LIFESTYLE BEHAVIOURS AND BELIEFS OF PREGNANT WOMEN WITH GESTATIONAL DIABETES: A LONGITUDINAL FOLLOW-UP STUDY

BY

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DECLARATION

I, ……Stephanie Marie Krige………., hereby declare that the work on which this dissertation/thesis is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other university.

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ABSTRACT

Women with gestational diabetes mellitus (GDM) have increased risk of adverse pregnancy outcomes such as delivering Large-for-gestational-age babies, preeclampsia or birth trauma, as well as increased risk of developing type 2 diabetes (T2DM) later in life. Lifestyle management through a healthy diet and physical activity both during and after a GDM pregnancy is the first line treatment option in GDM management and for delaying the onset of T2DM. The research for this Master thesis had two main aims: firstly, to investigate the dietary intake and beliefs related to dietary intake of pregnant women with GDM in Cape Town, and whether they adhere to established dietary recommendations and secondly, to investigate the change in dietary intake, physical activity and associated factors as well as beliefs related to these lifestyle behaviours in women with GDM from pregnancy to a postpartum follow-up assessment.

Methods: For the first aim a cross-sectional study was conducted on 239 pregnant women with GDM in Cape Town and for the second aim, 98 women were followed-up 3 to 15 months postpartum. Assessments included: a quantified Food Frequency Questionnaire (qFFQ), General Practice Physical Activity Questionnaire (GPPAQ) and beliefs relating to specific dietary components were assessed using the Theory of Planned Behaviour (TPB).

Results: At baseline, the majority of the sample had inadequate intakes of vitamin D (87.4%), folate (96.5%) and iron (91.3%), and the dietary intake of these women was not optimal and fell short in meeting several nutritional guidelines for pregnant women with hyperglycaemia. At follow-up, the dietary changes made during pregnancy were not maintained postpartum. Fruit and vegetable intake (F&V) fell short of the recommended 400g intake at both baseline and follow-up. The intake of carbohydrates, added sugar, table sugar, sugar sweetened beverages (SSBs), pulses and energy-dense foods increased significantly from pregnancy to postpartum.

In conclusion, women with prior GDM fail to maintain the dietary changes made during pregnancy. These women being at risk for the development of T2DM would benefit from interventions supporting behaviour change towards a healthier lifestyle in pregnancy and continued in the postpartum period.

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"It always seems impossible until it is done" – Nelson Mandela

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ABBREVIATIONS

ADA	American Diabetes Association
ADIPS	Australasian Diabetes in Pregnancy Society
AGA	Appropriate-for-gestational-age
aHEI-2010	alternative Healthy Eating Index - 2010
AI	Adequate Intake
AICR	American Institute for Cancer Research
AMED	Alternate Mediterranean Diet
BMI	Body Mass Index
CDA	Canadian Dietetic Association
DASH	Dietary Approaches to Stop Hypertension
DED	Dietary energy density
EAR	Estimated Average Requirements
ECDCDM	Expert Committee on the Diagnosis and Classification of Diabetes Mellitus
FBDG	Food based dietary guideline
FFQ	Food Frequency Questionnaire
FPG	Fasting Plasma Glucose
F&V	Fruits and Vegetables
GCT	Glucose Challenge Test
GDM	Gestational Diabetes Mellitus
GI	Glycaemic Index
GIGT	Gestational Impaired Glucose Tolerance
GL	Glycaemic Load
GLUT4	Glucose Uptake Transporter 4
GSH	Groote Schuur Hospital
GWG	Gestational Weight Gain
HAPO	The Hyperglycaemia and Adverse Pregnancy Outcome
IGT	Impaired Glucose Tolerance
IINDIAGO	Integrated Intervention for reducing Diabetes risk after gestational diabetes
IADPSG	International Association of the Diabetes and Pregnancy Study Groups
IQ	Intelligence Quotient
IQR	Interquartile range
LGA	Large-for-Gestational-age
LSM	Living Standards Measure

MET	Metabolic Equivalent
MMH	Mowbray Maternity Hospital
MNT	Medical Nutrition Therapy
MVPA	Moderate to Vigorous Physical Activity
NEC	Necrotising Enterocolitis
NICE	National Institute for Health and Care Excellence
OGTT	Oral Glucose Tolerance Test
OHA	Oral Hypoglycaemic Agents
PA	Physical Activity
PAI	Physical Activity Index
qFFQ	quantified Food Frequency Questionnaire
RACGP	Royal Australian College of General Practitioners
RDA	Recommended Daily Allowance
RPG	Random Plasma Glucose
SADHS	South Africa Demographic and Health Survey
SGS	Small-for-gestational-age
SSB	Sugar Sweetened Beverages
SEMDSA	Society for Endocrinology, Metabolism and Diabetes of South Africa
TPB	Theory of Planned Behaviour
T1DM	Type 1 Diabetes Mellitus
T2DM	Type 2 Diabetes Mellitus
WCRF	World Cancer Research Fund
WHO	World Health Organisation

Chapter 1: Introduction

1.1 Introduction and motivation for study

Gestational diabetes (GDM) dates to as far back as 1828, whereby Heinrich Gottleib Benewitz described a pregnant woman with severe hyperglycaemia, exhibiting excess glucose production who delivered a baby that was macrosomic and still born. The term 'gestational diabetes' was coined only in 1957 by ER Carrington (McIntyre et al., 2015). For many years, the Expert Committee on the Diagnosis and Classification of Diabetes Mellitus (ECDCDM, 1997) defined GDM as "any degree of glucose intolerance with onset or first recognition during pregnancy". This definition was used whether or not the condition persisted after pregnancy. Due to the fact that many women have undiagnosed type 2 diabetes (T2DM), the American Dietetic Association (ADA 2017) recommends to "test for undiagnosed diabetes at the first prenatal visit in those with risk factors, using standard diagnostic criteria" and "Women diagnosed with diabetes in the first trimester of pregnancy, should be classified as having preexisting pregestational diabetes (type 2 diabetes or, very rarely, type 1 diabetes)" (ADA, 2017). GDM is therefore defined as "diabetes diagnosed in the second or third trimester of pregnancy that was not clearly overt diabetes prior to gestation" (ADA, 2017).

In 2015, the International Diabetes Federation (IDF) estimated a worldwide prevalence of 20.9 million women had hyperglycaemia in pregnancy of which an estimated that eighty-five percent was due to GDM (IDF, 2017). In Africa, the prevalence of GDM varies in different countries, ranging from 0% in Tanzania, 3.7% in Ethiopia, 7.7% in Morocco and 13% in Nigeria (Macaulay et al., 2014; Mwanri et al., 2015). When using the International Association of the Diabetes and Pregnancy Study Groups (IADPSG) (2010) criteria of diagnosis, the prevalence of GDM in South Africa is estimated to be as high as 25.6% (Adam and Rheeder, 2017).

GDM put both the mother and the unborn child at risk of developing complication during and after the pregnancy. The Hyperglycaemia and Adverse pregnancy Outcome (HAPO) study (HAPO Study Cooperative Research Group, 2008), which was a large prospective study conducted on 25, 505 pregnant women in nine countries, showed a linear relationship between maternal glucose values when fasted as well as one, and two hours after administration of a 75g Oral Glucose Tolerance Test (OGTT) at 24 to 32 weeks' gestation and the following adverse pregnancy outcomes: Large-for-gestational-age (LGA, >90th centile) babies, primary cesarean section, clinical neonatal hypoglycemia, neonatal hyperinsulinemia, fetal adiposity, preeclampsia and birth trauma/shoulder dystocia. Children of GDM mothers have an 8-fold increased risk of developing diabetes/prediabetes at 19-27 years of age, while offspring with Large-for-Gestational-age (LGA) were at significant risk of developing metabolic syndrome in childhood (Boney et al., 2005; Clausen et al., 2009; Murphy and Finer, 2015).

Women with a history of GDM have an increased risk of developing overt diabetes, essentially T2DM, later in life (Minooee et al., 2017; Zhu and Zhang, 2016). The cumulative incidence of T2DM in women with previous GDM increased significantly in the first 5 years postpartum and appeared to level after 10 years. The conversion rate to T2DM ranged from 2.6 to 70% over a period of 6 weeks to 28 years post- delivery (Kim et al., 2002), 33-50% in 5 years (Oldfield et al., 2007) and 60% in 10 years (Metzger et al., 1998). Furthermore, these women had a 3-fold increase in the risk of the metabolic syndrome (Damm, 2009; Ramezani Tehrani et al., 2012).

Several factors have been identified which may increase the risk of women, who previously had GDM, to developing T2DM and include: physical inactivity, overweight and obesity and an unhealthy diet (WHO, 2015). Optimal weight management and healthy lifestyle that include a healthy diet and physical activity are essential postpartum to prevent or decrease the risk of T2DM. We think that women are more conscious of their health during pregnancy and have a healthier diet during that period but fall back to unhealthy habits after child birth in the absence of GDM which may accelerate their progression to T2DM.

1.2 Aims and objectives

The **broad aim** of this research was to investigate the dietary intake and physical activity and associated factors as well as beliefs related to these lifestyle behaviours of a sample of women in Cape Town, South Africa during pregnancy with GDM and in the postpartum period.

For these purposes two specific aims and several objectives for each aim have been formulated as outlined below.

Aim 1:

To investigate the dietary intake and beliefs related to dietary intake of pregnant women with GDM in Cape Town, and whether they adhere to established dietary recommendations.

The specific objectives that were formulated for Aim 1 include:

- To assess and describe the dietary intake of pregnant women in terms of energy, carbohydrates, proteins, fats and micronutrients using a quantified Food Frequency Questionnaire (qFFQ)
- To compare the dietary intake of carbohydrate, protein, vitamins and minerals with current dietary standards for healthy pregnant women e.g. estimated average requirements (EARs) and adequate intake (AIs)
- To calculate and describe the macronutrient distribution as a percentage of total energy intake

- To compare the macronutrient distribution as a percentage of total energy intake with recommended macronutrient distribution ranges from different diabetes associations;
- To calculate and describe the daily intake of the following food groups: fruit and vegetables, Table sugar, sugar sweetened beverages (SSBs).
- To compare the intake of fruit and vegetables (F&V) with the WHO recommendation of 400g per day
- To compare the intake of SSBs to 0 mL per day as recommended by the Society for Endocrinology, Metabolism and Diabetes of South Africa (SEMDSA, 2017)
- To compare the intake of added table sugar to 0 g based on recommendation by WHO for total sugars added to foods to be <5% total energy (WHO, 2015).
- To assess and describe the most commonly held beliefs in relation to the intake of F&V and sugary foods and drinks.
- To identify associations between sociodemographic and other factors and meeting the recommendations of macronutrients, F&V, SSBs and sugar.

Aim 2: To investigate the change in dietary intake, physical activity and associated factors as well as beliefs related to these lifestyle behaviours in women with GDM from pregnancy to a postpartum follow-up assessment.

Secondary aim: To investigate the association between postpartum Body Mass Index (BMI) and change in dietary intake, Physical Activity (PA) and associated factors

The specific objectives that were formulated for Aim 2 include:

- To conduct one follow-up assessment of the same sample of women 3-15 months postpartum in order to compare the dietary intake during GDM pregnancy and post pregnancy
- To assess and describe the dietary intake of energy, carbohydrates, protein, fat and micronutrients as well as indicator food groups (F&V, pulses, processed meats, SSBs, added table sugar, energy-dense foods, refined starches and unrefined starches) using a quantified Food Frequency Questionnaire (qFFQ) at baseline and follow-up (3-15 months postpartum).
- To compare baseline and follow-up dietary intake of carbohydrates, fats, proteins, vitamins and minerals as well as indicator food groups (F&V, pulses, processed meats, SSBs, added table sugar, energy-dense foods, refined starches and unrefined starches).

- To calculate and compare baseline and follow-up macronutrient distribution as a percentage of TE.
- To compare physical activity at the follow-up interview with the baseline physical activity level.
- To assess and describe the weight status (BMI) and waist circumference at follow-up.
- To describe the following characteristics of the infants born from the GDM pregnancy: age of child at follow-up, birth weight, classification of infant birth weight, gestational age at birth, and infant nutrition.
- To assess body weight and shape perceptions of women at follow-up
- To investigate the association between BMI at follow-up and the following variables: age of mother, age of infant at follow-up/number of months postpartum, Living Standard Measure (LSM), waist circumference, infant birth weight, gestational age at birth, number of children, average birth weight of children.
- To assess the beliefs in relation to the intake of F&V, sugar, fat, fibre and physical activity and determine any associations with the actual intake of the indicator food groups at follow-up
- To compare the beliefs in relation to the intake of F&V, sugar, fat, fibre and physical activity at follow-up with baseline.
- To assess the diabetes management during pregnancy and postpartum and the beliefs in relation to diabetes risk.

1.3 Outline of thesis

Chapter 2 provides a literature review on risk factors for the development of GDM as well as T2DM in women who had GDM. The review also gives an overview of the various components of the management of GDM including pharmacological treatment, medical nutrition therapy, physical activity and weight management recommendations as well as post-natal recommendations for women who had GDM. Lastly, the available research on post-natal lifestyle interventions for women with a history of GDM to prevent the development of T2DM are critiqued. Chapter 3 covers the first secondary aim of this research and is presented as the first article of this research entitled "Dietary Intake and Beliefs of Pregnant Women with Gestational Diabetes in Cape Town, South Africa". The second article covers the other secondary aims of this research and is presented in Chapter 4 entitled "Dietary intake of women with prior gestational diabetes: the change from pregnancy to postpartum period". The final chapter, Chapter 5, presents an overview of the results reported in Chapters 3 and 4, final conclusions as well as recommendations. Please note that the article in Chapters 3 has been published in an international journal (see reference below) while the article in chapter 4 is presented in a non-specific journal article format in order to prepare this research for publication. There is thus unavoidable overlap between content and references of chapters 3 and 4.

1.2 Contributions by candidate

The Master's candidate was responsible for:

- Conceptualizing the research study and developing the questionnaire used with her supervisors
- Conducting data collection and training fieldworkers to assist with data collection for 239 baseline and 98 follow-ups.
- Conducting one-on-one follow-up interviews with follow-up patients, including collecting anthropometric data, diet history using a qFFQ and completing the questionnaire.
- Liaise with the facility staff at Groote Schuur Hospital (GSH) and Mowbray Maternity Hospital (MMH) for data collection purposes.
- Organising data collection and incentives, managing fieldworkers and contacting patients and scheduling meetings for follow-up appointments.
- Data capturing, categorising foods into indicator food groups, calculating portions from grams for refined and unrefined starches groups, calculating PA index from GPPAQ questionnaire, calculating LSM scores from LSM questionnaire,
- Running statistical tests and comparisons on analysed data and compiling all tables
- Assisting statistician with running statistical analyses of multivariate analysis and univariate analysis
- Compiling all chapters of the thesis
- Editing Article 1 for publication in a scientific journal.

1.3 Article from thesis

Krige SM, Booley S, Levitt NS, Chivese T, Murphy K, Harbron J. Dietary Intake and Beliefs of Pregnant Women with Gestational Diabetes in Cape Town, South Africa. *Nutrients*. 2018; 10(9). pii: E1183. doi: 10.3390/nu10091183.

Chapter 2: Literature Review

2.1 Definition and criteria for diagnosis of hyperglycaemia in pregnancy

To date there is no consensus on the diagnostic criteria for hyperglycaemia in pregnancy; different countries/associations have different diagnostic criteria as seen in Table 2.1. Pregnancies complicated by hyperglycaemia are classified as pre-existing diabetes or hyperglycaemia first detected in pregnancy, which includes both gestational diabetes mellitus (GDM) and overt diabetes (SEMDSA, 2017; WHO, 2013). According to the World Health Organisation (WHO) (2013) report, "hyperglycaemia first detected at any time during pregnancy should be classified as either 'diabetes mellitus in pregnancy' if the diagnostic criteria for non-pregnant adults are met, or 'gestational diabetes' for lesser degrees of hyperglycaemia defined by fasting, 1-hour and 2-hour post-glucose load" (SEMDSA, 2017,WHO, 2013). The American Diabetes Association (ADA) defines GDM as "diabetes diagnosed in the second or third trimester of pregnancy that was not clearly overt diabetes prior to gestation" (ADA, 2017)

Most associations recommend screening for pre-existing diabetes at the first antenatal visit and routine testing for GDM is done again at 24-28 weeks gestation (ADA, 2017; IADPSG, 2010; NICE Guideline, 2015; SEMDSA, 2017) but testing can be done at any time during pregnancy (WHO, 2013). The standard tests used for the diagnosis of GDM are the random plasma glucose (RPG) test, the fasting blood glucose (FBG) test, the 1 or 2 hour OGTT (Oral Glucose Tolerance Test) which may be 50g or 75g. Thompson et al., (2013) showed that the majority of associations use the 75g OGTT following the International Associations of the Diabetes and Pregnancy Study Groups (IADPSG, 2010).

The different diagnostic criteria used by the different associations are listed in Table 2.1. Various organizations stipulate to diagnose GDM with a fasting blood glucose level 5.1 to 6.9 mmol/L (CDA 2018, SEMDSA 2017, WHO 2013 and IADPSG 2010), a 1-h 75g OGTT ≥ 10.0 mmol/l (SEMDSA 2017, CDA 2018, ADA 2017, WHO 2013, IADPSG 2010, ADIPS 1998) or a 2-h 75g OGTT ≥ 8.5 mmol/l (ADA 2017, CDA 2018, IADPSG 2010). The diagnostic criteria of the Canadian Dietetic Association (CDA) (2018), SEMDSA (2017), WHO (2013) and International Association of the Diabetes and Pregnancy Study Groups (IADPSG) (2010) differentiate between GDM and overt diabetes. Overt diabetes or diabetes in pregnancy is diagnosed by fasting blood glucose level ≥ 7.0 mmol/l or 2h 75g OGTT ≥ 11.0 mmol/l (SEMDSA 2017, WHO 2013, IADPSG 2010) or Random plasma glucose level ≥ 11.0 mmol/l (IADPSG, 2010). The criteria of the Western Cape, American Dietetic Association (ADA) (2017), Australasian Diabetes in Pregnancy Society (ADIPS) (1998) and National Institute for Health and Care Excellence (NICE) (2015) are slightly different as all women with FBG ≥ 5.1 mmol/l or OGTT ≥ 10.0 mmol/l (1h) or 8.5 mmol/l (2h) are diagnosed with GDM. In the Western Cape public health sector a different diagnostic criteria are used which are in line with the NICE guidelines (2015) : Impaired Glucose Tolerance (IGT) (fasting blood glucose of 5.5-6.9 mmol/l and/or 2h OGTT between 7.8 – 11.0 mmol/l) or GDM (fasting blood glucose ≥7.0 mmol/l and/or OGTT ≥ 11.1 mmol/l). Whichever the diagnostic criteria being used, it is known that there is a continuous risk of adverse pregnancy outcomes with increasing glycaemia (WHO, 2013).

Table 2. 1 Summary of diagnostic criteria for GDM. Adapted from **(Thompson et al., 2013)**

ORGANISATION	WHO IS SCREENED AND WHEN	METHOD OF SCREENING	SCREEN POSITIVE THRESHOLD	DIAGNOSTIC TEST	DIAGNOSTIC THRESHOLD FOR GDM AND OVERT DIABETES
SEMDSA 2017	High risk women* at first booking All women at 24-28 weeks	75g OGTT	2h≥8.5-11mmol/l	75g OGTT at 24-28 weeks	GDM: fasting: 5.1 – 6.9mmol/l 1h ≥10.0 mmol/l 2h≥8.5-11mmol/l Overt diabetes: fasting: ≥7.0 mmol/l 1h: N/A 2h≥ 11.1 mmol/l
Western Cape (Adam and Rheeder, 2017)	All women	Random glucose	8-11 mmol/l	Fasting glucose	>6.0mmol/l -> glucose profile
CDA 2018	All women <20 weeks pregnancy	50g GCT (preferred) Alternative “1-step” 75g OGTT	N/A	75g OGTT at 24-28 weeks	1.50g GCT: Fasting ≥ 5.3 mmol/l; 1h ≥ 10.6 mmol/l; 2h ≥ 9.0 mmol/l 2. 75g OGTT: Fasting ≥ 5.1 mmol/l; 1h ≥ 10.0 mmol/l; 2h ≥ 8.5 mmol/l One abnormal value needed for diagnosis GDM: diagnosed in 2nd or 3rd trimester Overt diabetes: diagnosed in 1st trimester
ADA 2017	1. All women at first antenatal visit 2.High risk women at 24-28weeks	“One-step” 75-g OGTT or “Two-step” 50-g (non-fasting) screen followed by a 100-g OGTT for those who screen positive	N/A	N/A	75g OGTT Fasting ≥ 5.1 mmol/l 1h ≥ 10.0 mmol/l 2h ≥ 8.5 mmol/l One abnormal value needed for diagnosis
ADIPS 1998 (updated 2010 (AIHW and Welfare, 2010)	1.All women 26-28 week 2.Only ‘high risk’ [1]	50g or 75g GCT (non-fasting)	50g GCT≥7.8mmol/l 75g GCT≥8.0mmol/l	75g OGTT	Fasting ≥ 5.5 1h ≥ 10.0 2h ≥ 8.0 One abnormal value needed for diagnosis
IADPSG 2010	All women at first prenatal visit	‘One-step’ 75g OGTT	N/A	24 to 28 weeks’ gestation with a 75-g OGTT	Fasting ≥ 5.1 1h ≥ 10.0 2h ≥ 8.5 One abnormal value needed for diagnosis Overt diabetes: FPG ≥7.0mmol/l A1C ≥ 6.5% RPG ≥ 11.1 mmol/l
NICE Guidelines 2015	Women with risk factors [2] at first antenatal visit All women at 24-28 weeks	Risk factors	N/A	75g OGTT	GDM: Fasting ≥ 5.6 2h ≥ 7.8 One abnormal value needed for diagnosis

WHO 2013	1.Women with risk factors [3] 2.All women At any time during pregnancy	1.Risk factors 2.'One-step' 75g OGTT	N/A	75g OGTT	GDM: fasting: 5.1 – 6.9mmol/l 1h ≥10.0 mmol/l 2h≥8.5-11mmol/l Diabetes in pregnancy: fasting: ≥7.0 mmol/l 1h: N/A 2h≥ 11.1 mmol/l

GCT Glucose Challenge Test, GDM Gestational Diabetes Mellitus, OGTT Oral Glucose Tolerance Test, FPG Fasting Plasma Glucose, RPG Random Plasma Glucose, SEMDSA: Society for Endocrinology, Metabolism and Diabetes of South Africa; CDA Canadian Dietetic Association; ADA: American Dietetic Association; ADIPS Australasian Diabetes in Pregnancy Society; IADPSG: International Association of the Diabetes and Pregnancy Study Groups; NICE: National Institute for Health and Care Excellence; WHO: World Health Organisation

*Repeated glycosuria, Previous GDM, Family history of diabetes (first-degree relative), History of stillbirths of unknown origin, previous congenital anomalies and suspicion of polyhydramnios in present pregnancy, History of high-birth weight infant ≥ 4.5 kg, Obesity (body mass index (BMI) > 30 kg/m2), History of polycystic ovarian syndrome, History of unexpected perinatal death, Women of South-Asian descent

[1] Glycosuria, age>30, obesity, family history of diabetes, past history of GDM or Glucose Intolerance, previous adverse pregnancy outcome, and belonging to a high risk ethnic group.

[2] Body Mass Index>30kg/m^2 , previous macrocosmic baby weighing ≥ 4.5Kg, previous GDM, family history of diabetes (First degree relative with diabetes, family origin with high prevalence of diabetes such as South Asia (specifically women whose country of origin is India, Pakistan or Bangladesh), Black Caribbean, Middle Eastern (specifically women whose country of origin is Saudi Arabia, United Arab Emirates, Iraq, Jordan, Syria, Omar, Quarter, Kuwait, Lebanon or Egypt)

[3] Older women, obese women, previous history of glucose intolerance, any pregnant women who has elevated fasting, or casual blood glucose levels, those with a history of GDM, those with a history of large-for-gestational-age babies, women from certain high risk ethnic groups, strong family history of diabetes mellitus.

2.2 Factors contributing to the development of GDM

A variety of factors have been identified that contribute to the development of GDM. Mwanri et al. (2015) and Macaulay et al., (2014) reported that the increase in prevalence of GDM in sub-Saharan Africa over the last few decades is likely caused by lifestyle changes associated with urbanisation, including changes in dietary patterns and reduced physical activity, which resulted in overweight and obesity. Several risk factors for the development of GDM have been identified and can be classified as modifiable, non-modifiable and intermediate. The non-modifiable and intermediate risk factors include a family history of T2DM, overweight and obesity, increasing maternal age, macrosomia, stillbirth or GDM in previous pregnancies, current glycosuria and polyhydramnios (Mwanri et al., 2015; Petry, 2010).

Although some risk behaviours may be very hard to change or avoid, they are modifiable, at least in theory. Modifiable risk factors that have previously been identified in the literature to increase GDM risk include; a lack of physical activity (Chasan-Taber, 2015; C Zhang et al., 2006; Redden et al., 2011), diet quality (Bowers et al., 2012; Chen et al., 2009), smoking (Cupul-Uicab et al., 2012; Mattsson et al., 2013), lack of sleep (Reutrakul et al., 2017; Twedt et al., 2015; Herring et al., 2014) and alcohol intake (Xiong et al., 2001). Recent studies, show that the quality of diet during pregnancy may be a potential modifiable risk factor to developing GDM (Bao et al., 2014; Chen et al., 2012; Bowers et al., 2012; Tobias et al., 2012; Radesky et al., 2008, C Zhang et al. 2006).

Modifiable risk factors, are ‘modifiable’ to a certain extent. Indeed, while diet quality may be modifiable, certain underlying factors affect the food we consume. For instance, globalization of the food industry has resulted in the presence of global food industries which make affordable and accessible food, causing a considerable trend toward energy-dense foods which affect the nutrition of the individuals who consume them as they are high in sugar, salt, fats, and oils (Black, 2016). Furthermore, with urbanisation and new technologies, jobs are promoting a more sedentary lifestyle (Black, 2016). People have less time and space to have their own food garden or do physical activity. Such underlying factors are unfortunately out of the control of the individual and depend on urban planners, laws and politics and fiscal measures. A review by Thow et al. (2010) showed that by imposing substantial taxes on unhealthy foods, which can influence their consumption may improve health outcomes such as body weight and chronic disease risk. Such food taxes and subsidies, have shown to be effective in high-income countries but still need to be studied in developing countries.

2.3 Management of hyperglycaemia in pregnancy

A meta-analysis of studies demonstrated that uncontrolled diabetes in pregnancy may be associated with reduced Intelligence Quotient (IQ) and reduced motor/psychomotor development in children

(Robles et al., 2015). Optimal control of glycaemia is the key focus of treatment for women with GDM. Currently, guidelines for pregnant women with diabetes recommend initial diet and lifestyle intervention followed by oral hypoglycaemic agents and insulin, if diet alone does not achieve the glycaemic targets (Cheng, 2013; ADA, 2018; SEMDSA, 2017).

2.3.1 Pharmacological management of GDM

Insulin is the preferred therapy for diabetes in pregnancy and the pharmacological treatment of choice in many developed countries (ADA, 2018; Thompson et al., 2013; SEMDSA, 2017). It is indicated for all women with GDM who fail to meet target blood glucose levels. The requirements for insulin rise gradually as the pregnancy progresses and insulin dosages need to be adjusted frequently to meet the target blood glucose levels. In selected patients with T2DM, overt diabetes and GDM, oral hypoglycaemic agents (OHA) may be used which include metformin and glibenclamide. Metformin, which is from the class of drugs called biguanides, is used if glycaemic targets are not met by dietary and lifestyle changes alone. Glibenclamide (glyburide), which is from the class of drugs called solphonylureas, is used if glycaemic targets are not met with metformin or for women who decline insulin (SEMDSA, 2017).

Hebert et al. (2009) reported that glyburide concentrations in umbilical cord plasma can reach as much as 70% of maternal levels and that glyburide may cause of neonatal hypoglycemia and macrosomia at a higher rate of than would insulin or metformin. However, patients with GDM who do not respond to diet therapy or metformin can be successfully treated with glyburide (SEMDSA 2017,Kremer and Duff, 2004). While Metformin may slightly increase the chances of prematurity, its use is associated with less weight gain in women and a lower risk of hypoglycemia in neonates than with the use of insulin (ADA, 2017). In a cohort study by Thompson et al. (2013) it was found that, women taking sulphonylureas, or sulphonylureas plus metformin had higher perinatal mortality compared to women on insulin, but not in women on only metformin. Recenly, Polasek et al. (2018) demonstrated that metformin is an effective treatment for pregnant women with T2DM. ADA (2017) recommends to inform all patients treated with pharmacological agents that these do cross the placenta and that to date, no undesirable effect to the foetus have been reported.

2.3.2 Monitoring and target for blood glucose control

It is recommended that all pregnant women with GDM or overt diabetes self-monitor their blood glucose levels (Blumer et al., 2013; SEMDSA, 2017). The Endocrine Society, further suggests testing before each meal, including fasting blood sugar upon waking and either 1 or 2 hours after the start of each meal, as well as, at bedtime and during the night. They recommended to choose the time, post-meal, when the approximate postprandial peak in blood glucose is most likely to occur (Blumer et al., 2013). The glycaemic targets are displayed in Table 2.2. These targets have been adopted by SEMDSA 2017 and recommend to pregnant women with GDM in South Africa.

Table 2. 2 Endocrine Society Clinical Practice guideline for Glycaemic and A1C targets in pregnant women with Diabetes **(Blumer et al., 2013)**

Preconception blood glucose, A1C	As close to normal as possible with no hypoglycaemia* Ideal preconception blood glucose levels not established; risks for congenital anomalies by A1C levels not precisely known
Pregnant women with overt diabetes or GDM	Pre-prandial: ≤95 mg/dL (≤5.3 mmol/L)†‡
	Lower pre-prandial target ≤90 mg/dL (≤5.0 mmol/L)§‖
	1-h after start of meal: ≤140 mg/dL (≤7.8 mmol/L)§‖ 2-h after start of meal: ≤120 mg/dL (≤6.7 mmol/L)§‖
Pregnant women with overt diabetes	A1C ≤7% (ideally, ≤6.5%)§
Labor and delivery, women with overt diabetes or GDM	72-126 mg/dL (4.0-7.0 mmol/L)*

*Less strong recommendation, low quality evidence
†Fasting target: strong recommendation, low quality evidence
‡Other meals: strong recommendation, very low quality evidence
§Less strong recommendation, very low quality evidence
‖If achieved safely with no hypoglycaemia

2.3.3 Medical Nutrition Therapy (MNT) for GDM

While, pharmacological agents are helpful in managing GDM, they are not without side effects. Therefore, it is recommended that medical nutrition therapy (MNT) be first line treatment for women with hyperglycaemia first detected in pregnancy (CDA, 2018). Indeed, Moses et al. (2009) showed that a low Glycaemic Index (GI) diet effectively reduces the need for insulin in GDM. Thus demonstrating the importance on MNT alone or in conjunction with pharmacological management to be an effective treatment for GDM.

There is no international consensus for the dietary management of GDM as seen by the recommendations by different associations in Table 2.3. The primary objective however in MNT during a GDM pregnancy is to normalise blood glucose levels and to provide adequate maternal and foetal nutrition throughout the pregnancy, energy intake for adequate maternal weight gain and necessary vitamins and minerals (Reader, 2007). SEMDSA (2017) recommends: "Dietary consistance (amount and timing of food intake) must be maintained to facilitate tight glycaemic control without inducing hypoglycaemia". The various recommendations are discussed more in detail in the following sections.

Table 2. 3 Dietary recommendation in GDM from different associations

	SEMDSA (2017)	GDA and DGGG (2014)	Endocrine Society - International society based in Washington (2013)	ADA (2007)	Fourth International Workshop-Conference on Gestational Diabetes Mellitus, 1998	CDA (2006)	*FAO*(2001) /IOM**
Energy				1500-2800/day +340kcal 2nd trimester +452kcal 3rd trimester	25 kcal/kg body weight		*+85kcal 1st trimester +285kcal 2nd trimester +475kcal 3rd trimester*
Carbohydrates	40% carbohydrate (complex, low-glycaemic index, high fibre)	40-50% (30g fibre from grain, fruit and veg)	35-45% 3 meal and 2-4 snack including evening snack		35-45% of total energy	45-50% TE	**45-65% TE At least 175g/d**
Added sugars	<5% total energy					<10%	***<25% TE***
Protein	20% protein	20-25%		20%	protein 20-25%,		**10-25% At least 71g/d**
Total Fats	40% fat (at least 50% unsaturated)	30-35%		≤30% TE	fat 35-40%)	Up to 40% TE	**20-35% TE**

TE: Total Energy, SEMDSA: Society for Endocrinology, Metabolism and Diabetes of South Africa; GDA: German Diabetes Association; DGGG: German Society for Gynaecology and Obstetrics, ADA American Dietetic Association, CDA Canadian Dietetic Association, FAO Food and Agricultural Organisation, IOM Institute of Medicine.

*guidelines for normal pregnancy >18 years

2.3.3.1 Meal patterns and macronutrient distribution

In dietetic practice, it has been recommended that MNT plans for all women with GDM should include three meals and three to four snacks to ensure equal distribution of energy and carbohydrates throughout the day (Blumer et al., 2013; Canadian Diabetes Association, 2006; SEMDSA, 2017; ADA, 2018). These recommendations are not different for women on insulin or metformin only. A bedtime snack is recommended as it is associated with lower ketonemia in pregnant women with GDM (Spanou et al., 2015).

2.3.3.1 Energy

The energy requirements during pregnancy remain controversial and are influenced by several factors, including pre-gestational weight status, gestational weight gain and fat deposition (Butte et al., 2004). The ADA (Reader, 2007) recommends /day +1423 kJ (+340 kcal) in the second trimester and +1891 kJ

(+452 kcal) in the third trimester while Metzger et al., (1998) recommends energy requirements for GDM based on 25 kcal/kg actual pregnancy body weight. The IOM recommendation is 6,276 – 11,715 kJ (1500–2800 kcal) +356 kJ (+85 kcal) in the first trimester, +1192 kJ (+285 kcal) in the 2nd trimester and +1987 kJ (+475 kcal) in the 3rd trimester but is based on healthy active Americans and Canadians at the reference height and weight and does not necessarily reflect the energy requirements of the woman in South Africa. The most recent guidelines of the American Diabetes Association (ADA, 2018) indicate that the optimal energy requirements of women with GDM are unknown and no research could be traced that investigated whether their energy requirements are different to a pregnancy without GDM. Jovanovic (2018) reported that the energy requirements for obese women with GDM may be much lower, as preliminary studies indicated that diets between 6300 kJ (1500 kcal) and 7560 kJ (1800 kcal) resulted in improved fasting and mean daily glucose levels, without the development of ketonemia. The Canadian Diabetes Association (2006) does not recommend calorie restrictions as this may result in weight loss and ketosis and may be inadequate in nutrients such as protein and calcium. However, the ADA (2007) recommends slight energy restriction for slower weight gain in obese pregnant women, to be used with caution so as to avoid foetal and maternal compromise or ketonuria. The presence of ketones in urine or blood ketone during pregnancy may indicate starvation ketosis that can be caused by inadequate energy or carbohydrate intake, omission of meals or snacks, or prolonged intervals between meals. Ketoacidosis in pregnancy can affect foetal growth and damage organ development, especially the central nervous system, resulting in neurodevelopmental delay (Ozorowski and Hagner-Derengowska, 2018; Glaser et al., 2012)

3.3.3.2 Carbohydrates

Carbohydrates are the main source of energy to carry out bodily functions. Carbohydrates are digested into simpler sugars such as glucose which is the source of energy for body cells. In diabetes, glucose metabolism is hindered, leaving high levels of unutilized glucose in the blood. As such, in diabetes, it is important to have a tight control on dietary carbohydrates, which directly affect blood glucose levels. The recommended amount of carbohydrate in GDM ranges from 35 – 50% total energy as seen in Table 2.3. The Estimated Average Requirements (EAR) for carbohydrates recommended by the IOM for a healthy pregnancy is 135g per day and the Recommended Daily Allowance (RDA) is 175g per day (Trumbo et al., 2002). It has been previously indicated that low carbohydrate diet (<42% Total energy) improved glucose control, decreased insulin requirement, decreased the incidence of LGA and decreased cesarean sections (Major et al., 1998 cited in (Butte, 2000). However, in a more recent RCT by Moreno-Castilla et al. (2013) comparing a low carbohydrate diet (40% of the total diet energy content as CHO) or a control diet (55% of the total diet energy content as CHO) demonstrated that a diet with reduced carbohydrate did not decrease the number of women requiring insulin and resulted in similar pregnancy outcomes. While consensus is still required as to the recommended amount of carbohydrates, Petry (2010) formulated dietary advice, which includes consuming small meals regularly, choosing carbohydrate that are slowly absorbed so as to maintain blood glucose levels, keeping the portions of carbohydrate consistent and allowing the consumption of sugar-containing foods as long as they do not affect blood sugar levels or weight gain. More recently Hernandez et al., (2018) has stipulated that rather than restricting carbohydrates, GDM could benefit from improving the quality of carbohydrates; favoring low GI over high GI foods. It has also been suggested that carbohydrates are not well tolerated in the morning and this should be compensated by no more than 30g carbohydrates at breakfast (Mahan and Raymond, 2016). Some good sources of carbohydrates are brown or whole-wheat bread, brown rice, whole-wheat pasta, starchy vegetables such as butternut, pumpkin, corn and peas.

3.3.3.3 Fibre

The FDA (2016) has defined dietary fibre as "non-digestible soluble and insoluble carbohydrates (with 3 or more monomeric units) and lignin that are intrinsic and intact in plants; isolated or synthetic non-digestible carbohydrates (with 3 or more monomeric units) determined by the FDA to have physiological effects that are beneficial to human health". Dietary fibre and similar types of carbohydrates have gained particular interest because of their effect on post prandial glucose and insulin response (Zhang et al., 2006). A woman's diet before pregnancy can affect her risk of developing GDM. Zhang et al. (2006) showed that total dietary fibre, in particular cereal and fruit fibre intakes were strongly and inversely associated with GDM risk in a sample of pre gravid women. In the prospective cohort study in 13,110 pregnant women in the Nurses' Health Study II, it was found that 10g/d increment in fibre were associated with 26% reduced risk of GDM (Pistollato et al., 2015; Zhang et al., 2006). Louie et al. (2011) reported that both a high fibre diet and a low glycaemic diet in GDM women lowered the prevalence of LGA, macrosomia and emergency caesarean section. Thus, showing that both a high fibre diet and low GI diet in GDM pregnancy can produce optimal pregnancy outcomes. The Adequate Intake (AI) in pregnancy is 28g of fibre daily (Trumbo et al., 2002). Good sources of dietary fibre include fruits, vegetables, oats, nuts, seeds and wholegrains.

2.3.3.4 Protein

Protein is necessary for foetal growth and development. Furthermore, since proteins and amino acids are essential in glucose metabolism, and a high protein diet may, by increasing gluconeogenesis and promoting insulin resistance, have an effect on glucose homeostasis (Trembley 2007 in Bao et al., 2013). The type of protein may also have an impact on the risk of developing GDM. Pre-pregnancy animal protein, especially red meat intake was associated with higher risk of GDM (Bao et al., 2013; C Zhang et al., 2006), and vegetable protein sources especially nuts and legumes were associated with lower risk of developing GDM (Bao et al., 2013). The risk of diabetes in individuals with a high intake of meat is not limited to pregnancy alone. In a 10-year of follow-up prospective cohort study, Sluijs et al. (2010) found that higher intake of total protein and animal protein increased the risk of T2DM, but there was no relation between vegetable protein intake and T2DM risk. It has been found that varying the quality rather than the quantity of protein can modulate insulin resistance caused by Western diets and that fish have the best effects on insulin sensitivity (Tremblay et al., 2007). In a Cochrane review of acceptably controlled trials of dietary advice in pregnant women Kramer and Kakuma (2003) found an improvement in foetal growth and a reduced risk of foetal and neonatal death with balanced energy/protein supplementation. It was proven not beneficial to supplement with high/balanced-protein alone and could potentially to harmful to the foetus. Studies on the effect of high protein diets in pregnant women with GDM are lacking. The recommendations for protein vary from 20-25% total energy as per Table 2.3. The EAR for protein in pregnancy is 0.88g/kg/day and the RDA is 71g per day. Some good sources of protein include poultry, eggs, dairy products, fish, pulses and legumes.

2.3.3.5 Fats

Fat consists of fatty acids and glycerol. Fat plays an essential role in the body by aiding in the absorption of fat-soluble vitamin A, D, E and K, by serving as insulation and having a structural role in the bi-layer membranes. Fats also serve in the effective transmission of electrical impulses in the nervous system and provide storage for surplus energy in the body. Fatty acids play a crucial role in glucose homeostasis (Bowers et al., 2012). More than the amount of fat in one's diet, the type of fat is important. It has been shown that polyunsaturated fats are associated with reduced incidence of glucose intolerance in pregnant women (Wang et al., 2000) and that high dietary saturated fat is an independent risk factor for GDM (Bo et al., 2001). Similarly, high dietary animal fat and cholesterol were associated with elevated GDM risk (Bowers et al., 2012). The recommended intake of fats during a GDM pregnancy varies from 30% to 40% of total energy as illustrated in Table 2.3. While the RDA of total fat is not determined in pregnancy, the RDA of the two essential fatty acids linoleic acid and α-Linolenic acid are 13 g/day and 1.4 g/day respectively. Some good sources of fats are fatty fish such salmon and herring, avocado, nuts and seeds, olives and oil.

2.3.3.6 Fruits and vegetables

Fruits and vegetables (F&V) are an essential component of a healthy and balanced diet. This is because of their concentration in bioactive nutritive molecules such as nutrients, vitamins, minerals and fibres as well as non-nutritive phytochemicals, namely phenolic compounds, flavonoids and bioactive peptides (Septembre-Malaterre et al., 2018), all of which have numerous health benefits. Indeed, the FAO/WHO (2005) has stated the benefits of F&V in the prevention and management of cancers, cardiovascular disease, obesity and diabetes and thus recommend 400g of F&V daily (FAO/WHO, 2005).

Muraki et al. (2013) found that a eating more whole fruits, particularly blueberries, grapes, and apples, was associated with a significantly reduced risk of T2DM. According to Schneider et al. (2007) many South African women fall short of this recommendation with the average intake of 226g in women 15 years and above. Sahariah et al. (2016) reported that including a daily snack of leafy green vegetables, fruit, and/or milk had a potential protective effect against the development of GDM amongst pregnant women in Mumbai, where women initially had a low intake of F&V. In South Africa, many women in poor economic settings do not have access to sufficient micronutrient-rich foods. Asemi et al. (2013) investigated the effects of a diet rich in fruit and vegetables as part of the Dietary Approaches to Stop Hypertension (DASH) diet in a RCT on 32 women with GDM between 24 and 28-week pregnancy and reported beneficial effects blood glucose levels, including Fasting Plasma Glucose (FPG) and serum insulin levels.

2.3.3.7 Pulses

A legume is any plant that grow in pods and a 'pulse' is the dry edible seed within the pod. Pulses such as lentils or beans are lower in fat and have a higher protein and fibre content than legumes like peanuts and soy. Sievenpiper et al. (2009) investigated the effects of pulses on glycaemic response in adults, and found that markers of longer term glycaemic control were improved by pulses both alone or as part of a low-GI or high-fibre diet. This could be beneficial in gestational diabetes as well. In South Africa, the Food Based Dietary Guidelines (FBDG) (2013) recommend to eat "Eat dry beans, split peas, lentils and soya regularly". A Canadian study found that consuming ½ cup cooked pulses (~99g) per day or more is associated with higher nutrient intakes and improved diet quality. Higher nutrient intakes were noted for fibre, protein, folate, magnesium, iron, potassium and zinc (Mudryj et al., 2012; Global Pulse Confederation, 2018). In South Africa, commonly consumed pulses are sugar beans, lentils, chickpeas and split peas.

2.3.3.8 Processed meats

By definition from the WHO (2015), processed meat refers to "meat that has been transformed through salting, curing, fermentation, smoking, or other processes to enhance flavour or improve preservation". Often additives such as salt, flavouring and nitrates are added in the process. Most processed meats are made from pork or beef, but may also contain other red meats, poultry, offal, or meat by-products such as blood (WHO 2015, website). Fung et al. (2004) in a 14-year follow-up study on women aged 38 to 63 years, found a positive association between the consumption of red and processed meats and the development of T2DM. The World Cancer Research Fund (WCRF) and American Institute for Cancer Research (AICR) recommends to avoid processed meat and to consumption 500 g or less of red meat per week (Kassier, 2016). Some examples of processed meat include hot dogs (frankfurters/viennas), ham, sausages, bacon, salami, as well as canned meat and meat-based preparations and sauces.

2.3.3.9 Energy-dense snack foods

The term energy density refers to the number of kilojoules per gram of the food item. When speaking of energy-dense snack, we refer to food that are high in energy, refined carbohydrates, sugars and fats and low in water and nutrients. Thus providing many kilojoules without much nutrition or satiety (Martin et al., 2015). According to the FBDG (2013), "a high intake of energy from highly processed, energy-dense, micronutrient-poor, oily and salty take-away convenience foods and beverages, are major contributors to morbidity and mortality in South Africa". In a prospective study by Wang et al. (2008) a positive association was found between dietary energy density (DED) and development of T2DM. The association was independent of baseline BMI, total energy intake, fat intake and lifestyle factors. The study also found that the risk of developing T2DM was 60% higher in the high DED group as compared to the lower DED group. While a more recent study by The InterAct Consortium et al, (2013) found no association between DED of solid and semi-solid foods and risk of T2D, they do recommend to choose low energy-dense foods, in support of current WHO recommendations to prevent chronic diseases. Some examples of energy-dense snack foods are biscuits, muffins, cakes and puddings, pies, sweets, chocolates and crisps.

2.3.3.10 Sugar

According to the FBDG (2013), "the term 'sugar' refers to sucrose or table sugar, while the term 'sugars' is used to describe the monosaccharides (glucose, fructose and galactose) and disaccharides (sucrose, maltose and lactose) in food". Sucrose is a source of glucose which is the fuel molecule of body cells. Glucose is an important fuel for muscles contraction and normal glucose metabolism is essential for health (Richter and Hargreaves, 2013). However, too much sugar can be detrimental to health. In a study by Raben et al. (2011), in slightly overweight healthy subjects over 10 weeks, a diet high in sucrose resulted in significantly higher postprandial glycaemia, insulinemia, and lipidemia compared to a diet rich in artificial sweeteners. Since foods with added sugar may replace healthier, more nutrient-dense food choices, ADA (2018) recommends that people with diabetes and those at risk to avoid foods with added sugar. Evidence indicates that a high intake of added sugar can reduce the intake of micronutrients (FBDG, 2013). In a case control study by Morisset et al. (2014) on a sample of pregnant women with GDM, dietary intervention resulted in a concomitant reduction in total CHO, fructose, glucose, and sucrose intakes as well as a significant reduction in the number of refined grain products and fruit juice servings in those with GDM as compared to the controls. Although the study did not investigate the effect on glycaemic control, it was found that women with GDM in the intervention group had significantly lower the rate of weight gain than the controls. Sucrose may come in the form of table sugar or be added to foods such as preserves, sauces and dressing, sweet treats and pastries.

2.3.3.11 Sugar Sweetened Beverages (SSBs)

The South African Food Based Dietary Guidelines (2013) state that "As sugar, especially those in SSBs, is strongly implicated in obesity, reducing its intake is a means of helping to prevent can help to prevent related conditions including type 2 diabetes, cardiovascular diseases and cancer of the colon and breast". Findings from a study by Chen et al. (2009) showed a higher risk of developing GDM in women who had a higher consumption of sugar-sweetened cola (≥5 servings/week) pre-pregnancy. ADA (2018) recommends that diabetics and those at risk of developing diabetes should avoid sugar-sweetened beverages in a means to control weight and reduce the risk of CVD and fatty liver. SSBs refer to all sweetened beverages, fizzy or non-fizzy, squashes, juice mixes, sweetened dairy drinks, and fruit juice. As per Foster-Powell et al., (2002) fruit juices may have a lower glycaemic index than carbonated beverages, but their low satiety level means they can lead to excessive energy intake, thus their consumption should also be limited in the prevention of diabetes (Muraki et al., 2013). There is a dearth of studies of SSBs on glycaemic control in GDM women.

2.3.3.12 Refined carbohydrates versus wholegrains

In recent years, sucrose has been regarded as a threat in the modern diet although many forms of starch affect blood glucose and insulin concentrations in a similar way (Willett et al., 2002). Food structure affects postprandial blood glucose and insulin responses (Slavin, 2003). In the refining process, the bran and some of the germ is removed from the whole grain leaving a relatively higher concentration of starch in refined grains (Slavin, 2003). Whole grains include, as the name implies, grains that have not been removed of the bran and the germ, unlike refined grains. Not only do whole grains contain more fibre, but also lignans, tocotrienols and phenolic compounds, and anti-nutrients such as phytic acid, tannins and enzyme inhibitors associated with improved health status (Slavin, 2003). Whole foods are also known to slow digestion and absorption of carbohydrates. In diabetic patients, there is evidence that consuming wholegrains and minimally refined cereal instead of products made with white flour and potatoes improved glycaemic control and reduced hypoglycaemic episodes among persons treated with insulin. These dietary changes, have also shown to lower the risk of cardiovascular disease and can therefore be recommended for an overall healthy diet (Willett et al., 2002).

2.3.3.13 Micronutrients

During pregnancy, the micronutrient requirements increase more than those of macronutrients, and inadequate intakes can result significant consequences for both the mother and the developing foetus.

With globalisation, and a low nutritional quality of the modern diet (Black, 2016) supplements are often required during pregnancy. The micronutrient recommendations for pregnant women with GDM are currently the same as those for pregnant women with normoglycaemia (Table 2.4). The role of vitamin D, Iron and calcium in GDM pregnancy will be discussed in more detail in the following sections.

Table 2. 4 Dietary recommendations in pregnancy Recommended Daily Allowance (RDA) by the Food and Nutrition Board, Institute of Medicine, National Academies (2011)

PREGNANCY > 18Y	EAR	RDA	AI
Total Fibre (g/d)			28
Vit A (µg/d)	550	770	
Vit C (mg/d)	70	85	
Vit D (µg/d)	10	15	
Vit E (µg/d)	12	15	
Vit K (µg/d)			90
Vit B_1 (mg/d)	1.2	1.4	
Vit B_2 (mg/d)	1.2	1.4	
Vit B_3 (mg/d)	14	18	
Vit B_6 (mg/d)	1.6	1.9	
Folate (µg/d)	520	600	
Vit B_{12} (µg/d)	2.2	2.6	
Pantothenic Acid (mg/d)			6
Biotin (mg/d)			30
Choline (µg/d)			450
Calcium (mg/d)	800	1000	
Chromium (µg/d)			29
Copper (µg/d)	800	1000	
Fluoride (mg/d)			3
Iodine (µg/d)	160	220	
Iron(mg/d)	22	27	
Magnesium (mg/d)	290-300	350	
Manganese (mg/d)			2.0
Molybdenum (µg/d)	40	50	
Phosphorus (mg/d)	580	700	
Selenium (µg/d)	49	60	
Zinc (mg/d)	9.5	11	
Potassium (g/d)			4.7
Sodium (g/d)			1.5
Chloride (g/d)			2.3

Vitamin D

Vitamin D which consists of cholecalciferol (vitamin D3) which is derived from cholesterol and synthesized by the animal organisms and ergocalciferol (vitamin D2) which is derived from ergosterol, found in vegetables (Marangoni et al., 2016). Since vitamin D is associated with markers of glucose homeostasis (Senti et al., 2012), vitamin D deficiency during pregnancy is commonly associated with an increased risk of developing GDM (Zhang et al., 2015) and pre-eclampsia (De-Regil et al., 2016). There is evidence that vitamin D supplementation should be included as part of routine antenatal care for all pregnant women (De-Regil et al., 2016). The RDA for vitamin D in pregnancy is 15 microgram daily and the EAR is 10 microgram per day (Trumbo et al., 2002). The requirements in GDM might be higher; Asemi et al., (2013) showed that two doses of 50,000 IU (1.25 mcg) had beneficial effects on glycaemia and total and LDL-cholesterol concentrations in GDM women. While supplementation is the best while to achieve high doses of vitamin D, dietary sources include dairy products, egg and liver.

Iron

Iron plays an important role in the oxygen-carrying function of red blood cells. Studies have shown that iron also influences glucose metabolism (Rajpathak et al., 2009). Qiu et al., 2011 found that women consuming more haem iron experienced at least two-fold higher risk of developing GDM compared to those who reported lower intakes of haem iron. It is suggested by Wilson et al. (2003) that this may be because iron affects the synthesis and secretion of insulin in the pancreas, and also interferes with the insulin- extracting capacity of the liver. Some studies have shown that high haemoglobin concentration is an independent risk factor for GDM (Lao et al., 2002, Lao & Ho 2000). However, iron supplementation is associated with a lower risk of LBW in pregnant women without anaemia (Palma et al., 2008). The RDA for iron in pregnancy is 27mg daily and the EAR is 22mg per day (Trumbo et al., 2002), however, the Department of Health of South Africa (2015) clinical practice guideline, it stipulates that pregnant women should be supplemented with 170mg ferrous sulphate daily. Haem iron is present exclusively in haemoglobin and myoglobin from animal sources, including red meat and poultry. Non-haem iron is abundant in cereals, vegetables, fruit, beans and dairy products, accounts for more than 85% of dietary haem intake.

Calcium

Calcium is an important mineral found in the body and is necessary for many bodily functions including bone health. Calcium is essential in muscle contractions and in glucose uptake after insulin binds to muscle cells, As such muscle is one of the important sites implicated in insulin resistance (Kolsoon Safary, 2016). Osorio-Yáñez et al. (2017) found that higher levels of maternal periconceptional dietary Ca intake, particularly intakes of Ca-rich low-fat dairy products and whole grains, are associated with lower GDM risk. The EAR for calcium in pregnancy is 800mg per day and the RDA is 1000mg per day. Dietary sources of calcium include dairy products, green leafy vegetables, wholegrains and fish.

2.3.3.14 South African Studies on dietary intake during pregnancy

To date, there have been no investigations of dietary intake in pregnant women with gestational diabetes in South Africa. Eight studies have been conducted between 2004 and 2018 on pregnant women and adolescents (Tshitaudzi, 2003; Mostert et al., 2005; Klinger, 2004; Kesa and Oldewage-Theron, 2005; Jaffer, 2008; Cape et al., 2004; Cormick et al., 2018; Bopape et al., 2008). Four included pregnant adolescents and adults from 13 to 40 years in the Limpopo area (Tshitaudzi, 2003; Mostert et al., 2005; Cape et al., 2004; Bopape et al., 2008), two studies in the Western Cape included pregnant women aged 18 - 40 years (Klinger, 2004) and women and adolescents (Klinger, 2004; Jaffer, 2008), one included pregnant women and adolescents from the Vaal triangle (Kesa and Oldewage-Theron, 2005), and one in different areas of South Africa; namely Cape Town, East London and Johannesburg and in Harare, Zimbabwe (Cormick et al., 2018), included pregnant women aged 20 years and above. The different dietary assessment methodology applied were Food Frequency Questionnaires (FFQ) (Tshitaudzi, 2003; Kesa and Oldewage-Theron, 2005; Jaffer, 2008), 24h recalls (Mostert et al., 2005; Cormick et al., 2018) or a combination of both (Klinger, 2004; Bopape et al., 2008). Further analysis involved blood sampling (Tshitaudzi, 2003; Mostert et al., 2005; Klinger, 2004; Cape et al., 2004; Bopape et al., 2008).

Results showed an average energy intake of 7387.3 kJ (1765.6 kcal) (SD ±1415.2kJ/346.6kcal) (Cormick et al., 2018), 8425.71 ± 2279 kJ (Kesa and Oldewage-Theron, 2005) and 9123kJ (Tshitaudzi, 2003). Average protein reported was between 54.7 ±7.8g and 73.18 ± 23 g, carbohydrates ranged from 230.8 ±57.5g to 292.45 ± 72.2g and fats were between 48.4g and 62.29 ± 23.7 g (Tshitaudzi, 2003; Kesa and Oldewage-Theron, 2005; Cormick et al., 2018). Many of the women fell short of the requirements for iron (Tshitaudzi, 2003; Mostert et al., 2005; Klinger, 2004; Kesa and Oldewage-Theron, 2005; Cape et al., 2004; Bopape et al., 2008) and folate (Tshitaudzi, 2003; Mostert et al., 2005; Cape et al., 2004; Bopape et al., 2008). Two studies showed inadequate intake of vitamin B12 (Bopape et al., 2008; Cape et al., 2004)while two showed vitamin B12 intake above recommendations (Tshitaudzi, 2003; Klinger, 2004). The diets of the pregnant women included in these studies consisted mostly of starches, and the principle sources were maize meal and bread (Bopape et al., 2008; Mostert et al., 2005; Kesa and Oldewage-Theron, 2005; Jaffer, 2008). Sugar and SSBs were highly consumed food items (Mostert et al., 2005; Kesa and Oldewage-Theron, 2005; Jaffer, 2008) and two studies reported inadequate fruit and vegetable intake(Mostert et al., 2005; Jaffer, 2008).

2.3.4 Physical activity recommendations for GDM

Physical activity has been known to improve glucose homeostasis through its direct or indirect impact on insulin sensitivity (Tobias et al., 2011). SEMDSA (2018) recommends regular moderate intensity exercise at least 30 min daily throughout pregnancy. According to the CDA (2018) supervised or unsupervised exercise only or diet and exercise in combination and low glycaemic load (GL) diets, all led to similar reductions in the number of women gaining excessive weight in pregnancy. ADA (2018) recommends that women at risk for or diagnosed with gestational diabetes mellitus do regular moderate physical activity before and during their pregnancies as tolerated. Considering the added hyperglycaemia, the same considerations and precautions concerning T2DM should also be considered women with GDM are engaging in physical activity (Padayachee and Coombes, 2015). These guidelines for exercise in GDM are found in Table 2.5. When comparing moderate and vigorous exercise during pregnancy, Ehrlich et al. (2016) found that overweight or obese women engaging in vigorous exercise during a GDM pregnancy had significantly lower gestational weight gain independent of the volume of exercise performed. Tobias et al. (2011) found that greater physical activity before and during early pregnancy lowers the risk of GDM. Barakat et al. (2013) reports that regular moderate-intensity exercise during the second to third trimesters of pregnancy can reduce the risk of macrosomia in a GDM pregnancy. In a meta-analysis of 10 systematic reviews by Russo et al. (2015), 28% lower risk for developing GDM was found in those assigned physical activity intervention compared to control groups. Diet or exercise or both reduced Gestational Weight Gain (GWG) on average by 20% CDA (2018). Although it is good for pregnant women with or without GDM to engage in physical activity, it is recommended that a trained and experienced exercise specialist tailor the exercise to the individual's needs and risks (Padayachee and Coombes, 2015).

Table 2. 5 Exercise guidelines for GDM (Padayachee and Coombes, 2015)

TYPE OF EXERCISE	INTENSITY	DURATION	FREQUENCY
Aerobic (large muscle activities in a rhythmic manner) e.g., walking, running, swimming and cycling	Moderate 60%-90% of APHRM RPE 12-14 Previously sedentary Owt/Ob should begin training at 20%-30% of APVO2R RPE 12-14 Vigorous RPE 14-16	≤ 30 min continuously (up to 45 min if self-paced)	No more than two consecutive days without exercising
Resistance (multi joint exercises, large muscle groups) e.g., dumbbells, resistance band and pregnancy Pilates	Moderate 50% 1RM 5-10 exercises 8-15 repetitions 1-2 sets	60 min	At least 2 but ideally 3 times a week

APHRM: Age predicted heart rate maximum; RPE: Rate of perceived exertion; Owt: Overweight; Ob: Obese; APVO2R: Age predicted VO2 reserve; RM: Repetition maximum

2.3.5 Weight management recommendations for GDM

ADA (2018) recommends pregnancy weight gain for overweight women to be 15–25 lb (6.8 - 11.3 kg) and for obese women to be 10–20 lb (4.5 - 9.0 kg) which are in line with IOM (2009) recommendations. Identifying the recommendations for weight gain during pregnancy, has been a controversial topic over the last 50 years. However, it has been demonstrated that insufficient weight gain during pregnancy resulted in low birth weight infants, which in turn is a risk for infant mortality, disability and mental retardation (Abrams et al., 2000). Excessive weight gain on the other hand leads to complications such as infant macrosomia which in turn increases the likelihood of caesarean section in obese pregnant women. Boney et al. (2005) demonstrated that children born from obese mothers were more likely to develop metabolic syndrome. This suggests that obesity in pregnancy may have metabolic factors that affect foetal growth and postnatal outcomes. Furthermore, children who are LGA at birth and exposed to diabetes or maternal obesity intrauterine are at increased risk of developing Multiple Sclerosis. Studies have also shown that excessive gestational weight gain (GWG) is associated with postpartum weight retention and that failure to lose pregnancy related weight by 6 months postpartum constitutes an important predictor of obesity in mid-life (Amorim et al., 2007). Women having had GDM are at increased risk of developing T2DM within 5 years post pregnancy, therefore the retention of pregnancy weight is of particular concern in this population. Ideally, weight gain should be within the IOM recommendations (Table 2.6) and studies have shown the best pregnancy outcomes when weight gain is within these ranges IOM (2009). Weight management in South African women is of particular concern; indeed, South Africa Demographic and Health Survey (SADHS) (2016) reported that 24% of women in South Africa were severely obese (BMI ≥ 35kg/m^2) with a higher prevalence of severe obesity amongst Black and Coloured (Mixed Ancestry) women.

Table 2. 6 Recommended Rate and Total Weight Gain for Singleton Pregnancies Based on a Woman's Prepregnancy BMI (IOM, 2009)

PREPREGNANCY BMI	**MEAN[1] RATE OF WEIGHT GAIN IN THE 2ND AND 3RD TRIMESTER** KG/WEEK	**RECOMMENDED TOTAL WEIGHT GAIN[2]** KG
BMI <18.5	0.5	12.5 - 18
BMI 18.5 - 24.9	0.4	11.5 - 16
BMI 25.0 - 29.9	0.3	7 - 11.5
BMI ≥30.0[3]	0.2	5 - 9

[1] Rounded values
[2] Calculations for the recommended weight gain range assume a gain of 0.5 to 2 kg (1.1 to 4.4 lbs) in the first trimester
[3] A lower weight gain may be advised for women with a BMI of 35 or greater, based on clinical judgement and a thorough assessment of the risks and benefits to mother and child

2.4 Risk factors for the development of T2DM in women who had GDM

GDM usually resolves after pregnancy. However, women having had GDM are more likely to develop GDM in subsequent pregnancies or develop T2DM (Damm, 2009). Minooee et al. (2017) found that women with prior GDM have a 2.15-fold higher risk of developing T2DM compared to women who had a non-GDM pregnancy. Other previous research reported that the conversion rate from GDM to T2DM ranges from 2.6 to 70% over a period of 6 weeks to 28 years after delivery (Kim et al, 2002), 13.1% after 5.2 years and 18.9% after 9.0 years (Feig et al., 2008).

Amongst women with prior GDM, certain risk factors have been found to influence the conversion rate to T2DM. These risk factors include a family history of diabetes, an older age at delivery (Löbner et al., 2006; Minooee et al., 2017), increased insulin requirements during pregnancy, higher birth weight of the child and the presence of serological markers such as islet autoantibodies and serum concentrations of C-reactive protein (Löbner et al., 2006). Modifiable risk factors include higher parity, postpartum BMI (Löbner et al., 2006; Minooee et al., 2017), postpartum waist circumference, hip circumference, waist-hip-ratio, systolic blood pressure, diastolic blood pressure, fasting blood sugar, 2-hr blood sugar (Minooee et al., 2017) and duration of breastfeeding (Gunderson et al., 2015, 2012). While diet and lifestyle play an important role in the modifiable risk factors, dietary changes from GDM pregnancy to postpartum have been investigated by Stage et al., (2004) in Denmark and Fehler et al. (2007) in Canada, but no such studies have been conducted in South Africa.

2.4.1 Post-natal recommendations for women who had GDM

GDM usually resolves after pregnancy. However, women having had GDM are more likely to develop it again in subsequent pregnancies or of developing T2DM (Damm, 2009). Post GDM, women are advised to test for diabetes at around 6 weeks postpartum, but the recommendations for postpartum testing vary according to different associations (Table 2.7). In South Africa, SEMDSA (2017) recommends lifestyle changes made during pregnancy should be maintained and breastfeeding should be encouraged. Intervention programs post GDM generally propose a diet low in energy and fat diet with moderate intensity physical activity (e.g., brisk walking) for 150-180 min per week in order to lose 5%-7% of their initial body weight (Gabbe et al., 2012; Katula et al., 2010; Knowler et al., 2002; Shih et al., 2013; Wasalathanthri, 2015), these are in line with the lifestyle recommendations by the different associations (Table 2.7) and each are discussed in more detail in the following sections.

Table 2. 7 Guidelines for postnatal diabetes prevention care of women who have had GDM adapted O'Reilly 2014

GUIDELINE TOPIC	SEMDSA 2017	RACGP 2012	TG LTD. 2014	ADIPS 2014	NICE 2008	ADA 2014
Postnatal screening	6 weeks after delivery; 2h-OGTT	6–12 weeks after delivery; OGTT	6–12 weeks after delivery; 75 g OGTT	6–12 weeks after delivery; OGTT	6 weeks after delivery; FPG	6–12 weeks after delivery; 75 g OGTT
Repeat Screening	yearly	3 yearly	6–12 weeks after delivery; 75 g OGTT	Yearly; OGTT if contemplating further pregnancy	yearly	1–3 Yearly; yearly if IFG or IGT, otherwise 3 yearly
Repeat screening test	OGTT	FPG	FBG or RBG	75g OGTT or FPG	FPG	75g OGTT
Lifestyle recommendations	Weight control Healthy diet and exercise Encourage breastfeeding	General healthy eating Increase physical activity (30 min brisk walking 5 days a week) and/or weight loss. Encourage breastfeeding	Healthy diet and exercise	Weight control Healthy diet and exercise	Weight control Healthy diet and exercise Encourage breastfeeding	Weight loss 7% body weight Low fat Increase fibre at 14 g/1000 kcal and whole grains Increased PA to 150 min/week moderate activity

IFG: Impaired Fasting Glucose; IGT: Impaired Glucose Tolerance, FPG: Fasting Plasma Glucose, FBG: Fasting Blood Glucose, RBG: Random Blood Glucose, OGTT: Oral Glucose Tolerance Test.
RACGP: Royal Australian College of General Practitioners; TG Ltd: Therapeutic Guidelines Limited; ADIPS: Australian Diabetes in Pregnancy Society; NICE: National Institute for Health and Care Excellence; ADA: American Diabetes Association.

2.4.1.1 Postpartum dietary recommendations and weight management

After a GDM pregnancy, SEMDSA (2017) recommends for women to achieve and maintain a weight loss of >5% and ADA (2014) recommends postpartum weight loss of 7% body weight. Indeed, modest weight loss postpartum is associated with improved glucose metabolism (Ehrlich et al. 2014). As for the dietary recommendations; energy intake post GDM pregnancy should be between 4184- 5021kJ/d (1000-1200 kcal/d) (Gabbe et al. 2012) and 5021 - 7531kJ/d (1200–1800 kcal/d) (Katula et al. 2010). Fats should provide no more than 30% of total energy (SEMDSA 2017, ADA 2014) and saturated fats to ≤10% of total energy (SEMDSA 2017). Dietary fibre should be increased to 14 g/1000 kcal or more (SEMDSA 2017, ADA 2014) and whole grains should be prioritised over refined grains (ADA 2014).

Different dietary patterns have been studied with similar outcome on post GDM women. A low GI diet has a significant effect on improving glucose tolerance and reducing the body weight of post GDM women (Ghani et al. 2014; Shyam et al. 2013). Beneficial weight changes among women with a history of GDM, have been found in those following healthy dietary patterns including reducing the amount of energy-dense foods, such as fast foods and SSBs, increasing the amount of fruit and vegetables (Chasan-Taber et al. 2014, Tobias et al., 2016), controlling portion size (Chasan-Taber et al. 2014; Gabbe et al. 2012) and consuming of leaner meats, more whole grains, nuts, legumes, and less red and processed meats, and refined carbohydrates, as part of either the "2010 Alternative Healthy Eating Index (aHEI-2010), the Alternate Mediterranean Diet (AMED), or the DASH diet" (Tobias et al. 2016).

2.4.1.2 Postpartum physical activity

Exercise post pregnancy is beneficial to both mother and baby. The benefits according to Mottola (2002) include "improved cardiovascular fitness, facilitated weight loss, more energy, and improved psychosocial well-being for the mother". ADA (2014) recommends to increase PA to 150 min/week of moderate-intensity physical activity. The Royal Australian College of General Practitioners (RACGP, 2012) recommends post GDM women to increase physical activity to 30 minutes of brisk walking 5 days a week (O'Reilly, 2014). Exercise training is the most potent stimulus to increase skeletal muscle Glucose Uptake Transporter 4 (GLUT4) expression; by contributing to improve utilisation of insulin which enhances glucose uptake and storage as glycogen in muscles post exercise (Richter and Hargreaves, 2013). As such, it was found by Bao et al. (2014) that each five Metabolic Equivalents (MET) hours per week or 100min per week of moderate-intensity physical activity reduced the risk of developing T2DM after a GDM pregnancy by 9%. In the same study; compared to those who maintained their physical activity level, women who increased their physical activity level by 7.5 MET-h/week or 150min per week of moderate-intensity physical activity reduced the risk of developing T2DM after a GDM pregnancy by 47%. However, more than increasing physical activity level, reducing sedentary behaviour is essential in reducing the risk of developing T2DM post GDM. Sedentary behaviour is an energy expenditure of 1.5 METs or less while in a sitting or reclining posture whilst awake (Barnes et al., 2012). Participating in regular Moderate to Vigorous Physical Activity (MVPA) of 150min per week and reducing sedentary behaviour during pregnancy and postpartum are important health messages to communicate during and after a GDM pregnancy to prevent T2DM (Johnson et al., 2016).

2.4.1.3 Breastfeeding

CDA (2018) recommends, that in a means to avoid hypoglycaemia in neonates as well as future childhood obesity, and diabetes for both the mother and child, women with GDM should be encouraged to breastfeed immediately after birth and for at least 4 months. Breastmilk is beneficial to the neonate and has also been associated with a lower risk of many diseases including obesity, type 1 and 2 diabetes in preterm infants (Chung et al., 2007). Breastfeeding also benefits mothers and Gunderson et al. (2012, 2015) found that higher intensity of breastfeeding in mothers at 6-9weeks was associated with increased glucose sensitivity and improved glucose metabolism; thus reducing maternal risk of DM post GDM pregnancy. While breastfeeding improves birth spacing, it can also prevent breast cancer and may reduce a woman's risk of ovarian cancer (Victora et al., 2016)

2.5 Critique of post-natal lifestyle interventions for women with a history of GDM to prevent the development of T2DM.

One meta-analysis (Gilinsky et al. 2015) and two systematic reviews (Jones et al., 2017; Guo et al., 2016) investigated the effect of lifestyle interventions on prevention of T2DM development in women with previous GDM (Table 2.8). A further four individual RCTs were traced that were published after 2014 and thus not included in the above-mentioned review articles (O'Dea et al., 2015; Holmes et al., 2018; Peacock et al., 2015; Liu et al., 2018). The studies were conducted in the US, Australia, Ireland and Mid-eastern countries (China, Malaysia, and Hong Kong). No studies to date investigating a lifestyle intervention in post GDM women have been conducted in Africa or South Africa.

The meta-analyses and individual studies all used a RCT study design which is the preferred study design as it compares a group of individuals receiving an intervention with a control group who does not, and in this way reduces bias from the results of the study. The interventions consisted of sample sizes ranging from 25 participants to as many as 1180 participants (Gilinsky et al., 2015). The study samples included women in their postpartum period anywhere from immediately post-delivery to as far as 12 years post GDM pregnancy (Gilinsky et al., 2015).

Most of the interventions consisted of a combination of diet and physical activity (Liu et al., 2018; Holmes et al., 2018; Jones et al., 2017; Gilinsky et al., 2015; Peacock et al., 2015; O'Dea et al., 2015; Guo et al., 2016). One intervention consisted of only diet (Shyam et al., 2013). The duration of the interventions typically ranged from 12 weeks to a year, but could go up to 6 years (Gilinsky et al., 2015).

For the dietary component, the most frequent mode of delivery of nutrition education, coaching or dietary counselling were mostly via an initial face-to-face session with trained personnel such as dietitians, health workers, trained nurses or counsellors for an hour (Liu et al., 2018; Holmes et al., 2018; Gilinsky et al., 2015; Peacock et al., 2015; O'Dea et al., 2015; Guo et al., 2016) and the message was then reinforced by further one-on-one sessions alone (O'Dea et al., 2015; Guo et al., 2016) or in combination with telephone calls (Liu et al., 2018; Gilinsky et al., 2015; Peacock et al., 2015; Guo et al., 2016). Some of the dietary advice included: "appropriate energy; inclusion of appropriate amounts of fish, eggs, low-fat milk, lean meat and reduction in fatty meats and animal fat in the diet; avoidance/reduction of simple sugars and refined carbohydrates; and inclusion of more fibre-rich food, such as whole grains, wheat flour with standard grade, corn/ corn starch, brown rice, vegetables and fruits" (Liu et al 2018), Mediterranean diet pattern (O'Dea et al. 2015), glycaemic load (Guo et al. 2016).

Ten interventions used technology as a mode of information delivery with minimal face-to-face interaction (Jones et al., 2017). The intensity of the interventions varied from weekly to biannually, with monthly and biweekly contacts being most common (Guo et al., 2016). The recent intervention by (Liu et al., 2018) included more intense dietary intervention with six face-to face sessions with a dietitian including energy calculation, menu planning and weight goals.

The use of pedometers as exercise trackers were reported (Holmes et al., 2018; Gilinsky et al., 2015; Peacock et al., 2015). Logging in activity from the pedometer was used as a platform to provide information, motivation and report of their progress. Some studies included exercise sessions of one-hour per week (O'Dea et al. 2015) to 30 minutes per day of set physical activity recommendations (Liu et al. 2018)

In most studies, the control groups received standard care with some educational material (Holmes et al., 2018; Gilinsky et al., 2015; O'Dea et al., 2015). In Peacock et al. (2015) the controls were placed on to a waiting list, and received the diet workshop after the intervention group. In Liu et al (2018), the controls received awareness of diabetes via oral or written information pamphlets, modification of diet and means to increase physical activity at subsequent annual visits but specific individualized programmes were not offered.

The weight reduction of intervention groups were significantly higher compared to the control groups (Liu et al., 2018; Holmes et al., 2018; Jones et al., 2017; Gilinsky et al., 2015). While O'Dea et al. (2015) reported no significant weight loss between the intervention and control group, significant improvements were found in anthropometric measures from baseline to end of programme assessment (EOP). Weight loss in the intervention groups varied from a median Interquartile Range (IQR) of -2.5 (2.3) kg (intervention group) versus +0.2 (1.6kg), (control group) after 3 months (Peacock et al., 2015) to a mean (SD) of 3.9 (7.0) kg (intervention group) vs 0.7 (3.8) kg (control group) ($P = 0.02$) after 6 months (Holmes et al., 2018). Liu et al. (2018) reported a mean weight loss of 2.01kg in the intervention group that was more pronounced among participants who were overweight at baseline. There was also significant reduction in waist circumference and body fat in the intervention groups as compared to the control groups reported by Liu et al. (2018) who reported decreased waist circumference (1.76 cm vs 0.73 cm; $P = 0.003$) and body fat (0.50% vs 0.05% increase; $P = 0.001$). Similar significant reductions in anthropometric measures were reported by Guo et al. (2016) and Gilinsky et al. (2015).

The intervention outcome on glucose metabolism was varied amongst the studies. A significant decrease in 2h OGTT reported in the intervention group compared with the control group in five RCTs reviewed by Guo et al. (2016) and O'Dea et al. (2015). However, no significant effects were established on fasting blood glucose in the intervention groups as compared to the control groups (Holmes et al., 2018; Gilinsky et al., 2015; O'Dea et al., 2015). Gilinsky et al. (2015) reported three of thirteen lifestyle interventions to have had at least one significantly positive effect of on glycaemic outcome and Jones et al., (2017) reported only one intervention to have slightly reduced insulin resistance in the intervention group compared to the control group. As for progression to T2DM, amongst the three studies reported by Gilinsky et al. (2015) that investigated this, the findings at 36 months and 51 months were non-significant for rate reduction in diabetes risk. Amongst the twelve studied reported by Guo et al. (2016), the incidence of T2DM ranged from 5.0% to 7.4% (the mean=6.0%) per year for the lifestyle intervention and 0% to 17.9% per year for the comparison group (mean=9.3%).

The effect of lifestyle intervention on dietary behaviour and physical activity were varied amongst the RCTs. There were positive outcomes on dietary behaviour; whether a feeling of empowerment when presented with opportunity for poor food choices amongst the intervention group (Peacock et al. (2015) or overall improved dietary behaviour (Guo et al. (2016), Gilinsky et al. (2015). There were no significant differences between intervention and control groups on diet adherence or physical activity reported by O'Dea et al. (2015). Jones et al., (2017) also reported improved physical activity in one study but failure to reach physical activity goals in four studies. Other findings included reduction in bodily pain to be significant in the intervention group (P = 0.007) reported by Holmes et al. (2018).

Overall, the interventions that demonstrated a large effect on both of the primary outcomes of T2DM development, insulin resistance and weight were those with the highest intensity (Guo et al., 2016). It is important to consider the most effective mode for delivering nutrition or health education to post GDM women. Indeed, face to face interventions showed better results on decreasing both insulin resistance and weight- related measures compared with technology-based interventions (Guo et al., 2016). Similarly, Liu et al. (2018) who had high intensity face-to-face contact reported significant weight losses after delivery in women who had GDM. However, Jones et al., (2017) who reported on multimodal home-based interventions with minimal face-to face contact reported many challenges including loss to follow-up and low recruitment rates resulting in a low ability to detect the result of the interventions, and difficulties to engage women and improve health in this population. Poor attendance rates was not limited to multimodal home-based interventions but also reported by O'Dea et al. (2015). Holmes et al. (2018) reported a lack of participation due to time constrains, unavailability of childcare, or desire not to leave their baby. As such, these considerations need to be taken into account when planning interventions in this population.

2.6 IINDIAGO

IINDIAGO (Integrated INtervention for DIAbetes rIsk after GestatiOnal diabetes) is an integrated health system intervention aimed at reducing T2DM risk in disadvantaged women after GDM in South Africa. It aims to develop and test an intervention located at community-based Well Baby clinics where ongoing healthcare will provide support to the mother postpartum and assist her to maintain the lifestyle changes she may have undertaken in pregnancy and have the added benefit of improving the baby's nutrition and the family's lifestyle, thus ultimately reducing diabetes risk among the family as a whole. In an endeavour to relate key-nutrition messages for the IINDIAGO intervention, this longitudinal follow-up study on the dietary intake and beliefs relating to dietary intake in GDM women and post GDM was undertaken.

2.7 Conclusion

In South Africa, it is estimated that the prevalence of GDM is likely to be as high as 25.6% (Reader, 2007). Women with GDM are a high-risk group for developing T2DM and together with their infants represent a unique target group for intervention. Although there is compelling evidence that health promotion interventions for high-risk groups reduce the progression to T2DM, there are limited data for women with prior GDM and none to our knowledge from low and middle-income countries. No data could be traced for studies related to dietary intake during and after GDM pregnancy.

Table 2. 8 Summary of literature on post GDM interventions to prevent T2DM.

REFERENCE AND LOCATION	STUDY DESIGN AND SAMPLE SIZE	POPULATION	INTERVENTION	RESULTS	CONCLUSION
Gilinsky et al., 2015 US, China Australia, Malaysia, Hong Kong,	Meta-analysis of Interventions n=13 Inclusion: RCT, controlled trials and pre-post studies.	Women with previous GDM. Stage: 6 weeks – 12 years postpartum. Sample sizes of RCT from=25 to n=1180	• Intervention length: 2 weeks to 6 years • Intensity of interventions: one was face-to-face every 3 months until 36 months, weekly phone calls for 5 wks., one study included 8 weekly 2h group, 8 studies included initial 30min/1h face-to-face consultations with follow-ups by phone calls/sms/newsletter. One was online delivery. • Staff: 4 studies included a dietician, one a research nutritionist, on a research physiologist, 3 included trained personnel. • Type of info given: 10 studies targeted increased PA via exercise session and or pedometers. Nine studies included personalised dietary counselling/meal plans. • Controls: standard care, written dietary advice/newsletter	• Diet Change in dietary intake reported in 6 studies, all reported positive outcomes on dietary variables in the intervention group • Anthropometry Five studies of the lifestyle interventions resulted in a statistically significant weight (kg) reduction • Glycaemia Based on data from four lifestyle interventions studies there was no statistically significant reduction in fasting blood glucose • Progression to T2DM Based on 3 studies reporting on progression to T2DM. There were no significant rate of reduction in diabetes risk at 36 months and 51 months.	• Meta-analyses for weight and BMI were statistically significant, however not not sufficient to be clinically significant. • Dietary change alone is as effective as dietary change plus++ physical activity for weight-loss • Trials lacked power and duration to demonstrate reduction in diabetes risk. • Challenges within this group appear in recruitment and adopting lifestyle changes.
Guo et al, 2016 Chinese and US database	Systematic review RCT, pilot studies, feasibility testing of RCT N=12	Women with previous GDM Age 29 -43 years Targeted Behaviour change Outcome measures: T2DM and weight	Interventions: • Diet plus physical activity (n=8) physical activity plus lifestyle modification (n=2) either dietary or physical activity intervention alone (n=2) • primary strategy being in-person sessions (n=6) + telephone contacts. • technology-based interventions (e.g., telephone-based n=5 vs. internet-based n=1) which included internet-based tools, social media, pedometers, or cell phones. Number of sessions: 1 to 19 sessions • frequency: from weekly to biannual sessions the most common being monthly and biweekly sessions • Duration: 12 weeks to 3 years.	T2DM development: • The incidence of T2DM varied from 5.0% to 7.4% (the mean=6.0%) annually in the lifestyle intervention groups and 0% to 17.9% annually for the control group (mean=9.3%). IR: • Five studies showed a significant decrease in 2h-OGTT the intervention group compared with the comparison group. Weight: • A significant reduction in weight-related measures was found in the intervention group compared with the comparison group in 8 of 12 studies. • Dietary behaviour: Improvement dietary behaviours was reported in 6 of 12 studies revealed including increased fruit/vegetable consumption and decreased fat and glycaemic load intake.	• Short-term efficacy in preventing T2DM development, reducing insulin resistance, and decreasing weight in women with a GDM history was shown in the majority of lifestyle interventions. • Positive outcomes were reported regardless of the duration being 6 weeks or 4 years of childbirth. • Higher intensity interventions showed a considerable effect on insulin resistance and weight. • Compared with technology-based interventions, in-person interventions showed better results on reducing both insulin resistance and weight- related measures.

Jones et al, 2017 CINAL and MEDLINE database	Systematic review of RCT N=10	multimodal home-based interventions to reduce T2DM risk in women with prior GDM.	Interventions • Mailing or telephone with no or minimal face-to-face interaction • Sample sizes: 28 – 59 participants • Duration of intervention: 12weeks to 12 months Phase of intervention: post-delivery to 4years postpartum	• Significant decreased weight in intervention groups n=4 • Improved dietary behaviour n=4 • Improved PA n=1, Failure to reach PA goals n=7 • No changes in glucose metabolism n=2, Decline in IR n=1	• Low recruitment rates and loss to follow-up resulted in lack of power for detecting the effects of the intervention. • changes in women's physical activity behaviours postpartum were not statistically significant..
Liu et al., 2018 Tianjin, China	RCT N=586	The Tianjin Gestational Diabetes Mellitus Prevention Program. GDM pregnancy at 26-30 weeks and follow up for 4 years postpartum Inclusion age: 20 -49 years	Intervention: • Six one-on-one sessions with dieticians and two telephone calls in the first year. • Calorie calculation, exchange list, menu plan with set weight loss objectives. • Set physical activity recommendations; 30 minutes per day • Monitoring of diet and PA from week 4 to month 12 control: • Received diabetes awareness via oral and written information, diet modification and increase in physical activity at each annual visit. • Did not receive specific or individualized programmes	• Significantly more weight loss was reported in the intervention group (0.82 kg; 1.12% of initial weight) compared to the control group (0.09 kg; 0.03% of initial weight) ($P = 0.001$) among 79% of participants who completed the 1-year trial. • Overweight (body mass index ≥24 kg/m2) women lost significantly more weight. At baseline the mean weight loss was 2.01 kg (2.87% of initial weight) in the intervention group and 0.44 kg (0.52% of initial weight) in the control group ($P < .001$). • Women in the intervention group had a significantly, greater decrease in waist circumference (1.76 cm vs 0.73 cm; $P = .003$) and body fat (0.50% vs 0.05% increase; $P = .001$) compared to the control group.	• The 1-year lifestyle intervention resulted in significant postpartum weight losses in women with previous GDM, especially amongst women who were overweight 1 to 5 years after delivery • A significant reduction in daily energy intake at months 3 to 9 (131-176 kcal/d) resulted in greater weight loss among overweight women with GDM in the intervention group.
Holmes et al, 2018 Northern Ireland	Multicentre RCT N=60 Intervention n=29 Control n=31	Inclusion criteria: • Women with GDM in their recent pregnancy • aged 18 years and older • (BMI > 25 kg/m2)	intervention (PAIGE) • 1-hour educational program by trained health educator at 6-week OGTT • a free 3-month referral to Slimming World which is a commercial weight management organization • In addition to usual care, they received a pedometer, and monthly telephone calls and weekly text support for 1 month • a booklet which described the program containing the headings: "Healthy Eating, Physical Activity, Triggers and Desires for Food, Breastfeeding, and Planning Your Next Pregnancy" Control: usual care, educational DVD	• At 6 months after randomization, there was significant weight loss of 3.9 (7.0) kg in the intervention group of compared with 0.7 (3.8) kg in the control group. • A significantly greater reduction in BMI and waist circumference were reported in the intervention group than in the control group • For fasting and 2-hour plasma glucose levels, there were no significant difference was observed between the groups at baseline or at 6 months • In the intervention group, there was a significant decrease in bodily pain ($P = 0.007$).	• Weight loss such as in the PAIGE programme could be beneficial in the prevention of T2DM in overweight women with previous GDM • The obstacles faced by women in the post pregnancy which affected their participation in the lifestyle intervention were "time constrains, unavailability of childcare, or desire not to leave their baby"

O'Dea et al., 2015 Galway, Ireland	Mixed methods RCT, N=50 Intervention, n=24 Control n=26	Women with history of GDM in past 1-3 years, • At least one of: IFG, IGT or IR • Plus at least one of: BP>130/80, TC>4.5, LDL>2.5, TG>1.69, HDL<1.29 • And: BMI>30kg/m^2 WC>88cm	Intervention • Duration: 12 weeks + 1-year follow-up • Intensity of intervention: 2.5 hours per week which included a one-to-one session with a specialist nurse, physiotherapist, or dietician and included a motivational interview and setting individual goals, a 1-hour group exercise programme and a group education seminar Control: • standard care which included routine follow-up by their GP and informational pamphlets on reducing the risk of diabetes.	Biochemistry • no significant effect on FPG values(p=0.36) or IR (p=0.94) • The outcome for GT2h was significant (p= 0.03) but not for FBG (p=0.67) or IR (p=0.33) Anthropometry • In intervention group, significant improvements from baseline to EOP were found in: weight, BMI, WC, Estimated METmax, TC, HDL, LDL but not sustained at 1-year follow-up Behaviour • The differences between groups on adherence to diet or physical activity were not significant.	• Poor attendance remains a barrier to successful lifestyle interventions post GDM pregnancy. • Group or community based lifestyle intervention programmes can lead to positive outcomes and have life affirming effects for some women. • However for those with less social support, home based interventions via the use of mail, telephone, or internet/email may be more feasible and successful
Peacock et al., 2014 Brisbane, Australia	RCT N=31 Intervention (I) group n=16 Control (C) group n=15	Women with a history of GDM (6 to 24 months prior) and BMI > 25kg/m^2	Intervention group: • Four one-hour coaching workshop with RD over 3 months. • Exercise tracking using Pedometer • Weekly logging on to web-based platform receive progress, updates, and on diet and exercise suggestions to prevent diabetes. Control group: • Put on waiting list, received diet workshop *after* the 3 months assessment.	Median (IQR) result: Significant weight reduction in the intervention group of -2.5 (2.3) Kg versus the control group +0.2 (1.6kg), (p=0.002) Significant decrease in waist circumference in the intervention group of -3.6 (4.5) cm versus the control group -0.1 (3.6) cm (p=0.07) Significant decrease in hip circumference in the intervention group of -5.0 (3.3) cm versus -0.2 (2.6) cm in the control group (p=0.002) Intervention group felt "empowered when presented with opportunity for poor food choices" (p=0.036)	Four sessions of counselling and a web-based activity were sufficient to show weight loss, improved physical activity levels and improve constructs associated with lifestyle behaviours.

RD = Registered Dietitian, GP = General Practitioner, RCT= Randomised Control Trial, GDM= Gestational Diabetes, OGTT= Oral Glucose Tolerance Test, GDM= Gestational Diabetes Mellitus, T2DM= Type 2 Diabetes Mellitus, BMI= Body Mass Index, IR= Insulin Resistance, PA= Physical Activity, IQR= Interquartile range, IGF=Impaired Fasting Glucose, IGT=Impaired Glucose Tolerance, BP= Blood Pressure, WC= Waist Circumference, TC=Total Cholesterol, TG= Triglycerides, HDL=High density Lipoproteins, LDL=Low density lipoproteins, DVD= digital video disc, EOP=End of programme

Chapter 3 : Dietary Intake and Beliefs of Pregnant Women with Gestational Diabetes in Cape Town, South Africa

Abstract: This study investigated the dietary intake of pregnant women with GDM and their beliefs relating to the consumption of fruits and vegetables (F&V), and sugary foods and drinks. A cross-sectional study was conducted on 239 pregnant women with GDM in Cape Town. Dietary intake was assessed using a quantified Food Frequency Questionnaire and beliefs relating to food choices were assessed using the Theory of Planned Behavior (TPB). The mean energy intake was 7268kJ, carbohydrate was 220(±104.5) g, protein 60.3(±27.5)g and fat 67.7(±44.2)g. The macronutrient distribution was 55% carbohydrates, 14.5% protein and 30.5% fat of total energy. The majority of the sample had inadequate intakes of vitamin D (87.4%), folate (96.5%) and iron (91.3%). The median(IQR) amount of added table sugar and sugar sweetened beverages (SSBs) was 4.0(0.00-12.5)g and 17.9(0.0 – 132.8)g per day, respectively. Only 31.4% met the recommendation (400g per day) (FAO/WHO, 2005) for F&V. Beliefs that it was not easy to exclude sugary foods/drinks and that knowing how to control cravings for sugary foods/drinks are areas to target messages on the sugar content of SSBs. In conclusion, the dietary intake of these women was not optimal and fell short of several nutritional guidelines for pregnant women with GDM. The strongly held beliefs regarding sugary foods/drinks may contribute to poor adherence to nutritional guidelines among pregnant women in South Africa

3.1. INTRODUCTION

Gestational diabetes mellitus (GDM) is defined as glucose intolerance of variable degree with first onset or recognition during pregnancy (WHO, 2013) that is not clearly overt diabetes with resolution post-delivery (SEMDSA, 2017). The prevalence of hyperglycemia in pregnancy has been increasing worldwide. The estimated global prevalence is 16.2%, with the vast majority being due to GDM diagnosed in women living in low and middle-income countries (IDF, 2017) Mwanri et al. (Mwanri et al., 2015) reported an increase in the prevalence of GDM in sub-Saharan Africa over last 50 years. Recently, the prevalence of GDM in South Africa was estimated to be as high as 25.6% using the International Association of the Diabetes and Pregnancy Study Groups (IADPSG) criteria (Adam and Rheeder, 2017). The causes of hyperglycemia during pregnancy are multifactorial. An exponential increase in insulin resistance during the second and third trimesters of pregnancy predispose some women to develop hyperglycemia. This is likely to be due to changes in lifestyle associated with urbanisation, including a Western style diet and sedentary lifestyle, which lead to overweight and obesity (Macaulay et al., 2014). Recently, the prevalence of GDM in South Africa was estimated to be as high as 25.6% using the IADPSG criteria (Adam and Rheeder, 2017).

While there is no international consensus over the diagnostic criteria for GDM, it is well established that uncontrolled diabetes during pregnancy poses numerous risks for the mother and fetus (Adam and Rheeder, 2017; SEMDSA, 2017). The Hyperglycaemia and Adverse Pregnancy Outcome (HAPO) study (HAPO Study Cooperative Research Group, 2008) found that, outside of overt diabetes, there was an association between increasing blood glucose levels and a number of adverse pregnancy and birth outcomes such as birth weight above the 90^{th} percentile, shoulder dystocia, neonatal hypoglycaemia, hyperbilirubinemia, preeclampsia and caesarian delivery. Although GDM usually resolves after child birth (Buchanan et al., 2002), it is associated with long-term health risks to the mother including postnatal depression, weight retention (Tieu et al., 2017), GDM in future pregnancies and T2DM in later life (Bellamy et al., 2009; Kim, 2014; Minooee et al., 2017; Zhu and Zhang, 2016). The consequences for the infant place them at risk of adiposity, impaired glucose tolerance and cardiovascular health problems in adulthood (Tieu et al., 2017).

Optimal control of glycaemia is the key focus of GDM treatment. Currently, guidelines for pregnant women with diabetes recommend initial diet and lifestyle intervention followed by oral hypoglycemic agents and insulin , if diet alone does not achieve glycemic targets (Cheng, 2013; ADA, 2018; SEMDSA, 2017). After pregnancy, continuation of these healthy lifestyle practices is recommended for weight loss and reduced long-term health risks. While different associations have proposed dietary guidelines for women with GDM, there is a lack of consensus on the recommended macronutrient distribution as summarized in Table 3.1.

Recent Cochrane reviews reported that dietary interventions have proven successful in: reducing the incidence of GDM and marginally lower fasting blood glucose levels at 32 to 36 weeks in pregnant women (Tieu et al., 2017), meeting postpartum weight goals, decreasing postpartum depression and reducing the incidence of large-for-gestational-age (LGA) and neonatal fat mass in pregnant women with GDM (Brown et al., 2017). These dietary interventions have included a focus on macronutrient distribution (Goodarzi-Khoigani et al., 2017), the promotion of a Mediterranean diet (Assaf-Balut et al., 2017), a low GI diet (Louie et al., 2011) and increasing dietary fibre (Cuilin Zhang et al., 2006).

While a few studies have investigated the diet of pregnant South African women (FAO/WHO, 2005; Bopape et al., 2008; Cape et al., 2004; Cormick et al., 2018; Jaffer, 2008; Kesa and Oldewage-Theron, 2005; Klinger, 2004; Mostert et al., 2005; Tshitaudzi, 2003), no studies to date have investigated the diet of pregnant women with diabetes in Africa or South Africa. Studies in pregnant women have found concerning high levels of inadequate dietary inakes for iron, folate, vitamin A, vitamin C, calcium and zinc (Bopape et al., 2008; Cape et al., 2004; Kesa and Oldewage-Theron, 2005; Mostert et al., 2005; Tshitaudzi, 2003). Diets were also very low in F&V intake (Kesa and Oldewage-Theron, 2005; Mostert et al., 2005) It is thus unknown whether they meet dietary guidelines and goals as proposed by various organizations for a healthy pregnancy and for optimal glucose control. In addition, investigating the underlying beliefs that shape dietary intake behaviours is needed to plan effective nutrition education programmes that promote lifestyle changes (Newson et al., 2013). The primary aim of the current study was to investigate the dietary intake of pregnant women with GDM in Cape Town, South Africa and whether they adhere to established dietary recommendations in order to determine the dietary inputs needed in this population. The secondary aims of the study sought to investigate their beliefs related to sugary foods and drinks, and F&V intake and the association between sociodemographic factors and dietary intake.

Table 3. 1 Dietary recommendation in Gestational Diabetes from different associations

MACRONUTRIENTS	(SEMDSA 2017)	ADA (2007) (READER 2007)	FOURTH INTERNATIONAL WORKSHOP-CONFERENCE ON GESTATIONAL DIABETES MELLITUS, 1998 (METZGER ET AL. 1998)	CDA (2006)(CANADIAN DIABETES ASSOCIATION 2006)	FAO*(2002) /IOM* (TRUMBO ET AL. 2002)
Energy		1500-2800/day +340kcal 2nd trimester +452kcal 3rd trimester	25 kcal/kg body weight		*+85kcal 1st trimester* *+285kcal 2nd trimester* *+475kcal 3rd trimester*
Carbohydrates	40% carbohydrate (complex, low-glycaemic index, high fibre)		35-45% of total energy	45-50% T. E	45-65% T.E At least 175g/d
Added sugars	<5% total energy			<10%	*<25% T.E*
Protein	20% protein		protein 20-25%,		10-25% At least 71g/d
Total Fats	40% fat (at least 50% unsaturated)		fat 35-40%)	Up to 40% T.E	20-35% T.E

SEMDSA, Society for Endocrinology, Metabolism, and Diabetes of South Africa; ADA, American Diabetes Association; CDA, Canadian Diabetes Association; FAO, Food and Agricultural Association; IOM, Institute of Medicine.
*recommendations for normal pregnancy

3.2 MATERIALS AND METHODS

A cross-sectional study design with an analytical component was used. The target population was pregnant women with hyperglycemia first diagnosed in pregnancy attending Groote Schuur hospital (GSH) or Mowbray Maternity Hospital (MMH) in Cape Town, South Africa. GSH is a tertiary referral hospital for high risk pregnancies while MMH is a secondary hospital for lower risk pregnancies. Participants were included if they were in the third trimester, thus ≥ 28 weeks' gestational age (GA) and were screened for hyperglycemia from 24 weeks GA and diagnosed by the hospital's medical doctors with hyperglycemia for the first time during the current pregnancy. Pregnancies complicated by hyperglycemia are classified as either pre-existing diabetes, thus women who were diagnosed with type 1, type 2 or other forms of diabetes before pregnancy (pre-gestational diabetes), or hyperglycemia first detected in pregnancy, which includes gestational diabetes mellitus (GDM) and overt diabetes. Although both GDM and overt diabetes are first recognized during pregnancy, in overt diabetes the diagnostic criteria for diabetes in non-pregnant adults are met, while GDM is a lesser degree of hyperglycemia that is not clearly overt diabetes with resolution postpartum (SEMDSA, 2017; WHO, 2013).

Most international organisations have adopted the IADPSG guidelines as described by the WHO for the diagnosis of hyperglycemia in pregnancy using universal glucose tolerance testing at 24-28 weeks with a 75 g OGTT as GDM when fasting blood glucose >5.1-6.9mmol/l, 1 hour ≥10.0mmol/l or 2 hour ≥8.5-11.0mmol/l or overt diabetes when fasting blood glucose ≥7.0mmol/l or 2 hour ≥11.1 mmol/l (Rani and Begum, 2016). Although SEMDSA (SEMDSA, 2017) also recommends the use of the aforementioned criteria, the diagnostic criteria used at facility level are not consistent and decided independently by each facility. In the Western Cape public health sector a different diagnostic criteria are used (Adam and Rheeder, 2017). The diagnostic criteria used at GSH and MMH and therefore the inclusion criteria for the study were as follows: IGT (fasting blood glucose of 5.5-6.9 mmol/l and/or 2h OGTT between 7.8 – 11.0 mmol/l) or GDM (fasting blood glucose ≥7.0 mmol/l and/or OGTT ≥ 11.1 mmol/l) and were in line with the NICE guidelines (NICE Guideline, 2015). For convenience, the blanket term GDM will be used for both IGT and GDM.

Women were excluded if they were younger than 18 years, had a multiple pregnancy or were diagnosed with Type 1 Diabetes Mellitus (T1DM) or T2DM before the onset of this pregnancy. Treatment received in the form of pharmacotherapy, dietary and exercise guidelines or any other were not an exclusion criterion as it was difficult to establish the amount and type of exposure received in this population. The dietary and exercise recommendations that women with hyperglycemia in pregnancy receive in the public health sector of South Africa are not standardized across facilities and provinces. In Cape Town patients could be referred to the dietitian on diagnosis of GDM, however no standardized criteria for referrals exists. Patients are either seen on the day of diagnoses or scheduled an appointment in 1-2 weeks as an outpatient depending on the availability of the dietitian. An initial dietetic consultation is about 30 minutes and usually involves taking a diet history and providing recommendations accordingly. Energy requirements, personalized meal plans, menus and diet exchanges are not calculated. The limited time for consultations and dietary inputs are due to the high number of patients requiring dietetic consultations together with the small number of dietitians employed in the public health sector. By 28 weeks, patients may or may not have seen a dietitian, it is not standard practice. Patients could also have been exposed to group nutrition talks as inpatients or as an outpatient, in the waiting room by a midwife on healthy eating during gestational diabetes pregnancy. Exercise recommendations are mostly not provided, but in interspersed instances could be given if a biokineticist, physiotherapist or student interns are at the clinics.

3.2.1 Sample size and recruitment

According to Mostert et al.(Mostert et al., 2005) in 2005, 23.9 to 26.1 % of South African pregnant women, had inadequate intakes of various macronutrients. Using this proportion (26.1%), a 99%

confidence interval and 7.5% level of significance from a population size of one million, a sample size of 228 was calculated using OpenEpi.

A sample of n=239 pregnant women with GDM were recruited from antenatal clinics at GSH and MMH as well as in-patients at GSH using a consecutive sampling technique. The files of all patients attending the diabetic antennal clinic the files of patients admitted in the ward were screened by fieldworkers. Patients that fitted the inclusion criteria, were provided with information on the study both verbally and by means of a written information sheet and were invited to participate in the study. Patients with existing co-morbidities such as high blood pressure or HIV were not excluded from the study. At MMH and GSH, a private room was allocated for interviews to take place. Inpatients were interviewed at their bedside.

The study was approved by the University of Cape Town, Faculty of Health Sciences, Human Research Ethics Committee (HREC REF 229/2015 and 230/2015), participation was voluntary and each participant signed an informed consent form.

3.2.2 Questionnaire development

An interview-administered questionnaire was developed for this study. The different sections were developed and reviewed by an expert panel of dietitians to confirm the appropriateness of questions, coverage of core concepts and the level and comprehensibility of the questions. This ensured construct and content validity. A draft questionnaire was developed and reviewed several times before its finalization. It was then pilot tested on five people from the relevant population to check whether there was any difficulty in answering the questions, and revised accordingly. All field workers were trained to standardise in the administration of the questionnaire. The completion of one questionnaire took forty to fifty minutes.

3.2.3 Demographics and disease related history

Sociodemographic and obstetric history data included age, race, gestational age, number of pregnancies, previous GDM and number of living children. Self-rated questions on current physical activity level and food choices were reported as well as interest in being part of a wellness program for GDM.

3.2.4 Socioeconomic status

Socioeconomic status was assessed using the Living Standard Measurement (LSM) which was developed by the South African Advertising Research Foundation (SAARF)(SAARF, n.d.). The LSM is a wealth measure segmentation tool to profile the South African consumer market and has been used in many different studies (Martins, 2006; Schonfeldt, Gibson and Vermeulen, 2009). The questionnaire includes a list of 29 household items and respondents select all items they own. Each item on the LSM list has a weightage score. From the combination of household items in ownership by a participant, a LSM score is calculated using the LSM calculator (SAARF, n.d.). Ten wealth groups have been identified based on the participants' socioeconomic status from the lowest (LSM 1) to the highest (LSM 10) (Haupt, 2006). The LSM gives an indication of the food cash expenditure of the participant which can be as high as 70% of their total cash expenditure, in LSM categories 1 to 3, to as low as 5% of total cash expenditure in the wealthiest consumers (Martins, 2006).

3.2.5 Dietary intake assessment

For the purpose of this study, a picture-sort (Kumanyika et al., 1997) quantified Food Frequency Questionnaire (qFFQ) was developed to assess the usual dietary intake of the study participants after their GDM diagnosis. The food list was compiled by an expert panel of registered dietitians using existing qFFQs that were used to assess dietary intake of educators from low socio-economic areas in the Western Cape (Seme, 2013) and pregnant women in Soweto, Johannesburg, (Wrottesley, Pisa and Norris, 2017) as well as the FFQ proposed in the Dietary Assessment and Education Kit (DAEK) (Steyn and Senekal, 2004) which was developed from extensive research to enable researchers to have a resource that was adapted to the local South African diet and available foodstuff. The FFQ included 103 food items, with some items having sub-item categories (see Supplementary file). In order to increase respondent accuracy in recalling foods consumed during the administration of the questionnaire, each food item on the FFQ list was represented by the appropriate visual card developed for the DAEK by Senekal and Steyn (Steyn and Senekal, 2004). Study participants sorted the picture cards into 2 stacks according to foods they did and those they did not consume within the last two weeks. Using the cards from the stack of food items consumed over the last two weeks, the respondents were asked, to recall their portion size and their frequency of intake over the last two weeks. A small booklet derived from the DAEK manual, representing different portion sizes, was used to assist with portion sizes estimation. For data analyses, the household portion was converted into grams using the DAEK and then multiplied by the frequency of intake in the last two weeks and converted to daily intake. Each food item consumed on the FFQ was coded and the daily intake of energy, macro- and micronutrients were calculated for each participant using the South African food composition tables (Wolmarans et al., 2010). Participants who had an implausible daily energy intake of <2,092kJ (500kcal) or >20,920kJ (5,000kcal) (Cheng et al., 2009) were excluded from data analyses (n=9). In order to determine the adequacy of dietary intake the daily intake of protein (in grams), carbohydrates (in grams), fibre (in grams), vitamins and minerals was compared to the DRIs for pregnant women as established by the Institute of Medicine (Trumbo et al., 2002). Proteins, carbohydrates and fats were computed as a percentage of total energy (TE) intake and categorized to reflect the percentage of women that consumed according to different international guidelines (Table 2.1).

The daily intake of teaspoons of sugar was calculated for each participant by adding the total number of level teaspoons of sugar added to tea/coffee and used in porridge or vegetables. The daily intake of SSBs were calculated by adding the intake of squashes, fruit juice, carbonated beverages and sweetened milk drinks in millilitres. Fruit and vegetable (F&V) intake was calculated by summing the grams of all vegetables (excluding potato which is high in carbohydrates) and all fruits (excluding avocado pear which is high in fat) eaten per day.

Nutritional analysis is based on dietary intake alone and did not include dietary supplementation.

3.2.6 Beliefs

The theory of planned behaviour (TPB) was used in order to understand what motivates behaviour change so as to help GDM women adopt a healthier lifestyle. The TPB suggests that intention is the immediate precursor of behaviour (Ajzen, 1991). Further the TPB states that intention is predicted by an individual's attitude, subjective norms (the perceived social pressure to perform or not perform the behaviour) and perceived behavioural control (the perception of ease or difficulty of the particular behaviour), while each of these predictor constructs are determined or underlined by behavioural beliefs (about the consequences of performing the specific behaviour), normative beliefs (about the support/ no support of specific referents of performing the specific behaviour) and control beliefs (about barriers or facilitators of the performing the specific behaviour), respectively. These beliefs are unique to each behaviour and target population (Fishbein and Yzer, 2003). It provides in-depth understanding of the behaviour within the specific population and context. To change an individual's intention and behaviour with regards to a specific behaviour, these elicited beliefs need to be addressed/ or challenged in intervention (or communication). Hence, we conducted a formative qualitative study (results not reported in this article) using in depth interviews with 50 pregnant women with GDM at MMH and GSH to elicit their salient behavioural, normative and control beliefs (most commonly held beliefs i.e. those that first come to mind), in relation to the specific dietary behaviours (sugary foods and drinks and F&V). The interview guide for the in depth interviews was constructed according to the TPB (Ajzen, 1991) .The salient beliefs were categorised and the frequency with which they were mentioned during the in-depth interviews were recorded. An expert panel of five experienced dietitians reviewed all the beliefs to finalize beliefs to be included in the study questionnaire. Frequency of belief reporting combined with expert insights of panel members in the target population and lifestyle behaviours were considered in identifying the beliefs to be included in the study questionnaire. This process followed is in line with the recommendation by Krueger and Casey (Krueger and Casey, 2009) for managing qualitative data. About 75% of the elicited beliefs were used as the bases of the belief statements to be included in the study questionnaires. These beliefs were converted into incomplete sentences with bipolar endpoints (agree vs. disagree). By completing the sentence, the participant expresses a positive or negative evaluation of the belief statement. The bipolar endpoints were expressed as a 7-point Likert scale namely, 1 = strongly disagree, 2 = disagree, 3 = disagree somewhat, 4=neither agree nor disagree, 5=agree somewhat, 6=agree, 7=strongly agree. Using the Likert scale allows the evaluation of the strength of the belief within the target population by calculating the mode of each belief. For this study we developed belief statements according to the TPB questionnaire development guidelines outlined by Francis et al.(Francis et al., 2004)

3.3 DATA ANALYSES

STATISTICA version 13.3 (software Incorporated, 2017) and STATA 15 (Corporation, 2016) were used to clean and analyze the data. The data were tested for normality using Shapiro Wilks tests (p>0.05= normal). Data with a normal distribution were described using means and standard deviations (SD). Medians and inter-quartile ranges (IQR) were used for data with a non-normal distribution. For ease of comparison to other studies (FAO/WHO, 2005; Bopape et al., 2008; Cape et al., 2004; Cormick et al., 2018; Jaffer, 2008; Kesa and Oldewage-Theron, 2005; Klinger, 2004; Mostert et al., 2005; Tshitaudzi, 2003) , both median(IQR) and mean(SD) were recorded in Table 3.3. Categorical data were described using frequencies and percentages. Beliefs statement were expressed using mode values. Spearmen correlation co-efficient and their p-values were computed to test associations between beliefs and the food intakes. Univariate logistic regression analyses were done to explore the associations between sociodemographic factors and health related perceptions with selected dietary variables (macronutrients as a percentage of TE as well as sugar, SSBs and F&V intake). To create dichotomous dietary variables to divide the group in those who met and did not met the dietary guidelines, the following cut-points were used: sugar and SSBs were 0g while total F&V was 400g per day. Practical cut-points for macronutrient intake as a % of TE were used namely: 45% for carbohydrates, 15% for protein and 35% for fats. Manual intelligent logistic regression was used, with the binary outcome of reaching recommended intake (yes/no) for each of the major food groups. Variables with p-values < 0.1 at univariate analysis, were included in the multivariate regression (forward stepwise). If the food group had no variables that were significant at p< 0.1, no multivariate regression was carried out. Variables tested for association were socio-demographic variables, self-reported reproductive health and the hospital they were treated in. A p-value of <0.05 was considered significant and 95%Cis were reported for all odds ratios and other estimates.

3.4 RESULTS

3.4.1 Socio-demographic history and pregnancy history

The mean (SD) age of the women was 32.2 (5.3) years and the mean gestational age was 33.0 (3.4) weeks. Table 3.2 shows that just more than one-third of the women had an advanced maternal age of ≥ 35 year. The majority, (73.6%), of the participants was recruited from GSH. Half of the sample was Mixed ancestry, 34.7% were Black, and the remaining 6.5% were either White or Indian. The majority of the sample had an LSM score between 6 and 9 and 64.4% reported that their food choices are 'mostly healthy'. Most participants (97.5%) were willing to participate in a wellness program should one be available and the preferred means of communication were evenly distributed between one-on-one, group sessions and social media (Table 3.2).

Table 3. 2 Sociodemographic profile and pregnancy history of sample (n=239)

VARIABLE	CATEGORIES	N	PERCENTAGE OF TOTAL SAMPLE N=239 (%)
Recruitment hospital	*GSH*	176	73.6
	MMH	63	26.4
Age	*< 35 years*	154	64.4
	≥ 35 years	85	35.5
	Min:20 years, max 43 years		
Gestational Age	*< 33 weeks*	108	45.2
	≥ 33 weeks	131	54.8
Race	*Black*	83	34.7
	White	3	1.3
	Indian	6	2.5
	Mixed Ancestry	141	58.9
	Other	6	2.5

Living Standard Measurement	*LSM ≤ 4*	6	2.5
	LSM 5 - 7	95	39.8
	LSM 8 - 10	138	57.8
Number of children	*0*	55	23.0
	1	67	28.0
	2	68	28.4
	3 - 6	49	20.5
Parity	*1st*	39	16.3
	2nd	62	25.9
	3rd	78	32.6
	4th	35	14.6
	5th to 10th	25	10.6
GDM in previous pregnancy	*Yes*	50	20.9
	No	150	62.7
	N/a if 1st pregnancy	39	16.3
What do you think of the food choices you make most of the time? (4 or more times per week)	*Most very healthy*	9	3.7
	Mostly healthy	154	64.4
	Mostly unhealthy	66	27.6
	Mostly very unhealthy	10	4.1
If a wellness program was available for pregnant women, would you enroll?	*Yes*	233	97.5
	No	6	2.5
What is the preferred way in which you like to receive information on health and nutrition?	*One-on-one*	64	26.7
	Group session	71	29.7
	Print material	38	15.9
	Social media	60	25.1

GSH: Groote Schuur Hospital, MMH: Mowbray Maternity Hospital

3.4.2 Dietary intake

The mean daily energy intake was 7268kJ (Table 3.3). As for fibre intake, 80.9% consumed below the recommended 28g/day. For the micronutrients, a high percentage of the sample had inadequate intakes of vitamin D (87.4%), folate (96.5%) and iron (91.3%), which are particularly important micronutrients in pregnancy.

Table 3. 3 Mean and adequacy of macronutrients, vitamins and mineral intake per day by the sample (n=230)

MACRO -NUTRIENTS AND VITAMINS	Mean (SD)	Median (IQR)	(Cut point)	Percentage of sample that fell below cut point (%)
Total energy (kJ)	7268.0 (3527.5)	6437.9 (4863.3 – 8687.7)		
Protein (g) (%TE)	60.3 (27.5) 14.7 (3.4)	55.0 (41.4 – 70.8) 14.6 (12.5 – 16.9)	71g/day [a*]	*93.5*
Total fat (g)	67.7 (44.2)	58.2(38.8 – 82.1)		

(%TE)	33.1 (7.9)	31.8 (28.0-37.9)	40% TE [b]	*83.4*
MUFA (g) (%TE)	23.9 (16.6) 11.0 (3.4)	19.9 (13.2 – 27.5) 10.6 (8.5 – 13.1)	 ≤20% TE[c]	 *97.8*
PUFA (g) (%TE)	17.6 (14.6) 8.0 (3.8)	13.4 (8.5 – 21.4) 7.1 (5.7 – 9.7)	 ≤10% TE[c]	 *78.2*
Saturated fat (g) (%TE)	20.1 (14.1) 29.9 (6.1)	17.2 (11.1 – 24.0) 29.0 (17.9-59.5)	 <50% total fat [b]	 *99.6*
Cholesterol (g)	265.6 (243.2)	194.9 (121.3 – 310.1)	<200mg [c]	*52.1*
Carbohydrates (g)	220.0 (104.5)	197.4 (142.9 – 270.4)	135g/day [a]	*21.7*
Fibre (g)	21.7 (11.3)	20.0 (14.8 – 26.4)	28g[a]	*80.9*
Alcohol (g)	0.019 (0.2)	0.00 (0.00 – 0.00)		
FAT SOLUBLE VITAMINS				
Vitamin A (mcg)	1058.2 (645.4)	877.3 (598.7 – 1396.5)	550 mcg/day [a]	20.4
Vitamin D (ug)	5.5 (5.1)	4.0 (2.4 – 6.6)	10 ug/day [a]	87.4
Vitamin E (mg)	13.4 (10.0)	10.9 (7.0 – 16.1)	12 mg/day [a]	60.0
WATER SOLUBLE VITAMINS				
Thiamin (mg)	1.3 (0.7)	1.2 (0.9 – 1.6)	1.2 mg/day [a]	30.9
Riboflavin (mg)	2.0 (1.5)	1.5 (1.0 – 2.4)	1.2 mg/day [a]	25.2
Niacin (mg)	21.7 (11.4)	19.2 (14.9 – 26.9)	14 mg/day [a]	30.4
Vitamin B6 (mg)	2.9 (1.6)	2.7 (1.8 – 3.7)	1.6 mg/day [a]	6.5
Vitamin B12 (mcg)	4.5 (4.2)	3.1 (2.1 – 5.2)	2.2 mcg/day [a]	21.7
Pantothenate (mg)	4.5 (2.3)	4.0 (2.9 – 5.7)	6 mg/day [a]	80.0
Biotin (mcg)	34.7 (19.4)	30.9 (22.9 – 42.1)	30 mcg/day [a]	47.8
Folate (ug)	244.8 (149.8)	218.2 (154.2 – 291.5)	520 ug/day [a]	96.5
Vitamin C (mg)	97.4 (124.7)	61.5 (36.2 – 124.7)	70 mg/day [a]	56.5
MINERALS				
Calcium (mg)	651.9 (402.7)	561.1 (379.2 – 789.7)	800mg/day [a]	75.6
Iron (mg)	13.4 (8.0)	11.6 (9.0 – 15.7)	22 mg/day [a]	91.3
Magnesium (mg)	251.5 (128.3)	231.2 (177.8 – 296.2)	290 (19-30y) 300 (31-50y) mg/day [a]	74.3
Phosphorus (mg)	1005.8 (491.7)	902.7 (672.6 – 1198.1)	580 mg/day [a]	16.1
Potassium (g)	2038.2 (945.1)	1881.1 (1400.4 – 2376.7)	4.7g/day [a]	98.3
Sodium (mg)	1741.5 (944.0)	1531.8 (1138.8 – 2079.2)	1500mg/day [a]	48.3
Zinc (mg)	10.3 (4.5)	9.7 (7.3 – 12.2)	9.5 mg/day [a]	42.6
Copper (ug)	1.1 (0.6)	1.0 (0.7 – 1.3)	800 ug/day [a]	32.6
Manganese (mg)	2.2 (1.3)	1.9 (1.3 – 2.9)	2.0 mg/day [a]	53.9

[*]excludes dietary data<2,092kJ and >20,920kJ

Data was non-normally distributed, thus Median (IQR) applies. Mean (SD) was included to compared with results from previous studies. Dietary analysis does not include vitamin and mineral supplements.

[a] EAR or AI when EAR is not available, [a*]RDA (IOM 2011) (Ross et al., 2011)

[b]SEMDSA 2017 (SEMDSA, 2017)

[c]TLC guidelines by National Heart, Lung, and Blood Institute (2005)(NHBLI, 2006)

Table 3. 4 shows the macronutrients as a percentage of total energy and sugar, SSBs and F&V intake The median(IQR) amount of added sugar and SSBs was 4.0g (0.00- 12.5) and 17.9g (0.0 – 132.8) per day, respectively. A quarter (25.1%) consumed more than one small glass of SSBs per day, one third (33.5%) had more than two teaspoons of sugar per day and only 31.4% of the sample consumed the recommended 400g or more of F&V daily.

Table 3. 4 Breakdown of the macronutrient distribution of the sample and the percentage of participants' macronutrients intake as percent of total energy and intake of table sugar, SSBs and F&V

MACRONUTRIENTS AND FOOD CATEGORIES	PERCENTAGE OF TOTAL GROUP (N=230) (%)
Carbohydrates (% Total energy)	
≤ 40	7.8
40 – 45	12.1
45 – 50	13.9
>50	66.0
Protein (% Total energy)	
≤ 10	7.4
10 – 15	47.8
15 – 20	38.3
>20	6.5
Fat (% Total energy)	
≤ 30	35.2
30 – 35	25.2
35 – 40	20.0
>40	19.5
Teaspoons sugar*	
0 tsp	*34.7*
less than or equal 2 tsp	*31.8*
more than 2 tsp	*33.5*
SSBs (small glasses)	
Up to ½ small glass	*63.6*
½ to 1 small glass	*11.3*
More than 1 small glass	*25.1*
Fruit and Vegetables	
Less than 200g	*28.9*
Between 200g and 400g	*39.3*
400g and more	*31.4*

3.4.3 Beliefs relating to the intake of sugary foods and drinks and F&Vs

For all the behavioural, control and normative belief statements relating to F&V intake the mode was 6 indicating that the participants agree with the statements (Table 3.5). Agreement with behavioural beliefs indicated that participants were aware of the health benefits of eating more F&V such as feeling better physically and assisting weight loss. Agreement with the normative beliefs shows that participants believed they had support from family or peers to consume more F&V. Agreement with the control beliefs indicated the participants' perceived ease /difficulty in consuming more F&V.

Beliefs relating to sugar intake had a mode of 6, except that participants disagree (mode = 2) with the statement that "low sugar/ sugar-free foods taste good or are tasty", indicating a perceived difficulty to consuming low sugar/sugar-free foods.

There were significant positive correlations, albeit weak, between dietary intake of F&V and the belief that F&V make you feel better physically (r = 0.16, p= 0.0176) as well as F&V are easy to find in shops nearby (r= 0.15, p =0.0221), (Table 3.5). Significant negative correlations were found between dietary intake of sugar or SSBs and the beliefs that it was easy to exclude sugary foods/snack/drinks in 'their' daily diet (sugar: r=-0.259, p<0.001; SSBs: r-0.246, p<0.001), knowing how to control cravings would make it easier to eat less sugary foods/snacks/drinks (sugar r= -0.153 p=0.0205; SSBs r= -0.152 p=0.0209) and low sugar/sugar-free foods/snacks/drinks taste good (sugar r= -0.271 p<0.001; SSBs r= -0.129 p=0.0498). Significant negative correlations were also evident between dietary intake of sugar, but not SSBs, and the beliefs that eating less sugary foods/snacks/drinks will help reduce the risk of disease such as diabetes (r=-0.184, p=0.0049) and eating/drinking less sugary foods/snacks/drinks is up to themselves (r = -0.149 p =0.02).

3.4.4 Univariate association analyses

Table 3.6 shows the results of univariate analysis for associations between dietary intake variables (sugar, SSB and protein as a % of TE) and sociodemographic or health related variables.: Age was significant for SSB intake (OR, 1.06, 95%CI, 1.01 – 1.11, p =0.029) with younger participants being 94% more likely to meet the recommendation for SSBs (0g) than older participants. Participants from GSH were 77% more likely to meet the recommended amount of SSBs (0g) than those from MMH (OR, 0.33, 95%CI 0.17 – 0.64, p<0.01). Participants who self-rated 'mostly very healthy' food choices were 86% more likely more likely to meet the recommended amount of SSBs (0g) than those who self-reported 'mostly unhealthy' food choices (OR, 0.14, 95% CI, 0.02 – 0.77, p=0.02) and participant with the higher number of children were 29% more likely more likely to meet the recommendation for SSBs (0g) than participants with no children (OR 1.29, 95%CI, 1.04 – 1.59, p=0.02). Participants from GSH were 91% more likely to meet the recommended intake of sugar (0g) than those from MMH (OR, 0.09, 95%CI, 0.03 – 0.25, p<0.001). Participants who self-rated 'mostly very healthy' food choices were 84% more likely to meet the recommended intake of sugar (0g) than those who self-rated 'mostly unhealthy' food choices (OR, 0.16, 95% CI, 0.03 – 0.81, p=0.03). The variables which were significant for meeting the recommended protein intake of 15% of TE were age (OR, 1.09, 95%CI, 1.03 – 1.14, p=0.002) with younger participants (<33 years) being 9% more likely to meet the recommendation for protein intake (15% TE) than older participants (>33years). Participants from GSH were 61% more likely to meet the recommended amount of protein than those from MMH (OR, 0.39, 95%CI, 0.20 – 0.73, p= 0.003) and participants who self-rated 'mostly very healthy' food choices were 93% more likely to meet the protein recommendation on 15% TE than those who self -reported 'mostly very healthy' food choices (OR, 0.07, 95% CI, 0.01 – 0.59, p=0.02). Race, gestational age, LSM score and number of pregnancies were not associated with meeting recommended intake of table sugar, SSBs and 15% protein of TE. There were no significant associations between other dietary intake variables (F&V, 35% fat and 50% carbohydrates of TE) and the sociodemographic or health related variables (results not reported in Table 3.6).

3.4.5 Multivariate association analyses

In multivariate analysis (results not reported in a Table), participants from GSH were 59% more likely to meeting the SSBs recommendation (0g) than participants from MMH (OR, 0.41, 95%CI, 0.20 – 0.86, p=0.019) and those who self-rated 'mostly very healthy' food choices were 84% more likely to meet the recommendation of SSBs (0g) than those who self-reported 'mostly unhealthy' food choices (OR, 0.16, 95% CI, 0.03 – 0.98, p=0.05). Younger participants (<33 years) were 5% more likely to meet the recommendation for protein intake (15% TE) than older participants (>33years) (OR, 1.05, 95%CI, 1.00 – 1.11, p= 0.07), Participants from GSH were 63% more likely to meet the recommended amount of protein than those from MMH (OR, 0.37, 95%CI, 0.18 – 0.74, p= 0.005) and participants who self-rated 'mostly very healthy' food choices were 28% more likely to meet the protein recommendation on 15% TE than those who reported 'mostly very healthy' (OR, 0.72, 95% CI, 0.03 – 1.06, p=0.06).

3.5. DISCUSSION

The dietary intake of the pregnant women with GDM in this study was not optimal and fell short of several nutritional guidelines. The total energy intake (7268 kJ) was lower than the 11844 kJ (2830kcal) recommended by the IOM (Trumbo et al., 2002) for a normal weight female in third trimester of pregnancy. However, energy requirements during pregnancy remain controversial and are influenced by several factors, including pre-gestational weight status, gestational weight gain and fat deposition (Butte et al., 2004). The IOM recommendation is based on healthy active Americans and Canadians at the reference height and weight and does not necessarily reflect the energy requirements of the woman in our sample. The most recent guidelines of the American Diabetes Association (ADA, 2018) indicate that the optimal energy requirements of women with GDM are unknown and no research could be traced that investigated whether their energy requirements are different to a pregnancy without GDM. Jovanovic (2018) reported that the energy requirements for obese women with GDM may be much lower as preliminary studies indicated that diets between 6300 kJ (1500 kCal) and 7560 kJ (1800kCal) resulted in improved fasting and mean daily glucose levels, without the development of ketonemia. As national surveys indicated that 64% (Shisana et al., 2014) and 62.2% (Statistics South Africa, 2016) of South African women aged 15 and older are overweight or obese, it is possible that such lower energy requirements reflect the needs of the majority of women in our sample. With a dearth of comparable studies on GDM women, our energy intake was slightly lower than the energy intakes of 7677.2 kJ (1834 kcal) (Cormick et al., 2018), 8425.7 kJ (2013.6 kcal) (Kesa and Oldewage-Theron, 2005) and 9123 kJ (2180 kcal) (Tshitaudzi, 2003) previously reported for non-diabetic pregnant South African women. GDM women at MMH and GSH are referred to the hospital dietitian for a one-on-one counselling session and/or they receive dietary information from the diabetes educator or nurse after their GDM diagnosis. At the time of administering the questionnaire, most participants had previous dietary counselling. It is possible that they might have changed their diet after counselling, or they might have been inclined to report more favourably on their intake. As energy requirement are not calculated during consultations, portion control of energy-dense foods would remain an essential strategy during dietary counselling session.

The macronutrient distribution as a % of TE was not optimal if evaluated against the 2017 SEMDSA guidelines (SEMDSA, 2017) that recommend carbohydrates to be up to 40% of TE, 40% of TE from fats and 20% TE from protein as well as other international associations recommending carbohydrates <50% of TE for GDM women (Table 2.1). In a country where food insecurity is high and carbohydrate rich foods such as maize meal, rice and bread are the staple diet (MacIntyre et al., 2002), the macronutrient distribution of the women in this study (55% for carbohydrates and 14.5% for protein) could be expected. Research in the form of RCTs is needed to establish whether this type of macronutrient distribution is problematic for optimal glycemic control in women with GDM in South Africa. There was however no significant association found between carbohydrate or protein intake and LSM.

When comparing the actual grams of carbohydrate, protein and fat to other studies that were conducted on non-GDM pregnant women in South Africa, it is noted that the mean carbohydrate intake of our participants (220g±104.5g) was similar to the 230g (SD ± 57.5) reported by Cormick et al. (2018), but slightly less than the 292.45 ± 72.2g by (Kesa and Oldewage-Theron, 2005) and 334.7g reported for pregnant adolescents by Tshitaudzi (2003). The protein intake (60.3±27.5g) was in line with the other South African studies namely, 54.7±7.8g by Cormick et al. (2018), 60.9g by Tshitaudzi (2003) and 73.2±23 g Kesa and Oldewage-Theron (2005). However, total fat intake of 67.7g (±44.2g) was slightly higher than previous studies namely 59.1±6.4g Cormick et al. (2018), 62.3± 23.7g (Kesa and Oldewage-Theron, 2005) and 48.4g in Tshitaudzi (2003). For optimal blood glucose control and general health purposes during pregnancy, it is important to consider the type of carbohydrates consumed. It is recommended that carbohydrate intake should consist mostly of vegetables, legumes, fruits, dairy and whole grains (ADA, 2018). In our sample 80% of participants were below the recommended 28g of fibre per day, similar to the findings of Tshitaudzi (2003) and Mostert et al. (Mostert et al., 2005) in pregnant South African women. Fibre is an important dietary component during pregnancy as it is beneficial to prevent constipation and haemorrhoids and assists in stabilizing blood glucose levels. Louie (Louie et al., 2011) reported that a high fibre diet in women with GDM was significantly associated with a lower prevalence of LGA, macrosomia and emergency caesarean section compared to a low glycemic index diet

F&Vs are an essential source of dietary fibre, but only 31.4% of participants met the WHO/FAO (FAO/WHO, 2005) recommendation of 400g or more per day. The low F&V intake could possibly be due to the lack of affordable options in close vicinity of the households (Temple and Steyn, 2011a). In line with this, our participants who had higher F&V intakes strongly held the belief that these items are easy to find in shops close to them and that they make you feel better physically. However, none of the sociodemographic factors tested, including LSM, were associated with the consumption of F&V. It is possible that the LSM were not sensitive enough to discriminate between SES of participants or that participants might not be aware of the WHO/FAO recommendation of 400g of F&V and how to incorporate it in their daily diet. This may be an area to address in dietary intervention in this population. Participants agreed that F&Vs are affordable and do not take a long time to prepare, therefore it is likely that unavailability is hindering intake. Interventions aiming at increasing F&V consumption in this population could encourage consuming seasonal F&V and planting their own vegetables at home or developing community gardens.

SSBs are a source of high glycemic carbohydrates. The intake of refined carbohydrates in the form of SSBs is strongly discouraged for optimal blood glucose control (ADA, 2018). In our sample of pregnant women, 63% reported drinking up to half a small glass (125ml) of SSB daily. A higher intake of SSBs was found in younger women and those who self-reported that their diet consists mostly of ‘unhealthy food choices’. Those who consumed more SSBs believed that it was not easy to exclude sugary foods/drinks from their diet and that low sugar/sugar free food/drinks do not taste good. Therefore, focus is required on addressing healthy alternatives to SSBs which taste good and satisfy cravings. Practical ideas may include fruit infused water or recipes for homemade ice tea and awareness of the equivalent number of spoons of table sugar present in SSBs.

Another source of glycaemic carbohydrates is table sugar. Only 34.7% of our participants reported not adding sugar to hot beverages or porridge. A higher consumption of table sugar was significantly associated with women attending MMH and those who self-reported that their diet consists of ‘mostly unhealthy’ food choices. As women with high risk pregnancies and poorly controlled blood glucose levels are treated at GSH, it is possible that more emphasis has been placed on the role of diet on blood glucose levels in women receiving care there than with women attending the secondary community based hospital (MMH). Mothers having had GDM in a previous pregnancy may have been more cautious and have applied their knowledge from previous experience. There were more significant associations between beliefs and table sugar intake, than with the intake of SSBs. For instance, a lower sugar intake was significantly associated with agreement with five beliefs including eating less sugar will reduce their risk of disease such as diabetes, eating less sugary foods/snacks/drink is easy, low sugar foods/snacks/drinks are tasty and that eating less sugar was up to them. This may indicate that there is a stronger awareness of or emphasis on the impact of added table sugar in glycaemic control than with SSBs. The participants also believed that knowing to control ‘their’ cravings for sugary foods/snacks/ drinks during pregnancy will make it easier for them to eat less of these foods. Sweet cravings have been reported to appear in late GDM pregnancy (Belzer et al., 2010). Different theories exist to explain food cravings in pregnancy, one of which is ‘nutrient deficits’ (Orloff and Hormes, 2014). Many participants’ micronutrient intake fell short of the recommendations in pregnancy, in keeping with findings of poor micronutrient intakes in pregnant women in South Africa (Bopape et al, 2008; Mostert et al., 2005; Cormick et al., 2018). The majority of the GDM participants fell below the recommendations for iron, calcium and folic acid which are essential micronutrients in pregnancy. However, if participants were underreporting, as found in South African population (Orcholski et al., 2015) it is likely that the reported micronutrient levels are not a true reflection of the participants’ actual micronutrient intake. On the other hand, with the intake of energy-dense, nutrient poor foods such as SSBs and added table sugar and a low intake of

F&V, the finding that the micronutrient intake was inadequate may be plausible. Several micronutrients are especially important for GDM women. For example: iron plays an important role in pregnancy and blood glucose metabolism (Rajpathak et al., 2009) and calcium plays a critical role in muscle contraction and in glucose uptake by cells (Richter and Hargreaves, 2013). Vitamin D deficiency is common during pregnancy even in countries with sunny climates, as South Africa, and is associated with an increased risk of developing pre-eclampsia (De-Regil et al., 2016) and GDM (Zhang et al., 2015). Dairy products and dark green leafy vegetables can be encouraged as a source of calcium and vitamin D. The mean dietary folate intake of the participants (excluding supplements) was 244.8 micrograms, which fall well below the recommended 600 micrograms. However, all pregnant women in the public-sector health service are given a folic acid supplement of 5mg a day, which far exceeds the increased requirements of 600 micrograms during pregnancy. While supplementation of folate in pregnancy is given to reduce the chances of neural tube defects, a recent study by Zhu (Zhu et al., 2016) illustrated that this daily supplementation may increase the risk of GDM. This is therefore a possible cause for concern and the policy in South Africa and elsewhere may need reviewing. However, further evidence of the potential adverse effects of excess folate in pregnancy is still needed, and for now the benefits of folate supplementation during pregnancy outweigh the potential risks of excess folate during pregnancy.

This study is limited by the fact that all variables were self-reported, which may not necessarily reflect the true situation. We aimed to improve the validity of these outcome measures by going through rigorous processes to ensure a well-developed questionnaire. We did not use an objective method to verify energy and nutrient intake nor another dietary intake method such as a 24-hour recall to validated the FFQ results. It may be likely that participants under-reported their dietary intake to impress the fieldworker by not admitting 'unhealthy foods' or due to memory gaps common when recalling items over the last 2 weeks. Underreporting is common in obese populations (Meng et al., 2013; Scagliusi et al., 2009), however this has not been investigated in GDM. Current body weight was not measured, however pre-pregnancy weight and BMI classification would be the ideal measures for the estimation of energy requirements. The picture-sort method used with the FFQ, improves ease and accuracy of response in diet recall (Wengreen et al., 2001). As the number of participants that were classified in some categories of sociodemographic variables were small, the sample size restricted statistical power of univariate and multivariate analyses.

3.6 CONCLUSION AND RECOMMENDATIONS

This study found that the macronutrient distribution in pregnant women with GDM in Cape Town did not meet the dietary guidelines of local and international associations as carbohydrate intake are high and protein and fat intakes are low. Inadequate amounts of dietary fibre, F&V and key micronutrients important for pregnancy were consumed and the intake of added table sugar and SSBs were too high in our population. We recommend that interventions be developed and tested for women with GDM in Cape Town to: (1) establish the macronutrient distribution required for optimal glucose control (2) meet the recommendations of 400g/d for F&V and 28g/d for fibre, and (3) limit intake of added table sugar and SSBs. This study contributes to new knowledge as it investigated the diet of GDM women in Cape Town, which had not previously been done. The study reveals beliefs underlying the dietary intake of F&V, table sugar and SSB. The strongly held beliefs regarding sugary foods/drinks may contribute to poor adherence to nutritional guidelines.

Table 3. 5 Beliefs associated with the intake of Fruits and Vegetables and Sugar

BELIEFS RELATED TO FRUIT AND VEGETABLE	BELIEF TYPE	MODE	FREQUENCY OF MODE (%)	CORRELATION OF BELIEF WITH F&V INTAKE* (RHO, P-VALUE)	
Eating fruits and vegetables every day will make me feel better physically.	Behavioral	6.0	49.8	0.159 (0.0176)	
Eating fruits and vegetables every day will help control my weight.	Behavioral	6.0	53.9	0.081 (0.2215)	
Eating less fruit will help control my blood sugar levels (i.e. to reduce the risk of diabetes).	Behavioral	6.0	37.6	-0.036 (0.5816)	
Vegetables do not take a long time to prepare	Control	6.0	34.3	0.019 (0.7651)	
Fruits and vegetables are affordable.	Control	6.0	45.6	0.029 (0.6605)	
Fruits and vegetables are easy to find in the stores/ shops nearby.	Control	6.0	54.8	0.151 (0.0221)	
I am confident that I can eat the recommended amount of fruits and vegetables every day.	Control	6.0	44.7	0.101 (0.1241)	
Most people who are important to me eat fruits and vegetables every day.	Normative	6.0	38.9	0.052 (0.4310)	
BELIEFS RELATED TO SUGAR	BELIEF TYPE	MODE	FREQUENCY OF MODE (%)	CORRELATION OF BELIEF WITH SUGAR INTAKE* (RHO, P-VALUE)	CORRELATION OF BELIEF WITH SSB INTAKE* (RHO, P-VALUE)
Eating less sugary foods/snacks/ drinks will help reduce the risk of diseases e.g. diabetes.	Behavioral	6.0	51.5	-0.184 (0.0049)	-0.109 (0.0978)
It is also important to limit my intake of sugary foods/snacks/drinks after the pregnancy.	Behavioral	6.0	60.7	-0.175 (0.0074)	0.028 (0.6720)
Decreasing the amount of sugary foods/snacks/ drinks I eat will help control my weight.	Behavioral	6.0	54.0	-0.004 (0.9454)	-0.064 (0.3373)
Increasing the amount sugary foods/snacks/drinks I eat and drink make me feel unwell (tired, headache, dizzy, signs of hyper glycaemia etc).	Behavioral	6.0	44.4	-0.021 (0.7431)	0.063 (0.3347)
I want to reduce the amount of sugary foods/snacks/ drinks I eat and drink to prevent pregnancy/ birth complications.	Behavioral / Control	6.0	53.6	-0.055 (0.4056)	-0.016 (0.8048)
It is easy to exclude sugary foods/snacks/drinks from my daily diet.	Control	6.0	33.2	-0.259 (<0.0001)	-0.246 (<0.0001)
Foods/snacks/drinks that are low sugar/ sugar free are easy to find in my surroundings.	Control	6.0	39.9	-0.022 (0.7356)	-0.069 (0.2923)
Eating/drinking less sugary foods/snacks/drinks is up to me.	Control	6.0	56.1	-0.149 (0.0230)	-0.128 (0.0522)
Knowing how to control my cravings for sugary foods/snacks/ drinks during pregnancy will make it easier for me to eat less of these foods.	Control	6.0	54.6	-0.153 (0.0205)	-0.152 (0.0209)
Low sugar/ sugar-free foods/snacks/ drinks are expensive.	Control	6.0	42.3	0.011 (0.8585)	-0.002 (0.9749)
Low sugar/ sugar-free foods taste good/ are tasty.	Control	2.0	27.3	-0.271 (<0.0001)	-0.129 (0.0498)
People around me eat/serve sugary foods/snacks/drinks at most events/ functions (social, religious, or work events)	Normative	6.0	46.9	-0.031 (0.6409)	0.061 (0.3562)

*Spearman Rank Order Correlation;
Behavioral beliefs: are the perceived consequences (positive or negative) of the behavior ; Control beliefs: are factors that facilitate or hinder the behaviour; Normative beliefs: extent to which other people are important to them think they should or should not perform a certain behavior **(Ajzen, 1991)***

Table 3. 6 The Univariate association between sociodemographic factors and the proportion of participants consuming the recommended intakes of SSBs, added sugar and Protein

VARIABLES	SSBS			ADDED SUGAR			% PROTEIN		
Recommendation	**0g**			**0g**			**15% of Total Energy**		
	OR	*95% CI*	*P-value*	*OR*	*95% CI*	*P-value*	*OR*	*95% CI*	*P-value*
Age	1.06	1.01 – 1.11	**0.03**	1.06	0.61 – 1.87	0.82	1.09	1.03 – 1.14	**<0.01**
Gestational age	0.88	0.52 – 1.49	0.64	0.99	0.57 – 1.71	0.97			
Hospital *GSH* versus									
MMH	0.33	0.17 – 0.64	**<0.01**	0.09	0.03 – 0.25	**<0.01**	0.39	0.20 – 0.73	**<0.01**
GDM in previous pregnancy	0.68	0.43 – 1.06	0.09	0.51	0.27 – 1.0	**0.05**			
Race – *Black versus*									
White	3.4	0.29 – 39.1	0.33	0.73	0.06 – 8.35	0.80	0.46	0.04 – 5.32	0.54
Indian	0.85	0.15 – 4.92	0.86	0.29	0.03 – 2.61	0.27	0.46	0.08 – 2.68	0.39
Colored	1.46	0.83 – 2.57	0.19	0.69	0.39 – 1.22	0.20	0.67	0.38 – 1.16	0.15
LSM	0.99	0.90 – 1.09	0.92	0.95	0.56 – 1.05	0.31	1.03	0.94 – 1.14	0.53
Self-reported food choice									
***"Mostly very healthy"* versus**									
Mostly healthy	0.36	0.07 – 1.94	0.24	0.51	0.11 – 2.35	0.39	0.16	0.02 – 1.36	0.09
Mostly unhealthy	0.14	0.02 – 0.77	**0.02**	0.16	0.03 – 0.81	**0.03**	0.07	0.01 – 0.59	**0.02**
Mostly very unhealthy	0.20	0.23 – 1.71	0.14	0.60	0.08 – 4.40	0.62	0.21	0.02 – 2.52	0.22
Self-reported physical activity level									
"very inactive" versus									
Inactive	1.07	0.38 – 3.01	0.89	0.54	0.18 – 1.57	0.26	1.15	0.40 – 3.12	0.79
Active	1.04	0.39 – 2.72	0.93	0.88	0.33 – 2.31	0.79	1.61	0.60 – 4.30	0.34
Very active	1.25	0.36 – 4.26	0.72	0.85	0.24 – 2.98	0.81	2.68	0.76 – 9.37	0.12
No of children	1.29	1.04 – 1.59	**0.02**	1.14	0.92 – 1.41	0.22	1.14	0.92 – 1.40	0.23
Wellness program – *Yes versus no*	2.87	0.51 – 15.9	0.23	3.89	0.69 – 21.7	0.12	1.0		

Manual intelligent logistic regression was used, with the *binary outcome of reaching recommended intake (yes/no) for each of the major food groups*. Variables with p-values less than 0.1 at univariate analysis, were included in the multivariate regression (forward stepwise). If the food group had no variables that were significant at p< 0.1, no multivariate regression was carried out. Variables tested for association were socio-demographic variables, self-reported reproductive health and the hospital they were treated in. A p-value of <0.05 was considered significant and 95%CIs were reported for all odds ratios and other estimates.

Chapter 4 : Dietary intake of women with prior gestational diabetes: the change from pregnancy to postpartum period.

Abstract

This study investigated the dietary intake of women after a GDM pregnancy and their beliefs relating to their dietary intake, physical activity and their future diabetes risk. A longitudinal follow-up study was conducted on 98 women post GDM in Cape Town, and compared to their intake during the index GDM pregnancy. Dietary intake was assessed using a quantified Food Frequency Questionnaire and beliefs were assessed using questions guided by the Theory of Planned Behaviour (TPB). Results showed 20.4 % of the participants were overweight and 73.4% were obese according to their BMI. Carbohydrate intake increased significantly from 182.5(125.9 – 263.3) g at baseline to 204.6(159.8 – 288.6) g at follow-up (p=0.04). The Median (IQR) of table sugar, SSBs and energy-dense foods all increased significantly ($p<0.05$) from baseline to follow-up. The percentage of participants being inactive decreased from baseline to follow-up; from 71.7% to 42.3% respectively. Overall, the dietary intake of women in Cape Town from GDM pregnancy to postpartum changed significantly. While certain changes were favourable to reducing the risk of developing T2DM such as increase in pulses, decrease in processed meats, a major concern lies in the increased carbohydrate intake from refined starches, table sugar and SSBs, which are key messages to be targeted in nutrition interventions in post GDM women.

4.1 INTRODUCTION

Type 2 Diabetes Mellitus (T2DM) is a major contributor to morbidity and mortality in South Africa (Pheiffer et al. 2018). Currently 5.4% of adults in South Africa are affected by T2DM and this figure is expected to increase by 2045 (IDF, 2017). The rise in T2DM is paralleled with the rise in obesity and is due to urbanisation, nutrition transition and increased sedentary lifestyle (Hu (2011) . While the causes of T2DM are multifactorial, one sub-population, is of particular concern. Women who have experienced Gestational Diabetes (GDM), have a 2.15-fold higher risk of developing GDM in future pregnancies as well as T2DM in later life (Bellamy et al., 2009; Kim, 2014; Minooee et al., 2017; Zhu and Zhang, 2016). Gestational diabetes, by WHO (2013) definition, is a glucose intolerance of variable degree with first onset or recognition during pregnancy; that is not clearly overt diabetes with resolution post-delivery (SEMDSA, 2017). This condition affected approximately 20.9 million women worldwide in 2015 (IDF, 2015). In South Africa, the prevalence of GDM is estimated to be as high as 25.6% when using the IADPSG 2010 diagnostic criteria (Adam and Reeder, 2017). The rate at which women convert from GDM to T2DM ranges from 2.6 to 70% over a period of 6 weeks to 28 years after delivery (Kim et al, 2002); 33-50% after 5 years (Oldfield et al., 2007) and 60% after 10 years (Metzger, 1998).

Certain risk factors have been found to influence the conversion rate to T2DM. The risk factors which may be classified as non-modifiable include family history of diabetes, older age at delivery (Minooee et al, 2017, Lobner et al, 2006), insulin requirement during pregnancy (Lee et al., 2007), being diagnosed with GDM before the 24th week of gestation (Capula et al., 2013), large birth weight of child and serological markers post pregnancy such as the presence of islet autoantibodies and serum concentrations of C-reactive protein (Löbner et al., 2006). Modifiable risk factors include pre-pregnancy BMI > 25kg/m^2 (Capula et al., 2013; Torloni et al., 2009; Minooee et al., 2017), high parity (Minooee et al, 2017, Lobner et al, 2006), increased waist or hip circumference, increased waist-hip-ratio, raised systolic or diastolic blood pressure, high fasting blood glucose or 2-hr blood glucose (Minooee et al., 2017).

Lifestyle factors may increase the risk of developing T2DM after GDM. Chen et al., 2014 reported that a high energy intake in post-GDM women was associated with accelerated progression to type T2DM due to a faster decline in insulin sensitivity and β-cell compensation, independent of adiposity. On the other hand, a low GI diet has a significant effect on improving glucose tolerance and reducing body weight of post GDM women (Gani et al., 2014, Shyam et al., 2013). Modest postpartum weight loss is associated with improvements in glucose metabolism (Ehrlich et al., 2014). Furthermore, participating in regular Moderate to Vigorous Physical Activity (MVPA) of 150 minutes per week and reducing sedentary behaviour during pregnancy and in the postnatal period appear to be important health messages to communicate during and after a GDM pregnancy to prevent T2DM (Johnson 2012). Furthermore, Gunderson et al (2012, 2016) reported that higher intensity of breastfeeding in mothers at 6-9weeks was associated with increased glucose sensitivity and better glucose metabolism; thus reducing maternal risk of DM post GDM pregnancy. A healthy lifestyle is crucial to prevent or delay the progression to T2DM.

According to Wasalathanthri (2015), lifestyle interventions can reduce the incidence of DM by at least 50% (Ratner et al., 2008; Knowler et al., 2002) in high risk individuals, such as those with a history of GDM. Indeed, lifestyle interventions can delay or stop the pathophysiologic processes, such as the exhaustion of the beta-cell that occurs in response to long term insulin resistance (Mendelsen et al., 2014; Krebs et al., 2013). In a systematic review by Guo et al. (2016) it was reported that lifestyle interventions post GDM significantly reduced the annual T2DM incidence ranging from 0% to 17.9% for the comparison groups (mean=9.3%) to 5.0% to 7.4% (mean=6.0%) for the lifestyle intervention groups. Dietary interventions that have investigated the prevention of T2DM after GDM include a focus on macronutrient distribution (Goodarzi-Khoigani et al., 2017), promotion of a Mediterranean diet (Assaf-Balut et al., 2017), a low GI diet (Louie et al., 2011) (Shyam et al., 2013), increasing dietary fibre (Cuilin Zhang et al., 2006) or a conventional healthy diet (Chun Yu Louie et al., 2013). Most of these studies have been conducted in developed countries and are thus not applicable to the South African context.

Longitudinal follow-up studies conducted in Singapore (Chen et al 2012), Canada (Fehler et al., 2007) and the UK (Lie et al., 2013) compared the dietary intakes of women during gestational diabetes and the same women postpartum. The studies found that dietary changes made during pregnancy were not maintained during the postpartum period. Lie et al. (2013) maintained that recovery from GDM, tiredness, maternal attachment and childcare were the main barriers to healthy eating and physical activity behaviours in postpartum. Lie et al. (2013) also found that womens' concern about the future and desire to adpot a healthy lifestyles did not necessarily influence behaviour because of both, a sense of fatalism and a lack of overt symptoms.

In order to understand what motivates behaviour change, Ajzen (1991) suggested the Theory of Planned Behaviour (TPB). This theory suggests that intention is the immediate precursor of behaviour (Ajzen, 1991). Furthermore, the TPB states that intention is predicted by an individual's attitude, subjective norms and perceived behavioural control. Subjective norms are the perceived social pressure to perform or not perform the behaviour and perceived behavioural control is the perception of ease or difficulty in performing the particular behaviour. Since, beliefs are unique to each behaviour and target population, they provide in-depth understanding of the behaviour within the specific population and context (Fishbein and Yzer, 2003). These elicited beliefs need to be addressed or challenged in an intervention in order to change an individual's intention and behaviour with regards to a specific behaviour such as in women with GDM to adopt a healthier lifestyle, and thus reduce the risk of developing T2DM.

In South Africa, the latest SEMDSA 2017 guidelines are used for managing diabetes. These indicate that lifestyle interventions (diet and exercise) and/or drug therapy i.e. Metformin, may have a role in preventing T2DM in women who had GDM. A balanced healthy diet, including at least five servings of fruit and vegetables per day, and low in sugar, salt and fat is recommended to prevent the development of T2DM in post GDM women (American College of Obstetricians and Gynecologist, 2001). According to Mwanri et al (2015) in order to improve maternal and child health and to reduce T2DM in South Africa, the prevalence and the risk for GDM may provide evidence on how to target interventions so as to reduce the magnitude of the problem. However, no research on interventions post GDM have been conducted in South Africa. The IINDIAGO (Integrated INtervention for DIAbetes rIsk after GestatiOnal diabetes) project is an integrated health system-based intervention aimed at reducing T2DM risk in disadvantaged women after gestational diabetes in South Africa. The intervention will include dietary intake and physical activity components according to MRC framework for interventions. Investigating the underlying beliefs that shape dietary intake behaviours is needed to plan effective nutrition education programmes that promote healthful lifestyle changes (Newson et al., 2013). The aim of this study is to conduct a formative assessment to assess the dietary intake and salient beliefs in relation to these specific dietary components: fruit and vegetables, fibre, sugar and fat intake and physical activity of pregnant women with GDM at least 28-weeks gestation (baseline) and again at the follow-up 3 to 15 months postpartum to compare any changes in beliefs and dietary intake between those two periods.

4.2 MATERIALS AND METHODS

4.2.1 Study design, participants and recruitment

A longitudinal follow-up study was conducted among pregnant women with GDM that attended two public health care facilities in Cape Town, South Africa. The women were recruited during pregnancy for initial baseline assessments and one follow-up assessment which took place between 3 and 15 months postpartum. The target population at baseline as per Krige et al. (2018) were pregnant women with hyperglycaemia first diagnosed in pregnancy attending Groote Schuur hospital (GSH) or Mowbray Maternity Hospital (MMH) in Cape Town, South Africa. GSH is a tertiary referral hospital for high risk pregnancies while MMH is a secondary hospital for lower risk pregnancies. Participants were included if they were in the third trimester, thus ≥ 28 weeks' gestational age (GA) and were screened for hyperglycaemia from 24 weeks GA and diagnosed by the hospital's medical doctors with hyperglycaemia for the first time during the index pregnancy. The diagnostic criteria used at GSH and

MMH for hyperglycaemia in pregnancy was the inclusion criteria for the study and were outlined as follows: IGT (fasting blood glucose of 5.5-6.9 mmol/l and/or 2h OGTT between 7.8 – 11.0 mmol/l) or GDM (fasting blood glucose ≥7.0 mmol/l and/or OGTT ≥ 11.1 mmol/l) and is in line with the NICE guidelines (NICE Guideline, 2015). Women were excluded if they were younger than 18 years, had a multiple pregnancy or were diagnosed with T1DM or T2DM before the onset of this pregnancy.

From the baseline study conducted by Krige et al. (2018), all the names, contact details and the expected due date of the participants who had consented for follow-up were logged in a database. Fieldworkers contacted participants telephonically at least 3 months after the expected due date and confirmed that all went well at delivery as well as the baby's age before informing about the follow-up study. Upon agreeing to participate in the follow-up study, an appointment was scheduled at either GSH or MMH. Patients were sent a text message (Short Message Service, SMS) the day before as a reminder of their appointment the following day. The interviews were conducted in a private room allocated for the study. As a token of appreciation all participants received a gift pack containing a shopping voucher, baby products and transport compensation.

4.2.2 Sample size

A retrospective power calculation was carried out from the first 9 follow-ups. In order to identify any changes in the mean (±SD) intake of four of the food groups from the qFFQ, a sample size of at least 75 was suggested. A total of 98 participants were recruited at follow-up. The flow of participant recruitment from baseline to final follow-up assessment is illustrated in Figure 4.1.

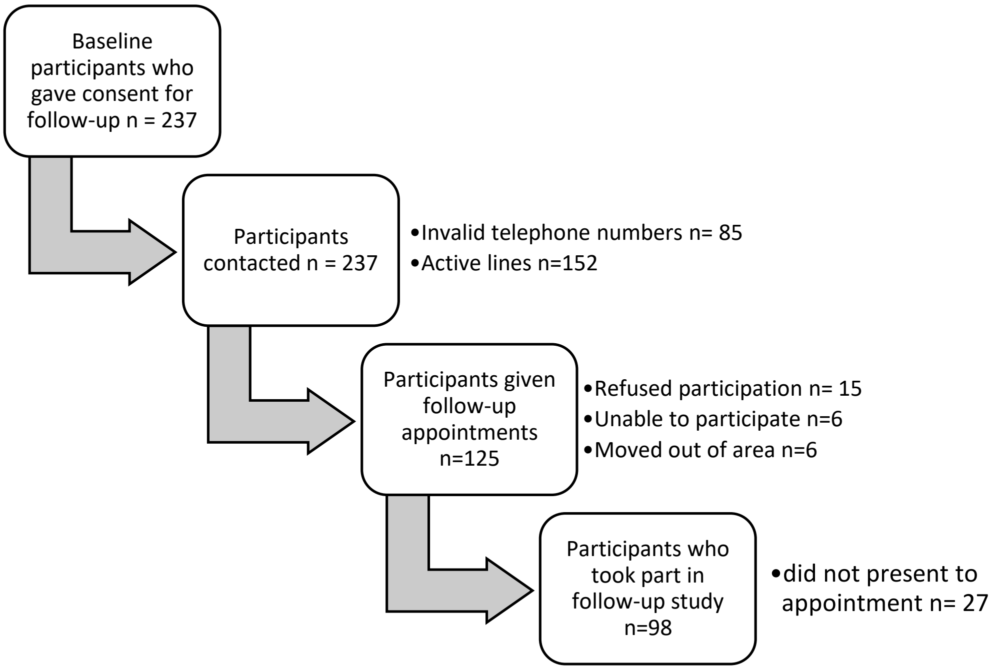

Figure 4. 1 Flow of participant recruitment from baseline to follow-up assessment

The study was approved by the University of Cape Town, Faculty of Health Sciences, Human Research Ethics Committee (HREC REF 229/2015 and 230/2015) and permission was obtained from the Chief Operating Officer of each hospital. Participation was voluntary and each participant signed an informed consent form.

4.2.3 Measures

4.2.3.1 Questionnaire

An interview-administered questionnaire was developed for the purpose of this study. The different sections were put together and reviewed by an expert panel, including dietitians and researchers from the IINDIAGO collaboration to confirm the appropriateness of questions, coverage of core concepts and the level and comprehension of the questions, this ensured construct and face validity. The baseline questionnaire (Krige et al. 2018) had sociodemographic questions, a quantified FFQ and belief statements. The follow-up questionnaire comprised of the same sections as the baseline for the dietary-related beliefs and the qFFQ, with added questions on the mother's current breastfeeding practices, actual weight, current perception of weight status, body shape and weight loss goals. These factors were included as they may all influence the risk to develop T2DM. A summary of the respective assessments made at baseline and follow-up are listed in Table 4.1.

Table 4. 1 Summary of data collected at baseline and follow-up

INFORMATION COLLECTED	BASELINE 28+ weeks gestation	FOLLOW-UP 3- 15 months
Age, race, gestational age, parity	√	
Level of education, employment, type of housing, marital status		√
Perceived weight gain during pregnancy	√	√
Perceived health status, physical activity and food choices	√	√
LSM calculation	√	
Dietary intake (qFFQ)	√	√
Physical Activity (GPPAQ)	√	√
Beliefs in relation to fruit, vegetables, fat, sugar, fibre and physical activity	√	√
Beliefs related to diabetes risk		√
Measured weight and height		√
Baby's birth weight (from RtHB)		√
Body image perception		√
Diabetes management during pregnancy		√
Number of children and diabetic pregnancies	√	√
Breastfeeding practices		√
History of diet counselling		√
Knowledge and concern of risk for developing T2DM post GDM pregnancy		√

LSM: Living Standards Measure, qFFQ: quantified Food Frequency Questionnaire, GPPAQ: General Practice Physical Activity Questionnaire, RtHB: Road-to-Health Book, T2DM: Type 2 Diabetes Mellitus, GDM: Gestational Diabetes

4.2.3.2 Anthropometric measurements of mother

The weight of all participants was measured at follow-up to the nearest 0.1kg using an electronic scale (Seca 813 High Capacity Scale, max.200Kg). The scale was placed on firm flooring such as tiles. The individuals were asked to remove all excess heavy clothing as well as shoes and to stand with both feet in the centre of the scale while looking straight ahead (WHO, 2011).

Height was measured to the nearest 0.1cm using a Seca stadiometer. Individuals were asked to remove their shoes as well as any hair accessories that could interfere with the measurement. The measurements were taken while standing feet together with heels, buttocks, shoulders and the back of their head touching the scale of the stadiometer and the head in the Frankfurt plain position (WHO, 2011).

BMI was calculated as weight (kg) divided by height (meters) squared (NHLBI, 2000) and classified as underweight for BMI < 18.5 kg/m^2, overweight as a BMI ≥ 25 up and < 30 kg/m^2, and obese as a BMI ≥ 30 kg/m^2(WHO, 2011). A healthy or desirable BMI is considered to be from ≥ 18.5 and < 25 kg/m^2.

Waist circumference was measured to the nearest 0.1 cm using a stretch-resistant tape. The measurement was taken at the midpoint between the lower margin of the last palpable rib and the top of the iliac crest. The participant was asked to stand with feet close together, arms at the side and body weight evenly distributed. The participants wore one layer of thin clothing and were asked to relax, and the measurement was taken at the end of a normal expiration (WHO 2008). According to The National Heart, Lung, and Blood Institute (NHLBI) (2000) a waist circumferences of >88cm, puts women at an increased risk of T2DM, hypertension and CVD.

4.2.3.3 Infant measurements

At the follow-up assessment, all the participants brought along the Road to Health Booklet (South African growth chart) of the child born from the index GDM pregnancy at baseline. From the booklet, the following information was recorded: infant's date of birth, age, birthweight, gestational age at birth. The gestational age and birthweight were used to classify the infants either as Small-for-gestational-age (SGS), Appropriate-for-gestational-age (AGA) or Large-for-gestational-age (LGA) as per the University of Colorado Medical Centre classification of new-borns by birthweight and gestational age by Battaglia and Lubchenco (1967).

4.2.3.4 Sociodemographic information

Sociodemographic information available from the baseline interview were age, race and Living Standards Measure (LSM). At follow-up the additional questions that were asked included highest level of education, employment status, social grants received from government, type of housing, number of rooms in the house, number of adults living in the house and marital status.

4.2.3.5 Perceptions of weight, body shape and weight loss goals

Questions on perceived weight status including whether participants were happy, somewhat happy or unhappy with their current weight and whether they thought their weight gain during their last pregnancy was too little, just right or too much. They were also asked whether they were happy with their weight before pregnancy. The participants were asked to indicate their current weight goal (gain weight, lose weight (1-4kg), lose weight (>5 kg), or stay the same. Perceptions of body weight were assessed using Stunkard's body image figures (Stunkard AJ, 1983) used in a study by Mciza et al. (2005) in an African population. Eight silhouettes were allocated letters from A to H from left to right and the participants were asked to choose the silhouette they perceived as: thin, normal weight, fat and very fat; the one (they) wanted to look like, the one (their) partner wants them to look like and the one (they) think they look like the most. For each response, the letter code was recorded and used for comparison analyses. As per previous studies, the images 1 and 2 were underweight; images 3 and 4 were appropriate weight; image 5 through 7 were overweight and images 8 was obese (Lynch et al., 2009; Bhuiyan et al., 2003).

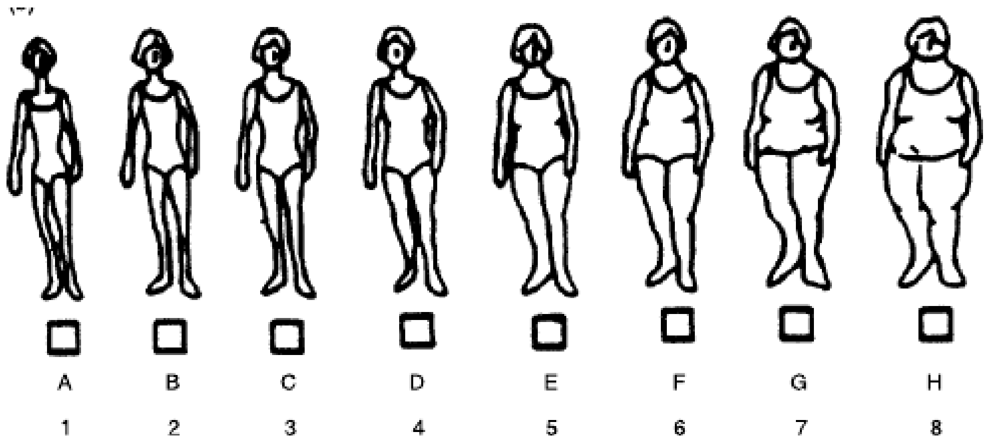

Figure 4. 2 Images for perceived body shape from the Figure Rating Scale adapted from Stunkard AJ (1983) Images 1 and 2 = underweight; images 3 and 4 = appropriate weight; image 5 to 7 = overweight; images 8 = obese.

4.2.3.6 Health perception and diabetes management

Participants were questioned on how they would rate their health since their last pregnancy as: excellent, good, fair or poor. The participants were asked which method was used to manage their diabetes during their last pregnancy: diet and lifestyle changes, oral agents, insulin injection, or none, whether their pharmacotherapy was stopped after pregnancy, whether they were currently on any pharmacotherapy for hyperglycaemia and whether or not they went to have their blood glucose levels checked after pregnancy, how long after delivering their baby they went for a check-up and reasons for not going for their check-up.

Participants were asked whether they had received any dietary advice for managing their weight/blood glucose levels after the pregnancy and how often they were able to follow or implement the recommendations provided.

4.2.3.8 Infant history and feeding practices

Participants were asked the number of children they gave birth to. For each child, they were asked the birth year, birthweight and whether they were treated for diabetes during that pregnancy. Past and current feeding practices were questioned for the index pregnancy; the type of feeding: exclusive breastfeeding, mixed feeding or formula feeding; the duration of breastfeeding and whether they received any breastfeeding advice and if so, from whom did they receive the advice.

4.2.3.7 Beliefs

The Theory of Planned Behaviour (TPB) was used in order to understand what motivates behaviour change. The TPB suggests that intention is the immediate precursor of behaviour (Ajzen, 2012). The belief statements were developed in accordance with the guidelines outlined in the TPB manual for researchers by Francis et al. (2004) and included normative, control, and behavioural belief statements on F&V, fat, fibre, sugar, wholegrains, physical activity and diabetes risk. The most prominent beliefs held during the baseline assessments were re-questioned at follow-up to evaluate any changes in these beliefs over time. The belief statements were assessed using a 7-piont Likert scale namely, 1 = strongly disagree, 2 = disagree, 3 = disagree somewhat, 4=neither agree nor disagree, 5=agree somewhat, 6=agree, 7=strongly agree. Using the Likert scale scores, a mode was calculated for each belief thus producing an evaluation of the strength of the belief within the target population.

Beliefs statements on the risk and concern for developing T2DM post pregnancy were formulated by a panel of dietitians and adapted from Jacob (2013). Eleven statements were chosen to be included in the follow-up questionnaire and was assessed with the same 7-point Likert scale.

4.2.3.8 Dietary intake assessment

For the purpose of this study, a picture-sort method (Kumanyika et al., 1997) in conjunction with a quantified Food Frequency Questionnaire (qFFQ) was developed to assess the dietary intake of the study participants at baseline (Krige et al. 2018) and follow-up. The FFQ included 103 food items, with some items having sub-item categories. In order to increase respondent accuracy in recalling foods consumed during the administration of the questionnaire, each food item on the FFQ list was represented by the appropriate picture card developed for the DAEK manual by (Steyn and Senekal, 2004). Study participants sorted the picture cards into 2 piles according to foods they did and those they did not consume within the last two weeks. The portion size and frequency of intake of foods consumed over the last two weeks were then enquired about. A small booklet derived from the DAEK manual, representing different portion sizes, was used to assist with portion sizes estimation. For data analyses, the household portion was converted into grams using the DAEK manual and then multiplied by the frequency of intake within the last two weeks and then converted to daily intake by dividing by the 14 (total number of days in two weeks). Each food item consumed was coded and the daily intake of energy, macro- and micronutrients were calculated for each participant at baseline and at follow-up using the SAMRC food composition tables (Wolmarans et al., 2010). Participants who had an implausible daily energy intake of <2,092kJ (500kcal) or >20,920kJ (5,000kcal) (Cheng et al., 2009) were excluded from data analyses (n=6: n =3 baseline, n=3 follow-up)

The 103 food items included on the FFQ were categorised into eight indicator food groups as indicated in Table 4.2. To create dichotomous dietary variables, the groups were divided into "those that met" and "those that did not meet" the dietary guidelines, the cut-points outlined in Table 4.2 were used. The indicator food groups were utilised in dietary analysis as dichotomous variables and scored as follows: 1 if in the desirable group and 0 if in the undesirable group. A total diet score was calculated per participant ranging from 0 to 7 and compared from baseline to follow-up (Table 4.9). Scores 0-3 were grouped and classified as having an unhealthy diet. Scores 4-7 were grouped and classified as having a healthy.

Table 4. 2 Foods included in food categories

CATEGORIES	CUT OFF POINTS	ITEM INCLUDES AS APPEARS IN FFQ
Table sugar(g)	0g/day	sugar added to tea/coffee and sugar used in porridge or vegetables.
SSBs (g)	0ml/day	squashes, fruit juice, carbonated beverages and sweetened milk drinks
Fruit and Vegetables (g)	≥ 400g/day	Apples, apricot, pineapple, plum, pears, bananas, grapes, mango, paw paw, melons, oranges, naartjies, peaches, strawberries. Yellow/orange veg (butternut, pumpkin, carrots, sweet potato, gem squash, mealies), Green veg (spinach, peas, green beans, broccoli), cabbage, cauliflower, lettuce, mixed vegetables, tomatoes.
Pulses (g)	≥ 1 ½ cup/week	lentils, cooked dried beans and baked beans.
Processed meats (g)	< 2x90g servings/week	cold meats (ham, polony, salami), sausages (pork, beef, Vienna, frankfurters) and take-away meat (burger patties and fried chicken) and pies
Energy-dense snacks and foods (g)	< 2x 50g servings/week	sweets, chocolates, biscuits (sweet and salted), rusks, crisps, pastries (cookies, muffins, cake, pancakes/waffles, scones, milk tart, cheesecake, pudding), fat cakes, samosas and pizza
Refined starches (g)	< 3 x ½ cup servings/day	mealie meal, white rice, samp, white bread, cornflakes, white pasta dishes, refined cereals
High fibre starches (g)	≥ 2x ½ cup servings/day	Brown or low GI bread, brown rice, brown pasta, high fibre cereals (Weetabix, martabella), oats, muesli, whole wheat biscuits (Provita)

Reference for cut-offs used: Tables sugar and SSBs (Gulland, 2015) used in Krige et al., 2018; Fruit and vegetables (FAO/WHO, 2005), Pulses (Global Pulse Confederation, 2018; Mudryj et al., 2012), Processed meats (Kassier, 2016), Energy-dense snacks and foods, refined and high fibre starches - adapted (Vorster, Badham and Venter, 2013)

Change in dietary intake was calculated for each participant using the formula (amount in grams at follow-up) minus (amount in grams at baseline). Since data was non-normal as per Shapiro Wilks Test ($p>0.05$) the Median (IQR) was reported in Table 4.10. The change in macronutrient intake and food groups were tested for correlations.

4.2.3.9 Physical activity assessment

The General Practice Physical Activity Questionnaire (GPPAQ) was used to assess the physical activity level of each study participant (NHS, 2009). GPPAQ was commissioned by the UK Department of Health and developed by the London School of Hygiene and Tropical Medicine as a validated short measure of physical activity to assess patients at risk of heart disease, stroke, kidney disease and diabetes and support people to reduce or manage the identified risk through individually tailored advice. Good validity and test-retest reliability coefficients have been reported for the GPPAQ (Ahmad et al., 2015; Chatterjee et al., 2017; Smith et al., 2017). The test involves two sections; the first one asks for the physical activity level required for work and the responses options were: unemployed, most of time sitting, most of time standing or walking, work involves definite physical effort and work involves vigorous physical activity. The second section includes the question; "How much time in the last week did you spend on each of the following activities?":1. Physical exercise, 2. Cycling, 3. Walking, 4. Housework/Childcare, 5. Gardening/DIY. The response options were "None", "Some but less than an hour", "One hour but less than three hours" and "3 hours or more". The data was then entered in to the ParmCalc website (Alnasir, 2018) and for each participant, the Physical Activity Index (PAI) was calculated and categorised as "Active", "Moderately Active", "Moderately Inactive" and "Inactive".

4.3 DATA ANALYSIS

STATISTICA version 12.0 was used for statistical analyses and data was cleaned to check for any errors. Continuous data was tested for normality using Shapiro Wilks Test ($p>0.05$=normal). Descriptive statistics, included frequencies for categorical data and mean (SD) for continuous normal data and median (IQR) for non-normal continuous data. Sociodemographic, dietary and PA variables were compared between those who continued the study to those who were interviewed only at baseline. To test for significant differences in socio-demographic variables between participants who only completed the baseline assessments (n= 239 minus 98= 141) versus those who completed both baseline and follow-up assessments (n=98) Mann Whitney U test was used for continuous data and Chi square test was used for categorical data.

For paired nominal data such as change in variables from baseline to follow-up the McNemar test was used where 2x2 tables were available. Pearson Chi Square Test was used for categorical data with tables larger than 2x2. Wilcoxon Matched Pairs Test was used if data were not normally distributed. Spearman Correlation Test was used to test for correlations between two continuous variables. Kruskal Wallis Test was used to compare independent samples of equal or different sizes. A p-value of <0.05 was considered significant. Significant salient beliefs were identified (to become the focus of the belief-based messages to be included in the IINDIAGO intervention study).

4.4 RESULTS

4.4.1 Sociodemographic profile

The flow of the study was illustrated in figure 4.1. There were no significant differences between those who completed the study and those who were only included in the baseline sample for the following variables: age, gestational age, GDM in previous pregnancy, race, hospital, F&V, table sugar, SSBs, proteins, fats and physical activity. The energy intake of participants who were only in the baseline sample was significantly higher (Median(IQR)= 6839.9 kJ (5315.7 – 8710.7)) compared to the energy intake (median(IQR) = 5674.4 kJ (4555.6 – 8021.9) of those who participated in the follow-up assessments (p=0.023). Also, the carbohydrate intake of participants who were only in the baseline sample was significantly higher (Median(IQR)= 209.2g (162.1 – 280.5) compared to the carbohydrate intake (median(IQR) = 182.5g (125.9 – 263.3)) of those who participated in the follow-up assessments (p=0.014). The majority (74.5%) of participants at follow-up were recruited at GSH at the time of their pregnancy. Almost two-thirds (64.3%) of the sample were below the age of 35 years and half (56.1%) were of mixed-race ancestry. Three quarters of participants were married or living with a partner. Follow-up assessments took mostly place 3-6 months (73.5%) or 6-9 months (10.2%) postpartum. Forty-three percent had secondary level education and 42.3% percent had matric/grade12. Just more than half of the participants had a Living Standards measure (LSM) of 8-10 and 48% were employed. Less than half were receiving a social support grant and the majority lived in a formal built house. Thirty-six percent had two-roomed houses and forty-six percent had two adults living in the house.

Table 4. 3 Sociodemographic and socio-economic status profile of participants (n=98)

VARIABLE		N	PERCENTAGE (%)
Recruitment hospital	*Groote Schuur Hospital*	73	74.5
	Mowbray Maternity Hospital	25	25.5
Recruitment Age at baseline	*< 35 years*	63	64.3
	≥ 35 years	35	35.7
	Min: 20 years, max 43 years		
Race	*Black*	38	38.8
	White/Indian/Asian	5	5.1
	Mixed-race ancestry	55	56.1
Marital status At follow-up	*Married/living with partner*	73	74.5
	Widowed/divorced/single/dating	25	25.5
Follow-up visit: No of months postpartum	3 to <6 m	72	73.5
	6 to <9 m	10	10.2
	9 to <12m	9	9.2
	12 to 15m	7	7.1
Highest level of education At follow-up	*Primary school (Grade 1 to 7)*	5	5.2
	Secondary school (Grade 8 to 10)	43	43.3
	Grade 12 /Matric	42	42.3
	Tertiary/Diploma	9	9.3

Living Standard Measurement at baseline	*LSM ≤ 4* *LSM 5-7* *LSM 8-10*	1 43 54	1.0 43.8 55.1
Employment status At follow-up	*Employed, salaried* *Unemployed* *A full-time homemaker* *Student*	47 23 24 4	47.9 23.5 24.4 4.1
Receiving a grant At follow-up	*Yes, child grant* *No grant*	46 52	46.9 53.1
Type of housing At follow-up	*Built formal unit* *Informal shack/shelter/hostel /Wendy house*	79 19	80.6 19.4
No of rooms in house At follow-up	*1* *2* *3* *≥4*	29 36 23 10	29.6 36.7 23.5 10.2
Number of adults living in your house? At follow-up	*1* *2* *≥3*	5 48 45	5.1 48.9 45.9

GSH: Groote Schuur Hospital, MMH: Mowbray Maternity Hospital, LSM: Living standards measure, GDM: gestational diabetes mellitus. * Mixed-race ancestry: this population group in South Africa are also referred to as the Cape Coloureds in Cape Town and has a mixed ancestry with genetic material mainly from Khoisan, Bantu African, Northern European, South Asia and South-East Asia origins. No of rooms in house: All rooms and bedrooms, excluding bathrooms and kitchen if separate

4.4.2 Anthropometric data of participant

At follow-up, almost all (98.7%) participants had a waist circumference greater than 88cm and the median waist circumference was 103.0cm. The median BMI was 34.6 kg/m^2 and 73.5 % of participants were classified as obese (Table 4.4). Both waist circumference and BMI were not significantly different when compared against the time the participants were assessed postpartum (Table 4.4).

Table 4. 4 Anthropometric data of participants (n=98)

	FOLLOW-UP			Number of months postpartum n(%)			
ANTHROPOMETRIC DATA	*n*	*%*	*Median (IQR)*	≥3 to <6 months *n=72*	≥6 to <9 months *n=10*	≥9 months n=16	*p-value*[#]
Waist circumference, cm	94*		103.0 (76.0 – 139.0)				
No increased risk for metabolic complications <80cm	2	2.0		2 (2.8)	0 (0.0)	0 (0.0)	0.829
Increased risk for metabolic complications ≥80cm	4	4.1		3 (4.2)	0 (0.0)	1 (7.7)	
Substantially increased risk for metabolic complications ≥88cm	88	98.7		66 (92.9)	10 (100.0)	12 (92.3)	
BMI, kg/m²	98		34.6 (29.7 – 39.7)				
Normal weight (≥18.5 to <25)	6	6.1		5 (6.9)	0 (0.0)	1 (6.3)	0.824
Overweight (≥25 to <30)	20	20.4		16 (22.2)	2 (20.0)	2 (12.5)	

Obese	72	73.5	51 (70.8)	8 (11.1)	13 (18.1)
Class 1 (≥30 to <35)	26	26.5	21 (29.2)	2 (20.0)	3 (18.7)
Class 2 (≥35 to <40)	22	22.4	15 (20.8)	2 (20.0)	5 (31.3)
Class 3 (≥40)	24	24.5	15 (20.8)	4 (20.0)	5 (31.3)

IQR: Interquartile range; BMI: Body Mass Index
*missing data due to unperformed measurements
[#]Pearson Chi Square Test

4.4.3 Infant related information

The average age of the infants at follow-up was 5.4 months and the mean(SD) birth weight was 3242 (647.5) g. Amongst the infants born from the index pregnancy, 65.3% were AGA (Appropriate-for-gestational-age), while 27.6% were LGA (Large-for-gestational-age) (Table 4.5). The mean(SD) birth length was 49.5(3.5) cm and the mean(SD) gestational age was 37.8 weeks (1.5). Ten infants (10.2%) were born premature (<37 weeks gestation). The majority of infants were born by caesarean section (61.2%). While 89.7% of participants reported breastfeeding their infants, 21.4% reported to have or intended to exclusively breastfeed for 6 months. Of the 72 infants (< 6 months), 44.4% were exclusively breastfeeding at the time of the assessment. Twenty-nine percent exclusively breastfed for 6 months or more. Seventy-two percent initiated complementary feeding at 6 months while 19.2% introduced food before 6 months. The average number of children per participant was 2.55 (1.03) and the mean(SD) birthweight of all children a mother had was 3.26(0.53) kg.

Table 4. 5 Anthropometry and feeding of participants' infants

INFANT-RELATED INFORMATION	*n*	*Percent age (%)*	*Mean (SD)*
Age of child at follow-up, months			5.4 (3.0)
Infant gestational age at birth, weeks			37.8 (1.5)
Infant Anthropometry			
Infant birth weight, g			3242 (647.5)
Small-for-gestational age (< 10th percentile)	4	4.8	
Appropriate-for-gestational age (≥ 10th and < 90th percentile)	64	65.3	
Large-for-gestational age (≥ 90th percentile)	27	27.6	
Infant Nutrition			
Breastfed (any amount of time) (n=98)	88	89.7	
Currently exclusively breastfed (< 6months n=72)	32	44.4	
Currently on formula milk (n=98)	65	66.3	
Currently on any other foods or drinks, other than breast milk or formula (n=98)	41	41.8	
Duration of exclusive breastfeeding (or intention to if infant <6 Months (n=32)			
Less than 6 months	7	21.8	
6months	19	59.4	
More than 6 months	6	18.7	

Timing of weaning (or intention to if infant <6 months)			
Before 6 months (2-5 months)	19	19.4	
At 6 months	71	72.4	
After 6 months (7-11 months)	8	8.2	
Total number of children, n			2.55 (1.03)
Average birth weight of children, kg			3.26 (0.53)

4.4.4 Diabetes management

From our sample of post GDM women, 69.4% were treated with Metformin during pregnancy and 34.7% required insulin at some point during pregnancy (Table 4.6). Most of the participants (91.8%) said to have made diet and other lifestyle changes to manage their blood glucose levels, however 57.7% of the participants stopped their dietary changes and 79.4% stopped metformin shortly after the index pregnancy. At follow-up, 53.1% said to be currently adopting diet and lifestyle changes and 10.2% were on pharmacotherapy; either continued from pregnancy management or re-initiated at some point postpartum. While 62.2% of participants said to have tested their blood glucose levels postpartum, only 4.9% did an OGTT. Half of the participants tested their blood glucose level before 6 weeks. The main reason for not going for the 6 week postpartum OGTT, were that they were not informed of this test (35.1%) or they were self-monitoring their blood glucose at home with a personal glucometer (29.7%).

Table 4. 6 Diabetes related information of participants (n=98)

DIABETES-RELATED INFORMATION	n	Percentage (%)
GDM management during pregnancy (n=98) (more than one answer possible)		
Diet and lifestyle (% yes)	90	91.8
Metformin (% yes)	68	69.4
Insulin (% yes)	34	34.7
None (% yes)	3	3.1
Number who stopped treatment after pregnancy (n=98)		
Diet and other lifestyle (n=90)	52	57.7
Metformin (n=68)	54	79.4
Insulin (n=34)	33	97.0
Number of participants on treatment at follow-up (continued from pregnancy and re-initiated) (n=98) (more than one answer possible)		
Diet and other lifestyle (% yes)	52	53.1
Metformin (% yes)	8	8.2
Metformin and Insulin (% yes)	2	2.0
Number who tested blood glucose level postpartum (% yes)	61	62.2
Type of test performed (n=61) (more than one answer possible)		
Oral Glucose Tolerance Test	3	4.9
Finger prick	59	96.7
Other e.g. urine dip stick	11	18.0
Timing of blood glucose level test postpartum (n=61)		
< 6week	30	49.2
6 weeks	15	24.6
> 6weeks	16	26.2
Reason for not testing blood glucose level postpartum (n=37)		
Self-monitored (with personal glucometer)	11	29.7
Was told it was unnecessary if on medication	2	5.4
Was not informed to check blood glucose levels	13	35.1
Was too busy/ had no time	6	16.2
None	5	13.5

4.4.5 Comparison between baseline and follow-up dietary intake

The median (IQR) of energy increased, although not significantly, from 5674.4 (4555.6 – 8021.9) kJ at baseline to 6666.8 (5053.5-8929.8) kJ at follow-up (Table 4.7). Carbohydrate intake increased significantly from 182.5(125.9 – 263.3) g at baseline to 204.6(159.8 – 288.6) g at follow-up (p=0.048). There were no significant changes in the intake of micronutrients from baseline to follow-up. The intake of added table sugar, SSBs and energy-dense foods all increased significantly ($p<0.05$) from baseline to follow-up. Processed meats decreased from *17.2 (7.7 – 37.8*) g at baseline *to* 11.9 (4.3 – 23.8) g at follow-up (p=0.007), while pulses increased significantly from 4.4 (0.0 – 14.3) g at baseline to 8.6 (0.0 – 24.3) g at follow-up. Refined starch portions increased significantly from 1.4 (0.7 – 2.9) g portions to 2.5 (1.0 – 4.2) g portions (p=0.004) at follow-up. There was no significant change in F&V or high fibre starch intake from baseline to follow-up (Table 4.7).

Table 4. 7 Comparison between baseline and follow-up dietary intake of nutrients

	Median (IQR) BASELINE	Median (IQR) FOLLOW-UP	*p*-value*
MACRONUTRIENTS			
Total energy (kJ)	5674.4 (4555.6 – 8021.9)	*6666.8 (5053.5-8929.8)*	*0.086*
Protein (g)	52.0 (39.7 – 67.2)	*52.6 (39.5 – 69.8)*	*0.734*
Total fat (g)	52.6 (35.1 – 70.7)	*56.6 (38.9 – 87.6)*	*0.138*
MUFA (g)	18.2 (12.1 – 24.7)	*20.2 (13.2 – 30.3)*	*0.413*
PUFA (g)	13.3 (8.3 – 21.6)	*13.7 (9.7 – 22.4)*	*0.267*
Saturated fat (g)	14.5 (9.2 – 21.6)	*15.9 (11.4 – 24.5)*	*0.078*
Cholesterol (g)	185.0 (100.7 – 302.6)	*191.7 (132.6 – 279.2)*	*0.870*
Carbohydrates (g)	182.5 (125.9 – 263.3)	*204.6 (159.8 – 288.6)*	*0.048*
Fibre (g)	18.6 (14.8 – 26.4)	*19.8 (15.7 – 25.8)*	*0.922*
Added sugar (g)	4.1 (1.5 – 11.4)	*61.9 (44.4 – 89.8)*	*0.014*
Alcohol (g)	0.0 (0.00 – 0.00)	0.00 (0.00 – 0.00)	*0.012*
Mean (SD):	0.029 (0.283)	0.732 (3.211)	
MICRONUTRIENTS			
Vitamin A (mcg)	878.0 (575.1 – 1333.9)	937.6 (578.2 – 1457.5)	*0.255*
Vitamin D (ug)	4.2 (2.3 – 6.9)	3.6 (2.3 – 6.8)	*0.485*
Vitamin E (mg)	10.7 (6.9 – 15.9)	11.4 (7.2 – 16.1)	*0.318*
Thiamin (mg)	1.1 (0.8 – 1.5)	1.1 (0.9 – 1.5)	*0.842*
Riboflavin (mg)	1.2 (0.7 – 2.2)	1.5 (0.9 – 2.4)	*0.068*
Niacin (mg)	18.5 (15.3 – 25.3)	18.7 (14.7 – 27.9)	*0.493*
Vitamin B6 (mg)	2.7 (1.7 – 5.6)	2.6 (1.9 – 3.8)	*0.564*
Vitamin B12 (mcg)	2.8 (1.7 – 5.3)	3.1 (1.9 – 5.0)	*0.959*
Pantothenate (mg)	3.5 (2.6 – 5.7)	3.8 (2.9 – 5.4)	*0.459*
Biotin (mcg)	28.5 (21.9 – 41.6)	27.1 (20.5 – 34.8)	*0.143*
Folate (ug)	218.6 (136.6 – 290.4)	208.4 (158.4 – 274.1)	*0.863*
Vitamin C (mg)	58.8 (37.9 – 116.4)	65.8 (31.9 – 104.0)	*0.057*
Calcium (mg)	444.7 (304.8 – 751.9)	470.0 (344.1 – 605.7)	*0.797*
Iron (mg)	11.2 (8.6 – 15.0)	11.8 (9.3 – 16.1)	*0.402*
Magnesium (mg)	212.4 (164.8 – 259.6)	211.7 (163.3 – 283.4)	*0.910*
Phosphorus (mg)	838.3 (582.7 – 1080.7)	811.9 (609.8 – 1099.8)	*0.618*
Potassium (mg)	1742.5 (1265.7 – 2344.5)	1690.9 (1384.0 – 2258.4)	*0.981*
Sodium (mg)	1475.7 (1078.1 – 1944.7)	1525.9 (1108.5 – 2063.5)	*0.135*
Zinc (mg)	9.1 (6.9 – 11.6)	8.6 (6.5 – 11.2)	*0.870*
Copper (mg)	0.9 (0.7 – 1.1)	0.9 (0.7 – 1.1)	*0.250*
Manganese (mg)	1.8 (1.3 – 2.9)	1.9 (1.2 – 2.6)	*0.615*
INDICATOR FOOD GROUPS			
Table Sugar(g)	4.0 (0.0 – 10.0)	*9.7 (3.4 – 19.5)*	*0.000*
SSBs (g)	10.0 (0.0 – 107.2)	71.4 (0.0 – 250.0)	*0.002*
Fruit and Vegetables(g)	255.0 (178.6 – 451.4)	273.2 (132.1 – 416.4)	*0.498*
Pulses (g)	4.4 (0.0 – 14.3)	8.6 (0.0 – 24.3)	*0.039*
Processed Meats (g)	*17.2 (7.7 – 37.8)*	11.9 (4.3 – 23.8)	*0.007*
Energy-Dense Foods (g)	15.7 (2.9 – 36.9)	37.9 (12.1 – 67.3)	*0.000*
Refined Starches (portions)	1.4 (0.7 – 2.9)	2.5 (1.0 – 4.2)	*0.004*
High Fibre Starches (portions)	2.7 (1.4 – 4.1)	2.6 (1.6 – 3.7)	*0.282*

*Wilcoxon Matched Pairs Test - excludes data <2,029kJ and >20,290kJ (n=6)

4.4.6 Macronutrient distribution

Table 4.8 shows the macronutrient distribution of the sample at baseline and follow-up. The majority of participants had a carbohydrate intake ≥50% and a fat intake ≤30% of Total Energy (TE). For protein intake, the percentage of participants in the 10.1-15.0% category almost doubled from baseline (34.7%) to follow-up (60.0%). For those having ≥20% TE from protein, the percentage decreased from 8.4% at baseline to 0.0% at follow-up. The median percentage of protein from TE decreased from 15.1% at baseline to 13.7% at follow-up (p=0.000).

Table 4. 8 Macronutrient distribution at baseline and follow-up

	Percentage (%) BASELINE	Percentage (%) FOLLOW UP	*p*-value
Carbohydrates (% Total energy)			
Median (IQR)	53.5 (45.5 – 58.1)	53.3 (47.3 – 57.9)	*0.702**
≤ 40.0	8.4	3.2	*0.509***
40.1 – 45.0	16.8	8.4	
45.1 – 50.0	13.7	25.6	
≥50.1	61.0	63.2	
Protein (% Total energy)			
Median (IQR)	15.1 (12.8 – 17.1)	13.7 (11.8 – 15.6)	*0.000**
≤ 10	9.5	10.5	*0.063***
10.1 – 15.0	34.7	60.0	
15.1 – 20.0	47.4	29.5	
≥20.1	8.4	0.0	
Fat (% Total energy)			
Median (IQR)	31.4 (27.3 – 38.5)	31.7 (27.8 – 36.9)	*0.882**
≤ 30	41.1	35.7	*0.692***
30.1 – 35.0	17.9	29.5	
35.1 – 40.0	20.0	18.9	
≥40.1	21.1	15.8	

excludes data <2,029kJ and >20,290kJ (n=6)
*Wilcoxon Matched Pairs Test
**Pearson Chi Square Test

4.4.7 Diet scores and PAI at baseline and follow-up

At follow-up, a significantly lower percentage of participants consumed 0g table sugar compared to baseline where only 13.0% reported not consuming any table sugar (p=0.002). The number of participants having >0ml SSBs increased from 50.0% at baseline to 71.7% at follow-up, although this was non-significant. There was a significant decrease in the number of participants reaching the recommended intake of F&V from 30.4% at baseline to 26.1% at follow-up (p=0.000). Significantly more participants at follow-up (10.9%) had 1½ portions or more of pulses per week than at baseline (5.4%). The number of participants having two or more 90g portions of processed meats decreased from baseline (41.3%) to follow-up (22.8%). The number of participants having two or more 50g portions of energy-dense foods significantly increased from 53.2% at baseline to 73.9% at follow-up (p=0.017). There was a significant increase in the number of participants having 3 portions or more of refined starches from baseline to follow-up (23.9% to 34.8% respectively). The percentage of participants having 2 portions or more of high fibre starches decreased significantly from 63.0% at baseline to 59.8% at follow-up. The Median(IQR) diet score decreased significantly from 4 (3,5) at baseline to 3 (2,4) at follow-up. The number of participants having an unhealthy diet score of 0-3 increased from 46.7% at baseline to 64.1% at follow-up although this was non-significant.

Table 4. 9 Diet score as at baseline and follow-up

	N (%) BASELINE	*N (%)* FOLLOW UP	*p*-values
Table sugar(g)			
0g (score 1)	38 (41.3)	12 (13.0)	*0.002**
>0g (score 0)	54 (58.7)	79 (85.9)	
SSBs (ml)			
0 ml *(score 1)*	46 (50.0)	26 (28.3)	0.072*
>0ml *(score 0)*	46 (50.0)	66 (71.7)	
Fruit and Vegetables (g)			
< 400g (score 0)	64 (69.6)	68 (73.9)	*0.000**
≥400g (score 1)	28 (30.4)	24 (26.1)	
Pulses (g)			
< 1 ½ cup /week (score 0)	86 (93.5)	82 (89.1)	*0.000**
≥ 1 ½ cup /week (score 1)	5 (5.4)	10 (10.9)	
Processed meats (g)			
< 2x 90g portions/week (score 1)	*54 (58.7)*	*71 (77.2)*	*0.000**
≥2x 90g portions/week (score 0)	*38 (41.3)*	*21 (22.8)*	
Energy-dense foods and snacks (g)			
< 2x 50g portions/week (score 1)	41 (44.6)	24 (26.0)	0.012*
≥2x 50g portions/week (score 0)	49 (53.2)	68 (73.9)	
Refined starches (portions)			
< 3 portions/day (score 1)	70 (76.1)	60 (65.2)	0.002*
≥3 portions/day (score 0)	22 (23.9)	32 (34.8)	
High fibre starches (portions)			
< 2 portions/day (score 0)	34 (36.9)	37 (40.2)	0.034*
≥ 2 portions/day(score 1)	58 (63.0)	55 (59.8)	
Diet Score			
Median (IQR)	4 (3,5)	3 (2,4)	0.001**
0-3	43 (46.7)	59 (64.1)	0.301*
4-7	49 (53.3)	33 (35.9)	

excludes data <2,029kJ and >20,290kJ (n=6)
IQR: Interquartile range
*McNemar Square Test
**Wilcoxon Matched Pairs Test

4.4.8 Association between variable and change in diet from baseline to follow-up

No significant associations were found between change in dietary intake of macronutrients or food groups and the age of the baby at follow-up or the BMI of participants (Table 4.10). The following variables were also tested for associations with change in dietary intake: age of mother, number of months postpartum, LSM, waist circumference, infant birth weight, gestational age at birth, number of children, and average birth weight of children. No significant associations were found between these variables and change in dietary intake (results not included in table).

Table 4. 10 Change in dietary intake from pregnancy to follow-up and correlations with BMI, education, employment, currently on metformin, recruitment hospital.

NUTRIENT / FOOD GROUP	Change in dietary intake Amount (Follow-up – baseline) Median(IQR)	Correlation of Change in dietary intake with baby's age at follow-up* rho, *p*-value	Correlation of Change in dietary intake with BMI* rho, *p*-value
Total energy (kJ)	390.7 (-1646.9 - 2408.1)	-0.08 (0.412)	0.07 (0.497)
Protein (g)	0.48 (-17.4 – 19.5)	-0.18 (0.078)	0.02 (0.792)
Total fat (g)	4.91 (-17.4 – 33.3)	-0.08 (0.411)	0.12 (0.223)
MUFA (g)	0.36 (-6.98 – 12.3)	-0.10 (0.339)	0.14 (0.161)
PUFA (g)	1.07 (-5.92 – 8.82)	-0.00 (0.974)	0.02 (0.804)
Saturated fat (g)	0.97 (-4.93 – 9.22)	-0.12 (0.217)	0.16 (0.121)
Cholesterol (g)	10.7 (-101.2 – 88.4)	-0.14 (0.161)	0.07 (0.491)
Carbohydrates (g)	22.7 (-49.4 – 79.8)	-0.03 (0.718)	0.05 (0.618)
Fibre (g)	1.02 (-7.48 – 6.24)	-0.20 (0.050)	-0.07 (0.473)
Table Sugar(g)	2.00 (-0.20 – 12.1)	-0.04 (0.690)	-0.07 (0.505)
SSBs (ml)	20.7 (-9.35 – 129.5)	0.12 (0.246)	0.08 (0.429)
Fruit and Vegetables(g)	-15.4 (-133.0 – 97.0)	-0.16 (0.125)	-0.05 (0.585)
Pulses (g)	0,00 (-7.20 – 15.0)	-0.13 (0.197)	-0.03 (0.713)
Processed Meats (g)	-4.30 (-22.1 – 6.4)	0.09 (0.374)	0.11 (0.272)
Energy-Dense Foods (g)	18.1 (-8.10 – 44.7)	-0.03 (0.747)	0.20 (0.058)
Refined Starches (portions)	0.5 (-0.46 – 1.78)	0.02 (0.840)	-0.03 (0.740)
High-Fibre Starches (portions)	-0.14 (-1.49 – 0.69)	-0.16 (0.142)	-0.17 (0.113)

*Spearman Correlation matrix

4.4.9 Weight perception, and body Image

Irrespective of BMI, the majority of participants correctly identified the 'thin' (88.8%), 'fat' (98.8%) and 'very fat' body images (Table 4.11). Sixty-seven percent of participants correctly identified the 'normal weight' body images, while 27.6% thought the overweight body images were 'normal weight'. There were no significant differences between BMI categories and identifying body images. There were also no significant associations between the time post-partum and the following variables: weight goals, body figure they want to look like, body figure they think they look like, weight satisfaction and perceptions of a thin, normal weight and overweight/obese figure.

Fifty-six percent of participants chose the overweight figures when asked what image they want to look like. There was a significant association between the image they want to look like and BMI categories. Participants who wanted to like the overweight images had higher BMI than those who wanted to look like the normal weight images. The majority (63.9%) of obese participants indicated that they want to look like the overweight images while the majority of normal weight (66.7%) and overweight (60.0%) participants indicated that they want to look like the normal weight images (p=0.036).

When asked which image they think their partner would like them to look like, 42.8% of the participants chose a normal weight and 41% chose an overweight image.

The majority of participants (84.7%) thought they looked like the overweight images. There was a significant association between BMI categories and their perception of the images they thought they looked like the most (p=0.000). Participants who thought they looked like the overweight images had higher BMI than those who were normal weight and underweight. Most of the obese participants correctly identified themselves as overweight/obese however nearly half (47.4%) of the overweight participants thought they looked like the ‘normal weight’ images. Only 33.3% of normal weight participants correctly perceived themselves as normal weight.

Almost half of the participants were unhappy with their current weight (Table 4.12). Participants who were unhappy with their current weight had a significantly higher BMI than those who were happy or those who were somewhat happy with their weight (p=0.000). There was also a significant association between BMI categories and participant’s response to how happy they were with their current weight. Fifty percent of the normal weight participants, 45% of the overweight participants and 22% of the obese participants were happy with their current weight. More than half of the obese participants were happy with their current weight. Regarding the participants’ weight gain, fifty percent of the overweight participants said they wanted to stay the same weight while, 65% of the obese participants wanted to lose more than 5kg. The BMI of participants who wanted to lose weight was significantly higher than the BMI those who want to stay the same weight. Irrespective of BMI, most participants (54.1%) thought their weight gain in the index pregnancy was just right. There were no significant associations between perceived weight gain during their last pregnancy and BMI or BMI categories.

Forty percent of the sample indicated that their current food choices are less healthy than their food choices during pregnancy, while 40% indicated that they were the same. Almost a third of the participants indicated that they currently eat more food or the same amount of food than in the index pregnancy. Forty-five percent self-rated their health as ‘good’. No significant associations were found between BMI or BMI categories and questions related to food choices, amount of food eaten and the rating of their current health.

Table 4. 11 Weight perception of Stunkard images in relation to participant's BMI

PERCEPTION OF IMAGE(number of image)	**Total group**				**BMI**			
	n	**%**	**Median (IQR) BMI**	**p-value***	**Normal n (%) (n=6)**	**Overweight n (%) (n=20)**	**Obese n (%) (n=72)**	**p-value**
Image they thought looked thin				0.202				0.356
Underweight (1 – 2)	87	88.8	34.5 (29.7 – 40.0)		6 (100.0)	17 (85.0)	64 (88.8)	
Normal weight (3 – 4)	7	7.1	34.4 (29.4- 35.8)		-	3 (15.0)	4 (5.5)	
Overweight (5 – 7)	4	4.1	40.4 (35.0 – 46.3)		-	-	4 (5.5)	
Image they thought looked normal weight				0.860				0.989
Underweight (1 – 2)	4	4.1	37.4 (30.6 – 43.9)		-	1 (5.0)	3 (41.6)	
Normal weight (3 – 4)	67	68.4	34.9 (29.7 – 39.3)		4 (66.6)	14 (70.0)	49 (60.1)	
Overweight (5 – 8)	27	27.6	33.9 (27.9 – 40.0)		2 (33.3)	5 (25.0)	20 (27.8)	
Image they thought looked fat				0.162				0.130
Underweight (1 – 2)	0	0.0	-		-	-	-	
Normal weight (3 – 4)	1	1.0	26.8 (26.8 -26.8)		-	1 (5.0)	-	
Overweight (5 – 8)	97	98.9	34.8 (29.7 – 39.7)		6 (100.0)	19 (95.0)	72 (100.0)	
Image they thought looked very fat				-				-
Underweight (1 – 2)	0	0.0	-		-	-	-	
Normal weight (3 – 4)	0	0.0	-		-	-	-	
Overweight (5 – 8)	98	100.0	34.6 (29.7 – 39.7)		6 (100.0)	20 (100.0)	72 (100.0)	
Image they want to look like				**0.039**				**0.036**
Underweight (1 – 2)	3	3.1	30.6 (27.4 – 47.0)[a,b]		-	1(5.0)	2(2.8)	
Normal weight (3 – 4)	40	40.8	31.0 (28.7 – 37.6)[a]		4 (66.7)	12(60.0)	24(33.3)	
Overweight (5 – 8)	55	56.1	36.7 (32.1 – 40.2)[b]		2 (33.3)	7 (35.0)	46 (63.9)	
Image their partner wants them to look like				0.198				**0.134**
Underweight (1 – 2)	7	7.1	30.4 (23.8 – 34.5)		2 (33.3)	1 (5.3)	4 (6.1)	
Normal weight (3 – 4)	42	42.9	33.9 (29.3 – 39.1)		2 (33.3)	12 (63.2)	28 (42.4)	
Overweight (5 – 8)	41	41.8	35.4 (30.1 – 39.7)		2 (33.3)	5 (26.3)	34 (51.5)	
Image they look like the most				**0.000**				**0.000**
Underweight (1 – 2)	2	2.0	23.8 (23.8 – 23.8)[a]		2 (33.3)	-	-	
Normal weight (3 – 4)	13	13.3	28.7 (27.3 – 29.4)[a]		2 (33.3)	9 (47.4)	2 (2.7)	
Overweight (5 – 8)	83	84.7	35.9 (30.6 – 40.6)[b]		2 (33.3)	11 (57.9)	70 (97.2)	

[a – b] Post-hoc test: Medians with the same letter do not differ significantly.

*Kruskal Wallis test

Table 4. 12 Body image and health perception in relation to participants' BMI

BODY IMAGE AND HEALTH PERCEPTION	Total group n	%	Median (IQR) BMI	p-value*	BMI Normal n(%) (n=6)	Overweight n(%) (n=20)	Obese n(%) (n=72)	p-value
Current weight satisfaction				**0.000**				**0.011**
Happy	31	31.6	30.1 (28.4 – 35.8)[a]		3 (50.0)	9 (45.0)	19 (22.2)	
Somewhat happy	23	23.5	32.2 (28.4 – 38.6)[a]		2 (33.3)	7 (35.0)	14 (19.4)	
Unhappy	43	43.8	38.3 (33.6 – 43.0)[b]		1 (16.7)	4 (20.0)	38 (52.8)	
Perceived weight gain during index pregnancy				0.283				0.549
Too little	10	10.2	34.9 (29.4 – 38.3)		-	3 (15.0)	7 (9.7)	
Just right	53	54.1	33.9 (29.3 – 38.7)		5 (83.3)	11 (55.0)	37 (51.4)	
Too much	34	34.7	35.9 (30.1 – 43.0)		1 (16.7)	6 (30.0)	27 (37.5)	
Current weight goal				**0.000**				**0.000**
Gain weight	3	3.1	29.7 (24.0 –39.7)[a,b]		1 (16.7)	1 (5.0)	1 (1.4)	
Lose weight (1-4KG)	24	24.5	34.8 (29.5 – 38.5)[a]		2 (33.3)	5 (25.0)	17 (23.6)	
Lose weight (>5Kg)	52	53.1	36.6 (32.7 – 42.1)[a]		1 (16.7)	4 (20.0)	47 (65.3)	
Stay the same	18	18.4	29.4 (27.3 – 30.1)[b]		2 (33.3)	10 (50.0)	6 (8.3)	
Current food choices versus index pregnancy				0.366				0.608
Healthier	19	19.4	33.0 (29.4 – 37.4)		-	6 (30.0)	13 (18.1)	
Less healthy	40	40.8	35.5 (30.4 – 39.9)		-	9 (45.0)	31 (43.1)	
No change	39	39.7	34.5 (29.4 – 41.5)		6 (100.0)	5 (25.0)	28 (38.9)	
Current food amount versus pregnancy				0.433				0.534
More food	31	31.6	33.6 (29.7 – 39.1)		1 (16.7)	7 (35.0)	23 (31.9)	
Less food	35	35.7	33.9 (29.3 – 37.4)		1 (16.7)	11 (55.0)	23 (31.9)	
The same	32	32.6	37.2 (31.4 – 41.6)		4 (66.7)	2 (10.0)	26 (36.1)	
Rate current health				0.079				0.366
Excellent	19	19.4	34.5 (29.4 – 38.7)		-	6 (30.0)	13 (18.1)	
Good	45	45.9	33.8 (29.3 – 37.6)		6 (100.0)	8 (40.0)	31 (43.1)	
Fair	23	23.5	35.9 (30.6 – 43.9)		-	5 (25.0)	18 (25.0)	
Poor	11	11.2	38.9 (31.1 – 45.6)		-	1 (5.0)	10 (13.9)	

[a – b] Post-hoc test: Medians with the same letter do not differ significantly.

*Kruskal Wallis test

4.4.10 Physical Activity Assessment

There was a significant change in the physical activity at work from baseline to follow-up (0.000) (Table 4.13). The number of participants that are working decreased from 59.2% at baseline to 40.8% at follow-up while the number of participants spending time doing work-related standing or walking or definite physical activity increased from baseline (20.4% and 2.0% respectively) to follow-up (23.7% and 5.1% respectively).There was a significant decrease in the number of participants who reported no physical exercise in the last week from 91.8% at baseline to 76.5% at follow-up and those reporting between 1 and 3 hours increased from 4.1% at baseline to 10.2% at follow-up (p=0.000). While cycling was not popular amongst our participants (1.0% at baseline and 3.0% at follow-up), many engaged in walking; 48.9% reported more than 3 hours at baseline and 51.0% at follow-up. Many participants reported 3 hours or more of housework, and the number increased although non-significantly, from baseline (68.4%) to follow-up (90.8%). Overall, while 71.4% of participants were classified as 'inactive' at baseline, only 43.8% were inactive at follow-up. The number of active/moderately active participants increased significantly from 8.7% at baseline to 22.2% at follow-up. There was no significant correlation found between BMI and PAI score at baseline (r= -0.05, p = 0.557) nor at follow-up (r= -0.08, p=0.409).

Table 4. 13 Physical Activity Assessment (GPPAQ)

	BASELINE		*FOLLOW-UP*		
GPPAQ-RELATED INFORMATION	*n*	*Percentage (%)*	*n*	*Percentage (%)*	*p-value**
Physical Activity involved in work:					**0.000***
Not currently working	58	59.2	43	43.8	
Most of the time sitting	18	18.4	15	15.3	
Most of the time standing or walking	20	20.4	23	23.7	
Involves definite physical effort	2	2.0	5	5.1	
Involves vigorous physical activity	0	0.0	0	0.0	
Number of hours in last week spent doing physical exercise					**0.000***
None	90	91.8	75	76.5	
Some but less than one hour	2	2.0	6	6.1	
One hour but less than 3 hours	4	4.1	10	10.2	
3 hours or more	2	2.0	5	5.1	
Number of hours in last week spent cycling:					0.983*
None	97	98.9	93	94.9	
Some but less than one hour	1	1.0	2	2.0	
One hour but less than 3 hours	0	0.0	1	1.0	
3 hours or more	0	0.0	0	0.0	
Number of hours in last week spent walking:					**0.026***
None	8	8.2	8	8.2	
Some but less than one hour	14	14.3	11	11.2	
One hour but less than 3 hours	28	28.6	26	26.5	
3 hours or more	48	48.9	50	51.0	
Number of hours in last week spent doing housework/childcare					0.092*
None	5	5.1	0	0.0	
Some but less than one hour	8	8.2	2	2.0	

One hour but less than 3 hours	18	18.4	4	4.1	
3 hours or more	67	68.4	89	90.8	
Number of hours in last week spent doing gardening					**0.000***
None	88	89.8	82	83.6	
Some but less than one hour	4	4.1	7	7.1	
One hour but less than 3 hours	4	4.1	4	4.1	
3 hours or more	2	2.0	3	3.1	
Physical Activity Index					0.000*
Inactive	70	71.4	43	43.8	
Moderately Inactive	20	20.4	33	33.7	
Moderately Active	6	6.1	11	11.2	
Active	2	2.0	9	9.2	
Physical Activity index					*0.000***
Active/Moderately Active	8	8.7	20	22.2	
Inactive/Moderately Inactive	84	91.3	70	77.8	

*Pearson Chi-Square Test
**McNemar Test
GPPAQ – General Practice Physical Activity Questionnaire

4.4.11 Beliefs in relation to dietary intake and physical activity

Most participants were in agreement (mode=6) with the beliefs related to F&V intake at both baseline and follow-up. For the behavioural beliefs between 41 and 71% of participants believed that F&V help control their weight, make them feel physically better and improve their blood glucose levels. For the normative belief, 40% at baseline and 53% at follow-up agreed that people around them ate F&V. There were no significant changes in beliefs related to F&V intake from baseline to follow-up. Participants who felt confident that they can eat the recommended amount of fruit and vegetables also had significantly higher intakes of F&V (r=0.22, p= 0.034).

At both baseline and follow-up, 50 to 61% of the participants were in agreement for the beliefs relating to the health benefits of eating less fat. Participants did not agree that healthy takeaways and/or street foods were accessible in their surroundings not that they did not have enough time to prepare healthy meals regularly. Participants also disagreed with the statement that eating less fat makes them stay hungry and this belief correlated with lower intake of energy-dense foods (r= 0.25, p=0.016). The belief that participants were expected to eat the food that is being served at social, religious, cultural, work-related events or functions was positively associated with the intake of energy-dense foods (r= 0.28, p=0.005). Participants believed that it was easy to exclude high fat foods from their daily diet and a higher agreement score was associated with a lower intake of energy-dense foods (r=-0.32, p=0.001). Significantly more participants at follow-up up versus baseline agreed with the statement that healthy take-away foods were easy to find in their surroundings (p=0.039). The mode for the belief that they are expected to eat the food served at social events/functions shifted from 2 at baseline to 6 at follow up, however this was not significant (p=0.054). There was a significant change in the belief that low fat/fat free foods are tasty from baseline to follow-up (p=0.008).

The majority of participants were in agreement, both at baseline and follow-up, with the sugar related beliefs. There was a change in the mode for the belief that low sugar/sugar free food are tasty from 2 at baseline to 6 at follow-up, however, this was not significant. Agreement with beliefs that It is easy to exclude sugary foods/snacks/drinks from their daily diet and that low sugar/ sugar-free foods taste good/ are tasty correlated with lower intake of added sugar (r= -0.31, p=0.002 and r= -0.26, p=0.011) and SSBs (r= -0.29, p= 0.004 and r= - 0.27, p=0.007). Participants who believed that foods/snacks/drinks that are low sugar/ sugar free are easy to find in my surroundings had lower the intake of SSBs than those who disagreed (r= -0.34, p=0.000).

Participants were in agreement with most of the beliefs related to physical activity at both baseline and follow-up. At baseline, participants disagreed with the statement that there were no accessible, safe, affordable opportunities for them to be physically active, while at follow-up they were in agreement. The change was however not significant (p=0.165). At baseline, 85.7% of participants agreed that being uncomfortable or overweight makes it difficult to do physical activity while 68.4% agreed at follow-up. The change in this belief was significant (p=0.009). Participants who believed that it is possible to find time for physical activity had a higher PAI (r=0.24, p=0.021).

The majority of participants were in agreement, both at baseline and follow-up, with the fibre related beliefs. No significant correlations were found with the beliefs relating to wholegrains and the intake of high-fibre starches or refined starches.

Table 4. 14 Change in beliefs and behaviours from baseline to follow-up n=98

		BASELINE		FOLLOW-UP			Correlation between beliefs and indicator food groups**
BELIEF TYPE	FRUIT AND VEGETABLE RELATED BELIEFS	Mode	Frequency of mode n(%)	Mode	Frequency of mode n(%)	*p*-value*	Rho (p-value)[1]
BEH	Eating fruits and vegetables every day will make me feel better physically	6	46 (48.9)	6	64 (65.3)	0.949	0,09 (0.361)
BEH	Eating fruits and vegetables every day will help control my weight.	6	52 (53.1)	6	70 (71.4)	0.699	-0,17 (0.092)
BEH	I am confident that I can eat the recommended amount of fruits and vegetables every day.	6	42 (42.8)	6	54 (55.1)	0.736	0,22 (0.034)
BEH	Eating less fruit will help control my blood sugar levels (i.e. to reduce the risk of diabetes).	6	41 (41.8)	6	53 (54.1)	0.718	-0,12 (0.246)
CONT	Fruits and vegetables are affordable	6	37 (37.7)	6	50 (51.0)	0.554	0,11 (0.259)
CONT	Fruits and vegetables are easy to find in the stores/ shops nearby .	6	53 (54.1)	6	71 (72.4)	0.459	-0,09 (0.370)
CONT	Knowing how to control my cravings will make it easier for me to eat more of healthy foods.	6	43 (43.9)	6	57 (58.2)	0.302	-0,11 (0.274)
NORM	Most people who are important to me eat fruits and vegetables every day.	6	40 (40.8)	6	53 (54.1)	0.690	0,08 (0.399)
	FAT RELATED BELIEFS						Rho (p-value)[2]
BEH	Eating less fat will help reduce the risk of diseases e.g. heart disease, cholesterol	6	50 (51.0)	6	60 (61.2)	0.125	-0,00 (0.979)
BEH	Decreasing the amount of fat I eat will help me control my weight.	6	54 (55.1)	6	62 (63.3)	0.129	0,06 (0.557)
BEH	Eating less fat will help control my blood sugar levels (to reduce the risk of diabetes).	6	51 (52.0)	6	61 (62.2)	0.633	0,10 (0.321)
BEH	Eating less fat makes me stay hungry.	2	41 (41.8)	2	54 (56.3)	0.421	0,25 (0.016)
BEH	Healthy takeaways and/or street foods are easy to find in my surroundings.	2	38 (38.8)	2	45 (45.9)	0.039	-0,11 (0.274)
BEH	I do not have enough time to prepare healthy meals regularly.	2	31 (31.6)	2	42 (42.8)	0.790	0,04 (0.699)

		BASELINE		FOLLOW-UP			Correlation between beliefs and indicator food groups**
BELIEF TYPE	FAT RELATED BELIEFS (CONTINUED)	Mode	Frequency of mode n(%)	Mode	Frequency of mode n(%)	*p*-value*	Rho (p-value)[2]
CONT	When I am at events (functions), I am expected to eat the food that is being served (social, religious, cultural, work-related events).	2	34 (34.7)	6	44 (44.9)	0.054	0,28 (0.005)
CONT	Low fat/ fat-free foods taste good/ are tasty.	2	27 (27.6)	6	41 (41.8)	0.008	-0,04 (0.648)
CONT	It is easy to exclude high-fat foods from my daily diet.	6	37 (38.1)	6	50 (51.0)	0.298	-0,32 (0.001)
CONT	Low-fat/healthy fat options are expensive.	6	35 (35.7)	6	48 (49.5)	0.675	0,05 (0.60)
CONT	Knowing how to control my cravings for fatty foods will make it easier for me to eat less fatty food	6	45 (46.4)	6	55 (56.1)	0.225	0,11 (0.289)
NORM	It is important to me to eat less fat if my doctor tells me do so.	6	57 (58.1)	6	64 (66.7)	0.224	0,13 (0.211)
	PHYSICAL ACTIVITY RELATED BELIEFS						Rho (p-value)[5]
BEH	Being physically more active will make me feel healthy and fit (more energy)	6	58 (59.2)	6	76 (77.6)	0.883	0,17 (0.103)
BEH	Being uncomfortable/ heavy (overweight) after pregnancy makes it difficult to do physical activity (or exercise).	6	48 (48.9)	6	47 (48.5)	0.009	0,00 (0.964)
BEH	Meeting the recommended levels of physical activity (150 min per week) is hard for me.			2	41 (42.3)	-	-0,16 (0.126)
BEH	Being physically active (exercise) helps to control my weight.	6	55 (56.1)	6	72 (73.5)	0.533	0,02 (0.779)
CONT	Finding time to be physically more active is possible.	6	46 (47.4)	6	54 (55.1)	0.060	0,24 (0.021)
CONT	There are no accessible, safe, affordable opportunities for me to be physically active.	2	32 (32.6)	6	44 (44.9)	0.165	-0,14 (0.180)
CONT	I am confident that I can increase my levels of physical activity (be physically more active).	6	45 (45.9)	6	72 (73.5)	0.162	0,13 (0.194)
NORM	People who are important to me will support me to be physically more active.	6	47 (47.9)	6	76 (77.6)	0.447	0,10 (0.344)
NORM	Having an exercise “buddy” or “group “will help me to be physically more active	6	49 (50.0)	6	64 (65.3)	0.238	0,11 (0.267)

		BASELINE		FOLLOW-UP			Correlation between beliefs and indicator food groups**	
BELIEF TYPE	SUGAR RELATED BELIEFS	Mode	Frequency of mode n(%)	Mode	Frequency of mode n(%)	*p*-value*	Rho (p-value)[3]	Rho (p-value)[4]
BEH	Eating less sugary foods/snacks/ drinks will help reduce the risk of diabetes in the future.	6	45 (45.9)	6	57 (58.2)	0.197	-0,14 (0.159)	-0,09 (0.363)
BEH	Decreasing the amount of sugary foods/snacks/ drinks I eat will help control my weight.	6	53 (53.1)	6	72 (73.5)	0.920	-0,01 (0.875)	0,01 (0.883)
BEH	It is important to limit my intake of sugary foods/snacks/ after my pregnancy	6	56 (57.1)	6	75 (76.5)	0.180	-0,12 (0.251)	-0,10 (0.320)
BEH	Eating/drinking less sugary foods/snacks/drinks is up to me.	6	46 (46.9)	6	66 (67.3)	0.579	-0,04 (0.701)	-0,03 (0.742)
CONT	It is easy to exclude sugary foods/snacks/drinks from my daily diet.	6	32 (32.6)	6	52 (53.1)	0.316	-0,31 (0.002)	-0,29 (0.004)
CONT	Foods/snacks/drinks that are low sugar/ sugar free are easy to find in my surroundings.	6	41 (42.3)	6	55 (56.1)	0.510	-0,10 (0.307)	-0,34 (0.000)
CONT	Knowing how to control my cravings for sugary foods/snacks/ drinks will make it easier for me to eat less of these food.	6	50 (51.5)	6	54 (56.3)	0.170	-0,05 (0.602)	-0,01 (0.891)
CONT	Low sugar/ sugar-free foods/snacks/ drinks are expensive.	6	43 (43.8)	6	47 (47.9)	0.249	0,02 (0.848)	0,07 (0.504)
CONT	Low sugar/ sugar-free foods taste good/ are tasty.	2	29 (29.6)	6	35 (35.7)	0.143	-0,26 (0.011)	-0,27 (0.007)
NORM	People around me eat/serve sugary foods/snacks/drinks at most events/ functions (social, religious, or work events)	6	38 (38.7)	6	68 (69.4)	0.188	0,15 (0.130)	0,11 (0.287)
	FIBRE (WHOLEGRAIN) RELATED BELIEFS						Rho (p-value)[6]	Rho (p-value)[7]
BEH	It is easy to include high fibre/ wholegrain bread and cereals my daily diet.	6	39 (39.8)	6	56 (57.1)	0.893	-0.17 (0.103)	0.13 (0.200)
BEH	Eating wholegrain bread and cereals every day will help control my weight	6	48 (48.9)	6	74 (75.5)	0.806	0.01 (0.892)	-0. 06 (0.568)
BEH	Eating more high fibre/ wholegrain food/ snacks keeps me fuller for longer.	6	51 (52.0)	6	63 (64.3)	0.790	-0.13 (0.219)	-0.07 (0.487)
CONT	High fibre/ wholegrain bread and cereals foods taste good/ are tasty.	6	41 (41.8)	6	52 (53.1)	0.314	-0.05 (0.638)	-0.07 (0.453)

		BASELINE		FOLLOW-UP			Correlation between beliefs and indicator food groups**	
BELIEF TYPE	FIBRE (WHOLEGRAIN) RELATED BELIEFS (CONTINUED)	Mode	Frequency of mode n(%)	Mode	Frequency of mode n(%)	*p*-value*	Rho (p-value)[6]	Rho (p-value)[7]
CONT	Foods and snacks that are high in fibre/ whole grain are easy to find in my surroundings.	6	47 (48.4)	6	63 (64.3)	0.569	-0.15 (0.146)	-0.09 (0.360)
CONT	High fibre/ wholegrains breads and cereal are expensive.	6	46 (47.9)	6	54 (56.9)	0.387	0.01 (0.907)	0.01 (0.907)
CONT	I am confident that I can eat more high fibre/ wholegrain foods and snacks every day.	6	39 (40.2)	6	52 (53.1)	0.563	0.00 (0.929)	0.00 (0.960)

The bipolar endpoints were expressed as a 7-point Likert scale namely, 1 = strongly disagree, 2 = disagree, 3 = disagree somewhat, 4=neither agree nor disagree, 5=agree somewhat, 6=agree, 7=strongly agree; categorised as AGREE (5-7), NEUTRAL (4), DISAGREE (1-3)
BEH = Behavioural beliefs: are the perceived consequences (positive or negative) of the behaviour ; CONT= Control beliefs: are factors that facilitate or hinder the behaviour; NORM = Normative beliefs: extent to which other people are important to them think they should or should not perform a certain behaviour (Ajzen, 1991)*
*Wilcoxon Paired Test
**Spearman rank order correlations:
[1]Correlation between the score of F&V related beliefs at follow-up with F&V intake at follow-up
[2]Correlation between the score of fat related beliefs at follow-up with Energy-dense food intake at follow-up
[3]Correlation between the score of sugar related beliefs at follow-up with sugar intake at follow-up
[4]Correlation between the score of sugar related beliefs at follow-up with SSB intake at follow-up
[5]Correlation between the score of physical activity related beliefs at follow-up with physical activity index at follow-up
[6]Correlation between the score of wholegrain related beliefs at follow- up with high fibre starches intake at follow-up
[7]Correlation between the score of wholegrain related beliefs at follow-up with refined starches intake at follow-up

4.4.12 Beliefs related to diabetes risk

As per Table 4.15, the first six beliefs show that the majority of participants were in agreement with the beliefs relating to diabetes risk. The majority of participant (86.7%, 83.6% and 80.6%) agreed that they would need to change their eating habits, food choices and cooking practices respectively, should they develop diabetes.

Table 4. 15 Beliefs relating to diabetes risk

BELEIFS RELATED TO DIABETES RISK	**STRONGLY DISAGREE / DISAGREE n(%)**	**SOMEWHAT DISAGREE/ NEUTRAL/ SOMEWHAT AGREE n(%)**	**STRONGLY AGREE / AGREE n(%)**
Having a healthy body weight will help me to reduce my chances of developing diabetes.	4 (4.1)	1 (1.0)	93 (94.9)
I have a higher risk of developing Gestational Diabetes in my next (or a future) pregnancy.	11 (11.2)	10 (10.2)	77 (78.6)
I am concerned about my risk of developing Gestational Diabetes during my next (or a future) pregnancy.	7 (7.1)	7 (7.1)	84 (85.7)
As I had diabetes in my last pregnancy, I have a higher risk of developing diabetes in the future.	11 (11.2)	10 (10.2)	77 (78.6)
I am concerned about my risk of developing diabetes and its associated complications.	3 (3.1)	4 (4.1)	91 (92.6)
It is important to me to reduce my risk of developing diabetes.	2 (2.0)	1 (1.0)	95 (96.9)
If I was to develop diabetes, I would need to eat specific foods that are different to the rest of my family	19 (19.4)	10 (10.2)	69 (71.1)
If I develop diabetes, I would need to change my current eating habits	10 (10.2)	3 (3.1)	85 (86.7)
If I develop diabetes, I would need to change my current food choices	12 (12.2)	4 (4.1)	82 (83.6)
If I develop diabetes, my current cooking practices would have to change	15 (15.3)	4 (4.1)	79 (80.6)
The dietary advice that I received for managing my blood sugar levels after pregnancy was helpful	29 (29.6)	6 (6.1)	63 (64.3)

The bipolar endpoints were expressed as a 7-point Likert scale namely, 1 = strongly disagree, 2 = disagree, 3 = disagree somewhat, 4=neither agree nor disagree, 5=agree somewhat, 6=agree, 7=strongly agree.

4.5 DISCUSSION

In this sample of principally Black and Coloured (Mixed Ancestry) women who attended two hospitals in the Cape Town metropole for managing their GDM, most had secondary level education, were unemployed with medium to high LSM. The diabetes management reported was mainly diet and other lifestyle change and Metformin. One third required Insulin during the index pregnancy. Most participants reported checking their blood glucose levels postpartum, however only very few did the recommended OGTT at 6 weeks postpartum. While, several risk factors are known to contribute to the development of T2DM post GDM, BMI, diet, physical activity, breastfeeding and psychosocial beliefs were explored in this study.

With regards to BMI, the majority of our sample was obese (BMI≥30kg/m^2). SADHS (2016) reported that 24% of women were severely obese (BMI ≥ 35kg/m^2) with a higher prevalence of severe obesity amongst Black and Coloured (Mixed Ancestry) women. While severe obesity was most prominent in the same ethnic groups, the percentage in our sample was double that reported by SADHS (Statistics South Africa, 2016). He et al. (2015) reports that postpartum practices such as breastfeeding for 3 to 6 months may assist in losing weight postpartum. However, the participants were interviewed at 5.4 months' post GDM pregnancy, yet, less than half of those with infants less than 6 months were exclusively breastfed at the time of interview. Breastfeeding is important not only for the mothers' postpartum weight management, but also for the infants. While the majority of the infants were born at a weight appropriate-for-gestational (AGA), being born from a GDM pregnancy, they are at risk of adiposity, impaired glucose tolerance and cardiovascular health problems in adulthood (Tieu et al., 2017). Although WHO (2003) recommends introducing of complementary foods at 6 months of age, 18% of participants reported starting their infant with weaning foods earlier than 6 months.

The results of this study demonstrate significant changes between the dietary intake during GDM pregnancy and postpartum. In Krige et al. (2018) it was demonstrated that these women were exposed to dietary education and may or may not have had a consultation with a dietitian during their pregnancy but nevertheless failed to meet the dietary recommendations for GDM pregnancy. In this follow-up study, when scored for the indicator food groups, there was a significant decrease in the diet score from GDM pregnancy to follow-up, showing a regression in the diet quality of the participants. Failure to maintain dietary changes from GDM pregnancy to postpartum have been reported by Stage et al., (2004) in Denmark and Fehler et al. (2007) in Canada. No such studies have previously been conducted in South Africa. The indicator food groups which contributed mostly to the worsening of the dietary intake/ or quality post pregnancy were an increase in the intake of refined starches, table sugar, SSBs, and energy-dense foods.

Our study showed that the consumption of refined starches increased while the intake of high fibre starches and F&V decreased at follow-up. As per the beliefs, the participants agreed that F&V were affordable however, the majority found that whole grain bread and cereals were more expensive. This is also found in a study by Temple and Steyn (2011b) who found that healthier food options including whole grain bread and brown rice were more expensive than white bread and white rice respectively. Yet, our study shows that the participants made more efforts to eat unrefined starches during their pregnancy compared to postpartum. Among the refined starches in the indicator food groups, white rice, white pasta, refined cereals and maize meal were frequently consumed. In South Africa, maize is the principle grain crop and the staple food for the majority of South Africans and white maize is mainly for human consumption, while yellow maize is used as animal feed (SADAFF, 2016). The whiter and more refined maize meal is the preferred and the most consumed type of maize meal by South African consumers (Khumalo 2011). However, Khumalo et al, (2011) found that female maize meal consumers in Giyani, Limpopo province in South Africa, were willing to accept yellow unrefined maize meal for nutritional purposes. In our study, the two main beliefs showing significant correlation with refined staple consumption were beliefs pertaining to taste and price, with participants finding wholegrains to be expensive. With studies such as that by Khumalo et al (2011) showing potential acceptability by South African consumers; nutrition interventions for GDM and post GDM women could target the health benefits of less refined starches such as yellow maize meal. Indeed, replacing refined starches with unrefined ones could reduce the overall carbohydrate and added sugar intake. While there are no guidelines for the ideal percentage of calories from carbohydrates, protein and fats, SEMDSA (2017) does suggest that macronutrient distribution be individualised for people with or at risk of developing T2DM. In our study, the consumption of both carbohydrates and added sugar increased significantly postpartum.

From our indicator food groups, table sugar intake doubled and SSBs increased significantly from baseline to follow-up. According to University of Witwatersrand (2016) South Africans consume between 12 and 24 teaspoons of sugar per day of which 4 to 8 teaspoons are from SSBs. With high consumption in the general population, it is likely that our participants had a high intake of sugar and SSBs even before pregnancy. However, they managed to decrease their sugar intake during pregnancy, and returned to their previous consumption level postpartum. This population of women is at risk of developing T2DM and the belief statements relating to diabetes risk demonstrate that the participants are aware of this (Table 4.14). While the social constructs around behaviour change are very complex they are not limited to behaviour change alone. Environmental factors (Kremers et al., 2006), sociodemographic factors (Krige et al., 2012), laws and policies play a huge role in determining the eating patterns of a population. The South African sugar tax for example was implemented in April 2018 and aims to reduce the consumption of SSBs by increasing the price of beverages containing more than 4g sugar per 100ml (SARS, 2018; University of Witwatersrand, 2016). Future studies will be able to compare sugar consumption before and after the sugar tax law.

Amongst the indicator food groups, the intake of pulses increased significantly while consumption of processed meats decreased significantly from baseline to follow-up. Overall, the median (IQR) for protein remained similar at baseline and at follow-up. However, the distribution of percentage protein decreased significantly from baseline to follow-up; the number of participants consuming 10-15% of their total energy from protein almost doubled from baseline to follow-up. The most likely reason for a change in source of protein may have been that during pregnancy, women crave for meaty foods as reported by Orloff and Hormes (2014). After pregnancy, without cravings the participants may have opted for pulses as their source of protein rather than the meats. Alternatively, they may have replaced protein foods with carbohydrates.

As for energy-dense food, their intake doubled from baseline to follow-up. However, the increase in intake of fats from baseline to follow-up was not significant. In this study, the food items in the energy-dense category are traditionally high fat foods and homemade such as muffins, cake, tarts, cheesecake, and pudding. However, nowadays, these products are mostly bought and the food industry promote their products as 'low-fat' only to increase the sugar content of these foods (Nguyen, Lin and Heidenreich, 2016). It is possible that as a result, consuming energy-dense foods increase the carbohydrate intake more than the fat. This may be a target for nutrition intervention amongst GDM and post GDM women; to consume less industrially processed food such as 'snack' and take-away foods and wherever possible, to cook or bake homemade meals. Interestingly, the belief that one is expected to eat the foods being served at social events was significantly and positively associated with the intake of energy-dense foods. Furthermore, disagreement with the belief that eating less fat makes you stay hungry and agreement with the belief that it is easy to exclude high fat foods were significantly associated with the intake of energy-dense foods. This shows that participants may, at an individual level be willing to exclude energy-dense food, but being exposed to energy-dense foods at social events may influence their choices. While the TPB suggests that intention is the immediate precursor of behaviour (Ajzen, 2012), discrepancies may arise between intention and behaviour. Indeed, Schwarzer (2008) suggests that this may be due to several reasons one of which being that people might give in to temptations. One strategy to remedy this is coping planning. Coping planning is learning to develop appropriate strategies to cope with barriers which arise when adopting and maintaining new behaviours (Schwarzer, 2008). Assisting post GDM women with coping plans for social events or functions may be beneficial to post GDM interventions. Such coping plans may include choosing from the healthier food platters, bringing their own food to events or not going to events on an empty stomach to avoid overindulging on the energy-dense foods.

The intake of F&V remained low at both baseline and follow-up, and the slight increase in median (IQR) was not significant. At both times, the majority of participants fell short of the recommended 400g/day.Agreement with the control beliefs relating to F&V indicated that they were aware of the health benefits of eating more F&V such as assisting weight loss, feeling better physically and controlling their blood glucose levels. Agreement with the behavioural beliefs indicated the participants' perceived ease in consuming more F&V such as F&V are affordable or are easy to find in the stores/shops nearby. Agreement with the normative beliefs shows that participants believed they had support from family or peers to consume more F&V. While the beliefs relating to the intake of F&V are conducive to consuming more F&V, it is not represented in the reported intake of the participants. The belief that participants are confident to be able to consume more F&V had a positive and significant association with the intake of F&V. This shows that participants had the knowledge and motivation to increase their F&V intake, however other factors may have opposed to this change. As suggested by Krige et al. (2018), the reason may be due to affordability and accessibility of F&V (Temple and Steyn, 2011a). Interestingly, the change in F&V consumption had no significant association with the employment status or level of education.

The participants were more physical active at follow-up as compared to baseline as illustrated by an increase in the Physical Activity Index. While 72% of participants were inactive during pregnancy this percentage decreased significantly to nearly half post-pregnancy. However, the percentage remaining inactive and moderately inactive amongst our sample is still high (77%). There was a significant increase in the percentage of participants engaging in definite physical activity and gardening from baseline to follow-up. Participants who were employed post-pregnancy were significantly more activity at work. Interestingly, a study by Malambo et al. (2016) reported high levels of inactivity amongst overweight and obese working Black South African women. Furthermore, Malambo et al. (2016) found that in South Africa, women were 34% less likely to engage in vigorous physical activity and that rural inhabitants were more inactive than urban inhabitants. Physical inactivity, overweight and obesity and an unhealthy diet are risk factors for the development of T2DM (WHO, 2015). However, we did not find an association between BMI and PAI score. Participants believed that finding time to be physically more active was possible and that having and exercise buddy would help them to be more active. Encouraging post GDM women to participate in regular MVPA (Moderate to Vigorous Physical Activity) of 150mins per week and reducing sedentary behaviour during pregnancy and postpartum are important health messages to communicate during and after a GDM pregnancy to prevent T2DM (Johnson et al., 2016).

Furthermore, practical ways of including physical activity in daily activities could be encouraged as well as encouraging physical activity in the work environment.

A major concern amongst post GDM women is weight, as being overweight/obese contributes to the risk of developing T2DM. In our sample of women, almost half were classified with severe obesity according to their BMI. As per their perceived weight, the majority of the participants correctly identified the thin, normal weight and overweight body images and the overweight participants correctly identified themselves with the overweight body image. The obese participants wanted to look like the overweight figures and the overweight and normal weight participants wanted to look like the normal weight figures. This shows that participants are realistic in terms of weight loss goals. Indeed, the majority of the obese participants said to want to lose more than 5kg but half of the overweight participants wanted to stay the same weight. Overall, more than half of the participants wanted to look like the overweight figure showing than they actually desired to be heavy. This is a factor in African communities whereby, being overweight or 'fat' is associated to good health and prosperity, there is desire amongst women to be overweight. Indeed, studies have shown that there is stigma attached to being underweight in black communities. Furthermore, irrespective of their HIV status, thin people are perceived to be sick and HIV infected and are often rejected from their community (Hurley et al., 2011; Matoti-Mvalo and Puoane, 2011). While the HIV status of participants was not disclosed in the study, this reality cannot be disregarded. Social stigmas with regards to body weight within the Coloured communities are unknown. Interestingly, while being overweight was a desirable trait amongst the participants, obesity was less well perceived. Most of the obese participants were unhappy with their current weight and wanted to lose weight. While body weight perception was not the main focus of this research, the results from this study reveals a need for body weight intervention in post GDM women.

Finally, as per the dietary analysis, the diet of the participants changed after pregnancy yet the majority of participants reported that their current food choices were similar to during the index pregnancy. In term of the amount, more than half reported having the same or more than during pregnancy. Their current eating behaviours were not in line with diabetes management/prevention yet their beliefs with regard to their risk of developing diabetes showed that they were informed and concerned about their risk of developing GDM and/or T2DM in the future. The participants agreed that they would need to change their eating habits, food choices and cooking practices respectively, should they develop diabetes. This shows that the participants may not be aware that a 'diabetic diet' is in fact a healthy and balanced diet for them and should be the same for the whole family.

4.6 CONCLUSION AND RECOMMENDATIONS

Overall, this study demonstrated the change of diet of women in Cape Town from GDM pregnancy to postpartum, while certain changes were favourable to reducing the risk of developing T2DM such as increase in pulses, decrease in processed meats and an increase in physical activity, others were not. A major concern lies in the increased carbohydrate intake from refined starches, added sugar and SSBs. Unfortunately, the beneficial dietary changes, did not make up for the risky diet changes. This study demonstrated that in the absence of GDM, participants failed to maintain the dietary efforts made during pregnancy such as reducing the intake of added sugar and SSBs. Although the physical activity level improved slightly, the overall dietary trend, would favour weight gain rather than weight loss in the participants which would add to the risk of developing T2DM. While behaviour change may be complex, this study demonstrates that with support and education these women are capable of changing their diet even if only for the duration of the pregnancy. It therefore, necessary that advice and information be continued postpartum to sustain lifestyle changes as supported by Stage et al., (2004).

Recommendations for diet targeted interventions post GDM in the South African context should focus on (1) increasing F&V intakes, (2) increasing high fibre foods, such as unrefined starches and pulses (3) decrease the amount of added sugars and SSBs and favour home-made products to industrially produced foods. (4) Time management towards including or increasing daily physical activity level. (5) Coping planning strategies for social events or functions.

Chapter 5: Conclusion and Recommendations

The prevalence of diabetes and obesity is growing worldwide and South Africa has not been spared of the trend. Globally, in 2014, 8.5% of adults above 18 years were affected by diabetes which is the leading cause of blindness, kidney failure, heart attacks and lower limb amputations. As for obesity, in 2016, 13% of adults above the age of 18 were obese (WHO, 2018). In South Africa, an estimated 41% of women are obese (World Obesity Observatory, 2016) while 5.4% of adults are affected by T2DM (IDF, 2017) and these figures are expected to increase in the coming decades (OECD, 2017). Obesity is a risk factor for non-communicable diseases such as diabetes and GDM. Women who have had GDM are at higher risk of developing T2DM compared to women who had a normal pregnancy (Minooee et al. (2017). In South Africa, GDM is managed closely at hospitals in the public sector, however, once women have delivered their baby, they are lost to the healthcare system. Lifestyle interventions are critical both during and after pregnancy to prevent or delay the onset of T2DM. In an endeavour to launch a lifestyle intervention for these women, a formative assessment of their dietary intake, physical activity and beliefs relating to these lifestyle factors during and after pregnancy as well as their weight status and factors that may influence their weight management strategies post-partum was necessary to target relevant and culturally acceptable messages.

Two hundred and thirty-nine women, aged 32.2 (5.3) years in their third trimester of pregnancy with a confirmed diagnosis of diabetes in pregnancy were recruited and considered our baseline sample. Half of the sample was Mixed ancestry, 34.7% were Black, and the remaining 6.5% were either White or Indian. Most of the participants had secondary level education, were unemployed with medium to high LSM. From the baseline sample, 98 were interviewed 5.4 months postpartum and were considered our follow-up sample. At follow-up, three quarters of the participants were obese, which is much higher than the obesity prevalence for South African women (SADHS 2016). Furthermore, half of the participants were severely obese (BMI≥35kg/m^2) and 98.7% had a waist circumference of 88cm or above. It is problematic that most of the participants actually desired to be heavy as they wanted to look like the overweight/obese images and were happy or somewhat happy with their weight. This is likely to be for cultural reasons. In term of weight loss goals, the majority of the obese participants indicated that they want to lose more than 5kg but it is concerning that half of the overweight participants wanted to stay the same weight. While, one of the limitations of the baseline study was failure to report pre-pregnancy weight or BMI, these figures suggest that a majority of the participants were likely to have been overweight or obese pre-pregnancy. This may be of concern for the foetus. A study by Lesseur et al (2014) on the relationships between maternal prepregnancy obesity and gestational diabetes and placental DNA methylation demonstrated that infants exposed to prepregnancy obesity and gestational diabetes, had higher placental leptin methylation. Altered leptin profile in utero may contribute to the lower expression of appetite regulators, affect feotal neural development, and, contribute to metabolic programming of obesity and related disorders in adulthood. It is also concerning that 1 in 10 infants were born prematurely as these infants are at increased risk of developing pulmonary, cardiovascular and metabolic disorders later in life (Luu et al., 2016).

During pregnancy, the participants attempted to improve their dietary intake, however they still fell short of several nutritional guidelines. At follow-up it was clear that they ate more table sugar, SSBs, refined starches and energy-dense foods. Furthermore, the overall diet score decreased significantly showing an unhealthier diet at follow-up compared to baseline. This demonstrates that they failed to maintain the dietary changes made during pregnancy.

The macronutrient distribution as a percentage of TE was not optimal at baseline when compared to the SEMDSA (2017) guidelines for GDM that recommends carbohydrates to be up to 40% of TE, 40% of TE from fats and 20% TE from protein as well as other international associations recommending carbohydrates <50% of TE for GDM women. At both baseline and follow-up, the carbohydrate intake was above 50% TE. The median(IQR) of protein as a % TE decreased significantly from baseline to follow-up. As for fats, the distribution remained at 31% TE at baseline and follow-up. A higher carbohydrate intake could be expected from developing countries as starches such as maize meal provide the most economical source of food. At baseline, many participants' micronutrient intake fell short of the recommendations in pregnancy and there were no significant increases were found at follow-up. This is likely to have been due to the high intake of energy-dense, nutrient poor foods such as SSBs and added table sugar and a low intake of F&V.

On the whole, the diet of participants was significantly higher in carbohydrates and added sugar at follow-up than at baseline. Considering the risk of diabetes, a major concern amongst our participants was the intake of SSBs, table sugar and refined starches. Although it is recommended to exclude SSBs and added sugars in persons with diabetes, 63% of the women at baseline reported drinking up to half a small glass (125ml) SSBs daily and 65.3% of participants reported adding table sugar to hot beverages or porridge. The mean intake of sugar doubled and SSBs increased significantly from baseline to follow-up. Amongst the pregnant women, a higher intake of SSBs was found in younger women. Participants who self-reported that their diet consists mostly of 'unhealthy food choices' had higher intakes of both table sugar and SSBs. At baseline and follow-up, those who believed that It is easy to exclude sugary foods/snacks/drinks from their daily diet had a lower intake of added sugar and SSBs.

The consumption of refined starches increased significantly. The participants, in the absence of GDM symptoms, opted for the more refined starches like white maize meal, white rice and pasta which were likely cheaper than the unrefined equivalents. Indeed, the majority believed that whole grain bread and cereals were expensive. Furthermore, energy dense snacks including fried foods, muffins, cake, tarts, cheesecake, pudding were highly consumed amongst the participants, especially at follow-up. Indeed, their intake doubled from baseline to follow-up. The beliefs relating to fats and fatty foods showed, social factors were likely to have influenced food their choices related to energy-dense foods. Nutrition education directed at eating less industrially processed food such as 'snack' and take-away foods and wherever possible, to cook or bake homemade meals may be beneficial to these women.

The intake of F&V was low at both baseline and follow-up, and failed to meet the FAO/WHO recommendation of 400g per day. Furthermore, the intake of F&V decreased significantly from baseline to follow-up. At baseline, participants who consumed more F&V believed that these items are easy to find in shops close to them and that they make you feel better physically. At follow-up, more participants believed that eating F&V made them feel better physically and can help control their weight, as well as being affordable. However, none of the sociodemographic factors tested, including LSM, were associated with the consumption of F&V. Participants who felt confident that they can eat the recommended amount of fruits and vegetables had significantly higher intakes of F&V than those that did not feel confident in eating the recommended amount of F&V.

While the dietary intake of post pregnancy deteriorated by an increase in the intake of refined starches, table sugar, SSBs, and energy-dense foods, improvements were found in the significant increase in pulses and a decrease in the consumption of processed meats from baseline to follow-up. Pulses are high in fibre and are not only a healthier alternative to processed meats but also a cheaper source of protein. Nutrition education to support this change should be encouraged during and after pregnancy.

The majority of participants at both baseline and follow up were inactive or moderately inactive and fell below the recommended WHO (2010) recommendations of 150min/week. However, improvements were found in the participants' physical activity level at follow-up. Indeed, the percentage of participants that were 'active' and 'moderately active' increased significantly from baseline to follow-up. When comparing physical activity levels during pregnancy with postpartum, the number of women engaging in physical exercise whether at work or out of work increased significantly postpartum. It is however important to note that women were interviewed in there 3rd trimester of pregnancy and therefore limited exercise is expected. After the birth of their baby, women were significantly more engaged in childcare at follow-up. This is coherent to similar studies by Lie et al., (2013) who stated that the main barriers to healthy eating and physical activity behaviours in the immediate post-natal period were due to recovery from GDM, tiredness, maternal attachment and the demands of childcare. Participants believed that being uncomfortable or overweight makes it difficult to do physical activity, significantly less participants believed so at follow-up. Also, participants who believed that it is possible to find time for physical activity were more active. Physical activity post GDM is important in diabetes prevention and therefore interventions aimed at supporting women in the postpartum period are essential. Practical ideas may be to encourage mothers to create exercise groups, homebased exercises or engaging in daily activities with more intensity, such as when walking, to walking briskly. Physical Activity in South Africa is greatly associated with social context as stated by Malambo et al. (2016). Indeed, women in rural areas engage in less physical activity as physical activity is of lower intensity there as compared to urban areas. Also, women living in townships have less access to safe opportunities to do physical activity.

Overall the participants' beliefs in relation to their diabetes risk were not coherent with their behaviour. Indeed, their dietary intake regressed significantly, yet 40% stated that their current food choices were similar to during the index pregnancy and 19% stated that their food choices had improved. The participants' beliefs with regard to their risk of developing diabetes showed that they were informed and concerned about their risk of developing GDM and/or T2DM in the future and agreed that they would need to change their eating habits, food choices and cooking practices, should they develop diabetes. The majority believed that they must eat specific foods different to the rest of family should they be diagnosed with diabetes. This belief is wrong as people diagnosed with diabetes should eat a healthy and balanced diet like the rest of their family. The majority of participants were adopting diet and lifestyle changes to manage their diabetes but failed to maintain these changes postpartum. Their poor dietary behaviours were shown in the fact that while most of the participants were able to stop pharmacological management in the early postpartum period, a small percentage were still on medication or had to be reinitiated at the time of follow-up.

Recommendations

In the current South African context, women with GDM in the public sector receive basic hospital care with little or no dietary intervention. The IINDIAGO project is an integrated health system intervention aimed at reducing T2DM in disadvantaged women after GDM in South Africa. The intervention will be located at community-based Well Baby clinics where ongoing healthcare will provide support to the mother postpartum and assist her to maintain the lifestyle changes she may have undertaken in pregnancy and have the added benefit of improving the baby's nutrition and the family's lifestyle, thus ultimately reducing diabetes risk among the family as a whole. With the current data from this project, we recommend that key-nutrition messages for women who had GDM should be focussed on the following:

- Proper dietary counselling and intervention need to begin from pregnancy with a focus on life-long lifestyle changes.
- Education is needed with regards to the excess intake of SSBs and added sugar in GDM and diabetes prevention.
- Encourage women to meet the recommendations of 400g/d for F&V and 28g/d for fibre;
    - This may be achieved by encouraging home-grown vegetable gardens.
    - Providing support to communities with spaces to grow vegetables and basic agricultural equipment.
    - Educate pregnant women with GDM on how to incorporate fruit and vegetables in their cooking by providing practical recipes or meal ideas with locally available fruit and vegetables.
- Supporting the consumption of wholegrain starches as a healthier option to refined starches – this applies not only to brown bread but also coarse maize meal, brown rice and whole-wheat pasta.
- Educate pregnant women with GDM to limit their intake of energy-dense foods, table sugar and SSBs, both during pregnancy and after, and favour home-made products to industrially produced foods.
    - This may be achieved by providing culturally acceptable and practical recipes.
    - Encouraging women to connect and share ideas and recipes to stay healthy.
    - Messages should be focused on young pregnant women.
    - Coping planning should be taught to women to enable them to manage their dietary intake when exposed to energy-dense food such as at social events/ functions or in the workplace.
    - Alternatives to SSB can be given, such as flavoured water using fresh fruit or mint leaves.
- Women with GDM need to be informed on the importance of regular diabetes check-ups post GDM.
- Encouraging the consumption of pulses as an affordable source of protein and fibre and discouraging the consumption of processed meat products which are high in fat salt and nitrates.
- Finding ways to promote physical activity in the South Africa context for both urban and rural inhabitants. This may be in terms of exercising in groups rather alone for both safety and

motivation, giving practical exercises that can be done at home with improvised equipment available in the household and how to integrate physical activity in daily activities with their babies and household chores.

- Future research should investigate the optimal macronutrient distribution for optimal glucose control.

Limitations

- Another dietary intake method such as a 24-hour recall was not used to validate the FFQ results.
- There is a chance that participants under-reported their dietary intake to impress the fieldworker by not admitting 'unhealthy foods' or due to memory gaps common when recalling items over the last 2 weeks. Nevertheless, the results already indicate that their dietary intake is not optimal and should be improved.
- Body weight was not measured during pregnancy, however pre-pregnancy weight and BMI classification would be the ideal measures for the estimation of caloric requirements. However, it is well known that the majority of women within the public sector do not know their pre-pregnancy weight and it would require a longitudinal follow-up from pre-pregnancy to post-pregnancy to fully investigate weight change in these women.
- The questionnaire took about 40 minutes to complete and participants may have found this long and tiresome. However, fieldworkers did ensure that participants were comfortable, could use the restrooms or eat during the questioning if desired to alleviate the burden of participation as much as possible.
- Sampling for the follow-up study may have been biased as it was based on the ability to contact participants and the willingness for them to participate in the study. However, statistical analysis was done between the participants who only completed the baseline assessments versus those who completed both baseline and follow-up assessments, and no significance was found between the sociodemographic variables tested. Those who did not continue with the study had a higher energy and carbohydrate intake and may therefore have had an unhealthier dietary intake than those who continued in the study. Participants who did not continue in the study were likely to have been less concerned about their health. This could have influenced the study outcome, by strengthening the results observed, as the diet in the 98 that follow-up shows significant changes towards an unhealthier diet as compared to during pregnancy.
- Participants may have received dietary education at some point between the baseline interview and follow-up which could have influence their responses.

- The use of field workers for data collection could have created slight inconsistencies in the administration of the questionnaires, however all fieldworkers were well-trained and standardized before data collection started.

Final conclusion

On a dietary level, pregnant women with GDM in Cape Town fell short of the dietary guidelines of local and international associations as carbohydrate intake are high and protein and fat intakes are low. Inadequate amounts of dietary fibre, F&V and key micronutrients important for pregnancy were consumed and the intake of energy-dense foods and snacks, added table sugar and SSBs were too high. The study reveals beliefs underlying the dietary intake of F&V, table sugar and SSB. The strongly held beliefs regarding sugary foods/drinks may contribute to poor adherence to nutritional guidelines. Our follow-up study successfully identified changes in dietary from GDM pregnancy to postpartum. With an already high intake of sugar and SSBs during pregnancy, their intake increased further postpartum, adding to their risk of developing T2DM. These women showed that they are capable of changing their diet as seen in this study, whether only for the duration of a pregnancy under the pressure of a 'fear factor' however their efforts failed to be maintained in the absence of GDM.

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APPENDIX A

nutrients

MDPI

Article

Dietary Intake and Beliefs of Pregnant Women with Gestational Diabetes in Cape Town, South Africa

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Abstract: This study investigated the dietary intake of pregnant women with gestational diabetes mellitus (GDM) and their beliefs relating to the consumption of fruits and vegetables (F&V) and sugary foods and drinks. A cross-sectional study was conducted on 239 pregnant women with GDM in Cape Town. Dietary intake was assessed using a quantified Food Frequency Questionnaire and beliefs relating to food choices were assessed using the Theory of Planned Behaviour (TPB). The mean energy intake was 7268 KJ, carbohydrate was 220 (±104.5) g, protein 60.3 (±27.5) g and fat 67.7 (±44.2) g. The macronutrient distribution was 55% carbohydrates, 14.5% protein and 30.5% fat of total energy. The majority of the sample had inadequate intakes of vitamin D (87.4%), folate (96.5%) and iron (91.3%). The median (IQR) amount of added table sugar and sugar sweetened beverages (SSBs) was 4.0 (0.00–12.5) g and 17.9 (0.0–132.8) mL per day, respectively. Only 31.4% met the recommendation (400 g per day) for F&V. Beliefs that it was not easy to exclude sugary foods/drinks and that knowing how to control cravings for sugary foods/drinks are areas to target messages on the sugar content of SSBs. In conclusion, the dietary intake of these women was not optimal and fell short of several nutritional guidelines for pregnant women with hyperglycaemia. The strongly held beliefs regarding sugary foods/drinks may contribute to poor adherence to nutritional guidelines among pregnant women with GDM in South Africa.

Keywords: hyperglycaemia first detected in pregnancy; gestational diabetes; GDM; dietary intake; beliefs; SSBs; fruits and vegetables; sugar intake; pregnancy nutrition

1. Introduction

Pregnancies complicated by hyperglycaemia are classified as pre-existing diabetes or hyperglycaemia first detected in pregnancy, which includes both gestational diabetes mellitus (GDM) and overt diabetes [1,2]. The prevalence of hyperglycaemia in pregnancy has been increasing worldwide. The estimated global prevalence is 16.2%, with the vast majority being due to GDM diagnosed in women living in low and middle-income countries [3]. Mwanri et al. [4] reported an

APPENDIX B

Participant information and informed consent form

Study: Lifestyle behaviours and beliefs of women with Gestational diabetes mellitus (GDM) regarding dietary intake and physical activity: a longitudinal follow-up study.	
Researchers: Ms Sharmilah Booley (PI); Janetta Harbron (PI), Stephanie Krige	
Division of Human Nutrition, Department of Human Biology, Faculty of Health Sciences, University of Cape Town	

Dear Study Participant

You are invited to be a participant in our study. The purpose of the study is to determine what beliefs you have regarding the intake of fruit, vegetables, fat and sugar and physical activity. The reason why we are interested in your beliefs is because we have found in an earlier study among pregnant women that many did not have a healthy diet and tended to have a high intake of foods high in fat, sugar, and a low intake of fruit and vegetables. We realise that people have certain beliefs about different foods and in order for us to develop a programme which assists pregnant women to consume healthier foods and be physically active; we first need to understand how they feel about certain foods and physical activity. We would also like to assess these beliefs and behaviours both during and after your pregnancy to identify any change over time.

'You can take part in this study if you are pregnant, older than 18 years and you have been diagnosed with diabetes mellitus during this pregnancy (also known as gestational diabetes) or impaired glucose tolerance'. You will not be included in this study if you had diabetes before pregnancy. If you decide to take part in this research you will be requested complete a questionnaire with me about your feelings and beliefs regarding the foods mentioned and physical activity, we mentioned above. We would also like you to return to GSH 3 months after delivery to complete another questionnaire. The researcher will contact you for these purposes. Your patient sticker will be used to obtain your file number and your contact details for follow up 3 months postpartum.

'You may lose your place in the queue by participating in this study. If this does happen you will however be placed at the front of the queue when you return to the waiting area'. This will be arranged with the sister-in-charge of the clinic. Your participation is completely voluntary and you do not have to take part if you do not wish to. Furthermore, you are welcome to withdraw at any time should you wish to do so without giving any reason. Your decision to take part or not take part in this study will not influence your medical treatment now or in the future.

The questionnaires will each take about 40 - 50 minutes at your bed side (in-patients) or in a private room (out-patients). Only the researchers in this study will know your personal information and your name will not be given to anyone (you will be allocated a code). Your study information will be stored in a computer database that can only be used by the study researchers. When any results are published, no names will be linked to any of the results.

If you agree to participate we request that you answer a few questions regarding your beliefs about fruit, vegetable, fibre, fat and sugar intake and physical activity. You will also be requested to answer questions on your food intake in relation to fruit, vegetables, fat and sugar and on how physically active you are. There will also be some questions on your background (e.g. age, level of education, qualifications etc.) and your health status in pregnancy. At 3 months follow-up, we will measure your weight and height and ask you similar questions on your diet and physical activity and some other questions on breastfeeding, your weight goals and body shape perceptions. We would also like to know your child's birth weight. There are no risks involved in taking part in this study.

While the information provided by you will not directly benefit you at present, in the long term we hope to use this information to develop a wellness programme for pregnant women to prevent gestational diabetes. In order to thank you for your participation we will provide you with a brochure on 'Healthy Eating Guidelines for Diabetics' after completion of the baseline interview. We will also provide you with refreshments, a gift and a voucher during the follow-up assessments. If you have any concerns about your diet, please speak to your doctor for a referral to the Dietetics Department at Groote Schuur Hospital. A summary of the findings will be sent to the Sister-in-charge at the maternity unit (ward MJ).

This research was approved by the University of Cape Town's, Faculty of Health Sciences, Human Research Ethics Committee (FHS-HREC). Should you have any questions about the research please feel free to contact me Ms Sharmilah Booley at 021 406 6310/ 083 500 8139; Janetta Harbron (021 406 6769) or Stephanie Krige (0728279713) at any time. The UCT FHS Human Research and Ethic Committee can be contacted on 021 406 6338 in case you have any questions regarding your rights and welfare as research subjects on this study. If you are willing to participate please sign at the end of this form.

Cut……………………………………………………………………………………….

Declaration by participant

By signing below, I………………………………………………………….... agree to take part in this study. The study has been explained to me, I have had the opportunity to ask questions about it and my questions have been answered well. I know that I am free to ask questions at any time during the study. The decision to be a part of this study is my own. I know that I am free to withdraw from the study at any time, and that it will not count against me in any way. I have carefully read/listened to the information and understand the study and what will be expected of me.

I may be contacted for the postpartum follow up assessment ☐

Signature………………………… Date……………………

If illiterate [1]

I have witnessed the accurate reading of the consent form to the potential participant, and the individual has had the opportunity to ask questions. I confirm that the individual has given consent freely.

Print name of witness………………………… Date ……………

Signature of witness …………………………

Declaration by the investigator:

I declare that I did not force the participant to take part in this study and that I will do no harm to the participant. I will ensure that their personal information is kept confidential and that their privacy will be protected.

Investigator name……………………………… Date…………………

Investigator signature…………………………

APPENDIX C

GDM STUDY – PHASE 2 FOLLOW-UP QUESTIONNAIRE

Participant No: _________________

Date of interview: _________________

Patient sticker

Section C: Child measurements	
Child's date of birth	
Child's age	
Birthweight	
Birth head circumference	
Birth length	
Gestational age at birth	
How was child delivered?	**Normal** □ **C/section** □ **Other** □ **Specify** __________

Section B: Measurements of mother	
weight	Kg
height	m
Waist circumference	cm

	Section 1: Socio-demographic Information	
1.1	What is your highest level of education	**Never went to school** ☐ **Primary school (Grade 1 to 7 OR Sub A to Std 5)** ☐ **Secondary school (Grade 8 to 10 OR Std 6 to 8)** ☐ **Grade 12 /Matric** ☐ **Tertiary/Diploma** ☐
1.2	Are you currently (can select more than one)…?	**Employed, salaried** ☐ **Self-employed** ☐ **Unemployed** ☐ **A full-time homemaker** ☐ **Student** ☐
1.3	Do you currently receive a social or disability grant…?	**Yes** ☐ **No** ☐ ***If No go to question 1.5***
1.4	If yes, please specify what type of grant(s) (can be more than 1)	
1.5	What type of housing do you live in?	**Built formal unit** ☐ **Informal shack/shelter/hostel** ☐ **other**☐ **Specify,** ______________________
1.6	How many rooms does your house have? (don't include bathroom & kitchen if separate)	**Number of rooms** ______________________
1.7	How many people older than 18 years old are living in your house?	
1.8	Are you…?	**Single** ☐ **Married/living with partner** ☐ **Widowed/divorced** ☐

	Section 2: Weight and Health	
2.1	How happy are you with your current weight?	**Happy** ☐ **Somewhat happy** ☐ **Unhappy** ☐
2.2	Do you think your weight gain during your last pregnancy was:	**Too little** ☐ **Just right** ☐ **Too much** ☐
2.3	What is your current weight goal, Do you want to……?	**Gain weight** ☐ **Lose weight (1-4Kg)** ☐ **Lose weight (>5Kg)** ☐ **Stay the same** ☐
Instruction to fieldworker: Present the laminated card with different body size images to the participant before asking her the following: (Record the letter corresponding to the body size chosen) Please look at the 9 pictures of women with different body sizes and then…		
2.4	Choose the picture of the woman that you think is …….?	**Thin** _____ **Normal weight** _____ **fat** _____ **very fat** _____
2.5	Choose the picture of the woman that you think …….?	**You want to look like** _____ **Your husband/partner wants you to look like** _____
2.6	Which of the pictures do you think you look like the most?	**Picture number** _________
		Other ☐

	Section 3: Diabetes management		**Y / N**	**If yes, did you stop after pregnancy?**	**If yes, are you currently on this treatment?**
3.1	What was your diabetes management during your last pregnancy? (you may tick more than one option)	*Diet and lifestyle changes*			
		Oral agents (Metformin)			
		Insulin injection			
		None			
3.2	Did you go to have your blood sugar checked after your baby was born?		**Yes** ☐ **No** ☐ ***If no, skip to question 3.5***		
3.3	If yes, how many weeks/months after your pregnancy did you go?		_________weeks/___________months		
3.3	If you went to be checked for diabetes after your pregnancy, what test did you have?		**Oral glucose Tolerance Test** ☐ **Finger prick** ☐ **Other e.g. urine dip stick** ☐ **Don't remember** ☐ **N/A** ☐		
3.4	If you went to be checked for diabetes after your pregnancy, what were the results?		**Diabetes** ☐ **No diabetes** ☐ **Can't remember** ☐ **Not applicable** ☐		
3.5	If you did not go to be checked for diabetes after your pregnancy, why did you not go?				

Section 4: Infant history			
4.1 How many children do you have? Please list the children and their details below:			___________________
Child nr	**When was the child born?**	**Birth weight of child**	**Were you treated for diabetes during the pregnancy?**
			Yes ☐ **No** ☐
			Yes ☐ **No** ☐
			Yes ☐ **No** ☐
			Yes ☐ **No** ☐
			Yes ☐ **No** ☐

Section 5: Infant feeding		
5.1	Are you currently breastfeeding?	**Yes** ☐ **No** ☐ ***If No, skip to question 5.4***
5.2	If yes, is it exclusive breast feeding?	**Yes** ☐ **No** ☐ ***If No, skip to question 5.4***
5.3	How long do you intend to exclusively breastfeed?	________weeks/__________months
5.4	Did you breastfeed your youngest baby?	**Yes** ☐ **No** ☐ ***If No, skip to question 5.6***
5.5	If yes, for how long did you breastfeed?	________weeks/__________months
5.6	Currently, is your baby consuming any formula milk?	**Yes** ☐ **No** ☐
5.7	Is your baby consuming any other foods or drinks, other than breast milk or formula?	**Yes** ☐ **No** ☐
5.8	When did you/ do you plan to introduce foods other than breast milk, formula or water to your infant?	**_____________ months** **Don't know** ☐
5.9	Did you receive advice for breastfeeding after your last pregnancy?	**Yes** ☐ **No** ☐
5.10	If yes, a) what type? (can select more than 1 option)?	**One-on –one** ☐ **Pamphlets** ☐ **Group talks** ☐ **Other, specify** …………………………………
	b) From whom? (can select more than 1 option)?	**RD** ☐ **Nurse** ☐ **Doctor** ☐

		Other ☐ **Please specify**____________

Section 6: Nutrition		
6.1	Did you receive dietary advice for managing your weight/blood sugar levels/GDM after your last pregnancy?	**Yes** ☐ **No** ☐
6.2	If yes, (a) what type? (can select more than 1 option)?	**One-on –one** ☐ **Pamphlets** ☐ **Group talks** ☐ **Other, specify** …………………………………..
	(b) From whom? (can select more than 1 option)?	**RD** ☐ **Nurse** ☐ **Doctor** ☐ **Other** ☐ **Please specify**____________
6.3	How often are you able to follow the nutrition recommendations provided to you?	**Always** ☐ **Most of the time** ☐ **Half of the time** ☐ **Sometimes** ☐ **Never** ☐

Section 7: Current health state			
7.1	How would you rate your health so far since giving birth?	**Excellent** ☐ **Good** ☐ **Fair** ☐ **Poor** ☐	
7.2	How would you rate your current level of physical activity:	**Very inactive** ☐ **Inactive** ☐ **Active** ☐ **Very active** ☐	
7.3	What do you think of the food choices you make most of the time (on 4 or more times per week):	**Mostly very healthy** ☐ **Mostly healthy** ☐ **Mostly unhealthy** ☐ **Mostly very unhealthy** ☐	
7.4	How many fruit do you eat (1 fruit = 1 med or 2 small)	Per day OR	
		Per week	
7.5	How many vegetables do you eat (1 veg = ½ cup cooked)	Per day OR	
		Per week	

7.6	Think about the type of food you eat. In comparison to when you were pregnant do you currently eat?	**Healthier** ☐ **Less healthier** ☐ **The same (no change)** ☐
7.7	Think about the AMOUNT of food you eat. In comparison to when you were pregnant do you currently eat?	**More food** ☐ **Less food** ☐ **The same (no change)** ☐

Fieldworker: I am going to ask you now a few questions and I want you to tell me if you "Strongly disagree", "Disagree", "Neither agree nor disagree", "Agree", "Strongly agree". –Please use the laminated scale to indicate your belief as accurately as possible. There is no right or wrong answer. ADD the scale for the fieldworker here		
Section 8: ***Agree/disagree statements***		**Answer**
8.1	Having a healthy body weight will help me to reduce my chances of developing diabetes.	1—2—3—4—5—6—7
8.2	I have a higher risk of developing Gestational Diabetes in my next (or a future) pregnancy.	1—2—3—4—5—6—7
8.3	I am concerned about my risk of developing Gestational Diabetes during my next (or a future) pregnancy.	1—2—3—4—5—6—7
8.4	As I had diabetes in my last pregnancy, I have a higher risk of developing diabetes in the future.	1—2—3—4—5—6—7
8.5	I am concerned about my risk of developing diabetes and its associated complications.	1—2—3—4—5—6—7
8.6	It is important to me to reduce my risk of developing diabetes.	1—2—3—4—5—6—7
8.7	If I was to develop diabetes, I would need to eat specific foods that are different to the rest of my family	1—2—3—4—5—6—7
8.8	If I develop diabetes, I would need to change my current *eating habits*	1—2—3—4—5—6—7
8.9	If I develop diabetes, I would need to change my current *food choices*	1—2—3—4—5—6—7
8.10	If I develop diabetes, my current *cooking practices* would have to change	1—2—3—4—5—6—7
8.11	The dietary advice that I received for managing my blood sugar levels after pregnancy was helpful	1—2—3—4—5—6—7

1	2	3	4	5	6	7
Strongly disagree	Disagree	Disagree somewhat	Neither agree nor disagree	Agree somewhat	Agree	Strongly agree

Section C: Belief statements	
Fruit and vegetable intake	
1. Eating fruits and vegetables every day will make me feel better physically	Disagree—1—2—3—4—5—6—7-Agree
2. Eating fruits and vegetables every day will help control my weight.	Disagree—1—2—3—4—5—6—7-Agree
3. I am confident that I can eat the recommended amount of fruits and vegetables every day.	Disagree—1—2—3—4—5—6—7-Agree
4. Preparation of vegetables does not take a long time.	Disagree—1—2—3—4—5—6—7-Agree
5. Fruits and vegetables are affordable	Disagree—1—2—3—4—5—6—7-Agree
6. Most people who are important to me eat fruits and vegetables every day.	Disagree—1—2—3—4—5—6—7-Agree
7. Fruits and vegetables are easy to find in the stores/ shops nearby.	Disagree—1—2—3—4—5—6—7-Agree
8. Eating less fruit will help control my blood sugar levels (i.e. to reduce the risk of diabetes).	Disagree—1—2—3—4—5—6—7-Agree
9. Knowing how to control my cravings will make it easier for me to eat more healthy foods.	Disagree—1—2—3—4—5—6—7-Agree
Fat intake	
1. Eating less fat will help reduce the risk of diseases e.g. heart disease, cholesterol	Disagree—1—2—3—4—5—6—7-Agree
2. Decreasing the amount of fat I eat will help me control my weight.	Disagree—1—2—3—4—5—6—7-Agree
3. Eating less fat makes me stay hungry.	Disagree—1—2—3—4—5—6—7-Agree
4. When I am at events (functions), I am expected to eat the food that is being served (social, religious, cultural, work-related events).	Disagree—1—2—3—4—5—6—7-Agree
5. Low fat/ fat-free foods taste good/ are tasty.	Disagree—1—2—3—4—5—6—7-Agree
6. It is easy to exclude high-fat foods from my daily diet.	Disagree—1—2—3—4—5—6—7-Agree
7. Low-fat/healthy fat options are expensive.	Disagree—1—2—3—4—5—6—7-Agree
8. Healthy takeaways and/or street foods are easy to find in my surroundings.	Disagree—1—2—3—4—5—6—7-Agree
9. I do not have enough time to prepare healthy meals regularly.	Disagree—1—2—3—4—5—6—7-Agree
10. It is important to me to eat less fat if my doctor tells me do so.	Disagree—1—2—3—4—5—6—7-Agree
11. Eating less fat will help control my blood sugar levels (to reduce the risk of diabetes).	Disagree—1—2—3—4—5—6—7-Agree
12. Knowing how to control my cravings for fatty foods will make it easier for me to eat less fatty foods.	Disagree—1—2—3—4—5—6—7-Agree
Sugar	
1. Eating less sugary foods/snacks/ drinks will help reduce the risk of diabetes in the future.	Disagree—1—2—3—4—5—6—7-Agree
2. People around me eat/serve sugary foods/snacks/drinks at most events/ functions (social, religious, or work events)	Disagree—1—2—3—4—5—6—7-Agree
3. Decreasing the amount of sugary foods/snacks/ drinks I eat will help control my weight.	Disagree—1—2—3—4—5—6—7-Agree
4. It is easy to exclude sugary foods/snacks/drinks from my daily diet.	Disagree—1—2—3—4—5—6—7-Agree
5. It is important to limit my intake of sugary foods/snacks/ after my pregnancy	Disagree—1—2—3—4—5—6—7-Agree
6. Foods/snacks/drinks that are low sugar/ sugar free are easy to find in my surroundings.	Disagree—1—2—3—4—5—6—7-Agree
7. Eating/drinking less sugary foods/snacks/drinks is up to me.	Disagree—1—2—3—4—5—6—7-Agree
8. Knowing how to control my cravings for sugary foods/snacks/ drinks will make it easier for me to eat less of these food.	Disagree—1—2—3—4—5—6—7-Agree
9. Low sugar/ sugar-free foods/snacks/ drinks are expensive.	Disagree—1—2—3—4—5—6—7-Agree
10. Low sugar/ sugar-free foods taste good/ are tasty.	Disagree—1—2—3—4—5—6—7-Agree
Fibre (wholegrain foods)	
1. High fibre/ wholegrains breads and cereal are expensive.	Disagree—1—2—3—4—5—6—7-Agree
2. It is easy to include high fibre/ wholegrain bread and cereals my daily diet.	Disagree—1—2—3—4—5—6—7-Agree
3. High fibre/ wholegrain bread and cereals foods taste good/ are tasty.	Disagree—1—2—3—4—5—6—7-Agree

4. Foods and snacks that are high in fibre/ whole grain are easy to find in my surroundings.	Disagree—1—2—3—4—5—6—7-Agree
5. Eating wholegrain bread and cereals every day will help control my weight	Disagree—1—2—3—4—5—6—7-Agree
6. High fibre/ wholegrains breads and cereal are expensive.	Disagree—1—2—3—4—5—6—7-Agree
7. Eating more high fibre/ wholegrain food/ snacks keeps me fuller for longer.	Disagree—1—2—3—4—5—6—7-Agree
8. High fibre/ wholegrain foods help control my blood sugar levels.	Disagree—1—2—3—4—5—6—7-Agree
9. I am confident that I can eat more high fibre/ wholegrain foods and snacks every day.	Disagree—1—2—3—4—5—6—7-Agree
Physical activity	
1. I do not want to be physically more active.	Disagree—1—2—3—4—5—6—7-Agree
2. Being physically more active will make me feel healthy and fit (more energy)	Disagree—1—2—3—4—5—6—7-Agree
3. Finding time to be physically more active is possible.	Disagree—1—2—3—4—5—6—7-Agree
4. Being uncomfortable/ heavy (overweight) after pregnancy makes it difficult to do physical activity (or exercise).	Disagree—1—2—3—4—5—6—7-Agree
5. There are no accessible, safe, affordable opportunities for me to be physically active.	Disagree—1—2—3—4—5—6—7-Agree
6. Meeting the recommended levels of physical activity (150 min per week) is hard for me.	Disagree—1—2—3—4—5—6—7-Agree
7. I am confident that I can increase my levels of physical activity (be physically more active).	Disagree—1—2—3—4—5—6—7-Agree
8. People who are important to me will support me to be physically more active.	Disagree—1—2—3—4—5—6—7-Agree
9. Having an exercise “buddy” or “group “will help me to be physically more active.	Disagree—1—2—3—4—5—6—7-Agree
10. Even if I were feeling tired I could increase my physical activity levels.	Disagree—1—2—3—4—5—6—7-Agree
11. Being physically active (exercise) helps to control my weight.	Disagree—1—2—3—4—5—6—7-Agree
Section D: Dietary intake assessment NB! Think back to the last two weeks and divide the food cards into two piles i.e. foods you did eat and foods you did not eat.	

A. Food Item (with FMP numbers)	*B. Description of food item*	*C. Amount consumed*	*D. Portion size*	*E. Times/day*	*F. Times/week*
DAIRY – BLUE					
1. Sugar in tea/coffee			Tbs/tsp heaped/level		
1. Sugar in cooking (veg/ porridge)			Tbs/tsp heaped/level		
2. Milk in tea/coffee	Full cream / low fat (2%)/ fat-free		Little / milky		
2.Milk with porridge	Full cream/ low fat (2%)/ fat-free		Cup		
3. Buttermilk/maas			Small or large glass		
4. Milk drinks (Eg Steri stumpi)			Small or large glass or ml		
5. Yoghurt	Plain / fruit & sweetened Fat-free/low fat/full cream		100ml tub/ 180ml tub/ heaped Tbs		
6. Cottage cheese			Heaped Tbs		
7. Hard Cheese			Slice / matchbox		
8. Processed cheese			Wedges/Tbs		
9. Ice cream & Ice lollies			Scoops or heaped Tbs or nr of lollies		
STARCH - BROWN					

A. Food Item (with FMP numbers)	B. Description of food item	C. Amount consumed	D. Portion size	E. Times/day	F. Times/week
1. Brown bread/rolls			Slice		
1. White bread/rolls			Slice		
2. Whole wheat /Low GI bread			Slice		
2. Fat cakes			Small = 1 matchbox; Med = 2 matchboxes Lrg = 3 matchboxes		
3. Breakfast cereals	Specify type		½ or ¾ of a Bowl No of biscuits		
4. Maize porridge soft			Bowl		
4. Maize porridge stiff			Bowl		
4. Mabele/martabella soft			Bowl		
4. Mabele/ stiff			Bowl		
4. Oats			Bowl/ Tbs		
5. Pasta without sauce			Heaped serving spoon		
6. Pasta dishes			Heaped serving spoon ½ cup dough model		
7. Rice			Heaped serving spoon ½ cup dough model		
7. Samp/mealie meal			Heaped serving spoon ½ cup dough model		
7. Wheat rice			Heaped serving spoon ½ cup dough model		
8. Pizza and savoury tart	Med/large		slices		
FATS - TAN					
1. Brick margarine	Type		Thin / med /thick		
1. Tub margarine	Type		Thin / med /thick		
1. White margarine	Type		Thin / med /thick		
1. Butter	Type		Thin / med /thick		
2. Animal fat i.e lard			Thin / med /thick		
3. Cream and substitutes			Tbs/tsp		
4. Oils	Sunflower / fish oil / canola oil / olive oil		Tbs/tsp		
5. Salad dressing			Tbs/tsp		
5. Mayonnaise			Tbs/tsp		
SPREADS - PINK					
Cheese spread			Thin / med /thick		
Honey/syrup			Heaped Tbs/tsp		
Jam			Heaped Tbs/tsp		
Peanut butter			Thin / med /thick		
Sandwich spread			Thin / med /thick		
EGGS - YELLOW					
Boiled			1 egg		

A. Food Item (with FMP numbers)	*B. Description of food item*	*C. Amount consumed*	*D. Portion size*	*E. Times/day*	*F. Times/week*
Fried			1egg		
Omelet			1 egg		
Scrambled			1 egg		
FRUIT - ORANGE					
1. Apples, pears			Small / med /large		
2. Bananas			Small / med /large		
6. Grapes			Nr of grapes		
8. Mango/paw paw					
9. Melons			Slices		
11. Oranges, Naartjies			Small / med /large		
12. Peaches			Small / med /large		
16. Dried fruit	Type:		units		
17. Fruit juice			ml or small glass or tall glass		
SOUP, LEGUMES, NUTS – pale green					
1. Soups			Ladle/bowl		
2. Legumes & lentils			½ cup dough model		
3. Seeds & nuts, peanuts			Handful		
FISH AND SEAFOOD - BEIGE			Per picture		
1. Fried fish			matchbox		
2. Grilled/smoked/dried fish			matchbox		
3. Plichards & sardines			Tin/units		
3. Tuna - tinned			Tin		
MEAT - RED					
1. Beef & Ostrich	cut		Matchbox		
2. Patties & mince			Small/medium Tbs		
3. Burgers & take-aways	Type:		Burger/no pieces With or with out chip/drinks		
4. Chicken – with skin	Grilled/fried		Thigh / wing / drumstick / breast		
4. Chicken – without skin	Grilled/fried		Thigh / wing / drumstick / breast		
5. Cold meat			slice		
7. Meat pies			Size - ruler		
8. Mutton			matchbox		
9. Pork			matchbox		
10. Sausage & vienna			Ruler and thick or thin		
11. Traditional & organ meats			Units/serving sp		
13. Dry sausage & biltong			Cm / no pieces		
VEGETABLES - GREEN			.		
2. Avocado			½ or ¼		
5. Orange/yellow veg (butternut, pumpkin, carrots, sweet potato, gem squash, mealies)			½ cup dough model		

A. Food Item (with FMP numbers)	*B. Description of food item*	*C. Amount consumed*	*D. Portion size*	*E. Times/day*	*F. Times/week*
6. Green veg (spinach, peas, green beans, broccoli)			½ cup dough model		
7. Cabbage, cauliflower, lettuce			½ cup dough model		
12. Mixed vegetables			½ cup dough model		
15. Potatoes			Nr med		
16. Potato chips			½ cup dough model		
20. Tomatoes			Nr or ½ cup		
BISCUITS, CAKES, PUDDINGS					
1. Biscuits/cookies	Type		nr		
2. Biscuits/savoury	Type		nr		
3. buns/muffins/scones			Small/med/large		
4. Cakes and tarts			nr		
5. Doughnuts/éclairs			nr		
6. Pancakes/waffles			Size		
7. Pudding/custard			nr		
8. Rusks			nr		
SNACKS, SWEETS & COLD DRINKS - PINK			ml or can or small glass or tall glass		
1. Carbonated cold drinks			ml or can or small glass or tall glass		
1. Diet cold drinks			ml or can or small glass or tall glass		
2. Energy drinks			ml or can or small glass or tall glass		
2. Squashes			small glass or tall glass		
3. Crisps			small packet – 40g		
4. Sweets			nr		
4. Chocolates			50g bar or slab or nr of blocks from slab		
SAUCES AND CONDIMENTS - GRAY					
1. Cheese and white sauces			Tbs		
2. Tomato sauce & other			Tbs		
ALCOHOLIC DRINKS - GRAY					
1. Beer & cider & coolers			ml/bottles/shots		
2. Wine			ml/bottles/shots		
3. Spirits			ml/bottles/shots		
4. Liquers and fortified wine			ml/bottles/shots		
Other			ml/bottles/shots		

Section E: Physical activity (GPPAQ)	
1. Please tell us the type and amount of physical activity involved in your work. Please tick one box only.	
I am not employed (e.g. retired, retired for health reasons, unemployed, full-time carer etc.)	
I spend most of my time at work sitting (such as in an office)	
I spend most of my time at work standing or walking. However, my work did not require much intense physical effort (e.g. shop assistant, hairdresser, security guard, childminder, etc.)	
My work involves definite physical effort including handling of heavy objects and use of tools (e.g. plumber, electrician, carpenter, cleaner, hospital nurse, gardener, postal delivery workers etc.)	
My work involves vigorous physical activity including handling of very heavy objects (e.g. scaffolder, construction worker, refuse collector, etc.)	

2. During the last week, how many hours did you spend on each of the following activities?				
	None	**Some but less than 1 hour**	**1 hour but less than 3 hours**	**3 hours or more**
Physical exercise such as swimming, jogging, aerobics, football, tennis, gym workout etc.				
Cycling, including cycling to work and during leisure time				
Walking, including walking to work, shopping, for pleasure etc.				
Housework/Childcare				
Gardening/DIY				