall and specific infant cardiovascular defects. Cnattinguis *et al.* (1998)found that the rates of preeclampsia increase with increasing maternal weight gain.

2.1.4.5 *The effect of undernutrition on pregnancy outcome*

A large body of evidence suggests that maternal weight gain during pregnancy is an important determinant of fetal growth. Inadequate prenatal weight gain is a significant risk factor for IUGR and LBW in infants (Wells & Murray, 2003). Although the biological mechanism underlying this association is unknown, it appears that a rate of pregnancy weight gain below the lower limit of the IOM recommended range is related to high risk of pre-term birth (Abrams *et al.*, 2000). Abrams and Selvin (1995) cite that a study of trimester weight gain and birth weight in 3000 white women in the USA showed that weight gain in the second trimester was more strongly associated with fetal growth than weight gain in the first or third trimester. Malnourished women are more likely to have stillbirths or to deliver LBW babies. LBW babies suffer from reduced immune competence and suboptimal cognitive development and learning capacity.

Cnattinguis *et al.* (1998) declare that inadequate weight gain has been linked to an increased risk of the delivery of a small-for-gestational–age infants, but its association with other adverse pregnancy outcomes is less certain. Wells and Murray (2003) states that almost twice as many women who gain inadequate weight according to the IOM recommendations deliver a low birth weight infant compared with women who gained within the IOM recommendations. Figure 2. 4 illustrates selected causes and consequences of maternal malnutrition.

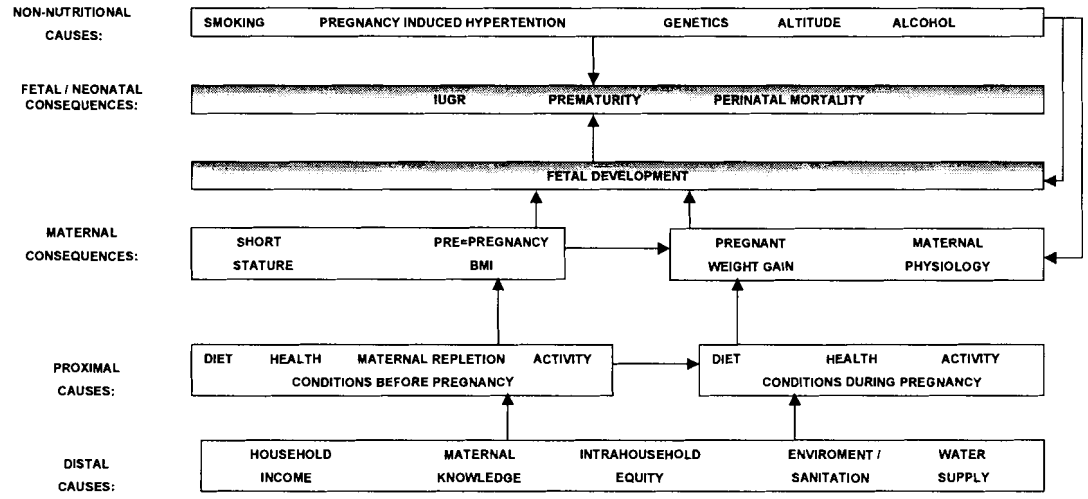


FIGURE 2. 4 Selected causes and consequences of maternal malnutrition (WHO, 1995)

2.1.4.6 Multiple pregnancy and pregnancy outcome

Fagen (2000) states that woman pregnant with twins or multiple fetuses should gain more weight than those pregnant with singletons. A study in Washington State of 217 teenage pregnancies showed that for twin pregnancies, a mean weight gain for optimal pregnancy outcomes was 20kg. The mean weight gain of that less than optimal outcome was 17 kg and this group showed a slowing of weight gain during the last 10 weeks of pregnancy. This group's pregnancy outcomes were associated with babies with a birth weight < 2500g, gestational age of 37 weeks or less or Apgar scores at 5 minutes of less than 7. Similarly, a study of 163 twin births in the Chicago area showed that poor maternal weight gain and poor pattern of gain were associated with unfavourable pregnancy outcome.

2.1.4.7 *The weight gain in pregnant adolescents and pregnancy outcomes*

Suitor (2000) states that studies concerning maternal nutrition of adolescents have reported that adolescents generally gain more weight during pregnancy than adults and gain more weight in producing infants of optimal size. The larger pregnancy weight gain and the associated increases in body fat during adolescence have been attributed primarily to previous incomplete growth. Due to this there is a concern that gestational weight gain may contribute to overweight and obesity in young mothers. The restriction of gestational weight gain in pregnant adolescents may increase the risk for a LBW. The recommendation for adolescents less than two years post menarche is to stay within the IOM-recommended BMI-specific weight range without restricting weight gain or encouraging weight gain at the upper end of the range.

2.2 THE USE OF THE ANTROPOMETRY OF PREGNANT WOMEN TO PREDICT THE PREGNANCY OUTCOME

Maternal anthropometry indicators have been useful for screening women for nutritional status and predicting unfavourable infant outcomes related to pregnancy, such as LBW, perinatal neonatal and infant mortality and poor infant growth. Anthropometric indicators identify women with nutritional problems, but do not reveal the determinants of the problem. The cause may be related to inadequate energy intake, specific nutrient deficiencies, infections, high expenditure or endemic diseases such as malaria. An anthropometrical assessment of maternal status during pregnancy is commonly based on height, weight, BMI, mid-upper arm circumference and various measures of skinfold thickness, such as triceps and subscaplupar skinfold thickness (WHO, 1995).

2.2.1 Body mass index

The Food and Nutrition Board (FNB) (2002) states that a growing literature supports the use of the BMI (defined as weight in kilograms divided by the square of height in metres) as predictor of the impact of body weight on morbidity and mortality risks. As an index of healthy weight and as a predictor of morbidity and mortality risk, it has supplanted weight for height tables, which were derived primarily from white populations and relied on questionable estimates of frame size. BMI, although only an indirect indicator of body composition, is now used to classify underweight and overweight individuals.

The IOM recommendation categorises the pregnant women according to their pre-pregnancy BMI and in these categories are there specific weight gain ranges which are advisable for

pregnant women during pregnancy, to enhance the potential outcome of the infant. Women with a BMI < 19.8 are at high risk of delivering a low birth weight infant (ADA, 2002).

For most clinical and epidemiological applications, body size is judged on the basis of the BMI, which is easy to determine, accurate and reproducible. The main disadvantages of relying on the BMI are:

- That it does not reflect body fat content reliably, which is an independent predictor of health risk
- That very muscular individuals may be misclassified as overweight (FNB, 2000).

2.2.2 Mid-upper arm circumference

The mid-upper arm circumference (MUAC) is largely independent of gestational age and regarded as a proxy indicator of maternal pre-pregnancy weight or early pregnancy weight, the MUAC changes very little during pregnancy. Although the correlation between pre-pregnancy weight and MUAC is statistically significant, in most of the studies reported by WHO the association between pre-pregnancy weight and MUAC is too weak to permit MUAC to substitute for pre-pregnancy BMI in individuals. The risk of lower infant outcomes, such as LBW, neonatal morbidity and IUGR increases with the MUAC < 23.5 cm in pregnant women (WHO, 1995).

2.2.3 Skin fold thickness

Changes in skin fold thickness have been widely used to estimate changes in the fat content of pregnant women. Skin fold thickness measurements suggest that more maternal fat is accumulated centrally than peripherally. Skin fold thickness can be measured quickly with relatively inexpensive equipment. Proper use requires extensive training and monitoring to achieve reproducible measurements consistently. To convert skin fold thickness measurements to estimates of body fat, standard regression equations are used. The most widely used regression equations for interpreting skin fold thickness in pregnant women have been developed in studies of non-pregnant subjects (IOM,1990).

Longitudinal studies of skin fold thickness in late pregnant women suggest that skin fold thickness in late pregnancy may be increased by water retention. The magnitude of this hydration effect may also vary from one measurement site to another. Especially during late pregnancy, skin fold thickness measurement may be less indicative of body fat content. By combining skin fold thickness measurements with arm circumference measurements, it is possible to estimate arm muscle area, which reflects the amount of lean tissue (IOM, 1990).

2.2.4 Anthropometry and LBW

An analysis of misclassification was undertaken in the WHO Collaborative study and the data showed that for the prediction of LBW, maternal pre-pregnancy weight and achieved weights at 20, 28 and 36 weeks performed equally well as indicators. The similar odds ratios (ORs) in the range 2.4-2.6 were found in about 50% of the studies which met the criteria. When LBW is broken down into its components of small for gestational age (SGA) and pre-term delivery, the indicators perform well in predicting LBW and as well as predicting the SGA. For the prediction risk of pre-term delivery, only pre-pregnancy weight and pre-pregnancy BMI met the criteria in over 40% of the studies and the indicators have moderate combined ORs of 1.33 and 1.42. The data of these studies use fixed cut-off values at the 25th percentile of the cluster in which it was placed; each individual study was examined for sensitivity and specificity for each indicator relative to each outcome (WHO,1995).

2.3 DIETARY INTAKE AND PREGNANCY OUTCOMES

Pregnancy is a time for growth and additional demand for nutrients. Subcommittees of the IOM are currently reviewing and revising the 1989 Recommended Dietary Allowances (RDAs) for pregnancy and lactation in the United States and Canada. A number of the old RDAs have been reviewed and been replaced by Adequate Intakes (AIs) and some of the old RDAs by new RDAs (Fagen, 2000). Table 2. 2 illustrates the most current RDAs and AIs and Figure 2. 5 demonstrates the nutrient needs of pregnant women, expressed as percentage of the RDA for adult non-pregnant women. During pregnancy, women need higher amounts of most nutrients, with the exception of vitamin A, than at other times (Wardlaw, 1997)

TABLE 2. 2

DIETARY REFERENCE INTAKES: RECOMMENDED DIETARY ALLOWANCE AND ADEQUATE INTAKES FOR WOMEN

MACRO & MICRO NUTRIENT	14 – 18 YEARS OF AGE	19 - 50 YEARS OF AGE	PREGNANT	LACTATING
Energy kJ	9945.6	10206	+ o 1st tri. + 1 428 2nd Tri + 1 898 3rd Tri	+ 2 100
Protein	46	46	71	71
Vitamin A (µg RE)	700	700	770 (>18yr) 750 (≤18yr)	1300 (>18yr) 1200 (≤18yr)
Vitamin D (µg)* AI	5	5	5	5
Vitamin E (mg ∝-TE)	8	15	15	19
Vitamin K (µg)	55	90	90 (>18yr) 75 (≤18yr)	90 (>18yr) 75 (≤18yr)
Vitamin C (mg)	60	75	85 (>18yr) 80 (≤18yr)	120 (>18yr) 115 (≤18yr)
Thiamin (mg)	1.0	1.1	1.4	1.5
Riboflavin (mg)	1.0	1.1	1.4	1.6
Niacin (mg NE)	14	14	18	17
Vitamin B6 (µg)	1.2	1.3	1.9	2.0
Folate (µg)†	400	400	600	500
Vitamin B12 (µg)	2.4	2.4	2.6	2.8
Biotin (µg) * AI	25	30	30	35
Pantothenic acid (mg) * AI	5	5	6	7
Choline (mg)*AI	400	425	450	550
Calcium (mg) *AI	1300	1000	1000 (> 18yr) 1300 (≤ 18yr)	1000 (> 18yr) 1300 (≤ 18yr)
Phosphorus (mg)	1250	700	700 (> 18yr) 1250 (≤ 18yr)	700 (> 18yr) 1250 (≤ 18yr)
Magnesium (mg)	360	310	350 (> 18yr) 400 (≤ 18yr)	310 (> 18yr) 360 (≤ 18yr)
Fluoride (mg)* AI	3	3	3	3
Iron (mg)	15	18	27	9 (> 18yr) 10 (≤ 18yr)
Zinc (mg)	12	12	11 (> 18yr) 12 (≤ 18yr)	12 (> 18yr) 13 (≤ 18yr)
Iodine (mg)	150	150	220	290
Selenium (µg)	50	55	60	70

• Adequate Intakes (AI)

tri, trimester; RE, retinal equivalents; ∝-TE, alpha-tocopherol; NE, niacin equivalents

† This is synthetic folic acid from fortified foods or supplements (Shabert, 2004).

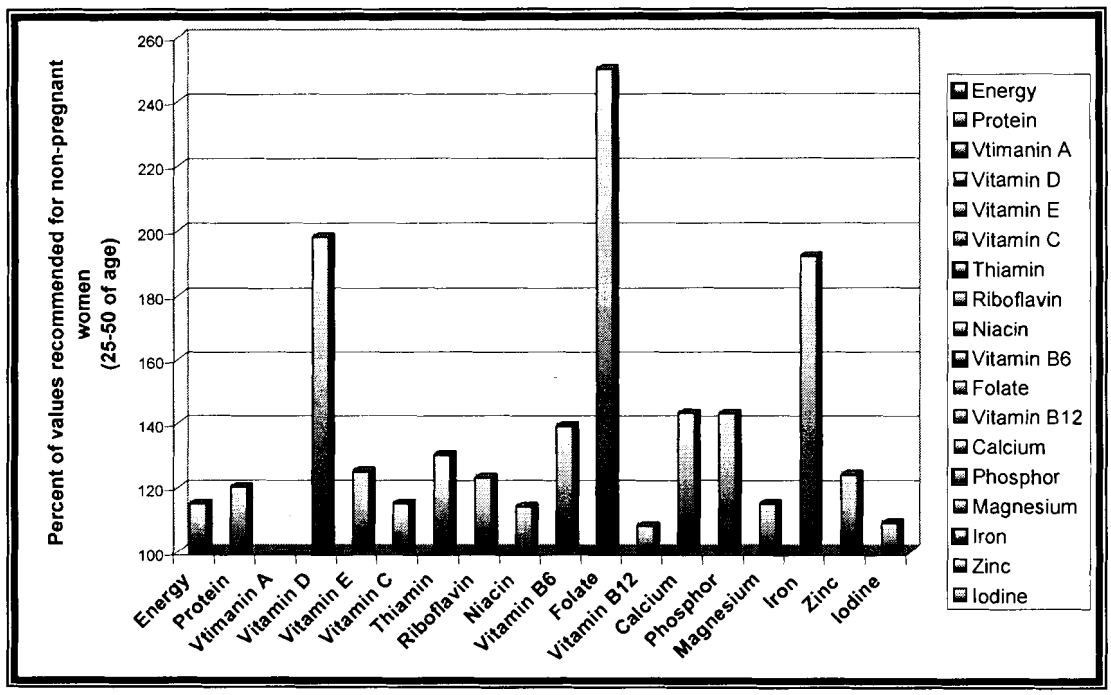


FIGURE 2. 5 NUTRIENT NEEDS OF PREGNANT WOMEN, EXPRESSED AS PRECENTANGE OF THE RDA FOR ADULT NON-PREGNANT WOMEN (WARDLAW, 1997).

2.3.1 Macronutrient status and pregnancy outcome

2.3.1.1 Energy intake

Additional energy is required during pregnancy to support the metabolic demands of pregnancy and fetal growth. The 2002 DRIs for energy for pregnant females in the first trimester are the same as for females who are not pregnant (10 092kJ/day), but they increase about a additional 1 428kJ to 1 512kJ/day during the second trimester and another 470kJ/day in the third trimester (IOM, 2002). Das and Jana (1998) cite that studies in pregnant Indian women showed that basal energy expenditure (BEE) during the first trimester of pregnancy was not significantly different from the BEE of non-pregnant women. BEE was progressively and significantly increased during the second and third trimester, as measured with the Benedict Roth metabolism apparatus.

Durnin (2002) monitored basal metabolic rate (BMR) throughout pregnancy in a group of Scottish women and found a fall in BMR in the early stages of pregnancy. They calculated that the total saving in BMR due to this initial decrease is balanced against the subsequent rise in BMR as pregnancy progresses, so that the total BMR during the first 30 weeks is approximately equivalent to the total BMR for 30 weeks in the non-pregnant state. This is unless a pregnant woman increases her physical activity during the first 30 weeks of pregnancy and the energy cost of activities is also increased due to the increased body weight. Due to the increased tissue synthesis and increased mass of metabolically active tissues such as maternal cardiovascular, renal and renal work during pregnancy, there is an increase in the basal metabolism (IOM, 1990).

The energy balance may be changed in any of the following ways to meet the requirements for pregnancy:

- a reduction in BMR
- mobilization of maternal fat stores
- reduction in physical activity
- an increased food intake.

Underweight women, living under constraints of hard physical work and limited good food supply cannot increase their food intakes and can also not modify their activity patterns. Since a woman living under these conditions also generally has little fat reserves to mobilize, her only option is a reduction in BMR. The severity of the situation will determine whether the infant will be small for gestational age at birth (King *et al.*, 1994).

Optimal fetal growth occurs only when the mother is able to accumulate a critical amount of extra body stores during pregnancy. Many of the cases of intrauterine growth restriction and LBW are

caused by short maternal stature, low prepregnancy body mass index, due to low energy intake and a low gestational weight gain (Kramer, 2003).

2.3.1.2 Carbohydrate intake

The recommendation of the carbohydrate needs during pregnancy is that the pregnant women need to consume more than 100 g of carbohydrate daily (Wardlaw, 1997). For the first time, the IOM has established DRIs for carbohydrate intake during pregnancy. The estimated average requirement (EAR) is 135g/day and the AI is 175g/day (IOM, 2002). This amount of carbohydrates prevents ketosis, which can be harmful for the fetus (Shabert, 2004). Ketosis is not desirable for the growing fetus as the fetal brain is uses the ketone bodies poorly. This suggests that ketones could slow the fetal brain development. Researchers stress the need for a pregnant woman not to "crash" diet or fast for more than 12 hours. A pregnant woman can develop significant ketosis after only 20 hours of fasting. This risk factor is very small due to the fact that even non-pregnant women usually eat twice this amount needed to prevent ketosis (Wardlaw, 1997).

Lenders *et al.* (1997) found that pregnant adolescents who consume high sugar diets are at an increased risk of SGA infants and the pregnant women of Puerto Rican ethnicity are at increased risk for shortened gestation. Further work on the association between sugar intake and birth outcome is needed and until more is known, the recommendations of sugar intake of 10% of the total energy needs to be advised to the pregnant women.

2.3.1.3 Fat intake

There are no particular requirements for extra fat intake, which would be met by a normal diet (Udipi *et al.*, 2000). The amount of fat in the diet should depend on energy requirements for proper weight gain. However, for the first time the IOM recommends an AI of 13g/day for the amount of n-6 polyunsaturated fatty acids (linoleic acid) and an AI of 1.4g/d for the amount of n-3 polyunsaturated fatty acids (α-linolenic acid) in the diet (IOM, 2002).

2.3.1.4 Protein intake

Although the need for additional protein to support the synthesis of maternal and fetal tissues is well recognized, the required magnitude of the increase is uncertain. Efficiency of protein utilization in pregnant women appears to be about 70%, the same as that observed in infants. Needs are also variable, increasing as pregnancy proceeds, with greater demands occurring during the second and third trimesters (Fagen, 2000). The current Recommended Dietary Allowance (RDA) of protein is 71g for pregnant females, this is 25 grams (g) more than the RDA for females who are not pregnant. It is based on 1.1g/kg/day using the prepregnant weight (IOM, 2002). Protein deficiency during pregnancy has adverse consequences, but limited intakes of

protein and energy usually occur together, making it hard to separate the effects of energy deficiency from those of protein deficiency. Studies have shown that providing extra energy to mothers influences pregnancy outcome as much as providing energy and protein together (Fagen, 2000). A meta-analysis by Kramer (1993) showed that the nutritional advice to increase energy and protein intakes and of balanced energy and protein supplementation has slightly increased the maternal weight gain and fetal growth, even in undernourished women. The data also showed that to increase the protein supplementation, there are no long-term benefits to the child in terms of growth or neuro-cognitive development. Neither balanced iso-energetic protein supplementation nor high-protein supplementation appears beneficial to either mother or infant and may even impair fetal growth. The same can be said for energy and protein restriction in pregnant women who are overweight or exhibit high weight gain.

However, all pregnant women should make sure they consume 71g of protein daily.

2.3.2 Micronutrient status and pregnancy outcome

Maintenance of health during the course of pregnancy requires an adequate supply of vitamins and minerals (Fagen, 2000). The requirement for many micronutrients increases during pregnancy and the risk of maternal deficiencies must be considered since a marginal maternal status can adversely affects the obstetrical outcome. Micronutrient deficiencies contribute to impaired growth, health and development. A randomized double-blind study by Hiniger *et al.* (2003) showed that the use of combined micronutrient supplements, at nutritional doses, improved babies' birth weight and maternal biological status. Villamor *et al.* (2002) state that a daily consumption of multivitamin supplements by pregnant women, who is infected with HIV, increased the immunologic profile of the mothers and reduced the risk of LBW, severe pre-term birth, and fetal losses. Costello and Osrin (2003) state that the present body of work on multiple micronutrient interventions is not sufficient to draw a conclusion on their effects on neonatal well-being, due to the fact that most of the studies concentrated on single micronutrients and a range of outcomes.

2.3.2.1 Vitamins

Folic acid

According to Fagen (2000), a pregnant woman's folic acid needs increase during pregnancy in response to the demands of maternal erythropoiesis and fetal and placental growth. The 1998 RDA is 600µg that includes a 200µg increase over the RDA for non-pregnant females. The IOM recommended that 400µg per day should come from fortified foods or supplements and 200µg

per day should come from food and beverages. A Tolerable Upper Intake Level (UL) was set at 800-1000µg per day from fortified foods or supplements (IOM, 1998). The key role of folate in DNA synthesis means that deficiency is associated with dysfunction in rapidly dividing cells. The relationship between periconceptional folate deficiency and neural defects is now well established, as is the benefit of supplementation (Costello & Osrin, 2003). Observational studies have suggested that lower maternal serum folate levels are associated with pre-term birth. A large U.S. study suggests an association between higher maternal serum folate at 30 week gestation and higher Apgar scores.

Another significance of folic acid and its potential influence on pregnancy outcome is its role in preventing neural tube defects, such as spina bifida and anencephaly. Two randomized trials in Europe have strengthened the association between periconceptional supplementation with folic acid and the prevention of neural tube defects. The Medical Research Council Vitamin Study done on 1817 women showed that there was a 75% reduction in the risk of recurrence of neural tube defects, when pregnant women were supplemented with folic acid. The second study showed that periconceptual supplementation with a multivitamin containing 800µg of folic acid reduced the incidence of neural tube defect in the infants born. In both these studies, folic acid supplementation was associated not only with a significant reduction in birth defects, but also with an increase in recognized spontaneous abortions. It may be that folic acid acts through an unusual mechanism called teratanasia, a selective promotion of spontaneous abortion of defective fetuses (Fagen, 2000).

Brown *et al.* (1997) reported that studies have shown that red cell folate levels exceeding 906mmol/L are the best for preventing neural tube defects. According to the Centers of Disease Control (CDC) (1992), the neural tube closes by 28 days of gestation, before most women realize they are pregnant. Supplementation with folic acid should be done ideally throughout the childbearing years. To accomplish this The Food and Drug Administration (FDA) has ruled that, effective January 1998, products made with enriched flour or grain products, such as bread, rice and pasta should contain additional folic acid, just as they contained additional iron, niacin and other vitamins. Women of child bearing age should be encouraged to include generous amounts of folic acid sources in their diets, that is foods such as dark green leafy vegetables, legumes, orange juice, soy, wheat germ, almond and peanuts. In addition, women who are planning a pregnancy should begin with periconceptional supplementation of folic acid at levels of 400 to 800 µg per day.

Fagen (2000) cites that women who smoke, consume moderate or heavy amounts of alcohol or use recreational drugs are at risk for marginal folate status. Users of oral contraceptives,

antiepileptic medication and some other prescription drugs, as well as those with malabsorption syndromes, may have low serum or red blood cell folate levels.

Vitamin A

The RDA for vitamin A is 750µg retinol equivalents (RE), or 2800 IU, for pregnant females 18 and under and 770µg retinol equivalents (RE), or 3000 IU, for women over the age of 18 (IOM, 2001). Excessive consumption of vit A does appear to be teratogenic. At least seven case reports of adverse pregnancy outcome have been associated with a daily ingestion of 25,000 IU or more of vitamin A (Fagen, 2000). Rothman *et al.* (1995) state that pregnant women who take vit A supplements at levels as low as 2.5 times the RDA – 10.000 IU per day, an amount easily available in a general multiple vitamin supplement, increase the risk of delivering a baby with a cranial neural crest defect five times more than women who take 5000IU or less per day. Fagen (2000) cites that these findings do not apply to beta-carotene, a precursor of vit A. Vit A poses the most danger when taken in these amounts 2 weeks prior to conception and during the first 2 months of gestation. Due to the fact that animal liver contains 9000 IU of vit A per 3-oz (90g) portion, women contemplating a pregnancy or in the early stages should eat only small amounts of liver infrequently.

Costello and Osrin (2003) cite that serum vit A levels probably do not correlate with maternal infection or neonatal Apgar scores. The possible effect of vit A deficiency on pre-term birth has not been replicated. A large cluster randomized trial in Nepal showed no effect of vit A supplementation on neonatal mortality or morbidity in the first 6 months.

Vitamin D

The Adequate Intake (AI) for vitamin D (vit D) is 5µg (200 IU)/day, the same as that for non-pregnant women. The DRIs also include a UL of 50µg/day during pregnancy (IOM, 1997). Vit D has long been appreciated for its positive effects on calcium balance during pregnancy. Vit D and its metabolites cross the placenta and appear in fetal blood in the same concentration as found in maternal circulation. Maternal deficiency of vit D and the subsequent limitation in placental transport to the fetus have been associated with neonatal hypocalcemia or enamel hypoplasia, or both. Vit D levels are often low in such infants. However, excessive amounts of vit D may be harmful during gestation. Severe infantile hypocalcaemia has been reported in newborn infants (Fagen, 2000).

Tocopherol (Vitamin E)

Vitamin E (vit E) needs are believed to increase somewhat during pregnancy, but vit E deficiency in humans is rare and has not been linked to either damage to offspring or reduced fertility (Fagen, 2000). The antioxidant properties of tocopherol have been associated with malformation

and fetal death. Studies have found no association between maternal plasma or serum tocopherol and gestational duration or Apgar scores (Costello & Osrin, 2003). The 2000 RDA of 15 mg of alpha-tocopherol equivalents (alpha-TE) for women who are not pregnant is the same as the RDA for those who are pregnant (IOM, 2000). The UL is 800mg/day for pregnant females of age or younger and 1000mg/day for pregnant women 19 to 50 years old (IOM, 2000).

Vitamin K

The RDA for vitamin K during pregnancy is 90mg/day for women over age 18 and 75 mg/day for females 18 years of age and younger (IOM, 2001). The typical diet provides an adequate amount of vitamin K. No ULs for vitamin K during pregnancy have been defined. Given the recent association of vitamin K and bone, health, adequate intakes of vitamin K during pregnancy are further supported (Zittermann, 2001)

Ascorbic acid (Vitamin C)

An additional 10mg/day of vitamin C (vit C) is recommended for pregnant females. The total recommendation of 80 to 85 mg/day is met by a typical American diet (IOM, 2000). Large population studies showed that ascorbic acid deficiency has not been associated with adverse pregnancy outcomes (Fagen, 2000). Costello and Osrin (2003) state that the involvement of ascorbate in collagen stabilization and protection from reactive oxygen species support a role for it in maintaining membranes. A lower plasma and leukocyte ascorbate have been associated with premature rupture of membranes and preeclampsia.

Thiamin intake

Costello and Osrin (2003) state that in studies where thiamin intake has been linked to birth weight on the basis of dietary assessment in the first trimester, there has been no observational association of thiamin levels with stillbirth. The RDA for thiamin during pregnancy has been established at 1.4mg /day (Fagen, 2000).

Cobalamin (Vitamin B_{12})

The RDA for vitamin B_{12} (vit B_{12}) during pregnancy is established at 2.6 μg (Fagen, 2000). The megaloblastic anemia of cobalamin deficiency highlights its association with defects in DNA synthesis, cell multiplication and metabolism. Low serum cobalamin levels have been associated with pre-term birth. Severe gestational deficiency may also be associated with intrauterine death (Costello & Osrin, 2003).

Pyridoxine (Vitamin B_6)

The 1998 RDA for vitamin B_6 (vit B_6) during pregnancy is 1.9 mg per day. In 1998, a UL for vit B_6 was set at 80-100 mg/day (Fagen, 2000). Pyridoxine appears to play an important role in the

development of the central nervous system. A possible association of vit B_6 deficiency with lower Apgar scores was reported in several studies (Costello & Osrin, 2003).

2.3.2.2 Minerals

Calcium intake

The pregnant women routinely exhibit extensive adjustments in calcium metabolism, largely as a result of the influence of hormonal factors. Human chorionic somatomammotropin from the placenta progressively increases the rate of bone turnover. Estrogen, largely derived from the placenta, inhibits bone resorption, provoking a compensatory release of parathyroid hormone, which maintains the serum calcium level while enhancing intestinal absorption. The nett effect of these changes, which predate fetal skeletal mineralization, is the promotion of progressively increasing fetal skeletal demands for mineralization. Fetal hypercalcemia and subsequent endocrine adjustments ultimately stimulate the mineralization process. Approximately 30 g of calcium is accumulated during pregnancy, almost all of it in the fetal skeleton (25 g) (Fagen, 2000).

The AI for calcium during pregnancy is 1300mg/day for women younger than 19 years of age and 1000 mg/day for older women. Due to the fact that the maternal hormones increase the absorption and utilization of calcium, the AI for pregnant women and for non-pregnant women are similar. The UL for calcium during pregnancy is established at 2500mg/day (Fagen, 2000).

If women consume less calcium than the AI, the calcium may leach from calcium reservoirs in the maternal skeleton, of which the total requirement of pregnancy (30g) amounts to about 2.5%. Multiparous women with poor calcium intake can exhibit evidence of clinical osteomalacia. Neonatal bone density may relate to the adequacy of maternal calcium consumption during pregnancy (Fagen, 2000).

Iron

A marked increase in the maternal blood supply during pregnancy increases the demand for iron. With the availability of this mineral, either from the diet or supplements, total erythrocyte volume increases by 20% to 30%. Active bone marrow may utilize an extra 500mg of elemental iron during pregnancy and the term fetus and placenta accumulate 250-300mg of elemental iron. Overall, the pregnant women should have between 700 and 800mg of extra iron, most of which is needed during the last half of pregnancy when the heaviest maternal and fetal demands occur. The RDA for iron during pregnancy is a 30 mg/day (Fagen, 2000).

Administrative Committee on Coordination and Subcommittee on Nutrition (1992) cite that iron deficiency (ID) is the most common nutritional disorder in the world, affecting over one billion people, particularly women of childbearing age and preschool-aged children. Anemia is a serious outcome of ID. The global estimated prevalence of anemia in pregnant women is 51%, with a prevalence of 56% in developing countries. Fagen (2000) cites that maternal anemia, defined by a hematocrit value of less than 32% and haemoglobin level of less than 11g/dL, occurs in some pregnant women who do not use iron supplements. An anemic woman is clearly less able to tolerate hemorrhage with delivery and is more prone to develop puerperal infection, however the fetal effects of maternal anemia are poorly understood (Fagen, 2000).

According to Hallberg *et al.* (1993), there are multiple causes of anemia and other causes other than ID often include malaria, intestinal parasites, other nutrient deficiencies such as folate and vitamin B_{12} and genetically determined haemoglobinopathies such as thalassaemia. At least half of the anemia worldwide is directly due to dietary ID (DeMaeyer & Adiels-Tegman, 1985; Administrative Committee on Coordination, 1992). Factors contributing to ID include diets with insufficient iron, reduced dietary iron availability, increased iron requirements to meet reproductive demands and losses due to parasitic infections (DeMaeyer & Adiels-Tegman, 1985; Hercberg *et al,* 1987; Administrative Committee on Coordination, 1992).

A significant increase in maternal and fetal mortality and risk of premature delivery has been related to severe anemia in pregnant women. Although a strong correlation between maternal anemia and birth weight has been shown, it has not been demonstrated that there is a higher prevalence of anemia in babies of mothers with ID (Soysa, 1987). Dannhauser *et al.* (2000) cites that recently, however, attention was drawn to the fact that a high hemoglobin concentration during pregnancy should be a matter of concern, than a low haemoglobin concentration. It was also highlighted that anemia diagnosed early on in pregnancy and not later in pregnancy, might be associated with poor pregnancy outcome. On the other hand, it has been found that infants of mothers with moderate and severe anemia at 37-41 weeks of pregnancy had significantly lower cord serum ferritin levels and hence poor iron stores at birth. A ID leads to reduced work capacity, diminished attention, memory and learning ability and growth retardation in infants, as well as to increased susceptibility to infection (Lozoff, 1988; Beard *et al,* 1993).

Zinc

The 2001 RDA for zinc is 11 mg/day (for those age 19 and older) and 12mg (for those age 18 and younger) during pregnancy (IOM, 2001). The average zinc intake of pregnant women is 11.1 mg/day (Murtaugh & Weingart, 1995). Due to the fact that zinc stored in maternal bones is somewhat unavailable, a zinc-deficient diet does not effectively lead to zinc mobilization. As a result, a dietary deficiency is quickly reflected in the maternal mineral balance. Maternal zinc

status may be inversely related to the level of prenatal iron supplementation, as excess iron inhibits zinc absorption (Fagen, 2000). Zinc interacts with more than 300 enzymes and proteins and the effects of deficiency are wide ranging. Maternal acrodermatitis enteropathica (an inborn defect of zinc absorption associated with severe hypozincemia) leads to a reversible propensity for fetal malformation and leads to wider concern about the possibility of zinc deficiency in the general population. Lower zinc intakes have been associated with pre-term delivery (Costello & Osrin, 2003). According to Costello and Osrin (2003), some studies found lower maternal plasma zinc to be a risk factor for congenital malformations and other studies did not.

One study found lower maternal plasma zinc to be a risk factor for pre-term delivery (Sikorski *et al.*, 1990) and others did not (Islam *et al.*, 1994; Tamura *et al.*, 2000). Some supplementation trials have shown that supplementation reduces the incidence of pre-term delivery (Cherry *et al.*, 1989; Garg *et al.*, 1993; Castillo-Duran *et al.*, 2001), increases gestation duration (Ross *et al.*, 1985; Kynast & Saling, 1986; Cherry *et al.*, 1989; Garg *et al.*, 1993; Goldenberg *et al.*, 1995) and improves Apgar scores (Garg *et al.*, 1993). Other studies demonstrate no effect on pre-term delivery (Hunt *et al.*, 1985; Ross *et al.*, 1985; Kynast & Saling, 1986; Mohomed *et al.*, 1989; Caulfield *et al.*, 1999), gestational duration (Caulfield *et* al., 1999) or Apgar scores (Hunt *et al.*, 1984; Mohomed *et al.*, 1989). Some studies found that maternal leucocyte zinc has a positive association with intrauterine growth and other studies did not. Due to these contradictions there is more research necessary in the area of zinc and pregnancy outcomes (Costello & Osrin, 2003). Of more concern, a recent study in Bangladesh randomly allocated 559 pregnant women to zinc (30mg daily) or placebo (cellulose) from 4 months gestation to delivery. At follow-up, infants in the placebo group had higher scores on mental and psychomotor development indices than those in the zinc supplementation group (Costello & Osrin, 2003). Because there is largely contradiction among studies on zinc intake and pregnancy outcomes, larger randomized controlled trials to obtain clarification on the zinc intake and the pregnancy outcomes are required.

Iodine

An additional 70 μg of iodine for pregnant females has been added to the RDA of 150μg for females who are not pregnant – making the RDA for iodine during pregnancy 220 μg/day. This amount should be adequate to provide for fetal iodine demands. The UL in pregnancy is 900 to 1100μg/day (IOM, 2001). According to Fagen (2000), maternal iodine deficiency has long been recognized as a cause of cretinism in infants. Data suggest that suboptimal iodine nutrition of the mother may compromise development of the fetus, even when cretinism does not occur. Findings indicate that iodine deficiency may lead to a spectrum of subclinical deficits that place the child at a developmental disadvantage. According to Costello and Osrin (2003), the beneficial

effect of iodine supplementation on endemic cretinism, goiter and infant mortality has been established in a trial in Zaire.

Magnesium

The RDA of 360-400 mg of magnesium in pregnancy includes an increase of 40-90mg to meet the needs of fetal and maternal tissue growth. The term fetus accumulates 1 g of magnesium during gestation (Shabert, 2004). The IOM has noted that magnesium supplementation during pregnancy has been linked to reduced incidence of preeclampsia and intrauterine growth retardation. The UL for magnesium from supplements or pharmacological agents during pregnancy is 350 mg/day (IOM, 1997). Low serum magnesium levels have been questionably associated with pre-term labour (Kurzel, 1993). Some magnesium supplementation studies have shown benefits to rates of pre-term birth and others have not. Supplementation seems to have no effect on Apgar scores. A Cochrane review of six controlled trials (heavily weighted by two studies) concludes that supplementation starting before the third trimester results in a lower incidence of pre-term birth (Costello & Osrin, 2003).

Copper

The RDA for copper during pregnancy is 1000μg/day, 100μg/day more than non-pregnant women (IOM, 2001). The copper content of many diets of pregnant women is only marginal, however, it is currently unknown whether moderate dietary copper deficiency is of consequence to the developing human fetus (Fagen, 2000). Copper deficiency affects many cuproenzymes, leading to defects in adenosine triphosphate (ATP) production, lipid peroxidation, hormone activation, angiogenesis and abnormalities of vasculature, skeleton and lung (Breskin *et al.*, 1983). One study found an association of low maternal plasma copper with pre-term rupture of membranes. Cord serum copper has been negatively associated with pre-term delivery (Costello & Osrin, 2003). Copper deficiency has been found to be teratogenic in animals and copper deficiency may also compromise pregnancy outcome in humans. Excess iron supplementation inhibits copper absorption (Fagen, 2000).

Fluoride

The AI for fluoride in pregnancy is 3 mg/day and the UL is 10mg/day (IOM, 1997). The role of fluoride in prenatal development is somewhat controversial. Development of the primary dentition begins at 10 to 12 weeks of pregnancy and from the sixth to the ninth month, the first four permanent molars and eight of the permanent incisors begin to form. Thus, 32 teeth are forming and developing during gestation (Fagen, 2000).

Multivitamin intake and pregnancy outcomes

Requirements for many micronutrients increase during pregnancy and the risk of maternal deficiencies must be considered since a marginal maternal status can adversely affect the obstetrical outcome. A daily consumption of multivitamin supplements increases the haemoglobin concentrations and could lower the rate of ID or anemia. (Villamor *et al.,* 2002). Micronutrient deficiencies contribute to impaired growth, health and development (Hininger *et al.,* 2003). A randomized double-blind study of Hininger *et al.* (2003) suggests that the use of combined micronutrient supplements, at nutritional doses, improved babies birth weight and maternal biological status. A double-blind randomized controlled trail of Czeizel (1993) suggests that combinations of vitamins and minerals reduces stillbirth rates. A double-blind, factorial randomized controlled trial of HIV infected pregnant women, suggests that multiple micronutrients improve the fetal death rates (Fawzi *et al.*, 1998). These preliminary results need to be confirmed in further larger studies, but suggest that pregnant women should be encouraged to have optimal micronutrient nutrition (Hininger *et al.,* 2003).

2.4 SUMMARY

Accumulation of extra body stores of nutrients during pregnancy is critical for optimal fetal growth and can be directly influenced by the dietary intake (Kramer, 2003). According to Fagen (2000), the 1989 RDA states that during the second and third trimesters of pregnancy, an additional 300kcal/day (1260kJ) is needed. A lower energy intake as the requirement could cause short maternal stature, low pre-pregnancy body mass index, which could cause, excess intrauterine growth restriction and LBW (Kramer, 2003). Ketosis could develop if a pregnant woman does not consume more than 100g of carbohydrates per day, which could cause fetal brain impairment. Protein limitation during pregnancy has adverse consequence, but a protein limitation usually occurs with an energy limitation and this makes it difficult to separate the effects of energy deficiency from those of protein deficiency. Micronutrient deficiencies contribute to adverse pregnancy outcomes especially in vitamins and minerals such as folic acid, vitamin A, vitamin B_{12}, iron and zinc. Folic acid supplementation significantly showed to prevent neural tube defects, such as spina bifida and anencephaly and the vitamin study showed a 75% reduction in the risk of recurrence of neural tube defects (Fagen, 2002). The excessive intake of vitamin A does appear to be taratogenic (Fagen, 2000) and increase the risk of delivering a baby with a cranial neural crest defect (Rothman *et al.,* 1995). However these adverse outcomes do not apply to beta-carotene (Fagen, 2000). Vitamin B_{12} deficiency could cause a megaloblastic anemia, which could be associated with defects in DNA sythesis, cell multipication, and metabolism and pre-term delivery (Costello & Osrin, 2003). The maternal blood supply increases during pregnancy and the iron demand increases. An iron deficiency during the early pregnancy period (Dannhauser *et al.*,

2000), could lead to anemia and this increases the risk of premature delivery, maternal and fetal mortality (Soysa, 1987). A larger body of contradiction in connection with zinc intake and adverse pregnancy outcomes is present in the research field and further research is necessary to accomplish clarity (Costello & Osrin, 2003). The WHO (1995) cites that a LBW, prematurity and IUGR remain the leading causes of perinatal morbidity, mortality, neurodevelopment impairments and disabilities among newborn babies. Not only dietary intakes have a effect on the pregnancy outcomes, but other factors such as, behavioural factors like smoking, 150mg/day caffeine intake, alcohol intake (ADA, 2002) and psychosocial factors, psychological and distress can cause increase risk of pre-term deliveries, impairment of fetal growth and perinatal mortality. According to Harrison *et al.* (2001), there is an association between low socioeconomic status, malnutrition and a maternal age less than 16 years or more than 35 years, which can also be associated with triggers of pre-term deliveries. HIV (Villamor *et al.*, 2002), malnutrition (Wells & Murray, 2003), obesity (ADA, 2002) and gaining weight outside the IOM guidelines (IOM, 1990) could also be associated with adverse pregnancy outcomes. To have optimal pregnancy outcomes, a balanced healthy diet and lifestyle is necessary (Fagen, 2000).

CHAPTER 3

THE ASSOCIATION BETWEEN DIETARY INTAKES AND PREGNANCY OUTCOMES: THE THUSA MAMA STUDY

3.1 INTRODUCTION

Numerous factors interact to determine the progress and outcome of pregnancy. Although much remains to be learned about the role of nutrition in modifying this process, it is well accepted that the nutritional status of the pregnant woman affects the outcome of her pregnancy (Fagen, 2000). Across the world there is a high prevalence of adverse outcomes to pregnancy, which can be life threatening for both the mother and her baby. For the mother, poor nutritional status, infection, stress at home and at work all contribute, separately or together, to increasing her risk of ill health and limiting her ability to provide an adequate supply of nutrients to the developing fetus. Sub-optimal fetal growth is associated with higher fetal mortality, as well as neonatal and infant morbidity and mortality. Infants who are born small have greater risk of poor physical and neurocognitive development (Jackson *et al.*, 2003) and the infant's risk of long-term adverse health outcomes, such as hypertension, obesity, glucose intolerance and cardiovascular disease may increase (Fagen, 2000). Maternal nutrition has been the focus of considerable research and public health policy during the past two decades. Using both observational and experimental study designs, researchers have investigated the potential causal links between pregnant women's intakes of energy and protein and the outcome of pregnancy. Interest has centered on birth weight as an outcome, especially in populations with a high prevalence of maternal under nutrition, low birth weight and perinatal mortality (Kramer, 1993).

There is little causal evidence on the effect of maternal micronutrient supplementation on pregnancy outcome and infant health and survival in the developing world. Although prenatal multivitamin and mineral supplements are commonly consumed in developed countries, these practices are less common in developing countries, in which existing antenatal iron-folate programmes achieve low coverage and have been ineffective (Christian *et al.*, 2003). The American Dietetic Association position paper states: "*It is the position of the American Dietetic Association that women of childbearing potential should maintain good nutritional status through a lifestyle that optimises maternal health and reduces the risk of birth defects, sub-optimal fetal development and chronic health problems in their children. The key components of a health-*

promoting lifestyle during pregnancy include appropriate weight gain; consumption of a variety of foods in accordance with the Food Guide Pyramid; appropriate and timely vitamin and mineral supplementation; avoidance of alcohol, tobacco and other harmful substances; and safe food-handling. In particular for medical nutrition therapy, pregnant women with inappropriate weight gain, hyperemesis, poor dietary patterns, phenylketonuria (PKU), certain chronic health problems, or a history of substance abuse should be referred to a qualified dietetics professional."

In this substudy of the Thusa Mama Study just the dietary data was analyzed, The aim of this substudy of the Thusa Mama Study was to evaluate the association between dietary intake and pregnancy outcome in pregnant women who visited a clinic on a regular basis. This includes a number of factors that have an impact on dietary intake, or are affected by dietary intake. Factors that were investigated in this study were socio-demographic background, blood concentration of haemoglobin, the macronutrient dietary intake (especially energy and protein) and micronutrient dietary intake (especially iron, folic acid, calcium, zinc, vitamin A and vitamin C). The outcomes that were investigated were mainly the outcomes of the infant's birth weight, length, head circumference and gestational age. The project was called the Thusa Mama Study, because 'Thusa' is the Tswana word for help and it was the aim of the study to eventually help mothers.

3.2 METHODOLOGY

Data collecting process

A letter was written to the District Manager, Department of Health to obtain permission to conduct the study in the Potchefstroom Primary Health Care Clinic. Permission was granted. The Ethics Committee of the North-West University approved the project. The study was done over a one-year period. Pregnant South African women visiting the midtown antenatal clinic in Potchefstroom were asked to volunteer as participants in the Thusa Mama study. The inclusion criteria are listed in Table 3.1. At the first visit, the participants (n = 98) signed an informed consent form (Appendix A). Dieticians and final year Dietetic students of the North-West University collected data on the participants' background information (including age, educational status, occupational status, average household income, marital status and pregnancy history) by using structured demographic questionnaires (Appendix B). Early in the pregnancy the information regarding their nutritional intake was collected by fieldworkers, using a Food Frequency Questionnaire (FFQ), attached as Appendix C. The reason why a FFQ was used is that FFQ has become the primary method for measuring dietary intake in epidemiologic studies. Such questionnaires are directed to the dietary exposure of conceptual interest in most applications, which is average intake over a period of time. FFQs are extremely practical in epidemiologic applications as they are easy for

trained fieldworkers to complete. A FFQ is easy to computerise and inexpensive (Willett, 1998). Food portion photo books were used to estimate portion weights. A Maternal Health questionnaire (Appendix D) was used to fill in other details measured by a registered nurse in the Clinic, such as smoking status, alcohol intake and haemoglobin levels measured by Haemoglobin meter. The Clinic nurses did blood tests for Human Immunodeficiency Virus (HIV) only for subjects who gave their consent.

TABLE 3. 1

INCLUSION CRITERIA FOR THE THUSA MAMA STUDY

INCLUSION CRITERIA
➢ Pregnant women
➢ Black or coloured ethnic group
➢ On their first visit to the clinic
➢ Still within the first 28 weeks of pregnancy
➢ Living (sleeping) in the Potchefstroom municipal area (Ikageng town, with the exclusion of the most remote extension and those living on farms) for follow-up
➢ Planning to give birth in the Potchefstroom Hospital
➢ Expecting one baby only (not twins and triplets)

To determine the weight gain during pregnancy, each participant's weight and height was recorded on a form similar to the one in Appendix E. It was decided to use only weight and height for this study and not all the measurements shown on the form, because skin folds are not applicable for this part of the study.

The weight was measured using a Precision electronic scale (A & D Company, Tokyo, Japan), and the height by using the clinic's own equipment (wall-mounted stadio-meter). The

anthropometry measurements were done by dieticians, final year Dietetics students and post-graduate Sport Science students. Each participant was followed up for a minimum of three visits. Where possible, the visit was done within 14 to 28 weeks of gestation, the second within the 30 to 32 weeks and the third within 36 to 38 weeks. Most participants were followed up for more than three visits. Taxi fees were reimbursed for each visit (R10/visit).

At birth, a hospital visit was done to record the infant's birth weight, which was measured by the hospital with a spring scale (Salter model 40A, Japan); length and head circumference, measured with an unstretchable tailoring tape made of linen (Butterfly brand, China), gestational age and Apgar scores were recorded. The form used for data collection is attached as Appendix F. To determine the gestational age of baby, the following criteria were used: Sonar dates (for most of the babies), palpations and for premature babies, the *Farr system* (Harrison *et al.,* 2001).

Mothers at risk for poor pregnancy outcomes (underweight, positive HIV status and those not gaining weight during the pregnancy) received the necessary interventions, such as advice from dieticians, medical care, standard clinic nutrition supplements (folic acid, iron and vitamin C tablets and a ready to mix meal if the mother qualified for the Protein Energy Malnutrition [PEM] scheme.)

Statistical Analysis:

Pregnancy weight gain was categorized as optimal weight gain, insufficient weight gain and excessive weight gain according to the IOM guidelines (IOM, 1990). For statistical analysis a regression analysis was use to estimate the mother's pre-pregnancy weight in order to calculate the pre-pregnancy BMI, as described by Olson and Strawderman (2003). The regression was done back to week 14 (gestational age), as the weight gain is linear from there on and thus to give a more realistic regression analysis. Weight gain between visits was used to calculate an average weekly gain. The FFQ data were converted to daily intakes and each FFQ (n = 98) was analyzed by using the computer programme *Food Finder*®(Medical Research Council, Tygerberg, 2000).

All statistical analyses were done using *Statistica*® (version 7). The association between pre-pregnancy BMI and weekly weight gain, dietary intake, age and birth data, with adjustment for smoking and HIV status were assessed. Three Nutrient Index categories were defined, the vitamin supplementation, which the participants were receiving at the clinic were not added to the micronutrient intake of each participant. The micronutrient intake of each participant was compared with the RDA and if the intake was lower than 66% of the RDA (1997-calcium; 1998-folate; 2000-vitamin C; 2001-iron, zinc, vitamin A), the micronutrient was classified as low intake, with a rating of one. If the micronutrient intake was between 67 – 100% of the RDA, a rating of

two was allocated to the micronutrient and if the intake was more than 100%, a rating of three was allocated. A mean micronutrient intake was determined for each participant and the different means were distributed into Nutrient Index categories 1, 2 or 3. Nutrient Index 1 represents a poor dietary intake, Nutrient Index 2 an adequate dietary intake and Nutrient Index 3 a good dietary intake.

Descriptive statistics of each Nutrient Index category (1-3) were calculated for intake of: total energy, total protein, plant protein, animal protein, total fat, carbohydrate, dietary fibre, calcium, iron, haem iron, magnesium, zinc, vitamin A, thiamin, riboflavin, niacin, vitamin B_6, folic acid, vitamin B_{12}, vitamin C and vitamin E. Descriptive statistics of the age, pre-pregnancy weight, total weight gain, weekly weight gain and the haemoglobin concentration of the mother were also calculated. Descriptive statistics of the baby's birth weight, length and head circumference and gestational age were also calculated. Subjects were classified according to BMI category and the categories were compared regarding weekly gain and total weight gain according to IOM guidelines.

A frequency distribution was calculated for the participants' qualification, occupation, total household income, number of people in the house, type of house, type of toilet, water facility, the behavioural factors like smoking and alcohol habits and the HIV status. A frequency distribution was also calculated for the comparison of weight gain according to IOM guidelines, classified as too low, appropriate or too high and the Nutrient Index category, which was classified as poor, adequate and good.

A Spearman Rank Order correlation coefficient was calculated for the associations between dietary intake of energy, total protein, animal protein, total fat, calcium, iron, haem iron, zinc, vitamin A, vitamin B_6, folic acid, vitamin C, the mother's age, total income, haemoglobin levels, total weight gain, weekly weight gain and the baby's birth weight, length and head circumference and gestational age at birth.

3.3 RESULTS

Of the 98 women included in the study, data of 91 women could be analyzed. Two pregnancies ended in miscarriage and five women were lost during the follow-up. This group of volunteers was a sub-sample of the total number of 478 pregnant women who attended this clinic during a period of a year. Comparison of age, parity and haemoglobin values between the total group and

the sub-sample showed that the sub-sample group was similar to the total group, with the only difference being that the sub-sample group attended the clinic from an earlier stage of pregnancy (mean 22 weeks compared with 28 weeks gestation of the total group). Only 32 of the 91 women consented to an HIV test, of which eleven were HIV positive and 21 tested negative. None of the women were symptomatic at the time of the study, or received antiretroviral medication. Only 6.2% of the women smoked and 6.1% of the women drank alcohol. All of the participants had singleton pregnancies.

Table 3.2 shows the demographic data of the group (n=91) collected through a demographic questionnaire on the first visit to the clinic. The results in Table 3.2 show that most of the participants (98.9%) spoke an African language i.e. Xhosa, Zulu, Tswana or Sotho and only 1.1% spoke English or Afrikaans. Only one out of every five women were married, a third of the participants lived with the babies' father but were not married and most of the women lived with relatives or friends. Less than half of the women (48.4%) expected their first baby. About 25% of the women had no school education at all, or only primary school education. More than one third (39.5%) of the participants had a qualification of grade eleven and twelve. Only 20% of the women had a higher qualification than grade twelve. More than half of the participants were unemployed, with most of those employed being domestic workers (50%) and responsible for their own income (40.5%). Only one-fifth of the participants were financially supported by the baby's father. Less than one-third (32%) of the women were financially supported by the grandparents or parents. More than half of the women (68.1%) received a monthly income of less than R 1 000 and just more than one-fifth (23.1%) of the participants received between R1 001 and R 2 000. The rest of the women received between R 2 001 and R 5 000 per month. One-quarter of the women lived in informal housing and only one-third had access to piped water from a tap inside their homes. Less than 10% of the women did not have access to electricity.

Table 3.3 shows the women who gained inadequate, adequate and excessive weight according to the IOM's weekly recommendation [n=87] (IOM, 1990). Of those with a pre-pregnancy BMI < 19.8, classified as underweight (n=14), 2 women gained inadequate weight per week, 1 women gained adequate weight per week and 11 gained more than the guidelines of IOM's weekly recommendations. The group with normal pre-pregnancy BMI (19.6 - 26) [n=45], 14 woman gained inadequate weight per week, 9 women gained adequate weight per week and 22 gained more than the guidelines of IOM's weekly recommendations. The group with a pre-pregnancy BMI > 26 (n=28) was classified as overweight, none of these women gained inadequate weight per week, 12 women gained adequate weight gain per week and 16 gained more than the guidelines of IOM's weekly recommendations. Figure 3.1 shows the mean, minimum and maximum total weight gain of the participants in each diet category. It can be seen that the

participants in the good Nutrient Index diet group had the highest mean total weight gain, but it was not significantly different from the other diet groups. In the poor and adequate diet groups, there were also participants who had a higher weight gain than the IOM guideline recommendations. Table 3.4 shows the pre-pregnancy BMI distribution of the participants in the different Nutrient Index categories. From this table it can clearly be seen that most of the women fell in the normal weight category before pregnancy, regardless of the type of Nutrient Index diet. It also shows that there were participants with a poor Nutrient Index diet, who were overweight or obese. Table 3.5 shows the data regarding the pre-pregnancy BMI compared to the mother's age, weight gain, dietary intake and the baby's outcomes. No significant differences between the dietary variables of the different groups were found, except for age, the obese women being older than the normal weight and underweight women. It also showed no significant differences in birth weight, length or head circumference.

TABLE 3. 2: DEMOGRAPHIC DATA OF THE PARTICIPANTS (N = 91)

DEMOGRAPHIC DATA	%
First language:	
African language (Xhosa/Zulu/Tswana/Sotho)	98.9%
English / Afrikaans	1.1%
Martial status:	
Married, live with baby's father	17.7%
Live with partner, baby's father (not married)	32.2%
Live with partner, not baby's father (not married)	2.3%
Widow, live alone with other relatives	1.1%
Never married, live alone	1.1%
Never married, live with relatives/friends	45.6%
Other Children	
Yes	51.6%
No	48.4%
Highest Qualification:	
None	7.7%
< Grade 8	18.7%
Grade 8-10	9.9%
Grade 8-10 + trade	4.4%
Grade 11-12	39.5%
Grade 11-12 + trade	11%
Grade 12 + tertiary education	8.8%

TABLE 3. 2 (CONTINUED)

DEMOGRAPHIC DATA (CONTINUED)	%
Employment:	
Employed	48.4%
Unemployed	51.6%
Occupation	
Professional (teacher/nurse/other with tertiary education)	9%
Self-employed, formal	6.8%
Office work / sales assistant	29.7%
Domestic service / cleaner	50%
Informal sector (hawker)	4.5%
Main Source of Income	
Own salary / wage	40.5%
Parents / Grandparents	32%
Relative's pension	2.2%
Husband / Partner	20.9%
Other: brother or sister	4.4%
Total Household Income per month	
< R 500 per month	28.6%
R 500 – R1 000 per month	39.5%
R1 001 – R2 000 per month	23.1%
R2 001 – R 5 000 per month	8.8%

TABLE 3. 2 (CONTINUED)

DEMOGRAPHIC DATA	%
Type of household and services	
Brick house	73.6%
Zinc informal house	23.1%
Other: prefabricated/wood	3.3%
Access to Electricity	92.3%
Water: Tap inside house	35.2%
Tap outside in own yard	54.9%
Communal tap within 200 m from house	9.9%

TABLE 3. 3

WEIGHT GAIN BELOW, WITHIN OR ABOVE THE IOM'S RANGES (N = 87)*

UNDERWEIGHT (BMI < 19.8)		
< 0.45 kg / week (Inadequate)	0.45 – 0.49 kg / week (Lower end of range)	> 0.49 kg / week (Upper end of range)
14.3 % (n = 2)	7.1% (n = 1)	78.6 % (n = 11)
NORMAL WEIGHT (BMI 19.8 – 26)		
< 0.31 KG / WEEK (Inadequate)	0.31 – 0.44 KG / WEEK (Lower end of range)	> 0.44 KG / WEEK (Upper end of range)
31.1% (N = 14)	20% (N = 9)	48.9% (N = 22)
OVERWEIGHT (BMI > 26)		
< 0.1 KG / WEEK (Inadequate)	0.1 – 0.3 KG / WEEK (Lower end of range)	> 0.3 KG / WEEK (Upper end of range)
0	42.9 % (N = 12)	57.1% (N = 16)

*n=87, sufficient data for 87 subjects only

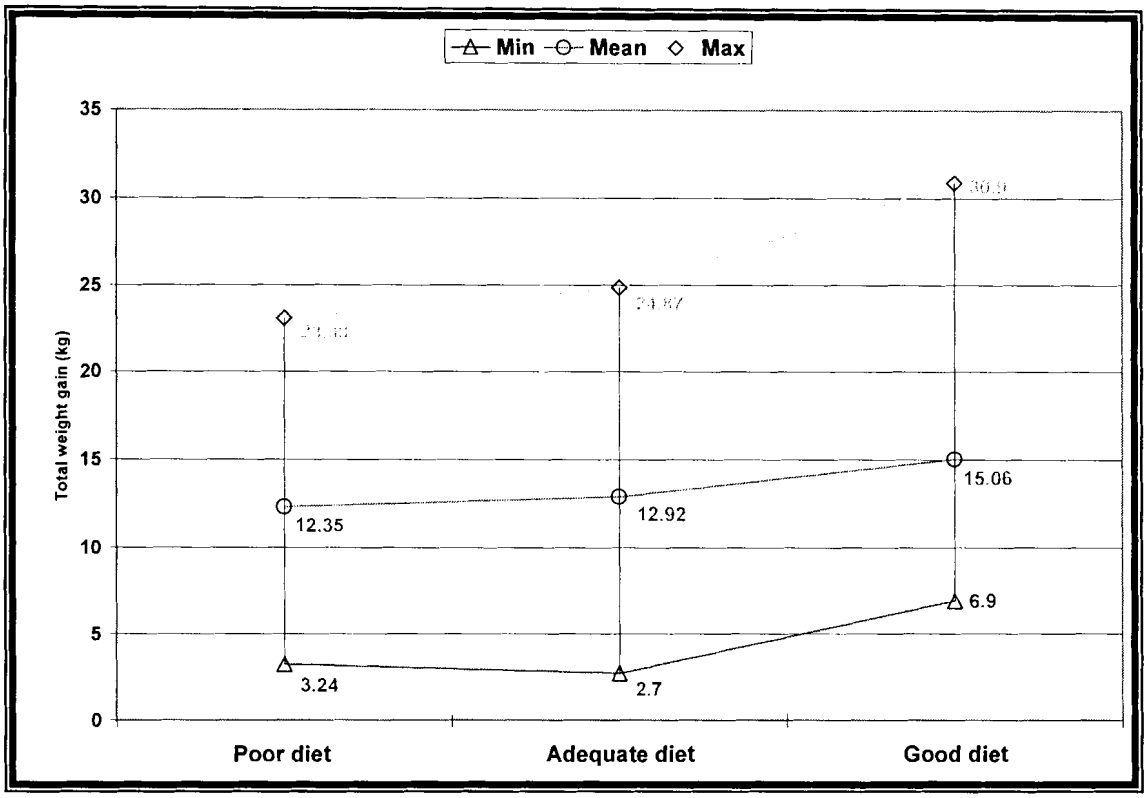


FIGURE 3. 1 **The mean-, minimum- and maximum total weight gain of the participants in each diet category**

TABLE 3. 4

THE PREPREGNANCY BMI DISTRIBUTION OF THE PARTICIPANTS, IN THE NUTRIENT INDEX CATEGORIES

NUTRIENT INDEX	UNDERWEIGHT (BMI < 19.8)	NORMAL WEIGHT (BMI 19.8 – 26)	OVERWEIGHT (BMI > 26)	OBESITY (BMI >29)
1 = POOR DIET (N = 24)	5 (20.8%)	11 (45%)	6 (25%)	2 (8.3%)
2 = ADEQUATE DIET (N = 36)	5 (13.88%)	17 (47.22%)	6 (16.66%)	8 (22.22%)
3 = GOOD DIET (N = 30)	6 (20%)	18 (60%)	0 (0%)	6 (20%)

TABLE 3. 5

A COMPARISON OF THE MOTHER'S AGE, WEIGHT GAIN, DIETARY INTAKE AND THE BABY'S OUTCOMES ACCORDING TO PRE-PREGNANCY [a]BMI OF THE MOTHER

WOMEN WITH A PRE-PREGNANCY [a]BMI < 19.8					
	n	Mean	[b]Min	[c]Max	[d]SD
Age (years)	14	24.71*	18.00	40.00	6.32
Weekly weight gain (kg)	14	0.64	0.340	0.94	0.17
Energy intake (kJ)	14	12 497.86	6 467.00	17 988.00	3568.03
Protein intake (g)	14	92.89	35.30	183.10	38.70
Iron intake (mg)	14	11.61	4.30	15.50	3.72
Birth weight (kg)	13	3.18	2.60	3.70	0.33
Birth length (cm)	13	50.31	46.00	57.00	3.07
Head circumference (cm)	13	34.46	33.00	38.00	1.56
WOMEN WITH A PRE-PREGNANCY [a]BMI (19.9-26)					
	n	Mean	[b]Min	[c]Max	[d]SD
Age (years)	47	26.38	14.00	37.00	5.69
Weekly weight gain (kg)	45	0.49	0.12	1.08	0.24
Energy intake (kJ)	45	11 678.13	5 014.00	20 149.00	3 809.04
Protein intake (g)	45	79.56	23.80	178.70	29.08
Iron intake (m)	45	10.98	4.90	19.60	3.83
Birth weight (kg)	42	3.08	1.90	4.12	0.45
Birth length (cm)	39	49.67	44.00	57.00	2.81
Head circumference (cm)	39	34.82	31.00	40.00	1.89
WOMEN WITH A PRE-PREGNANCY [a]BMI >26					
	n	Mean	[b]Min	[c]Max	[d]SD
Age (years)	31	29.55 *	19.00	47.00	7.10
Weekly weight gain (kg)	28	0.44	0.13	1.13	0.27
Energy intake (kJ)	29	12 248.28	4 069.00	21 799.00	4085.69
Protein intake (g)	29	86.22	22.60	175.60	29.99
Iron intake (m)	29	13.32	3.70	30.00	5.48
Birth weight (kg)	26	3.20	2.49	4.20	0.50
Birth length (cm)	26	50.92	45.00	58.00	3.33
Head circumference (cm)	26	34.54	32.00	37.00	1.53

Numbers may vary due to incomplete data

[a]BMI: body mass index

[b]Min: minimum

[c]Max: maximum

[d]SD: standard deviation

* Significant difference ($P < 0.05$)

Figure 3.2 shows the distribution of the total number of the pregnant women in the different Nutrient Index diets groups. Figure 3.3 shows the mean intake of protein divided into plant protein and animal protein, compared in the different Nutrient Index groups. The women with a good diet had a mean total protein intake of about 10g more than those with an adequate diet. The participants with an adequate nutrient intake had a mean total protein intake of also 10g more than those with a poor Nutrient Index diet. The plant protein intake in all three groups was almost similar, whereas the animal protein intakes were higher in the adequate and good Nutrient Index diet groups, than in the poor Nutrient Index diet group.

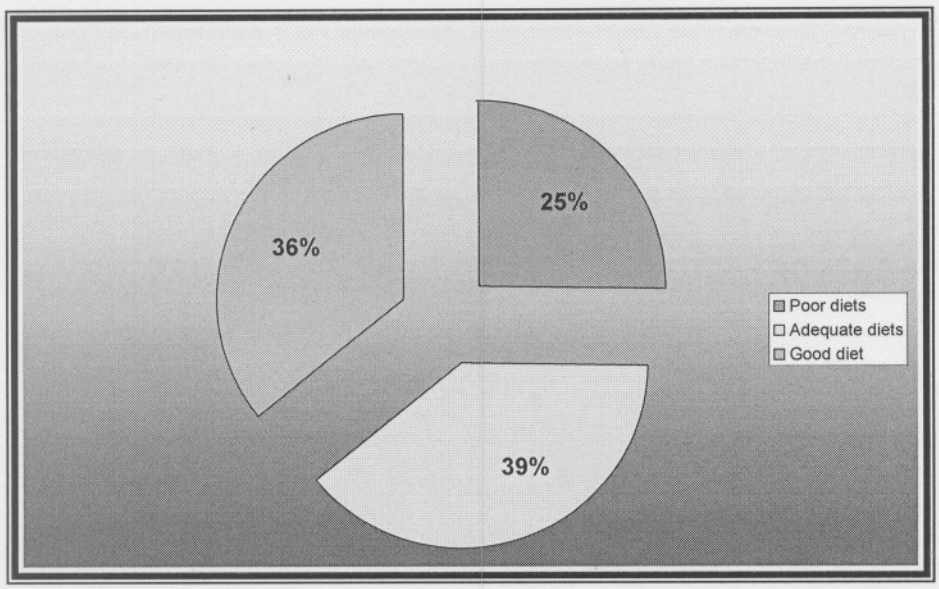
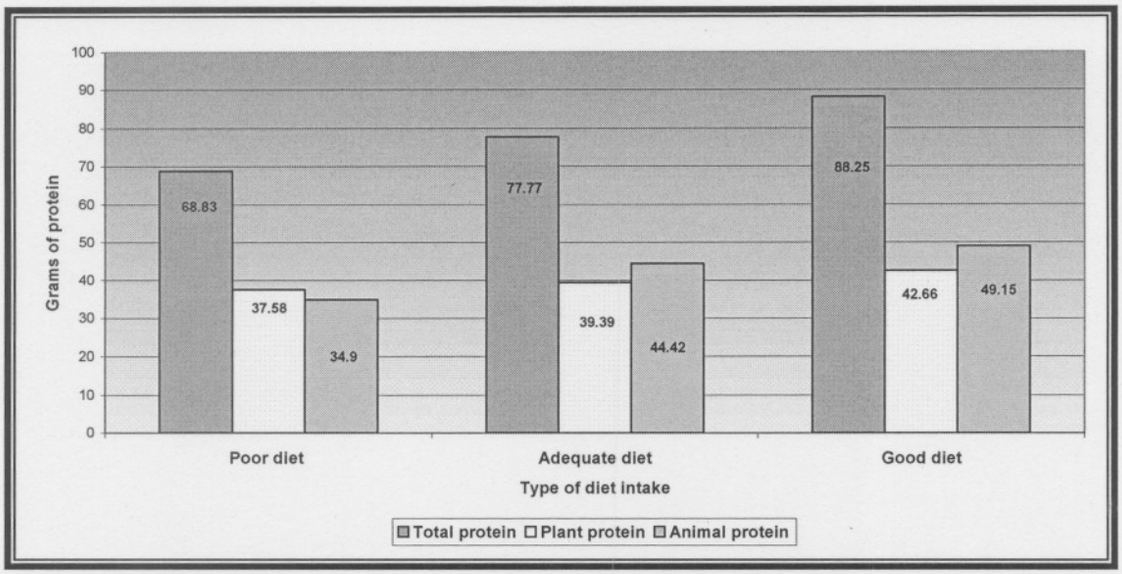


FIGURE 3. 2 The distribution of participants in different diet categories.



*** The sum of plant and animal protein intakes as calculated by Food finder® was not exactly equal to the total protein intakes**

FIGURE 3. 3 The participants' mean protein, plant protein and animal protein compared in different diet categories

Figure 3.4 – Figure 3.6 show the intake of selected micronutrients of the participants with a poor, adequate and good diet Nutrient Index respectively as a percentage of the RDA. All three figures show clearly that the iron intakes and the folic acid intakes were very low, even if the participants had an adequate or good Nutrient Index. In the poor Nutrient Index group, some of the participants had a higher range of the 95% confidence interval of the zinc and vitamin A. In the adequate Nutrient Index diet group, the average intakes for vitamin A, vitamin C and zinc were higher than 100% of the RDA. In the good Nutrient Index group some of the participants had consumed more than 100% of the RDA of vitamin A, zinc and vitamin C. All three groups had an average calcium intake lower than 100% of the AI and a very low intake of folic acid and iron.

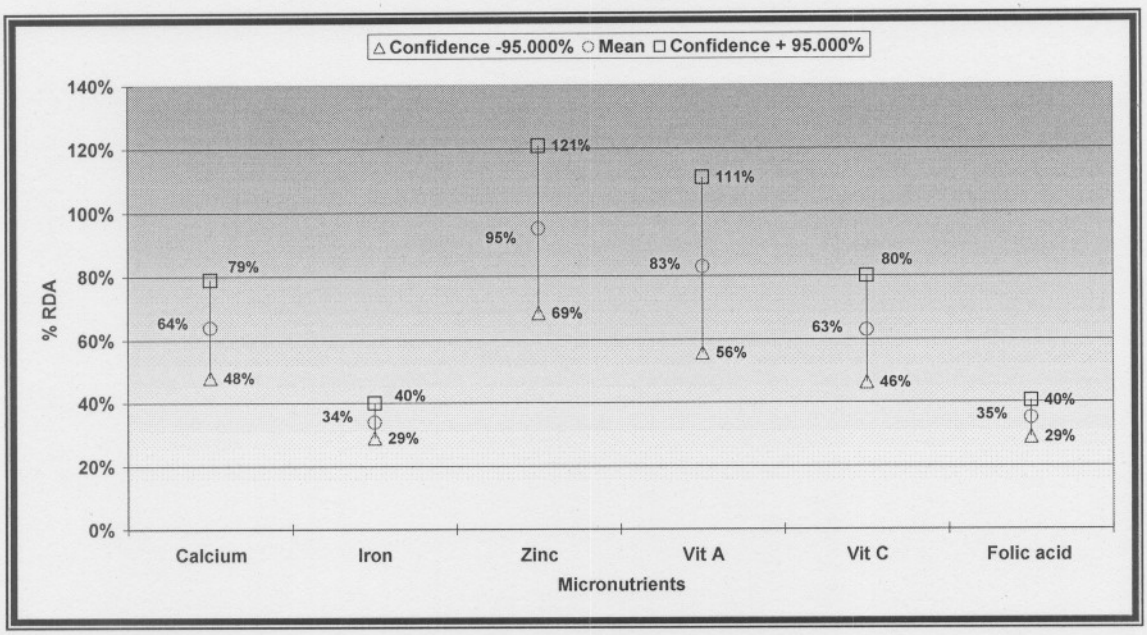


FIGURE 3. 4 **Selected micronutrient intakes of the participants with a poor Nutrient Index, as a percentage of the RDA**

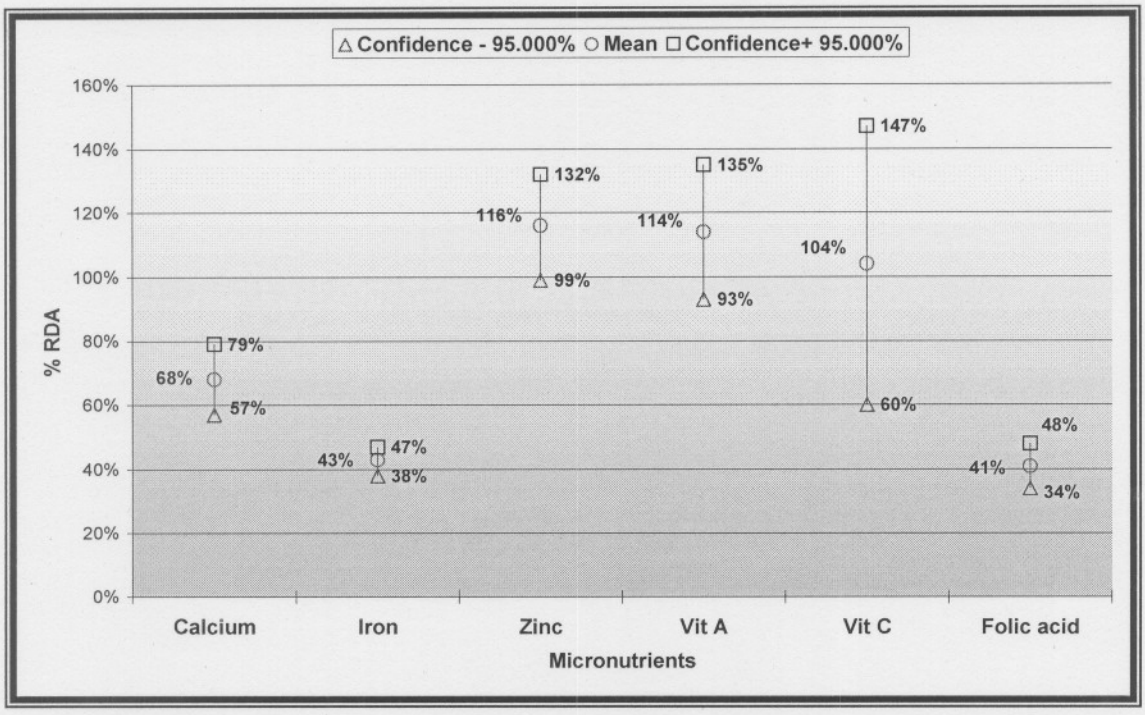


FIGURE 3. 5 **Selected micronutrient intakes of the participants with an adequate Nutrient Index, as a percentage of the RDA**

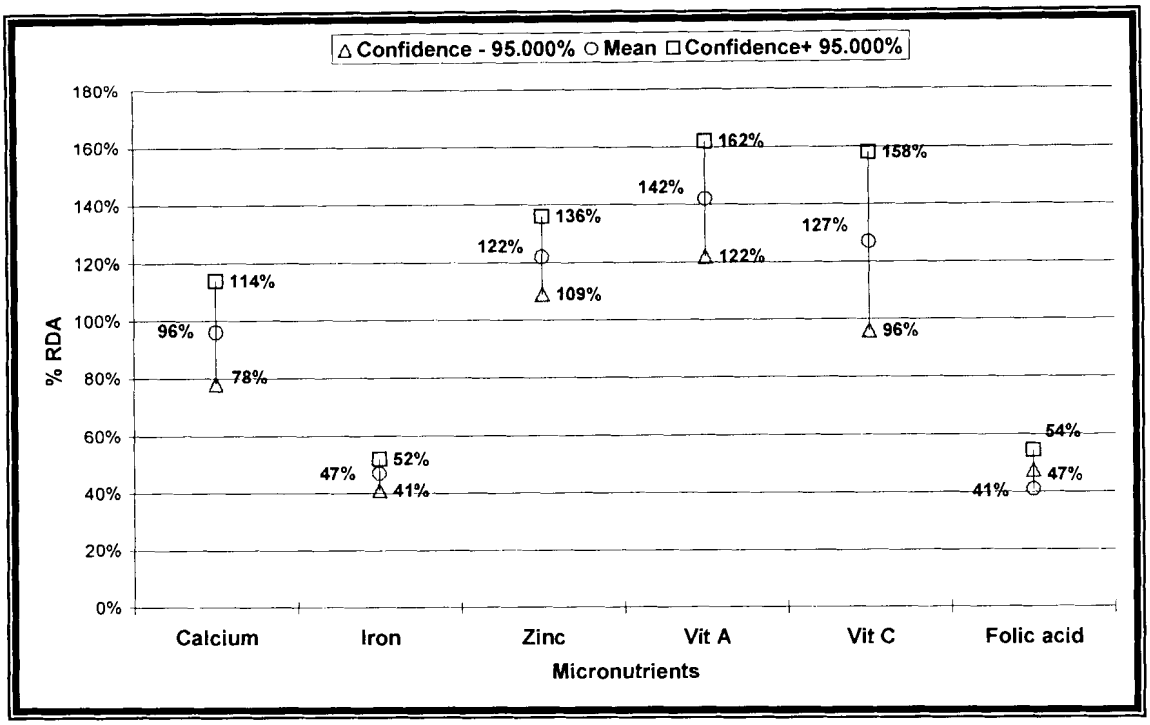


FIGURE 3. 6 Selected micronutrient intakes of the participants with a good Nutrient Index, as a percentage of the RDA

Figure 3.7 shows the comparison of the means of selected micronutrient intakes of the participants in the different Nutrient Index diet groups with the RDA. There were no significant differences in the three dietary groups regarding the selected micronutrients. Figure 3.7 shows that the participants in all three groups consumed lower quantities of iron and folic acid than the RDA.

The mean hemoglobin values of the pregnant women differ in the three different diet groups:

- The good diet group had a mean hemoglobin value 11.77g/dL
- The adequate diet group had a mean hemoglobin value of 12.11g/dL
- The poor diet group had a mean hemoglobin value of 11.63g/dL

There were no significant correlation between the dietary iron intake and the hemoglobin concentrations of the pregnant women.

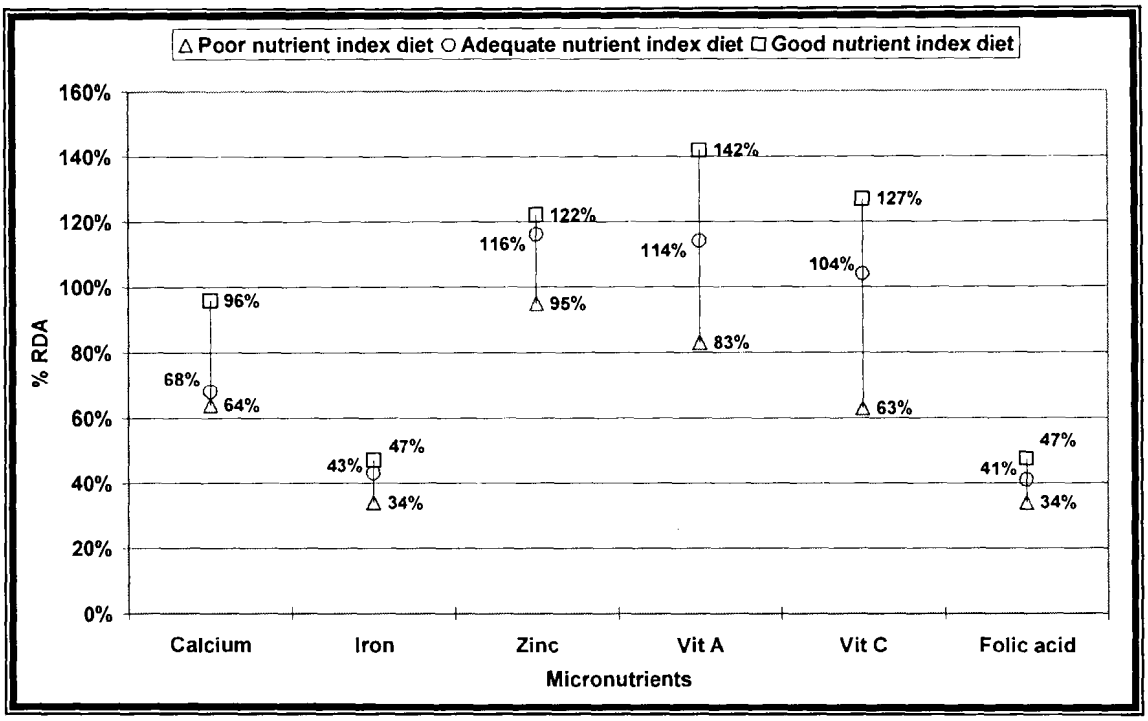


FIGURE 3. 7 **Mean intakes of selected micronutrients of the participants in the different Nutrient Index groups.**

Table 3.6 shows the list of the typical foods the participants mostly were eating and the micronutrient (calcium, iron, vitamin A, vitamin C, thiamin, riboflavin, folic acid) content status of the food. The indicated vitamins and minerals in the typical foods are the vitamins and minerals higher or equal to 10 % of the RDA per portion of the food, which could have made an important contribution to the daily intake of the vitamins and minerals.

TABLE 3. 6

A LIST OF THE TYPICAL FOODS THE PARTICIPANTS WERE EATING AND THE MICRONUTRIENT (CALCIUM, IRON, ZINC, VITAMIN A, VITAMIN C, THIAMIN, RIBOFLAVIN, FOLIC ACID) CONTENT OF THE FOOD

TYPE OF FOOD	TYPICAL FOOD EATEN WEEKLY	MICRONUTRIENTS
CARBOHYDRATE	Mabella (100g)	Thiamin, Riboflavin, Fe, Zn
	Maize meal soft / stiff (100g)	Thiamin, Riboflavin, Fe, Zn
	Brown bread (1 slice)	Fe, Thiamin, Riboflavin
	Potatoes baked (100g)	Ca, Vitamin C
	Fried chips in sunflower oil (100g)	Ca, Fe, Zn, Thiamin,
PROTEIN (ANIMAL PROTEIN)	Boerewors (100g)	Thiamin, Riboflavin, Fe, Zn,
	Liver (90g)	Fe, Zn, Vitamin A, Thiamin, Riboflavin, Vitamin C (23 mg & 10% RDA = 8 mg), Folic acid
	Chicken liver (90 g)	Fe, Zn, Vitamin A, Thiamin, Riboflavin, Vitamin C(13.5 mg & 10% RDA = 8 mg), Folic acid
	Pilchards (90g)	Ca, Fe, Vitamin A
	Eggs (1)	Vitamin A, Riboflavin
	Beef mince (90g)	Ca, Fe, Zn, Folic acid
PROTEIN (PLANT PROTEIN)	Dry beans (1 cup)	Fe, Zn, Thiamin, folic acid
	Soya mince (1 cup)	Ca, Fe, Zn, Thiamin, folic acid
DAIRY PRODUCTS	Full cream milk (1 cup) Maas (1 cup)	Ca, Vitamin A, Riboflavin
FAT	Margarine (hard brick) – 100g	Vitamin A
	Sunflower oil (100g)	None of selected vitamin or minerals
	Chicken feet (100g)	None of the selected vitamins or minerals
FRUITS	Apple (2 ¾ in diameter)	Vitamin C
	Pear (2 ½ in diameter)	Vitamin C

TABLE 3.6 (CONTINUED)

TYPE OF FOOD	TYPICAL FOOD EATEN WEEKLY	MICRONUTRIENTS
VEGETABLES	Spinach (1 cup)	Ca, Fe, Vitamin A, Thiamin, Riboflavin, Vitamin C, folic acid
	Tomato and onion (100g)	Vitamin A, Vitamin C
	Pumpkin (1 cup)	Vitamin A, Riboflavin, Vitamin C
	Carrots (1 cup)	Vitamin A
	Chakalaka (spicy carrot salad) (1 cup)	Zn, Vitamin A, Thiamin, Riboflavin, Vitamin C, Folic acid
	Cabbage (1 cup)	Vitamin A, Vitamin C
	Beetroot (1 cup)	Vitamin C
SPREADS	Peanut butter (1 tablespoon)	Zn, Thiamin, Riboflavin, Folic acid
	Jam (1 tablespoon)	None
SNACKS	Full cream custard (100 ml)	Ca, Riboflavin
DRINKS	Orange juice (1 cup)	Vitamin A, Thiamin, Vitamin C, Folic acid
	Tea (8 fl oz)	None
	Coffee (6 fl oz)	None
SOME OF THE PARTICIPANTS CONSUMED THE FOLLOWING		
ANIMAL PROTEIN	Red meat (90g)	Chicken (White meat)
	Chicken (White meat) with skin (90g)	Vitamin A, Thiamin, Riboflavin, Ca, Fe, Zn
	Chicken (Dark meat) with skin (90g)	Vitamin A, Thiamin, Riboflavin, Ca, Fe, Zn

Ca → Calcium Fe → Iron Zn → Zinc

(Langenhoven *et al.*, 1991; Mahan & Escott-Stump, 2000)

Figure 3.8 shows the data of a comparison of mean (95%) birth weights (kg) in the different types of Nutrient Index diets . This shows that the birth weight of the babies in the poor and in the good Nutrient Index groups were similar. In the adequate Nutrient Index groups the babies' weight were slightly higher than in the other two groups. None of the birth weights were less than 2.5 kg.

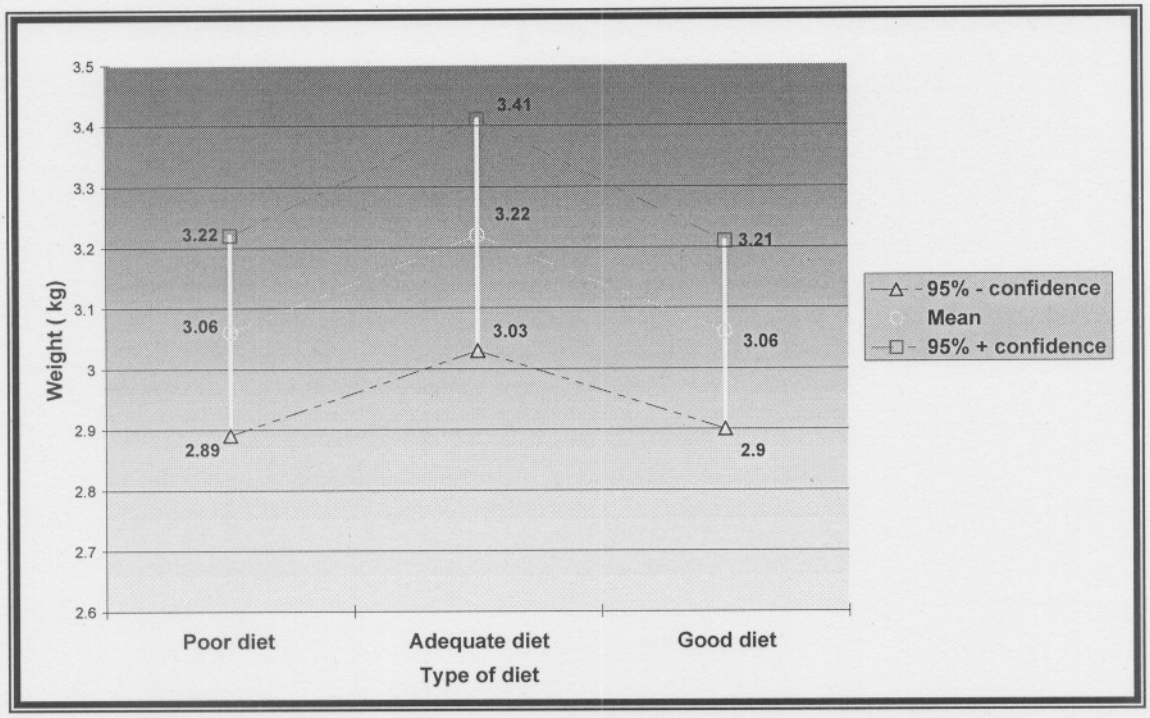


FIGURE 3. 8 **Data of the different type of diets compared with the outcome of birth weight (kg)**

Figure 3.9 shows the data of a comparison of mean (95% CI) of birth length between the different types of Nutrient Index diet groups. There were no significant differences in the babies' length in the different Nutrient Index groups. However, the babies of the participants in the adequate Nutrient Index diet group showed a slightly longer length than in the other two groups. This difference was not significant.

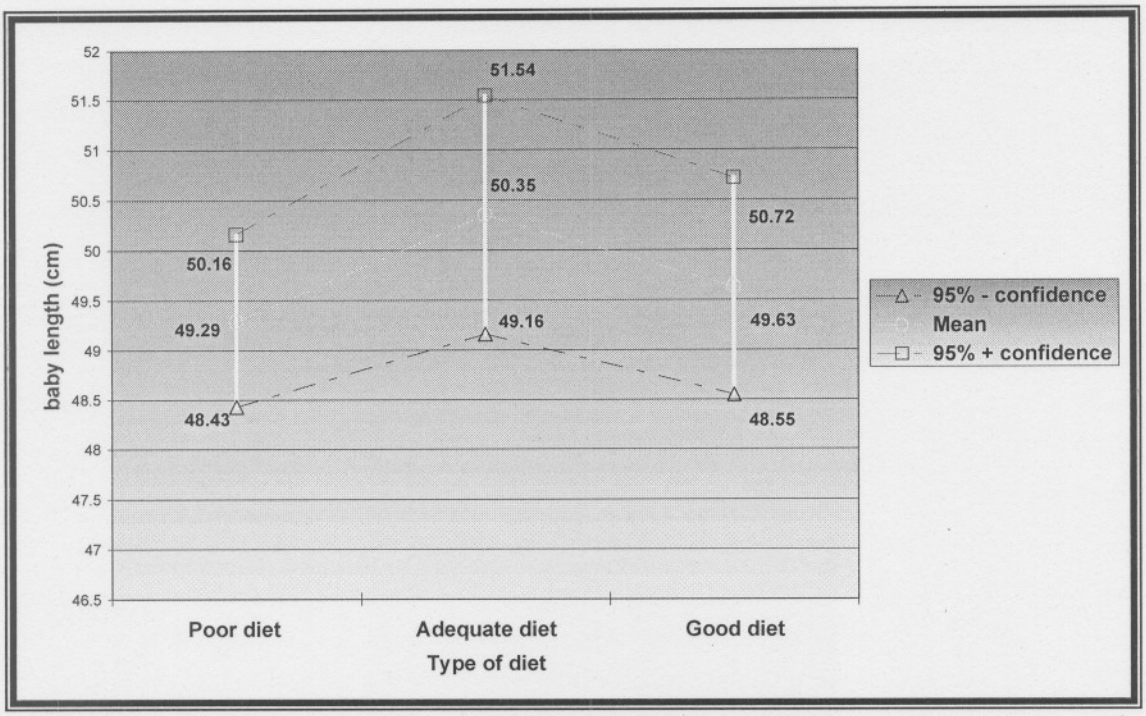


FIGURE 3. 9 **Data of the different type of diets compared with the outcomes of birth-length (cm)**

Figure 3.10 shows the head circumference (mean, 95% CI) as an outcome of the babies, compared in the different Nutrient Index diet groups. It shows that the participants' babies' head circumferences in the group with the poor Nutrient Index diet were slightly lower than in the other two groups.

Table 3.7 shows the correlations between the outcomes of the babies, nutrient intake, demographic data and the mothers' hemoglobin concentration, weight gain, previous pregnancy and total income. The number of previous pregnancies of a mother had a significant correlation ($p<0.05$) with animal protein, total fat intake, vitamin A, haemoglobin concentration, baby length and the age of the mother. There was a positive correlation ($p<0.05$) between the baby's weight and the iron intake of the mother, and the baby's weight and the baby's length. The total weight gain had a significant positive correlation ($p<0.05$) with baby's length, total income and weekly weight gain. The weekly weight gain had a significant positive correlation ($p<0.05$) with the total income.

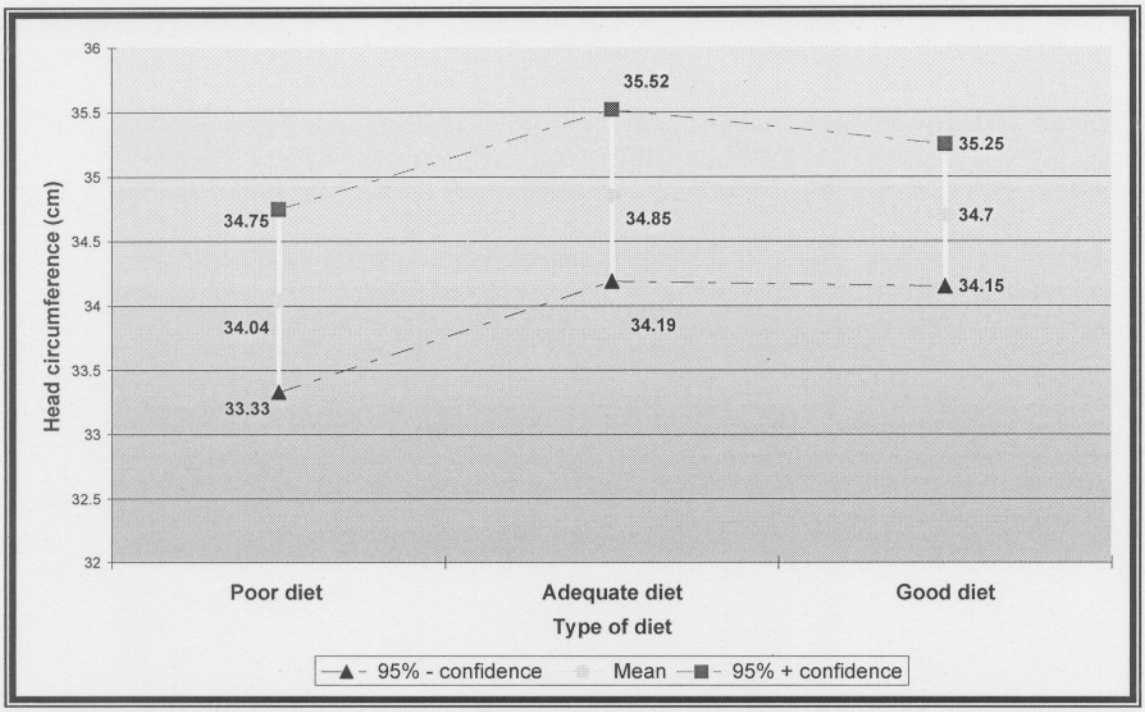


FIGURE 3. 10 Data of the different type of diets compared with the outcomes of baby's head birth-circumference (cm)

TABLE 3. 7

SIGNIFICANT CORRELATIONS ($p<0.05$) BETWEEN MOTHERS' DIETARY INTAKES, HAEMOGLOBIN CONCENTRATION, AGE AND TOTAL INCOME WITH MOTHERS' TOTAL AND WEEKLY WEIGHT GAIN AND BABIES' WEIGHT AND LENGTH AT BIRTH

VARIABLES	ANIMAL PROTEIN INTAKE	TOTAL FAT INTAKE	IRON INTAKE	VIT A INTAKE	MOTHER'S HB	AGE	BABY'S LENGTH	TOTAL INCOME	WEIGHT GAIN / WEEK
NUMBER OF PREVIOUS PREGNANCIES OF A WOMAN	-0.29	-0.21	-	-0.24	-0.3	0.44	-0.21	-	-
BABY'S WEIGHT	-	-	0.23	-	-	-	0.34	-	-
TOTAL WEIGHT GAIN	-	-	-	-	-	-	0.34	0.37	0.94
WEIGHT GAIN / WEEK	-	-	-	-	-	-	-	0.33	-

Hb → Haemoglobin Vit A →Vitamin A

3.4 DISCUSSION

Demographic factors

Table 3.2 shows that the participants of this study mainly spoje an African language. Most of these were single women, living with relatives and those with jobs have a low income. These living conditions are typical of low-income families in South Africa (Vorster *et* al., 1997) therefore, the participants in this study can be identified as a low socio-economic class. According to the IOM (1980), if a woman is from a low socio-economic group, factors like age, food pattern, behavioural factors such as smoking, stress, alcohol abuse and anxiety, and environmental factors might influence the body fat, BMI or relative weight, lean body mass and total weight gain of the mother. These factors indirectly influence the outcomes of the baby. These low socio-economic groups could not afford different types of foods or large amounts of a variety of foods. These low socio-economic women had a typical diet (see Table 3.6), which consists mostly of mabella, maize meal, eggs, chicken feet, apple, pear, cabbage, spinach and full cream milk. The mabella or maize meal, was sometimes replaced with brown bread with jam or peanut butter on it. Most Sundays they ate potatoes and chicken or beef with beetroot and carrots. Food such as, tripe, pilchards, boerewors, dry beans, soya mince, beef mince and maas were eaten when they had money. Spinach or cabbage was replaced with tomato and onion sauce. Custard was eaten as a dessert and they had tea or coffee for drinks.

Weight gain according IOM recommendations

Table 3.3 shows the weekly weight gain of the pregnant women according to IOM recommendation. None of the overweight women (BMI> 26) gained insufficient weight. Less than a quarter of the women (n=22) gained a total weight during pregnancy that is inside the range of the IOM recommendation. Most of these women were in the overweight group, the second most were in the normal weight group and just one woman was in the underweight group. More than 50% of the women (56%) gained more weight than what was recommended by the IOM guidelines. Of these women, most (45%) were in the normal weight group, 33% were in the overweight group and 22% were in the underweight group. Table 3.3 clearly shows the tendency to gain weight above the recommendation for all the women, not only those that were overweight. This finding is consistent with the findings of Keppel and Taffel (1993), Caulfield *et al.* (1996) and Carmicheal *et al.* (1997). Wells and Murray (2003) also found that nearly 40% of women in Colorado gained excessive weight during pregnancy. In the Thusa Mama study, the total of the pregnant women that gained weight above the IOM recommendation was even higher (55%). This means that nutrition education must be an essential part of the pregnancy education. Even when a woman is underweight, or if she has a normal weight, education regarding weight gain is necessary. She also needs education and advice regarding the energy intake to gain sufficient

weight, regarding the guidelines of IOM for optimal baby outcomes. Although most of the women had a low household income, their energy intakes were sufficient to gain excessive weight.

Total weight gain according to the different diet categories

Figure 3.1 illustrates that some of the participants with a poor and adequate Nutrient Index diet had a minimum total weight gain of 3.24 kg and 2.7 kg respectively, which is lower than the IOM recommendation. In the good Nutrient Index group, a minimum weight gain of 6.9 kg was seen, which is lower than the IOM recommendations if the women had a pre-pregnancy BMI smaller than 26. Some of the participants had a maximum weight gain above the IOM recommendation. In all three of the Nutrient Index diet categories, most of the women had a total weight gain between 12.35 kg – 15.06 kg, which is in the range of the IOM recommendation, except if the women who gained a total weight of 15.06 kg had a BMI more than 26. This illustrates that women with a poor or adequate Nutrient Index diet regarding the micronutrients, might gain more than the adequate weight gain and this could influence the baby's outcomes. The incidence of small-for-gestational-age and/or LBW birth is reduced when the maternal weight gain is within the IOM recommendations (Suitor *et al.*, 2000). Education for pregnant women is an essential part of prenatal care and can help to improve the dietary intake. This education will promote nutritionally adequate dietary intake during pregnancy and the incidence rates of LBW births may decrease (Widga & Lewis, 1999). According to Abrams *et al.* (2000), when a pregnant woman gains weight above the IOM recommendation, she could suffer from excessive postpartum weight retention. The IOM (1990) cites that high gestational weight gain is associated with an increased birth weight, which in turn is associated with some increase in the risk of fetopelvic disproportion, operative deliveries, birth trauma, asphyxia and mortality.

There is a similarity between the results shown in Table 3.4 and Figure 3.1. The higher the weekly weight gains, the higher the total weight gain. Figure 3.1 shows that even with a poor or an adequate diet some of the participants gained weight above the IOM recommendations. Table 3.4 also shows that the participants in the poor Nutrient Index diet group were not only underweight, but some were also normal (45%) and others were even overweight (25%) or obese (8.3%). As in the adequate Nutrient Index diet group, some of the participants were underweight (13.88%), overweight (16.66%) or obese (22.22%). In the good Nutrient Index diet, 20% of the participants were underweight. These results also showed that other factors like age, socio-economic status, BMI or relative weight, height, lean body mass, body fat, genetic factors, behavioural factors like smoking, stress, alcohol abuse and anxiety and environmental factors might influence the total weight gain of the mother and the outcomes of the baby. These findings are similar to the findings of the IOM (1980).

Data regarding age, weight gain, dietary intake and birth data for mothers with consideration of their pre-pregnancy BMI.

Table 3.5 illustrates that there were no significant differences between the dietary intakes and the pregnancy outcomes of the three groups of participants. No correlation was found between the dietary energy or protein intakes and mothers' weekly weight gain. The lack of correlation between the dietary intakes and the weight gain may be due to under or over-reporting of dietary intake (Klesges *et al.,* 1995). Most women had adequate energy and protein intakes with reference to the recommended allowances (WHO, 1985). According to Klesges *et al.* (1995), it is now widely recognized that reported energy intakes in dietary surveys underestimate usual energy intake. Food frequency under-reporting is worse among women than men, and is more pronounced among overweight and obese than among lean individuals. Low socio-economic status, characterized by low income, low educational attainment and low literacy levels increases the tendency to under-report to a greater degree than those who experience frequent hunger. As these women were from a low socio-economic status, especially overweight women may have underreported their intake.

Women with a pre-pregnancy BMI > 26 were significantly older ($p<0.05$) with a mean age of 29.55 years than the women with pre-pregnancy BMI <19.8 and between 19.8 and 26. It also illustrates that underweight women were significantly younger ($p<0.05$) than the normal weight and overweight women. Harrison *et al.* (2001) is of the opinion that a maternal age less than 16 years or more than 35 years, associated with low socio-economic status and malnutrition can be associated with triggers of pre-term deliveries. The mean birth weight of the three groups did not differ much (3.18 kg, 3.08 kg and 3.20 kg). There were also no differences between the three groups for the length (50.31cm, 49.67cm and 50.92cm) and the head circumferences (34.46cm, 34.82cm and 34.54cm) of the babies. None of these differences were statistically significant. Edwards *et al.* (1996) found that women with a BMI <19.8 are at high risk of delivering a low birth weight infant if their prenatal weight gain is inadequate. They state that even women with a BMI > 29.0 should gain at least 7.0kg and those who lose weight or gain less than 6kg are more likely to deliver an infant small for gestational age. Excessive weight gain in women with a BMI >26 also places the child at risk of being large for gestational age (Galtier-Dereure *et al.*, 2000). The Thusa Mama study showed no significant correlation between the rate of weight gain of the mother and birth weight of the baby. This could be due to the fact that mothers at risk for poor pregnancy outcomes (underweight, positive HIV status and those not gaining weight during the pregnancy) were treated according to standard protocol, individualy. This included advice from dieticians, medical care and standard clinical nutritional supplements (folic acid, iron and vitamin C tablets and a ready to mix meal if the mother qualified for the Protein Energy Malnutrition [PEM] scheme).

Different Nutrient Index diet categories

In Figure 3.2, the distribution of the participants into different Nutrient Index diet categories, is demonstrated. It illustrates that the participants had a low socio-economic status, just a quarter of the participants had a poor Nutrient Index diet intake, 39% of the participants had an adequate Nutrient Index diet intake and 36% of the participants had a good diet. These dietary intakes, however, do not reflect their low socio-economic status and weight gain. It might be due to under-reporting or over-reporting. This might also be because the whole household gives special care for the pregnant women and the new unborn baby, meaning that they could allocate more food for her to eat. There is a great possibility that the community or neighbours also help to increase food security in a household were they know that there is a pregnant women and when the household security is low.

Protein intake

Figure 3.3 demonstrates that the estimated average of the participants in all three groups had a sufficient dietary protein intake. The participants in the poor Nutrient Index diet had an average total protein intake of 66.83g per day. Of this protein intake, more than half of the protein intake was from plant protein and the rest from animal protein. In the adequate and the good Nutrient Index groups, the animal protein intake was higher than the plant protein intake. From this it is clear that the total protein intake was higher in the adequate and good nutrient diet group because the animal protein intake was higher than in the poor Nutrient Index diet group. According to Rush *et al.* (1988), the estimated average intake of protein by low-income enrolled in the Supplemental Food Programme for Women, Infants and Children (WIC) was higher than the 1980 RDA of 74 g/day, even before participation in the programme. However, inadequate energy intake may contribute to protein deficiency if there is compensatory catabolism of protein and amino acids to meet energy needs. The most recent Recommended Dietary Allowance (RDA) for protein is 71 g of protein; this increases by 25 g daily, over non-pregnant women's protein requirement (IOM, 2002). From Figure 3.3 it can be seen that when the energy intake is adequate, the protein intake might also be adequate. If a pregnant woman is malnourished or if she has a positive HIV status, the importance of adequate protein intake needs to be emphasized. This is because the compensatory catabolism of protein and amino acids may contribute to protein deficiency. This protein deficiency alone and in combination with energy restriction, results in consistently decreased fetal growth (IOM, 1990).

Micronutrient intake

Figure 3.4 – Figure 3.6 illustrate selected micronutrient intakes of the participants with a poor, adequate and good Nutrient Index diet respectively as a percentage of the RDA. In the poor and adequate diet, the participants' average intakes of calcium were almost similar (64% & 68%, respectively). The 95% confidence interval in the poor Nutrient Index diet group was 48% to 79% and in the adequate Nutrient Index diet group it was 57% to 79%. The upper levels of these two groups were the same, but the lower level of the poor Nutrient Index group was lower than that of the adequate Nutrient Index group. The participants with a good Nutrient Index diet had a mean calcium intake of 96% of the AI, with 95% confidence intervals of 78% to 114%. The lowest 95% confidence interval percentage of the calcium intake in the good Nutrient Index group was similar to the highest interval of the other two groups. The foods which were consumed and which were rich in calcium were: milk, maas, pilchards with bones, soya mince, spinach with small quantities of potatoes, red meat, chicken meat and custard. It seems as if the poor and adequate Nutrient Index diet groups consumed mostly the same amount of food rich in calcium. The reason for a lower average calcium intake might be due to lower intake of milk. It might be a possibility that the participants' income was too low to buy meat and chicken regularly and if these animal protein foods were consumed, very small portions were consumed. The AI for pregnant and non-pregnant women is similar at 1300mg per day. If a woman consumes less calcium than the AI, the calcium may leach from the calcium reservoirs in the maternal skeleton. This causes osteomalacia or lower bone density (Fagen, 2000). These mothers' bone density was not measured and further research should be done on this topic. Most of the participants did not reach the AI for daily calcium intake and in the future, more education can be done on calcium intake.

The participants in the poor Nutrient Index group had the lowest average iron intake of 34% of the RDA, where the average intake of iron in the adequate diet was 43% and in the good diet the average iron intake was 47% of the RDA. The average iron intake was one of the lowest micronutrient intakes of all three groups. The women in the poor diet group consumed mostly plant protein, which could have contributed to the low iron intakes, but where animal protein could have contributed to a higher iron intake. The foods mostly consumed by the women with 10% or more iron of the RDA (per portion) were: mabella, maize meal, brown bread, potatoes, boerewors, tripe, pilchards, beef mince, dry beans, soya mince and spinach (Table 3.6). The reason why the iron intakes were so low could be due to the fact that these types of food were not eaten on the same day, maybe a small portion once a week. This means that a small amount of the iron was consumed daily from maize meal, mabella, brown bread, potatoes and sometimes only one type of animal or plant protein (dry beans or soy mince). The absorption of nonheme iron (iron found in plant protein) is less well absorbed than the heme iron (iron found in animal protein). These women in the adequate diet group probably ate animal protein (chicken or beef)

more often, meaning that the absorption of the heme iron is higher and this could increase the iron status of the women in the adequate diet group. The women in the good diet group consumed even more food or different types of food rich in iron and most probable food with heme iron, which contributed to a higher iron status, than the other two groups. It is possible that these women in the good diet had a higher income and could buy more meat products regularly. However, all three groups did not consume adequate iron according to the RDA and it is necessary to emphasize the type of foods and quantity during education of the mothers. The global estimated prevalence of anemia in pregnant women is 51% (Administrative Committee on coordination and subcommittee on Nutrition, 1992). Scholl and Hediger (1994) and Steer *et al.* (1995) states that anemia that is diagnosed in the early stage of pregnancy could be associated with poor pregnancy outcomes. These pregnant women had a very low iron intake and the pregnancy outcome could have been poor, but the women received an iron supplement daily. This shows that clinical care for pregnant women is very important and during nutrition education the mothers need to be educated regarding the combination of iron sources foods to increase the iron absorption.

The dietary iron intake did not correlate significantly with the hemoglobin concentration of the participants; this could probably be due to the standard iron supplementation that the participants received at the clinic. The hemoglobin levels for blacks averages 5-10g/L less than the levels of white of most ages; these hemoglobin level is between 11 – 15 g/dL (Lee & Nieman, 1993). The mean hemoglobin values of the different diet groups showed that the mean hemoglobin levels of the participant did fall into the range of the normal levels, this could probably due to the iron supplementation.

The 95% confidence intervals of zinc intake show that the lowest intake of zinc in the three Nurtrient Index groups, was in the poor Nutrient Index group (69%) and the highest zinc intake was almost similar in both the adequate (135%) and good diet groups (136%). The average zinc intake of the participants in the adequate and good diet were higher than the RDA. This could probably be because the participants in the adequate and good diet group consumed mostly large quantities of: mabella, maize meal, beef mince, dry beans, toppers mince, red meat, chicken meat and chakalaka. These types of foods (per portion) contain 10% of the RDA of zinc and could contribute to the high intakes of zinc in the women. In the poor diet group, the participants consumed a smaller amount of these food sources of zinc. The reason for the lower intakes of these foods might be that the women in the poor diet groups were eating more maize meal, potatoes and less red and chicken meat daily. The best food sources of zinc are animal protein foods, which are relatively expensive. Low zinc intakes have been associated with pre-term deliveries (Constello & Osrin, 2003). According to Costello and Osrin (2003), some studies found lower maternal plasma zinc to be a risk factor for congenital malformations and other

studies did not. There is a large amount of contradiction regarding low maternal plasma zinc levels and more research is necessary. The Thusa Mama Study also found no association between low maternal zinc intakes and pre-term deliveries, because the zinc intakes were most probably adequate.

The mean intake of vitamin A was higher than 80% of the RDA for women in the poor Nutrient Index diet and higher than 100% of the RDA in the adequate and good Nutrient Index diet groups. This could probably have been because the women had a relatively high intake of tripe (beef or chicken), pilchards, eggs, milk, brick margarine, spinach, tomato and onion, pumpkin, carrots, chakalaka, custard and orange juice. These foods provide more than 10% of the RDA per portion. In the good Nutrient Index diet group the participants could have consumed a large quantity of fruit juice, which could contribute largely to the vitamin A intake. The participants in the poor Nutrient Index diet group could probably not afford meat and orange, green and yellow vegetables. They obtained their vitamin A mostly from brick margarine, tripe, pumpkin, spinach, eggs and pilchards. If a pregnant women could consume more than 2.5 times the RDA, which is easily available in general multivitamins, this would increase the risk of delivering a baby with a cranial neural crest defect five times more than pregnant women consuming 5 000IU vitamin A per day (Rothman *et al.*, 1995). Fagen (2000) cites that vitamin A supplementation is dangerous during 2 weeks prior to conception and the first 2 months of gestation. The mothers must be warned against animal liver, due to the high contents of 9000IU per 90 g liver. This must be limited to small portions during the first 2 months. Advice is necessary regarding the amount of vitamin A intakes and further studies are necessary to see what the abortion effect of high doses of vitamin A regarding liver is in very low socio-economic groups.

Participants in the poor diet group had an average vitamin C intake of 63% of the RDA with a 95% confidence interval of 46% to 89%. In the adequate and good diet groups the participants consumed more than 100% of the RDA, these high concentrations of vitamin C could have come from large orange juice intakes. The other types of food sources of vitamin C, which the participants in the poor, adequate and good diet consumed, were potatoes, apple, pear, spinach, tomato and onion, pumpkin, orange juice and beetroot. The participants in the poor Nutrient Index group had a lower intake of vitamin C and this could be because they consumed small amounts of orange juice due to income limitations and that they consumed less fresh fruit and vegetables. The babies of participants with lower vitamin C intakes did not show prematurity or malformation functions and no adverse pregnancy outcome was found when a mother had a high vitamin C intake. According to Costello and Osrin (2003), a lower plasma and leukocyte ascorbate have been associated with premature rupture of membranes and pre-eclampsia. Fagen (2000) stated that a large population study showed that vitamin C deficiency has not been associated with adverse pregnancy outcomes.

The foods containing 10% or more of the RDA of folic acid that were mostly consumed by the women were tripe, pilchards, beef mince, dry beans, soya mince, red meat, chicken meat, spinach and chakalaka (Table 3.6). The reason why the folic acid intakes were so low, could be due to the fact that the types of food which actually could have made a contribution were eaten once a week or less frequently. Just a small amount of folic acid was consumed daily from spinach and sometimes from chakalaka. The participants in the poor Nutrient Index group had the lowest average folic acid intake of 35% of the RDA, where the average intake of folic acid in the adequate diet was 41% and in the good diet the average iron intake was 47% of the RDA. The average folic acid intake was with iron one of the lowest micronutrient intakes of all three groups. The women in the poor diet group consumed mostly plant protein, which could have contributed to the very low folic acid intakes. The women in the adequate diet group probably ate animal protein (chicken or beef) more often, where the women in the good diet group consumed even more food or different types of food rich in folic acid than the other two groups. It is possible that these women in the good diet had a higher income and could buy more meat products regularly. However, all three groups did not even consume 50% of the RDA and it is necessary to emphasize the type and quantity of foods during nutrition education to the mothers. If the women of the Thusa Mama study had consumed more regular red meat and chicken, it would have been possible that the folic acid intake would have increased. Foods such as tripe, pilchard, dry beans beef and soya mince were consumed whenever these women had money to buy these items and mostly probable the infrequently intake of these foods had a small contribution to the folic acid intake. Small amount of the folic acid was consumed daily from spinach and chakalaka. According to Fagen (2000), a pregnant woman's folic acid needs increase during pregnancy in response to the demands of maternal erythropoiesis and fetal and placental growth. The key role of folate in DNA synthesis means that deficiency is associated with dysfunction in rapidly dividing cells. The relationship between periconceptional folate deficiency and neural defects is now well established (Costello & Osrin, 2003). Observational studies have suggested that lower maternal serum folate levels are associated with pre-term birth. These pregnant women had a very low folic acid intake and the pregnancy outcome could have been poor, but the women received a folic acid supplement daily. This shows that clinical care for pregnant women is very important.

Figure 3.7 shows the comparison of the means of essential micronutrient intakes of the participants in the different Nutrient Index groups with the RDA. This is a clear summary of the three previous figures. From this figure it can be seen that the participants in the different Nutrient Index groups had the same eating pattern, but that the quantity and type of foods containing different vitamins and minerals influence the type and amount of micronutrients. The average intakes of calcium, iron and folic acid of all three groups were lower than the RDA and this could be due to the unavailability of fresh milk in the townships, income limitations, eating pilchards without the bones, infrequent eating of tripe and the overcooking of spinach. All three

groups had an average iron intake less than 50% of the RDA. This could be that the foods rich in iron and which really could make a difference in the iron intake, were too expensive for daily use, such as red meat and beef tripe. There were no poor pregnancy outcomes due to daily iron supplementation. The mean intakes of zinc in all three groups were just below or above 100% of the RDA and this could be due to the larger intakes of maize meal, mabella, brown bread and smaller amounts of dry beans, soya mince, beef mince and red meat. The vitamin A intakes depended on the consumption of tripe, carrots, milk and eggs. The good and adequate diet groups had a high intake of the vitamin C and this might be due to high intakes of orange juice, potatoes, apple, pear, spinach, tomato and onion, pumpkin and beetroot. The poor diet group's mean intake was lower than 80% of the RDA. Income limitation could be responsible for lower intakes of orange juice and fresh fruits. The folic acid intakes of all three groups were very low being lower than 50% of the RDA. This means that the participants had small portions of pilchards, tripe, beef mince, dry beans and soya mince which were eaten infrequently. Therefore, small amounts of folic acid were consumed daily from maize meal, mabella, brown bread, potatoes and maybe only one type of animal or plant protein (dry beans or soy mince).

Foodstuffs, Cosmetics and Disinfectants Act, 1972

Since October 2004, the Foodstuffs, Cosmetics and Disinfectants Act no. 54 of 1972, was adapted to make staple food fortification compulsory. The Act states that all types of maize meal, wheat flour and bread needs to the fortified with vitamin A, thiamine, riboflavin, niacin, pyridoxine, folic acid, iron and zinc (Act no. 54 of 1972). The Thusa Mama study was done before this act was adapted. A reassessment of the Thusa Mama study will show different results with the intake of these vitamins and minerals, meaning that the iron and folic acid intake will increase in all three groups due to the fact that maize meal and bread were mostly eaten by the pregnant women in all three Nutrient Index groups. However, pregnant women will still receive folic acid and iron supplementation as a standard procedure from the clinics. This fortification programme could indirectly improve the fetal development by increasing the folic acid and iron intake of pregnant women who do not visit the clinics. This is due to the fact that a folic acid deficiency could lead to neural defects in the fetus (Costello & Osrin, 2003) and iron deficiency could increase the risk of premature delivery, maternal and fetal mortality (Soysa, 1987).

Typical food intake

Table 3.6 shows a list of the typical foods the participants were eating and the micronutrient (calcium, iron, zinc, vitamin A, vitamin C, thiamin, riboflavin, folic acid) content of the food. Most of the foods the participants consumed were inexpensive food like, maize meal, mabella, brown bread, eggs, pilchards, cabbage, chakalaka, tomato and onion, apple, pear, peanut butter, chicken feet and spinach. The participants also drank tea or coffee daily, often with milk and

sugar. Vegetables like beetroot, pumpkin and carrots were eaten more than once a week. Potatoes, tripe and boerewors were consumed if there was money in the house and dry beans and soya mince were eaten when available. The animal protein intakes were limited by the income and some participants consumed animal protein on a regular basis, whereas other participants consumed animal protein infrequently. Only participants with sufficient income consumed red meat or chicken and larger quantities of orange juice. Milk was consumed if the income allowed and if it was available. Hard brick margarine was used frequently and custard has been used as a desert.

The different types of diet compared with the baby' birth weight

Figure 3.8 shows data of the different types of diet compared with baby's birth weight. It illustrates that the birth weights were almost the same, but with a slightly higher birth weight in the adequate diet group. A large body of evidence suggests that maternal weight gain during pregnancy is an important determinant of fetal growth (Wells, 2003). IOM (1990) states the higher the pre-pregnancy weight and the higher the gestational weight gain, the higher birth-weight will occur. Obese women are at a greater risk of hypertension, gestational diabetes, induced labour and caesarean section (ADA, 2002). Also, if pregnant women gain less weight than is recommended in the IOM guidelines, the risk increases for a premature birth. In the Thusa Mama study, the average mothers' babies had a normal birth weight and there was no significant difference between the three diet groups.

The different types of diets compared with the baby's birth lenght.

Figure 3.9 shows the data of the different Nutrient Index groups compared with the minimum, mean and maximum outcomes of the babies' length. It demonstrates that the participants' babies in all three groups had almost similar birth lengths, but most of the birth lengths in the adequate diet group were slightly increased. This could probably be due to the slightly higher birth weights of the babies in the adequate Nutrient Index diet group. However, there was no significant difference between the three groups.

The different types of diet compared with the baby's birth head circumference

Figure 3.10 shows a comparison of the babies' head circumference as an outcome in the different Nutrient Index groups. This confirms that all three groups' participants' babies had similar head circumferences. However, there was a slightly lower mean head circumference in the poor Nutrient Index group, which was not significantly different from the other two groups. The slightly smaller head circumferences could be due to lower micronutrient intakes. Head circumference is a standard measurement for serial assessment of growth in infants from birth to 36 months

(Hammond, 2000). All the mothers received very good clinical care and supplements (iron, folic acid and vitamin C) and mothers with low pre-pregnancy BMI received supplementation from the protein and energy programme. However, further research is needed to investigate this slight effect of low micronutrient intake of the mother on the head circumference of the baby.

Correlations between the outcomes of the baby, nutrient intake, demographic data and participants' body composition.

Table 3.7 shows that the number of previous pregnancies of a woman had a significantly ($p<0.05$) negative correlation with animal protein intake, total fat intake and vitamin A intake. The decrease in these nutrients may perhaps be due to more children in the household to feed, while the income stayed the same and the mother could afford less animal protein foods. The decrease in vitamin A intake could be the lower intake of animal protein. These three dietary nutrients need to be investigated specifically in pregnant women with previous babies and a control group. Table 3.7 demonstrated furthermore that the mothers with more previous pregnancies had a significantly lower ($p<0.05$) haemoglobin concentration. It could be that the fetus slightly depletes the mother's haemoglobin concentrations (Fagen, 2000) and during the delivery, the mother could have larger amounts of blood loss and the mothers did not eat enough animal protein after the pregnancy to recover the haemoglobin concentrations. A significantly positive correlation between more pregnancies and age was shown. This is logical since the older a mother, the more children she might have. There was a significantly negative correlation ($p<0.05$) between the baby's birth length and the number of previous pregnancies a mother had. This could be due to depletion of micronutrients and insufficient weight gain during pregnancy and should be investigated further. Table 3.7 shows a significantly positive correlation between the birth weight and the mothers iron intake ($p<0.05$), but no correlation between mothers hemoglobin concentration and birth weight of the infant ($p<0.09$). There were also no correlation between the mothers' hemoglobin concentrations and the infants birth length ($p<0.34$) or the head circumference ($p<0.32$). According to Fagen (2000), during pregnancy 250-300mg of iron accumulates in the fetus and the placenta and this means that for optimal growth, a higher iron intake is necessary. Soysa (1987) states that there is a strong correlation between maternal anemia and birth weight. If a mother had iron deficiency, the birth weight decreased and the risk for pre-term babies increased. Table 3.7 shows that there was a significant correlation between total weight gain and baby's length, total income and weekly weight gain. This shows that the mother's total weight gain is positively associated with optimal growth of the baby. Suitor (2000) states that if a mother's total weight gain is inside the IOM recommendation, the size of the baby will be more optimal. With a higher total income, there is more money available for different types

of food and animal protein and this might lead to a higher energy intake, which could lead to a higher weekly weight gain and to a total weight gain.

HIV

Only some of the subjects were tested for HIV/AIDS (Acquired Immunodeficiency Syndrome). When partial correlations were calculated, HIV status and smoking might have been confounding factors and adjustment for HIV status and smoking has been done.

Limitation of the study

The Thusa Mama study had a number of limitations. Participants were included on the day the researchers visited the clinic, which was sometimes irregular. Different persons did the anthropometric measurements, because it was impossible for one person to do all the anthropometric measurements and questionnaires. Faulty-communication between researchers and the participants may be common where there is a language difference, although trained field workers and clinical personnel were used as translators where possible. The food frequency questionnaires could be confusing to uneducated persons and even though it was explained to them, over and under-reporting could have happened. The field workers used picture books for aids to help estimate the amount of foods and this could lead to over or under estimation of the food portions that these participants consumed. The pre-pregnancy weight of the pregnant women was unknown, and this needed to be calculated using a regression analysis. This analysis could not be done if less than three weights were available and was found to be the most accurately estimated up to week 14 and not pre-pregnancy. Pre-pregnancy weight and BMI used in the study were in most cases calculated from a regression equation and not the actual measured weight and BMI. Throughout the Thusa Mama study, the maize meal and bread were not already fortified with iron, zinc, folic acid and vitamin A. This could influence the dietary outcome if this study were to be done again. As already mentioned, the dietary intakes of the women were influenced by the clinical care. If pregnant woman was underweight or if she was HIV^+, the clinic gave nutrition supplements as soon as the weight became a risk factor for poor outcomes. The pregnant women also received nutrition education regarding food choices and healthy eating during pregnancy.

3.5 CONCLUSION AND RECOMMENDATIONS

The aim of the Thusa Mama Study was to evaluate the association between dietary intake and pregnancy outcome in pregnant women who visited a clinic on a regular basis. This includes a number of factors that have an impact on dietary intake. Factors that were investigated in this study were socio-demographic background, blood concentration of haemoglobin, the

macronutrient dietary intake (especially energy and protein) and micronutrient dietary intake (especially iron, folic acid, calcium, zinc, vitamin A and vitamin C). The outcomes that were investigated were mainly the outcomes of the infant's birth weight, birth length, birth head circumference and gestational age.

The most important associations found in this study are as follows:

- An increase in the animal protein intake increased the total protein intake
- All three Nutrient Index groups had a low mean iron and folic acid intake.
- There was a significantly negative correlation between the number of previous pregnancies of a mother and animal protein intake, fat intake, vitamin A intake and haemoglobin concentration of the mother and a positive correlation between number of previous pregnancies of a mother and age.
- The iron intake of the mother had a significantly positive correlation with the baby's weight.

Pregnant women should be a priority target population for the prevention of poor outcomes. Nutrition education and health care is important during pregnancy and should be emphasized whether pregnant women are underweight, normal weight or overweight. If pregnant women visit the clinic regularly, they receive nutrition counseling whenever there are reasons for concern. Underweight, HIV^+ mothers can receive nutritional supplementation from the South African Government. This lowers the poor pregnancy outcomes and can change risk factors into minor risk factors. Each pregnant woman received vitamin C, iron and folic acid supplementation. The results of the dietary intake showed that all the women needed iron and folic acid supplementation. Hickey *et al.* (1995) confirmed that good and timely care in both the underweight and overweight individuals can change poor pregnancy outcomes into positive pregnancy outcomes. The results found in the Thusa Mama study showed no significant correlations between pre-pregnancy BMI, weight gain during pregnancy and the pregnancy outcomes and this could be due directly to the timely and good nutrition care the mothers received at the clinic. If this study was to be repeated in a group who do not visit the clinic regularly, different outcomes could perhaps have been seen. To trace these participants will be very difficult and it would make the study very expensive and almost impossible.

From the results the tendency of women to gain excessive weight during the pregnancy period cannot be ignored and the importance of the IOM recommendations must be emphasized more at the clinics. Weekly weight gain needs to be carefully monitored. Excessive prenatal weight gain in overweight and obese women increases the risk of maternal hypertension, postpartum weight

retention and macrosomia in the infant and may necessitate caesarean delivery and perinatal complications (Gaultier – Dereure *et al.,* 2000). The total income had an influence on what type of foods and the quantity of foods which were consumed. However, some of the selected micronutrients intakes were lower than the RDA, which could have adverse pregnancy outcomes. The Thusa Mama study showed no adverse pregnancy outcomes. This could be due to the supplementation the mothers received at the clinic. The fact that the birth weight and the dietary iron intake had a significantly positive correlation cannot be ignored and in this field, further research is necessary. The ADA (2000) stated that it would be ideal to write a nutrition protocol for the professional nurses in the Primary Health Care setting to guide the nurses in educating and managing pregnant women. During the development of the protocol, nutrition guidelines need to be considered to prevent low birth weight (in underweight women) and postpartum weight retention. Maternal nutrition status before and during gestation is one of the strongest determinants of pregnancy outcomes (Fagen, 2000). Therefore, the Institute of Medicine (IOM) (1990) weight gain recommendation should be recommended until further research and until a new set of guidelines, based on scientific evidence, are developed. According to Theron and Thompson (1993), although weight gain alone is not a good screening tool, weight gain outside the IOM's recommendations is associated with twice as many poor pregnancy outcomes than weight gains within the recommended range (IOM, 1990). Suitor (2000) states that when maternal weight gain is within the IOM recommended range, the incidence of small-for-gestational-age and/or LBW birth is reduced. Pre-pregnancy BMI, net maternal weight gain and weight gain above the IOM recommendations may increase the risk of caesarean delivery. As Chomitz *et al.* (1995) stated: "Pregnancy provides a window of opportunity to educate women about benefits of a good diet and a healthy lifestyle".

CHAPTER 4

SUMMARY, CONCLUSION & RECOMMENDATIONS

4.1 AIMS OF THE STUDY

The pregnancy outcomes in pregnant women who regularly visited a clinic and their dietary intake were evaluated during the Thusa Mama Study. Selected factors, which could influence the pregnancy outcomes, were investigated during their clinic visits. Factors such as socio-demographic background, blood concentration of haemoglobin, the macronutrient dietary intake (especially energy and protein) and micronutrient dietary intake (especially iron, folic acid, calcium, zinc, vitamin A and vitamin C) were examined. The outcomes that were investigated were mainly the outcomes of the infant's weight, birth length, head circumference and gestational age. The project was called the Thusa Mama Study because 'Thusa' is the Tswana word for help and it was the aim of the study to eventually help mothers.

4.2 SUMMARY

In the Thusa Mama Study, 98 pregnant black women were included and of these 98 women, two women had miscarriages and five women were lost during the follow-up visits. The data of 91 women were analysed. They were a sub-sample of a total of 478 pregnant women, who attended the midtown antenatal clinic in Potchefstroom during a period of one year. The data, which were collected included demographic information, haemoglobin concentrations and food frequency questionnaires. Anthropometric measurements were used to monitor their bodily changes consisted of weight and length. During the first visit, the demographic and food frequency questionnaire forms were completed. The haemoglobin concentration and weight gain were captured at each visit. At birth, the babies' birth data was obtained from Potchefstroom hospital, where these mothers gave birth.

The Thusa Mama study showed no correlation between pre-pregnancy BMI or weight gain during pregnancy and pregnancy outcomes. Most of the pregnant women, regardless of their pre-pregnancy BMI, appeared to gain excess weight in relation to the IOM's recommendations. As described in the literature, this outcome could lead to a number of complications and health risks.

No correlation was found between energy or protein intake of the mothers and the mother's weekly weight gain. The study showed that if the animal protein intake increased, the total protein increased. The women with a pre-pregnancy BMI lower than 19.8 were significantly younger than the women with a BMI higher than 26.

The outcomes of the three Nutrient Index groups showed that the average women had an adequate intake of the macronutrients, however the micronutrient intake of folic acid and iron in all three groups was lower than 50% of the RDA. It is crucial to educate the low socio-economic mothers on healthy eating and the daily intake of foods containing iron and folic acid. This is due to the results found in the Thusa Mama study concerning the low iron and folic acid intake, regardless of the type of diet. Iron and folic acid deficiencies can cause adverse outcomes during pregnancy. It is of utmost importance that pregnant women from a low socio-economic group attend antenatal clinics, where the clinic staff can emphasise the essentiality of daily supplementation of iron and folic acid during pregnancy. Although all three groups had a low iron and folic acid intake, there were no adverse outcomes. This shows the importance of the antenatal clinic care, where mothers who are at risk to have poor pregnancy outcomes receive assistance from dieticians and the clinic staff. The Thusa Mama study's mothers received medical care and standard clinic nutrition supplementation such as, folic acid, iron and vitamin C. When a mother qualified for the Protein Energy Malnutrition Scheme, she also received a ready to mix maize meal, which enhanced her chances for optimal pregnancy outcomes.

A reassessment of the Thusa Mama study might show an increase in the iron and folic acid intakes of the pregnant women. This might be a result of the fact that since October 2004, all maize meal and bread has been fortified with iron and folic acid. This Act (Act no. 54 of 1972) was adapted only after the data of the Thusa Mama study was collected.

There was no significant difference between the three diet groups and the babies' outcomes, although there was a slightly lower birth head circumference in the poor diet group.

Number of previous pregnancies had significantly negative correlations with animal protein intake, fat intake and vitamin A intake of pregnant women. There was also a significantly negative correlation between the number of previous pregnancies and the haemoglobin concentrations.
The babies' birth weight had a significantly positive correlation with the iron intake of the mothers. Although the iron intakes were low in all three groups, there were no adverse baby birth weight outcomes. The main reason for this was that the women received iron supplementation at the antenatal clinics.

4.3 CONCLUSION

The Thusa Mama study focuses on one of the most important parts of a woman's life cycle. The adverse outcomes and sub-optimal growth is of great concern and needs to be investigated to promote sufficient nutrition for optimal growth in fetuses. In conclusion, it is essential for pregnant women to have a good balanced diet, but if the pregnant woman is from a low socio-economic group, good clinical care is crucial, where these women can receive iron and folic acid supplementation and outstanding help with nutrition education on healthy eating during pregnancy. It is also important that the mothers should be educated on the weight gain regarding the IOM's recommendation, to prevent excessive weight gain and to minimise the adverse outcomes during pregnancy. In more rural areas, where health care is less available, further research is necessary regarding the dietary intake and pregnancy outcomes.

4.4 RECOMMENDATIONS

The clinic staff needs to monitor the weight gain of pregnant women in more detail according to the IOM recommendations (IOM, 1990). If pregnant women gain inadequate or excessive weight, the clinic staff needs to educate the mother on the risk and complications this weight could have on the pregnancy outcomes and the clinic staff needs to give the appropriate assistance. Pregnant women need to follow a healthy balanced diet. Most pregnant women need to take an iron and folic acid supplement because none of the women had adequate intakes of these nutrients. Animal protein foods are important as a macronutrient source to consume during pregnancy and provide iron and zinc, which are necessary to have optimal fetal growth. Pregnant women need to attend an antenatal clinic during pregnancy.

APPENDIX

APPENDIX A

INFORMED CONSENT FORM

MATERNAL AND INFANT HEALTH PROJECT: PU FOR CHE
INFORMED CONSENT FORM

Title of the project: THUSAMAMA

Name:_____No:_____
Address:_____Tel no:_____
Age:_____

INFORMED CONSENT
I, the undersigned.....(full name in print), have read the details of the project or, listened to the oral explanation thereof, and declare that I understand it. I have had the opportunity to discuss relevant aspects with the researcher and declare that I voluntarily participate in the project. I hereby give consent to participate in the project.

_____
Signature of volunteer

Witnesses:_____ _____
Signed at_____on_____

For subjects under the age of 21, signed consent of a parent/guardian is necessary.
I, _____(full name in print) the parent/guardian of the person named above, hereby consent that he/she may participate in the THUSAMAMA project)

Signature_____ Date_____
Relationship_____

MATERNAL AND INFANT HEALTH PROJECT: PU FOR CHE
INFORMED CONSENT FORM

Title of the project: THUSAMAMA

Name:_____No:_____
Address:_____Tel no:_____
Age:_____

INFORMED CONSENT
I, the undersigned.....(full name in print), have read the details of the project or, listened to the oral explanation thereof, and declare that I understand it. I have had the opportunity to discuss relevant aspects with the researcher and declare that I voluntarily participate in the project. I hereby give consent to participate in the project.

_____
Signature of volunteer
Witnesses:_____ _____

Signed at_____on_____

For subjects under the age of 21, signed consent of a parent/guardian is necessary.
I, _____(full names in print) the parent/guardian of the person named above, hereby consent that he/she may participate in the THUSAMAMA project)

Signature_____ Date_____
Relationship_____

APPENDIX B

DEMOGRAPHIC QUESTIONNAIRE

PREGNANCY WEIGHT GAIN & OUTCOMES

Demographic Questionnaire (All the information on this questionnaire is confidential)

Date: _____ Interviewer: _____

1. Subject number: _____
2. File number: _____

   Home address: _____

   _____

   Telephone _____
3. Birth date - Year: _____/ Month: _____/ Date: _____
4. First language: ___ Tswana=1, Sotho=2, Xhosa=3, Zulu=4,
5. Second language: ___ English=5, Afrikaans=6, Other, specify.....
6. Marital status:
   1=live with husband
   2=live with partner, baby's father (not married)
   3=live with partner, not baby's father (not married)
   4=widow, live alone with other relatives
   5=divorced, live alone with other relatives
   6=never married, live alone
   9=never married, live with relatives/ friends
7. Other children? Yes (1) ☐ No (2) ☐

   Ages of other children: _____
8. What is your highest qualification? ☐
   1. None
   2. < St. 6 (Gr. 8)
   3. St. 6 – 8 (Gr. 8 – 10)
   4. St. 6 – 8 (Gr. 8 – 10) + trade
   5. St. 9 – 10 (Gr. 11 – 12)
   6. St. 9 – 10 (Gr. 11 – 12) + trade
   7. St. 10 (Gr. 12) + Technikon, University, College
9. Do you have a job at the moment? Yes (1) ☐ No (2) ☐
10. If yes, what kind? _____
    1. Professional (teacher/nurse/other with tertiary education)
    2. Self-employed formal
    3. Office work/ sales assistant
    4. Domestic service/ cleaner
    5. Informal sector (hawker, car-minder)

11. Do you work:
    1. part-time (1 – 3d/ week),
    2. full-time (5 – 6d/ week)

12. What is the source of income?

    1. Own work
    2. Parents/ Grandparents
    3. Relative's pension
    4. Partner
    5. Child
    6. Other, specify.....
    7. Breadwinner's occupation (refer item 10)

13. What is your total household income per month?

    1. <R500/month
    2. R501-1000/month
    3. R1001-2000/month
    4. R2001-5000/month
    5. R5001+/month

14. How many people eat/ sleep/ live in your house?

    1. Children <12
    2. Children 12 – 18
    3. Adults

15. Information regarding members of household

Member	*Educational level*	*Present job*

16. In what type of house do you live?

    1. Brick house
    2. Zinc house
    3. Other _____

17. What type of floor is mainly in your house?

    1. Mud/ ground/ animal source
    2. Cement
    3. Tiles/ Bricks
    4. Carpet

18. What type of toilet do you have? ☐

1. Outside, long-drop
2. Outside, chemical
3. Outside, water-flush
4. Outside, pit
5. Inside, water-flush

19. Where do you get your drinking water? ☐

1. Collect from fountain, river, etc.
2. Communal tap
3. Outside tap
4. Inside tap
5. Other: _____

20. What do you use for transport? ☐

1. Family's own car
2. Neighbour/relative/friend's car
3. Taxi
4. Bicycle
5. Other: _____

21. Do you have access to electricity? Yes=1 No=2 ☐

22. Which of the following do you have in your house?:

1. Electric stove ☐
2. Refrigerator ☐
3. Television ☐
4. Radio ☐
5. Telephone ☐

23. Have you received any nutritional education from a qualified Health Professional?

1. Healthy eating during pregnancy? Yes (1) ☐ No (2)
2. Oral rehydration therapy? Yes (1) ☐ No (2)
3. Breastfeeding practices? Yes (1) ☐ No (2)

APPENDIX C

FOOD FREQUENCY QUESTIONNAIRE

FOOD FREQUENCY QUESTIONNAIRE

INSTRUCTIONS: Circle the subject's answer. Fill in the amount and times eaten in the appropriate columns.

SUBJECT NO: .....

I shall now ask you about the type and the amount of food you have been eating in the last few months. Please tell if you eat the food, how much you eat and how often you eat it. We shall start with maize meal porridge.

Do you eat maize meal porridge? YES 1 NO 2
If YES, what type do you have at home now?

Brand name: .....
Don't know 2
Grind self 3

If brand name given, do you usually use this brand?
YES 1 NO 2 DON'T KNOW 3
Where do you get your maize meal from? (May answer more than one)

Shop	1
Employer	2
Harvest and grind self	3
Other – specify	4
Don't know	5

FOR OFFICE USE

FOOD	DESCRIPTION	Amount	TIMES EATEN				CODE	AMOUNT/ DAY
			Per day	Per week	Per month	Seldom Never		
Maize meal porridge	Stiff ('pap')						e4225 4250	
Maize meal porridge	Soft ('slap pap')						e4225 4250	
Do you pour milk on your soft porridge? YES 1 NO 2 If YES, what type of milk (whole fresh, sour, 2 %, fat free, milk blend)? ..... INSTRUCTION: Show subject examples.								
If YES, how much milk?								
Do you pour sugar on your soft porridge? YES 1 NO 2								
If YES, how much sugar?							9012	
Maize meal porridge	Crumbly (phutu)						e4225 4250	
Ting								
Mabella Coarse Fine Rice	Stiff						4082	
Mabella Coarse Fine Rice	Soft						4082	

FOOD	DESCRIPTION	Amount	TIMES EATEN				CODE	AMOUNT/ DAY
			Per day	Per week	Per month	Seldom Never		
Do you pour milk on your mabella porridge? YES 1 NO 2 If YES, what type of milk (whole fresh, sour, 2 %, fat free, milk blend)? ..... INSTRUCTION: Show subject examples.								
If YES, how much milk?								
Do you pour sugar on your mabella? YES 1 NO 2								
If YES, how much sugar?							9012	
Oats							4032	
Do you pour milk on your oats? YES 1 NO 2 If YES, what type of milk (whole fresh, sour, 2 %, fat free, milk blend)? ..... INSTRUCTION: Show subject examples.								
If YES, how much milk?								
Do you pour sugar on your oats? YES 1 NO 2								
If YES, how much sugar?							9012	
Breakfast cereals	Brand names of cereals at home now: Don't know						4036	
Do you pour milk on your cereal? YES 1 NO 2 If YES, what type of milk (whole fresh, sour, 2 %, fat free, milk blend)? ..... INSTRUCTION: Show subject examples.								
If YES, how much milk?								
Do you pour sugar on your cereal? YES 1 NO 2								
If YES, how much sugar?							9012	
Samp	Bought Self ground with fat without fat						4043	
Samp and beans							A014	
	Are the amounts of samp and beans the same as in the picture? YES NO If NO, do you use more beans than in the picture or less? MORE LESS							
Samp and peanuts							A013	
	Are the amount of samp and peanuts the same as in the picture? YES NO If NO, do you use more peanuts than in the picture or less? MORE LESS							
Rice	White Brown Maize rice						4040 4134 4043	
Pastas	Macaroni Spaghetti Other						4062	

FOOD	DESCRIPTION	Amount	TIMES EATEN				CODE	AMOUNT/ DAY
			Per day	Per week	Per month	Seldom Never		
You are being very helpful. Can I now ask you about meat? CHICKEN, MEAT, FISH How many times per day/week do you eat meat, fish or chicken? .....X/day .....X/week								
Chicken:	Boiled, nothing added						1521	
	Fried: in butter/crumbs Not coated						1634 1520	
	Roasted, grilled						1520	
	Stewed						1520	
	What vegetables are in the stew?							
	Don't know							
Do you eat chicken skin? ALWAYS 1 SOMETIMES 2 NEVER 3								
Chicken bones stew							A003	
Chicken feet	How do you cook it?						A004 1609	
Chicken offal	How do you cook it?						1610	
Red meat:	How do you like meat? With fat Fat trimmed							
Beef	Fried – with bone							
	Fried – without bone							
	Stewed – with bone						A001	
	Stewed – without bone						A001	
	Grilled – with bone							
	Grilled – without bone							
	Minced						1585	
Mutton	Fried – with bone						1522	
	Fried – without bone						1571	
	Stewed – with bone						1511	
	Stewed – without bone						1511	
	Grilled – with bone							
	Grilled – without bone							
	Minced						1662	

FOOD	DESCRIPTION	Amount	TIMES EATEN				CODE	AMOUNT/ DAY
			Per day	Per week	Per month	Seldom Never		
Pork	Fried – with bone							
	Fried – without bone							
	Stewed – with bone							
	Stewed – without bone							
	Grilled – with bone							
	Grilled – without bone							
Beef Offal	Intestines: boiled, nothing added						161	
	Stewed with vegetables							
	Tripe						1546	
	Heart						1565	
	Lungs							
	Liver						1515	
	Kidneys						1518	
	Other specify:							
What vegetables are usually put into meat stews?								
Wors sausage	Fried Grilled						1526	
Bacon							1501	
Cold meats	Polony						1514	
	Ham						1564	
	Viennas						1531	
	Other specify:							
Canned meat	Bully beef						1535	
	Other specify:							
Meat pie	Home made Bought						1548	
Hamburger	Home made Bought						A015	
Dried beans, peas, lentils	How do you prepare them?							
Soya products e.g. Toppers	Brands at home now Don't know..... Show examples						3527	
Pilchards in tomato chilli brine	Whole						2557	
	Mashed with fried onion						A005	
Fried fish	With batter/ crumbs						2523	
	Without batter/crumbs						2509	
Other canned fish	Tuna							
	Pickled fish Other:						2562	
Fish cakes	Home made (describe) Frozen Bought						2531	

FOOD	DESCRIPTION	Amount	TIMES EATEN				CODE	AMOUNT/ DAY
			Per day	Per week	Per month	Seldom Never		
Eggs	Boiled poached Scrambled Fried						1001 1025 1003	
WE NOW COME TO VEGETABLES AND FRUIT How many times per day/week do you eat vegetables? .....X/day .....X/week								
Cabbage	How do you cook cabbage?							
	Boiled, nothing added							8066
	Boiled with potato and onion and fat							A006
	Fried, nothing added							A007
	Boiled, then fried with potato, onion							A006
	Other:							
	Don't know							
Spinach / morogo / other green leafy	How do you cook spinach?							
	Boiled, nothing added						8071	
	Boiled fat added						8209	
	Boiled with – onion, tomato & fat						A011	
	-onion, tomato & potato						8212	
	- with peanuts							
	Other:							
	Don't know							
Tomato and onion 'gravy'	Home made - with fat - without fat						 A012 A016	
	Canned (Is this the amount of pap you eat? How much more or less?)						8221	
Pumpkin	How do you cook pumpkin?							
	Cooked in fat & sugar						A010	
	Boiled, little sugar and fat						A009	
	Other:							
	Don't know							

FOOD	DESCRIPTION	Amount	TIMES EATEN				CODE	AMOUNT/ DAY
			Per day	Per week	Per month	Seldom Never		
Carrots	How do you cook carrots?							
	Boiled, sugar & fat						8129	
	With potato/ onion						A008	
	Raw, salad Chakalaka						8015 A025	
	Other:							
	Don't know							
Mealies / Sweet corn	How do you eat mealies? On cob –with fat -without fat						8033	
	Off cob –with fat -without fat						8261	
Beetroot salad	Home made Bought						8005	
Potatoes	How do you cook potatoes?							
	Boiled/baked - with skin						8046	
	- without skin						8045	
	Mashed						8187	
	Roasted						8189	
	French fries						8048	
	Salad						8236	
	Other:							
Sweet potatoes	How do you cook sweet potatoes?							
	Boiled/baked - with skin						8057	
	- without skin						8214	
	Mashed						8058	
	Other:							
	Don/t know							
Salad vegetables	Raw tomato						8059	
	Lettuce						8031	
	Cucumber						8025	
Other vegetables specify:								
FRUIT: Do you like fruit? YES NO How many times per day/week do you eat fruit? .....X/day .....X/week								

FOOD	DESCRIPTION	Amount	TIMES EATEN				CODE	AMOUNT/ DAY
			Per day	Per week	Per month	Seldom Never		
Apples/Pears	Fresh						7001	
Pears	Fresh Canned						7053 7054	
Bananas							7009	
Oranges / naartjies							7031	
Grapes							7020	
Peaches	Fresh Canned						7036 7038	
Apricots	Fresh Canned						7003 7004	
Mangoes	Fresh						7026	
Guavas	Fresh Canned						7021 7023	
If subject eats canned fruit: Do you have custard with canned fruit? YES 1 NO 2								
Custard	Home made Ultramel						0004	
Wild fruit / berries	Stamvrugte Noen-noem Klappers Maroelas Nastergals Other – specify						7070	
Dried fruit:	Types:							
Other fruit:								
BREAD AND BREAD SPREADS								
Bread Bread rolls	White						4001	
	Brown						4002	
	Whole wheat						4003	
Do you spread anything on the bread? ALWAYS 1 SOMETIMES 2 NEVER 3 If YES, what do you spread?								
Margarine	What brand do you have at home now? ..... Don't know Show examples						6508 6521	
Butter	What brand do you have at home now? ..... Home made Don't know						6502	

FOOD	DESCRIPTION	Amount	TIMES EATEN				CODE	AMOUNT/ DAY
			Per day	Per week	Per month	Seldom Never		
Peanut butter							6509	
Jam/syrup/ honey							9008	
Marmite/Fray Bentos etc.							9501	
Fish/meat paste							1512	
Cheese	Type:						0010	
Atchar							3004	
Polony							1514	
Other spreads: specify								
Dumpling							4001	
Vetkoek							4057	
Provita, crackers etc.								
FATS: What fats do you use and where do you use them?								
Margarine	Where used: on bread							
	with vegetables** Number of spoons ..... /number in family							
Butter	on bread with vegetables** Number of spoons ..... /number in family							
Holsum / vegetable fat	Where used: Number of spoons ..... /number in family						6508	
Oil	Where used: Number of spoons ..... /number in family						6510	
Dripping	Where used: Number of spoons ..... /number in family							
Mixed fat (makhuru)	Where used: Number of spoons ..... /number in family							

FOOD	DESCRIPTION	Amount	TIMES EATEN				CODE	AMOUNT/ DAY
			Per day	Per week	Per month	Seldom Never		
Lard	Where used: Number of spoons ..... /number in family						6520	
Mayonnaise/ salad dressing	Number of spoons ..... /number in family						6573	
Cream	Fresh/Long life /canned Orley whip						6503	
DRINKS:								
Tea							9514	
Sugar/cup tea							9012	
Milk / cup tea	What type of milk do you use in tea?							
	Fresh / long life whole						0006	
	Fresh / long life 2%							
	Fresh / long life fat free						0072	
	Whole milk powder Brand						0009	
	Skimmed milk powder Brand						0008	
	Milk blend Brand						0068	
	Whitener Brand						0039	
	Condensed milk						0002	
	Evaporated milk						0003	
	None							
Coffee								
Sugar / cup coffee							9012	
Milk / cup coffee	What type of milk do you use in coffee?							
	Fresh / long life whole						0006	
	Fresh / long life 2 %							
	Fresh / long life fat free						0072	
	Whole milk powder Brand						0009	
	Skimmed milk powder Brand						0008	
	Milk blend Brand						0068	
	Whitener Brand						0039	

FOOD	DESCRIPTION	Amount	TIMES EATEN				CODE	AMOUNT/ DAY
			Per day	Per week	Per month	Seldom Never		
	Condensed milk						0002	
	Evaporated milk						0003	
	None							
Milk as such	What type of milk do you drink as such?							
	Fresh / long life whole						0006	
	Fresh / long life 2 %							
	Fresh / long life fat free						0072	
	Sour / Maas						0006	
	Buttermilk						0001	
	Whole milk powder Brand						0006	
	Skimmed milk powder Brand						0072	
	Milk blend Brand						0068	
Milk drinks Brand	Nestle Milo Other						0023	
Yoghurt	Drinking yoghurt Thick yoghurt						0044 0020	
Squash	Sweeto SixO Oros/Lecol - with sugar - artificial sweetner Kool Aid Other						9013 9013 9002 9013 9002	
Fruit juice	Fresh/Liquifruit/Ceres Tropica Concentrates e.g. Halls Nectars Flavour							
Fizzy drinks Coke, Fanta	Sweetened Diet						9001 9013	
Mageu/Motogo							9562	
Home brew							9516	
Tlokwe							9516	
Beer							9506	
Spirits							9510	
Wine red							9508	
Wine white							9518	
Liqueur							9517	
Other: specify								

FOOD	DESCRIPTION	Amount	TIMES EATEN				CODE	AMOUNT/ DAY
			Per day	Per week	Per month	Seldom Never		
SNACKS AND SWEETS:								
Potato crisps							4275	
Cheese curls Niknaks etc.							4067	
Peanuts	Raw Roasted						6001 6007	
Raisins							7022	
Peanuts and raisins								
Chocolates	Name						9024	
Candies	Sugars, gums, hard sweets						9009	
Sweets	Toffees, fudge, caramels						9014	
Biscuits	Type							
Cakes & tarts	Type							
Scones							4029	
Rusks							4160	
Savouries	Sausage rolls Samoosas Biscuits e.g. Bacon kips Other						1534 4196 4162	
PUDDINGS:								
Canned fruit	Type							
Jelly							9004	
Custard	Homemade Ultramel						0004	
Baked pudding							4181	
Instant pudding							4066	
Ice cream Sorbet							6507 6516	
Other: specify								
SAUCES / GRAVIES / CONDIMENTS:								
Atchar							3004	
Tomato sauce Worcester sauce							3027	
Chutney							9524	
Pickles							8176	
Packet soups							3046	
Others:								
INSECTS:								
Locusts								
Mopani worms								
Others:								

FOOD	DESCRIPTION	Amount	TIMES EATEN				CODE	AMOUNT/ DAY
			Per day	Per Week	Per month	Seldom Never		
WILD BIRDS OR ANIMALS (hunted in rural areas or on farms)								
MISCELLANEOUS: Please mention any other foods used more than once/two weeks which we have not talked about:								

Use of salt and vitamins:

What type of salt do you use? Fine iodised (1)..... Coarse (2).....

Do you add salt ro food while it is cooked? Yes (1) ..... No (2) .....

Do you add to you food salt at the table? Yes (1)..... No (2) .....

Do you eat salty food (salted peanuts, chips)? Often .....Seldom.....Never .....

(1) (2) (3)

Do you take any vitamin tablets or syrup, other than those supplied by the clinic? Yes (1) ..... No (2) .....

APPENDIX D

MATERNAL HEALTH QUESTIONNAIRE

THUSAMAMA: **Maternal health questionnaire**

1. Subject number: ..... 2. File number: .....

3. Allergies: ..... 4. Patient notes (p15-24).....

.....

.....

5. Mental health notes (p 28): .....

6. Present medication (p 28): .....

7. HIV & STD (p 29 – 30): Date: ..... Test: ..... Result

8. Chronic medication (p 31): .....

9. Problems with menstrual cycle (p 32): .....

10. Do you smoke? Yes..... No..... If yes, how many cigarettes/day? .....
For how many years? .....
If no, have you ever smoked? .....
If yes, number of years and cigarettes/d

11. Do you take snuff? Yes..... No.....

12. Do you drink alcohol (p 32)? Yes..... No ..... If yes, amount per day/ week.....

13. Examination (p32): Blood pressure: date:..... systolic BP..... diastolic BP.
date:..... systolic BP..... diastolic BP..
date:..... systolic BP..... diastolic BP..

Haemoglobin: date:..... Hb: .....
date:..... Hb: .....
date:..... HB: .....

14. Other visits (p 33, 34).....

15. Midwifery history (p 37 – 52) .....

16. Type of delivery (normal/ Cesarean): 1..... 2..... 3..... 4.....5..

17. Complications during previous childbirth:.....

18. Investigation (p 37-52):
Urine: date:..... blood..... protein.....glucose.....other.....
date:..... blood..... protein.....glucose.....other.....
date:..... blood..... protein.....glucose.....other.....
date:..... blood..... protein.....glucose.....other.....

19. SF measure: date:.....SF: ..... date:.....SF: .....
date:.....SF: ..... date:.....SF: .....

APPENDIX E

ANTHROPOMETRIC DATA FORM

Anthropometry DATASHEET

Subject number: _____ Date: _____

Body mass: _____ kg

Stature: _____ cm

Triceps: 1. _____ mm 2. _____ mm 3. _____ mm

Subscapular: 1. _____ mm 2. _____ mm 3. _____ mm

Thigh: 1. _____ mm 2. _____ mm 3. _____ mm

Calf: 1. _____ mm 2. _____ mm 3. _____ mm

Upper arm circumference: _____ cm

Hip circumference: _____ cm

Thigh circumference: _____ cm

Anthropometry DATASHEET

Subject number: _____ Date: _____

Body mass: _____ kg

Stature: _____ cm

Triceps: 1. _____ mm 2. _____ mm 3. _____ mm

Subscapular: 1. _____ mm 2. _____ mm 3. _____ mm

Thigh: 1. _____ mm 2. _____ mm 3. _____ mm

Calf: 1. _____ mm 2. _____ mm 3. _____ mm

Upper arm circumference: _____ cm

Hip circumference: _____ cm

Thigh circumference: _____ cm

APPENDIX F

BIRTH DATA COLLECTION FORM

THE THUSAMAMA PROJECT

Birth data

Subject number: .....

Date of birth: ..... Boy/Girl (underline)

Gestational age of baby: .....weeks Delivery: normal/Caesarean

Baby: Weight: .....kg Length: .....cm Head circumference: .....cı

Leg length: .....cm Arm length: .....cm Trunk length: .....cm

Apgar score (1min):..... Apgar score (5min):.....

Placenta: Weight: .....g

Mother: Weight before birth: .....kg Weight: .....kg (after birth)

Weight: .....kg (at dismissal) Health status: .....

Date of dismissal: .....

THE THUSAMAMA PROJECT

Birth data

Subject number: .....

Date of birth: ..... Boy/Girl (underline)

Gestational age of baby: .....weeks

Baby: Weight: .....kg Length: .....cm Head circumference: c

Leg length: .....cm Arm length: .....cm Trunk length: .....cm

Apgar score (1min):..... Apgar score (5min):.....

Placenta: Weight: .....g

Mother: Weight before birth: .....kg Weight: .....kg (after birth)

Weight: .....kg (at dismissal)

Date of dismissal: .....

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