Factors related to HbA1c in the first trimester of pregnancy

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ABSTRACT

The prevalence of gestational diabetes mellitus (GDM) in the world is 16.2% of live births associated with hyperglycemia in pregnancy, and 7.4% are caused by type 1 or 2 diabetes which is detected for the first-time during pregnancy. The prevalence of GDM in Indonesia reaches 3.6% and the highest rate is found in the Special Province of Yogyakarta (2.6%). One of the risk factors for GDM is excess nutrition which is influenced by daily intake. This study aims to determine the relationship between nutritional intake and body mass index (BMI) with HbA1c levels in first-trimester pregnant women. This study used a cross-sectional design. A simple random sampling with inclusion and exclusion criteria was employed, involving 47 pregnant women as subjects. Nutritional intake was measured with the semi-quantitative food frequency questionnaire (SQ-FFQ). The nutritional status of pregnant women is measured by BMI. HbA1c was measured by the turbidimetric inhibition immunoassay (TINIA) method. Analysis of research data using the Pearson product-moment correlation test and rank Spearman. The results of this study stated that there was a relationship between nutritional intake and BMI with HbA1c levels. Diagnosis of GDM and appropriate intervention can reduce the risk of complications of diabetes mellitus (DM).

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1. INTRODUCTION

Diabetes mellitus (DM) is a metabolic disorder, caused by disturbances in insulin secretion and insulin action. Gestational diabetes mellitus (GDM) is a disorder of glucose tolerance detected during pregnancy [1]. Diabetes can impact an individual's well-being and life in the long term [2]. The prevalence of mothers with GDM has increased over the last 20 years. There are 16.2% (21.3 million) live births associated with hyperglycemia in pregnancy, 86.4% are caused by GDM, 6.2% are caused by type 1 diabetes or type 2 diabetes that existed before, and 7.4% due to type 1 diabetes and type 2 diabetes that was first detected during pregnancy [3].

GDM can cause complications for both the mother and the fetus. New evidence suggests that the effects of GDM can be detrimental to both mother and fetus in the long term. For mothers, GDM can cause cardiovascular complications, chronic kidney disease, cancer, eclampsia, cesarean section, type 2 diabetes or recurrent GDM. Infants born to GDM mothers are at high risk of developing macrosomia, birth trauma, hypoglycemia, hypocalcemia, hyperbilirubinemia, respiratory distress syndrome, polycythemia, obesity and type 2 DM, increased blood pressure, cardiovascular disorders, and impaired neurocognitive development [4], [5].

The diagnosis of GDM is carried out by assessing the glycemic status of pregnant women. The glycemic status of pregnant women can be measured by assessing fasting blood sugar levels, assessing HbA1c levels, and assessing 2-hour plasma glucose. The HbA1c level represents the average blood glucose level over the past 2 to 3 months [6].

Risk factors for GDM include body mass index (BMI) >23kg/m2, spacing gap between pregnancies <2 years, family history of diabetes, advance maternal age and a history of GDM or birth to a large baby. The results of the analysis of various observational studies state that BMI is one of the risk factors that can affect GDM [7], [8]. This study aims to determine the relationship between nutritional intake and BMI with HbA1c levels in the first trimester of pregnant women.

2. RESEARCH METHOD

2.1. Scientific and ethical considerations

The research protocols and procedures were reviewed and approved by the Health Research Ethics Commission, Faculty of Medicine, Public Health and Nursing, Gadjah Mada University, Yogyakarta, Indonesia Number KE/FK/0987/EC/2022, 27 July 2022. There was a consent form at the beginning of the survey. Informed consent was approved and obtained by each research subject.

2.2. Study design and research subjects

The research design was a cross-sectional study. This research was the first part of an intervention study entitled "The effect of morning walks and vitamin D supplementation on serum 25(OH)D and HbA1c levels in the first trimester of pregnant women". The sampling technique used simple random sampling. Subjects were taken from Community Health Centers in Sleman Regency, Yogyakarta, Indonesia, which included Turi Health Center, Sleman Health Center, Pakem Health Center, Cangkringan Health Center, and Ngaglik 2 Health Center. Populations were 106 pregnant woment and the subjects of the study were 47 first-trimester pregnant women based on the inclusion and exclusion criteria. The estimated sample size was calculated using the independent sample size formula [9], [10]. The inclusion criteria were first-trimester pregnant women, parity less than 3, mothers with single pregnancies, and willing to become research subjects by signing informed consent. Subjects were excluded based on exclusion criteria, mothers with cardiovascular disease, polycystic ovarium syndrome, received insulin therapy, and had DM before.

The independent variable was nutritional intake involved the energy which was categorized into inadequate (<2,430 kkal), and adequate (≥2,430 kkal), protein with inadequate (<61 g), and adequate (≥61 g), fat with inadequate (<67.3 g), and adequate (≥67.3 g), monounsaturated fatty acid (MUFA) with inadequate (<14 g), and adequate (≥14 g), polyunsaturated fatty acid (PUFA) with inadequate (<1.4 g), and adequate (≥1.4 g), saturated fatty acid (SFA) with inadequate (<13 g), and adequate (≥13 g), fiber with inadequate (<35 g), and adequate (≥35 g), carbohydrate with inadequate (<385 g), and adequate (≥385 g), poysaccharide with inadequate (<193 g), and adequate (≥193 g), dissacharide with inadequate (<43 g), and adequate (≥43 g), monosacharide with inadequate (<42 g), and adequate (≥42 g), zinc with inadequate (<10 mg), and adequate (≥10 mg), calcium with inadequate (<1,200 mg), and adequate (≥1,200 mg), vitamin D with inadequate (<600 IU), and adequate (≥600 IU), and iron with inadequate (<18 mg), and adequate category (≥18 mg). The last independent variable was BMI which was categorized into less (<18.5 kg/m^2), normal (18.5-24.9 kg/m^2), overweight (25-25.9 kg/m^2), and obese (>25.9 kg/m^2). While the dependent variable was HbA1c levels in first-trimester of pregnant women with normal category (<5.7%) and diabetes (≥5.7%).

2.3. Data collection

Data collection was carried out from 26 February to 30 July 2022 by inviting subjects to the Public Health Center according to the work area. For subjects who were not present when invited, the enumerator came to each subject's home for data collection. BMI was measured by weighing using a foot scale with an accuracy of 0.1 kg and measuring height using a microtoise with an accuracy of 0.1 cm. Nutritional intake was measured with the semi-quantitative food frequency questionnaire (SQ-FFQ). Blood samples for checking HbA1c levels were taken from the cubital vein as much as 3 cc. Blood sampling was carried out by competent, trained, and skilled analysts under the supervision of a doctor in the Public Health Center. HbA1c examination was carried out at the Laboratory of Academic Hospital, Gadjah Mada University, Yogyakarta, Indonesia using the turbidimetric inhibition immunoassay (TINIA) method with the tina-quant HbA1c gene 3 reagents. Nutritional intake was entered using NutriSurvey software and the Indonesian food composition table (TKPI). Data collection was carried out by skilled and trained enumerators who were recruited from the Department of Midwifery and the Department of Nutrition, Health Polytechnic, Ministry of Health, Yogyakarta.

2.4. Statistic analysis

The normality test of food intake with HbA1c and BMI used the Kolmogorov-Smirnov test. The results found that most of the data were normally distributed and some data were not normally distributed. The relationship of nutrient intake in the form of energy, protein, fat, PUFA, SFA, carbohydrates, calcium, vitamin D, and iron with HbA1c levels was analyzed using the Pearson product moment test. While the relationship of nutrient intake in the form of MUFA, fiber, polysaccharide, disaccharides, monosaccharides and zinc with HbA1c levels was analyzed using the Spearman Rank test. The relationship is considered statistically significant if p<0.05.

3. RESULTS AND DISCUSSION

This research was conducted from February to July 2022. The research subjects were the first-trimester pregnant women who live in the working area of the Public Health Centers in Sleman Regency, Yogyakarta, namely the Turi Health Center, Sleman Health Center, Pakem Health Center, Cangkringan Health Center, and Ngaglik 2 Health Center with a total of 47 research subjects. The following are the characteristics of the research subjects.

Based on Table 1, it can be seen that the average BMI of pregnant women was 23.215 kg/m2 with a standard deviation of 5.096. The average HbA1c level was 5.009% with a standard deviation of 0.4947. In addition, the mean or average food intake consumed by pregnant women in the first trimester can also be known. In this study, most pregnant women were still not sufficient to meet their daily food intake when compared to the average food intake following Minister of Health Regulation Number 28 of 2019.

Table 1. Characteristics of research subjects (n=47)

Characteristics	Mean±SD	Median (min-max)
BMI (kg/m2)	23.215±5.096	21.7 (14.1-33.3)
HbA1c (%)	5.009±0.4947	4.9 (4.2-6.6)
Energy (kcal)	2,200±637	2,080.3 (528.9-3521.2)
Proteins (g)	61±21	59.3 (29.2-150.3)
Fat (g)	64±23	63.2 (2.4-126.5)
MUFA (g)	19±9	18.6 (3.4-64.6)
PUFA (g)	24±9	25.6 (0.8-55.4)
SFA(g)	21±8	19.2 (0.7-45.6)
Fiber (g)	27±12	25.3 (5.8-67.9)
Carbohydrates (g)	297±100	287.1 (105.3-575.8)
Polysaccharides	193±88	167.8 (92.7-510.7)
Dissacharides	43±24	35.6 (1.3-124.5)
Monosaccharides	42±27	36.5 (1.3-176.5)
Zinc (mg)	3±2	3.3 (0.2-12.8)
Calcium (mg)	1,804±729	1,872.5 (310.7-4156.9)
Vitamin D (IU)	401±166	380.9 (112.4-876.6)
Iron (mg)	21±5	20.4 (5.3-38.7)

In Table 2 it can be seen that most pregnant women have normal HbA1c levels. Most of the mothers aged 23-35 years (88.6%), with a gestational age of 9-12 weeks (89.9%), have one child (88.9%), have secondary/high school education (86.2%), and work as housewives (93.3%). Based on the results of the BMI characteristics, it was known that the majority of mothers with 52.3% have a normal BMI, 38.9% of 9-12 weeks of gestation, 60% of first pregnancies, 51.7% of secondary/high school education, and work as housewives as much as 56.7%.

Based on Table 2 it can also be seen that most mothers have normal HbA1c levels and BMI, but have not fulfilled the recommended adequate nutritional intake. Most mothers were still inadequate in consuming energy, protein, fat, fiber, carbohydrates, zinc, calcium, vitamin D and iron. The average pregnant woman still does not meet the recommended dietary allowances (RDA) standards. The nutritional adequacy rate is a value that indicates the average need for certain nutrients and must be fulfilled every day according to certain characteristics. However, the consumption of MUFA, PUFA, and SFA in the majority of mothers with normal HbA1c levels and mothers with normal BMI have met the recommended adequate nutritional intake or are already adequate.

In this study, it was found that the MUFA intake of most respondents was adequate, namely an average of 19 grams. According to Minister of Health regulation number 28 of 2019, the average need for MUFA intake in women aged 19-29 years is 12 grams per day, then added to the need during pregnancy in the first trimester of 2 grams so that the total recommended MUFA intake per day is 14 grams. The national health and nutrition examination survey (NHANES) study stated that high concentrations of SFA and MUFA can increase HbA1c levels [11]. Other research stated that someone with metabolically unhealthy obese (MUO) has higher levels of MUFA [12].

Table 2. Sociodemographic characteristics of pregnant women with HbA1c (n=47)

Variable	HbA1c		BMI			
	Normal	Diabetes	Underweight	Healthy weight	Overweight	Obesity
Age						
23-35 years	39 (88.6)	5 (11.4)	7 (15.9)	23 (52.3)	2 (4.5)	12 (27.4)
>35 years	3 (100)	0 (0)	1 (33.3)	0 (0)	1 (33.3)	1 (33.3)
Gestational age						
6-8 week	10 (90.9)	1 (9.1)	0 (0)	9 (81.9)	0 (0)	2 (18.2)
9-12week	32 (89.9)	4 (11.1)	8 (22.2)	14 (38.9)	3 (8.3)	11 (30.6)
Parity						
0	18 (90)	2 (10)	4 (20)	12 (60)	1 (5)	3 (15)
1	24 (88.9)	3 (11.1)	4 (14.8)	11 (40.7)	2 (7.4)	10 (37.0)
Education						
Low (primary education and junior high school/lower secondary education)	3 (100)	0 (0)	0 (0)	1 (33.3)	0 (0)	2 (66.7)
Medium (senior high school/upper secondary education)	25 (86.2)	4 (13.8)	5 (17.2)	15 (51.7)	1 (3.4)	8 (27.6)
High (bachelor's degree, master's degree)	14 (93.3)	1 (6.7)	3 (20.0)	7 (46.7)	2 (13.3)	3 (20.0)
Occupation						
Housewife	28 (93.3)	2 (6.7)	3 (10)	17 (56.7)	2 (6.7)	8 (26.7)
Employee	9 (75.0)	3 (25.0)	4 (33.3)	3 (25.0)	1 (8.3)	4 (33.3)
Self-employed	5 (100)	0 (0)	1 (20.0)	3 (60.0)	0 (0)	1 (20.0)
Energy						
Inadequate	28 (90.3)	3 (9.7)	7 (22.6)	14 (45.2)	2 (6.5)	8 (25.8)
Adequate	14 (87.5)	2 (12.5)	1 (6.3)	9 (56.3)	1 (6.3)	5 (31.3)
Proteins						
Inadequate	24 (88.9)	3 (11.1)	6 (22.2)	13 (48.1)	1 (3.7)	7 (25.9)
Adequate	18 (90.0)	2 (10.0)	2 (10.0)	10 (50.0)	2 (10.0)	6 (30.0)
Fat						
Inadequate	26 (86.7)	4 (13.3)	6 (20.0)	15 (50.0)	2 (6.7)	7 (23.3)
Adequate	16 (94.1)	1 (5.9)	2 (11.8)	8 (47.1)	1 (5.9)	6 (35.3)
MUFA						
Inadequate	7 (87.5)	1 (12.5)	0 (0)	40 (50)	1 (12.5)	3 (37.5)
Adequate	35 (89.7)	4 (4.1)	8 (20.0)	19 (48.7)	2 (5.1)	10 (25.6)
PUFA						
Inadequate	1 (100)	0 (0)	0 (0)	1 (100)	0 (0)	0 (0)
Adequate	41 (89.1)	5 (4.9)	8 (17.4)	22 (47.8)	3 (6.5)	13 (28.5)
SFA						
Inadequate	7 (100)	0 (0)	0 (0)	6 (85,7)	0 (0)	1 (14.3)
Adequate	35 (87.5)	5 (12.5)	8 (20.0)	17 (42.5)	3 (7.5)	12 (30.0)
Fiber						
Inadequate	37 (90.2)	4 (9.8)	8 (19.5)	18 (43.9)	3 (7.3)	12 (29.3)
Adequate	5 (83.3)	1 (16.7)	0 (0)	5 (83.3)	0 (0)	1 (16.7)
Carbohydrate						
Inadequate	33 (89.2)	4 (10.8)	7 (18.9)	18 (48.6)	3 (8.1)	9 (24.3)
Adequate	9 (90.0)	1 (10.0)	1 (10.0)	5 (50.0)	0 (0)	4 (40.0)
Zinc						
Inadequate	40 (88.9)	5 (11.1)	8 (17.8)	21 (46.7)	3 (6.7)	13 (28.9)
Adequate	2 (100)	0 (0)	0 (0)	2 (100)	0 (0)	0 (0)
Calcium						
Inadequate	23 (92.0)	2 (8.0)	4 (16.0)	12 (48.0)	2 (8.0)	7 (28.0)
Adequate	19 (86.4)	3 (13.6)	4 (18.2)	11 (50.0)	1 (4.5)	6 (27.3)
Vitamin D						
Inadequate	38 (90.5)	4 (9.5)	8 (19.0)	20 (47.3)	3 (7.1)	11 (26.2)
Adequate	4 (80.0)	1 (20.0)	0 (0)	3 (60)	0 (0)	2 (40.0)
Iron						
Inadequate	16 (94.1)	1 (5.9)	5 (29.4)	6 (35.3)	2 (11.8)	4 (23.5)
Adequate	26 (86.7)	4 (13.3)	3 (10.0)	17 (56.7)	1 (3.3)	9 (30.0)

The normality test for BMI data and HbA1c levels used the Kolmogorov-Smirnov test and obtained a normal distribution of data. Therefore, the relationship test in this study used the Pearson test. The results of the Pearson test presented in Table 3.

Table 3. Correlation of nutritional intake with HbA1c (n=47)

Category	HbA1c	
	r	p
Energy	0.001	0.993[1]
Proteins	-0.107	0.476[1]
Fat	0.108	0.470[1]
PUFA	0.028	0.853[1]
MUFA	-0.296	0.043[2]
SFA	0.161	0.281[1]
Fiber	0.056	0.709[2]
Carbohydrate	-0.009	0.950[1]
Polysaccharides	0.116	0.438[2]
Disaccharides	-0.021	0.891[2]
Monosaccharides	0.016	0.917[2]
Zinc	-0.293	0.046[2]
Calcium	0.131	0.382[1]
Vitamin D	-0.027	0.859[1]
Iron	0.055	0.713[1]
BMI	0.583	0.000[1]

[1]pearsons tes, t[2]spearman rank test

Table 3 showed that there was a significant relationship between the BMI of pregnant women and HbA1c levels, with a p-value of 0.000. Table 3 stated that MUFA (p=0.043) and Zinc (p=0.046) were related to HbA1c levels. MUFA and Zinc were negatively correlated. This showed that the greater the MUFA and Zinc values, the lower the HbA1c levels. There were variables that still have a significant value of less than 0.05 so it can be continued with multiple linear regression analysis.

The food consumed by pregnant women can be a risk factor for GDM. The results of previous studies showed that there was a relationship between the intake of MUFA and Zinc with the risk of GDM. MUFA is a monounsaturated fatty acid and is very good for consumption. MUFA can lower cholesterol in the blood, and it can reduce the risk of coronary heart disease and blood vessel blockage. A review conducted by Imamura stated that the consumption of MUFA can lower HbA1c levels compared to the consumption of carbohydrates, but does not affect fasting glucose. Red meat, nuts, milk, and vegetable oils are several types of food sources of MUFA [13]. Research conducted in Tangail, Bangladesh stated that there was a significant relationship between carbohydrate intake and changes in HbA1c levels in respondents who went on a diet (p<0.001), but found no relationship in respondents who received the other three treatments. Research conducted by Faridul states that low carbohydrate intake in diabetic patients causes high HbA1c levels [14]. According to Yamakawa *et al*. [15] HbA1c levels can increase significantly if there is an increase in carbohydrate intake from 45% to 60%.

Zinc is a micronutrient that plays an important role in body health. Various processes in the body require zinc, such as protein and deoxyribo nucleic acid (DNA) synthesis, wound healing, and immune function. Zinc is found in many plant and animal foods. Zinc deficiency can cause various disorders throughout the body, such as immune disorders, and growth failure. In addition, the risk of developing diabetes may increase due to zinc deficiency [16]. The study conducted by Tamura [17] stated that zinc supplementation can reduce plasma triglyceride levels, total cholesterol, fasting glucose, and HbA1c levels in patients with metabolic disorders including DM.

The recommended zinc intake for women aged 19-29 years is 8 grams and an additional 2 grams for pregnant women in the first trimester so the total intake of zinc that pregnant women must consume every day is 10 grams. This is still very less when compared to the average intake of zinc consumed by mothers as much as 3 grams. Zinc deficiency is a risk factor that causes diabetes and obesity. Research by Bandeira *et al*. [18] study stated that the percentage of glycated hemoglobin was found to be higher in individuals with low concentrations of zinc in plasma and erythrocytes. A meta-analysis conducted by Wang *et al*. [19] stated that zinc supplementation can help to prevent diabetes.

The results of a review conducted by Li *et al*. [20] stated that vitamin and mineral supplementation such as magnesium, zinc, selenium, and calcium, as well as vitamins D and E, can improve glycemic control and oxidative stress in GDM by reducing serum fasting plasma glucose (FPG), insulin, homeostasis models of assessment-insulin resistance (HOMA-IR), HOMA for β cell function (HOMA-B), high-sensitivity C-reactive protein (hs-CRP) and malondialdehyde (MDA) levels, and increasing total levels antioxidant capacity (TAC). Vitamin and mineral supplementation, including vitamin D, calcium plus vitamin D, zinc, and magnesium, can reduce oxidative stress status in GDM patients by increasing TAC levels and reducing MDA levels [20]. The results of this study stated that calcium was not related to HbA1c levels (p=0.382). This was contrary to the results of previous studies that there was a link between GDM and disturbances of calcium homeostasis and decreased oxidative phosphorylation of skeletal muscle. The increased risk of GDM can occur due to inadequate nutritional status and increased calcium requirements during pregnancy [21].

A deficiency of vitamin D in diabetics can lead to uncontrolled diabetes. Vitamin D supplementation in diabetics can help to increase glycemic levels. Research by Khan *et al*. [22] stated that vitamin D supplementation can improve the glycemic status of type 2 DM patients, as evidenced by a decrease in HbA1c levels. Research conducted by Mehta *et al*. [23] stated that supplementing vitamin D with calcium can significantly reduce HbA1c levels in type 2 DM patients.

Research conducted on pregnant women in India stated that giving vitamin D 1,000 IU and calcium supplementation 1,000 mg can play a positive role in glucose and fat metabolism, as well as oxidative stress in GDM [24]. Research conducted in Brazil stated that calcium intake has a significant relationship with HbA1c levels ($p<0.001$) [25]. Calcium plus vitamin D supplementation in women with GDM have a beneficial effect on the metabolic profile. Consumption of rich vitamins in nutrients such as vitamin A, carotene, vitamin B6, vitamin C, fiber, folic acid, potassium, and calcium is associated with a reduced risk of GDM [26]. One prospective cohort study stated that high pre-pregnancy calcium intake and intake of low-fat and high-calcium dairy products were associated with a lower risk of GDM [27].

Research conducted in Japan showed that HbA1c levels in pregnant women were mostly affected by iron deficiency compared to non-pregnant women. Some literature stated that high HbA1c levels are found in pathological conditions such as iron deficiency anemia (IDA) [28]. IDA is associated with low consumption of animal food containing iron [29]. Another study by Bhadarge *et al*. [30] suggested that IDA was associated with higher HbA1c levels.

Research by Zhou *et al*. [31] stated that the intake of high-protein and low-carbohydrate foods consumed by pregnant women is associated with GDM. Research conducted in Singapore on Asian women stated that high consumption of vegetable and animal protein is associated with a high risk of GDM [32]. In this study there was no relationship between protein and HbA1c levels. The results of this study may differ from previous studies due to differences in the number of research samples and the characteristics of the samples. The results of Faridul Islam's research also stated that there was no relationship between protein and HbA1c in respondents ($p=0.852$) [14].

For diabetics, fiber intake is very important because it can increase the thickness of food and delay the absorption of sugar into the bloodstream. Therefore, the consumption of fiber is effective for controlling blood sugar. Research conducted in Vietnam stated that increasing fiber intake by 2 grams per day for three months can reduce HbA1c levels in type 2 DM patients [33]. Another study conducted by Nguyen *et al.* [34] found that increasing fiber intake by 6 grams for 2 weeks can reduce fasting blood glucose in DM patients.

Table 4 showed that in the multiple linear regression with model 1 it was found that the BMI variable was significantly related to HbA1c levels ($p=0.000$). The results of this study indicate that there was a relationship between the BMI of pregnant women and HbA1c levels. The results of this study are in line with previous studies which stated that BMI before pregnancy was a risk factor for GDM with complications of preeclampsia, premature labor, gestational hypertension, and macrosomia. Research conducted in China showed similar results where overweight and obese before pregnancy and BMI increases starting from conception until 15-20 weeks of gestation increases the risk of GDM [35].

Table 4. Multiple linear regression analysis of nutritional intake with HbA1c (n=47)

Variable	Model 1			
	B	SE	t	p*
MUFA	-0.010	0.007	-1.523	0.164
Zinc	-0.012	0.027	-0.443	0.672
BMI	0.055	0.013	4.195	0.000

Being overweight, obesity and severe obesity can cause various complications. Babies of overweight, obese, and severely obese mothers are at risk of experiencing fetal malformations, stillbirth, increased risk of perinatal death, low appearance, pulse, grimace, activity, respiration (APGAR) scores in the first 5 minutes, and experiencing Erb's palsy. Pregnant women with a large BMI group (BMI 25-29.9 kg/m2) often do not receive special antenatal care [36]. Research conducted at Taiwan University Hospital stated that obese pregnant women have higher HbA1c levels than pregnant women with normal weight. Overweight or obesity is related to metabolic risk factors in early pregnancy and mothers can be more at risk for experiencing GDM [37]. Previous studies by Sun *et al.* [38] in Korea found that HbA1c levels ≥6.5% could detect DM in children and adolescents who were obese, this was in line with American Diabetes Association/World Health Organization (ADA/WHO) statements in establishing the diagnostic criteria for DM.

Pregnant women have an eating pattern that is not much different from other individuals in general. Pregnant women must continue to meet nutritional needs for the growth and development of the fetus. Apart from being necessary for the growth and development of the fetus, nutritional needs are also needed to ensure well-being during pregnancy. Pregnancy accompanied by hyperglycemia disorders must ensure adequate glycemic targets because it is the basis for managing GDM [39].

GDM has become a tremendous health and economic burden. Diagnosis of GDM and appropriate intervention in pregnant women can reduce the risk of complications due to DM. A study in Sweden stated that the prevalence of GDM in that country was low due to strict diagnostic criteria screening policies and low history of type 2 DM. An extensive GDM screening program and a strict GDM treatment system can reduce the risk of neonatal death and complications in the mother [36].

4. CONCLUSION

This study states that there was a relationship between nutritional intake and BMI with HbA1c levels. BMI was significantly related to HbA1c levels in the first trimester of pregnancy. Examining BMI for the first trimester and monitoring of nutritional intake during pregnancy is very necessary so that HbA1c levels are controlled. HbA1C levels have to be controlled to reduce the risk of developing GDM in pregnant women. HbA1c levels examination at least once during pregnancy and routine administration of zinc and intake of food containing MUFA are needed for screening and prevention of GDM in pregnant women. Routine administration of Zinc at the Primary Health Care during pregnancy is good for health.

The limitation of the study was the small sample because this study is a preliminary study of an intervention research. The intervention study entitled "The effect of morning walks and vitamin D supplementation on serum 25(OH)D and HbA1c levels in the first trimester of pregnant women". Further research is needed as a form of preventing complications due to GDM. Intervention before and during pregnancy is needed to reduce maternal and neonatal complications in overweight and obese women.

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REFERENCES

[1] E. U. Alejandro *et al.*, "Gestational diabetes mellitus: A harbinger of the vicious cycle of diabetes," *International Journal of Molecular Sciences*, vol. 21, no. 14, pp. 1–21, 2020, doi: 10.3390/ijms21145003.

[2] P. Saeedi *et al.*, "Global and regional diabetes prevalence estimates for 2019 and projections for 2030 and 2045: Results from the International Diabetes Federation Diabetes Atlas, 9th edition," *Diabetes Research and Clinical Practice*, vol. 157, p. 107843, 2019, doi: 10.1016/j.diabres.2019.107843.

[3] C. Pheiffer, S. Dias, and S. Adam, "Intimate partner violence: a risk factor for gestational diabetes," *International Journal of Environmental Research and Public Health*, vol. 17, no. 21, pp. 1–17, 2020, doi: 10.3390/ijerph17217843.

[4] J. K. M. Sundholm, L. Litwin, K. Rönö, S. B. Koivusalo, J. G. Eriksson, and T. Sarkola, "Maternal obesity and gestational diabetes: Impact on arterial wall layer thickness and stiffness in early childhood - RADIEL study six-year follow-up," *Atherosclerosis*, vol. 284, no. December 2018, pp. 237–244, 2019, doi: 10.1016/j.atherosclerosis.2019.01.037.

[5] J. Huet, G. Beucher, A. Rod, R. Morello, and M. Dreyfus, "Joint impact of gestational diabetes and obesity on perinatal outcomes," *Journal of Gynecology Obstetrics and Human Reproduction*, vol. 47, no. 9, pp. 469–476, 2018, doi: 10.1016/j.jogoh.2018.08.003.

[6] K. Wu *et al.*, "The utility of HbA1c combined with haematocrit for early screening of gestational diabetes mellitus," *Diabetology and Metabolic Syndrome*, vol. 10, no. 1, pp. 4–10, 2018, doi: 10.1186/s13098-018-0314-9.

[7] K. Giannakou *et al.*, "Risk factors for gestational diabetes: An umbrella review of meta-analyses of observational studies," *PLoS ONE*, vol. 14, no. 4, pp. 1–19, 2019, doi: 10.1371/journal.pone.0215372.

[8] B. Unnikrishnan *et al.*, "Risk factors of gestational diabetes mellitus: a hospital-based pairmatched case-control study in coastal South India," *South African Journal of Obstetrics and Gynaecology*, vol. 26, no. 1, pp. 13–17, 2020, doi: 10.7196/SAJOG.2020.v26i1.1518.

[9] N. E. Furlong, E. A. Lovelace, and K. L. Lovelace, *Research methods and statistics an integrated approach*. Santa Barbara: Harcourt College Publisher, 2000.

[10] S. Lemeshow, D. W. Hosmer, J. Klar, and S. K. Lwanga, *Adequacy of sample size in health studies*. Chichester: John Wiley & Sons Ltd., 1990. doi: 10.2307/2532527.

[11] E. A. Yu, P. J. Hu, and S. Mehta, "Plasma fatty acids in de novo lipogenesis pathway are associated with diabetogenic indicators among adults : NHANES 2003 – 2004," *The American Journal of Nutrition*, vol. 108, no. 3, pp. 622–632, 2018, doi: 10.1093/ajcn/nqy165.

[12] V. H. Telle-hansen, J. J. Christensen, G. A. Formo, K. B. Holven, and S. M. Ulven, "A comprehensive metabolic profiling of the metabolically healthy obesity phenotype," *Lipids Health Dis*, pp. 1–12, 2020, doi: 10.1186/s12944-020-01273-z.

[13] F. Imamura *et al.*, "Effects of saturated fat, polyunsaturated fat, monounsaturated fat, and carbohydrate on glucose-insulin homeostasis: A systematic review and meta-analysis of randomised controlled feeding trials," *PLoS Medicine*, vol. 13, no. 7, pp. 1–18, 2016, doi: 10.1371/journal.pmed.1002087.

[14] M. F. Islam, K. M. M. R. Linkon, M. Shyfullah, M. Hassan, M. E. S. Aoual, and M. J. Alam, "Association of dietary patterns with glycated hemoglobin (HbA1c) among type 2 diabetes patients: A cross-sectional Study," *Current Nutrition & Food Science*, vol. 17, no. 7, pp. 716–726, 2021, doi: 10.2174/1573401317666210222101504.

[15] T. Yamakawa *et al.*, "Dietary survey in Japanese patients with type 2 diabetes and the influence of dietary carbohydrate on glycated hemoglobin: The Sleep and Food Registry in Kanagawa study," *Journal of Diabetes Investigation*, vol. 10, no. 2, pp. 309–317, 2019, doi: 10.1111/jdi.12903.

[16] A. Fukunaka and Y. Fujitani, "Role of zinc homeostasis in the pathogenesis of diabetes and obesity," *International Journal of Molecular Sciences*, vol. 19, no. 2, 2018, doi: 10.3390/ijms19020476.

[17] Y. Tamura, "The role of zinc homeostasis in the prevention of diabetes mellitus and cardiovascular diseases," *Journal of Atherosclerosis and Thrombosis*, vol. 28, no. 11, pp. 1109–1122, 2021, doi: 10.5551/JAT.RV17057.

[18] V. da S. Bandeira *et al.*, "Association of reduced zinc status with poor glycemic control in individuals with type 2 diabetes mellitus," *Journal of Trace Elements in Medicine and Biology*, vol. 44, pp. 132–136, Dec. 2017, doi: 10.1016/j.jtemb.2017.07.004.

[19] X. Wang *et al.*, "Zinc supplementation improves glycemic control for diabetes prevention and management : a systematic review and meta-analysis of randomized controlled trials," pp. 76–90, 2019.

[20] D. Li, Z. Cai, Z. Pan, Y. Yang, and J. Zhang, "The effects of vitamin and mineral supplementation on women with gestational diabetes mellitus," *BMC Endocrine Disorders*, vol. 21, no. 1, pp. 1–15, 2021, doi: 10.1186/s12902-021-00712-x.

[21] K. Safary, H. M. Ahmed, and L. Moghaddam-Banaem, "Maternal calcium status in first half of pregnancy and gestational diabetes mellitus," *International journal of women's health and wellnes*, vol. 2, no. 1, pp. 1–5, 2016, doi: 10.23937/2474-1353/1510012.

[22] D. M. Khan, A. Jamil, F. A. Randhawa, N. F. Butt, and U. Malik, "Efficacy of oral vitamin D on glycated haemoglobin (HbA1c) in type 2 diabetics having vitamin D deficiency — a randomized controlled trial," *Journal of the Pakistan Medical Association*, vol. 68, no. 5, pp. 694–697, 2018.

[23] S. Mehta, P. Nain, B. K. Agrawal, and R. P. Singh, "Vitamin D with calcium supplementation managing glycemic control with HbA1c and improve quality of life in patients with diabetes," *Turkish Journal of Pharmaceutical Sciences*, vol. 19, no. 2, pp. 161–167, 2022, doi: 10.4274/tjps.galenos.2021.62357.

[24] P. Gunasegaran, S. Tahmina, M. Daniel, and S. K. Nanda, "Role of vitamin D-calcium supplementation on metabolic profile and oxidative stress in gestational diabetes mellitus: A randomized controlled trial," *Journal of Obstetrics and Gynaecology Research*, vol. 47, no. 3, pp. 1016–1022, 2021, doi: 10.1111/jog.14629.

[25] P. N. Brandão-Lima *et al.*, "Intakes of Zinc, Potassium, Calcium, and Magnesium of individuals with type 2 diabetes mellitus and the relationship with glycemic control," *Nutrients*, vol. 10, no. 12, pp. 1–12, 2018, doi: 10.3390/nu10121948.

[26] Q. Chen *et al.*, "A vitamin pattern diet is associated with decreased risk of gestational diabetes mellitus in Chinese women: Results from a case control study in Taiyuan, China," *Journal of Diabetes Research*, vol. 2019, 2019, doi: 10.1155/2019/5232308.

[27] C. Osorio-Yáñez, C. Qiu, B. Gelaye, D. A. Enquobahrie, and M. A. Williams, "Risk of gestational diabetes mellitus in relation to maternal dietary calcium intake," *Public Health Nutrition*, vol. 20, no. 6, pp. 1082–1089, 2017, doi: 10.1017/S1368980016002974.

[28] K. Hashimoto and M. Koga, "Influence of iron deficiency on HbA1c levels in pregnant women: Comparison with non-pregnant women," *Journal of Clinical Medicine*, vol. 7, no. 2, pp. 1–7, 2018, doi: 10.3390/jcm7020034.

[29] M. Z. Rahfiludin, S. P. Arso, T. Joko, A. F. Asna, R. Murwani, and L. Hidayanti, "Plant-based diet and iron deficiency anemia in Sundanese Adolescent Girls at Islamic Boarding Schools in Indonesia," *Journal of Nutrition and Metabolism*, vol. 2021, 2021, doi: 10.1155/2021/6469883.

[30] G. L. Bhadarge, P. Warjukar, P. Jain, P. Kute, and V. Shegaonkar, "Study of HbA1c in iron deficiency anaemia," *European Journal of Molecular and Clinical Medicine*, vol. 8, no. 1, pp. 314–319, 2021.

[31] X. Zhou *et al.*, "Maternal dietary pattern characterised by high protein and low carbohydrate intake in pregnancy is associated with a higher risk of gestational diabetes mellitus in Chinese women: A prospective cohort study," *British Journal of Nutrition*, vol. 120, no. 9, pp. 1045–1055, 2018, doi: 10.1017/S0007114518002453.

[32] W. W. Pang *et al.*, "Higher maternal dietary protein intake is associated with a higher risk of gestational diabetes mellitus in a multiethnic asian cohort," *Journal of Nutrition*, vol. 147, no. 4, pp. 653–660, 2017, doi: 10.3945/jn.116.243881.

[33] N. H. Giang *et al.*, "Fiber-focused nutrition counseling through nutrition software improved HbA1c of Vietnamese type 2 diabetes mellitus patients," *Asian Journal of Dietetics*, vol. 2, no. 2, pp. 65–70, 2020.

[34] L. T. Nguyen *et al.*, "Okara improved blood glucose level in vietnamese with type 2 diabetes mellitus," *Journal of Nutritional Science and Vitaminology*, vol. 65, no. 1, pp. 60–65, 2019, doi: 10.3177/jnsv.65.60.

[35] G. Li *et al.*, "Incidence and risk factors of gestational diabetes mellitus: A prospective cohort study in Qingdao, China," *Frontiers in Endocrinology*, vol. 11, no. September, pp. 1–9, 2020, doi: 10.3389/fendo.2020.00636.

[36] K. Hildén, U. Hanson, M. Persson, A. Magnuson, D. Simmons, and H. Fadl, "Gestational diabetes and adiposity are independent risk factors for perinatal outcomes: a population based cohort study in Sweden," *Diabetic Medicine*, vol. 36, no. 2, pp. 151–157, 2019, doi: 10.1111/dme.13843.

[37] I.-W. Yen *et al.*, "Overweight and obesity are associated with clustering of metabolic risk factors in early pregnancy and the risk of GDM," *PLOS ONE*, vol. 14, no. 12, pp. 1–9, Dec. 2019, doi: 10.1371/journal.pone.0225978.

[38] M. Sun, D. Sun, and D. Lee, "Comparison of HbA1c and OGTT for the diagnosis of type 2 diabetes in children at risk of diabetes," *Pediatrics and Neonatology*, vol. 60, no. 4, pp. 428–434, 2019, doi: 10.1016/j.pedneo.2018.11.002.

[39] J. Juan and H. Yang, "Prevalence, prevention, and lifestyle intervention of gestational diabetes mellitus in China," *International Journal of Environmental Research and Public Health*, vol. 17, no. 24, pp. 1–14, 2020, doi: 10.3390/ijerph17249517.

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