Available online: http://journal.ipb.ac.id/index.php/jgizipangan ***J. Gizi Pangan, August 2024, 19(Supp.2):288-297***
Accredited based on DGHE, Republic of Indonesia No. 79/E/KPT/2023
ISSN 1978-1059 EISSN 2407-0920

Sociodemographics and Dietary Intake Associations with Gestational Weight Gain Rates Among Gestational Diabetes Mellitus Mothers

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ABSTRACT

This study aims to assess the rates of Gestational Weight Gain (GWG) among pregnant mothers with and without Gestational Diabetes Mellitus (GDM) and to investigate the sociodemographic and dietary intake factors associated with the rates of GWG. This cross-sectional study involved 77 pregnant mothers visiting selected government clinics. Sociodemographics, medical records, and dietary intake were obtained through a self-administered questionnaire. The mean age of the participants was 30.48±5.0 years old with 48.1% (n=37) of them were GDM diagnosed. Moreover, 27 (73.0%) of GDM mothers experienced abnormal GWG. Their mean intakes were 1,481±389 kcal/day, macronutrients such as carbohydrate, protein, and fat were 199.9±59.3 g/day, 75.5±23.9 g/day, 44.1±15.3 g/day accordingly, fiber was 6.9±7.0 g/day and followed by micronutrients such as folate, calcium, iron, and zinc were 137.4±78.9 µg/day, 738.6±335.3 mg/day, 16.8±7.1 mg/day, and 6.0±2.6 mg/day respectively. This study reported no significant association between GDM status and GWG rates but there was a significant association between pre-pregnancy BMI and zinc intake with rates of GWG among pregnant mothers ($p<0.05$). In conclusion, the latest guidelines of GWG rates should include GDM status among pregnant mothers according to the specific pre-pregnancy Body Mass Index (BMI) to ensure, they can adhere to the new recommendations and lower the risk of pregnancy complications that may occur due to abnormal rates of GWG.

Keywords: gestational diabetes mellitus, gestational weight gain, pregnant women

INTRODUCTION

Pregnant mothers with Gestational Diabetes Mellitus (GDM) commonly gain excessive GWG. Sixty percent of pregnant women that were overweight and had GDM experienced excessive Gestational Weight Gain (GWG) and pre-pregnancy Body Mass Index (BMI), dietary intake pattern, and level of physical activity are correlated with GWG rates (Xie *et al.* 2020; Wu, *et al.* 2019). A study in Portugal also showed more than 50 % of obese GDM mothers gained gestational weight excessively (Ferreira *et al.* 2021).

GDM defined as the emergence of the glucose-intolerant occurs during pregnancy. International Diabetes Federation (IDF) mentioned GDM was prevalent in low to middle-income countries may be due to the limitation in accessing proper and developed maternal care (IDF 2020). The complications of GDM were potentially lethal to both mother and her child (IDF 2020).

GDM etiologies including in increased age among pregnant mothers, higher pre-pregnancy BMI, excessive GWG, sedentary lifestyle, and unhealthy dietary intake (Lewandowska *et al.* 2020; Yong *et al.* 2020; Hashim *et al.* 2019; Suliga *et al.* 2018; Viecceli *et al.* 2017; Horosz *et al.* 2013). To highlight, the complications of GDM are miscarriage, preterm delivery, pregnancy-induced hypertension, pre-eclampsia, cesarean delivery, and postpartum diabetes for mothers and macrosomia, and infant metabolic syndrome that may cause them to become susceptible to develop diabetes and cardiovascular disease later

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(Received 21-07-2023; Revised 06-11-2023; Accepted 11-03-2024; Published 31-08-2024)

in the adulthood (Lewandowska *et al.* 2020; Xie *et al.* 2020; Zhuang *et al.* 2020; Mastella *et al.* 2018).

International of Medicine (IOM) has revealed an endorsement of GWG in 2009 by the latest version (Gilmore & Redman 2015). The latest version considers re-examining and re-assessing the impact of different rates of GWG on the pregnancy's outcome (Gilmore & Redman 2015). Current IOM GWG recommendation demonstrated the pre-pregnancy BMI was classified according to the World Health Organization (WHO) BMI cut off poitns. The classifications are underweight (<18.5 kg/m²), normal weight (18.5–24.9 kg/m²), overweight (25.0–29.9 kg/m²), and obese (≥30.0 kg/m²) (Martínez-Hortelano *et al.* 2020). The suggested range of GWG recommendation throughout pregnancies were 5–18.0 kg, 11.5–16.0 kg, 7.0–11.5 kg, and 5.0–9.0 kg for underweight, normal, overweight, and obese BMI, respectively (Martínez-Hortelano *et al.* 2020).

The prevalence rates of GWG globally are still worrying as most acquired abnormal rates include insufficient and excessive. A 21%, 18%, and 31% of pregnant mothers experiencing inadequate of GWG in the USA, Europe, and Asia, respectively, while 51% population in the USA and Europe, and 37% of population in Asia gain excessive GWG (Goldstein *et al.* 2018). In developed Asian countries such as Singapore and Japan, nearly half population gained gestational weight excessively (Chee *et al.* 2019). Furthermore, in developing Asian countries like China and Malaysia, nearly half population of mothers had excessive GWG records (Chee *et al.* 2019).

The common factors influencing GWG are sociodemographic factors; maternal age, ethnicity, education level, household income, obstetrical histories; pre-pregnancy BMI and parity, and behavioral factors; dietary intake, and physical activity (Ferreira *et al.* 2021; Chee *et al.* 2019; Hashim *et al.* 2019; Suliga *et al.* 2018; Tan *et al.* 2011). Previous study shown a significant association between primiparous women, younger age, lower education level, higher household income level, high pre-pregnancy BMI, unhealthy dietary pattern, and not being physically active to experience excessive rates of GWG (Almeida *et al.* 2021; Ferreira *et al.* 2021; Rugină *et al.* 2020; Chee *et al.* 2019; Hashim *et al.* 2019; Suliga *et al.* 2018; Yong *et al.* 2016). Moreover, in Malaysia, higher pre-pregnancy BMI is also common among Indian mothers as the Indian population has metabolic syndrome that causes central obesity compared to the Malay and Chinese mothers population (Tan *et al.* 2011).

The implications of abnormal GWG have been explained extensively. For instance, mothers with excessive GWG will increase risk to develop GDM, delivery complications such as cesarean delivery, macrosomia baby, and pre-eclampsia and also postpartum weight retention which may lead to repetition of the vicious cycle of higher pre-pregnancy BMI incidence (Martínez-Hortelano *et al.* 2020; Chee *et al.* 2019; Hashim *et al.* 2019). Moreover, excessive GWG also cause the mother and her child to be susceptible to obese-related cardiometabolic as it related to mothers' insulin sensitivity, and their child's beta cell pancreas functions (Tam *et al.* 2018). Furthermore, insufficient weight gain also have complications which include growth retardation, preterm delivery, low birth weight, and neurocognitive degradation later in life (Xie *et al.* 2020; Chee *et al.* 2019; Tran *et al.* 2019)

At present time, there is a limited study on the associations between sociodemographic and dietary intakes with the rates of GWG among pregnant mothers with and without GDM in Selangor, Malaysia. Hence, the objectives of this study are to assess the GWG rates and the association of sociodemographics and dietary intake with GDM status among pregnant mothers.

METHODS

Design, location, and time

This cross-sectional study was conducted among pregnant mothers from two selected government clinics, Klinik Kesihatan Meru and Bandar Botanik, Selangor from February until July 2023. Seventy-seven participants involved in this study.

Ethical approval was obtained from UiTM Research Ethics Committee (REC/08/2021 (MR/678)) and Ministry of Health Medical Research Ethics Committee National Medical Research and Registry (NMRR) (Reference No: NMRR-19-4204-52471). The participants were well-informed and obtained a signed consent form prior to their recruitment. All data was kept confidentially and anonymous.

Sampling

Convenient sampling design was applied in this study. The sample size was calculated based census of pregnant mothers at second trimester and above, visiting antenatal appoitments in both clinics thus leading to only 156 samples after calculated using Raosoft Calculator Software. Inclusion criteria for participants were mothers in their second to third trimesters, age 20 to 45 years old, singleton pregnancy, and without chronic health history and conditions.

Data collection

Pregnant mothers' characteristics. The mother's age, ethnicity, educational level, monthly household income, parity, current gestational week, and the presence of the GDM status were self-administered.

Anthropometric measurements. Height, pre-pregnancy weight, and current weight were obtained from their antenatal records. Then, pre-pregnancy BMI and GWG rates were calculated and categorized accordingly (Martínez-Hortelano *et al.* 2020).

Dietary intake. The Frequency Food Questionnaire (FFQ) was used to determine mother's dietary intake. The frequency and portion size of each food item were taken with the researcher's guidance. The nutrients observed include energy, macronutrients (carbohydrates, protein, and fat), fiber, and micronutrients (folate, iron, calcium, and zinc). Nutrient intake was calculated using Nutritionist Pro Software by calculating the coefficient of intake frequency for one day on every food item and multiplied the coefficient with the nutrient content for one portion for one time eating over one day.

Data analysis

The data were analyzed using IBM SPSS 27. Categorical data was presented as frequency and percentages whereas for numerical data underwent descriptive analysis and was presented in mean and standard deviation or median and interquartile range depending on the normality distributions of the data. Independent t-test and Chi-Square or the Karl Fischer test were applied to achieve both objectives in this study. Not normally distributed variables were analysed using the Mann – Whiteney test. The statistical significance for this study was $p<0.05$.

RESULTS AND DISCUSSION

Characteristic and sociodemographic of mothers

Table 1 shows the characteristics of the study participants with a total of 77 mothers. About 48.1% (n=37) of the mothers were diagnosed with GDM. Meanwhile, mean pre-pregnancy BMI among mothers in this study was 24.9±6.1 kg/m^2, about 11.7% (n=9), 48.1% (n=37), 23.4% (n=18) and 16.9% (n=13) of them were underweight, normal, overweight, and obese, respectively. Mean GWG was 7.1±5.1 kg/week. About 39.0 % (n=30) of them had indequate GWG and 32.5% (n=25) had excessive GWG. Their mean was 30.5±5.0 years old with an average of 27.3±7.1 weeks of gestation, respectively. Majority were Malays with 89.6% (n=69). All 77 mothers in this study were married and most of them had more than one child, 68.9% (n=53). They received second (35.1%, n=27) and tertiary (62.3%, n=48) education. Lastly, 62.3% (n=48) of them had lowest monthly household income of less than RM4,850.

Meanwhile, their dietary intake were as follows; mean energy intake 1,481.3±388.9 kcal/day, carbohydrate 199.9±59.3 g/day, protein 75.5±23.9 g/day, and fat 44.1±15.3 g/day. Lastly, the mean micronutrients intake daily for folate, calcium, iron, and zinc were 137.4±78.9 µg/d, 738.6±335.3 mg/d, 16.8±7.1 mg/d, and 6.0±2.6 mg/d respectively.

The present study has shown the prevalence of inadequate GWG among mothers was the highest, 39.0 % (n=30) followed by the excessive and normal rates of GWG.This aligned with the findings from a study in conducted in Malaysia and Poland which reported high prevalence of indequate GWG (Chee *et al.* 2019; Suliga *et al.* 2018). However, most of the other studies found the prevalance of mothers experiencing excessive GWG was the highest compared to the other category, normal and inadequate rates of GWG (Chee *et al.* 2019; Suliga *et al.* 2018).

The associations between rates of GWG among mothers with and without GDM

Based on Table 2, it shows that there is no significant association between the GWG rates and GDM status among mothers.

Previous study shown that mothers with GDM have a higher tendency to excessively

Table 1. Characteristic of the participants and mothers (n=77)

Characteristics	Mean±SD	n (%)
Age (years)	30.5±5.0	
Ethnicity		
Malay		69 (89.6)
Chinese		1 (1.3)
Indian		7 (9.1)
Marital status		
Married		77 (100)
Not married		-
Parity		
1		24 (31.2)
2		32 (41.6)
3		15 (19.5)
4		6 (7.8)
Educational level		
No formal education		2 (2.6)
Primary education		-
Secondary education		27 (35.1)
Tertiary education		48 (62.3)
Monthly household income (RM)		
Less than RM4,850		48 (62.3)
RM4,850–RM10,959		28 (36.4)
More than RM10,960		1 (1.3)
Current gestational week (week)	27.3±7.1	
GDM Status		
Yes		37 (48.1)
No		40 (51.9)
Pre-pregnancy BMI (kg/m^{-2})[1]	24.9±6.1	
Underweight		9 (11.7)
Normal		37 (48.1)
Overweight		18 (23.4)
Obese		13 (16.9)
Rates of GWG (kg/week)[2]	7.1±5.1	
Inadequate		30 (39.0)
Normal		22 (28.6)
Excessive		25 (32.5)
Energy intake (kcal/day)	1,481.3±388.9	
Carbohydrate intake (g/day)	199.9±59.3	

Continue from Table 1

Characteristics	Mean±SD	n (%)
Protein intake (g/day)	75.5±23.9	
Fat intake (g/day)	44.1±15.3	
Fiber intake (g/day)	6.9±7.0	
Folate intake (µg/day)	137.4±78.9	
Calcium intake (mg/day)	738.6±335.3	
Iron intake (mg/day)	16.8±7.1	
Zinc intake (mg/day)	6.0±2.6	

BMI: Body Mass Index; GDM: Gestational Diabetes Mellitus; GWG: Gestational Weight Gain; RM: Ringgit Malaysia
SD: Standard Deviation
[1]Pre-pregnancy BMI was classified according to WHO 1995 cut-off points
[2]Rates of GWG are determined based on the 2009 International Of Medicine classification

gain gestational weight, especially if the mothers were obese in pre-pragnancy BMI (Ferreira *et al.* 2021). Moreover, in a study by Viecceli *et al.* (2017) among Chinese pregnant mothers, 57%of mothers with GDM also excessively gained gestational weight. The reason behind the phenomenon of excessive GWG rates was due to the infants' rapid growth and development, which may lead 15 to 45% of higher risk to deliver macrosomia baby (Gou *et al*. 2019; Hashim *et al.* 2019). In contrast, a study by Xie *et al.* (2020), reported 50% of mothers with GDM were more likely to experience inadequate rates GWG.

The associations of sociodemographics, dietary intake, and GWG rates

Based on Table 3, a chi-square test was performed to determine the associations between the sociodemographics, dietary intake and the GWG rates This present study found only pre-pregnancy BMI showed a significant association with the GWG rates, with regards to GDM status.

In a study in Batu Pahat, Johor, Malaysia also showed overweight and obese mothers has three times odds in experiencing excessive GWG rates as compared to normal weight mothers (Chee *et al.* 2019). It was suggested that pre-pregnancy BMI was an indicator for excessive GWG rates and development of the GDM (Xie *et al.* 2020; Hashim *et al.* 2019).

Association between sociodemographic and dietary intake factors with rates of GWG among mothers with and without GDM independently

Table 4 presented comparison of associated sociodemographic and dietary intake factors with the rates of GWG among pregnant mothers with and without GDM.

This finding has limited literature to support the significant association as most of the study only found the association of energy and macronutrient intakes among mothers with and without GDM where the author stated that the intakes for energy and macronutrients could be seen higher among GDM mothers (Hasbullah *et al.* 2019). As mentioned in an overview related with nutrients consumption during gestation, zinc

Table 2. The association between rates of GWG among pregnant mothers with and without GDM (n=77)

Characteristics	Rates GWG		X^2 statistic (df)	*p*
	Abnormal	Normal		
GDM, n (%)[1]			0.083 (1)	0.773
Yes	27 (73)	10 (27)		
No	28 (70)	12 (30)		

[1]Significance was determined using Pearson's Chi-Square statistical analysis; GWG: Gestational Weight Gain
GDM: Gestational Diabetes Mellitus

Table 3. Sociodemographic and dietary intake associated with the GWG rates (n=77)

Characteristics	Rates GWG		X^2 statistic (df)	t-stats (df)	*p*
	Abnormal	Normal			
Age (years)[1]				-0.02 (75)	0.983
Mean±SD	30.47±4.9	30.5±5.4			
Ethnicity, n (%)[3]			-		1.000
Malay	49 (89.1)	20 (90.9)			
Non-Malay	6 (10.9)	2 (9.1)			
Parity, n (%)[2]			1.362 (1)		0.243
Uniparous	15 (27.3)	9 (40.9)			
Multiparous	40 (72.7)	13 (59.1)			
Educational level, n (%)[2]			0.022 (1)		0.882
Lower education	21 (38.2)	8 (36.4)			
Higher education	34 (61.8)	14 (63.6)			
Monthly household income (RM), n (%)[2]			0.022 (1)		0.882
Lower-income	34 (61.8)	14 (63.6)			
Higher-income	21 (38.2)	8 (36.4)			
GDM status, n (%)[2]			0.083 (1)		0.773
Yes	27 (49.1)	10 (54.5)			
No	28 (50.9)	12 (45.5)			
Pre-pregnancy BMI[2] (kg/m^{-2}), n (%)			5.000 (1)		**0.025***
Normal (18.5–24.9)	22 (40)	7 (31.8)			
Abnormal (<18.5 & >24.9)	33 (60)	15 (68.2)			
Energy intake (kcal/day)[4]				0.25 (75)	0.800
Mean±SD	1,488.4±403.9	1,463.3±357.1			
Carbohydrate intake (g/day)[4]					0.471
Median±IQR	193.1±86.9	179.8±85.4			
Protein intake (g/day)[1]				-0.19 (75)	0.852
Mean±SD	75.2±25	76.3±21.6			
Fat intake (g/day)[1]				0.69 (75)	0.495
Mean±SD	44.9±16.5	42.2±11.7			
Fiber intake (g/day)[4]					0.554
Median±IQR	5.2±6.2	4.75±5.8			
Folate intake (µg)[4]					0.259
Median±IQR	121.1±64	84.3±117.1			
Calcium intake (mg)[1]				0.41 (75)	0.683
Mean±SD	748.6±353.5	713.8±290.9			
Iron intake (mg)[4]					0.506
Median±IQR	15.6±8.5	15.0±10.4			

Continue from Table 3

Characteristics	Rates GWG		X^2 statistic (df)	t-stats (df)	*p*
	Abnormal	Normal			
Median±IQR	15.6±8.5	15.0±10.4			
Zinc intake (mg)[4]					0.62
Median±IQR	5.8±3.1	5.25±2.8			

BMI: Body Mass Index; GDM: Gestational Diabetes Mellitus; GWG: Gestational Weight Gain; IQR: Interquartile Range; SD: Standard Deviation; Statistically significant p<0.05

[1]Significance was determined using Independent T-test; [2]Significance was determined using Pearson's Chi-Square test

[3]Significance was determined using the Karl Fischer test; [4]Significance was determined using Mann Whiteney test

Table 4. The comparison of associated sociodemographic and dietary intake factors with the rates of GWG among pregnant mothers with and without GDM independently (n=77)

Characteristics	Pregnant mothers with GDM (n=37)		*p*	Pregnant mothers without GDM (n=40)		*p*
	Abnormal GWG rates	Normal GWG rates		Abnormal GWG rates	Normal GWG rates	
Age (years)[1]			0.951			0.953
Mean±SD	31.6±4.3	31.7±5.6		29.4±5.2	29.5±5.1	
Ethnicity, n (%)[2]			1.000			1.000
Malay	25 (92.6)	10 (100.0)		24 (85.7)	10 (83.3)	
Non-Malay	2 (7.4)	0 (0)		4 (14.3)	2 (16.7)	
Parity, n (%)2			0.407			0.720
Uniparous	6 (22.2)	4 (40.0)		9 (32.1)	5 (41.7)	
Multiparous	21 (77.8)	6 (60.0)		19 (67.9)	7 (58.3)	
Educational level, n (%)[2]			1.000			1.000
Lower education	10 (37)	4 (40.0)		11 (39.3)	4 (33.3)	
Higher education	17 (63.0)	6 (60.0)	0.481	17 (60.7)	8 (66.7)	0.720
Monthly household income (RM), n (%)[2]						
Lower-income	15 (55.6)	7 (70.0)		19 (67.9)	7 (58.3)	
Higher-income	12 (44.4)	3 (30.0)	0.275	9 (32.1)	5 (41.7)	0.079
Pre-pregnancy BMI (kg/m^{-2}), n (%)[2]						
Normal (18.5–24.9)	8 (29.6)	5 (50.0)		14 (50.0)	2 (16.7)	
Abnormal (<18.5 & >24.9)	19 (70.4)	5 (50.0)		14 (50.0)	10 (83.3)	
Energy intake (kcal/day)[1]			0.356			0.562
Mean±SD	1,598.5±401.0	1,466.5±318.0		1,382.2±384.0	1,460.7±400.9	
Carbohydrate intake (g/day)[1]			0.598			0.949
Mean±SD	208.1±67.9	195.4±53.5		195.1±50.7	196.3±67.0	
Protein intake (g/day)[1]			0.219			0.105
Mean±SD	84.6±25.9	73.4±17.9		66.1±20.7	78.7±24.8	
Fat intake (g/day)[1]			0.388			0.929

Continue from Table 4

Characteristics	Pregnant mothers with GDM (n=37)		*p*	Pregnant mothers without GDM (n=40)		*p*
	Abnormal GWG rates	Normal GWG rates		Abnormal GWG rates	Normal GWG rates	
Mean±SD	48.3±15.6	43.6±11.0		41.6±17.0	41.1±12.6	
Fiber intake (g/day)[3]			0.96			0.358
Median±IQR	3.9±6.9	4.9±5.7		5.9±5.4	4.8±7.1	
Folate intake (µg/day)[1]			0.714			0.672
Mean±SD	156.4±84.4	143.0±127.9		156.4±84.4	143.0±127.9	
Calcium intake (mg/day)[1]			0.701			0.899
Mean±SD	807.4±356.8	757.2±331.3		807.4±356.8	757.2±331.3	
Iron intake (mg/day)[1]			0.798			0.911
Mean±SD	17.3±6.3	16.7±7.8		17.3±6.3	16.7±7.8	
Zinc intake (mg/day)[1]			0.024*			0.488
Mean±SD	6.8±2.4	4.9±1.5		6.8±2.4	4.9±1.5	

BMI: Body Mass Index; GDM: Gestational Diabetes Mellitus; GWG: Gestational Weight Gain; IQR: Interquartile Range; RM: Ringgit Malaysia; SD: Standard Deviation; *Statistically significant p< 0.05

1Significance was determined using Independent T-test; 2Significance was determined using the Karl Fischer test; 3Significance was determined using Mann Whiteney test

functioned to aid in biochemical functions such as involved in cellular division, expressing genes, and others that were associated with the infant's growth (Mousa *et al.* 2019). To compare, our study participants showed insufficient zinc intake when compared to Malaysian Recommended Nutrient Intake (MoH 2017).

CONCLUSION

In conclusion, most of the mothers in this study had inadequate GWG rates. Pre-pregnancy BMI was associated with the rates of GWG , however, in present study, there were no associations found between pre-pregnancy BMI and GDM status. Therefore, it is notable that pre-pregnancy BMI should be highlighted during early antenatal appointments, meanwhile, GWG pattern also should be monitored throughout the pregnancy to prevent the occurence of GDM.

This study has several limitations such as a limited participants involved therefore, could affect the findings. This might be due to the complications of administering FFQ as it was very time consuming and had higher risk of over- and under-estimate the intake of every food items listed.

ACKNOWLEDGEMENT

We would like to thank all participants who took part in this study for their support and participation. We would like to thank Universiti Teknologi MARA Research Management Centre (UiTM RMC) for providing financial support for this study through Geran Khas Penyelidikan (600-RMC/GPK 5/3 (147/2020).

DECLARATION OF CONFLICT OF INTERESTS

The author has no conflict of interest when conducting this study.

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