FACTORS ASSOCIATED WITH SUBOPTIMAL GESTATIONAL WEIGHT GAIN (GWG) AMONG PREGNANT WOMEN IN SELANGOR:

A MIXED METHOD STUDY

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By

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LIST OF PAPER AND CONFERENCES

During my Doctor of Public Health (DrPH) course, the following articles were finally drafted for submission at the Web of Sciences Journal and/or presented at national and international level. Overall, the thesis comprises the two submitted papers, which corresponds to the study's specific objectives as below:

Submitted paper:

1) Determinants of suboptimal gestational weight gain among antenatal women residing in the highest Gross Domestic Product (GDP) region of Malaysia

Nurul Farehah Shahrir[1], Rohana Abdul Jalil[1*], Noor Aman A Hamid [1], Zaiton Daud [2], Siti Harirotul Hamrok Asis

Journal: Nutrients (Under review)

2) "I'll eat everything, the same as before I was pregnant until..." : Understanding suboptimal gestational weight gain in Selangor, Malaysia

Nurul Farehah Shahrir[1], Rohana Abdul Jalil[1], Zaiton Daud [2], Siti Harirotul Hamrok Asis [3], Noor Aman A Hamid [1*]

Journal: Journal of Biosocial Science (Under review)

Conference Presentation:

1) World Conference on Public Health (e-conference), 12th December 2020

   • Gestational weight gain among pregnant women attending antenatal care in Selangor: What are the determinants? **(Oral presentation)**

2) Global Health Sciences Conference 2020 (GHSC 2020), Universiti Sultan Zainal Abidin, Terengganu, Malaysia (e-conference), 12th December 2020

   • Household food insecurity and its determinant among pregnant women attending antenatal care in Selangor, Malaysia (**Oral presentation)**

3) Nutrition Society of Malaysia Scientific Conference (e-conference), 24th November 2020

   • Anaemia among pregnant women attending antenatal care in Selangor: What are the determinants? **(Oral presentation)**

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LIST OF ABBREVIATIONS

ACOG	American College of Obstetricians and Gynaecologist
B40	Bottom 40% household income
BMI	Body Mass Index
CI	Confidence interval
CVD	Cardiovascular diseases
FI	Food insecurity
GDM	Gestational diabetes mellitus
GWG	Gestational weight gain
HCP	Healthcare provider
HFFSM	Household Food Security Survey Module
HG	Hyperemesis gravidarum
IDI	In-depth interview
IOM	Institute of Medicine
M40	Middle 40% household income
MCO	Movement Control Order
METs	Metabolic equivalents
MNT	Medical Nutrition Therapy

MOGTT	Modified oral glucose tolerance test
MOH	Ministry of Health
MREC	Medical Research Ethics Committee
NCD	Non-communicable diseases
NGO	Non-Governmental Organization
PPAQ	Pregnancy Physical Activity Questionnaire
SEM	Socioecological model
SGA	Small for gestational age
WHO	World Health Organization
WOCBP	Women of childbearing potential

LIST OF SYMBOLS

>	More than
<	Less than
=	Equal to
≥	More than and equal to
≤	Less than and equal to
α	Alpha
β	Beta
%	Percentage
Δ	Precision / Delta

ABSTRAK

FAKTOR-FAKTOR YANG BERKAIT DENGAN KENAIKAN BERAT BADAN TIDAK OPTIMA SEMASA HAMIL DALAM KALANGAN IBU MENGANDUNG DI SELANGOR : KAJIAN KAEDAH GABUNGAN

Latar belakang: Peningkatan peratus kejadian kenaikan berat ketika hamil yang tidak optima adalah sesuatu yang membimbangkan kesihatan awam. Kenaikan berat kehamilan yang tidak optima dikaitkan dengan kesan yang tidak baik kepada kesihatan ibu dan bayi dalam jangka masa pendek dan panjang. Maklumat yang tersedia mengenai faktor-faktor yang boleh diubahsuai yang menyumbang kepada kenaikan berat yang tidak optima adalah terhad. Kajian ini bertujuan untuk menentukan peratusan, dan faktor-faktor yang mempengaruhi kenaikan berat kehamilan dan menjelaskan faktor-faktor yang mempengaruhi pertambahan berat yang tidak optima dalam kalangan ibu mengandung di Selangor.

Kaedah: Kajian kaedah gabungan dengan reka bentuk penjelasan berurutan telah dijalankan di antara Januari 2020 hingga Jun 2021. Reka bentuk dua fasa ini bermula dengan kaedah kajian keratan rentas tinjauan kuantitatif, diikuti dengan fasa kualitatif menggunakan pendekatan fenomenologi. Bahagian tinjauan kuantitatif dijalankan pada Januari 2020 sehingga Mac 2020, diikuti fasa kualitatif pada Ogos 2020 sehingga Jun 2021. Persampelan berperingkat telah dijalankan. Sejumlah 475 wanita hamil pada trimester kedua dan ketiga yang memenuhi kriteria untuk kajian

kuantitatif dipilih dari 18 klinik kesihatan di Selangor. Analisa regresi logistik multinomial telah digunakan bagi tujuan analisa. Fasa 2 kajian menggunakan temuramah mendalam bertujuan meneroka faktor yang mempengaruhi kenaikan berat yang tidak optima berdasarkan dapatan dari fasa 1 tinjauan kuantitatif. Analisis tematik telah digunakan untuk mengenal pasti tema berulang. Seramai 20 orang peserta dipilih dari fasa 1 kajian.

Keputusan: Peratusan ibu hamil dengan kenaikan berat yang tidak mencukupi, mencukupi dan berlebihan adalah masing- masing 47.2% (95%CI:45.7,48.3), 29.9% (95%CI: 28.7,31.3) dan 22.9% (95%CI:21.7, 24.3). Menghidapi diabetis ketika mengandung (AdjOR 2.24,95%CI:1.31,3.83, p=0.003); pendapatan isi rumah pertengahan (M40) (AdjOR 2.33,95%CI:1.09,4.96, p=0.029), pendapatan isi rumah rendah (B40) (AdjOR 2.22,95%CI:1.07,4.72, p=0.039), dan indeks jisim badan pra-kehamilan obes (AdjOR 2.77,95%CI:1.43,5.35, p=0.002) mempunyai perkaitan yang signifikan dengan kenaikan berat yang tidak mencukupi. Indeks jisim badan berlebihan (AdjOR 5.18,95%CI:2.52,10.62, p<0.001) dan obes (AdjOR 17.95, 95%CI:8.13,36.95, p <0.001) mempunyai perkaitan yang signifikan dengan kenaikan berat yang berlebihan. Melalui temubual yang mendalam, indeks jisim pra-kehamilan yang berlebihan dan obes mempengaruhi kenaikan berat semasa hamil yang berlebihan melalui kesinambungan dan pertambahan gaya hidup pra-kehamilan yang tidak sihat, ditambah dengan kepercayaan, tekanan dari rangkaian sosial, interaksi dengan pihak kesihatan dan akses kepada makanan serta aktiviti fizikal semasa kehamilan. Obesiti pra-kehamilan dan diabetis semasa kehamilan mempengaruhi kenaikan berat kehamilan yang tidak mencukupi melalui, diagnosis diabetis sebagai

kesedaran, kesan emosi daripada diagnosis, strategi sekatan diet yang melampau, keutamaan kesihatan bayi berbanding kesihatan ibu, keutamaan pihak kesihatan dalam pengurusan diabetis berbanding status nutrisi ibu, dan tempoh menunggu yang lama untuk temujanji diet. Pendapatan isi rumah bulanan pertengahan (M40) dan rendah (B40) mempengaruhi kenaikan berat kehamilan yang tidak mencukupi melalui komitmen yang banyak, kos sara hidup yang tinggi dan pendapatan boleh guna yang terhad untuk makanan; berhenti kerja kerana mengandung dan menyebabkan kewangan isi rumah yang terhad; dan tiada wang simpanan, krisis kewangan yang teruk, dan ketidakjaminan dapatan makanan isirumah.

Kesimpulan: Pengenalpastian faktor risiko untuk kenaikan berat kehamilan yang tidak optima membolehkan program intervensi memberi tumpuan kepada ibu hamil berisiko tinggi untuk mengurangkan risiko dan kesan bahaya kepada ibu dan bayi.

KATA KUNCI: kenaikan berat kehamilan, indeks jisim badan pra-kehamilan, obesiti di kalangan ibu mengandung, diabetis, pendapatan isi rumah

ABSTRACT

FACTORS ASSOCIATED WITH SUBOPTIMAL GESTATIONAL WEIGHT GAIN (GWG) AMONG PREGNANT WOMEN IN SELANGOR: A MIXED METHOD STUDY

Background: The increasing prevalence of suboptimal gestational weight gain (GWG) worldwide is a public health concern. It is well recognized that suboptimal GWG was associated with adverse foetal and maternal outcomes both in short and long terms. There is limited information available regarding modifiable risk factors contributing to suboptimal GWG. This study aims to determine the proportion, associated factors with GWG, and to explain the factors associated with suboptimal GWG among pregnant women attending antenatal care in Selangor.

Materials and Methods: A mixed method study with sequential explanatory design was conducted between January 2020 and June 2021. The two-phase design started with a cross-sectional quantitative survey, followed by qualitative using phenomenology approach. The survey was conducted from January 2020 to March 2020, while the qualitative phase was followed consequently in August 2020 to June 2021. A multistage sampling was applied. There were 475 pregnant women in second or third trimester that fulfilled the inclusion and exclusion criteria, selected from 18 health clinics in Selangor. Multinomial logistic regression was used for analysis. The Phase two study used in-depth interview, exploring the factors influence suboptimal

GWG based on the findings derived in the quantitative survey. Thematic analysis was used to identify recurring themes. The participants consisted of 20 purposively selected samples from the phase one study.

Results: The proportion of inadequate, adequate and excessive GWG was 47.2% (95% CI; 45.7, 48.3), 29.9% (95% CI; 28.7.0, 31.3) and 22.9% (95% CI; 21.7, 24.3), respectively. Diabetes in pregnancy (AdjOR 2.24,95%CI:1.31, 3.83, p=0.003); middle (M40) monthly household income (AdjOR 2.33,95%CI:1.09, 4.96, p=0.029), low (B40) monthly household income (AdjOR 2.22,95%CI: 1.07, 4.72, p=0.039), and pre-pregnancy BMI obese (AdjOR 2.77,95%CI: 1.43, 5.35, p=0.002) were significantly associated with inadequate GWG. Pre-pregnancy BMI overweight (AdjOR 5.18, 95%CI: 2.52, 10.62, p<0.001) and obese (AdjOR 17.95, 95%CI: 8.13, 36.95, p <0.001) were significantly associated with excessive GWG. Through in-depth-interview, pre-pregnancy overweight and obese influenced excessive GWG through continuation and exaggeration of an unhealthy pre-pregnancy lifestyle, compounded by belief and knowledge, social network pressure, health care provider interaction, and accessibility to foods and physical activity during pregnancy. Pre-pregnancy obesity and diabetes in pregnancy influenced inadequate GWG through diagnosis of diabetes as a wake-up call, emotional impact of the diagnosis, extreme dietary restriction-coping strategies, prioritisation of foetal health over maternal health, healthcare provider prioritisation of diabetic control over maternal nutritional status, and a long waiting period for dietitian appointments. Middle (M40) and low (B40) monthly household income influence inadequate GWG through multiple commitment, high living cost and limited disposable income for food; quitting work

due to pregnancy and constrained household finance; and no saving, acute financial crisis, and household food insecurity with hunger.

Conclusion: The identification of risk factors for suboptimal GWG enables the scale up the intervention programme focusing on high-risk group women to lower the risk of adverse maternal and foetal outcomes.

KEY WORDS: Gestational weight gain, pre-pregnancy BMI, maternal obesity, diabetes, household income

CHAPTER 1

INTRODUCTION

1.1 Overview of gestational weight gain

Nutrition has become a priority for international public health agendas following the adoption of the Sustainable Development Goals (SDG) and the United Nations declaration of the Decade of Action on Nutrition (2016-2025). This encompasses nutrition in pregnancy. Maternal nutritional status contributes to the health and wellbeing of pregnant women and their offspring. This includes gestational weight gain (GWG) (Hod *et al.*, 2015). It is one of the indicators of the effectiveness of national health services and programmes (Nunnery *et al.*, 2018). GWG is defined as "the amount of weight a pregnant woman gains between the time of conception and the onset of labour" (IOM, 2009). It is comprised of both the product of conception and maternal physiological changes. The products of conception consist of the placenta, the foetus, and amniotic fluid, which contribute approximately 35% of total GWG. On average, the foetus represents about 25% of the total weight gain (IOM, 1990c). Meanwhile, the expansion of maternal tissues accounts for two-thirds of the total weight gain. It was contributed by the increase in the uterine and mammary tissue mass, an expansion of maternal blood volume, extracellular fluids, and fat stores.

1.2 Measurement of gestational weight gain

According to the Institute of Medicine, GWG can be estimated in five ways, namely total weight gain, net maternal weight gain, incremental weight gain, weight gain as a percentage of body weight, and as a percentage of recommended gain (IOM, 1990a). Total weight gain is used in research and surveillance, measured as the difference between pre-delivery and pre-pregnancy weight. However, this method has limited use in monitoring for patterns during pregnancy and influenced by gestation. Net maternal weight gain is another approach being used in research and surveillance. It is calculated as the difference between total weight gain and birth weight, or postpartum weight minus pre-pregnancy weight. While this strategy eliminates the correlation with birth weight, thus providing an estimate of maternal weight gain, the latter is influenced by time since delivery due to the effect of diuresis.

Another method used in clinical practice, research, and surveillance is incremental weight gain, which is characterized by weight gain between two or more specified periods. It is calculated by means of weight gain by trimester, cumulative weight gain to a specific point in gestation, or weekly or monthly rate of weight gain. Although this approach eliminates time dependency, the latter is affected by frequency or measurement. The other approach, weight gain expressed as a percentage of body weight, assumed that overall weight gain should be proportional to initial, or desirable, weight gain. However, it makes no distinction in weight gain patterns. It is computed using the formula: (pregnant weight/actual pre-pregnancy weight) x 100 or (pregnant weight/desirable pre-pregnancy body weight) x 100. Other method used in

clinics and research is to quantify weight gain as a percentage of the recommended gain, which is calculated as (total gain/recommended gain) x 100 or (incremental gain/recommended incremental gain for the same period) x 100. This method assumes that the percentage of gain at different points of gestation is comparable. While it eliminates time reliance, it does not imply a certain pattern of weight gain, lacks validated standards for recommended weight gain, and is subject to definitional issues. Another frequently used method is to assess the adequacy of the GWG ratio between observed total weight gain and expected weight gain (Laraia *et al.,* 2010). This method will be detailed in the methodology section of the chapter.

1.3 Gestational weight gain guideline

The Institute of Medicine (IOM) committees provide the recommendation rate of GWG to facilitate the clinical monitoring of pregnant women's weight changes, as numerous studies have revealed that GWG is a significant predictor of adverse maternal and infant outcomes in the short and long term. Women who gained less or more than the recommended amount of weight during pregnancy were referred to as having inadequate or excessive weight gain, respectively, or collectively as having suboptimal gestational weight gain. In the last century, between 1970 and 1990, the guideline recommendation for GWG was higher, at 20-25 pounds, to account for the high neonatal and infant mortality rates associated with poor GWG, low birth weight, and preterm birth (IOM, 1990b). Since then, as more women of reproductive age were obese than underweight, the short-and long-term health consequences, and the size of the infant at birth have become a concern. Moreover, more women were

becoming pregnant at an older age and with comorbidities such as diabetes and hypertension, which increased their risk of pregnancy complications and post-delivery morbidity. Hence, the revised guideline for weight gain in pregnancy was published in 2009.

The 2009 IOM GWG ranges have been developed based on the five most important outcomes, which were (1) caesarean delivery, (2) preterm birth, (3) small-or large-for-gestational-age, (4) postpartum weight retention, and (5) childhood obesity. The new guideline recommends that maternal weight gain should be based on pre-pregnancy body mass index (BMI) based on the 1995 WHO classification and it provides a specific GWG range for obese pregnant women (7-9 kg) as opposed to the general recommendation (7 kg) in the 1990 guideline. In addition, the GWG range for multiple pregnancies, short-statured women, adolescents, racial and ethnic groups, obesity classes II and III, and smokers were also included. The GWG range was provided for both total GWG and weight gain rate per week of gestation. The 2009 IOM GWG recommendation is shown in Table 1.1.

Table 1.1: Institute of Medicine (IOM) 2009 Gestational Weight Gain Guidelines

Pre-pregnancy BMI	**Total weight gain at term**	**Rate of weight gain in the 2nd and 3rd trimester; Mean (range)**
Underweight (<18.5 kg/m^2)	12.5–18 kg 28–40 lbs.	0.51 (0.44–0.58) kg/week 1 (1–1.3) lbs./week
Normal weight (18.5–24.9 kg/m^2)	11.5–16 kg 25–35 lbs.	0.42 (0.35–0.50) kg/week 1 (0.8–1) lbs./week
Overweight (25.0–29.9 kg/m^2)	7–11.5 kg 15–25 lbs.	0.28 (0.23–0.33) kg/week 0.6 (0.5–0.7) lbs./week
Obese (≥ 30.0 kg/m^2)	5–9 kg 11–20 lbs.	0.22 (0.17–0.27) kg/week 0.5 (0.4–0.6) lbs./week

In Malaysia, the weight of pregnant women will be measured at each antenatal visit. According to the third edition of the Perinatal Care Manual, there should be a progressive increase in weight of approximately 10-12.5 kg (25% of the women's pre-pregnancy weight) (MOH, 2013b). Hence, at the time this research was conducted in January to March 2020, the Malaysian Ministry of Health's practise followed the general rule for weight gain, which is based on gestational weeks, with weight gain of approximately 0.5-0.75kg/month during the first 20 weeks and 0.5-0.75kg/week thereafter, regardless of the women's pre-pregnancy BMI (MOH, 2013b).

1.3.1 The 2009 IOM GWG guideline policy implementation in Malaysia

In the year 2018, the Nutrition Division Ministry of Health Malaysia proposed that pregnant women's weight gain should be monitored using the 2009 Institute of Medicine (IOM) indicators (*Mesyuarat Bil.* 1/2018 @ 10 April 2018), and the policy document was endorsed in July, 2018 by the EXCO Committee Public Health Program Policy (MOH, 2018). The guideline was drafted by a multidisciplinary team of experts, and GWG surveillance has been carried out in accordance with the 2009 IOM recommendation since then. Afterwards, in July 2019, a three-month pilot project was launched in four primary care clinics in Kuala Lumpur, Selangor, Malacca, and Negeri Sembilan to determine the feasibility of implementing the IOM GWG guideline in clinical practise on a national scale. Subsequently, training on primary care implementation was held in 2020, followed by a full nationwide endorsement on January 1, 2021. Additionally, all zones received briefings and

training on the updated fourth edition of the Perinatal Care Manual (2020) from December 1–14, 2021.

Although the previous third edition of the Perinatal Care Manual recommended that pregnant women with an excessive GWG be screened for comorbidities such as gestational diabetes mellitus and pre-eclampsia, and those with an inadequate GWG be evaluated for tuberculosis, hyperthyroidism, or malignancy during pregnancy, there is no recommendation or structured referral pathway for nutritional counselling. The updated fourth edition manual has included specific section on perinatal nutrition care, highlighted the importance of prenatal nutrition care, promoting healthy eating habits throughout pregnancy, managing GWG, and nutrition care for specific pregnancy conditions. Additionally, maternal record book KIK 1(a) and (b) 96 has been amended to include a section on antenatal maternal weight gain monitoring (GWG) and the recommended GWG based on pre-pregnancy body mass index (BMI) (MOH, 2020).

1.4 The burden of gestational weight gain

The published literatures indicate that excessive GWG is more prevalent in developed countries compared to developing countries. In Pennsylvania (Weisman *et al.*, 2010), the U.K (Garay *et al.*, 2021) and Canada (Guo *et al.*, 2019), the prevalence of excessive GWG was 51.0%, 56.0% and 57.2%, respectively. In contrast, in Texas, a population based study among underprivileged Hispanic women at the US-Mexico border found that the prevalence of inadequate (30.4%) and excessive GWG (35.7%)

was almost similar (Walker *et al.*, 2009).

Meanwhile, in a population-based, nationally representative sample study by Amyx *et al.* (2021) in France, they found that the prevalence of adequate GWG decreased from 37.7% in 2010 to 36.2% in 2016, with an increasing prevalence of inadequate GWG and a reduction in the prevalence of excessive GWG from all pre-pregnancy BMI categories. This finding was observed with the increase in the prevalence of maternal overweight and obesity. In China, a retrospective study among 13 776 normoweight Chinese pregnant women showed that the majority (74.3%) had adequate weight gain, while only 14.7% of women had inadequate GWG (Wen and Lv, 2015).

According to a systematic review, meta-analysis, and meta-regression of observational studies across continents and ethnicity, Goldstein *et al.* (2018) found that in the US and Europe, both continents have a higher prevalence of excessive GWG (51%), compared to inadequate GWG (US: 21%, Europe: 18%). Meanwhile, in Asia, the author noted that more than half of pregnant women have suboptimal GWG, with a prevalence of inadequate GWG of 31% and excessive GWG of 37%, with the latter increasing to 51% when applying regional BMI categories, similar to the other two continents.

Irrespective of the overall increasing trend of excessive GWG globally, inadequate GWG remains a major public health problem, particularly in developing countries. In developing countries such as Ethiopia, Uganda, and West Sumatera, Indonesia the prevalence of inadequate GWG ranges from 62.5% to 69.3% (Asefa and Nemomsa,

2016; Soltani *et al.*, 2017; Wanyama *et al.*, 2018).

There were limited studies conducted in Malaysia pertaining to GWG, and the findings on the prevalence of GWG were inconsistent. Rozlan *et al.* (2012), Farhana *et al.* (2018) and Haniff *et al.* (2015) have conducted studies in hospital-based in Kuala Lumpur and Kelantan, respectively, and discovered that excessive GWG was higher (42.8%, 39.8%, 47.8%) than inadequate GWG (29.3%, 25.4%, 27.2%). Similarly, another cross-sectional study among 180 pregnant women in urban area in Batu Pahat district showed that 53.3% of the respondents had an excessive GWG rate, while 28.9% had an inadequate GWG rate (Chee *et al.*, 2019). In contrast, a study by Farhana *et al.* (2015) among 422 pregnant women in a rural area in Gua Musang, Kelantan, reported a higher prevalence of inadequate GWG (54.5%) compared to excessive GWG (13.0%). The difference in prevalence could be explained by variances in study location and demographic. Additionally, few other local studies utilised a different method to determine GWG adequacy that includes total GWG (Farhana *et al.*, 2015; Yaw *et al.*, 2017), GWG rate by trimester (Chee *et al.*, 2019), or GWG adequacy ratio (Farhana *et al.*, 2018; Haniff *et al.*, 2015). Also, some studies used self-reported pre-pregnancy weight (Chee *et al.*, 2019; Farhana *et al.*, 2018), whereas others used booked weight as a proxy for pre-pregnancy weight (Farhana *et al.*, 2015) or calculated pre-pregnancy weight (Haniff *et al.*, 2015), which may have had an influence on pre-pregnancy BMI status and, subsequently, GWG adequacy outcome. Additionally, variances in inclusion and exclusion criteria may have influenced the study's outcome, as some studies included women with comorbid conditions (Farhana *et al.*, 2015; Farhana *et al.*, 2018), while others excluded this

group (Yaw *et al.*, 2017; Yong *et al.*, 2016). Table 1.2 summarise the prevalence of GWG in other countries and Malaysia.

Table 1.2: Summary of prevalence of gestational weight gain in other countries and Malaysia

Prevelance		**Study design/setting**	**References**
Inadequate GWG	**Excessive GWG**		
62.5%	3.1%	Cross-sectional study, Uganda	Wanyama *et al.* (2018)
63.1%	11.3%	Cross-sectional study, West Sumatra Indonesia	Soltani *et al.* (2017)
49%	23.2%	Cross-sectional study, Iran	Abbasalizad Farhangi (2016)
69.3%	2.7 %	Cross-sectional study, Ethiopia	Asefa and Nemomsa (2016)
25.7%	44.1%	Prospective cohort study, Lebanon and Qatar	Abdulmalik *et al.* (2019)
16%	51%	Prospective cohort study, Pennsylvania	Weisman *et al.* (2010)
14.7%	11%	Cross-sectional study, China	Wen and Lv (2015)
24.7%	52.5%	Prospective cohort study, US	Chasan-Taber *et al.* (2016)
8.5%	74.3%	Prospective cohort study, Multicentre western countries	Restall *et al.* (2014)
27.2%	47.8%	Cross-sectional study, USM antenatal clinic, Kelantan	Haniff *et al.* (2015)
54.5%	13.0%	Cross-sectional study, Gua Musang health clinics, Kelantan	Farhana *et al.* (2015)
Gestational weight gain rate higher in obese/ overweight		Cross-sectional study, Selangor and Negeri Sembilan health clinics	Yong *et al.* (2016)
28.9%	53.3%	Cross-sectional study, Batu Pahat health clinics, Johor	Chee *et al.* (2019)
30.1%	27.7%	Cross-sectional study, Seremban health clinics	Yaw *et al.* (2017)
25.4%	39.8%	Cross-sectional mixed method study, Tertiary centre in Kelantan	Farhana *et al.* (2018)

1.5 Health care and antenatal care services in Malaysia

Malaysia has a dual healthcare system, with a government-run universal healthcare system that is funded by taxes and a private healthcare system (WHO, 2013). Through its national, state, and district offices, the Ministry of Health provides centrally administered public health services in Malaysia (Liyanatul Najwa *et al.*, 2016) offering a comprehensive range of services through primary health care clinics and hospitals. The wide range of multidisciplinary services provided by health clinics is designed to serve a population of 15,000 to 20,000 people, including general outpatient treatment, dental care, maternal and child care, and other services covering curative, rehabilitative, disease prevention, and health promotion (Juni, 1996), following shifts in Malaysia's health care system from disease-centred care to incorporate wellness services as well (Thomas *et al.*, 2011). It has a centralised and uniform health system where all sixteen states in Malaysia have a similar organisation of health care services provision and care protocols, including antenatal care.

In Malaysia, antenatal care services are delivered in both primary care and hospital settings, with patients being co-managed between the two. The service's goal is to enhance pregnancy outcomes by implementing management plans that includes a number of monitoring measures. In the 1980s, the Global Safe Motherhood Initiative was launched with the aim of enhancing prenatal care globally. The Risk Approach System is one of the tools utilised in the Safe Motherhood Initiative's attempt to minimize maternal mortality. Hence, the risk approach system has been implemented

since 1989 in Malaysia, which utilises a four-color coding scheme of red, yellow, green, and white, tagged based on patient's medical history and clinical evaluation (Ravindran *et al.*, 2003). The red colour code denotes life-threatening conditions that necessitate immediate referral and hospitalisation. Meanwhile, yellow denotes conditions that require shared care between a Family Medicine Specialist and an Obstetrician; green denotes shared care provided by medical officers and nurses at the clinic level; and white denotes the absence of the indicated risk factors (Yeoh *et al.*, 2015). Additionally, the Perinatal Care Manual was also released in 2012 and amended in 2013 to assist healthcare practitioners in managing pregnancies at all stages, including pre-pregnancy care, antenatal care, intrapartum care, postnatal care, and neonatal care. According to the third edition, 2013 Perinatal Care Manual, maternal weight of more than 80 kg or 45 kg or less during booking will be tagged as green colour coding (MOH, 2013b) as these women are at risk of suboptimal GWG and obstetric complications. Pregnant women will have a number of antenatal visits depending on the pregnancy risk and gravidity. For a normal, uncomplicated primigravida, ten antenatal visits are recommended; and for a normal, uncomplicated multigravida, seven antenatal visits are recommended until 40 weeks of pregnancy. Maternal weight gain is among many other components that will be monitored during the visit. Excessive weight gain >2 kg in a week, or maternal weight static or loss in a month were tagged as green, necessitating further investigation and management. This criteria was maintained in the updated 2020 fourth edition of the Perinatal Care Manual.

1.6 Determinants of gestational weight gain

1.6.1 Maternal determinants

Multiple factors determine maternal gestational weight gain (GWG). Maternal factors, including age, parity, ethnicity, educational level, marital and smoking status, certain medical illnesses, ability to be physically active, and access to nutritious foods may all contribute to maternal GWG. Understanding these aspects as determinants of the risk of suboptimal GWG is crucial. Maternal GWG is a modifiable risk factor in pregnancy, thus identifying pregnant women who are at risk is critical for effective interventions to be planned for optimal pregnancy outcomes (Janjua *et al.*, 2012).

Nulliparous women and younger ages were associated with excessive GWG. Restall *et al.* (2014) found that women aged less than 25 years and those aged 25–29 years were almost twice as likely, and women aged 30–34 years were 60% more likely to gain above IOM guidelines compared to women aged 35 years or above. On the other hand, Lindberg *et al.* (2016) found that older women tend to gain less weight during pregnancy. Hasan *et al.* (2018) reported that maternal age more than 35, and being multiparous was associated with inadequate GWG. Possible explanations include a poor anabolic response to pregnancy in advanced age, or alternatively, older women may be better self-controlled regarding lifestyle choices (Restall et al., 2014). In contrast, Suliga et al. (2018) found no association between maternal age and GWG.

Published literature showed ethnicity had an association with the GWG. In a retrospective cohort study of 7 385 women in Wisconsin, it was found that GWG was

significantly varied by ethnicity, with non-Hispanic black and other ethnic minority women have almost two-fold higher risk of inadequate GWG, while non-Hispanic white ethnic group had a higher risk of excessive GWG (Lindberg *et al.,* 2016). A similar finding of racial differences in GWG was reported in another study (Liu *et al.*, 2014). Moreover, Deputy *et al.* (2015) found that the Asian, non-Hispanic Black and Hispanic races were positively associated with inadequate GWG in overweight women, while the black and Alaskan Native races were positively associated with inadequate GWG in normoweight women. Meanwhile, in Malaysia, Chee *et al.* (2019) reported that excessive GWG was prevalent among both Malay and Chinese.

Other than that, education status has been linked to GWG. A study among 2 769 pregnant women by Cohen *et al.* (2016) showed that the majority of women with higher education had increased odds of gaining within the recommended amount of GWG, while those with less education had higher odds of having inadequate GWG compared to women with more education. However, the author also reported that among normoweight women, less education was associated with higher odds of excessive GWG. Qualitative studies reported that many women do not understand the importance of weight control how to achieve it due to lack of knowledge and skills (Anderson *et al.*, 2015; Ferrari *et al.*, 2013). In a cross-sectional study among pregnant women in a rural area in Bangladesh, it was found that women with less than five years of education had 1.7 times the odds of having inadequate GWG compared to those with more than ten years of education (Hasan *et al.*, 2018). Nonetheless, a meta-analysis involving 5 183 pregnant women showed that women with lower education attainment had a significantly increased risk of both inadequate

and excessive GWG (O'Brien *et al.*, 2019). Additionally, Huynh *et al.* (2014) reported that the association between maternal education status and excessive GWG varied depending on race and the neighbourhood's socioeconomic status.

Studies showed the socioeconomic status of pregnant women was associated with suboptimal GWG. A retrospective cohort study of 7 385 pregnant women found that women on Medicaid insurance (insurance for low-income pregnant women in the U.S.) and living in economically depressed areas were more likely to have inadequate GWG (Lindberg *et al.*, 2016), while women with commercial insurance and living in more affluent neighbourhoods were at higher risk for excessive GWG. In Bangladesh, Hasan *et al.* (2018) found that women living in the lowest wealth quintile had the highest risk of inadequate GWG. A qualitative study by Paul *et al.* (2013) exploring weight gain, diet, and physical activity among women in both high and low income groups found that low-income women's physical activity and dietary behaviours were more likely to promote a positive energy balance than those of high-income women. The study highlighted that, low-income women, for instance, described eating high-energy foods (fast foods, fried foods, soda, and high-fat toppings on vegetables), overeating (binge eating and eating large portions), eating few fruits and vegetables, and walking only as part of daily life. In contrast, high-income women cited eating nutritious foods to fulfil cravings and nausea, choosing less energy-dense foods to satisfy increased appetites, eating small, frequent meals to avoid hunger, bringing lunch from home to avoid overeating at work, and exercising often. Most of these behaviours were explained by the underlying behavioural, efficacy, and normative attitudes expressed by both groups of women. Meanwhile,

according to Black *et al.* (2008), pregnant women from low-income households report difficulties affording fresh food and lack of fresh food availability in their neighbourhood, leading them to choose fast food and junk food.

Previous studies showed that women's pre-pregnancy BMI was the strongest predictor of suboptimal GWG. In the U.S., a study among African American and Caucasian women revealed that overweight women were three times more likely to gain excessive weight, and obese women were four times more likely to exceed the recommended weight gain by IOM guidelines, compared to normoweight women (Krukowski *et al.*, 2013). Similar findings on the association of overweight and obese women with excessive GWG among healthy nulliparous cohort was reported by Restall *et al.* (2014). In Malaysia, a cross-sectional study among 180 pregnant women in the Batu Pahat district reported that women who were overweight or obese at pre-pregnancy were seven times more likely than women with normal pre-pregnancy BMI to have an excessive GWG rate (Chee *et al.*, 2019). Similar findings were also found in a cross-sectional study conducted in a rural area of Gua Musang, Kelantan, where pre-pregnancy overweight and obese were significantly associated with excessive GWG (Farhana *et al.*, 2015). In another cross-sectional study conducted in Selangor and Seremban, Yong *et al.* (2016) reported that the mean GWG rate for all pre-pregnancy BMI during the second and third trimesters was higher than the IOM recommendation. The author also found that women with high pre-pregnancy BMI were two to three-folds more likely to gain excessive weight. Meanwhile, Suliga *et al.* (2018) and Deputy *et al.* (2015) found that underweight women had significantly higher risk of inadequate GWG. In contrast, a study among

607 pregnant women in West Sumatera, Indonesia, showed that the majority (>60%) of pregnant women who had inadequate GWG were among those with normal BMI (Soltani *et al.*, 2017).

Other factors associated with inadequate GWG include short stature (<145cm), Hindu religion, and diabetes (Hasan *et al.*, 2018; Walker *et al.*, 2009), whereas maternal early menarche, urban residency, having a routine job, and hypertensive condition were associated with excessive GWG (Min *et al.*, 2014).

Adiposity is the result of positive energy balance, where the decline in energy expenditure is greater than calories intake, leading to accelerated fat deposition. The Institute of Obstetricians and Gynaecologists of the Royal College of the Physicians of Ireland recommends at least 30 minutes of exercise daily, whereas the Royal College of Obstetricians and Gynaecologists (RCOG) recommend at least 150 minutes of moderate-intense activity per week throughout pregnancy and to avoid a sedentary lifestyle. Participation in a wide range of recreational activities appears to be safe for pregnant women. However, activities with a high potential for trauma to the maternal or foetus should be avoided. There are many benefits attributed to physical activity and exercise for pregnant women and foetuses, including the prevention of excessive weight gain and postpartum weight retention that contribute to maternal obesity in the present and subsequent pregnancy (Farpour-Lambert *et al.*, 2018).

Decreased physical activity in pregnancy was associated with significantly higher GWG than maintaining or increasing physical activity (Olson and Strawderman,

2003). Restall *et al.* (2014) reported that women who had a decrease in exercise by 14–16 weeks of pregnancy were 50% more likely to acquire excessive GWG, and women who had greater sedentary behaviours were more likely to gain weight exceeding the IOM (2009) recommendations. In addition, a cross-sectional study among 491 overweight and obese women in North Carolina found that nearly three-quarters of the respondents failed to meet the national physical activity recommendations in the postpartum period. Women having a BMI ≥ 40 kg/m2 were reported to spend more time in sedentary activities than those with a lower BMI (Durham *et al.*, 2011).

Many pregnant women become more sedentary, particularly after reaching their third trimester (Huberty *et al.*, 2016). According to Pereira *et al.* (2007), there was a significant reduction in women's physical activity from the antenatal period to six months postpartum, where the prevalence of inadequate physical activity (less than 150 minutes per week of total activity) increased from 12.6% prior to pregnancy to 21.7% during the postpartum period. In contrast, a prospective cohort study among 1 276 Hispanic women showed that there was no significant association between type and intensity of physical activity during pre, early, mid and late pregnancy on the adequacy of GWG (Chasan-Taber *et al.*, 2014).

Diet may have a significant impact on GWG. Few observational studies have examined the independent associations of dietary patterns with GWG outcomes. A prospective cohort study among pregnant women in the US showed that energy intake and energy-adjusted intake of animal lipids and protein were significantly

positively associated with maternal weight gain, whereas a significant inverse association was evident for carbohydrates, after adjustment for the possible confounders (Lagiou *et al.*, 2004). In addition, adherence to a good diet quality during pregnancy assists in optimal GWG in normoweight women and improves foetal growth. A large prospective cohort study involving 66 597 pregnant women showed that normoweight women with healthy diet (Nordic diet) that was comprised of high portion of fruits and vegetables, whole grains, potatoes, fish, milk, and water, had significantly lower odds of excessive GWG compared to those with low diet adherence (Hillesund *et al.*, 2014). In contrast, a cross-sectional study assessing diet quality during pregnancy found that adequate GWG was not associated with diet quality, although inadequate intake of total vegetables was associated with excessive GWG when covariates were controlled (Shin *et al.*, 2014). Meanwhile, Olson and Strawderman (2003) found that consuming more and less food during pregnancy than prior to pregnancy was associated with greater and less GWG, respectively, compared with maintaining unchanged levels of food intake. Moreover, a qualitative study conducted among postpartum women by Goodrich *et al.* (2013) revealed that cravings were the most commonly cited intrapersonal barrier to healthy eating during pregnancy, with watching others consume unhealthy foods as an interpersonal barrier.

In many cultures, food taboos are common during pregnancy. These cultural practises and beliefs can influence pregnant women's dietary intake, which in turn has an effect on GWG. A cross-sectional study examining the prevalence of food taboos and their association with weekly weight gain rates in Malaysia found that a

higher prevalence of women who had food taboos had inadequate GWG (71.2%) and there was a significant association between having food taboos and the GWG rate (Mohamad and Ling, 2016). The most often reported reasons for avoiding the foods were concerns about the foetus's safety, such as miscarriage, difficult delivery, or deformed foetus, and sociocultural reasons that are deeply embedded in pregnant women's beliefs and attitudes (Diana *et al.*, 2018). Similar findings on food taboos among pregnant women were reported by Farhana *et al.* (2018).

Several studies have examined the relationship between smoking status and GWG. A cross-sectional study in Poland found that women who had quit smoking, particularly in the first trimester, had seven times the risk of excessive GWG (Suliga *et al.*, 2018). Similar finding was found in a cross-sectional study in Brazil where pregnant women who quit smoking after conception increased the odds of excessive GWG by 34% compared to non-smokers (Favaretto *et al.*, 2007). Meanwhile, Lindberg *et al.* (2016) found that former smokers were at increased risk for excessive GWG, and current smokers were at increased risk for inadequate GWG, relative to people who had never smoked. Although quitting smoking is a significant health-promoting change in lifestyle, it can also have an impact on metabolism. According to Bush *et al.* (2016), weight gain was associated with quitting smoking is mainly due to a decline in resting-state basal metabolic rate. Thus, the author emphasised health education for these women is important in assisting to achieve optimal GWG.

Knowledge of pre-pregnancy weight status was associated with knowledge of GWG recommendations. Women who knew their pre-pregnancy weight status were twice

as likely to be knowledgeable about GWG recommendations compared to women who did not know their pre-pregnancy weight status (Ledoux *et al.*, 2015). In addition, obese women tend to overestimate GWG recommendations. A longitudinal cohort study in San Francisco found that among overweight women, 24.1% reported significantly above the target weight gain as recommended by the IOM guidelines, compared with 4.3% of normoweight women (Stotland *et al.*, 2005). Furthermore, another study showed 74.0% of obese women had underestimated their BMI category, with 64.0% of them overestimated their recommended GWG (Shub *et al.*, 2013). Besides, women's knowledge of the risks associated with excessive GWG and maternal obesity was lacking, and they reported incorrect beliefs about safe weight management in pregnancy.

Women who misperceived their pre-pregnancy weight were more likely to exceed GWG recommendations among both normoweight and overweight/obese women. Mehta-Lee *et al.* (2013) reported that overweight or obese under assessors of pre-pregnancy weight were 2.5 times more likely to gain weight excessively compared to normoweight accurate assessors. In addition, another study by Herring *et al.* (2008) showed that the adjusted odds of excessive GWG was 2.0 (95% CI: 1.3, 3.0) in normoweight over assessors, 2.9 (95% CI: 2.2, 3.9) in overweight/obese accurate assessors, and 7.6 (95% CI: 3.4, 17.0) in overweight/obese under assessors compared with normoweight accurate assessors.

Psychological factors have a potential role in weight gain during pregnancy. However, there was a lack of consistent evidence of an association between

psychological factors and GWG. Brawarsky *et al.* (2005) found that women who reported high stress during pregnancy tended to have inadequate GWG. In contrast, a prospective study by Webb *et al.* (2009) found that pregnant women who gained more than the recommended range were more likely to have high depressive symptoms than women who met the weight gain recommendations. On the other hand, a longitudinal study among low-risk and low-income pregnant women found that depressive symptoms were not significantly associated with GWG (Walker and Kim, 2002).

1.6.2 Household determinants

Food security is defined as a state in which "all people at all times have both physical and economic access to sufficient food to meet their dietary needs for a productive and healthy life" (USAID, 1992). It is a complex, multidimensional concept. It consists of four components: availability (having sufficient quantities of appropriate quality food), accessibility (having adequate income or other resources to access food), utilisation (having adequate dietary intake, clean water, sanitation and health care to achieve nutritional well-being that meets physiological needs, and the ability to absorb and use nutrients in the body) and stability (a population, household, or individual who has access to adequate food at all times and is not at risk of losing access to food due to sudden shocks (e.g. an economic or climatic crisis) or cyclical events (e.g. seasonal food insecurity)) (FANTA, 2018; FAO, 2006). Household food insecurity is defined as whenever the availability of nutritionally adequate and safe food, or the ability to acquire it in socially acceptable ways, is limited or uncertain (Pinstrup-Andersen, 2009). In Malaysia, 24.8% of Malaysian household were at risk

of household food insecurity (Selamat *et al.*, 2015) and 41.3% of pregnant women were food insecure (Haniff *et al.*, 2015).

Pregnancy is a period of physical, behavioural, psychosocial changes, and specific nutritional needs, all of which can have a direct effect on the foetus's development and the future health of the women (Lindsay *et al.*, 2019b). Food insecurity (FI) is especially important for pregnant women since nutrient demands are higher, the effort necessary for food preparation is more difficult, and pregnant women may be forced to leave the workforce, especially later in pregnancy, resulting in financial constraints (Laraia *et al.*, 2006). Given that pregnancy is a crucial time for weight-related expectations for women, it presents a particular challenge concerning FI for women. Evidence shows that household food insecurity plays a significant role in the amount of weight gained during pregnancy, as the majority of women who are food insecure fail to meet GWG recommendations (Haniff *et al.*, 2015; Olson and Strawderman, 2008). Laraia *et al.* (2010) reported that women from food insecure households were associated with severe pregravid obesity, higher GWG, and higher adequacy of weight gain ratio. In addition, Metallinos-Katsaras *et al.* (2016) stated that overweight pregnant women with very low food security had higher GWG, but not among normoweight or obese women. Nevertheless, a meta-analysis showed that FI during the gestation period increased both the risks of inadequate and excessive GWG (Demétrio *et al.*, 2020). In addition, Laraia *et al.* (2015) found that women from any level of FI gained and retained greater weight postpartum at three and twelve months compared to women from food secure households.

1.6.3 Societal determinants

The effect of low social support on GWG varied significantly by BMI group. In a prospective cohort study among healthy pregnant women in New York by Olson and Strawderman (2003) found that low social support among low, normal, and obese BMI women was associated with significantly more weight gain than those women with average or high social support. However, the author highlighted that those high-BMI women who had low social support gained significantly less weight compared to high-BMI women with average or high social support.

Some women express that their social support networks contribute to the barrier to healthy behaviour. A qualitative study by Black *et al.* (2008) that examined the determinants of excessive weight gain in First Nations women living on a reserve, reported that pregnant women cited having encouragement from their mothers to eat for two, and some of them were offered high-sugar, high-fat foods by their family members that contributed to excessive GWG. Moreover, pregnant women also reported that their physical activity in pregnancy had decreased due to the influence of their friends and social networks, who discouraged exercise during pregnancy due to fear of miscarriage, preterm birth, and possibly having a cord around the baby's neck (Goodrich *et al.*, 2013). Women's pregnancy weight gain may be influenced by their partners' health behaviours. To date, there has been only one qualitative study on men's perceptions of their partners' GWG (Montgomery *et al.*, 2012). Among the themes that emerged include negative perceptions, eating behaviours, health impact, body changes, and their partner's perceptions of GWG. The author suggested that, given the partner's influence on maternal health behaviours, the involvement of

partners in antenatal care may help support the wife to achieve optimal GWG.

Pregnant women often describe receiving contradicting messages regarding GWG from their health care providers (HCPs), and this confusion may lead to suboptimal GWG. In a qualitative study examining women's perceptions of provider advice about diet and physical activity during pregnancy, Ferrari *et al.* (2013) reported that nutritional information received was described as confusing and constantly changing, not culturally relevant, overwhelming, and not individualized. In addition, advice on physical activities was generally vague and largely limited to being told to "walk". Other than that, on the healthcare provider part, Power and Schulkin (2017) reported that more than half of the providers stated they were not familiar with or had confidence in the IOM weight gain guidelines. The study discovered that physicians who were familiar with the IOM (2009) recommendations were more likely to counsel their patients about GWG and to inform them that excessive GWG increases the risk of pregnancy complications for both mother and infant, compared to those who lack of familiarity. In addition, the barriers cited by the HCPs include worries that weight gain counselling might offend the patient, lack of time, competing priorities, insufficient training, cultural differences, and difficulties in counselling women with a low level of education and low socioeconomic status, while patient interests are among the enablers for both physical activities and dietary advice (Whitaker *et al.*, 2016).

1.7 Maternal and foetal outcomes of suboptimal gestational weight gain

The IOM formulated the GWG guidelines with the purpose of optimising outcomes