ASSESSMENT OF RISK FACTORS AND PREGNANCY OUTCOME OF GESTATIONAL DIABETES MELLITUS (GDM)

Thesis submitted to

Mahatma Gandhi University, Kottayam

Emblem

for the award of Degree of

Doctor of Philosophy in Home Science-Food and Nutrition

(SCIENCE)

By

SHALY.C.M

Under the guidance and supervision of

PROF.DR.K.S.KUMARI

Former HOD of Home Science, St.Teresa's College & Former HOD of Food Science & Technology & Principal , Community College, Pondicherry University

HOME SCIENCE -FOOD AND NUTRITION

CENTRE FOR RESEARCH IN HOME SCIECE

ST.TEREESA'S COLLEGE

ERNAKULAM

DECEMBER, 2018

Declaration

I hereby declare that the dissertation entitled **"ASSESSMENT OF RISK FACTORS AND PREGNANCY OUTCOME OF GESTATIONAL DIABETES MELLITUS (GDM)**" submitted to Mahatma Gandhi University, Kottayam in fulfillment of the requirement for the award of the degree of Doctor of Philosophy in Home Science –Food and Nutrition (Science) is a record of original work done by me under the guidance of Prof. Dr. K.S. Kumari, Former HOD of Home Science, St.Teresa's College & Former HOD of Food Science & Technology & Principal , Community College, Pondicherry University, and it has not formed basis for the award of any Degree/Diploma/Associateship/Fellowship or similar title to any candidate of any other university.

Shaly.C M

Ernakulam

07/12/2018

Certificate

This is to certify that the dissertation entitled **"ASSESSMENT OF RISK FACTORS AND PREGNANCY OUTCOME OF GESTATIONAL DIABETES MELLITUS (GDM)"** submitted to Mahatma Gandhi University, Kottayam in fulfillment of the requirement for the award of the degree of Doctor of Philosophy in Home Science-Food and Nutrition (Science) is a record of original work done by Shaly.C.M during the period of her study in the Centre for Research in Home Science, St.Teresa's College, Ernakulam under my guidance and supervision. This dissertation has not formed basis for the award of any Degree/Diploma/Associateship/ Fellowship or similar title to any candidate of any other university and it represents an independent work on the part of the candidate.

Prof.Dr.K.S.Kumari

Supervising Guide

Signature of the Head of the Institution

Ernakulam

07/12/2018

Acknowledgement

I bow my head and lift up my heart to god Almighty for the blessings showered upon me for bestowing His grace through my teachers, friends, acquaintances and well wishers who extended their helping hands in this endeavour.

With a deep sense of gratitude and respect, I express my indebtedness to Prof. Dr. K. S. Kumari, my research guide, for her sustained and valuable guidance, constructive suggestions, critical assessment, unfailing help, constant encouragement and patient corrections throughout the research work which help in the improvement and successful completion of the study

I am grateful to Rev. Dr. Sr. Vinitha CSSI,the Director, Dr. Sajimol Augustine, the Principal, St. Teresa's College, Ernakulam, former Principals, academic and administrative staffs at the research centre for the timely help and support rendered.

I am grateful to Mahatma Gandhi University, Kottayam for providing me an opportunity to register as a research scholar and to UGC, New Delhi for granting me fellowship.

A special word of thanks to the authorities of Jubilee Mission Medical College and Elite Mission Hospital for granting me permission to carry out the research in their institutions. I remember with gratitude the help rendered by the following doctors Dr Sunil K. Menon, HOD, Department of Endocrinology, Dr Sareena Gilwas, HOD, Department of Gynecology, Dr Manoj, HOD, Dept of Neonatology, Dr Jiju Kandrassery Diabetologist,

Dr Jyothi Mary John Gynecologist and Cindin John Alappat, HOD, Dept of Nutrition in conducting the research.

Words are not enough to thank Dr. S. Krishnan, Associate Professor, Department of Statistics, College of Horticulture, Thrissur and Miss. Suvarna Shyam for the immense help extended in the statistical analysis of the data.

My deepest senses of obligations are due to all the subjects of my study without whose patient co-operation, I would not have been able to procure the data.

Thanks are also due to my teachers and colleagues at the Department of Home Science, Vimala College, Thrissur for the moral support and encouragement.

I wish to acknowledge the library staffs of Kerala Agriculture University, Thrissur and St. Teresa's College, Ernnakulam and Jubilee Mission Medical College Thrissur for their whole hearted cooperation in the collection of literature pertaining to the study.

I would also like to thank all my friends especially Jisha A Prabha and Subhasree, research scholars, M.G .University for the constant support rendered throughout my research.

I am indebted to my husband Mr Sreekumar, my daughter Ishani, my parents, inlaws and all other family members for their constant and unfailing support and prayers during the pursuit of my research activities.

Shaly C.M

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1. INTRODUCTION

Diabetes is a major cause of disability and premature death. Diabetes needs to be considered as an epidemic because of its rapidly increasing prevalence. According to WHO (2016) projections India will have maximum number of patients with diabetes (57.2 million) by the year 2025. With regards to this increasing trend of diabetes, it is more likely for women with child bearing potential to have Type 2 diabetes mellitus. The rates of women with unrecognized Type 2 diabetes is increasing especially among pregnant women.

Hyperglycemia in pregnancy has been divided into Pre-gestational diabetes (PGD) or pregnancy occurring in women with known diabetes, overt diabetes - diabetes first detected during pregnancy and Gestational diabetes mellitus (GDM).

The term GDM was introduced by O' Sullivan in 1961. WHO has defined Gestational diabetes mellitus (GDM) as glucose intolerance with onset or first recognition in pregnancy (WHO, 2013). It implies a form of hyperglycemia seen generally in late pregnancy which usually, but not always, reverts to normal after delivery.

Impaired glucose metabolism during pregnancy may lead to various types of adverse outcomes for both the mother and the fetus. It is associated with increased risk of prenatal and postnatal complications. Preeclampsia and cesarean sections are both increased in undiagnosed and untreated GDM. Macrosomia, hyperbilirubinimia, hypoglycemia and respiratory distress are the common disorders observed in the babies of GDM mothers.

GDM also predisposes the mother and the offspring to long term morbidity. Following a pregnancy complicated by GDM, women have a higher risk for the development of subsequent Type 2 diabetes in later life. Children of GDM mothers are also more prone to metabolic disorders. Hence GDM is becoming a public health concern globally as well as in India with fast increasing trend which parallels with increasing trend of diabetes and obesity. Therefore, it is important to pay rigorous attention to GDM, to prevent the vicious circle that contributes to the epidemic of obesity, insulin resistance and Type 2 Diabetes Mellitus.

Though it is one of the commonest metabolic problems of pregnancy, the complete cause of GDM is unknown. Pregnancy is a unique physiological state where life exists on life. The fetus is entirely dependent on mother for its healthy growth. To cope with the new environment of pregnancy, the body of the pregnant woman has to make biochemical and physiological changes. Progressive alterations occur in maternal carbohydrate metabolism also. As pregnancy advances insulin resistance and diabetogenic stress due to placental hormones necessitate compensatory increase in insulin secretion. When this compensation is inadequate gestational diabetes develops. Pregnancy thus unmasks the derangements in glucose homeostasis which becomes a marker of future Diabetes Mellitus.

The prevalence of GDM for a given population and ethnicity corresponds to the prevalence of impaired glucose tolerance in non-pregnant adult within that given

population. A recent review of data published over the past decade indicated that the highest prevalence was reported in Middle East and North Africa, whereas the lowest was in Europe (Zhu and Zhang ,2016).

The prevalence of GDM in India is increasing with the rising prevalence of diabetes. The prevalence varied from 3.8 to 21per cent in different parts of the country, depending on the geographical locations and diagnostic methods used. In India,it is estimated that about four million women are affected by GDM at any given time point (Kayal et al .,2015).

GDM has no signs or symptoms hence it can only be recognized by screening. GDM is most commonly diagonosed by routine blood examinations during pregnancy which detect high level of glucose in their blood samples. Testing for GDM is usually carried out between 24 th and 28th weeks of gestation. The screening of GDM is done by assessing the clinical risk factors or by the 50-g glucose challenge test (GCT).The diagnosis of GDM is made by the 75-g or 100-g oral glucose tolerance test (OGTT). A screen followed by the diagnostic OGTT is called the two-step approach, while OGTT directly without screen is called the one-step approach. The two-step and the one-step screening methods are also known as the selective and universal screening methods respectively.

The various preeminent health organizations recommend different glucose cut-offs for the diagnosis of GDM as a result, there many international diagnostic criteria available

for diagnosis. Different diagnostic criteria have been given by organisations like ADA (American Diabetes Association) WHO (World Health Organization), IADPSG (International Association of Diabetes & Pregnancy Study Group) & ACOG (American College of Obstetrics & Gynecology).There is a great demand for a uniform strategy in the diagnosis and classification of GDM. The World Health Organization (WHO) provides guidelines for numerous communicable and non-communicable diseases. WHO has published guidelines for GDM also in 1980, 1985, 1999 and 2013 which are popular globally.

Untreated glucose intolerance in pregnancy resulted in serious maternal and neonatal complications compared to women who were treated. Medical management is aimed at maintaining circulating glucose concentrations in the reference interval for pregnant women. The key elements of the management programme consists of education, nutritional therapy, exercise, and medical treatment. Attention to lifestyle factors is crucial to curb the burden of illness associated with GDM. However, the time around pregnancy or family planning may represent an ideal opportunity to advocate a healthy lifestyle for the family, as women in these specific time windows of their lives are generally better motivated to follow advice to improve pregnancy outcomes and infant health (Phelan , 2010).

The most appropriate method of management would be tailored treatment program in which diet, oral anti-diabetics or insulin therapy are selected according to the needs of

individual patient.The pregnant women in whom blood glucose control cannot be achieved with exercise and diet regulation must be switched to insulin or oral anti-diabetics.

Thus GDM offers an important opportunity for the development, testing and implementation of clinical strategies for diabetes prevention. Timely action taken in screening all pregnant women for glucose intolerance, achieving euglycemia in them and ensuring adequate nutrition may prevent in all probability, the vicious cycle of transmitting glucose intolerance from one generation to another.

Management of diabetes and its complications imposes a huge economic burden on the country like India where there is an estimated 62 million people living with diabetes. Hence effective preventive strategies are urgently needed in order to curb this epidemic. Early detection of the disesase risk as well as onset is the first step in implementing efficacious treatment and improving patient outcomes. Identification of high risk population by identifying the risk factors at an earlier stage would aid in the implementation of preventive strategies which will be more cost effective in a developing country like India.

With this background, the present study aimed at identifying the risk factors and pregnancy outcome of GDM mothers which would aid in formulating suitable strategies to prevent and manage Gestational Diabetes Mellitus and there by prevent the global burden of diabetes and obesity

Specific objectives

To identify the risk factors of GDM

To investigate the prenatal changes associated with GDM

To study the management strategies adopted by the GDM

To study the effect of GDM on maternal outcome

To study the effect of GDM on neonatal outcome

3. METHODOLOGY

Methodology is the constructive framework that describes the way in which research has to be undertaken. The present study entitled Assessment of risk factors and pregnancy outcome of Gestational Diabetes Mellitus (GDM) was a hospital based prospective study. The methodology adopted for the study is discussed under the following headings.

3.1 Locale of the study

3.2 Study design

3.3 Sample size determination

3.4 Screening and selection of the cases and controls

3.5 Tools and techniques of data collection

3.6 The phases of the study

a)Phase 1. Assessment of risk factors of GDM

b) Phase 2 Gestational follow up

c) Phase 3 Assessment of the pregnancy outcome

3.7 Analysis of data

3.1 Locale of the study

The present study was a hospital based study carried out in Thrissur district. Thrissur known as the cultural capital of Kerala is the fourth largest city in Kerala. The city serves as a centre for healthcare in the central Kerala with three medical colleges and many other superspeciality hospitals. Most of the people in the neighbouring districts namely Palakkad district, Malappuram district and northern part of Ernakulam district come to city of Thrissur for their medical care. Therefore availabililty and accessibility of hospitals was one of the factors in selection of Thrissur as the area of study.

Thrissur is the third largest urban agglomeration in Kerala. Rapid urbanization and industrialization and the resultant life style changes has become an independent risk factor for life style disorders especially diabetes and its associated disorders. However Thrissur, is a virgin area in terms of the present topic of research. All these factors have lead to the selection of Thrissur as the study area.

3.2 Study design

The study being a hospital based prospective case control study, was carried out in two hospitals in Thrissur district namely, Jubilee Mission Medical College and Elite Mission hospital. Availability of the sample population from different strata of the community in the hospitals, accessibility of the samples, co-operation on the part of the gynecologists and hospital authorities were some of the criteria considered during the selection of hospitals.

Jubilee Mission Medical College is a hospital where people from every strata of the community walk in and its gynecology department have referral status. The health care facilities in Jubilee Mission Medical College are a cost effective one which attracted the people from the neighbouring districts also. Elite Mission hospital is a multispeciality hospital which is a renowned centre for antenatal services. The study was approved by Ethical Clearance Committee of the hospital and was carried out for six months in each centre (**Appendix I)**. Hospital based studies allow detailed investigation of risk factors. The collection of secondary data and follow up data from medical records is also easier in a hospital environment.

A case-control study is a type of observational study used to determine the relative importance of a predictor variable in relation to the presence or absence of the disease. According to Luepker et al (2001) in a case-control study cases are compared with controls to determine whether the exposure of interest is more or less common in the cases. Hence case control method was adopted for the present study. The subjects both the cases and controls were observed prospectively from the time of enrollment until their delivery to assess the risk factors and pregnancy outcome of GDM. The study was carried out in three phases

Phase 1 Assessment of risk factors of GDM.

Phase 2 Gestational follow up

Phase 3 Assessment of pregnancy outcome

3.3 Sample size determination

Many Indian studies have shown that the prevalence of GDM has increased dramatically from 2 % (Agarwal et al., 1982) to 16% (Seshiah et al., 2004). The present study being a case control study the sample size was computed using the formula

$$N = \frac{4(Z_{\alpha} + Z_{1-\beta})^2}{(\ln OR)^2 P(1-P)}$$

P is the prevalence of exposure in the control. Prevalence rate of 19.8% was taken for the sample size determination based on a recent prevalence study done in urban area in South India (Balaji Bhavadharini et al., 2016)

OR = hypothetical odds ratio which was taken as 2.

So based on the above formula sample size was determined to be 324. The ratio of control to cases was taken as 1: 1 (162 cases and 162 controls). It was estimated that there will be 10% drop out as it is natural with any survey especially survey related to vulnerable group. So in addition to the estimated sample size of 324 an additional sample of 32 was envisaged. Hence a sample size of 356 pregnant women (178 controls and 178 cases) was recruited for the present study.

3.4 Screening and selection of the cases and controls

Purposive sampling method was used for the selection of samples. Samples were recruited from the pregnant women walking in to the outpatient unit of the gynecology department of the selected hospitals for antenatal checkups during the study period.

The pregnant women at 24-28 weeks of gestation who attended the outpatient clinic for regular antenatal check up were screened for GDM using Oral Glucose Tolerance Test (OGTT). Gestational age for the pregnant women was taken from the hospital records.

Langer (2006) opined that screening for GDM usually occurs between 24–28 weeks of gestation because insulin resistance increases during the second trimester and glucose levels will rise in women who do not have the ability to produce enough insulin to adapt to this resistance.

The pregnant women in their fasting state were made to take 75 g oral glucose load. The estimation of plasma glucose was done in the fasting state followed by post prandial estimation at one hour and two hour which was carried out in the hospital laboratory. Blood glucose was estimated by Glucose Oxidase Peroxidase method (GOD-POD method). In the present study GDM diagnosis was done based on World Health Organisation (WHO 2013) criteria. This criterion is popular globally due to the worldwide reach and authority of the WHO.

Cut off values for diagnosis of GDM by 75g, 2-hour OGTT (WHO 2013)

Gestational diabetes mellitus should be diagnosed at any time in pregnancy if one or more of the following criteria are met:

Table 1. diagnostic criteria of GDM

Fasting plasma glucose	5.1-6.9 mmol/l (92 -125 mg/dl)
1-hour plasma glucose	≥ 10.0 mmol/l (180 mg/dl) following a 75g oral glucose load
2-hour plasma glucose	8.5-11.0 mmol/l (153 -199 mg/dl) following a 75g oral glucose load

Samples were selected based on the inclusion and exclusion criteria. The pregnant women between the gestational age of 24- 28 weeks and who are newly diagnosed with GDM on the basis of Oral Glucose Tolerance Test (OGTT) were taken as cases. Pregnant women who attended the antenatal clinic during the study period, at gestational age of 24 -28 weeks with Normal Glucose Tolerance following the OGTT were selected as controls.

Inclusion criteria for cases

- Pregnant women between the gestational age of 24-28 weeks
- Newly diagnosed with GDM based on OGTT
- Willingness to participate in the study until delivery

Inclusion criteria for controls

- Pregnant women between the gestational age of 24-28 weeks
- Normal blood glucose value following OGTT

- Willingness to participate in the study until delivery.

Women with a known history of diabetes or with known chronic medical disorders such as cardiovascular disorders or kidney disorders were excluded from the cases and controls.

3.5 Tools and techniques of data collection

Accurate and reliable data collection is inevitable in maintaining the integrity of the research. The goal of the data collection process was to capture accurate information on targeted variables**.** Comprehensiveness, convenience and possibility of obtaining genuine information make interview method apt for procuring research data. Hence data collection was done by direct interview method using interview schedules that are prepared well in advance.

Various interview schedules that pose definite and concrete questions were formulated according to the data required in each phase of data collection. The objectives and conceptual frame work of the study were taken into account while formulating the interview schedule. According to Thanulingam (2000) interview schedule is a proforma containing a set of questions and are very useful in gathering information. Four detailed schedules were thus developed

- To assess the risk factors of GDM
- To assess the life style pattern of the subjects during the prepregnancy and pregnancy period.
- For gestational follow up
- To assess the pregnancy outcome

Anthropometric tools, various validated scales such as Perceived Stress Scale, Pregnancy Distress Questionnaire and Dietary Diversity Questionnaire were used for data collection. Hospital records were also utilised to collect secondary data.

3.5.1 Pretest

After developing the schedules, it was subjected to screening by a panel of doctors including gynecologist and diabetologist. Necessary modifications as suggested by the panel were made and it was pre-tested on a comparable group of 20 subjects prior to actual data collection for consistency and accuracy. The compatability of the previously validated stress scales were ascertained by a panel including a psychologist in the hospital.

Prior to the interview, informed consent was obtained from all study participants **(Appendix II).** The investigator personally interviewed all the subjects and the data was filled in by the investigator. The interview method of collecting data involves presentation of oral verbal stimuli and reply in terms of oral verbal responses. This can be

used through personal interviews and also can be carried out in structured way (Kothary, 2003).

3.6 .The phases of the study

3.6.1. Phase 1 Assessment of the risk factors of GDM.

In the first phase of the study, all the subjects both cases and controls who were enrolled into the study were interviewed using the formulated interview schedules which included appropriate questions to elicit detailed data regarding various variables that are postulated to be the contributing factors of GDM such as sociodemographic factors, anthropometric factors, biochemical and biophysical parameters, family health history, personal health profile, menstrual history and obstetric history **(Appendix III**). Life style factors such as dietary pattern, personal habits, sleep pattern, stress level and physical activity pattern was assessed using another interview schedule **(Appendix IV**). The Perceived Stress Scale (PSS) and Prenatal Distress Questionnaire (PDQ) were the validated scales used to assess the stress level of the subjects (**AppendixV**).

a)Sociodemographic factors

Sociodemographic factors such as age, religion, educational status, occupational status, monthly family income and type of family was collected from all the subjects using the schedule.

b) Anthropometric factors

Nutritional anthropometry is a measurement of human body at different ages and levels of nutritional status. It is based on the concept that an appropriate measurement should

reflect any morphological variation occurring due to significant functional physiological change (Anitha and Sushma, 2014). Anthropometric variables, particularly weight and height, are the most commonly employed measures of nutritional status in epidemiologic studies due to their simplicity and ease of collection (Willett and Hu, 2013). Heights, prepregnancy weight, prepregnancy BMI, weight gain in pregnancy are the anthropometric variables employed in this study.

Height

Heights of all the pregnant women were recorded using a stadiometer. The subjects were allowed to stand straight without footwear in a stadiometer and the height was recorded to the nearest accuracy of 0.1cm.

Weight

Weight of all the pregnant women was recorded using a bathroom scale with casual clothing and after removing their foot wear. The weight was recorded to the nearest accuracy of 0.5kg.Prepregnancy weight was recorded from the antenatal cards and also elicited from the subjects.

Prepregnancy BMI

According to Sebire et al. (2001) Body Mass Index (BMI) is a simple index of weight-for-height that is widely used to classify overweight and obesity in adults. It is a simple, safe, non-invasive and cheap way of estimating body mass and health. It was well established that an abnormal maternal BMI has deleterious effects on maternal and fetal

pregnancy outcome and also there is a tight link between maternal obesity and diabetes in pregnancy. The risk of GDM increases with maternal BMI (Torloni et al., 2009). In the present study prepregnancy BMI was calculated for all the pregnant women from the prepregnancy weight and height using the formula.

$$BMI = \text{weight (kg)} / \text{height (m}^2\text{)}$$

Pregnant women were classified according to the BMI classification by WHO (2009).

Gestational weight gain

Weight gained in pregnancy until 24 – 28 weeks of gestation was noted for all the samples. Their weight changes were monitored regularly in their follow up visits until delivery and the total weight gained in pregnancy was also noted. Costa et al (2012) opined that maternal weight gained in pregnancy could influence subsequent maternal insulin resistance.

Biochemical and Biophysical parameters

Haemoglobin

Measurement of hemoglobin (Hb) is a standard test for evaluation of physical status and anemia among pregnant women. High level of hemoglobin is the evidence of adequate nutrition and health. Haemoglobin levels were estimated for all the pregnant women by the cyanmethamoglobin method in the hospital laboratory. Anaemia was defined according to the WHO recommendations for anaemia in pregnancy as haemoglobin level < 11.0 g/l (WHO,2011).

Blood pressure

Blood pressure was measured as systolic and diastolic pressures. Blood pressure of all the samples was recorded using sphygmomanometer at the time of enrollment and in their follow up visits. The blood pressure readings were compared with the normal values given by Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (2007).

Family health history

A positive family history of diabetes predisposes a woman to have a higher chance of developing GDM (Chu *et al* 2007). Data regarding the known occurrence of diseases such as Type 1and Type 2 diabetes, thyroid problems, dyslipidemia, Poly Cystic Ovarian Disorders (PCOD), obesity, cardiovascular disorders and hypertensive disorders among the first degree relatives were collected from all the subjects. Parents, grandparents and siblings were included in the first degree relatives.

Personal health profile

Maternal health profile was determined by assessing the known occurrence of diseases such as thyroid problems, dyslipidemia, PCOD and hypertensive disorders prior to pregnancy or during this pregnancy until 24-28 weeks of pregnancy. Maternal thyroid

diseases and PCOD which is becoming a common disorder in pregnancy can have adverse effect on the pregnancy and the foetus (Sinha, 2012).

Menstrual history

A history of irregular menstruations demonstrates significant higher prevalence of GDM (Haver et al 2003). Hence menstrual details regarding the age at menarche, cyclic pattern and menstrual problems such as scanty periods, menorrhagia, amenorrhea, dysmenorrhea and irregular periods were collected from the subjects**.**

Obstetric history

Information regarding the obstetric history such as gravidity status, methods of contraception adopted, infertility problems and treatments, history of multiple pregnancies were gathered from the respondents. Data on Bad Obstetric History (BOH) such as abortions, still birth, preeclampsia, polyhdraminos, recurrent GDM, Urinary Tract Infections (UTI) in their previous pregnancies were gathered. Polyhydramnios is a medical condition describing an excess of amniotic fluid in the amniotic sac. Preeclampsia is a condition in which the pregnant woman has high blood pressure and protein in the urine. Details regarding the neonatal complications of previous pregnancies such as macrosomia, congenital anomalies were also collected from multigravida women.

Life style factors

A combination of life style factors such as lack of exercise, poor diet and stress increases the risk of metabolic disorders. Several observational studies have identified diet and lifestyle factors that are associated with GDM risk and demonstrated that time frames both before and during pregnancy may be relevant to the development of GDM. Findings from many observational studies had supported the role of prepregnancy diet and lifestyle factors in the development of GDM (Bao et al, 2014, Tobias et al, 2012). Life style characteristics of all the subjects during and before pregnancy were assessed. Prepregnancy period refers to a year prior to this pregnancy. Dietary pattern, personal habits, sleep pattern, stress level, leisure time activities and physical activity pattern are the variables included in the lifestyle factors.

a) Dietary assessment

Diet is a vital determinant of health and nutritional status of people. Adequate maternal nutrient intake during pregnancy is important to ensure satisfactory birth outcomes. A diet survey to study the dietary practices and food frequency pattern of the subjects was conducted on all subjects. The dietary intake during the pregnancy and prepregnancy period was gathered.

General dietary pattern

Detailed data on general dietary practices such as meal patterns, type and preference of oil, and intake of sugar and intake of salads were collected.

24 hour recall method

24-hour dietary recall method is to gather information on the usual eating pattern of the subjects. For the 24-hour dietary recall, the respondents were asked to remember and report all the foods and beverages consumed in the preceding 24 hours. The interviewer-administered 24-hour recall method was used to obtain the detailed data on the intake and portion size of food consumed by the subjects. The amount consumed by the subject was estimated by the respondent and expressed in terms of cups and spoons. Values of household measures eg. cups and spoons were converted into raw equivalents to compute the nutrient intake. The mean food and nutrient intake of the samples were computed and compared with the RDA using food composition table ICMR (2017) and ICMR (2010) respectively.

Dietary Diversity Score

Dietary diversity is a qualitative measure of the food consumption that reflects household access to a variety of foods and is also a proxy for nutrient adequacy of the diet of individuals. This score is a simple count of food groups that an individual has consumed over the preceding 24 hours.

Dietary diversity score was calculated by summing the number of unique food groups consumed during last 24 hours as described by FAO Dietary Diversity Questionnaire by Kennedy et al (2013). 16 item questionnaire was modified into 10 item questionnaire for the present study. Items like spices, condiments, beverages, sweets, oils and fats were excluded and items of similar groups were combined to a single group. If an individual

ate any quantity of any food group at least once per day was taken into count. Score 1 was given if a particular item was consumed and score 0 was given in not consumed. A score less than or equal to three was considered as low dietary diversity , scores between 4 and 6 was considered as medium and score greater than or equal to 6 was considered to be high dietary diversity. DDS questionnaire used in the present study is given in the (**Appendix)**

Nutrient Adequacy Ratio

The NAR for a given nutrient is calculated as the ratio of a subject's intake to the current recommended allowance. To estimate the nutrient adequacy of the diet, NAR was calculated for the energy and other nutrients.

$$\text{NAR \%} = \frac{\text{Nutrient intake}}{\text{Nutrient RDA}} \times 100$$

Adequacy of the nutrients was categorized as per Jood et al (1999)

NAR %	**Nutrient adequacy**
100% and above	adequate
75% and above	Marginally adequate
50-74 %	Moderately adequate
Less than 50%	inadequate

Food frequency questionnaire

A Food Frequency Questionnaire (FFQ) was used to obtain information about frequency of consuming different foods (daily, weekly, fortnightly, monthly, and occasionally/never). FFQ was specially tailored to obtain information regarding the frequency of intake of cereals, pulses, vegetables, milk and milk products, nonvegetarian food items, energy dense processed foods and foods from outside home. The questionnaire was scored on a 5 point scale. Score 5 was given if a particular item was consumed daily and score 1 if consumed occasionally or never

a)Personal habits and sleep pattern

Details on personal habits such as smoking, tobacco or pan chewing, alcohol consumption, sleeping hours, day time sleeping and sleep disturbances were collected from the subjects.

b) Stress

Stressful life events are events and situations that cause physical or emotional discomfort, fatigue, concern, anxiety, frustration. General stress and the pregnancy specified stress level of all the subjects were assessed using validated scales. Perceived Stress Scale was used to assess the general stress level of the subjects. The Perceived Stress Scale (PSS) was developed by Sheldon Cohen in 1983 (Cohen et al., 1983) and has become one of the most widely used psychological instruments for measuring nonspecific perceived stress.

It has been used in studies assessing the stressfulness of situations (Leon , 2007) and PSS predicts increased risk for disease among persons with higher perceived stress levels.

Pregnancy demands different adaptations that can cause stress (Dunkel Schetter & Tanner 2012). A revised version of the Prenatal Distress Questionnaire (PDQ;Yali & Lobel, 1999) was used to assess stress originating from issues common in pregnancy. The revised PDQ included 10 items and respondents had to indicate the extent to which they are feeling "bothered, upset, or worried at that point" about issues including medical care, physical symptoms, parenting, bodily changes, and the infant's health. Responses were measured on a 3-point scale ranging from 0 (not at all) to 2(very much).

c) Physical activity pattern and sedentary behaviours

Studies have revealed that physical activity participation before pregnancy or in early pregnancy significantly lower the risk of developing GDM (Tobias et al., 2011) and even prevention of glucose tolerance during pregnancy may be possible if women of reproductive age engage in leisure time physical activity in advance of becoming pregnant (Baptiste Roberts, 2011).Hence information regarding the type of occupational activity, time spent on household chores and exercises done during the pregnancy and pre pregnancy period was taken from the subjects. Details regarding the barriers to do exercises, types of sedentary behaviours involved in and the time spent on each item was also assessed from the subjects.

3.6.2. PHASE II GESTATIONAL FOLLOW UP OF THE PATIENTS

All the subjects both cases and controls were followed from 24 -28 th weeks of gestation until their delivery to monitor their glycemic control, weight changes, blood pressure changes and management of GDM. An interview schedule was developed to obtain follow up data from the patients at 28-32 weeks and 37-41 weeks **(AppendixVI**).

Glycemic control of the subjects was monitored by testing the fasting blood glucose level and the post prandial blood glucose level .

Weight gain during pregnancy consists of 30% maternal fat accretion (National Academy of Sciences, 1990) and might be characterized by progressive insulin resistance (Buchanan et al., 2005).So weight gain in pregnancy was monitored for all the subjects .

Blood pressure of the subjects was also assessed as hypertensive disorders were noted in significantly higher rates in GDM mothers. (Miyakoshi et al., 2004)

Women diagnosed with GDM are often intensively managed with increased obstetric monitoring, dietary regulation, and in some cases insulin therapy. (Tuffnell et al., 2003).Type of management strategies implemented for glycemic control such as diet therapy, drugs, insulin or combinations of these were also assessed during their follow up visits.

3.6.3. PHASE III ASSESSMENT OF PREGNANCY OUTCOME

A diagnosis of GDM heralds potential risks for the mother and the baby (Buchanan et al., 2007). Hence the pregnancy outcome of all subjects under study was investigated. Pregnancy outcome was broadly classified into maternal outcome and neonatal outcome. Data on maternal outcome and neonatal outcome was gathered using a formulated schedule. (**Appendix VII**).

3.6.3.1. Maternal outcome

GDM predisposes the mother to various short term and long term consequences. Information regarding mode of delivery (cesarean or vaginal delivery) were noted for all the subjects.

GDM mothers are prone to adverse pregnancy outcomes (Sendag ,2001). Incidence of associated antepertum and intra partum complications such as hypertensive disorders polyhydraminos,Urinary Tract Infection (UTI) and antepartum or post partum haemorrage was recorded for all the samples.

3.6.3.2. Neonatal outcome

Several studies have documented the association of maternal hyperglycemia and adverse neonatal outcomes. For the foetus or neonate of GDM mothers there is an increased risk of perinatal mortality (Shand et al., 2008) and morbidity (Watson et al., 2003), macrosomia (Kwik etal., 2007), congenital abnormalities, hyperbilirubinemia and neonatal hypoglycaemia (Turok et al., 2003). Thus, general neonatal characteristics,

neonatal anthropometry, neonatal complications, admission to NICU and requirement of phototherapy were the variables selected to investigate the neonatal outcome.

3.6.3.3.General neonatal characteristics

General neonatal characteristics such as term of birth (full term or preterm) and type of birth (livebirth or still birth) and AGAR scrore at five minutes were recorded for all the neonates**.** Hedderson et al (2003) opined that in a large cohort study GDM was an independent risk factor for spontaneous preterm birth. Preterm is defined as babies born alive before 37 weeks of pregnancy are completed (WHO 2014).

Apgar score is a method to quickly summarize the health of newborn children developed by Dr. Virginia Apgar (*Apgar Virginia 1985).*The Apgar scale is determined by evaluating the newborn baby based on five simple criteria on a scale from zero to two, then summing up the five values thus obtained. The resulting Apgar score ranges from zero to 10. The five criteria for APGAR score are Appearance, Pulse, Grimace, Activity and Respiration.

3.6.3.4. Neonatal anthropometry

Neonatal anthropometric assessments were carried out by using standard measuring procedures. Birth weight, crown heel length and head circumference of the baby are the anthropometric parameters noted. The weight of the newborn was measured using an electronic scale and an infantometer was used to measure the crown heel length of the

newborn. The head circumference of the newborn was measured between glabella and occipital prominence, using inch tape. Neonatal information was recorded with the help of a medical assisstant and also from the hospital records.

3.6.3.5. Neonatal complications

GDM is associated with numerous adverse neonatal outcomes. A higher proportion of children are born with macrosomia (Ostlund et al., 2003), hypoglycemia (Simmons et al., 2000) even when the condition is being treated. Detailed information regarding neonatal complications was collected from the records.

3.6.3.6.Macrosomia

Macrosomia is one of the most common complications of GDM. The HAPO study reported a co positive association between maternal glycemia, fetal hyperinsulinism and birth weight. (Metzger et al., 2002). A cut-off of 3.5 kg was used to define a macrosomic baby in the present study.

3.6.3.7. Metabolic disorders

Occurrence of metabolic disorders such as neonatal hypoglycemia, neonatal jaundice and hypocalcemia were noted as neonatal blood glucose was tested for these metabolic disorders immediately after delivery. Hypoglycemia in the first few days after birth is defined as blood glucose <40 mg/dL (UCSF, 2014).The fetus of GDM mothers by virtue

of being exposed to high concentration of glucose in utero responds by fetal β cell hyperplasia which results in fetal hyperinsulinemia which leads to hypoglycemia in the neonates (Singh et al., 2010). Incidence of neonatal jaundice and hypocalcemia was also reported in many studies (Das & Ankola , 2012) (HAPO, 2012).

3.6.3.8.Hematological and respiratory disorders

Hematological disorder such as polycythemia was noted. Polycythemia is a condition that results in an increased level of circulating red blood cells in the blood stream. Incidence of respiratory disorders such as Respiratory Distress Syndrome (RDS) was also noted. Mashiah *et al* (2009) suggested that GDM interferes with maturation, causing babies prone to respiratory distress syndrome due to incomplete lung maturation and impaired surfactant synthesis.

3.6.3.9.Congenital anomalies

Martinez-Frias et al (1998) concluded in their study that pregnancies complicated by GDM should be considered at risk of congenital anomalies. Occurrence of congenital anomalies was noted for all the neonates of the controls and cases.

3.6.3.10.NICU admission and phototherapy

Data regarding the admission to NlCU and requirement of phototherapy was also noted. In a retrospective case-control study, Michael 2009 have reported that 5-7% of infants

born to GDM mothers are admitted to NICU for various reasons mainly of hypoglycemia, perinatal distress and the rate is double the admission rate of length of hospital stay of newborns of normal mothers.

3.7. Analysis of data

The data collected was subjected to both qualitative and quantitative analysis. The data was coded and entered into excel worksheets. It was statistically analysed using SPSS version 16. Simple associations were assessed with frequency tables. The data was presented as absolute numbers and percentages. Mean and standard deviation were used to analyse the data. Fisher's exact test and χ^2 analysis were performed to test for differences in the proportions of categorical variables between cases and controls. Binary logistic regression analysis was used to assess the relationship between dependent and independent variables. The level $P < 0.05$ was taken as the cut-off value for significance.

2. REVIEW OF LITERATUE

The review of literature of the present study entitled “Assessment of risk factors and pregnancy outcome of Gestational Diabetes Mellitus (GDM)” are discussed under the following heads.

2.1 KNOWING ABOUT GDM

2.2 GLIMPSES FROM THE PAST

2.3 INTERGENERATIONAL TRANSMISSION OF GDM

2.4 PATHOPHYSIOLOGY

2.5 PREVALENCE

2.5.1 GLOBAL BURDEN OF GDM

2.5.2 INDIAN SCENARIO

2.5.3TREND IN SOUTH INDIA

2.6 SCREENING AND DIAGNOSIS

2.7 RISK FACTORS

2.8 COMPLICATIONS

2.8.1 SHORT TERM NEONATAL CONSEQUENCES

2.8.2 LONG TERM CONSEQUENCES TO THE OFFSPRING

2.8.3 MATERNAL CONSEQUENCES

2.9 MANAGEMENT OF GDM

2. REVIEW OF LITERATURE

2.1KNOWING ABOUT GDM

According to Ban Ki Moon (2010) millions of women and children die from preventable causes. These are not mere statistics. They are people with names and faces and in this 21st century their suffering is unacceptable. Globally, diabetes is the ninth leading cause of death in women, causing 2.1 million deaths per year (IDF,2015).The prevalence of diabetes is increasing globally and the number of people with this disease is projected to rise from 171 million in 2000 to 366 million in 2030 (Wild et al.,2004). Several factors have been identified that contribute to the rising prevalence of diabetes mellitus such as aging, population structure, urbanization, the obesity epidemic, and physical inactivity (Hunt and Schuller, 2007). Parallel to the increased prevalence of diabetes in the general population, the frequency of GDM had also increased tremendously.

GDM being common but controversial disorder (Turok et al., 2003) is defined by WHO as carbohydrate intolerance resulting in hyperglycemia of variable severity with onset or first recognition during pregnancy. This definition acknowledges the possibility that patients may have previously undiagnosed diabetes mellitus, or may have developed diabetes coincidentally with pregnancy (WHO, 2005). GDM brings about adverse pregnancy outcomes both to the mother and foetus. Recently, the American Diabetes Association defines GDM as diabetes diagnosed during pregnancy that is not clearly overt diabetes (ADA, 2014). GDM is the most common metabolic complication

occurring in pregnancy that imposes a significant economic burden with important short-term and long-term consequences for the mother and her baby (Dall et a.,l 2012). To the society as a whole there is the economic cost and the productivity of the family that is affected by this condition (Amos and McCarty ,2010).

2.2GLIMPSES FROM THE PAST

Heinrich Bennewitz in Berlin described GDM for the first time in 1824 in his medical dissertation. He described a clinical case of a woman with recurrent glycosuria in three successive pregnancies (Negrato and Gomes, 2013). In 1882, J Mathews Duncan, and obstetrician from London concluded from his experiences that diabetes may come during the pregnancy, diabetes may occur only during pregnancy being absent at other times, diabetes may disappear after pregnancy, recurring some time afterwards, pregnancy can occur during diabetes and pregnancy in diabetes is mostly associated with poor maternal and fetal outcome.

John Withridge Williams in 1909 reported differences in prognosis for women with early or late detection of glycosuria in pregnancy. Hurwitz and Jensen in 1946 described testing of carbohydrate metabolism in pregnancy by oral glucose tolerance test.(Knopp and John,2002). During the post war period in 1954 Dr. J. P. Hoet described glucose intolerance during and after pregnancy in a paper written in French and translated into English by Dr. F.D.W. Lukens. He used the terms “transitory diabetes of pregnancy” for

GDM, and “metagestational diabetes” for subsequent diabetes. (Hoet and Lukens 1954).

In1964 O'Sullivan and Mahan defined GDM if a pregnant woman undergoing a 3-h 100-g oral glucose tolerance test had glucose values exceeding 2 SDs above the mean on two of the four values. The WHO Expert Committee on Diabetes Mellitus published the first guideline on diabetes mellitus in 1965. They defined gestational diabetes as “hyperglycemia of diabetic levels occurring during pregnancy”. WHO published new guidelines in 1980, 1985, 1999 and 2013 after these initial attempts to define GDM.

2.3INTERGENERATIONAL TRANSMISSION OF GDM

Researches in humans and animals convincingly demonstrate that environmental perturbations in utero may permanently change organ structure and metabolism. It may alter homeostatic regulatory mechanisms among the offspring and these programmed changes may be the origins of adult diseases, including diabetes, cardiovascular disease and obesity. (Ross and Desai, 2005).The “fetal origin of adult disease” hypothesis proposes that gestational programming may critically influence adult health and disease (Barker, 1995). This association has been ascertained by the developmental programming hypothesis, which proposes that environmental stimuli acting during critical windows of development, including fetal or early postnatal periods, can induce permanent alterations in cell or tissue structure and function (Gluckman et al., 2008).

The metabolic imprinting caused by the obese and diabetic intrauterine environment can be transmitted across generations. Glucose intolerance in pregnancy is a strong stimulus that predisposes the offspring to an increased risk of developing glucose intolerance in the future. Pettitt and, Knowler (1988) suggested that a vicious cycle results, explaining the increases in obesity, gestational diabetes mellitus (GDM), and type 2 diabetes seen over the past several decades. The incidence and prevalence of glucose intolerance in any population is likely to be influenced by this vicious cycle. (Seshiah et al., 2004). GDM give rise to a vicious cycle in which mothers with GDM have babies with epigenetic changes who are prone to develop metabolic disease later in life, which will give rise to a new generation of mothers with GDM. This trend of passing a disease from one generation to another through epigenetic changes is known as transgenerational transmission (Catalano,2003).

Fig 1 Vicious cycle of intergenerational transmission of GDM.

Inorder to break this viscious cycle the preventive measures against type 2 diabetes should start during the intrauterine period and continue from early childhood throughout life (Tuomilehto, 2005).

2.4PATHOPHYSIOLOGY

Decreased maternal insulin sensitivity or increased insulin resistance is the underlying pathophysiology of gestational diabetes. Ben-Ziv & Hod (2008) suggested that Type 2 diabetes and GDM are probably the same disease but at different stages on the spectrum of glucose intolerance and there is a similarity in the pathogenesis of the two. In normal pregnancy, insulin resistance increases in the late second trimester to levels that approximate that seen in T2DM (Miehle et al ., 2012). However, GDM develops if beta-cell compensation is inadequate for the level of insulin resistance and hepatic glucose production (Metzger, 2010)

Pregnancy induces progressive changes in maternal carbohydrate metabolism. As pregnancy advances insulin resistance and diabetogenic stress due to placental hormones necessitate compensatory increase in insulin secretion. When this compensation is inadequate gestational diabetes develops (Desoye et al.,2008). During normal late pregnancy the requirement of insulin is high and differ only slightly between normal and gestational diabetic women. However, in contrast to healthy women, GDM women consistently show reduced insulin responses to nutrients (Homko et al., 2001).

Gestational diabetes mellitus represents an insulin resistant state, possibly due to the placental production of progesterone, cortisol, prolactin and other hormones which interfere with normal glucose metabolism (Buchanan and Xiang, 2005). They also stated that many other defects, such as alterations in the insulin signaling pathway, reduced expression of PPARγ and reduced insulin-mediated glucose transport have been found in skeletal muscle or fat cells of women with GDM.

According to Shao (2000) gestational diabetes occured when insulin receptors do not function properly. This is likely because of pregnancy related factors such as the presence of human placental lactogen that interferes with susceptible insulin receptors. Pregnancy as an insulin resistant state may reveal even the smallest pre-existing defects in insulin secretion or insulin sensitivity and as a consequence, relative β-cell failure appears (Yu et al.,2006) Thus, pregnancy may act as a "stress test", revealing a woman's predisposition to Type 2 Diabetes and providing opportunities for focused prevention of important chronic diseases (Kaaja and Greer ,2005).

2.5. PREVALENCE

2.5.1.GLOBAL BURDEN OF GDM

Diabetes is now a global epidemic. In 2015, an estimated 415 million people, corresponding 1 in 11 worlds' adult population had diabetes. The number is expected to grow to 642 million by 2040, corresponding to 1 in 10 adult populations (IDF,2015).

The magnitude of GDM varies according to the country and their ethnical groups. Many factors such as lifestyles, educational status, and history of diabetes in family play an important role (Moses et al., 1998). Higher rates have been reported in certain ethnic groups (ADA,2006). It is estimated that 16.8% of live births across the world in 2013 were in women who had some form of hyperglycemia in pregnancy (IDF 2013).

As per the Diabetes Atlas 2015 by International Diabetes Federation (IDF), one in seven births is affected by GDM. About 87 percent of cases of hyperglycemia in pregnancy were in low and middle-income countries. Review of data published over the past decade indicated that the highest prevalence was reported in Middle East and North Africa, with a median estimate of 13%, whereas the lowest was in Europe, with a median prevalence of 5.8% (Zhu, 2016).

Asian, Hispanic, and Native American women have an, increased risk of GDM when compared with non-Hispanic white women. Among ethnic groups in South-Asian Countries, Indian women have the highest frequency of GDM (16.7%) followed by Chinese (15%), Vietnam-born (9.6%) and Australian born (4.3%). For a given population and ethnicity, the risk of GDM, mirrors that of the underlying frequency of type 2 DM in that population (Savitz et al.,2008).

2.5.2 INDIAN SCENARIO

GDM is becoming a public health concern globally as well as in India with fast increasing trend. It affects approximately 14% of all pregnancies (Seshiah et al., 2008).The diabetes epidemic is more pronounced in India as the World Health Organization (WHO) reports shows a projected rates of 79.4 million in 2030 that is a 151% increase from 31.7 million in 2000 (Wild et al., 2004). A total number of 40.9 million of diabetic subjects was estimated by the International Diabetes Federation (IDF) and this is further set to rise to 69.9 million by the year 2025 (Sicree et al., 2006). The prevalence of GDM in India was 16.55% in the urban area and the frequency varied upto 21% in different parts of the country (Seshiah et al., 2011)

The number of diabetic subjects is expected to rise to 313,3 million by 2030.Over five million women in India, has been estimated to affect by gestational diabetes mellitus (GDM) and also estimates that 20.9 million or 16.2% of live births to women in 2015 had some form of hyperglycaemia in pregnancy. Among this 85.1% were due to gestational diabetes, 7.4% due to other types of diabetes first detected in pregnancy and 7.5% due to diabetes detected prior to pregnancy. India, being the second leading dweller of diabetic subjects (69.2 million) has become the “diabetes capital of the world” having around four million women with GDM alone (IDF, 2015).

2.5.3TREND IN SOUTH INDIA

In south India, the prevalence of GDM has increased from 1% in 1998 (Ramachandran et al., 1998) to 16.55% in 2004 (Seshiah et al., 2004).The data published in a community

based prevalence study the ‘Diabetes in Pregnancy Awareness and Prevention - DIPAP project where a total of 12,056 of pregnant women were screened in the urban, semi urban and rural areas of Tamilnadu, GDM was detected in 17.8% women in urban, 13.8% in semi urban and 9.9% in rural regimes. A prevalence study done in Kerala by Dr. paulose in 2008 found a prevalence rate of 11.2%. The study group comprised of patients who belonged to the higher sociecconomic strata. In 2014 a higher prevalence rate of 17% was noted in a study done in Kollam district Kerala (Sreekanthan et al .,2014). Jali et al. (2011) reported that the prevalence of GDM in India ranges from 3.8 per cent to 21 per cent depending upon the diagnostic method used

2.6.SCREENING AND DIAGNOSIS

GDM screening is important both for the maternal and fetal health. There is no single criterion regarding screening and diagnostic methods for GDM. Universal or risk based one step or two step procedure can be used for screening and diagnosis. Wide disparities could be observed in the guidelines for GDM screening and diagnosis among countries and between major societies worldwide. (Leary *et al., 2010).* Opinions as to the timing of GDM screening differ. The most recognised diagnostic test for GDM is the oral glucose tolerance test (OGTT) usually performed between 24–28 weeks gestation (Farrar et al ., 2012). According to WHO all pregnant women should be screened for GDM between 24^{th} and 28^{th} week of pregnancy (WHO 2006).

Different criteria exist for GDM screening and as a result studies investigating prevalence of GDM are often diverse in terms of methods employed, cut-off values used and consequently, results obtained (Nielsen., 2012).

First proposed in 1964, the O'Sullivan and Mahan criteria formed the basis for the majority of criteria that subsequently evolved. O'Sullivan and Mahan suggested the use of a 50 g 1 h glucose challenge test (GCT) to screen for GDM followed by a diagnostic test in those who were GCT positive (1 h post glucose load exceeds 140 mg/dl) using 100 g 3-h oral glucose tolerance test (OGTT).

Subsequently in 1982, Carpenter and Coustan introduced a correction factor and modified the O'Sullivan and Mahan criteria by adjusting for the differences in assay methods. This was later validated and thus the famous Carpenter and Coustan criteria for GDM came into existence and soon became widely accepted. (Paglia et al .,2011)

Several criteria for diagnosing GDM have been recommended by various national and international bodies including the American Diabetes Association (ADA),Australasian Diabetes in Pregnancy Study Group (ADIPS),Canadian Diabetes Association (CDA), European Association for the study of Diabetes (EASD), International Association of the Diabetes and Pregnancy Study Groups(IADPSG), International Classification of Diseases (ICD),National Diabetes Data Group (NDDG), the World HealthOrganization (WHO) and the Diabetes In India PregnancyStudy Group of India (DIPSI). These criteria differ in their requirement for the subject to be in a fasting state, the number of samples needed,

the amount of glucose adminstered and blood glucose thresholds for GDM detection (Linnenkamp ,2014)

To deal with the differences in diagnostic testing and to give clarity to the unanswered questions regarding the association of glucose with risks of adverse pregnancy outcomes, the Hyperglycemia and Adverse Pregnancy Outcomes (HAPO) study was planned. This study carried out by the International Association of Diabetes and Pregnancy Study Groups (IADPSG) identified the cut-off criteria by looking at neonatal outcome by glucose values. HAPO was a large multinational and multi center study, which included over 23,000 pregnant women (*Metzger, 2008)* . The diagnosis was to be made if any one of the values for fasting plasma glucose, 1-h glucose, or 2-h glucose equaled or exceeded the diagnostic threshold as shown FPG $\geq$ 92 mg/dl (5.1 mmol/l), 1 h $\geq$ 180 mg/dl (10.0 mmol/l),2 h $\geq$ 153 mg/dl (8.5 mmol/l).(IADPSG 2010) The World Health Organization has now adopted the IADPSG criteria.(Roglic and Colagiuri , 2014)

The NICE guideline advocate screening with fasting blood glucose rather than the 2-hour 75-g OGTT, and advises against the routine use of the OGTT (NICE, 2015).The ADA endorses the Carpenter and Coustan criteria and recommends that women with high risk of GDM undergo glucose testing as early as possible during pregnancy. The ADA recommends that the testing for GDM at 24–28 weeks be done either by one step approach using a 100 g OGTT or by two step process, with an initial test using 50 g GCT followed by the diagnostic OGTT using 100 g glucose load (ADA, 2016).

The Diabetes in Pregnancy Study Group of India (DIPSI) introduced simplified guidelines for screening and management of GDM in India. Pregnant women were given 75g anhydrous glucose in 250-300 ml of water and plasma glucose was estimated after 2 hour. A 2-hours plasma glucose ≥ 140 mg/dl was taken as GDM. The DIPSI criteria, because of its sheer simplicity, has been widely accepted and used in many parts of India and (*Goonewardene et al., 2013).* DIPSI follows this one step diagnostic procedure (Seshiah et al., 2009) and glucose tolerance test can be performed irrespective of last meal timing to diagnose GDM.

Large survey conducted all over India, covering 24 states reveals that more than half of the diabetologists and gynecologistss in India do not follow any of the recommended guidelines for the diagnosis of GDM possibly due to lack of awareness about the guidelines. This emphasizes the need for increased awareness about screening and diagnosis of GDM both among physicians and gynecologists (Mahalakshmi et al .,2016).

2.7.RISK FACTORS

A risk factor refers to any attribute, characteristic, or exposure of an individual, which increases the likelihood of developing a non communicable disease. WHO (1999) has noted that certain individuals were at high risk for GD The maternal risk factors, commonly termed as“traditional risk factors”, are higher maternal age, increased body weight, higher parity, previous delivery of a macrosomic infant, and family history of diabetes mellitus (Ben Haroush et al ., 2004).

Saydah et al., (2005) has found out that age is a clear risk factor for the development of GDM. The rate of incidence of GDM varies according to the age and, the incidence increases 12-fold between the ages of 25 and 45 years (Ross, 2006). Some racial and ethnic groups presented higher gestational diabetes mellitus frequencies Ethnicity has an impact on the prevalence of GDM and differs significantly among ethnic groups in the USA: 4.1% in Caucasians, 4.3% in African Americans, 7.0% in Latinas and 9.7% in Asians. However, all pregnant woman of Asian Indian ethnicity have an increased risk of GDM (Wahi et al., 2011).

Overweight and obesity are well-known risk factors for development of GDM. Retnakaran et al. (2009) reported that Asian women's pre-pregnancy BMI has a greater influence on the pregnancy related insulin resistance than that of Caucasian women.

A sixteen year follow up study has documented that the relative risk for women with a BMI of 35 kg/m2 was 38.8, compared to 20.1 for women with a BMI of 30-34.9 kg/m2. The Hyperglycemia and Adverse Pregnancy Outcome (Metzger et al., 2008) study reported that a higher pre-pregnant BMI and the BMI at 28 week are strongly correlated to increased insulin resistance at 28 week.

Short stature is described as another maternal risk factor .In a study done in Korea a higher prevalence of GDM was observed among shorter women .(Jang et al 1998). In

Brazil, women shorter than 151 cm show a 60% increase in GDM than women 160 cm or more (.Branchtein ,2000).

Lapolla (2010) demonstrated that excessive weight gain during first trimester increased the morbidity of GDM. Saldana et al. (2004) has found out the association between weight gain at the end of the second trimester and the risk of glucose intolerance and gestational diabetes mellitus.

Di Cianni et al. (2003) found greater ratio of women with gestational diabetes mellitus in the group with parity greater than or equal to two, in comparison to primiparas.

A history of GDM in the prior pregnancies is a risk factor for future GDM. Accrding to Getahun et al. (2010) the risk of GDM was 13.2-fold higher in women who had history of GDM.

Ferrara (2007) has suggested that polycystic Ovary Syndrome, multiparity, twin pregnancy and a family history of diabetes are well known risk factors of GDM.

Apart from the clinical reasons there are several lifestyle factors contributing to GDM. According to Althuizen et al. (2009) prepregnancy overweight as well as low physical activity and high-food intake during pregnancy are associated with GDM. Accumulating evidence suggested that high-fat diet, sweet food, and high intake of fruits or cholesterol were prominent risk factors for GDM pathogenesis (Ying et al., 2006). Macronutrient components of the diet in mid pregnancy may predict incidence of GDM. (Wang, 2000)

Zhang (2006) has pointed out that pregravid consumption of dietary fiber was significantly and inversely associated with GDM risk

2.8. COMPLICATIONS

GDM, if not managed properly, may lead to variety of complications, both for the mother and the baby during and after the pregnancy (Jolly, 2009).Accumulated evidence has shown that GDM is associated with a range of negative short or long-term health outcomes, both to pregnant women and their offspring. Meanwhile, these adverse effects can produce vicious cycles across generations.(Reece, 2004).

2.8.1. SHORT TERM NEONATAL CONSEQUENCES

In GDM pregnancy the hyperglycaemic intrauterine environment can affect multiple aspects of the health of the offspring throughout the course of its life. Even border-line GDM has been linked with an increased frequency of perinatal complications. At birth, offspring are more likely to be large, macrosomic and suffer from birth injury (ADA, 2004).), In a study in Mysore, South India, maternal fasting glucose at 30 weeks of gestation was positively associated with infant birth weight, ponderal index, and head circumference (Hill, 2005).

Macrosomia is the most common fetal complication with a reported incidence of 15%–45% (Esakoff, 2009,). Several studies suggest that there exist a linear relation between glycemia during pregnancy and infant body size. Yogev (2005) reported that in a study of 6,854 consecutive pregnant women screened for GDM, increasing glucose

concentration at screening was associated with higher prevalence of macrosomia. The HAPO Study Cooperative Research Group recently showed a strong and continuous correlation between maternal glucose levels and increased birth weight and cord-blood serum C-peptide levels (Metzger et al., 2008). GDM increases the offspring's predisposition to obesity and diabetes (Griffin et al.,2000), (Boney et al 2005) and is responsible for increased adiposity in children (Gillman et al., 2003). Shoulder dystocia is a serious complication of childbirth and is associated with increased foetal size.

2.8.2.LONG TERM CONSEQUENCES TO THE OFFSPRING

Although the immediate effects of maternal glucose on fetal growth are well described, the long-term consequences on the offspring are less clear. Maternal insulin resistance and corresponding hyperglycemia can result in fetal hyperinsulinemia, which can lead to excessive fetal growth associated with macrosomia and increased adiposity (Catalano and Hauguel-de, 2011). The results of a study done by (Tam et al., 2008) showed that in utero hyperinsulinemia is an independent predictor of abnormal glucose tolerance in childhood and increases the offspring's cardiometabolic risk.

GDM and fetal macrosomia significantly increase the child's risk of developing the metabolic syndrome in childhood. Mitanchez (2014) reported that impaired glucose tolerance, type 2 diabetes, hypertension, obesity, and dyslipidemia are the common long term complications seen among the infants of diabetic mothers. Kelstrup et al. (2013) found that exposure to intrauterine hyperglycaemia was associated with impaired insulin

sensitivity and relatively impaired insulin secretion in adulthood, both of which are characteristics of type 2 diabetes .The following figure depicts how maternal diabetes brings about long term consequences to the offspring. Hillier et al. (2007) reported a dose-response relationship between levels of maternal hyperglycemia in pregnancy and offspring obesity at age 5–7 years in a retrospective cohort study.

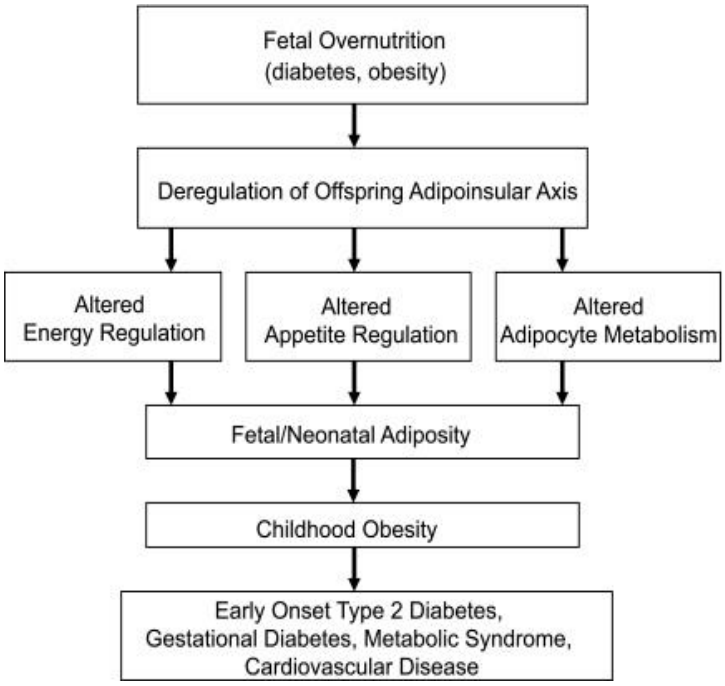

Fig (2) Potential pathways linking fetal over nutrition to long-term consequences in the offspring (Macmillan ,2006)

Some **s**tudies have established that gestational diabetes mellitus may increase the chance for birth defects (Vinceti et al., 2014) and also defects like autism, schizophrenia, depression in later life (Abel et al., 2013) . Fraser (2014) reported that relatively lower IQ was seen among the children of GDM mothers.

2.8.3.MATERNAL CONSEQUENCES

Pregnancies of GDM affected patients are often complicated by gestational hypertension or preeclampsia; rates are also increased for delivery by cesarean section or significant trauma during vaginal delivery (Yogev et al., 2004).Women with GDM have increased chances of developing pre-eclampsia (Montoro , 2005) and it predisposes the patient to perinatal complications such as perinatal death, prematurity and intrauterine growth retardation .Rowan et al. (2008) has also pointed out that women with GDM are at higher risk of hypertensive disorders including gestational hypertension, preeclampsia, and eclampsia. Women with GDM also have higher rates of caesarean sections and induced deliveries (Jhu et al.,2008). GDM also results in excess growth of the fetus, causing problems during labour and delivery for both mother and offspring, including birth lacerations and delivery by caesarean section (Metzeger et al., 2008). Gorgal (2012) found a 19.5% rate of non-elective cesarean delivery in women with GDM, compared with 13.5% in women without diabetes .

Evidence suggests that 30 to 50 percent of women diagnosed with gestational diabetes mellitus will go on to develop type 2 diabetes mellitus in future (Poth and Carolan, 2013). Even though most women return to a euglycaemic state shortly after delivery women who have had GDM have a substantially increased risk for development of Type 2 Diabetes. (Bellamy et al., 2009) The long-term consequences of gestational diabetes mellitus is the risk of developing cardiovascular disease, hypertension and stroke if left untreated (ADA , 2014). Up to 10per cent of patients with prior GDM are diagnosed with

Type 2 Diabetes soon after delivery and during a ten-year follow-up, the risk of developing Type2 Diabetes is approximately 40 per cent (Lauenborg et al .,2006).

2.9.MANAGEMENT OF GDM

Early recognition and management of GDM is important because the therapy can reduce the prenatal morbidity and mortality (Anderson et al., 2003). The important elements of the therapy include education, nutritional therapy, exercise, and medical treatment.

Zhang et al. (2014) suggested that more than 45% of GDM cases might have been prevented if women adopted an overall healthy diet and lifestyle and maintained a healthy body weight before pregnancy. Gestational diabetes mellitus knowledge among mothers can help decrease birth complications and outcomes. Poth and Carolan (2013) showed that the lack of appropriate knowledge of lifestyle and diet to prevent gestational diabetes mellitus contributes greatly to birth outcomes.

By increasing insulin sensitivity and improving glucose tolerance via several mechanisms such as physical activity has a beneficial effect on many aspects of insulin resistance syndromes (Dagfinn et al., 2016). Many studies evaluated the association between physical activity and gestational diabetes mellitus, however it has been stated that increasing physical activity could decrease the glucose intolerance in diabetic pregnant women (Cliantha and Jeff, 2015).

Sylvia et al. (2017) found a non significant reduction of gestational diabetes mellitus risk for women who were vigorously physical active or did brisk walking before pregnancy.

Even relatively modest, increase in habitual physical activity induce adaptations that can profoundly affect glucose tolerance and potentially decrease GDM risk ((Regensteiner, 2013)

Ruchat and Mottola (2013) provided a comprehensive overview of the effect of prenatal physical activity based intervention on glucose tolerance, insulin sensitivity, and GDM prevention. In a case-control study, participation in any recreational activities during the first 20 week of pregnancy was related to a 48% decreased GDM risk (Dempsey and Butler, 2011).

In addition to physical activity, studies of the association between dietary factors and the risk of GDM have just emerged over the last decade. Specific dietary counseling could be effective for control of gestational weight gain that might indirectly prevent GDM.(Zhang and Ning, 2013)

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4. RESULTS AND DISCUSSION

The results of the present study entitled “Assessment of risk factors and pregnancy outcome of Gestational Diabetes Mellitus (GDM)” are discussed under the following heads.

4.1. PHASE I ASSESSMENT OF RISK FACTORS OF GDM AMONG THE SUBJECTS

4.1.1. SOCIODEMOGARPHIC FACTORS

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4.1. PHASE I ASSESSMENT OF RISK FACTORS OF GDM AMONG THE SUBJECTS

In the first phase of the study the variables that are postulated to be the risk factors of GDM were analysed in detail and the results are given below.

4.1.1. SOCIODEMOGARPHIC FACTORS

The sociodemographic characteristics of all the respondents were obtained with special reference to their age, religion, education, occupation, income and type of family.

4.1.1.1AGE

The age wise distribution of the GDM and nonGDM respondents is presented in table 1

Table: 2.Distribution of the respondents based on age

Age	GDM	Non GDM	Total	Chi square
<20	6 (3.5)	4 (2.3)	**10 (2.89)**	**36.32***
20-24	57 (32.9)	101 (58.4)	**158 (45.66)**	
25-29	39 (22.5)	43 (24.9)	**82 (23.6)**	
30-34	66 (35.9)	25 (14.5)	**91(26.3)**	
35- 39	5 (2.9)	0 (0)	**5 (2.9)**	
Total	**173(100)**	**173(100)**	**346(100)**	

Figures in the parenthesis indicate the percentages *significance at five per cent level

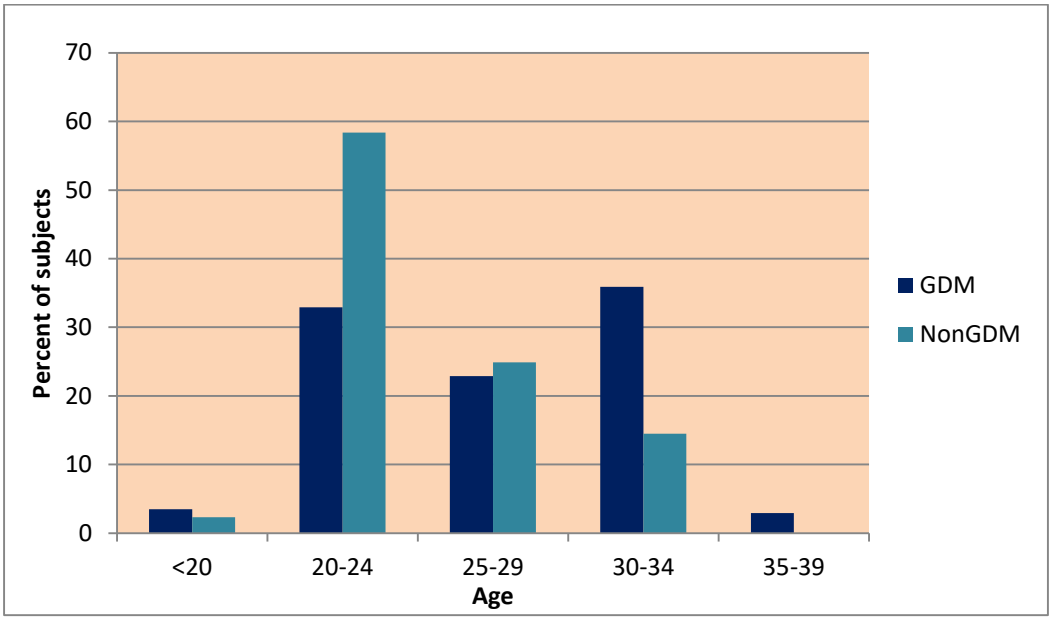

Fig 6. Age wise distribution of the respondents

Most of the subjects (45.66%) belonged to 20-24 age group followed by the age group of 30-34 (26.3%) and 25-29 (23.6%) respectively. Maternal age was found to be significantly (at 5% level) associated with the incidence of GDM. Although no age was exempted from the incidence of GDM, the chi-square analysis indicated a progressive increase in the incidence of GDM with age and it was more predominant in women of 30 years and above. Though the subjects above 35 years of age group were minimum (2.9%), all of them had developed GDM. Findings by Lao et al (2003) also indicated that the risk of GDM significantly and progressively increased from 25 years onwards. Bener et al (2011) observed women with GDM were significantly higher in the age group of 35-45years.In the modern society as Hollander et al (2007) pointed out the rising trend in

maternal age for the first as well as subsequent pregnancies due to changing social lifestyle play a pivotal role in the increased GDM incidence.

4.1.1.2. RELIGION

Kerala being a secular state possesses cultural diversity reflecting on the habits and practices of people and the data was analysed to study the association if any between the religious background of the respondents and incidence of GDM and presented in table 2

Table: 3 Distribution of the respondents based on the religion

Religion	GDM	Non GDM	Total	Chi square
Hindu	102 (59.0)	84 (48.6)	**186(53.7)**	
Christian	36 (20.8)	44 (25.4)	**80(23.12)**	
Muslim	35(20.2)	45 (26)	**80(23.12)**	**3.79**
Total	**173(100)**	**173(100)**	**346(100)**	

Figures in the parenthesis indicates the percentage

The distribution of the respondents according to religion is presented in the above Table 2.Religion is a dominant factor in the life of the people and Kerala is a multi religious society and religion is inextricably woven into all the major activities of society.

As obtained from the table majority of the GDM respondents belonged to Hindu religion (53.7%) followed by Christians (20.8%) and Islam (20.2%).The same trend was observed

among the control with subjects belonged to Hindu religion (48.6%) outnumbered Islam (26%) and Christian (25%). The Census Report of India, 2001, it was found that in Kerala, 56.2 per cent follow Hinduism, 24.7 per cent follow Islam and 19 per cent follow Christianity.However chisquare analysis failed to show any significant association between religious background of the respondents and GDM prevalence.

4.1.1.3. EDUCATION

Education is the single most important criterion for social and economic achievements of people (Economic Review, 2010).The following table presents classification of respondents on the basis of their educational status.

Table 4 Distribution of the respondents based on the education level

Education level	**GDM**	**Non GDM**	**Total**	**Chi square**
Graduation and above	95(54.91)	72 (41.61)	**167(48.26)**	**37.87***
Higher secondary	72 (41.6)	63 (36.4)	**135(39.01)**	
School level	6(3.5)	38 (22)	**44 (12.7)**	
Illiterate	0(0)	0(0)	**0**	
Total	**173 (100)**	**173 (100)**	**346(100)**	

Figures in the parenthesis indicate the percentage * Significance at five per cent level

The study population in general was literate and their educational status varied from school level (12.7%) to graduation and above (48.26%).The case control analysis indicated that majority of the GDM (54.9%) and nonGDM (41.61%) respondents had education upto graduation and above. Education upto school level was reported by 3.5 per cent of cases and 22 per cent of controls. The incidence of GDM in the present study seemed to be increasing with the educational status of the respondents to a significant level ($p<0.05$).This may be because the process of acquiring higher education elevates the age at marriage and maternal age as well which in turn predisposes GDM.

4.1.1.4. OCCUPATION AND INCOME

The results of the data analysed based on the occupational pattern and economic status are given in the table below

Table: 5. Occupation and family income of the respondents

Particulars	GDM	Non GDM	Total	Chi square
Occupational pattern				
Professional	9(5.2)	8(4.6)	**17 (4.91)**	
Office staffs	11(6.4)	12(6.9)	**23 (6.64)**	**0.102**
Self employed	5(2.9)	10(5.8)	**15 (4.33)**	
unemployed	148(85.5)	143(82.65)	**291 (84.1)**	

Total	**173(100)**	**173(100)**	**346 (100)**	
Monthly family income (Rs)				**3.12**
<10000	8(4.6)	9(5.2)	**17(4.91)**	
10000-20000	87(50.3)	82(47.4)	**169 (48.4)**	
20000-30000	64(37)	60 (34.7)	**124(35.8)**	
30000-40000	12 (6.9)	21 (12.1)	**33(9.53)**	
>40000	2(1.2)	1(0.6)	**3(0.86)**	
Total	**173(100)**	**173(100)**	**346 (100)**	

Figures in the parenthesis indicate the percentages

Kavitha (2011) has reported that occupation of a woman determines her thinking, awareness and decision making in matters of reproductive health. Among the respondents it was noted that majority (84.1 %) of them, including cases (85.5%) and controls (82.65%) were house wives and were not engaged in any type of income generating activities. The rest of the sample comprised of professionals (4.91 %), office assistants (6.64%) and self employed group (4.33%). The statistical treatment of the data could not reveal any significant association between GDM and occupational status of the respondents.

As far as economic status is concerned most of the respondents 50.3 per cent of cases and 47.4 per cent of the controls belonged to the category of a monthly income between

Rs10,000-20,000. This was followed by an income range of Rs 20,000-30,000 per month.Thirty seven per cent of GDM and 34.7 per cent of nonGDM respondents were grouped under this category. The chi square analysis showed no significant association between monthly income and GDM.

4.1.1.5. TYPE OF FAMILY

Family structure in the society has undergone several changes over the past decades .Variations in the family structure influences the well being of the individuals.

Table: 6 Distribution of the respondents based on the type of family

Type of family	**GDM**	**Non GDM**	**Total**	**Chi square**
Nuclear	112 (65.7)	109 (62)	**221 (63.87)**	**0.32**
Joint	61 (35.3)	64 (36.9)	**125 (36.1)**	
Total	**173 (100)**	**173 (100)**	**346 (100)**	

Figures in the parenthesis indicate the percentages

The nuclear family is the one which consists of a male, his wife and their unmarried children. Nuclear family is a rule of thumb as regard to Kerala and this was evident in the present study also. Nuclear system of family was more noticeable (63.87 %) among the respondents than the joint family system (36.1%). A higher prevalence of nuclear family

system has been reported in Kerala by Ukkru (2001). Although the incidence of GDM in nuclear families was almost double (65.7%) than that in joint families (35.3%), no significant association could be drawn between GDM and family structure.

4.1.2 ANTHROPOMETRIC FACTORS

4.1.2.1.HEIGHT AND WEIGHT OF THE RESPONDENTS

Table 7 reveals the mean height and prepregnancy weight of the respondents

Table: 7. Mean height and weight of the respondents

Particulars	**ICMR Standard**	**GDM**	**Non GDM**
Mean height (cm)	**161**	**155.9**	**158**
Mean prepregnancy weight(kg)	**55**	**59.3**	**57.57**

Though the mean height of the respondents both GDM (155.9cm) and nonGDM (158 cm) was less than the recommended height for Indian women (161 cm),the GDM group reported to have a shorter stature than nonGDM subjects. At the same time the prepregnancy weight was much above the standard weight recommended by ICMR (2010). So the respondent with GDM was found to be heavier and shorter than the nonGDM respondents. The association between short stature and a higher prevalence of GDM had been suggested by Moses et al (2004) and (Buchanan and Xiang, 2005).

4.1.2.2.PREPREGNANCY BODY MASS INDEX (BMI) OF THE RESPONDENTS

The prepregnancy BMI of all the respondents was assessed using prepregnancy weight and height. Prepregnancy weight was taken from the records and in some cases recalled by the respondents.

Table:8. Distribution of the respondents according to prepregnancy BMI

BMI classification WHO (2009) standard	**GDM**	**Non GDM**	**Total**	**Fisher's exact statistc**
Underweight <18.5	3 (1.7)	6 (3.46)	9 (2.6)	**5.613***
Normal range18.5-22.9	96(55.5)	117 (67.6)	213 (61.5)	
Overweight/obese ≥23	74 (42.8)	50 (28.9)	124 (35.83)	
Total	**173 (100)**	**173(100)**	**346(100)**	

Figures in the parenthesis indicates the percentage * Significance at five per cent level

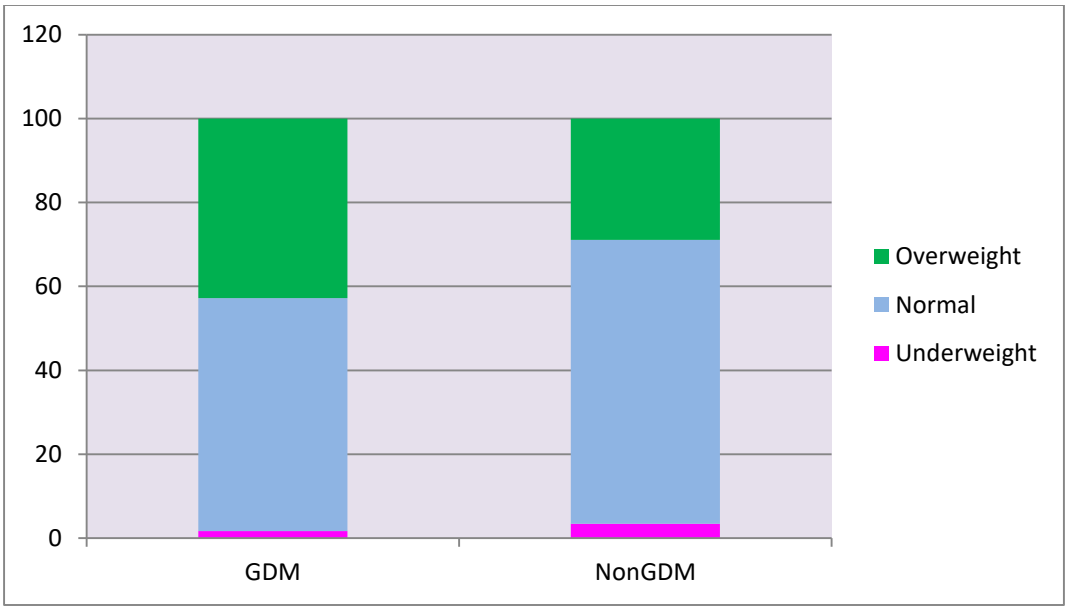

Fig 7. Prepregnancy BMI of the respondents according to WHO (2009) standard

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Under weight was observed in a few per cent of respondents (2.6%). Majority of the respondents (61.5%) were in the normal range category of BMI. This included 55.5 per cent of GDM and 67.6 per cent of nonGDM. Overweight/obese women constituted 35.83 per cent of the respondents with a reasonably good number in the GDM (42.8%) when compared to nonGDM (28.9%) suggesting that overweight/obesity may likely to predispose GDM. The statistical analysis using fischers test further proved that there was a significant ($p<0.05$) association between prepregnancy overweight/obesity and incidence of GDM. Sahay et al (2011) in their study also observed an increased prevalence of GDM with maternal obesity. Similar trend, increasing odds of GDM among women with prepregnancy obesity was also observed by Shin (2014

4.1.2.3. WEIGHT GAIN

The amount of weight gained during pregnancy is critical, since it can have short- and long-term effects on both infant and maternal health. An analysis of the weight gained in the early trimesters (upto 24 weeks) was done and the results are presented in the table below**.**

Table: 9. Weight gained up to 24 weeks of gestation

Weight gained	**GDM**	**NonGDM**	**Total**	**Chi square**
<6 kg	10(5.8)	8(4.6)	**18(5.2)**	**65.641****
6-7 kg	79(45.7)	148(85.5)	**227(65.6)**	
>7 kg	84(48.6)	17(9.8)	**101(29.2)**	
Total	**173 (100)**	**173 (100)**	**346 (100)**	

Figures in the parenthesis indicates the percentage

**Significance at 1% level

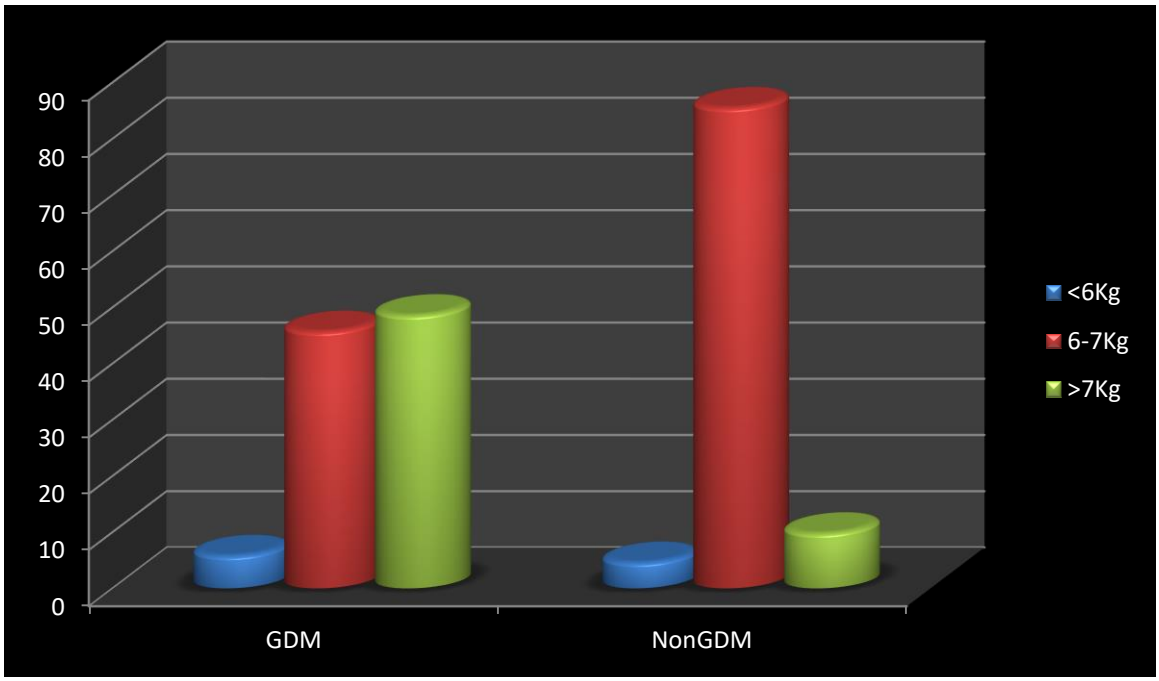

Fig 8. Weight gain pattern of the respondents

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As seen from the table 65.6 per cent of the respondents reported a weight gain of six to seven kilogram during pregnancy. But majority of them (85.5%) belonged to nonGDM group. Only 45.5 per cent of GDM women fell under this normal category. At the same time excessive weight gain in pregnancy (>7 kg) was mostly found among GDM women (48.6%) than their nonGDM counterparts (9.8%).

The difference observed in weight gained in initial trimesters of pregnancy among GDM and nonGDM respondents was statistically significant at one per cent level proving the risk of GDM owing to undue weight gain in pregnancy. As demonstrated by Lapolla et al (2010) excessive weight gain during first trimester increased the morbidity of GDM.

4.1.3 BIOCHEMICAL AND BIOPHYSICAL PARAMETERS

4.1.3.1. HAEMOGLOBIN LEVEL OF THE RESPONDENTS

One of the most important and frequently measurable health parameter in pregnant woman is the haemoglobin level. The blood haemoglobin level of the respondents was estimated and classified using WHO (2011) reference values and presented in the table below.

Table: 10. Haemoglobin level of the respondents

***Classification**	**Ref value Hb (g/dl)**	**GDM**	**Non GDM**	**Total**	**Chi-square**
Severe anaemia	Less than 7	Nil	Nil	-	**2.359**
Moderate anaemia	7 - 9.9	Nil	Nil	-	
Mild anaemia	10-10.9	5 (2.9)	11 (6.4)	16 (4.62)	
Normal	11 and above	168 (97.1)	162 (93.6)	330 (95.37	
Total		**173(100)**	**173 (100)**	**346 (100)**	

Figures in the parenthesis indicates the percentage

***WHO (2011)**

As obtained from the table irrespective of cases (97.1%) and control (93.6%) majority of the respondents had normal haemoglobin value of above 11g/dl. Severe or moderate anaemia was totally absent. Incidence of mild anaemia occurred only among a minority group (4.62%) affecting nonGDM women more than GDM population.The statistical

analysis failed to show any significant association between blood haemoglobin level and GDM. Timely intervention of iron supplementation right from the beginning may be the reason for nonexistence of severe and moderate anaemia among the respondents.

4.1.3.2.BLOOD PRESSURE LEVEL OF THE RESPONDENTS

The biophysical parameter constantly watched during pregnancy is blood pressure.The mean systolic and diastolic blood pressure of the respondents is given in table 11.

Table :11. Blood pressure level of the respondents

Blood pressure classification	**value (mm/Hg)**	**GDM**	**NonGDM**	**Total**	**Chi-square**
Normal	SBP≤120 and DBP≤80	155(89.6)	159 (91.9)	314(90.75)	**0.584**
Prehypertensive	SBP 120-139 and/or DBP 80-89	11 (6.4)	9 (5.2)	20 (5.78)	
Stage 1 hypertension	SBP140-159and /or DBP 90-99	7 (4)	5 (2.9)	12 (3.46)	
Stage 2 hypertension	SBP≥160and /orDBP≥100	Nil	Nil	Nil	
Total		**173(100)**	**173 (100)**	**346 (100)**	

Figures in the parenthesis indicates the percentage

The blood pressure readings were compared with the normal values given by Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (2007). Majority of the GDM (89.6%) and nonGDM (91.7%) sample were grouped under normal blood pressure category. Prehypertension and stage 1 hypertension was also noticed in a minimal number of respondents (5.78% and 3.46%) respectively. Although studies have reported the association of GDM and hypertension, in the present study no significant association could be drawn between hypertension and GDM

4.1.4 FAMILY HISTORY OF METABOLIC DISORDERS

Impaired glucose homeostasis is a condition that has a strong clustering in families and has a genetic component. Hence the incidence of common metabolic disorders among the members of the family of respondents was surveyed**.**

Table: 12 Family health history of the respondents

Disorders	**GDM N=173**	**Non GDM N=173**	**Total N=346**	**Fisher exact statistic**
Type 1 diabetes	-	-	-	
Type 2 diabetes	84 (48.5)	32(18.4)	116(33.52)	**46.72****
Thyroid problems	44 (25.4)	23(13.2)	67(19.36)	**9.37***

Dyslipidemia	10 (5.7)	15(8.6)	25(7.2)	**8.02**
Obesity	3 (1.73)	4(2.31)	7(2.02)	**3.912**
Cardiovascular disorders	11 (6.35)	5(2.8)	16(4.6)	**8.822***
Hypertensive disorders	16(9.24.)	13(7.5)	34(9.8)	**2.968**

Figures in the parenthesis indicates the percentage

**Significance at 1% level

*Significance at 5 per cent level

It was noticed that type 1 diabetes mellitus was totally absent where as Type 2 diabetes was the most predominant problem among the family members including 48.5 per cent of GDM and 18.4 per cent of nonGDM respondents. Positive family history of type 2 diabetes was significantly ($p<0.05$) higher among GDM than nonGDM, illustrating the strong positive association of type 2 diabetes and GDM. A positive family history of diabetes predisposes a woman to have a higher chance of developing GDM (Chu et al, 2007). The two disorders namely type 2 diabetes and GDM which share the same pathophysiology, characterized by increased insulin resistance and insulin secretory

impairment are also affected by the same environmental and genetic risk factors (BenHaroush et al, 2004).

The other morbidities like thyroid problems (25.4%), cardiovascular disorders (6.35%) and hypertensive disorders (9.24%) were also found to have a comparatively higher incidence among the family of the cases than the controls. Statistically significant positive association was seen between GDM and metabolic disorders like type 2 diabetes ($p<0.01$) thyroid problems ($p<0.05$) as well as cardiovascular disorders ($p<0.05$).

4.1.4.1. TYPE 2 DIABETES AMONG THE FIRST DEGREE RELATIVES

Now a further inquisitiveness as regard to type 2 diabetes mellitus is the inheritance from ancestors. Inheritance pattern of type 2 diabetes in the family with regard to parentage, single parentage and sibling was investigated and presented in table 12.

Table: 13. Type 2 diabetes among the first degree relatives of the respondents

Type 2 diabetes	**GDM N=84**	**NonGDM N=32**	**Total N=116**
Mother	26 (30.95)	9 (28.1)	**35(30.17)**
Father	23 (27.3)	18(56.25)	**41(35.3)**
Sibling	19 (22.6)	5 (15.6)	**24(20.6)**
Mother+Father	13 (15.4)	-	**13(11.2)**

Mother+Father+Sibling	3 (3.57)	-	**3(2.58)**

Figures in the parenthesis indicates the percentage

Among the cases (n=84) and controls (n=32) who had family history of type 2 diabetes, maternal inheritance of type 2 diabetes was more predominant among the GDM respondents (30.95%) than the controls (28.1%). According to Harder et al. (2001) a family history of T2DM in women with GDM was more frequent in the maternal and grand-maternal line than in the paternal and grand-paternal line. Tabak et al (2011) discovered in their study that maternal history of diabetes and history of diabetes in the maternal line seems to be a stronger predictor of GDM than paternal history**.**

4.1.5 PERSONAL HEALTH PROFILE

The health problem of the respondents is a first order pararmeter that is to be analysed and the results are furnished below.

Table: 14. Personal health problems of the respondents

Particulars	**GDM N=173**	**NonGDM N=173**	**Total N=346**	**Fisher's exact statistic**
No health problems	67(38.7)	104 (60.1)	**171(49.4)**	**19.816***
Hypothyroidism	38 (22)	26 (15)	**64(18.49)**	
Hyperthyroidism	15 (8.7)	13 (7.5)	**28(8.09)**	
PCOD	48(27.7)	26 (15)	**74 (21.3)**	

Dyslipidemia	-	-	-	
Hypertensive disorders	5 (2.9)	2 (1.2)	**7 (2.02)**	
Acanthosis Nigricans	-	-	-	
UTI	2 (1.2)		**2(1.2)**	

Figures in the parenthesis indicates the percentage

*Significance at 5% level

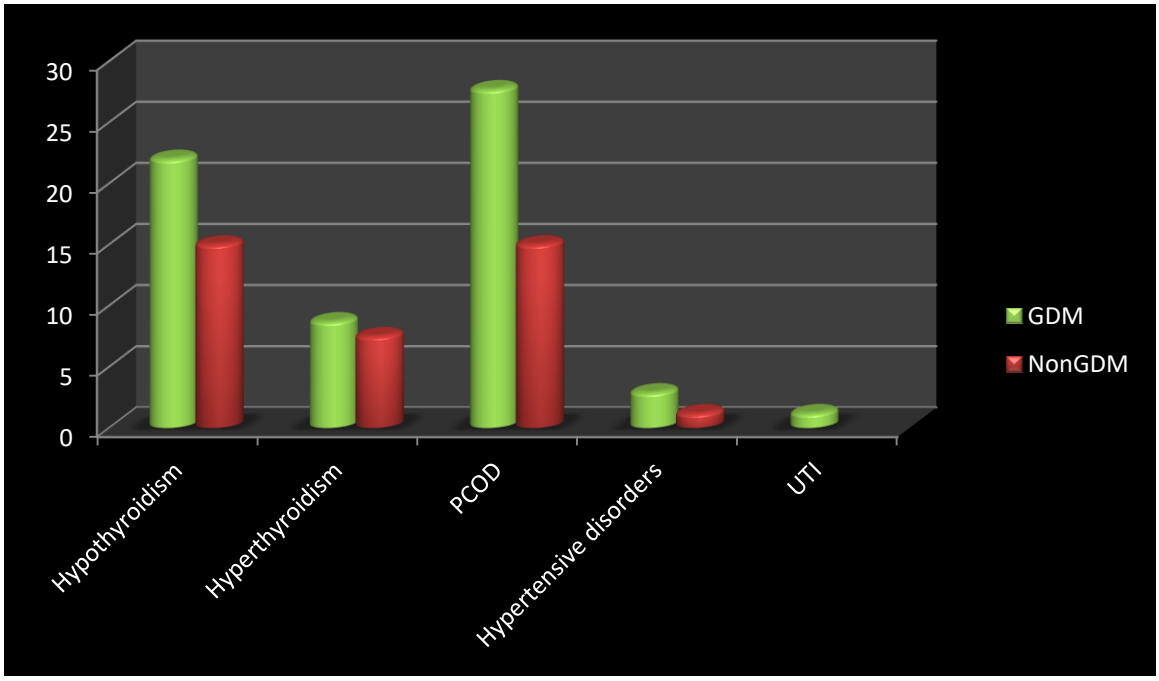


Fig 9. Health problems of the respondents

Hypothyroidism (18.49%), hyperthyroidism (8.09%) PCOD (21.3%), hypertensive disorders (2.02%) and UTI (1.2%) were the health problems observed among the respondents. The case control analysis revealed that PCOD was observed in 27.7 percent of the GDM respondents when compared to the nonGDM respondents with the incidence

rate being 15 per cent. Poly Cystic Ovarian Syndrome (PCOS) is one of the most common reproductive endocrinological disorders with a broad spectrum of clinical manifestations affecting about 6-8 per cent of women of reproductive years (Azziz et al, 2005). Kousta et al (2000) has also suggested that women with a history of GDM have significantly higher prevalence of Polycystic Ovary Syndrome (PCOS) compared to the reference group of women with normal glucose tolerance during pregnancy

Regarding the thyroid disorders, hypothyroidism (18.49%) was more observed among the respondents than the hyperthyroidism (8.09%). Hypothyroidism was observed in 22 per cent of the GDM respondents when compared to the nonGDM respondents group (15 %) Though small in number hypertensive disorder was also observed among the cases (2.9%) and controls (1.2%).Urinary tract infection was seen only in GDM respondents. (1.2%).

The fischers exact statistic revealed that there was a significant positive association ($p<0.05$) between personal health problems and GDM.

4.1.6. MENSTURAL HISTORY

Reproductive phase of a women's life begins with menarche. Hence an attempt to study the relationship if any between the menstrual history of the sample and the incidence of GDM was made.

Table: 15. Menstural history of the respondents

Particulars	**GDM**	**Non GDM**	**Total**	**Chi square**
Age at menarche				
<11 years	10 (5.7)	7 (4)	**17(4.91)**	
11-14years	159(91.9)	160(92.4)	**319(92.19)**	**1.825**
>14 years	4 (2.31)	6 (3.4)	**10 (2.89)**	
Total	**173(100)**	**173(100)**	**346(100)**	
Cyclic pattern				
Normal cycle	112(64.7)	142(82.1)	**254 (73.4)**	**13.326****
Irregular cycle	61 (35.3)	31(17.9)	**92 (26.5)**	
Total	**173(100)**	**173(100)**	**346(100)**	
Menstural problems				
Dysmenorrhea	29 (16.8)	22 (12.7)	**51 (14.7)**	**27.98****
Hypormennorhea	36 (20.8)	6 (3.5)	**42 (12.1)**	
Hypermennorhea	9 (5.2)	10 (5.8)	**19 (5.49)**	
No problems	99 (57.2)	135 (78)	**234 (67.6)**	

Figures in the parenthesis indicates the percentage

**Significance at 1% level

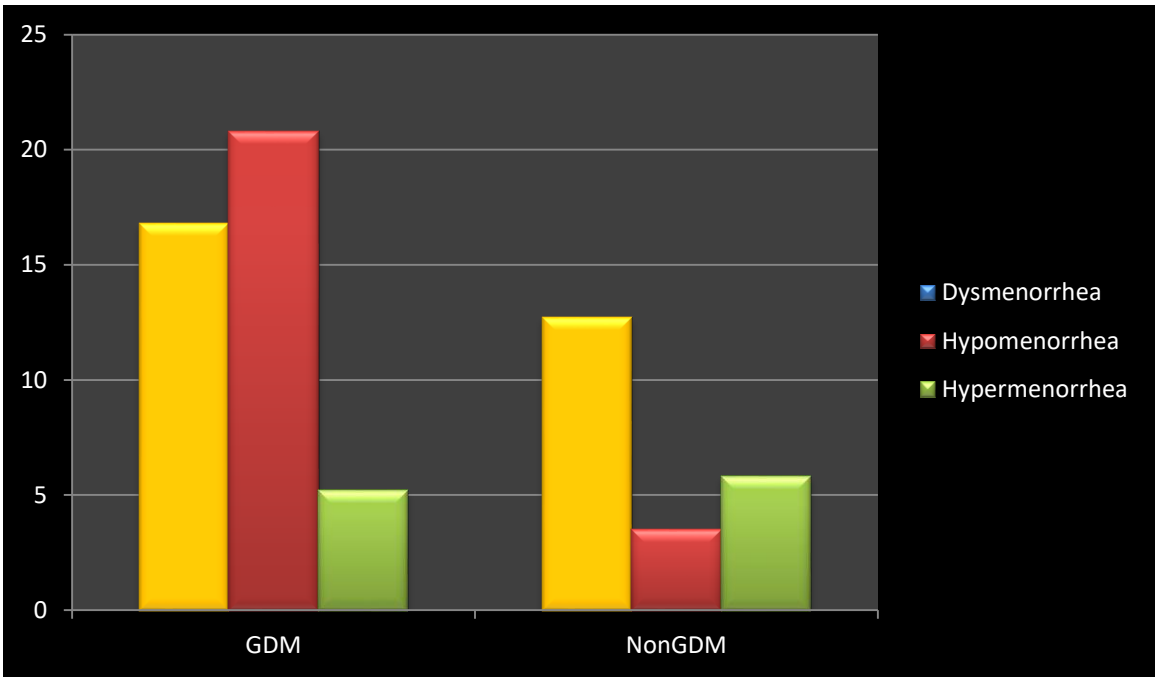


Fig 10. Menstural problems among the respondents

Regarding the age at menarche, majority of the respondents (92.19%), including cases (91.9%) and controls (92.4%) attained menarche at the age of 11 to 14 years. Malviya et al (2003) had reported that average age of menarche of Indian girls was 12.4 years. Further analysis using chisquare statistic, it was found that no association was found between the age at menarche and GDM.

Data on the cyclic pattern of mensturation showed that 35 per cent of the GDM respondents had irregular menstrual cycles in comparison to the nonGDM respondents (17.9%).The chi square analysis showed that irregular menstruation was significantly associated ($p<0.01$) with incidence of GDM. Haver et al (2003) had also concluded that irregular menstruation was a pointer towards the risk of GDM.

The incidence of menstrual problems was observed among 32 per cent of the total respondents. The case control analysis revealed a disproportionate distribution among the GDM and nonGDM with 16.8 per cent having dysmenorrhea, 20.8 per cent with hypomenorrhea and 5.2 per cent with hypermenorrhea among the GDM group. In the nonGDM group 12.7 per cent were having dysmenorrhea, 3.5 per cent were having hypomenorrhea and 5.8 per cent were having hypermenorrhea.

A history of menstrual problems observed among the respondents was found to be a predictor of gestational diabetes mellitus with a statistical significance at one per cent level.

4.1.7 OBSTETRIC HISTORY

A detailed obstetric history of the respondents including methods of contraception, parity, history of multiple pregnancy, infertility problems,infertility treatment and Bad Obstetric History (BOH) and outcome of pregnancy were recorded.

4.1.7.1. METHODS OF CONTRACEPTION ADOPTED

Contraception is a means of ensuring women's health by reducing the risk of frequent child bearing**.** The table below showed the various methods of contraception adopted by the respondents.

Table: 16. Methods of contraception adopted by the respondents

Methods of contraception	GDM	Non GDM	Total	Fisher's exact statistic
Condoms	17 (9.8)	18(10.4)	**35(10.11)**	**1.733**
Pills	2 (1.2)	5(2.9)	**7(2.02)**	
IUD	5 (2.9)	7 (4)	**12(3.46)**	
No contraception used	149 (86.1)	143 (82.7)	**292(84.3)**	
Total	**173(100)**	**173 (100)**	**346 (100)**	

Figures in the parenthesis indicates the percentage

The measures towards contraception adopted by the majority did not distinguish between GDM and nonGDM with majority (84.3 %) of the respondents not resorting to any artificial method. Among the ones who adopted contraception the methods were use of condoms (10.11 %), pills (2.02 %), IUD (3.46 %) without having much difference between cases and controls. The fischer statistic analysis could not find any significant association between methods of contraception and GDM.

4.1.7.2.PARITY

Parity refers to the number of children that a woman has given birth. Data regarding the parity of the respondents is given in the table below**.**

Table: 17. Parity pattern of the respondents

Parity	GDM	NonGDM	Total	Chi square
1	107 (61.8)	117 (67.6)	**224(64.7)**	**6.101***
2	47 (27.2)	29(16.8)	**76(21.96)**	
≥3	19 (11)	27(15.6)	**46(13.29)**	
Total	**173**	**173**	**346**	

Figures in the parenthesis indicates the percentage

*Significance at 5% level

The parity of the respondents did not follow a uniform pattern among the GDM and nonGDM with majority having single child (64.7%) followed by two (21.96%) and three or more (13.29%). However primi paras were comparatively less in number among cases (61.8%) than the controls (67.6%).GDM mothers reported having a larger family size with a parity of either two or more than two.

A positive significant association ($p<0.05$) was also evident between parity and GDM. A study on pregnant women in the Arabian region also had similar findings that multiparous women were more likely to have GDM than nulliparous women. (Al-Rowaily and Abolfotouh, 2010).

4.1.7.3.INFERTILITY AND MULTIPLE PREGNANCIES

Infertility is defined as absence of conception with an attempt to pregnancy during more than 12 months (Talmor and Dunphy, 2015). Details regarding the infertility problems, infertility treatments and multiple pregnancies are given in the table below.

Table: 18. History of infertility and multiple pregnancies among the respondents

Particulars	GDM N=173	Non GDM N=173	Total N=346	Chi square
Infertility problems	36 (20.8)	19 (11)	55 (15.89)	5.53*
Infertility treatments	30 (17.3)	6 (3.5)	36 (10.4)	16.401**

Multiple pregnancy	6 (3.34)	3 (1.73)	9 (5.2)	0.32

Figures in the parenthesis indicates the percentage

*Significance at 5% level

**Significance at 1 % level

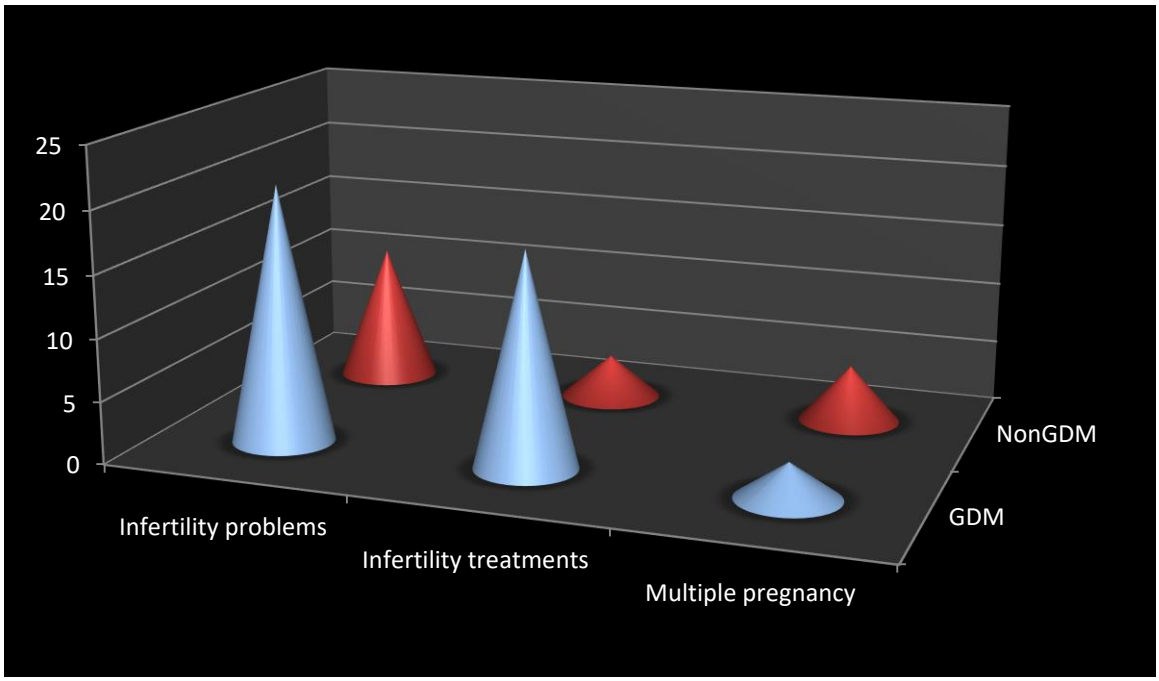


Fig 11. infertility problems, infertility treatments and multiple pregnancies among respondents

Infertility problems were observed in 20.8 per cent of the cases and in 11 per cent of the controls, but infertility treatment were under taken by 17.3 per cent of the cases and 3.5 per cent of the control group. Infertility problems ($p<0.05$) and infertility treatments ($p<0.01$) both associate with GDM at significant levels. Yang et al. (2014) had also put forth the association between fertility problems, fertility treatment and risk of GDM.

Multiple pregnancies were noted only in three per cent of the cases and two per cent of the controls. Statistical analysis did not draw any association between multiple pregnancy and GDM in the present study.

4.1.7.4.BAD OBSTETRIC HISTORY (BOH)

The term Bad Obstetric History (BOH) is applied to mothers who had adverse events in their previous pregnancies**.**

Table: 19. Bad Obstetric History of the respondents

Bad obstetric history	**GDM**	**NonGDM**	**Total**	**Fisher exact statistic**
Abortion	24(13.9)	8(4.6)	**32(9.24)**	**17.545****
Stillbirth	3(1.7)	1(0.6)	**4(1.15)**	
Preterm	-	-	**-**	
GDM	5(2.9)	-	**5(1.44)**	
UTI	12(6.9)	10(5.8)	**22(6.35)**	

Polyhydraminos	5(2.9)	2(1.2)	**7(2.02)**	
Csection	8(4.6)	6(3.5)	**12(3.46)**	
No bad obstetric history	120(69.4)	144(83.2	**264(71.09)**	
Total	**173**	**173**	**346**	

Figures in the parenthesis indicates the percentage

**Significance at 1 % level

UTI – Urinary Tract Infection

C-section –Caesarean section

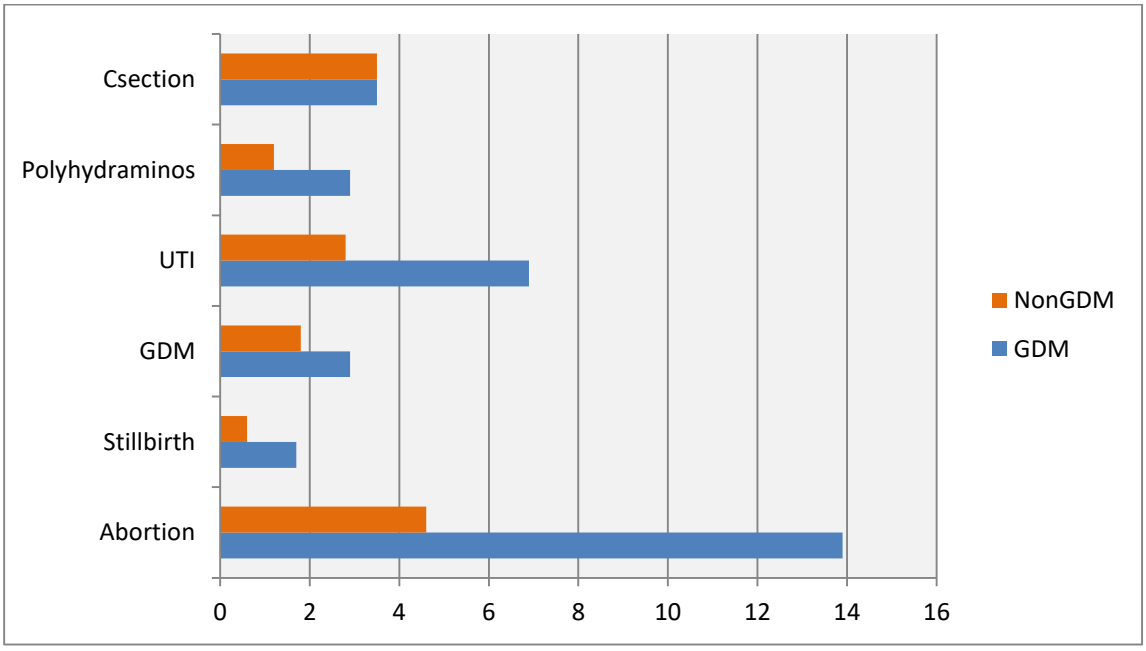


Fig 12. Bad obstetric history among the respondents

Majority of the nonGDM (83.2%) and GDM (69.4%) respondents did not have any adverse events during the previous pregnancies. The reduced rate of complications

among GDM mothers may be due to medical monitoring and appropriate medical intervention.

Despite this, a relatively higher percentage of GDM mothers had history of abortion (13.9%) and UTI (6.9) than their nonGDM counterparts (abortion 4.6% and UTI 5.8%). History of caesarean section (4.6%) and polyhydraminos (2.9%) was also reported to be higher among the cases than the controls (3.5 per cent and 1.2 per cent respectively).

Thus the Bad Obstetric History in the present study was found to have a strong positive association with GDM, to a highly significant level ($p<0.01$). A similar result was observed in a prospective case control study in China which reported the increased prevalence of GDM in women with previous Bad Obstetric History (Yang et al., 2005).

4.1.7.5. OUTCOME OF PREVIOUS PREGNANCY

Previous pregnancy outcome being an important determinant of subsequent pregnancy, an attempt was made to study the details in this respect and the results are given below.

Table:20. Outcome of previous pregnancy

Complications	**GDM**	**Non GDM**	**Total**	**Chi square**
Preterm	-	-	-	**6.87***
Macrosomia	13(7.5)	3(1.7)	**16(4.6)**	
Shoulder dystocia	-	-	-	
Congenital anomalies	4(2.3)	3(1.7)	**7 (2.02)**	

Neonatal death	-	-	-	
No complications	156(90.2)	167(96.5)	**323 (93.35)**	
Total	**173(100)**	**173(100)**	**346**	

Figures in the parenthesis indicates the percentage

*Significance at 5% level

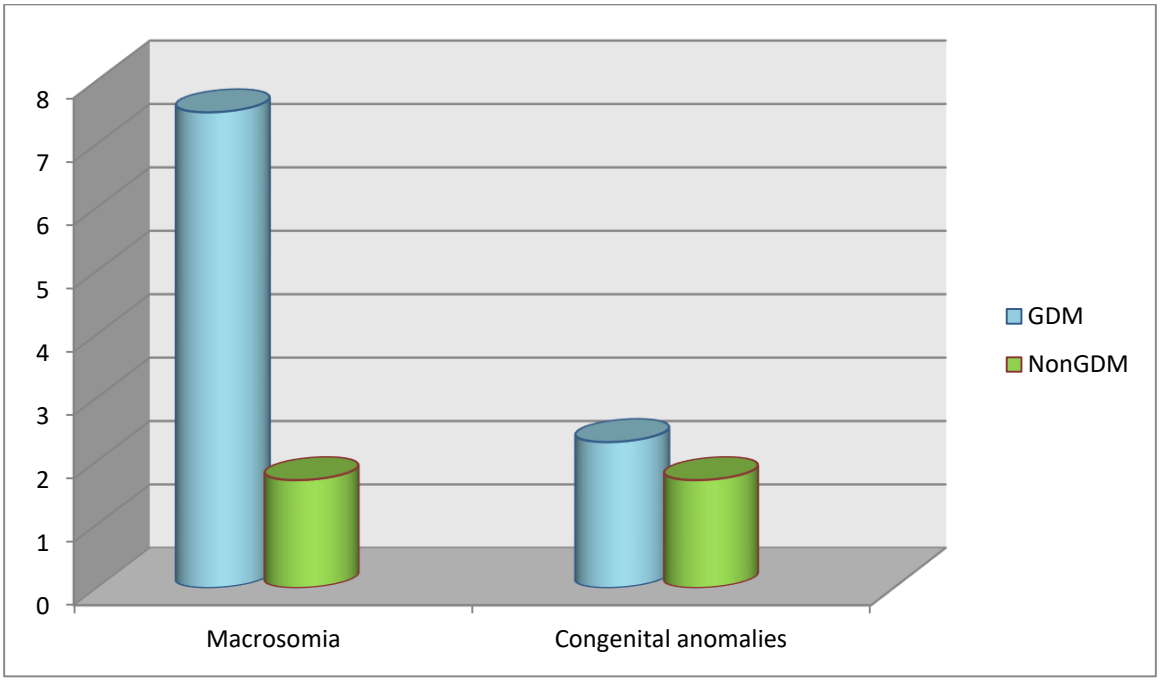


Fig 13.Outcome of previous pregnancy

As obtained from the table 96.5 per cent of nonGDM and 90.2 per cent of GDM respondents did not have any adverse outcome in their previous pregnancies.

Data regarding the previous pregnancy outcome revealed that macrosomia was observed more among cases (7.5%) than the controls (1.7%). Incidence of congenital anomalies

was also observed among the cases (2.3%) and controls (1.7%) though very less in number. Chisquare analysis showed a significant association between previous pregnancy outcome and GDM ($p<0.05$). Benharoush et al. (2004) had reported that specific outcomes in previous pregnancies such as giving birth to a child with macrosomia are considered as risk factors for GDM in the consecutive pregnancies.

4.1.8 DIETARY FACTORS

According to Shin et al. (2015) food and dietary factors affect glucose homeostasis, and the diet may be associated with GDM. Therefore the dietary factors of the respondents were analysed in detail and discussed below.

4.1.8.1.GENERAL DIETARY PATTERN

The dietary habit of a given population is influenced by the tradition, food availability, and socioeconomic status and to some extent the dietary awareness also. The general dietary pattern currently followed by the respondents is given in table below.

Table: 21. Dietary pattern of the respondents

Particulars	**GDM N=173**	**Non GDM N=173**	**Total N=346**	**Chi square**
Food habit				
Vegetarians	-	-	-	
Non-vegetarians	173 (100)	173 (100)	346 (100)	

No.of meals per day				
<3 meals	15 (8.7)	32(18.5)	47 (13.6)	**7.115**
≥ 3 meals	158 (91.3)	141(81.5)	299 (86.4)	
Type of oil used				
Single type	159(91.9)	163 (94.2)	322 (93.1)	**0.716**
Combination type	14 (8.1)	10 (5.8)	24 (6.9)	
Most preferred oil				
Coconut oil	151(87.3)	153 (88.4)	304 (87.9)	
Sunflower oil	12 (6.9)	13 (7.5)	5 (7.2)	**0.583**
Rice bran oil	10 (5.8)	7 (4)	17 (4.9)	
Intake of table sugar				
>2 teaspoons	73(42.2)	66(38.2)	139(40.2)	
<2 teaspoons	100(57.8)	107(61.8)	207(59.8)	**0.589**
Intake of salads				
<5 servings/week	133(76.9)	112(64.7)	245(70.8)	
>5 servings/week	40(23.1)	61(35.3)	101(29.2)	**6.166***

Figures in the parenthesis indicates the percentage *Significance at 5% level

All the respondents irrespective of cases and controls followed non vegetarianism. An intake of three or more meals was observed in 91.3 per cent of cases and in 81.5 per cent of controls. Use of single type of oil was more common among the cases (91.9%) and controls (94.2%). Coconut oil was the most preferred oil for cooking both by the cases (87.3%) and controls (88.4%).Sunflower oil (7.2%) and rice bran oil (4.9%) were the types used only by minority of the respondents. The composition of the edible oil basket in Kerala is quite distinct from that elsewhere in the country and is dominated by coconut oil (Maniyal Vijayakumar et al., 2015).

Majority of the cases (57.8%) and controls (61.8%) reported an intake of less than two teaspoons of sugar per day. The intake of sugar more than two spoons per day was in the ratio 42: 38 among the GDM and nonGDM group respectively. However there was no significant difference observed between GDM and nonGDM with respect to the above factors.

Whereas the salad intake presented a significant difference between GDM (23.1%) and nonGDM (35.3%) with an intake of more than five servings per week. Intake of salads was found to be more among the nonGDM.

Among the general dietary habits studied, significant negative association ($p<0.05$) was observed between salad intake and incidence of GDM. He et al. (2015) had found that vegetable intake was associated with a decreased risk of GDM. Although, Indian life style has a predilection for fresh fruits and vegetables traditionally, surveys indicate a consistently low consumption of it nowadays (Radhika et al ., 2011).

4.1.8.2.NIBBLING BEHAVIOUR OF THE RESPONDENTS

Snacking or nibbling between major meals is a way to provide energy as well as to promote healthy eating especially during pregnancy. Balanced three meals and snack consumptions are recommended to maintain normal body weight and to prevent ketone body production during pregnancy.

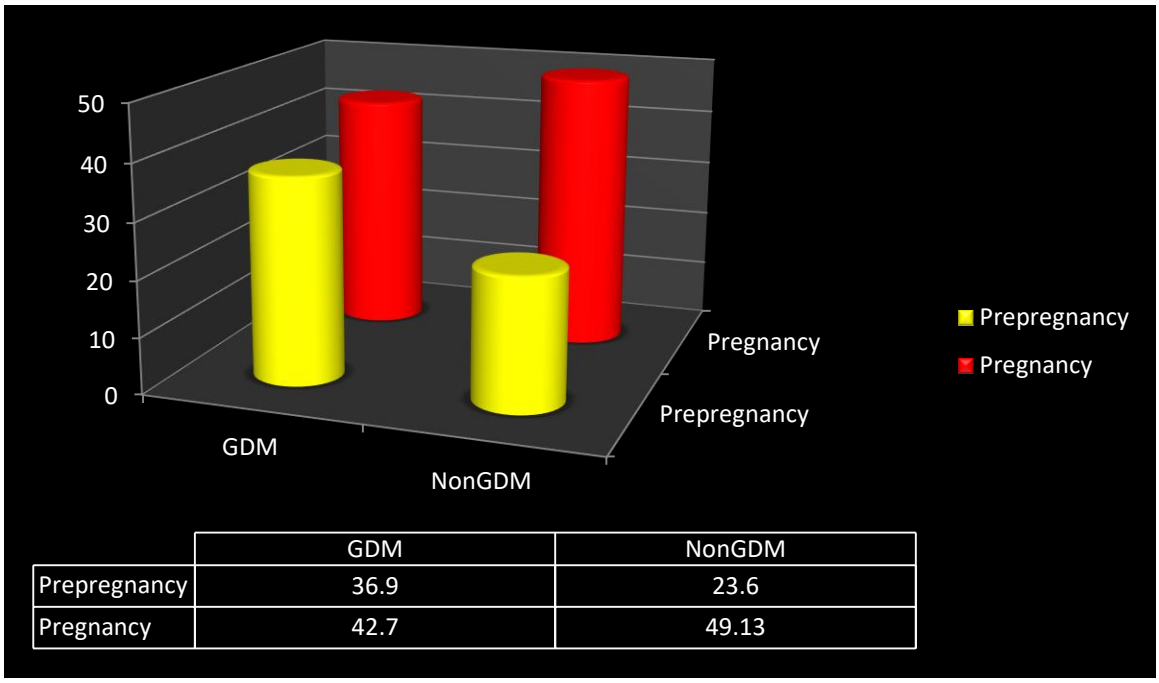
Table: 22. Nibbling behaviour of the respondents during prepregnancy and pregnancy period

Particulars	**Prepregnancy period**			**Pregnancy period**		
	GDM N=173	**Non GDM N=173**	**Total N=346**	**GDM N=173**	**Non GDM N=173**	**Total N=346**
Habit of nibbling	64(36.9)	41(23.6)	**105 (30.34)**	74 (42.7)	85 (49.13)	**159 (45.9)**
Chisquare	**6.01***			**8.02**		
Preferred item for nibbling						
Veg salad	-	12 (6.93)	**12 (3.46)**	10 (5.7)	23 (13.29)	**33 (9.53)**
Fresh fruit	12 (6.93)	2 (1.15)	**14 (4.04)**	12 (6.93)	32 (18.4)	**44 (12.7)**
Fried items	42	18	**60**	32	20(11.5)	**52**

	(24.2)	(10.4)	**(17.34)**	(18.49)		**(15.02)**
Sweets	10 (5.7)	9 (5.2)	**19** **(5.49)**	20 (11.5)	10 (5.7)	**30** **(8.67)**

Figures in the parenthesis indicates the percentage

*Significance at 5% level



	GDM	NonGDM
Prepregnancy	36.9	23.6
Pregnancy	42.7	49.13

Fig 14. Nibbling behaviour among respondents during pregnancy and prepregnancy period

During the prepregnancy period the habit of nibbling was reported by more number of GDM (36.9%) respondents than the nonGDM (23.6%) respondents. This difference was statistically significant ($p<0.05$) which indicated that nibbling behaviour might be a contributing factor for GDM.

The most preferred item for nibbling during prepregnancy period was fried items(17.34%).The percentage of GDM respondents (24.2%) taking fried items for nibbling was more when compared to the nonGDM (10.4%). Nobody among the cases had the habit of taking vegetable salad for nibbling whereas it was seen among the controls (6.93%). But intake of fresh fruits was seen more among the GDM (6.93%) than the nonGDM (1.15%).

During the pregnancy period the habit of nibbling increased both among the cases (42.7%) and controls (49.13%) when compared with the prepregnancy period. Chisquare analysis could not draw any significant association between the habit of nibbling during pregnancy period and GDM.

Fried items continued to be the most preferred item for nibbling during the pregnancy period also. But the percentage of respondents taking healthy items such as vegetable salad and fresh fruits during pregnancy period increased when compared with the prepregnancy period and the increase was more evident among the controls than the cases. The intake of vegetable salad and fresh fruits was reported more among the controls (13.29%, 18. 24%) than the cases (5.7%, 6.93%). This might be a protecting factor for the nonGDM respondents that prevent them from hyperglycemia. The intake of sweets was noted more among GDM (11.5%) than in the nonGDM (5.7%) Yang and Kim (1999) had reported that most of the diabetes mellitus patients consumed more snack than normal.

4.1.8.3.USE OF NUTRITIONAL AND HEALTH SUPPLEMENTS

Nutritional or health supplements are manufactured products that are taken with the intention of providing more nutrients than the regular diet. The details regarding the intake of such products during the pregnancy period are given in the table below.

Table: 23 Use of nutritional/health supplements

Particulars	**GDM N=173**	**Non GDM N=173**	**Total N=346**	**Chisquare**
Nutritional supplements				
Fe tablet	173(100)	173(100)	**346(100)**	**0.28**
Calcium tablet	173(100)	173(100)	**346(100)**	
Fish oil	21(12.1)	20(11.6)	**41(11.8)**	
Health drinks				
Mothers horlicks/ boost /any other	41(23.7)	16 (9.2)	**57 (16.5)**	**13.128***
Ayurvedic supplements				
Chyavanaprasam/ Aristam/Asavam/grutham	22 (12.7)	20(11.6)	**42 (12.1)**	**0.108**

Figures in the parenthesis indicates the percentage

*Significance at 5% level

Regarding the intake of nutritional supplements all the respondents (100%) took iron and calcium supplements as it was a compulsory practice in the hospitals to prescribe iron and calcium supplements for the pregnant women. Fish oil supplementation was reported by 12.1 per cent of the GDM and 11.6 per cent of the nonGDM respondents and ayurvedic supplementation like chyavanaprasam/arishtam by 12.7 per cent and 11.6 per cent respectively.

Consumption of health drinks such as mothers horlicks, boost were more popular than other supplements especially among the GDM subjects (23.7%) as against nonGDM subjects (9.2%). Chisquare analysis also indicated a positive association ($p<0.05$) between GDM and the intake of health drinks.

4.1.8.4. DIETARY DIVERSITY SCORE

Dietary diversity score reflects the variety of food items that a person consumes. It was calculated by summing the number of unique food groups consumed during last 24 hours as described by FAO Dietary Diversity Questionnaire by Kennedy et al (2013). Score 1 was given if a particular item was consumed and score 0 was given if not consumed. A score less than or equal to three was considered as low dietary diversity , scores between 4 and 6 was considered as medium and score greater than or equal to 6 was considered to be high dietary diversity.

Table: 24. Dietary Diversity Scores of the respondents

Total DDS	**GDM N=50**	**NonGDM N=50**	**Total N=100**	**Fisher exact statistic**
Low (<3)	6 (12)	3 (2)	**9 (9)**	
Medium (4-6)	16 (56)	21 (60)	**37 (37)**	**4.092**
High (>6)	28 (32)	30 (42)	**58 (58)**	

Figures in the parenthesis indicates the percentage

Dietary diversity score calculated on a sub sample (50 cases and 50 controls) among the cases and controls indicated a uniform trend among the cases and controls. Most of the cases (56%) and controls (60%) had medium dietary diversity scores. Low scores were observed only among 3.36 per cent of cases and 2.31 per cent of controls. The dietary diversity score among the respondents reflected the quality and variety of the diet including unique food groups.

4.1.8.5. MEAN NUTRIENT INTAKE OF THE RESPONDENTS

The nutrient intake of the respondents was computed using the data obtained by 24 hour recall and compared with the RDA suggested by ICMR (2010). The details are furnished in the table below.

Table: 25. Mean nutrient intake of the respondents

Nutrient	GDM (n=50)			Non GDM (n=50)	
	RDA	**Mean nutrient intake**	**Per cent of RDA met**	**Mean nutrient intake**	**Per cent of RDA met**
Energy	**2250kcal**	2309.7±113.9	102.65	2256.1±105.3	100.27
Protein	**82.2 g**	93.62±11	113.1	86.80±12.4	105.5
Fat	**30g**	42.06±6.7	140.2	44.66±5.9	148
Fiber	**30g**	22.36±12.4	74.53	25.06±9.4	83.5
Iron	**35mg**	29.46±9.4	84.1	30.86±7.3	88.17
Calcium	**1200mg**	1036.7±65	86.39	1126.7±79	93.8

The mean intake of energy (102.65%),protein (113.1%) and fat (140.2%) was equal to or above RDA for cases. But for controls only the fat intake (148%) was much above RDA and the rest was within the limit suggested by ICMR (2010). With respect to other nutrients studied such as fiber, iron and calcium a deficit was reported both by GDM and nonGDM subjects. Though overall picture indicated a uniform trend the consumption level of individual nutrient was comparatively better among the nonGDM group especially the intake of dietary fiber (83.5%controls and 74.15% cases).In the intake of iron (88.17% controls and 84.1% cases) and calcium (93.8% controls and 86.39% cases) nonGDM presented a better picture than GDM group.

4.1.8.6.NUTRIENT ADEQUACY RATIO (NAR)

The NAR for a given nutrient is the ratio of a subject's intake to the current recommended allowance. The adequacy of the nutrients was categorized as per Jood et al (1999)

Table:26. Nutrient Adequacy Ratio

Nutrients	GDM(n=50)				NonGDM(n=50)				Test statistic	p value
	Adequate	Marginally adequate	Moderately adequate	inadequate	Adequate	Marginally adequate	Moderatey adequate	inadequate		
Energy	**32(64)**	**18 (36)**	-	-	**21 (42)**	**29 (58)**	-	-	**4.86**	**0.028**
Protein	**46(92)**	**4 (8)**	-	-	**37 (74)**	**13 (26)**	-	-	**5.74**	**0.017**
Fat	**50(100)**	**0 (0)**	-	-	**45 (90)**	**5 (10)**	-	-	**3.368**	**0.066**
Fiber	**0 (0)**	**26 (52)**	**24 (48)**	-	**5 (10)**	**39 (78)**	**6 (12)**	-	**18.59**	**0.000****
Iron	**19 (38)**	**29 (58)**	**2 (4)**	-	**18 (36)**	**27 (54)**	**5(10)**	-	**14.89[a]**	**0.073**
Calcium	**20 (40)**	**26 (52)**		**4 (8)**	**1 (2)**	**25 (50)**	**23 (46)**	**1 (2)**	**13.44[a]**	**0.062**

a-Computed using Fisher's exact test

Figures in the parenthesis indicates the percentage

**Significance at 1% level

As read from the table, energy intake of majority of the cases (64%) reported was adequate. Also there were a good number (36%) of cases with marginally adequate energy intake. Among nonGDM majority (58%) had only marginally adequate intake of energy. But in the case of protein majority of GDM (92%) and nonGDM (74%) subjects reported adequate intake. Same was the case of fat (100% GDM and 90% nonGDM)

Micronutrient intake was only moderately adequate for the majority of the cases as well as controls. Fiber intake seemed to be very low with none in the cases and ten per cent in the controls having adequate intake. Marginally adequate intake was reported by 52 per cent of GDM and 78 per cent of nonGDM subjects. However it was obvious that nonGDM group had a reasonably good intake of dietary fiber than the GDM subjects.This difference observed was found to be statistically significant ($p<0.01$) indicating a favorable effect of dietary fiber in preventing GDM. Consumption of dietary fiber was significantly and inversely associated with GDM (He et al., 2015).

4.1.8.7. FOOD FREQUENCY PATTERN OF THE RESPONDENTS

A healthy diet in pregnancy period must be abundant with all the food groups to provide the nourishment both for the mother and the fetus. The details of frequency of consumption of various food items by the respondents are given below

Table: 27. Frequency of consumption of various food items

Food groups	GDM (N=173)					Non GDM(N=173)					P vlaue
	D	2/W	1/W	1/M	R/N	D	2/W	1/W	1/M	R/N	
Cereals	173 (100)	-	-	-	-	173 (100)	-	-	-	-	
Pulses	-	105 (60.7)	68 (39.3)	-	-	-	93 (53.7)	80 (46.2)	-	-	1.000
Milk/ milk products	133 (76.9)	40 (23.1)	-	-	-	129 (74.6)	44 (25.4)	-	-	-	0.13
Roots and tubers	-	11 (6.4)	162 (93.6)	-	-		26 (15.02)	147 (84.9)	-	-	0.829
Other vegetables	34 (19.6)	139 (80.3)		-	-	46 (26.5)	127 (73.4)		-	-	0.632
Green leafy vegetables	-	-	76 (43.9)	97 (56.1)	-	-	14 (8.1)	96 (55.5)	63 (36.4)	-	0.000**
Fruits	25 (14.5)	126 (72.8)	22 (12.7)		-	21 (12.1)	141 (81.5)	11 (6.3)		-	0.367
Red meat		30 (17.3)	105 (60.7)	21 (12.1)	17 (9.8)		50 (28.9)	100 (57.4)	15 (8.67)	8 (4.6)	0.162
Chicken		10 (5.8)	123 (71.1)	28 (16.2)	12 (6.9)		6 (3.5)	146 (84.4)	13 (7.5)	8 (4.6)	0.287
Fish	52 (30.1)	68 (39.3)	51 (29.5)	2 (1.2)		62 (35.8)	74 (42.8)	37 (21.4)			0.287
Egg		140.4 (80.9)	30 (17.3)	8 (31.2)			135 (78.03)	29 (16.8)	6 (22)		0.082

Sugars	**173 (100)**	-	-	-	-	**173 (100)**	-	-	-	-	
Fats	**173 (100)**					**173 (100)**					

Figures in the parenthesis indicates the percentage **Significance at 1% level

D -daily 1/w- once per week F- fortnightly 1/m- once per month R- rare N- never

Cereals, sugars, and fats were used by all the respondents on a daily basis (100%). Intake of pulses atleast twice per week was seen among most of the cases (60.7%) and controls (53.7%). Daily intake of milk and milk products was seen among 76.9 per cent of cases and 74.6 per cent of controls.

Consumption of protective foods like other vegetables and green leafy vegetables were found to be low among the respondents but the deficit intake was more evident among the cases than the controls. Daily intake of vegetables was seen only in 19.6 per cent of cases and 26.5 per cent of controls. Green leafy vegetable intake atleast once per week was reported by 43.9 per cent of cases in contrast to 55.5 per cent of controls. Daily intake of fruits was seen only among 14 per cent of the cases and 12 per cent of the controls. On further analysis significant negative association ($p<0.05$) could be drawn between the intake of green leafy vegetables and GDM. Low fruit and vegetable intake is considered as the sixth main risk factor for morbidity in the world (Lock et al., 2004).

Among the nonvegetarian foods majority of the cases (71.1%) and controls (84.4%) reported a frequency of use of chicken as well as red meat (cases-60.7%, controls-57.4%

respectively) atleast once per week. Daily consumption of fish was noticed among 30.1 per cent of the cases and 35.8 per cent of the controls.

4.1.8.8. CONSUMPTION OF PACKED AND PROCESSED FOODS

The changing environments and lifestyles have tremendous impact on the eating habits of the people. Since the life has become faster people use more of the convenient foods like processed and packed foods. Details of the frequency of consumption of processed and packed food items among the respondents are given in the following table.

Table: 28. Frequency of consumption of packed and processed foods

Food items	GDM(N=173)					NonGDM (N=173)					chi square
	D	1/W	F	1/M	R/N	D	I/W	F	1/M	R/N	
Fried items/savouries	24 (13.9)	61 (35.3)	92 (53.2)			20 (11.6)	33 (19.1)	115 (66.5)	-	-	**12.260****
Biscuits/cookies/ rusks	92 (53.2)	67 (38.7)	14 (8.1)			32 (18.5)	55 (31.8)	86(49.7)	-	-	**82.053****
Sugared bottled drinks	-	17 (9.8)	74 (42.8)	68 (39.3)	14 (8.1)		5 (2.9)	69(39.8)	54 (31.2)	45 (20.2)	**22.069***
Sweets	-	12 (6.9)	80 (46.2)	81 (46.8)	0 (0)	-	10 (5.8)	90 (52)	69 (39.9)	4 (2.3)	**5.73**
Jams /jellies	-	-	30 (17.3)	68 (39.3)	75 (43.4)	-	-	31 (17.9)	78 (45.1)	64 (37)	**1.572**
Pickles/pappads	-	65 (37.6)		64 (37)	39 (22.5)	5 (2.9)	62 (35.8)	69 (39.9)	38 (22)	4 (2.3)	**0.38**
Processed	-	-	65	83 (48)	25	-	-	64 (37)	79	30	**0.561**

meat/fish			(37.6)		(14.5)				(45.7)	(17.3)	
Ready to cook items	-	15 (8.7)	67 (38.7)	52 (30.1)	39 (22.5)	-	17 (9.8)	42(24.2)	61 (35.8)	43 (24.9)	**15.16**
Instant mixes	-	11 (6.4)	63 (36.4)	56 (32.4)	43 (24.9)	-	10 (5.8)	66 (38.2)	49 (28.3)	48 (27.7)	**0.859**

Figures in the parenthesis indicates the percentage **Significance at 1% level *Significance at 5% level

D -daily 1/w- once per week F- fortnightly 1/m- once per month R- rare N- never

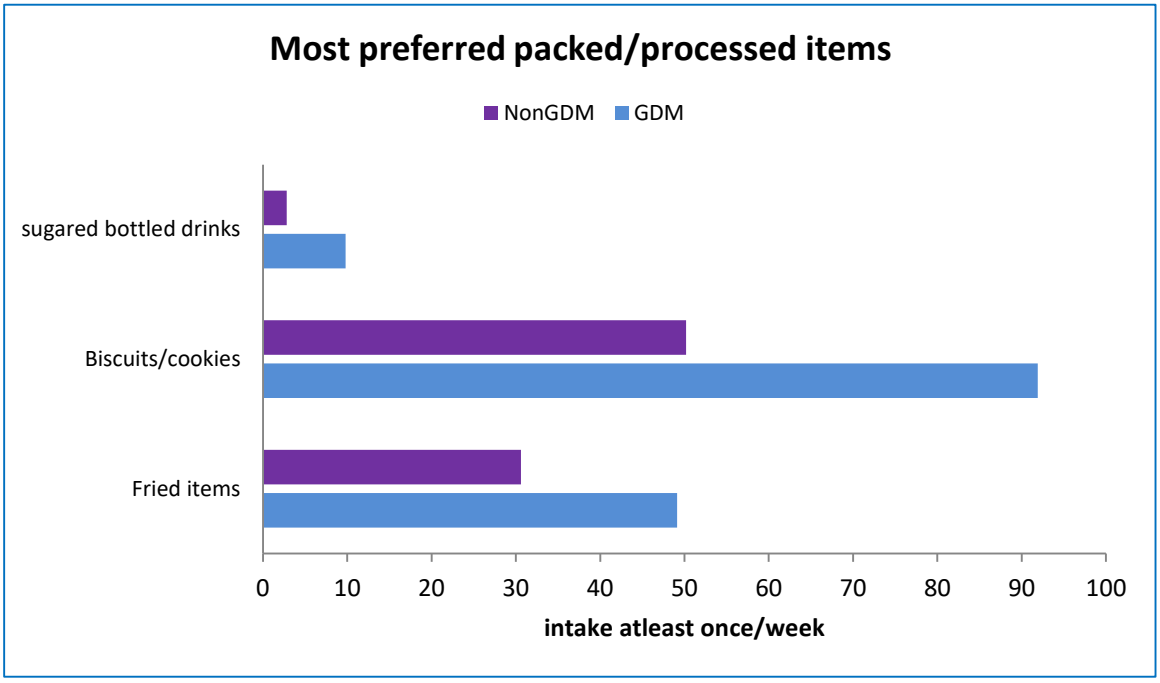


Fig 15. Most preferred packed/processesd items

The case control analysis in frequency of use of packed foods showed a highly significant ($p<0.01$) difference between GDM and nonGDMsubjects with regard to fried items and biscuits/rusk. The frequencies of intake of the above food items were significantly higher among GDM. Consumption of bottled drink was also found to be more frequent by the GDM than nonGDM with a statistical significance at five per cent level.

So a positive association could be drawn between the intake of fried items ($p<0.01$), biscuits/rusk ($p<0.01$), sugared bottle drinks ($p<0.05$) and GDM indicating its accelerating effect in the development of GDM. Excess consumption of fruit juices and sugar-sweetened beverages has been linked with obesity and diabetes (Malik et al., 2010).

4.1.8.9. PREFERENCES AND FREQUENCY OF CONSUMPTION OF FOOD FROM OUTSIDE

Consuming food from outlets such as hotels, fast food counters and snack bars have become a part of the life style of people. Hence the preferences and frequency of consumption of food from outside was studied.

Table: 29. Preferences and frequency of consumption of food from outside

Variables	GDM (N=173)	NonGDM (N=173)	Total (N=346)	Chi square

Frequency of eating out				
1-7 times /week	54 (31.21)	22 (12.7)	76(21.96)	8.348**
<1 time/week	119 (68.7)	151(87.2)	270 (78.03)	
Biryani/Fried rice				
1-7 times /week	13(7.51)	9(5.202)	22(6.35)	5.807
<1 time/week	160	164(94.7)	324 (93.6)	
Porotta				
1-7 times /week	2(1.15)	0(0)	2 (0.57)	2.064[a]
<1 time/week	171 (98.8)	173 (100)	344 (99.4)	
Dosa items				
1-7 times /week	23 (13.29)	20(11.5)	43 (12.4)	20.104
<1 time/week	150 (86.7)	153 (86.7)	303(87.57)	
Fried non veg items				
1-7 times /week	18 (10.4)	16 (9.24)	34(9.82)	0.048
<1 time/week	155 (84.97)	157 (88.4)	312 (90.17)	
Fried snacks				
1-7 times /week	73 (42.1)	44(25.4)	117(33.81)	37.212**
<1 time/week	100(57.8)	121(69.9)	221(66.1)	

Baked snacks				
1-7 times /week	22 (12.7)	18 (10.4)	40(11.5)	0.841
<1 time/week	151(87.2)	155 (89.59)	306(88.4)	
Desserts				
1-7 times /week	7 (4.04)	4 (2.31)	9 (2.6)	
<1 time/week	166 (95.9)	169 (97.6)	335 (96.8)	1.085

a-Computed using Fisher's exact test

Figures in the parenthesis indicates the percentage

**Significance at 1% level

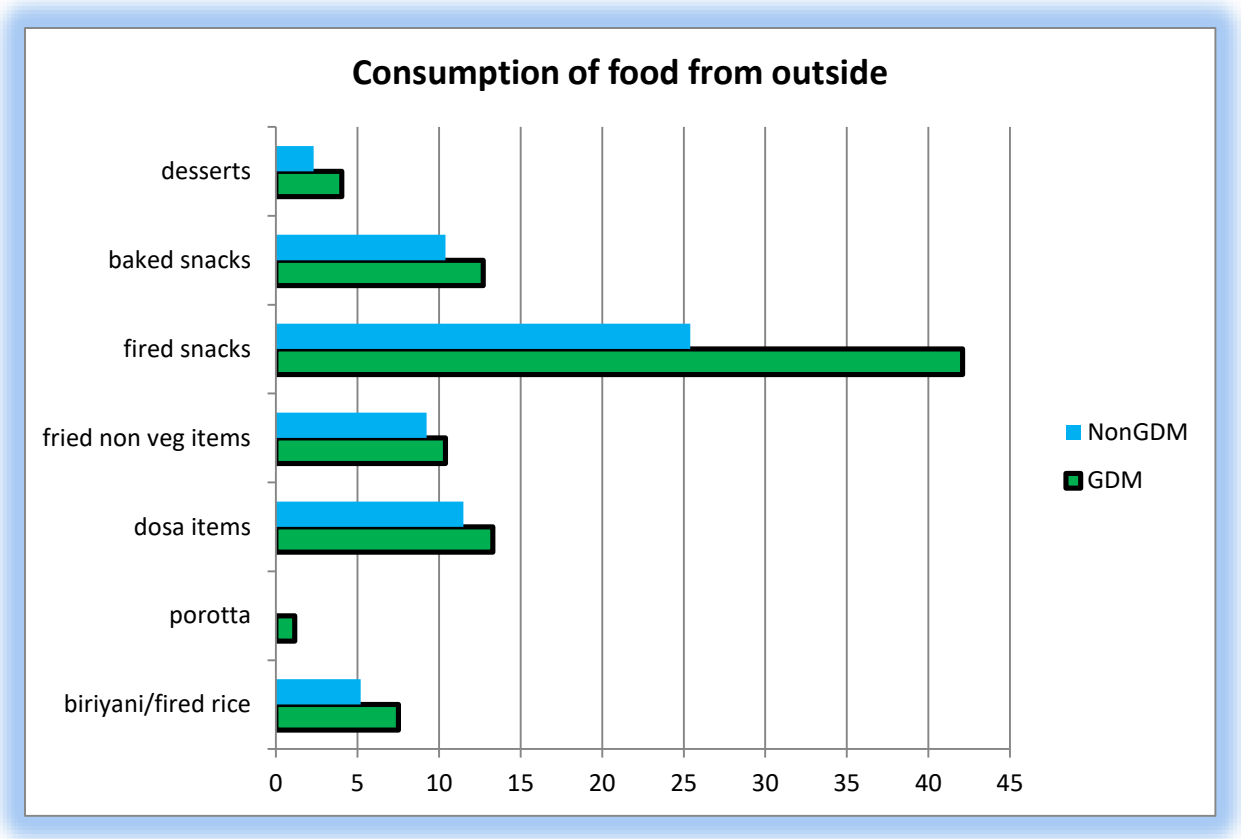


Fig 16. Consumption of food from outside

As seen from the table nearly 1/3 rd of the GDM subjects (31.4%) had the habit of consuming food from outside frequently (1-7 times/ week). Whereas only 12.7 per cent of the nonGDM group reported having such a habit. Chisquare analysis further proved a highly significant ($p<0.01$) difference between cases and controls in the consumption pattern indicating that frequent consumption of food from outside significantly contribute towards GDM.

Similarly among the various food items the subjects (both the cases and controls) preferred to take frequently from outside the fried snacks ranked first with a percentage

intake of 42% by GDM and 25.4% by nonGDM.The frequency of intake was up to seven times in a week. The difference in the frequency of intake was also found to be statistically significant at one per cent level explaining its possibility as a contributory factor of GDM.

Fried food consumption has been shown to be associated with increased risks of type 2 diabetes, metabolic syndrome as well as increased general and central obesity. (Sayonorea et al ., 2014). Martin et al. 2015 cautioned the associations of maternal habitual consumption of fried foods with adverse perinatal outcomes.

Other frequently taken food items from outside among the cases were dosa items (13.29%) followed by baked snacks (12.7%), fried non vegetarian items (10.4%), biriyani/fried rice (7.5%),desserts (4.04%) and porotta (1.15%) Among the controls the intake of dosa items and baked snacks was seen among 11.5 per cent and10.4 per cent respectively followed by fried nonvegetarian items (9.24%),desserts (2.31%) and biriyani/fried rice (5.2%).

It could be summed up stating that the order of preference for the food items followed a uniform pattern irrespective of GDM or nonGDM groups. But the frequency of intake (up to 7 times/week) was comparatively more among the GDM subjects than the nonGDM counterparts.

4.1.9 PERSONAL HABITS

Details regarding the personal habits such as smoking, alcohol consumption and pan chewing were recorded and the results showed that none of the respondents had such habits.

4.1.10 SLEEP PATTERN OF THE RESPONDENTS

Pregnant women are particularly vulnerable to sleep disturbances, due to hormonal changes, physical discomfort, or anxiety surrounding childbirth. Disturbed sleep affects several biological pathways. Hence the details of sleep pattern were recorded and the details are furnished below.

Table: 30 Sleep pattern of the respondents

Particulars	**GDM N=173**	**Non GDM N=173**	**Total N=346**	**Chisquare**	**P value**
Sleep quality					
Normal	152 (87.9)	156 (90.1)	**308 (89)**		
Disturbed	21 (12.1)	17 (9.82)	**38 (10.9)**		
Hours of sleep					
<6 hours	9 (5.2)	0 (0)	**9 (2.6)**	**18.31**	**2.32**
6-8 hours	156 (90.2)	173 (100)	**329 (95.1)**		
>8 hours	8 (4.6)	0 (0)	**8 (2.3)**		
Day time sleep					

<2 hours	63 (36.4)	29 (16.8)	**92 (26.6)**		
>2hours	110 (63.6)	144 (83.2)	**254 (73.4)**		

Figures in the parenthesis indicates the percentage

Majority of the respondents, both the cases (87.9%) and controls (90.1%) had normal sleep. Among those who had sleep disturbances GDM mothers constituted a higher percentage (12.1%) than the nonGDM mothers 99.8%).

Normal sleep hours (6 to 8 hours) were observed among majority of the cases (90.2%) and in all of the controls (100%). Regarding the day time sleep, a nap of more than 2 hours was reported among 63.6 per cent of cases and 83.2 per cent of controls.

The chisquare analysis showed no significant association between sleep pattern and GDM.

4.1.11 STRESS LEVEL OF THE RESPONDENTS

World Health Organization has emphasized the clinical relevance to promote the health status by not only treating physical symptoms but also instilling a positive mental state (Bech et al., 2016). Maternal stress during pregnancy brings about adverse outcomes both for the mother and the baby. There are different types of stress that affects the pregnant women. In the present study perceived stress and pregnancy specified stress were assessed using validated scales suggested by (Cohen et al .,1983) and (Yali and Lobel 1999) respectively.

4.1.11.1PERCEIVED STRESS LEVEL

In recent years there is a growing interest in knowing the degree to which prenatal exposures including maternal stress influences the health of both the mother and the foetus.So the stress level of the pregnant women was therefore assessed using the Perceived Stress Scale (PSS) developed by Cohen et al (1983)

Table 31 Perceived stress level of the respondents

Level of stress	**GDM N=173**	**NonGDM N=173**	**Total N=346**	**Chisquare**
Low (<20)	52(30.05)	54 (31.2)	**106(30.7)**	**1.498**
Medium(20-24)	67 (38.7)	71(41)	**138 (39.9)**	
High (>24)	54 (31.2)	48 (27.7)	**102 (29.1)**	

Figures in the parenthesis indicates the percentage

Low level of stress was reported by 30.05% of GDM and 31.2% of nonGDM subjects. The majority in the remaining was rated having stress at a medium level (GDM -38.75 and nonGDM- 41%).At the same time a high level of stress was reported among 31.2% of the GDM and 27.7% of the nonGDM group. Though there observed a difference in perceived stress level of cases and controls chi square analysis failed to show any significant association between GDM and stress level of the subjects.

4.1.11.2. PREGNANCY SPECIFIED STRESS LEVEL

Now a further inquisitiveness was made on the maternal stress which is specifically related to pregnancy because pregnancy itself is a stressful condition.According to Janeto (2013) pregnancy is a complex and dynamic condition and maternal psychological changes produce a cascade of reactions, including changes in blood flow to the uterus as well as alterations to the intrauterine sensory environment experienced by the fetus. Anxieties during pregnancy period such as delivery pain, caring of a newborn, paying for medical care, changes in the body shape, physical symptoms of pregnancy, complications of pregnancy were assessed using Pregnancy Distress Questionnaire (PDQ) developed by Yali and lobel (1999).

Table: 32. Pregnancy Specified Stress level of the respondents

Level of stress	**GDM**	**NonGDM**	**Total**	**Chisquare**
Low (<20)	50(28.9)	60(34.9)	110 (31.8)	**9.462****
Medium(20-23)	66(38.2)	81(46.8)	147 (42.7)	
High (>23)	57(32.9)	32(25.7)	89 (25.7)	

Figures in the parenthesis indicates the percentage

**Significance at 1 % level

An analysis of the pregnancy specified stress level of the subjects could bring out clearly the added stress in this respect among GDM than the nonGDM group.Majority of the GDM subjects were under stress either at medium (38.2%) or high (32.9%) level.In

contrast majority in the nonGDM reported having stress at a low level (38.2%) or medium (46.8%) level,projecting an association between pregnancy related stress.

Further analysis using chisquare proved beyond doubt the positive association between pregnancy related stress and the onset of GDM to a statistically significant ($p<0.01$) extent. Daniells et al. (2003) and Laraia et al .(2006) also had similar observations relating maternal stress and GDM.

4.1.12. PHYSICAL ACTIVITY PATTERN OF THE RESPONDENTS

Physical activity pattern of all the respondents were assessed in terms of their occupational activity, household activities, and leisure time activities.

Table:33. Physical activity pattern of the respondents

Particulars	**GDM N=173**	**Non GDM N=173**	**Total N=346**	**chisquare**
Occupational activity				
Sedentary	173	173	**346**	
Household chores Washing/mopping/laundering				
<3 hours	144(83.2)	143(82.65)	**297(85.8)**	**2.419**
>3 hours	29(16.7)	30(17.3)	**49 (14.1)**	
leisure time activities screen time/chatting/reading				

<3 hours	99(57.22)	105(60.6)	**204(58.9)**	**0.298**
>3 hours	74(42.77)	68(39.3)	**142 (41.04)**	

Figures in the parenthesis indicates the percentage

All the respondents including cases (1005) and controls (100%) followed a sedentary activity pattern.Most of them (cases 83.25 and controls 82.65) were engaged in household activities for a duration of less than three hours per day. having sedentary activity pattern. Majority of the cases (83.2%) and controls (82.65%) involved in household activities for less than three hours per day. Only 16.6 per cent of the GDM respondents and 17.3 per cent of the nonGDM respondents involved in household activities for more than three hours per day. Leisure time activities of interest to the cases and controls included activities such as reading chatting television watching.It was noticed that more number of GDM respondents (42.7%) than in the nonGDM (39.3%) were engaged in such activities for more than three hours per day.This was an indication of lack of physical activity among the subjects.

4.1.13. EXERCISE PATTERN OF THE RESPONDENTS

Physical inactivity is the fourth-leading risk factor for morbidity and early mortality worldwide (WHO,2010). In pregnancy, physical inactivity and excessive weight gain have been recognized as independent risk factors for maternal obesity and related pregnancy complications, including GDM (Artal, 2015). The exercise pattern of the

respondents was investigated through the habit, type and frequency of exercise in the prepregnancy as well as in the pregnancy period.

4.1.13.1. EXERCISE PATTERN OF THE RESPONDENTS DURING PREPREGNANCY PERIOD

Exercise, defined as any bodily movement produced by the contraction of skeletal muscles (American College of Sports Medicine, 2014) helps to remain healthy in all stages of life. Women who begin their pregnancy with a healthy lifestyle including regular exercise were found to have more favourable outcomes. So the exercise pattern of the respondents in prepregnancy period were analysed in detail.

Table: 34. Exercise pattern during prepregnancy period

particulars	**GDM N=173**	**Non GDM N=173**	**Total N=346**	**Chisquare**
Frequency of exercise				**20.239****
>5days/week	**10(5.7)**	**22(12.7)**	**32(9.24)**	
<5days/week	**33(19.07)**	**62(35.8)**	**95(27.4)**	
No exercise	**130 (75.14)**	**89 (51.44)**	**219 (63.29)**	
Type of exercises				

Aerobics	**7 (4.04)**	**11 (6.35)**	**18 (5.2)**	
Brisk walking	**16 (9.2)**	**37 (21.3)**	**53 (15.3)**	
Slow walking	**8 (4.62)**	**18 (10.4)**	**26 (7.51)**	
Yoga	**12 (6.93)**	**18 (10.4)**	**30 (8.67)**	

Figures in the parenthesis indicates the percentage

**Significance at 1 % level

Absence of any physical exercise during the prepregnancy period was reported by 75.14% of GDM and 51.44% of nonGDM subjects.This was followed by an exercise frequency of less than five days per week (19.07% controls and 35.8% cases).In short the prepregnancy exercise schedule was not very supportive with GDM subjects.

Among the nonGDM, though exercise habit was observed only among 48.56% the rest of them followed a moderately good exercise regime.This difference was found to be statistically significant at one per cent level which revealed the negative association of habit of exercise in the pregnancy period and GDM,ie lack of exercise at this stage may predispose to GDM. Among the types of exercise brisk walking was the one mostly opted by 21.3% of the controls and 9.2% of cases.

Slow walking (cases-4.62%, controls-10.4%), aerobics (cases 4.04%-,controls-6.35%) and yoga (cases-6.93% – controls10.4% %) were the other types of exercises done by the respondents. Gravard and Artal (2008) had also opined that exercising both prior to pregnancy has the greatest correlation with protection against developing GDM.

4.1.13.2EXERCISE PATTERN IN THE PREGNANCY PERIOD

Regular exercise during pregnancy is known to be associated with many benefits for the mother and her baby. Details regarding the exercise pattern of the respondents during the pregnancy period was noted.

Table: 35. Exercise pattern in the pregnancy period

Particulars	**GDM N=173**	**NonGDM N=173**	**Total N=346**	**chisquare**
Frequency of exercise				
<5days/week	15 (8.67)	40 (23.12)	39 (22.54)	
>5days/week	6 (3.46)	23 (13.29)	14 (8.09)	**18.696***
No exercise done	152 (87.8)	110 (63.5)	293(84.6)	
Type of exercises				
Aerobics	-	-	-	
Brisk walking	-	-	-	
Slow walking	14 (8.09)	21 (12.1)	35 (20.23)	
Yoga	4 (2.31)	6 (3.46)	10(5.7)	
Prenatal exercise	3 (1.7)	5(2.89)	8(4.6)	
No exercise done	152 (87.8)	141(81.5)	293(84.6)	

Figures in the parenthesis indicates the percentage *Significance at 5 % level

As seen in the table majority of GDM (87.8%) and nonGDM (63.5%) subjects did not do any exercise in pregnancy period. Lack of exercise during pregnancy period was more

evident among the cases than the controls reported. Of the remaining, 3.46 per cent of GDM and 13.29 per cent of the controls were reported doing exercise either regularly, a frequency of >5 days per week or less than five days per week (GDM 8.67% and nonGDM 23.12%).Hence it was obvious that more than 1/3 rd of the nonGDM subjects had the habit of doing exercise in pregnancy indicating its protective effect on GDM.

Chisquare analysis also showed a staistically significant ($p<0.05$) negative association between the habit of exercise during pregnancy period and GDM. Physical inactivity is one of the modifiable risk factors for lowering the risk of GDM, and preventing the onset of diabetes in people at risk (Symons & Hausenblas ,2004).

Regarding the type of exercises done during pregnancy period slow walking (20.23%) was the most opted exercise among the respondents followed by yoga (5.7%) and prenatal exercises (4.6%).Brisk walking and aerobics were not opted by any of the respondents. Similar observation was made in an earlier study where women viewed gentle to moderate physical activity as safe during pregnancy (Duncombe et al., 2007) and seems that women replace strenuous activities with lighter intensity activities as their pregnancy progresses, which leads to increased duration of light activity or decreased total volume of activity (Poudevigne and O'Connor, 2006)

Comparison of exercise pattern during prepregnancy and pregnancy period

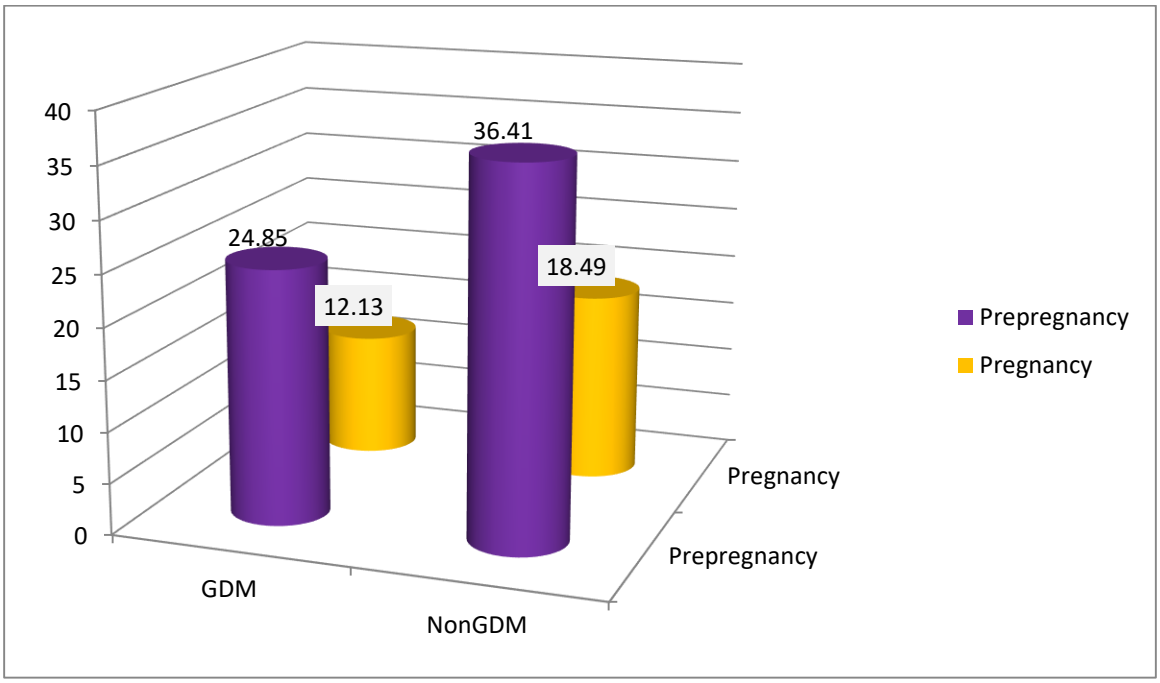


Fig17. Comparison of prepregnancy and pregnancy exercise pattern

4.1.13.3. BARRIERS TO EXERCSE IN THE PREGNANCY PERIOD

As the habit of exercise was found to decline in the pregnancy period, an attempt was made to investigate the common barriers confronted by them and the details are given below.

Table: 36. Barriers to exercise in the pregnancy period

Barriers	**Number of respondents (%) N=293**
Not aware about the benefits of exercise	**33 (13.06)**

Not aware about the type of exercise to be done	**48 (15.9)**
Lack of time	**52(15.9)**
Laziness	**48(21.5)**
Thinks that exercise should not be done in pregnancy period	**68 (32.3)**
Advised by the doctor to have rest	**17 (9.65)**
Thinks that the work at home/work are adequate	**27 (7.38)**

Figures in the parenthesis indicates the percentage

As obtained from the table the misconcept of exercise should not be done in pregnancy was the reason mentioned by 32.3% of the subjects. Laziness (21.550 and lack of time (15.9%) were also stated as reasons. Lack of awareness was yet another important factor that prevented them from doing exercise in pregnancy, which included ignorance of its importance (13.06%) and types of exercise which one was safe at pregnancy (15.9%) and household activities are enough and no need to have other exercises (7.38%).

Lack of awareness about physical activity among pregnant women was the predominant barrier to exercise. This pointed out the importance of educating the prospective mothers on the health benefits of physical activity.

4.1.14 BINARY LOGISTIC REGRESSION ANALYSIS OF GDM WITH VARIABLES

To determine the correlation between the risk factors and GDM, binary logistic regression was applied with suitable standard ($P<0.05$) to perform stepwise logistic regression analysis, using GDM as a dependent variable and the related factors in univariate analysis as an independent variable.The factors that were found to have a significant association ($P<0.01$) with GDM are given in the table below.

Table: 37. Binary logistic regression analysis of GDM

Particulars	**Odds ratio**	**95% CI**	**P value**
Socidemographic details			
Increasing maternal age	1.924	1.49-2.49	0.000
Family health history			
Type 2 diabetes	1.915	1.53-2.4	0.000
Thyroid problems	1.309	1.04-1.66	0.005
Personal health profile			
Hypothyroidism	2.445	1.46-4.1	0.001
PCOD	0.684	0.52-0.9	0.007
Menstural history			
Menstural problems	1.592	1.23-2.06	0.00
Anthropometric factors			
Above normalprepregnancy	1.094	1.02-1.18	0.008

BMI			
Above normal gestational weight gain	4.412	2.75-7.08	0. 001
Obstetric history			
Infertility problems	10.775	2.91-3.96	0.000
Bad Obstetric History	0.684	0.52-0.9	0.007
Outcome of previous pregnancy	1.145	1.06-1.24	0.001
Life style factors			
Lack of exercise in Prepregnancy period	2.853	1.81-4.5	0.003
Lack of exercise in Pregnancy period	1.706	0.4-3.09	0.001
Dietary factors			
Low intake of fibre	0.685	0.53-0.89	0.004
Low intake of salads	0.766	0.58-1.01	0.005
High intake of fried snacks	0.307	0.21-0.45	0.002
High intake ofsugared drinks	0.727	0.55-0.97	0.008

As read from the table, seventeen risk factors identified were possibly related to the risk of GDM. The factors such as age, family history of type 2 diabetes and thyroid problems, personal health problems such as hypothyroidism and PCOD, menstural

problems, prepregnancy BMI, gestational weight gain, infertility problems, Bad Obstetric History , outcome of previous pregnancy such as (macrosoima,congenital abnormalities) , high intake of fried snacks and sugared bottled drinks were found to be positively associated to statistically significant level ($p<0.01$) with the incidence of GDM.Low intake of fibre ,low intake of salads and lack of exercise in prepregnancy and pregnancy period were found to be inversely ($p<0.01$) associated with GDM.

Hence identifying these risk factors at an earlier stage could help reduce the incidence of GDM, thus ultimately improving maternal and neonatal outcome.

4.2. PHASE II GESTATIONAL FOLLOW UP

In the second phase of the study all the respondents (N=346) were followed from 24 to 28 weeks of gestation until delivery. During the follow up period, their glycemic control, blood pressure variations and weight changes of the respondents were monitored at 28 to 32 weeks and at 37 to 41 weeks of gestation. Treatment modalities adopted by the respondents were also recorded.

4.2.1 GLYCEMIC LEVEL OF THE RESPONDENTS DURING FOLLOW UP PERIOD

In order to prevent perinatal complications of mother and infant, the goal of glycemic control during pregnancy should be to bring plasma glucose level as close to normal as possible without development of hypoglycemia. The glycemic controls of the respondents were noted during the follow up period by measuring the blood glucose level. The fasting blood sugar values and the post prandial blood sugar values at 28-32 weeks and at 37 -41 weeks were analysed and compared with the normal values recommended by WHO (2013).

Table:38 Mean gestational glycemic levels of the respondents during follow up period

Blood sugar values	**Normal values mg/dl**	**GDM N=173**	**Non GDM N=173**	**GDM N=173**	**Non GDM N=173**
		Mean±SD		**Mean±SD**	
		28-32 weeks		**37-41 weeks**	
Mean FBS	92	104.20±9.99	84.53±4.39	119±14.3	86±3
Mean PPBS	140	141.79±14.71	107.7±7.09	164±12.1	110±11.4

FBS- Fasting Blood Sugar PPBS-Post Prandial Blood sugar

The mean fasting and post prandial blood sugar values of the GDM subjects at 28 to 32 weeks were 104.20±9.99 mg/dl and 141.79±14.71 mg/dl respectively. As the gestational age increased (37 to 41 weeks) there was an increase in the mean fasting (119±14.3mg/dl) and post prandial blood sugar values (164±12.1 mg/dl) of the cases. The

observations were in accordance with the results of the study Hyperglycemia and Adverse Pregnancy Outcomes (HAPO, 2008) which reported that insulin resistance increases exponentially with increasing gestational age. The blood sugar values of the control group were within the normal range at these time intervals.

4.2.2 BLOOD PRESSURE READINGS OF THE RESPONDENTS DURING GESTATIONAL FOLLOW UP

As hypertension often co-exists with diabetes (Contreras et al .,2000) the blood pressure changes of the respondents were recorded at 28-32 weeks and at 37-41 weeks of gestation during the follow up period and the results are given below.

Table:39 Blood pressure readings of the respondents during gestational follow up

Blood pressure classification	**value (mm/Hg)**	**GDM (N=173)**	**NonGDM (N=173)**	**GDM (N=173)**	**NonGDM (N=173)**
		28-32 weeks		**37-41 weeks**	
Normal	SBP≤120 and DBP≤80	150(86.7)	159 (91.9)	146(84.3)	156(90.8)
Prehypertensive	SBP 120-139 and/or DBP 80-89	15 (8.6)	9 (5.2)	19(10.9)	12(6.9)
Stage 1 hypertension	SBP140-159and /or	7 (4)	5 (2.9)	7(4)	5(2.9)

	DBP 90-99				
Stage 2 hypertension	SBP≥160and /orDBP≥100	Nil	Nil	Nil	Nil
Total		**173(100)**	**173 (100)**	**173(100)**	**173(100)**

Figures in the parenthesis indicates the percentage

The blood pressure readings were compared with the normal values given by Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (2007). Majority of the respondents both the cases (86.7%) and controls (91.9%) had normal blood pressure. Prehypertensive stage and stage 1 hypertension was observed among 8.6 per cent and 4 per cent of the GDM respondents compared to the nonGDM respondents (5.2% and 2.9% respectively). As observed from the table there was increase in the blood pressure values of the respondents as the gestational age progressed. At 37 – 41 weeks of gestation the per cent of prehypertensive respondents was more among the cases (10.9%) than their controls (6.9%).

4.2.3. TOTAL WEIGHT GAINED BY THE RESPONDENTS DURING PREGNANCY PERIOD

The total weight gained in the pregnancy period was recorded and compared with Institute Of Medicine (IOM,2009) guidelines for gestational weight gain.IOM has published revised gestational weight gain guidelines based on prepregnancy BMI ranges for underweight, normal weight, overweight and obese women. The BMI was categorized according to WHO Asia Pacific criteria 2009.

Table: 40. Total weight gained by the respondents during pregnancy

BMI category WHO (2009)	Normal weight gain ranges (kg)	GDM (N=173)				Non GDM (N=173)			
		Weight gain (kg)				Weight gain (kg)			
		BN	N	AN	Total	BN	N	AN	Total
Underweight(<18.5)	12-18	1	2	0	**3 (1.7)**	1	4	1	**6 (3.46)**
Normal (18.5-22.9)	11.5 - 16	5	73	18	**96 (55.5)**	12	91	14	**117 (67.6)**
Overweight /Obese (23- ≥25)	5 -11	1	26	47	**74 (42.7)**	10	36	4	**50 (28.9)**
Total		7 (4.04)	101 (58.3)	65 (37.5)	**173 (100)**	23 (13.29)	134 (77.4)	19 (10.9)	**173 (100)**

Figures in the parenthesis indicates the percentage

a-Computed using Fisher's exact test

BN- Below Normal N-Normal AN-Above Normal

Among the GDM subjects 4.04 per cent had below normal weight gain followed by 58.3 per cent with normal weight gain and 37.5 per cent with above normal weight gain. In the case of the nonGDM subjects below normal weight gain was observed in 13.29 % followed by 77.4% with normal weight gain and 10.9 per cent with above normal weight gain as suggested by IOM. Among all the BMI categories, gestational weight gain above the normal was more observed more among the overweight/obese GDM respondents

(37.5%) than the nonGDM respondents (10.9%). An increased weight gain above the normal influenced the subsequent maternal insulin resistance (Buchanan et al.,2005).

4.2.4. TREATMENT MODALITIES

Different treatment strategies were recommended by the diabetologists to control the blood sugar levels of the subjects. Dietary management was the corner stone in treatment of GDM. If the dietary management alone was not successful to control the blood sugar levels, insulin was resorted. Insulin dosage was fixed by the diabetologist according to the blood sugar levels of the respondents**.** Different treatment modalities adopted by the respondents were noted and given below.

Table: 41. Treatment modalities adopted by the respondents

Treatment modalities	**GDM (N=173)**
Meal plan	57 (32.9)
Meal plan +drug	3 (1.7)
Meal plan + insulin	113 (65.31)

Total	**173**

Figures in the parenthesis indicates the percentage

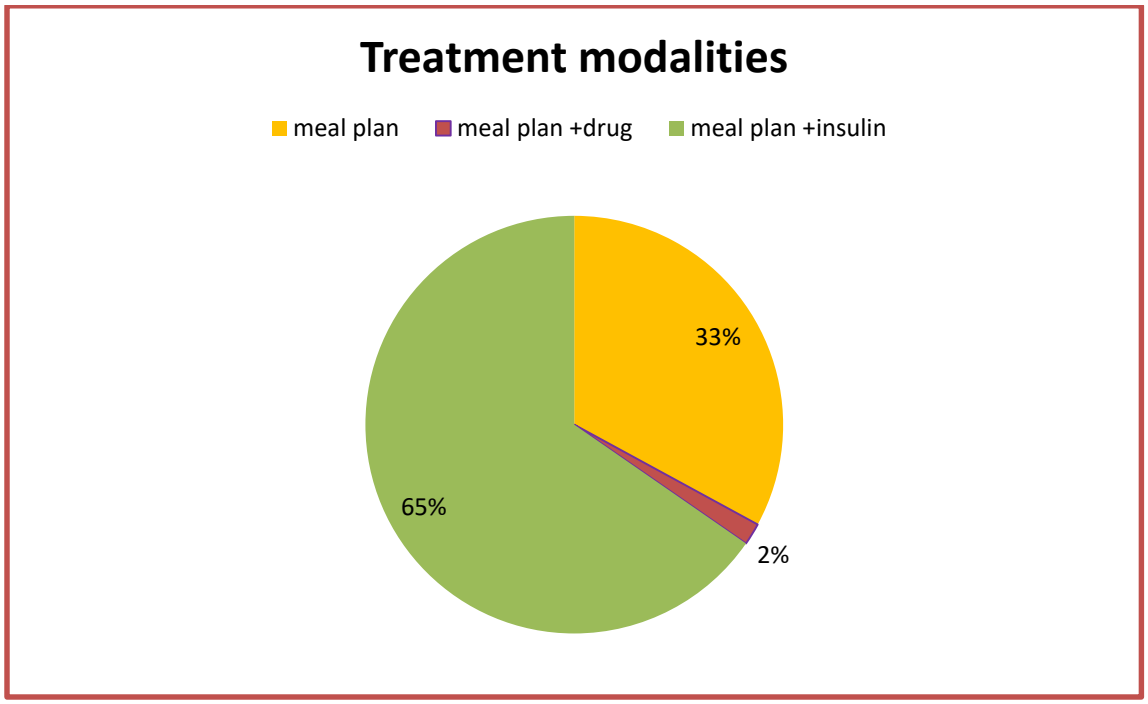


Fig 18. Treatment modalities of the respondents

Medical nutrition therapy was largely accepted in GDM management and this was evidenced as 32.9 per cent of the subjects could manage diabetes with meal plan alone. But majority of the GDM mothers (63.51%) had to depend on combination of meal plan and insulin for tight glycemic control because even mild blood sugar variations would bring about perinatal complications. According to ADA (2015) insulin is effective in the

management of GDM and supported as a first line option by many guidelines. Only 1.7 per cent of the subjects managed blood sugar levels with meal plan and drugs.

4.3. PHASE III ASSESSMENT OF PREGNANCY OUTCOME

Several studies have documented that increasing maternal carbohydrate intolerance in pregnant women was associated with an increase in the adverse maternal and fetal outcomes. Hence the maternal and fetal outcome was recorded in detail.

4.3.1. MATERNAL OUTCOME

The mode of delivery and complications of the respondents were noted.

4.3.1.1. MODE OF DELIVERY

Table: 42 Mode of delivery

Mode of delivery	**GDM N=173**	**Non GDM N=173**	**Total N=346**	**Chi square**
Normal vaginal delivery	152 (87.86)	163(94.2)	315(91.04)	
Caesarean	21 (12.1)	10(5.78)	31(8.95)	**32.34***
Total	173	173	346	

Figures in the parenthesis indicates the percentage

*Significance at 5 % level

Majority of the respondents including cases (87.6%) and controls (94.2%) had normal delivery. The incidence of caesarean delivery in total was 8.95 per cent. The rate of caesarean delivery was more among GDM group (12.1 %) when compared to nonGDM group (5.78%)**.** The statistical analysis revealed a positive significant association at five per cent level between GDM and cesarean section. The findings in this study coincided with prior literature that reported higher percentage of cesarean section in pregnant women with abnormal glucose tolerance (Reece and Coustan, 1995) (Hanson ,1993).

4.3.1.2.MATERNAL COMPLICATIONS

The adverse consequences of the respondents during delivery were noted and given in the following table.

Table:43. Maternal complications

Sl no	Maternal complications	GDM N=173	Non GDM N=173	Total N=346	Chisquare
1	**Hypertensive disorders**	10 (5.7)	5(2.89)	5(8.5)	
2	**Polyhydraminos**	12(6.93)	4(2.31)	16(4.62)	**43.43***
3	**UTI**	22 (12.71)	3(3.46)	28(8.09)	
4	**APH**	-	-	-	
5	**PPPH**	-	-	-	
6	**No complications**	136 (75.7)	161(91.32)	289 (83.52)	

Figures in the parenthesis indicates the percentage *Significance at 5 % level

APH- Antepartum haemorrhage PPH -Post partum haemorrhage UTI- Urinaty Tract Infection

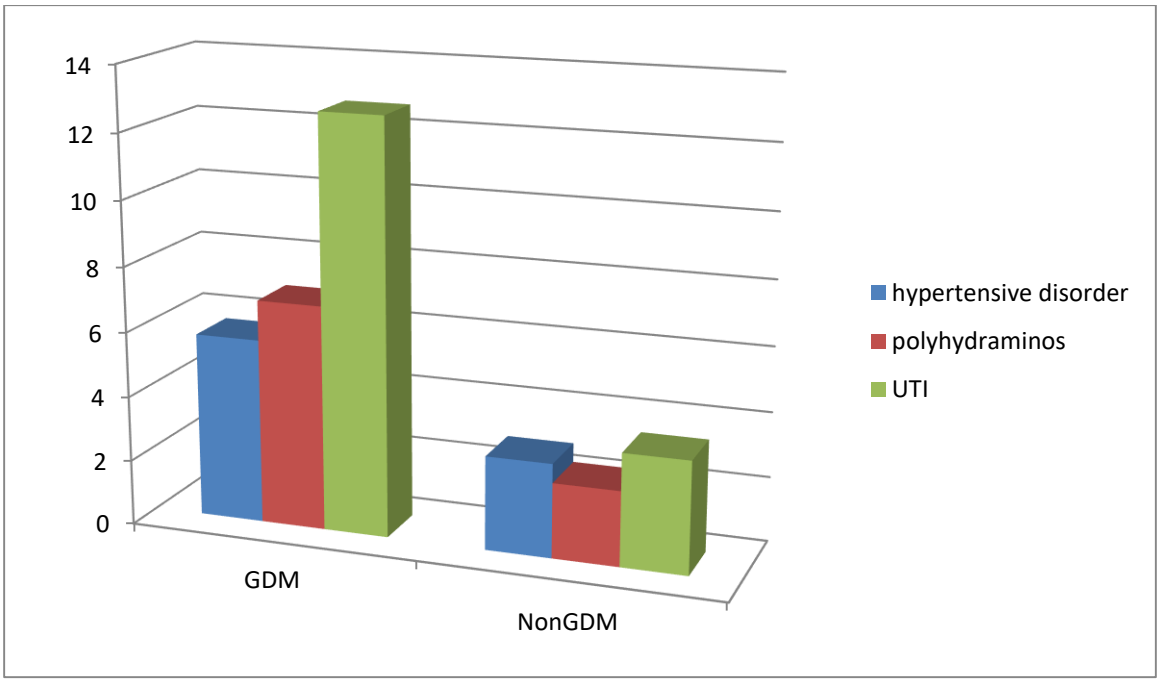


Fig 19. Maternal complications

Maternal complications were minimal among the nonGDM than the GDM. Nearly ¼ th of the GDM population was suffering from one or the other maternal complications.In contrast among nonGDM subjects it was only less than 10 per cent. Hypertensive disorders (8.5%), polyhydraminos (4.62%) and urinary tract infections (8.09%) were the maternal complications observed among the respondents.

Among the complications in pregnancy UTI was found to be more common than other types involving 12.7 per cent of GDM and 3.46 per cent of nonGDM subjects. In diabetic pregnancy, Urinary Tract Infection is the most commonly observed maternal infection,

because in addition to the anatomical and physiological changes seen in the renal tract during pregnancy diabetes mellitus usually suppresses the immune system and enhances the progression of infection (Chandel et al., 2012).

Polyhydraminos was seen in 6.93 per cent of the cases compared to 2.31 per cent of the controls.Dashe (2000) had suggested that there is a positive correlation between amniotic fluid volume and glucose concentration in amniotic fluid. It has also been reported that GDM women are more complicated with polyhydraminos than the normal pregnant women. (Goldman,1991).

Hypertensive disorders of pregnancy (HDP) was more observed in cases (5.7 %) than the controls (2.8%).Hypertensive disorders of pregnancy (HDP) is one of the leading causes of maternal morbidity and mortality (WHO,2011) and gestational diabetes tend to increase a woman's risk for hypertensive disorders (Bryson et al.,2003).

Chisquare analysis showed a significant positive association ($p<0.05$) between GDM and maternal complications. GDM is a major cause of perinatal morbidity and mortality, as well as maternal morbidity (Zhang et al.,2008)

4.3.2. NEONATAL OUTCOME

The hyperglycemic intrauterine environment in GDM pregnancy can affect multiple aspects of the health of the offspring. Results from the Hyperglycemia and Adverse Pregnancy Outcomes (HAPO,2008) study indicate that maternal hyperglycemia adversely affects neonatal outcomes. Hence the neonatal outcome was studied in detail.

4.3.2.1.NEONATAL CHARACTERISTICS

Since there were six twin pregnancies among the cases and three among the controls the total number of neonates for the study was 355 (cases-179, controls-176). Neonatal chararcteristics of all the neonates (N=355) were recorded in detail**.**

Table: 44. Neonatal characteristics

Sl no	**Particulars**	**GDM N=179**	**Non GDM N=176**	**Total N=355**	**Chisquare analysis**
1	**Term**				
	Full term	170 (94.9)	173(98.2)	**343 (96.6)**	**26.34***
	Preterm	9 (5.02)	3(1.7)	**12 (3.3)**	
2	**Birth type**				
	Live birth	179 (100)	176 (100)	**355 (100)**	
	Stillbirth	-	-		
3	**Mean APGAR score**	8.24±0.6	8.3±0.4		

Figures in the parenthesis indicates the percentage *Significance at 5 % level

As seen from the table 96.6 per cent of the neonates were full term including 98.2 per cent among nonGDM and 94.9 per cent among GDM group. Preterm neonates were more among the GDM respondents (5.02%) compared to the nonGDM (1.7%). Chisquare analysis clearly indicated a positive association ($P<0.05$) between premature birth and GDM. Prior studies have also pointed out the increased premature birth among women with GDM. (Villar et al.,2012, . Hedderson et al., 2003)

All of the respondents gave birth to live babies and no stillbirth was reported.This might be due to timely medical intervention and hospital based delivery system followedin Kerala.

APGAR score at five minutes was recorded for all the babies with the help of a medical assisstant. The five criteria for APGAR score were Appearance, Pulse, Grimace, Activity and Respiration.Total possible scores was 10.Babies securing scores above seven were considered as normal Scores are calculated out of 10 and scores above seven are considered to be normal. Mean APGAR score was found to be normal among the neonates and followed an equal trend among the neonates of cases (8.24±0.6) and controls (8.3±0.4).

4.3.2.2. NEONATAL ANTHROPOMETRY

Table : 45. NEONATAL ANTHROPOMETRY

Sl no	Neonatal anthropometry	GDM N=179	Non GDM N=176	Total N=355	Chi square

1	**Birth weight** Low birth weight(<2.5kg)	9 (1.11)	5 (2.27)	6 (1.69)	**4.43****
	Normal (2.5 kg -3.5 kg)	13 8 (88.2)	165 (93.75)	312 (87.8)	
	Large baby (>3.5 kg)	19 (11.7)	7 (3.96)	28 (7.88)	
2	Mean crown heel length(cm)	45.76±4.6	44.72±4.9		
3	Mean head circumference(cm)	33.5±4.1	33.4±4.2		

Figures in the parenthesis indicates the percentage **Significance at 1 % level

Neonatal anthropometry was studied in terms of birth weight,crown heel length and head circumference.Commonly infants exceeding 90th percentile for any specific gestation age are considered macrosomic or large for gestation age (LGA) In Indians, 3.45kg corresponds to the 90 th percentile of birth weight and hence the cut off for macrosomia used is 3.5kg (Paul et al., 2002).

As per the above criteria 93.75 percent of the newborns of nonGDM mothers had normal birth weight among GDM as against 88.25 per cent among GDM. Large baby or macrosomia which is a consequence of GDM was observed in 11.7 per cent of the neonates of the GDM mothers where as among nonGDM it was only 3.96 per cent. Low

birth weight was observed only among 1.69 per cent of neonates studied with a distribution of 1.69 per cent among the controls and among 1.11 per cent among cases.

The highly significant positive association ($p<0.01$) observed between GDM and birth weight of the neonate was a clear indication of the possibilities to have high risk babies to GDM mothers.

Several Indian studies have reported that average Crown Heel Length and Head Circumference of the neonates were 46-51cm and 32-37 cm respectively.(Kaur et al .,2013,Kataria et al.,2014,Taksande et al ., 2008).Findings in the present study was in accordance with this.

Mean crown heel length was almost same among babies of the cases (45.76±4.6cm) and controls (44.72±4.9cm).Same trend was observed among the cases (33.5±4.1cm) and controls (33.4±4.2 cm) regarding the mean head circumference of the neonates.

4.3.2.3. NEONATAL COMPLICATIONS

Infants born to mothers with gestational diabetes mellitus are known as high-risk infants in whom multiple complications develop and such complications include hypoglycemia, polycythemia, hyperbilirubinemia, hypocalcemia, neonatal respiratory distress syndrome (Nold and Georgieff ,2004).So the incidence of complications were noted for all the among the neonates (N=355) was studied and the results are given in the table.

Table : 46 Neonatal complications

Complications	GDM N=179	Non GDM N=176	Total N=355	Chi square
Macrosomia	21(11.7)	7(3.9)	28(7.8)	
Hypoglycemia	17(9.4)	-	17(4.7)	
Neonatal jaundice	38(21.2)	17(9.6)	55(15.4)	
Hypocalcemia	5(2.79)	-	5(1.4)	**59.796****
Polycythemia	-	-	-	
Congenital anomalies	-	-	-	
Respiratory distress	18(10.05)	4(2.27)	16(4.5)	
No complications	80(44.6)	145 (82.3)	225(63.3)	

Figures in the parenthesis indicates the percentage

** significant at 1% level

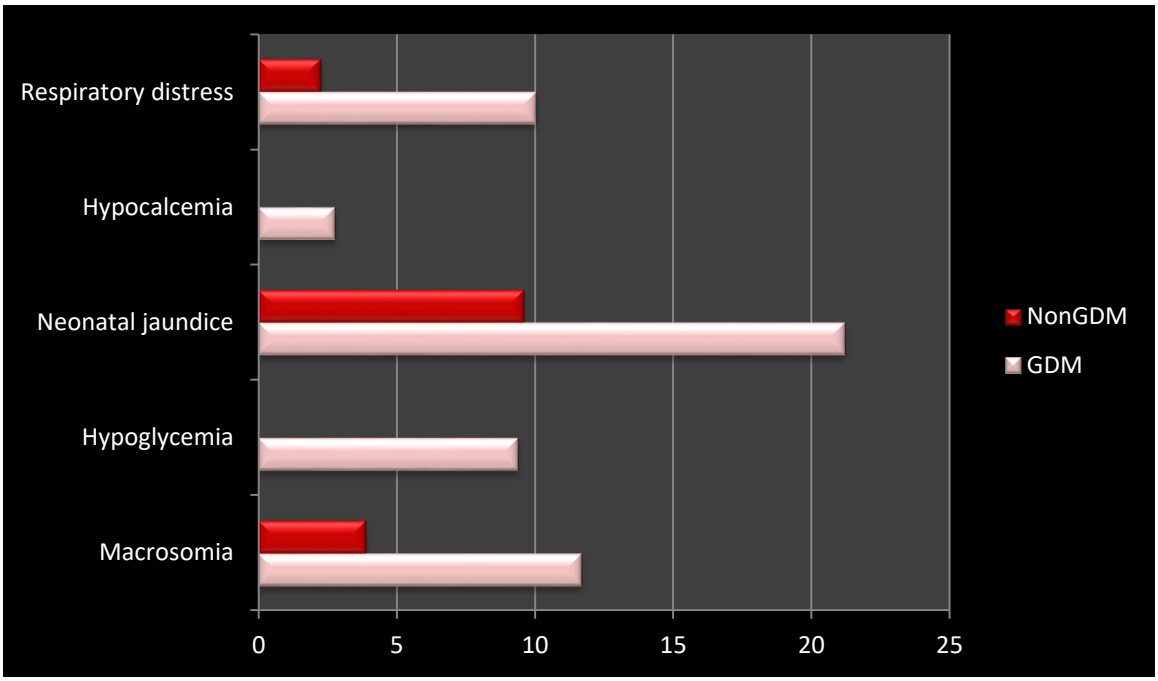


Fig 20. Neonatal complications

Only 44.6 per cent of the neonates born to GDM mothers were free of any health based complications whereas 82.3 per cent of the neonates of nonGDM mothers where out of were macrosomia respiratory distress hypoglycemia and hypocalcemia.

Analysis of the incidence of individual health complicatios neonatal jaundice ranked first with an incident rate of as high as 21.2 per cent among the newborns of GDM mothers as against 9.6 per cent among the neonates of control group.Next in the oder In the present study the most commonly occurred complication among neonates of the respondents was neonatal jaundice which was observed more among the cases (21.2%) than the controls (9.6%).

Macrosomia which is a fetal developmental anomaly unique to pregnancy in women with diabetes mellitus was also observed in higher percentages in infants of GDM mothers (11.7%) than the nonGDM controls (3.9%). As proposed by Pederson (1988) hyperglycemia-hyperinsulinemia hypothesis explained that hyperglycemia of mothers induces hyperglycemia of fetuses, and hyperplasia of pancreatic β-cells of fetuses results in hypersecretion of insulin, leading to excessive growth of fetuses. Esakoff (2009) also of the opinion that macrosomia is the most common fetal complication associated with GDM followed by hyperbilirubinemia.

Hypoglycemia (9.4%) was observed only among the neonates of GDM subjects and not in the nonGDM category. According to Blumer (2013) maternal hyperglycemia during labor and delivery can contribute to the risk of neonatal hypoglycemia.iHigher incidence of respiratory distress was also seen in higher percentages among the neonates of GDM (10.05%) than the nonGDM (2.27%) mothers.

The positive association of GDM with neonatal complication was ascertained with the chisquare analysis which showed significance at one per cent level.

4.3.2.4. NICU ADMISSION AND PHOTOTHERAPY TO NEONATES

Table: 47. NICU admission and phototherapy to neonates

Sl no	particulars	GDM N=179	Non GDM N=176	Total N=355	Chi square
1	NICU admission	29(16.2)	13(7.2)	42(11.8)	18.191**

2	Phototherapy	27(15.08)	11(6.14)	34(9.5)	2.087**

Figures in the parenthesis indicates the percentage ** significant at 1% level

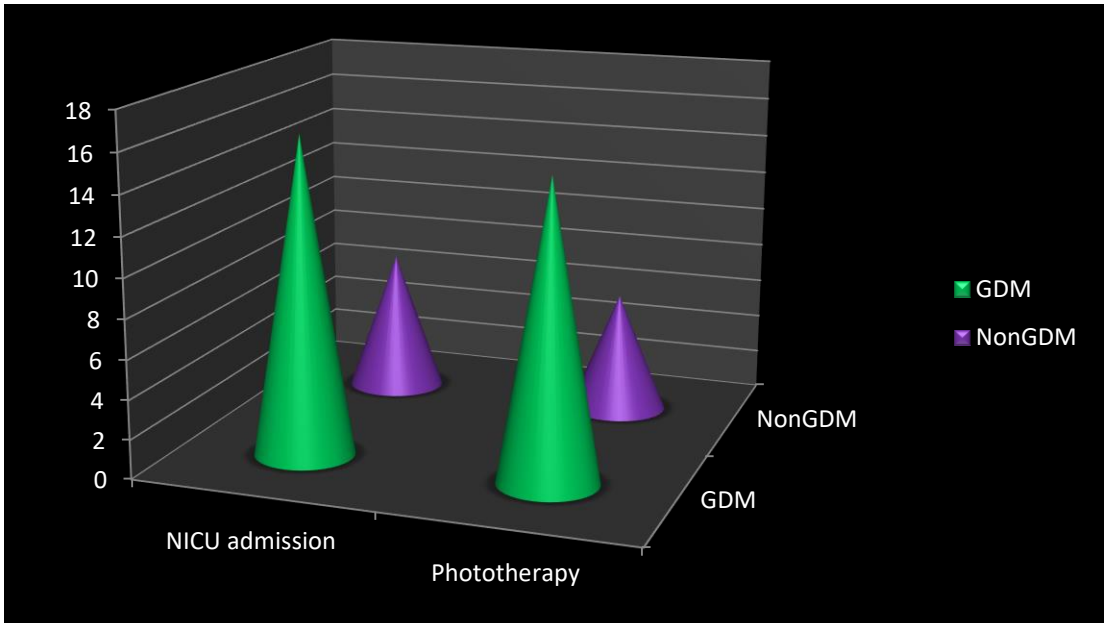


Fig 21.NICU admission and phototherapy

Admission of newborns to neonatal Intensive Care Unit was reported to be significantly ($p<0.01$) among GDM (16.2%) than the nonGDM (7.2%) groups. Incidence of neonatal complications such as hyperbilirubinemia and respiratory distress had increased the chances of admission to NICU.

In case of phototherapy also the requirement was significantly ($p<0.01$) higher for the neonates of GDM mothers (15.08%) when compared to the infants born to nonGDM mothers(6.14%).Phototherapy is normally given as a treatment for neonatal jaundice.

This increased rate of phototherapy requirement for neonates of GDM mothers may be due to the increased incidence of neonatal jaundice in this group.

Chi square analysis showed a statistically significant positive association between the NICU admission ($p<0.01$) as well as, the requirement of phototherapy ($P<0.01$) and incidence of GDM. Ostlund et al. 2003 and Bonomo et al. 2005 had also similar conclusions in their studies that increased complications in the neonates of GDM mothers increases the NICU admission and requirement of phototherapy.

5.SUMMARY AND CONCLUSION

The present study was a hospital based prospective case control type, carried out in Thrissur district. The hospitals selected were Jubilee Mission Medical College and Elite Mission. Ethical Clearance was obtained from the hospital. The duration of the study was for six months in each centre. Purposive random sampling method was used for the selection of samples and the sample size was computed statistically. Samples were recruited from the pregnant women who attended the outpatient unit of the gynecology department for antenatal checkups, from the selected hospitals during the study period.

The pregnant women who were at 24 to 28 weeks of gestation were screened for GDM using Oral Glucose Tolerance Test (OGTT). The test was carried out in the hospital laboratory by Glucose Oxidase Peroxidase method (GOD-POD method). The pregnant women in their fasting state were made to take 75 g oral glucose load. The estimation of plasma glucose was done in the fasting state followed by post prandial at one hour and two hour.GDM diagnosis was done based on World Health Organisation (WHO, 2013) criteria .Adopting the inclusion and esclusion criteria samples selected were classified into cases(n=178) and controls (n=178).The data was collected in three phases.

Phase 1 Identifying the risk factors of GDM.

Phase 2 Gestational follow up

Phase 3 Assessment of pregnancy outcome

Data collection was done by direct interview method. Interview schedules posing definite and direct questions to elicit required data in each phase of the study were developed. Anthropometric tools, other validated scales such as Perceived Stress Scale, Pregnancy Distress Questionnaire and Dietary Diversity Questionnaire were also used for data collection. Hospital records formed the source secondary data.

After developing the schedules, it was subjected to screening by a panel including gynecologist, diabetologist and dietitian. Necessary modifications as suggested by the panel were made and it was pre-tested on a comparable group of 20 subjects who were not included in the actual study to ensure consistency and accuracy. Data collection was done by direct interview method. Prior to the administration of interview schedule, informed consent was obtained from all the subjects.The investigator personally interviewed all the subjects and the data was recorded by the investigator.

In the first phase of the study, all the subjects both cases (n=178) and controls (n=178) who were enrolled into the study were interviewed to procure data regarding various variables that are postulated to be the contributing factors of GDM such as sociodemographic factors, family health history, personal health profile, menstrual history and obstetric history were gathered. Life style factors during their prepregnancy and pregnancy period such as dietary pattern personal habits, sleep pattern, stress level and physical activity pattern were also assessed. Anthropometric factors, biochemical and biophysical parameters were studied.

In the second phase of the study all the subjects both cases and controls were followed from 24 to 28 th weeks until their delivery to monitor their glycemic control, weight changes, blood pressure changes and management of GDM.

In the third phase of the study data on maternal outcome and neonatal outcome was gathered.

The data collected was subjected to both qualitative and quantitative analysis and was presented in frequency tables as absolute numbers and percentages. Statistical analysis was done using SPSS version 16. Mean, standard deviation, chisquare and binary logistic regression were the statistical tools used to analyse the data.

Major findings of the study

Phase 1 Assessment of risk factors of GDM

- Among the sociodemographic characteristics of the respondents such as age, religion, education, occupation, income and type of family, maternal age ($p<0.005$) and education ($p<0.005$) was found to be significantly associated with GDM.
- Anthropometric factors such as height, weight, prepregnancy BMI, weight gain during pregnancy were assessed. Statistical analysis revealed a significant association of GDM with prepregnancy BMI ($p<0.005$) and gestational weight gain ($p<0.001$).

- Majority of the respondents slipped into the normal category of haemoglobin level. No association could be drawn between maternal haemoglobin level and GDM in the present study.
- The biophysical parameter, blood pressure of the subjects was monitored and the statistical analysis revealed no association between GDM and blood pressure.

- Regarding the family health history,the incidence of type 2 diabetes (48.5%), thyroid problems (25.4%) cardiovascular disorders (6.35%) and hypertensive disorders (9.24%) were reported more among the cases than the controls.(18.4%,13.2%,2.8% respectively) . A significant statistical association could be drawn between family history of type 2 diabetes mellitus ($p<0.001$), thyroid problems ($p<0.005$) cardiovascular disorders ($p<0.005$) and GDM.

- Among the cases and controls who had family history of type 2 diabetes, maternal inheritance of type 2 diabetes was more predominant among the GDM respondents (30.95%) than the controls (28.1%).

- Hypothyroidism (18.49%), hyperthyroidism (8.09%) PCOD (21.3%), hypertensive disorders (2.02%) and UTI (1.2%) were the health problems observed among the

respondents. The fischers exact statistic indicated that there was a significant positive association ($p<0.005$) between personal health problems and GDM.

- Regarding the menstrual history irregular menstruation ($p<0.001$) and menstrual problems ($p<0.001$) were associated significantly with GDM. But no association could be drawn between age at menarche and GDM.
- A detailed obstetric history of the respondents including methods of contraception, parity, history of multiple pregnancy, infertility problems,infertility treatment Bad Obstetric History (BOH) and outcome of previous pregnancy were recorded. The measures towards contraception adopted by the majority did not distinguish between GDM and nonGDM with majority (84.3 %) of the respondents not resorting to any artificial method
- Data on the obstetric history showed that gravidity status ($p<0.005$) had significant positive association with GDM. Infertility problems ($p<0.05$) and infertility treatments ($p<0.01$) are both positively associated with GDM at significant levels.
- The Bad Obstetric History (BOH) of the respondents such as abortion was also positively ($p<0.001$) associated with GDM.

- The significance of the chi square statistics could present a strong relationship ($p<0.005$) between macrosomia and GDM when assessed based on the previous pregnancy outcomes.
- Life style factors of the respondents such as dietary pattern, personal habits, sleep pattern, stress level, physical activity pattern were assessed in detail. All the respondents were non vegetarians. Majority of the cases (82.7%) and controls (91%) followed three meal pattern. Coconut oil was the most preferred type of oil used among the respondents. The intake of sugar was more than two spoons per day was observed among 42 per cent of the GDM and 38 per cent of nonGDM group respectively.
- Majority of the respondents both among the cases (76.9%) and controls (64.7%) had intake of salads less than 5 servings per week and significant negative association($p<0.05$) was observed between salad intake and incidence of GDM
- The habit of nibbling during pregnancy period increased both among the cases (42.7%) as well as control (49.13%) when compared with the prepregnancy period (cases-36.9% ,controls-23.6%).%). The per cent of respondents opting healthy items for nibbling such as vegetable salad (9.53%) and fresh fruits (12.7%) was less among the GDM respondents when compared to the nonGDM respondents (13.29 % and 18.49%) respectively.

- Regarding the intake of nutritional supplements all the respondents took iron and calcium supplements as it was a compulsory practice in the hospitals to prescribe iron and calcium supplements during pregnancy.
- The per cent of respondents taking health drinks such as mothers horlicks, boost were more among the GDM respondents (23.7%) than in the nonGDM respondents (9.2%). A significant association was observed between the intake of health drinks and GDM ($P< 0.005$).
- An equal trend was observed among the cases and controls regarding the dietary diversity scores. Most of the cases (56%) and controls (60%) had medium dietary diversity scores. Low dietary scores were observed only in 3.36 per cent of cases and 2.31 per cent of controls.
- The mean intake of energy was above the RDA both for the cases (102.6%) and controls (100.27%). Protein intake was above the RDA for both the groups but higher among the cases (113.1%) than the controls (105.5%). The intake of fat was much above the RDA among the cases (140.2%) and controls (148%). Fiber intake did not meet the RDA among the cases (74.53%) as well as controls (83.5%).

- Micronutrient intake did not meet the RDA both among the cases and controls. The intake of iron in both the groups did not meet the RDA and the deficient

intake was more evident in the cases (84.17%) than the controls (88.17%).The intake of calcium was much low among the cases (86.9%) than the controls (93.8%).

- Nutrient adequacy ratio showed that, an adequate intake of macronutrients such as energy, protein and fat was observed in most of the cases and controls. Fiber intake seemed to be low which was evident in 48 per cent of the cases and 12 per cent of the controls .Low intake of fiber in the diet was negatively associated with GDM. ($p<0.001$).
- Frequency of consumption of various food items revealed that cereals, sugars, and fats were used by all the respondents on a daily basis (100%). Intake of pulses atleast once per week was seen among 60.7 per cent of cases and 53.7 per cent of controls .Daily intake of milk and milk products was seen among 76.9 per cent of cases and 74.6 per cent of controls.
- Daily intake of vegetables was seen only in 19.6 per cent of cases and 26.5 per cent of controls. Atleast once per week consumption of green leafy vegetables was reported among 43.9 per cent of cases in contrast to 55.5 per cent of controls. Daily intake of fruits was seen only among 14 per cent of the cases and 12 per cent of the controls. Significant negative association ($p<0.05$) could be drawn between the intake of green leafy vegetables and GDM

- Among the nonvegetarian foods majority of the cases (71.1%) and controls (84.4%) reported a frequency of use of chicken as well as red meat (cases-60.7%, controls-57.4% respectively) atleast once per week. Daily consumption of fish was observed among 30.1 per cent of the controls and 35.8 per cent of the controls.

- Fried items, biscuits and rusks were the most frequently used packed items both among the cases and controls. Intake of fried items atleast once per week was observed more among the cases (35.3%) than the controls (19.1%). Daily intake of biscuits/ rusks were observed in 53.2 per cent of cases and in 18.5 per cent of controls. Consumption of sugared bottle drink atleast once in a week was observed in 9.8 per cent of the cases and 2.9 per cent of the controls. Positive association could be drawn between the intake of fried items ($p<0.001$), biscuits/rusk ($p<0.001$) sugared bottled drinks ($p<0.05$) and incidence of GDM.

- Frequency of eating out atleast once per week was observed in 31.2 per cent of cases and in 12.7 per cent of controls. Chisquare analysis showed that habit of eating out was associated with GDM ($P<0.01$). Fried snacks were the most frequently consumed item among the respondents. The percentage of

respondents taking fried items from outside at least once per week was comparitively more among the cases (42.1%) than the controls (25.4%).

- None of the respondents had habits such as smoking, alcohol consumption and pan chewing
- Majority of the respondents (91.9%) had normal sleep but sleep disturbances was seen among 12.1 percent of the GDM respondents.No association could be drawn between sleep pattern and GDM.
- The pregnancy specified stress was noticed among 32.9 percent of the GDM respondents with significant association between GDM at one per cent level.
- All the respondents were having a sedentary activity pattern. The hours spent in household activities revealed that only 16.6 percent of the GDM respondents and 17.3 percent of the nonGDM respondents involved in household activities for more than three hours

- The habit of exercise during prepregnancy period was observed only in 24.85 percent of the GDM respondents when compared to the nonGDM (48.55 %).Considering the frequency of exercise most of the GDM respondents (76.7%) had frequency of exercise less than 5 days/week. Brisk walking (41.7%), slow walking (20.4%), aerobics (14.1%) and yoga (23.6%) were the various types of exercises done by the respondents during prepregnancy period. During

pregnancy period only 12.13 per cent of the GDM did regular exercise. A significant association between GDM and exercise pattern during pregnancy ($p<0.005$) and prepregnancy period ($p<0.001$) was observed.

- Among the 293 respondents who did not involve in any kind of exercises, the most commonly said barrier was that they thought exercise should not be done in the pregnancy period (32.3%) Using binary logistic regression analysis, risk factors that has positive and negative association with GDM was identified.
- The factors such as age, family history of type 2 diabetes and thyroid problems, personal health problems such as hypothyroidism and PCOD, menstural problems, prepregnancy BMI, gestational weight gain, infertility problems, Bad Obstetric History, outcome of previous pregnancy such as (macrosoima,congenital abnormalities) intake of fried snacks and sugared bottled drinks atleast once in a week was found to be positively associated with the incidence of GDM.
- Factors such as prepregnancy and pregnancy exercise level, intake of fibre and salads in the daily diet were found to have negative association with GDM.

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- In the second phase of the study all the respondents were followed until their delivery. During the follow up study it was observed that mean fasting and post

prandial blood sugar values increased as the gestational weeks increased. The mean fasting and post prandial blood sugar values of the cases at 28 to 32 weeks were 104.20±9.99 and 141.79±14.71 respectively. As the gestational age increased (37 to 41 weeks) there was an increase in the mean fasting (119±14.3) and post prandial blood sugar values (164±12.1) of the cases.

- Majority of the respondents both the cases (86.7%) and control (91.9%) had normal blood pressure. Prehypertensive stage and stage 1 hypertension was observed among 8.6 per cent and 4 per cent of the GDM respondents compared to the nonGDM respondents (5.2% and 2.9%) respectively.
- Gestational weight gain above the normal was more observed in the overweight/obese GDM respondents (37.5%) than the nonGDM respondents (10.9%).
- Majority of the subjects (63.51%) followed modified meal plan and insulin intake for tight glycemic control and 32.9 per cent of the subjects could manage diabetes with meal management alone. Drugs to control blood sugar were the option for only 3 percent of the subjects.
- In the third phase of the study the pregnancy outcome of the respondents was assessed.
- Normal delivery was seen in majority of the respondents (91.04 %).The incidence of caesarean delivery among the total subjects was 8.95 per cent. The rate of

caesarean delivery was more in GDM group (12.1 %) when compared to nonGDM group (5.78%).

- Hypertensive disorders (8.5%), polyhydraminos (4.62%) and Urinary Tract Infections (8.09%) were the maternal complications observed among the respondents. Polyhydraminos was seen in 6.93 per cent of the cases and in 2.31 per cent of the controls. Urinary tract infection was also seen in higher number among the cases (12.71%) than in the controls (3.46%).

- Regarding the term of the neonates 96.6 percent were full term neonates. Preterm neonates were seen in 5.02 per cent of the GDM respondents compared to the nonGDM respondents (1.7%).Chisquare analysis also showed a positive association ($P<0.05$) between premature birth and GDM
- Large baby or macrosomia a consequence of GDM was observed in 11.7 per cent of the neonates of the GDM mothers against 3.96 per cent in nonGDM group. Mean APGAR score followed an equal trend among the cases (8.24) and controls (8.3).
- Neonatal complications such as macrosomia (11.7%), respiratory distress (10.05%) hypoglycemia (9.4%) and hypocalcemia were seen in higher percentages among the neonates of GDM mothers than in the nonGDM mothers.

- The percentage of the respondents who required NICU admission were more (16.2%) in the GDM group than in the nonGDM group (7.2%).The requirement of phototherapy was also observed more among the GDM (15.08%) than the nonGDM (6.14%).

CONCLUSION

GDM a common pregnancy complication continues to be a clinical problem of interest. Due to the transgenerational impact, GDM has become an important public health issue. It predisposes significant short-term and long-term adverse health outcomes for both mother and offspring. This envisages the need to identify the risk factors, particularly modifiable factors for GDM and to adopt appropriate management strategies to promote the well being of mother and child. Factors that significantly influenced GDM identified in the present study, were age, education, prepregnancy BMI,rate of weight gain in the initial trimesters, family health history, cyclic pattern of mensturation, menstrual problems, previous history of abortions,macrosomia,infertility problems,infertility treatment ,pregnancy specified stress level, prepregnancy exercise pattern, and dietary factors. During the gestational follow up it was obvious that glycemic levels were hard to manage with the increase in gestational age. Diet therapy combined with insulin was the most opted treatment modality. Total weight gained in the gestation period was more among GDM subjects. Prehypertensive stage and stage 1 hypertension was observed in higher percentages among GDM respondents. Perinatal complications such as caesarean delivery, polyhydraminos and UTI were seen more in the GDM mothers. Macrosomia, neonatal jaundice, respiratory distress, hypocalcemia, hypoglycemia, and NICU

admission was more in the neonates of GDM mothers. The present study thus pointed out:

The importance of early detection and appropriate intervention for the management of GDM to ensure favourable pregnancy outcome.

The need to educate the prospective mothers on the adverse health consequences of GDM and to adopt suitable measures to control the risk factors contributing to GDM.