Evaluating the Association between Dietary Intake, Sunlight Exposure and Serum Vitamin D Level with Maternal Comorbidities in Hospital Pengajar Universiti Sains Malaysia (HPUSM)

by

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Dissertation submitted in partial fulfilment of the requirements for the degree of Bachelor in Nutrition with Honours

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CERTIFICATE

This is to certify that the dissertation entitled "Evaluating the Association between Dietary Intake, Sunlight Exposure and Serum Vitamin D Level with Maternal Comorbidities in Hospital Pengajar Universiti Sains Malaysia (HPUSM)" is the bone fide record of research work done by Miss Niranjanaa during the period October 2024 to January 2025 under my supervision. I have read this dissertation and in my opinion, it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation to be submitted in partial fulfilment for the degree of Bachelor in Nutrition with Honours.

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DECLARATION

I hereby declare that this dissertation is the result of my own investigations, except where otherwise stated and duly acknowledged, I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at Universiti Sains Malaysia or other institutions. I grant Universiti Sains Malaysia the right to use the dissertation for teaching, research and promotional purposes

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Date: .....

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CONTENTS

LIST OF ABBREVIATIONS

HPUSM - Hospital Pengajar Universiti Sains Malaysia

GDM - Gestational Diabetes Mellitus

GH- Gestational Hypertension

PE- Preeclampsia

SBP - Systolic Blood Pressure

DBP - Diastolic Blood Pressure

HDP - Hypertensive Disorders in Pregnancy

BMI - Body Mass Index

UVBR - Ultraviolet B Radiation

25(OH)D - 25-Hydroxyvitamin D

VEGF - Vascular Endothelial Growth Factor

RAS - Renin-Angiotensin System

SPSS - Statistical Package for the Social Sciences

JEPeM - Jawatankuasa Etika Penyelidikan Manusia

IOM – Institute of Medicine

RNI – Recommended Nutrient Intake

BSA- Body Surface Area

SEI- Sun Exposure Index

FFQ- Food Frequency Questionnaire

ABSTRAK

Mengkaji Hubungan Antara Pengambilan Diet, Pendedahan Matahari dan Tahap Serum Vitamin D dengan Komorbiditi Ibu Maternal di Hospital Pengajar Universiti Sains Malaysia (HPUSM)

Komorbiditi maternal merujuk kepada gabungan satu atau lebih penyakit yang dialami oleh wanita hamil. Kajian ini memberi tumpuan kepada gangguan hipertensi semasa kehamilan (HDP) dan Diabetes Mellitus Semasa Mengandung (GDM). Berdasarkan kajian populasi, kejadian gangguan hipertensi semasa kehamilan meningkat daripada 16.30 juta kepada 18.08 juta secara global, dengan peningkatan keseluruhan sebanyak 10.92% dari tahun 1990 hingga 2019. Lebih daripada 50% wanita yang mengalami GDM dijangka menghidap diabetes mellitus jenis 2 (T2DM) dalam tempoh 5 tahun selepas kehamilan. Beberapa kajian melaporkan peningkatan risiko preeklampsia apabila paras vitamin D adalah rendah, dan menurut ,vitamin D memainkan peranan penting dalam homeostasis glukosa.

Walau bagaimanapun, kajian mengenai interaksi antara pengambilan diet, pendedahan cahaya matahari, dan tahap serum Vitamin D dalam meramal kesihatan ibu masih terhad, terutamanya di Malaysia.Kajian rentas perbandingan ini bertujuan untuk membandingkan pengambilan diet Vitamin D, pendedahan matahari, dan tahap serum Vitamin D di kalangan wanita hamil yang sihat dan mereka yang mengalami komorbiditi ibu. Seramai 207 wanita hamil yang menghadiri penjagaan antenatal di HPUSM telah direkrut, dengan 152 orang dalam kumpulan sihat dan 55 orang dalam kumpulan komorbiditi ibu maternal. Subjek kajian dipilih berdasarkan teknik pensampelan bertujuan, yang memenuhi kriteria inklusi. Data dikumpul menggunakan soal selidik separa berstruktur untuk mendapatkan maklumat demografi, sejarah obstetrik, dan log

pendedahan matahari. Sementara itu, data pemakanan setiap subjek dinilai menggunakan soal selidik kekerapan makanan (FFQ) khusus Vitamin D separa kuantitatif. Pengambilan darah juga dilakukan untuk menganalisis tahap serum Vitamin D. Didapati terdapat hubungan signifikan antara usia ibu dan usia kehamilan. Walau bagaimanapun, tiada hubungan signifikan dilaporkan antara tahap serum Vitamin D, pendedahan matahari, dan pengambilan diet Vitamin D dengan kumpulan sihat dan komorbiditi ibu maternal. Secara keseluruhan, kajian ini mendapati tiada hubungan antara Vitamin D dengan komorbiditi ibu maternal.

ABSTRACT

Evaluating the Association between Dietary Intake, Sunlight Exposure and Serum Vitamin D Level with Maternal Comorbidities in Hospital Pengajar Universiti Sains Malaysia (HPUSM)

Maternal Comorbidities is defined as the combination of one or more diseases among pregnant women. This study focuses on hypertensive disorders in pregnancy (HDP) and Gestational Diabetes Mellitus (GDM). Based on a population-based study, the incidence of hypertensive disorders during pregnancy increased from 16.30 million to 18.08 million globally, with a total increase of 10.92 % from 1990 to 2019.

More than 50% of women with GDM are expected to develop T2DM within 5 years of the index pregnancy. Several studies reported increased risk of preeclampsia when Vitamin D levels are low and plays a role in glucose homeostasis. However, limited research has explored the interaction between dietary intake, sunlight exposure, and serum Vitamin D levels in predicting maternal health outcomes in Malaysia. Current comparative cross-sectional study aimed to compare dietary Vitamin D intake, sunlight exposure, and serum Vitamin D levels of healthy pregnant women and women with maternal comorbidities. A total of 207 pregnant women who attended antenatal care in HPUSM were recruited in the study, with 152 of them in healthy group and 55 of them in maternal comorbidities group. Study subjects who fulfilled the inclusion criteria were selected through purposive sampling technique. Semi structured questionnaire was used to collect data on sociodemographic, obstetric history and sun exposure log meanwhile dietary data of each study subject was assessed through semi-quantitative, vitamin D specific food frequency questionnaire (FFQ). Blood withdrawal was done to analyse serum vitamin D levels. A significant association is present between maternal age and gestational age across groups However, no significant associations were reported between serum vitamin D levels, sunlight exposure and dietary vitamin D intake with

healthy and maternal comorbidities groups. Conclusively, current study found that there is no association between vitamin D and maternal comorbidities.

CHAPTER 1: INTRODUCTION

1.1 Background of Study

Hypertensive disorders in pregnancy (HDP) are defined as chronic diseases among pregnant women which lead to enormous maternal and fetal morbidity and mortality (Wilkerson & Ogunbodede, 2019). Hypertensive disorders during pregnancy are classified into 4 categories, as recommended by the National High Blood Pressure Education Program Working Group on High Blood Pressure in Pregnancy namely, chronic hypertension, preeclampsia-eclampsia, preeclampsia superimposed on chronic hypertension, and gestational hypertension. Hypertension is reported as the most common medical disorder of pregnancy which complicates up to 1 in 10 gestations and affects an estimated 240,000 women (Mustafa et al., 2012). Based on the 2019 Global Burden of Disease study, the global incidence of HDP was reported to be 18.1 million, leading to 27.8 thousand deaths due to its complications in 2019. Chronic hypertension is defined as high blood pressure that either precedes pregnancy, is diagnosed within the first 20 weeks of pregnancy, or does not resolve by the 12-week postpartum check-up. Two categories of severity include mild (up to 179 mm Hg systolic and 109 mm Hg) and severe (≥ 180 systolic or 110 diastolic). Formerly known as pregnancy-induced hypertension or PIH, gestational hypertension is the new onset of hypertension after 20 weeks of gestation. The diagnosis requires patient to have elevated blood pressure (systolic ≥ 140 or diastolic ≥ 90 mm Hg).

Pregnant women who progress to severe gestational hypertension based on the degree of blood pressure elevation have worse perinatal outcomes than do women with mild preeclampsia, and require management similar to those with severe preeclampsia. Preeclampsia is a multiorgan disease characterized by the development of hypertension and proteinuria after 20 weeks of gestation. Elevated blood pressure (≥ 140 mm Hg

systolic or ≥ 90 mm Hg diastolic) plus proteinuria (> 0.3 g/24 hours) are indicators for diagnosis (Mammaro et al., 2009).

Diabetes mellitus encompasses a group of metabolic disorders characterized by elevated blood glucose levels resulting from defects in insulin action, insulin secretion, or both. It is primarily categorized into Type 1 Diabetes Mellitus (T1DM), Type 2 Diabetes Mellitus (T2DM), and Gestational Diabetes Mellitus (GDM). GDM, specifically, refers to any degree of glucose intolerance that either begins or is first identified during pregnancy (American Diabetes Association, 2010). This broad definition includes women whose glucose intolerance arises during pregnancy, as well as those with undiagnosed pre-existing diabetes prior to pregnancy (Petry, 2010).

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1.2 Problem Statement and Study Rationale

According to the previous National Health and Morbidity Survey 2016, the prevalence of hypertensive disorders in pregnancy (HDP) was recorded to be 5.8%. The overall prevalence of HDP in Malaysia was 6.5%. Highest prevalence of HDP was found at the state of Malacca (9.8%), followed by Sarawak (9.0%) and Perak (8.9%) while the lowest prevalence was found Pahang (2.6%) (Ratnam et al., 2024). In accordance to a population-based study regarding epidemiological trends of maternal hypertensive disorders of pregnancy at the global, regional, and national levels by Chiuve et al., 2012,

e incidence of hypertensive disorders of pregnancy increased from 16.30 million to 18.08 million with a total increase of 10.92 % from 1990 to 2019. Authors in this study have classified the incidence by age group. As a result, the age-standardized incidence rate decreased, with an estimated annual percent change of -0.68 (95 % confidence interval [CI] -0.49 to -0.86) (Chiuve et al., 2012). Referring to the incidence and prevalence,

the rate of mortality and morbidity were highest in the aged group of 25-29 years, followed by 30-34 and 20-24.

Kim Kim et al. (2002), stated that more than 50% of women with GDM are expected to develop T2DM within 5 years of the index pregnancy. However, the pregnant mother who has been diagnosed with GDM is subsequently at increased risk of developing T2DM (Bellamy et al., 2009) meanwhile her offspring is facing a higher risk of obesity, having impaired glucose tolerance, and diabetes during childhood and early adulthood (Dabelea et al., 2008; Hillier et al., 2007). Malaysia had a very rapid rises within one to two decades with the GDM prevalence currently is around 14-18% of all pregnancies ‘ Based on the 3rd Report of National Obstetrics Registry published by National Obstetrics Registry and Clinical Research Centre, Ministry of Health Malaysia (2015), the incidence of GDM was 8.66% in 2011 and slightly increased to 8.83% in 2012 seen from the 14 tertiary hospitals in Malaysia.

Current evidence suggests a potential association between Vitamin D deficiency during pregnancy cause maternal outcomes, such as increases the risk of preeclampsia, glucose intolerance, gestational diabetes, preterm birth and hypocalcemia crisis in the mother (Suárez-Varela et al., 2022). Vitamin D deficiency can be considered a global pandemic as it ranges from 18-84%, varying by geographical factors, ethnicity, local dressing norms, and culinary traditions (Ponsonby et al., 2010). For certain

population groups women living at high latitudes and low altitudes, with dark skin pigmentation or skin covered by clothing will be at increased risk of vitamin D deficiency (Grover & Morley, 2001), an exception to those with high dietary intake.

1.3 Research Question

1. What is the prevalence of maternal comorbidities in HPUSM?

2. What is the vitamin D status among pregnant women in HPUSM?

3. What is the association between dietary vitamin D intake serum vitamin D levels and maternal comorbidities?

1.4 Research Objectives

1.4.1 General Objective

To investigate the association between vitamin D and maternal comorbidities among pregnant women in HPUSM

1.4.2 Specific Objective

1. To determine the prevalence of maternal comorbidities among pregnant women in HPUSM

2. To determine serum vitamin D status during the third trimester of pregnancy

3. To determine sun exposure level and vitamin D intake among pregnant women.

4. To compare serum vitamin D, vitamin D intake, and sunlight exposure between the maternal comorbidities group and healthy group.

1.5 Research Hypothesis

1.5.1. Hypothesis 1

Null Hypothesis, H_0: There is no association between serum vitamin D levels and maternal comorbidities.

Alternative Hypothesis, H1: There is an association between serum vitamin D levels and maternal comorbidities.

1.5.2. Hypothesis 2

Null Hypothesis, H_0: There is no association between sun exposure and maternal comorbidities.

Alternative Hypothesis, H1: There is association between sun exposure and maternal comorbidities.

1.5.3. Hypothesis 3

Null Hypothesis, H_0: There is no association between diet and maternal comorbidities.

Alternative Hypothesis, H1: There is association between diet and maternal comorbidities

1.6 Significance of the Study

In line with the increased diagnosis of hypertensive disorders in pregnancy (Ratnam et al., 2024). along with gestational diabetes mellitus (Chu et al., 2009), corrective actions to reduce the risk of such maternal comorbidities and increased resources to manage appropriate vitamin D deficiency during pregnancy is required no doubt.

Despite available data that have shown findings supporting the link of vitamin D deficiency may play a role in the development of maternal comorbidities but epidemiologic studies on vitamin D deficiency as one of the risk factors for maternal comorbidities are still at their early stage (Leander-Griffith, 2025) (Wang et al., 2020). However, there is lack of Malaysian study which have investigated the association of vitamin D deficiency with the development of maternal comorbidities. Literature search of published articles on this particular issue demonstrated conflicting findings as well. Thus, the finding of this study may be beneficial in targeting strategies for prevention and intervention of maternal comorbidities along with vitamin D deficiency among Malaysian pregnant women. Characterising trends in maternal comorbidities (hypertensive disorders and gestational diabetes mellitus) might also help understand possible mechanisms for the increase of other comorbidities (Lee et al., 2017).

1.7 Conceptual Framework

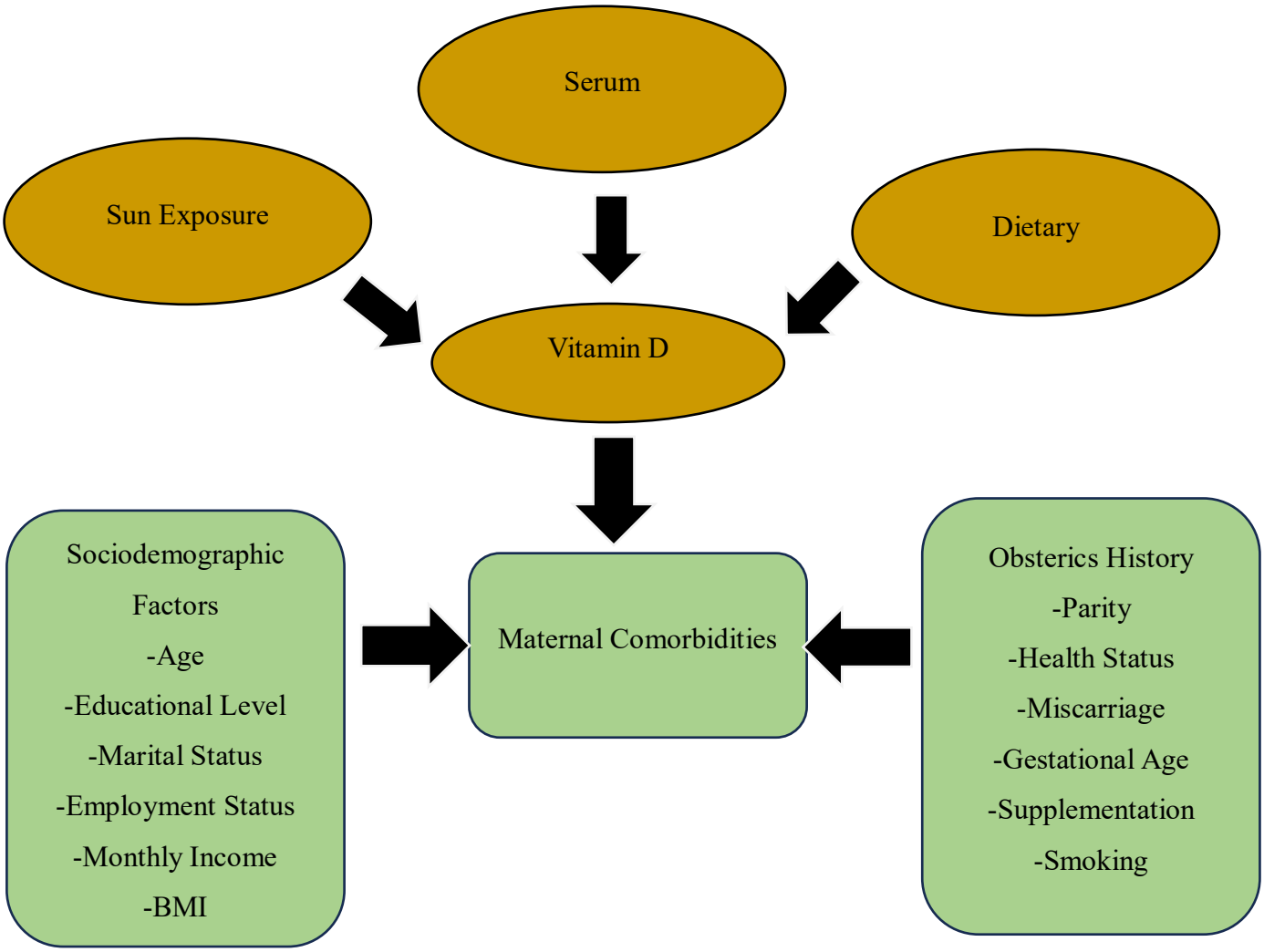


Figure 1.1: Conceptual Framework of Risk Factors of Maternal Comorbidities

CHAPTER 2

LITERATURE REVIEW

2.1 Maternal Comorbidities

Comorbid conditions encountered during pregnancy generally include diabetes and hypoglycaemia; thyroid disorders; hypertensive disorders; cardiac arrhythmias; thromboembolism; asthma; renal disease; urinary tract infections; sickle cell disease; headache; seizures; substance abuse; and intimate partner violence. The definition of comorbidity in general refers to two or more diseases present in a patient (Whelan, 2016)).

Prenatal presence of chronic conditions is known to decline functional capacity and overall health. It increases the risk of complications during pregnancy and childbirth with potential long-term outcomes for both mother and child. The various physiological changes during pregnancy can even unveil certain latent chronic conditions with a significant impact on physical and mental wellbeing. The tendency for adverse outcomes gets amplified when a pregnant woman has multiple long-term conditions -when the co-occurring diseases might exacerbate each other. A systemic review of maternal morbidities highlighted conspicuous research gaps. Despite progress, majority has investigated specific NCDs like gestational diabetes, pregnancy-induced hypertension, or other hormonal disorders (Pati et al., 2022).

2.1.1Hypertensive Disorders in Pregnancy (HDP) and Risk Factors

BMI shows a positive association towards the risk of developing HDP along with smoking and educational level. Compared to subjects with a prepregnancy BMI of <24.0 kg/m^2, subjects with a prepregnancy BMI of 24.0–27.9 and ⩾28.0 kg/m^2 showed a 1.79- and 3.11-fold higher risk of HDP, respectively. Another study reported that women who show a 5 kg/m^2 increase in BMI are associated with a 1.54- and 1.60-fold higher prevalence of HDP. A cohort study of Swedish subjects reported a lower risk of GH and PE among subjects who smoked cigarettes compared with those who did not smoke. However, for PIH, a recent study based on a Japanese perinatal registry has shown that subjects who smoked during pregnancy had a 1.20-fold higher risk for PIH compared with subjects who did not smoke during pregnancy.

Anemia is also a risk factor of HDP where a recent study based on a Japanese perinatal registry has shown that subjects who smoked during pregnancy had a 1.20-fold higher risk for PIH compared with subjects who did not smoke during pregnancy according to the database of the World Health Organization Multicounty Survey (WHOMCS) (Umesawa & Kobashi, 2016). A study by Ye et al., 2014 stated that 16.29% of 2001 women with a twin pregnancy developed HDP as compared with 5.02% of 110,385 women with a single pregnancy. Said result strongly supports previous reports indicating that the risk of HDP in women with a twin pregnancy was 2 or 3 times higher than those with a single pregnancy

2.1.2 Gestational Diabetes Mellitus (GDM) and Risk Factors

Gestational diabetes mellitus is a typical condition of glucose intolerance in which a woman previously undiagnosed with diabetes exhibits high levels of blood glucose during the third trimester of pregnancy. Compared to women who have a history of GDM, the risk of developing classical type 2 diabetes usually ranges from 20 to 50 % (Chen et al., 2014) the risk factors for GDM therefore might contribute directly to the insulin resistance or relative insulin deficiency, or they might be associated or correlated with other factors that they do (Petry, 2010). Generally, the most cited risk factors for the development of GDM are excessive adiposity and advanced maternal age (Zhang and Ning, 2011), epidemic of obesity (Mokdad et al., 1999), previous birth of a macrosomic baby (Ben-Haroush et al., 2004), weight, parity and a family history of T2DM (Petry, 2010; Zhang and Ning, 2011).

Several potentially novel risk factors of GDM proposed for example several studies have provided suggestive findings or evidence of dietary factors and/or physical activity that are associated with the development of GDM. Affirmatively, dietary intervention and dietary counseling or more specifically the Medical Nutrition Therapy (MNT) is the cornerstone of treatment for women with GDM. However, little information is available to allow evidence-based recommendations on the particular nutritional approaches and nutrients distribution to the management of GDM (Metzger et al., 2007).

2.2 Vitamin D

2.2.1 Role of vitamin D in Pregnancy

Generally, there are two forms of vitamin D which are D2 and D3. Vitamin D2 or also known as ergocalciferol is made of plants whereas vitamin D3 or cholecalciferol is made by animals and humans (Wagner et al., 2012). These forms of vitamin Ds require UV light especially in the spectrum of 280-320nm. There is a striking difference in vitamin D metabolism during pregnancy and fetal development compared with nonpregnant and non fetal states (Bikle et al., 1984). Vitamin D has an increasing interest in it effects on placental function and inflammatory response (Robinson et al., 2010). Healthy vitamin D status during pregnancy, typically is indicated by circulating concentrations of 5-hydroxyvitamin D (25(OH)D), is the subject of intense debate. This is because there is lack of data from well-powered, well controlled trials in pregnant women, particularly women with low circulating 25(OH)D at baseline (Kiely et al., 2020).

Recent studies emphasize the importance of nonclassical roles of vitamin D in pregnancy and the placenta. Along with the placenta producing and responding to vitamin D, vitamin D also functions as a modulator of implantation, cytokine production and the immune response to infection. Trophoblasts produces and responds to 1,25(OH)2D. 1,25(OH)2D regulates synthesis of hormones involved in pregnancy and influences the trophoblast anti-inflammatory and anti-microbial responses making it an essential component for a healthy pregnancy and optimal fetal development (Harms et al., 2011). Understanding the nonclassical roles of vitamin D in pregnancy and the placenta is crucial for promoting a healthy pregnancy and optimal fetal development (Kaludjerovic & Vieth, 2010). Research has also shown that vitamin D plays a vital role in fetal lung development and

immune function (Wang et al., 2020) Adequate levels of vitamin D during pregnancy have been linked to a reduced risk of respiratory infections and asthma in offspring. Additionally, vitamin D deficiency in pregnancy has been implicated in the development of childhood allergic diseases (Luo et al., 2022).

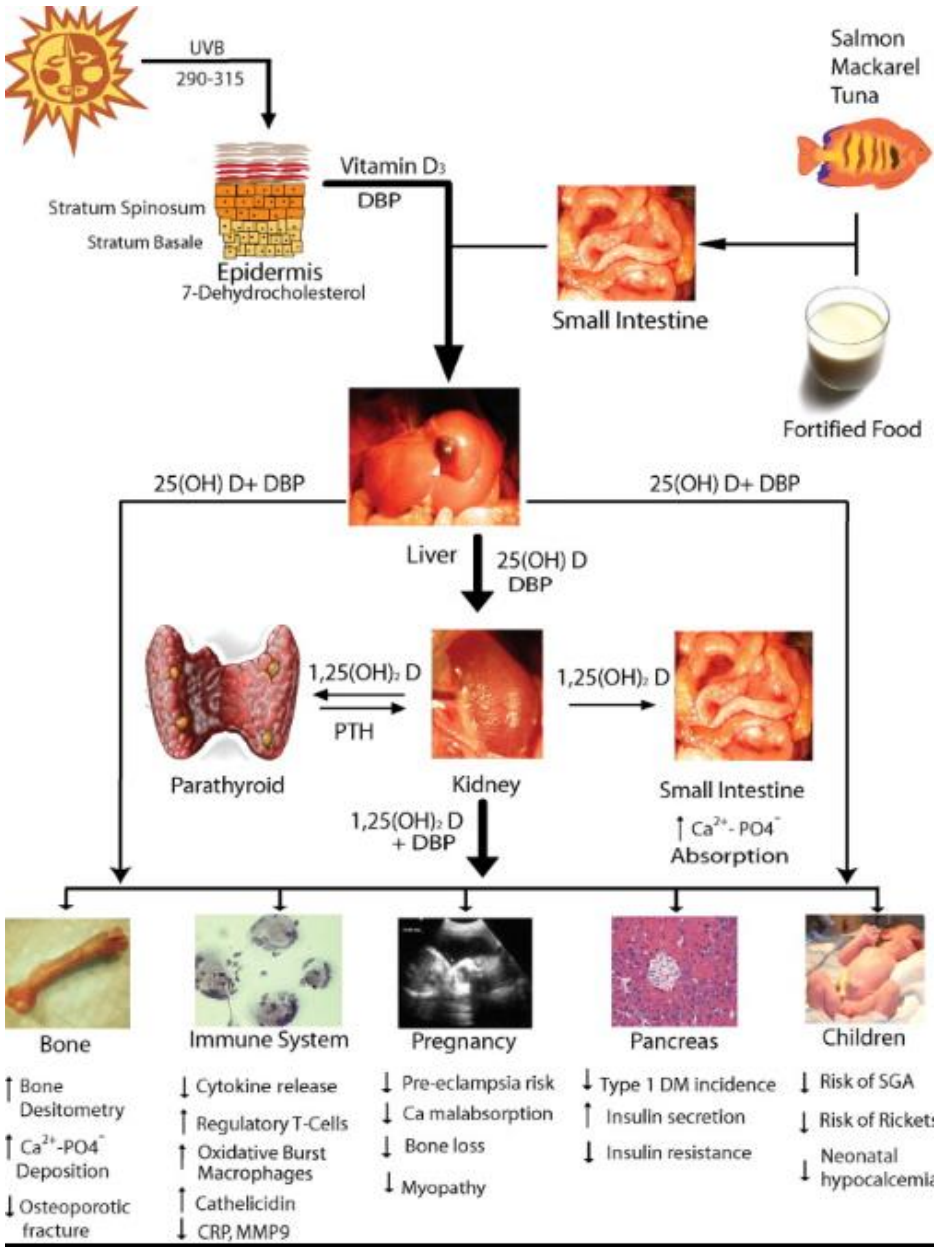


Figure 2.1: Vitamin D metabolism and tissue actions (Singla et al., 2014)

2.2.2 Vitamin D Status in Malaysia

A major community-based survey and selected sample studies were conducted in Malaysia to determine vitamin D status among the general population. For the adult population, a multi-ethnic study involving male and female teachers in Kuala Lumpur, Malaysia showed that 67.4% has vitamin D deficiency (<20 ng/mL) which includes Indian (80.9%), Malay (75.6%), others (44.9%), and Chinese (25.1%). A study conducted among Malay men and women indicated that 87% of women suffered vitamin D deficiency compared to 41% of men. Research shows that women's vitamin D levels are lower on average and because of this, special populations such as menopausal women need to be highlighted. One study among Chinese postmenopausal women (menopause period more than 5 years) in two main urban cities of Malaysia revealed that the majority had serum vitamin D deficiency (82.7%). Meanwhile, a multi-ethnic study reveals that there was substantially higher prevalence of deficiency among Malay postmenopausal women when compared to Chinese women, which were 71.3% and 12.2% respectively.

A large population of adolescents (1361 subjects) aged 12 to 13 years old in Perak, Selangor, and Kuala Lumpur revealed that 78.9% had vitamin D deficiency, where 1.5% were severely deficient; and 13.7% were having insufficiency. Among the subjects, only 7.4 % had an adequate level of vitamin D (Isa et al., 2022). The South East Asian Nutrition Survey (SEANUTS) was conducted throughout Malaysia from 2010 to 2011 (Sabah, Sarawak, and Peninsular Malaysia), involving 3542 children aged four to twelve

years old. Blood results revealed that 47.5% had low vitamin D levels, with girls (54.1%) having a substantially greater prevalence than boys (41.1%). Conversely, a study encompassing 402 children aged seven to twelve years in Kuala Lumpur discovered that 35.3% of children had vitamin D deficiency, and 37.1% of children had vitamin D insufficiency concentrations

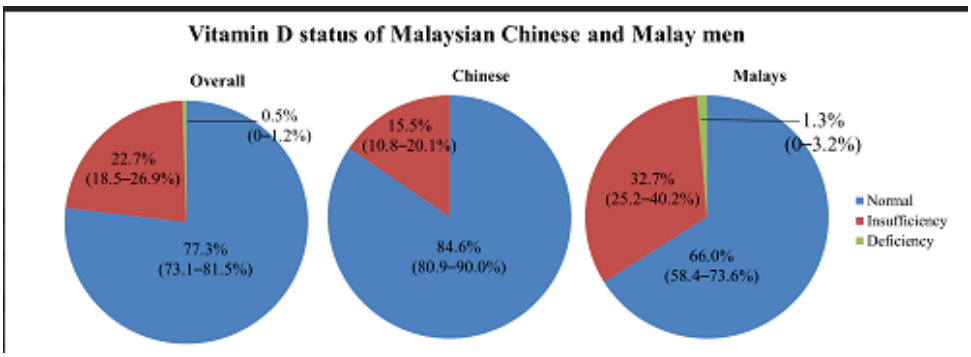


Figure 2.2: Vitamin D status among Chinese and Malay Men (Chin et al., 2014).

2.2.3 Maternal Vitamin D Deficiency

Vitamin D deficiency epidemic during pregnancy is caused by lack of adequate sunlight exposure needed to synthesize vitamin D_3 (cholecalciferol) in the skin along with oral intakes that are too low to meet the increased demands of pregnancy, even with regular use of prenatal vitamins containing 400 IU vitamin D_3 (Bodnar et al., 2007). Plus, since 25(OH) D is stored in the adipose tissue, there are evidence that obesity is a further risk factor for vitamin D deficiency (Ponsonby et al., 2010).

A study done among Malaysian pregnant women in their third trimester states that of the 535 pregnant women recruited, 42.6% were vitamin D deficient. The study found no association between age, educational level, monthly household income, work status, gravidity, parity, pre-pregnancy body mass index, total hours of sun exposure, total percentage of body surface area, and sun exposure index per day with vitamin D deficiency (Woon et al., 2019). Despite being a sunshine-rich country, vitamin D is still

highly prevalent in India with a statistic of 84%. Pregnant women with preeclampsia had lower vitamin D level as compared to normal women (Singla et al., 2014). A recent study in 274 pregnant women showed that vitamin D deficiency at or before week 22 of gestation was an independent predictor of preeclampsia. There is a 5-fold increase in the risk of preeclampsia among patients with 25(OH)D levels <15 ng/mL despite receiving prenatal vitamins (Singla et al., 2014).

2.3 Sources of Vitamin D

2.3.1 Dietary of Sources of Vitamin D

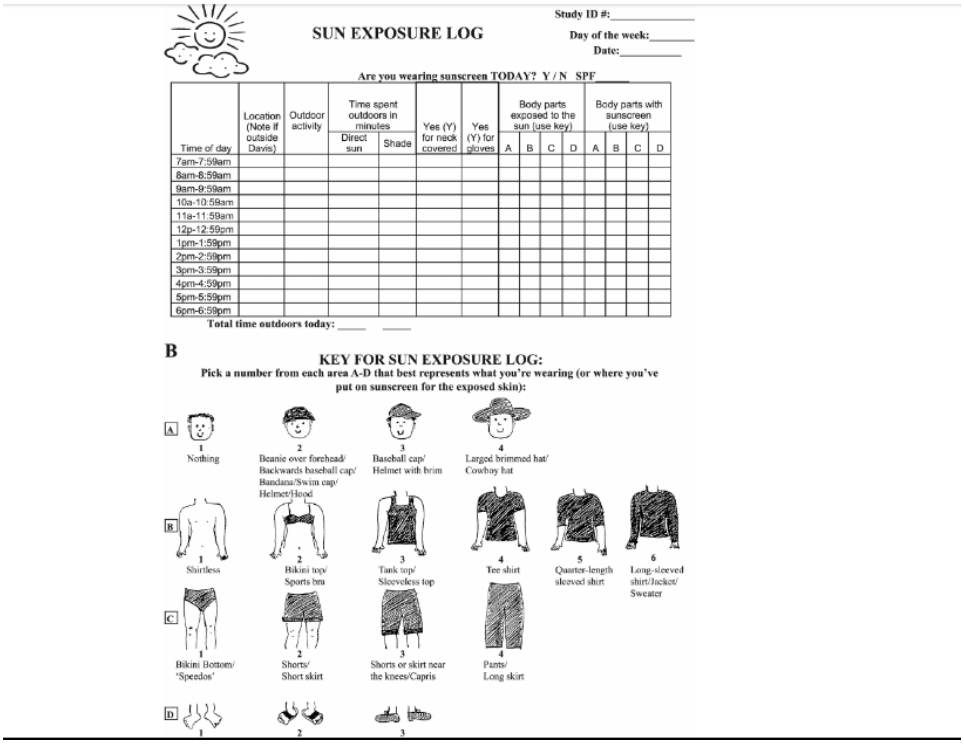
Only a limited range of foods qualify as rich sources of vitamin D. High amounts of vitamin D are found in fatty fish, including sardines, tuna mackerel, and salmon, as well as cod liver oil. Apart from providing ample amount of vitamin D, cod liver oil serves as a valuable source of vitamin A and n3- fatty acids. Eggs and their yolks, mushrooms, and liver are also recognized as sources of this essential nutrient (Giourga et al., 2023). A study conducted among Malaysian pregnant women in the third trimester displays a total of 80.4% of the vitamin D was obtained from food sources, while the rest were from dietary supplements (19.6%). The data in this study revealed that fish and fish products (35.8%) showed the highest contribution to vitamin D intake, followed by milk and milk products (28.2%), eggs (9.1%), meat and meat products (3.9%), others (1.3%), beverages (1.2%) and cereal and cereal products (0.9%)(Woon et al., 2019b). Nevertheless, is it vital to emphasize that sunlight remains the primary source of vitamin D intake, accounting for 90% of the body's daily vitamin D requirements (Giourga et al., 2023).

2.3.2 Sunlight Exposure

Sunlight-derived vitamin D triggers the downregulation of certain enzyme systems and the upregulation of others in the body to dispose of any vitamin D and unneeded metabolites in the body. Wise amount of sunlight exposure is not a clear-cut entity, but the amount of sunlight sufficient to achieve optimal vitamin D status varies depending on the time of year, the time of day, where you live (i.e., latitude), degree of skin pigmentation, clothing and what surface area of skin is exposed (Cockburn et al., 1980). In a study published by the Turkish Journal of Pediatrics, the style of clothing worn while outdoors was assessed for how much skin it exposed to the sunshine. "covered" style of dress was defined as one covers the hair and wear garments that completely covered the arms and legs. The study revealed that mothers whose clothing style was uncovered had mean serum 25-OHD levels higher than those of mothers wearing a covered style of clothing (Bahar Çuhacı-Çakır and Fatma Demirel, 2025).

There are many means of sun exposure evaluation. One method involves questionnaire where one section is dedicated to amount of daily sunshine exposure in the preceding week and the extent of skin covered by clothing. Another method, sun exposure was evaluated among pregnant Malaysian women in their third trimester using a Seven-day Sun Exposure Recall. Respondents were required to record their outdoor activities over the past one week (from 7am to 7pm) in terms of type of activity, duration (in minutes),

frequency (per week), clothing, sunscreen use, gloves, and umbrellas. Body surface area (BSA) exposed to sunlight was estimated by using the “Rule of Nine” adopted from Hall et al.. Sun exposure index (SEI) was calculated by multiplying the time spent outdoors with BSA exposed (Woon et al., 2019). Sun exposure diaries can also be utilized. In a study, each participant completed sun exposure diaries on 2 random days per week during the 12-wk intervention period. Extra sun exposure diaries were given to the participants to record high–sun exposure time periods that were outside the required days. The diaries contained key information to determine total UVB energy exposure and the percentage body surface area (BSA) exposed (BSAE) as shown in the figure below (Piccolo et al., 2019).



SUN EXPOSURE LOG

Study ID #:_____
Day of the week:_____
Date:_____

Are you wearing sunscreen TODAY? Y / N SPF____

Time of day	Location (Note if outside Davis)	Outdoor activity	Time spent outdoors in minutes: Direct sun	Time spent outdoors in minutes: Shade	Yes (Y) for neck covered	Yes (Y) for gloves	Body parts exposed to the sun (use key): A	B	C	D	Body parts with sunscreen (use key): A	B	C	D
7am-7:59am														
8am-8:59am														
9am-9:59am														
10a-10:59am														
11a-11:59am														
12p-12:59pm														
1pm-1:59pm														
2pm-2:59pm														
3pm-3:59pm														
4pm-4:59pm														
5pm-5:59pm														
6pm-6:59pm														

Total time outdoors today: ____ ____

B

KEY FOR SUN EXPOSURE LOG:

Pick a number from each area A-D that best represents what you're wearing (or where you've put on sunscreen for the exposed skin):

A
1 Nothing
2 Beanie over forehead/ Backwards baseball cap/ Bandana/Swim cap/ Helmet/Hood
3 Baseball cap/ Helmet with brim
4 Larged brimmed hat/ Cowboy hat

B
1 Shirtless
2 Bikini top/ Sports bra
3 Tank top/ Sleeveless top
4 Tee shirt
5 Quarter-length sleeved shirt
6 Long-sleeved shirt/Jacket/ Sweater

C
1 Bikini Bottom/ 'Speedos'
2 Shorts/ Short skirt
3 Shorts or skirt near the knees/Capris
4 Pants/ Long skirt

D
1
2
3

Figure 2.3: Sun Exposure Log

2.4 Maternal Comorbidities Associated with Vitamin D

Pregnant women are highly vulnerable to vitamin D deficiency. Clinical studies establish an association between vitamin D levels and adverse comorbidities such as preeclampsia and gestational diabetes, along with pregnancy outcomes like low birth weight, preterm labour, and caesarean delivery. A systematic review reported that maternal low levels of vitamin D during pregnancy lead to a greater risk of gestational diabetes, preeclampsia, and other complications (Suárez-Varela et al., 2022b).

2.4.1 Hypertensive Disorders in pregnancy and Vitamin D

Till today, trial evidence appears insufficient to lean towards a protective effect of Vitamin D during pregnancy against the risk of preeclampsia owing to a small sample size or low study quality. Plus, findings from observational studies regarding the association between maternal vitamin D status and HDP differ due to the large heterogeneity between study designs, lack of adherence to standardized outcome definitions, and different gestational weeks of Vitamin D detection (Si et al., 2022). According to Leander-Griffith, 2025., a study among non-black Hispanic women it is reported that Low vitamin D status during pregnancy may lead to an increased risk for hypertensive disorders in pregnancy. Nevertheless, more research on a larger sample size is needed to determine the true extent of the association of vitamin D status with

HDP in the general population and that of non-Hispanic Black women (Leander-Griffith, 2025).

2.4.2 Gestational Diabetes Mellitus and Vitamin D

Several studies have reported a significant relationship between vitamin D deficiency and GDM, while others did not find such an association. Opinions on the relationship between GDM and vitamin D deficiency are inconsistent. A total of 21 articles with a population of 16,177 have reported a relationship between vitamin D and the risk of GDM. Among that, 2 studies reported a significant relationship and 19 studies reported no significant relationship. This study also describes physical activity as an important confounder of the relationship of vitamin D and GDM. Due to sunlight exposure active women have less risk of developing impaired glucose tolerance and seem to have higher serum vitamin D levels than fewer active women. In this meta-analysis, a total of 43 articles compared the vitamin D levels between GDM and healthy subjects. In total 21 articles reported a relationship between vitamin D status and risk of GDM, 2 articles reported a significant relationship and 19 articles reported no significant relationship (Wang et al., 2020).

Studies provide sufficient rationale for the function vitamin D in glucose homeostasis. There are possible mechanisms that show the interrelation between the alteration in glucose metabolism and vitamin D status (Arshad et al., 2022).

CHAPTER 3

METHODOLOGY

3.1 Research Design

The research design of this study is a comparative cross-sectional study conducted among women in their 36th to 38th week of pregnancy. Data were collected at the Obstetrics and Gynaecology clinic at Hospital Pengajar Universiti Sains Malaysia (HPUSM). Analysis was performed to evaluate the association between dietary intake, sunlight exposure, and serum vitamin D levels. Additionally, the prevalence of maternal comorbidities among pregnant women who visited the Obstetrics and Gynaecology clinic was identified. This research was conducted in collaboration with an ongoing study, "Investigating the Role of Genetic Variations in Vitamin D Receptors in the Development of Postpartum Depression via Inflammatory Mediation (ViViDD Study)."

3.2 Sampling Method

Study subjects were selected through purposive sampling technique which is one of the non-probability sampling techniques. Study subjects who fulfilled all the inclusion criteria were recruited in the study.

3.3 Study Period

The period of data collection for this study was from 17 February 2024 to December 2024

3.4 Subject Criteria

3.4.1 Inclusion Criteria

1. Pregnant women receiving prenatal care at Hospital Pengajar Universiti Sains Malaysia (HPUSM)
2. Pregnant Women in the third trimester of pregnancy specifically 36^{th} to 38^{th} weeks of gestation
3. Willingness to participate in the study and provide informed consent
4. Availability for follow-up visits and completion of study assessments.

3.4.2 Exclusion Criteria

1. Pregnant women with a known history of vitamin D deficiency or receiving vitamin D supplementation prior pregnancy
2. Pregnant women with high-risk pregnancy diagnosed by the O & G Specialist

3.5 Study Location

Data collection was conducted at Obstetrics and Gynecology (O&G) clinic of Hospital Pengajar Universiti Sains Malaysia (HPUSM). Data was collected every Sunday, Tuesday, and Thursday from 8.00am until 12.00pm.

3.6 Sampling Method

Study participants were selected through a purposive sampling technique. This is due to the recruitment of pregnant women who are in their 3rd trimester, specifically falling within the range of 36th to 38th gestation weeks. The study subjects are classified into healthy and maternal comorbidities groups. The maternal comorbidities group comprises of study subjects with hypertensive disorders in pregnancy (HPD) and Gestational Diabetes Mellitus (GDM). On the other hand, healthy group comprises of subjects without HPD and GDM.

3.7 Sample Size Calculation

The primary focus of this study was to compare the sunlight exposure, dietary vitamin D intake, and serum vitamin D of healthy pregnant women and women with maternal comorbidities. Therefore, an appropriate sample size was required to investigate the association between dietary GI and nutritional status. The sample size of this study was computed via PS software, Version 3 (Appendix A). The calculation was according to the following input:

Type 1 error probability (α) = 0.05

Power = 0.8

Difference in population means (δ) on pre-pregnancy BMI = 2.8

Standard deviation (σ) = 4.1

Ration (m) = 1 (Thomas et al., 2006)

Output = 35 Drop out compensation of 20% = 7 Sample size = 42 study subjects per group

The sample size population was calculated with 80% power and 5% at significance level. The output demonstrated that 35 study subjects per group were required in this study.

After deliberating 20% drop out compensation, the total sample size needed in this study were 42 study subjects for healthy group and 42 study subjects for the maternal comorbidities group. However, this study has exceeded the minimum number of study subjects required for both groups which is 152 for the healthy group and 55 for the maternal comorbidities group.

3.7 Ethical Consideration

Ethical approval was obtained from the Jawatankuasa Etika Penyelidikan Manusia Universiti Sains Malaysia (JEPeM-USM) before the study (JEPeM Code: USM/JEPeM/PP/23030239). was started. Permission to collect data in O&G Clinic was also approved by Assoc.Prof.Dr. Tan Cheng Ling, Deputy Chairperson Jawatankuasa Etika Penyelidikan Manusia Universiti Sains Malaysia (JEPeM-USM) (Appendix I). The study subjects were given an informed consent form (Appendix J) attached with a document that explained the details regarding this study.

The study's purpose, procedures, participants' rights, and the potential risks and benefits of participation were thoroughly explained to the study subjects. They were guided through the process of providing informed consent and signed the consent form only after fully understanding the study's details. Participants were assured of the anonymity and confidentiality of the information they provided before agreeing to participate. All data collected from the study subjects were kept strictly confidential and used solely for research purposes. Participation in the study was entirely voluntary, and participants retained the right to withdraw at any time without any consequences

3.8 Research Tools

3.8.1 Questionnaire

Patients were interviewed to obtain information which included sociodemographic background, dietary intake, sun exposure evaluation,obstetrics history and data collection was carried out for 11 months.

3.8.1.1. Sociodemographic, Questionnaire

This section comprised a total of 18 questions. The initial five questions were structured to collect identification information, including the participant's name, research location, age, contact number, RN number, and ID number. RN number is

The subsequent questions were semi-structured and focused on various sociodemographic and lifestyle factors, including race, education level, marital status, height, weight, employment status, family planning, socioeconomic status, average sleep duration and smoking status during their pregnancy.

3.8.1.2 Sun Exposure Evaluation

There were five parts to this section, where patients were required to answer the first four parts during pregnancy whereas the fifth part was postpartum. However, the postpartum evaluation is not included in this study. Patients were evaluated via multiple-choice questions and a sun exposure log which is semi-structured. The first part consisted of the frequency of sun exposure during pregnancy with options rarely ($\leq$ 1 day), sometimes (2-4 days) frequently ($\geq$ 5 days). The second part consisted of the frequency of outdoor activity during pregnancy $<$ 60 minutes/week and $\geq$ 60 minutes/week. The third part consisted of the use of sunscreen during pregnancy with options yes and no. Patients were