UNIVERSITAS INDONESIA

MATERNAL DIETARY DIVERSITY AT THIRD TRIMESTER AND INFANT BIRTH WEIGHT IN EAST JAKARTA, INDONESIA

THESIS

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FACULTY OF MEDICINE
STUDY PROGRAM IN NUTRITION
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Submitted in partial fulfillment of the requirements for Master of Science in Community Nutrition

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AUTHOR'S DECLARATION OF ORIGINALITY PAGE

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ABSTRACT

Name : Nursyifa Rahma Maulida
Study Program : Community Nutrition
Title : Maternal Dietary Diversity at Third Trimester and Infant Birth Weight in East Jakarta, Indonesia

Background: Dietary Diversity Scores (DDS) has been examined related to nutrient adequacy and nutritional status. DDS can serve as a simple and reliable indicator of dietary quality that can predict birth outcomes such as birth weight has received a little attention.
Objective: The aim of this study is to examine the relationship between dietary diversity scores (DDS) among pregnant women in third trimester and Infant Birth Weight in East Jakarta.
Method: This cross sectional study was done in East Jakarta among pregnant women 19– 44 years with gestational aged >32 weeks, consist of 288 pregnant women. Respondents are chosen based on consecutive sampling method. A structured questionnaire was used to collect data on socioeconomic-demographic variables, maternal factors; anthropometric measurement to collect nutritional status of mother and infant; biochemical assessment (hemoglobin concentration); and dietary diversity scores method.
Result: 63.2% of pregnant women were high DDS. DDS had a significantly associated with the birth weight (Adj.OR=2.8). Mother's age 26–35 years (Adj.OR=2.5), body weight in late pregnancy (Adj.OR=2.6) and DDS were a strong predictor to increased the birth weight more than 3,000 gram. In addition, well-educated mother is one of the factor affecting the dietary diversity.
Conclusion: Dietary Diversity Scores at third trimester associated with infant birth weight.

Keywords ***:*** *Dietary Diversity Scores, Infant Birth Weight, Maternal Factor, Maternal Nutritional Status, Pregnant Women*

ABSTRACT

Name	:	Nursyifa Rahma Maulida
Study Program	:	Gizi
Title	:	Keragaman Makanan di Trimester Tiga pada Ibu Hamil dengan Berat Badan Lahir Bayi di Jakarta Timur, Indonesia

Latar Belakang: Keragaman Makanan telah diidentifikasi berhubungan dengan kecukupan zat gizi dan status gizi. Metode keragaman makanan merupakan indicator yang mudah dan reliable pada kualitas zat gizi yang dapat memprediksi hasil dari kelahiran memiliki ketertarikan untuk diketahui.
Objektif: Tujuan dari penelitian ini adalah untuk mengetahui hubungan antara keragaman makanan pada trimester tiga dengan berat badan lahir bayi di Jakarta Timur, Indonesia.
Metode: Penelitian ini menggunakan desain penelitian potong lintang di Jakarta Timur pada ibu hamil umur 19–44 tahun pada umur kehamilan >32 minggu, yang terdiri dari 299 ibu hamil. Responden dipilih menggunakan metode konsekutif. Kuesioner terstruktur digunakan untuk mengumpulkan data sosioekonomi demografi, faktor kehamilan; pengukuran antropometri untuk pengukuran status gizi pada ibu dan bayi; pengukuran biokimia (Hb), dan keragaman makanan.
Hasil: 63.2% ibu hamil memiliki keragaman makanan yang tinggi. Keragaman makanan berhubungan secara statistic dengan berat lahir (Adj.OR=2.8). Umur ibu sekitar 26-35 tahun (Adj. OR=2.5), berat badan ibu pada trimester tiga (Adj. OR=2.6), dan keragaman makanan adalah prediktor yang kuat untuk mempengaruhi berat badan lahir bayi. Selanjutnya, pendidikan ibu adalah satu faktor yang mempengaruhi keragaman makanan.
Kesimpulan: Keragaman makanan di trimester tiga pada ibu hamil berhubungan dengan berat badan lahir

Kata Kunci *:* Keragaman makanan, Berat badan lahir, Faktor kehamilan, Status gizi, Ibu Hamil

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LIST OF ABBREVIATIONS

WHO	:	World Health Organization
UNICEF	:	United Nations Children's Fund
FAO	:	Food and Agriculture Organization
FANTA	:	Food and Nutrition Technical Assistance
OECD	:	Organisation for Economic Cooperation and Development
CDC	:	Centers for Disease Control and Prevention
LBW	:	Low Birth Weight
IUGR	:	Intrauterine Growth Retardation
ACC	:	Administrative Committee on Coordination
SCN	:	Sub-Committee on Nutrition
SUMMIT	:	The Supplementation with Multiple Micronutrient Intervention Trial
DDS	:	Dietary Diversity Scores
IDDS	:	Individual Dietary Diversity Scores
HDDS	:	Household Dietary Diversity Scores
WDDS	:	Women Dietary Diversity Scores
WDDQ	:	Women Dietary Diversity Questionnaire
BMI	:	Body Mass Index
MUAC	:	Mid Upper Arm Circumference
GWG	:	Gestational Weight Gain
RDA	:	Recommended Dietary Allowance
RSUD	:	*Rumah Sakit Umum Daerah*
Riskesdas	:	*Riset Kesehatan Dasar*
Puskesmas	:	*Pusat Kesehatan Masyarakat*

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CHAPTER 1
INTRODUCTION

1.1. Background

The critical window of opportunity for child's health and development started from pregnancy to the age of two. It is known as the first 1,000 days of child's life [1]. As part of critical period of the 1,000 days, pregnant women play an important role to determine birth outcome including fetal growth and development [2]. Birth weight is one of several indicators that determine the fetal growth [2]. It has independent effects on fetal and neonatal mortality, where groups with lower mean birth weight often have higher infant mortality [2, 3].

Low birth weight (LBW) is defined as birth weight of infant less than 2,500g [4]. It can cause around 60-80% of morbidity and mortality in the neonatal period throughout the world, especially in the developing countries [5]. Moreover, LBW can affect the quality of future generations due to it can delay the growth and development of the child [6]. Eventually, LBW is the risk factor to chronic disease such as diabetes and ischemic heart disease [7]. Unexpectedly, the prevalence of LBW in Indonesia was around 10.2% that the number was still above the target of "The World Summit for Children"[8]. Several factors such as the fetus, placenta, and the mother can describe complex interaction contributing to birth weight [9]. Furthermore, GWG during pregnancy, maternal stature, and low pre-pregnancy BMI are the most important factors affecting the birth weight, where LBW mostly caused by intrauterine growth restriction (IUGR) especially in developing country [10].

The similar result was found from previous study in Indonesia that birth weight was affected by factors such as maternal nutritional status (chronic energy deficiency (CED), height [11], body mass index (BMI), and gestational weight gain (GWG)) [12]; socioeconomic status (education and wealth); and maternal factors (parity and birth interval) [11, 12]. Moreover, maternal nutrition including nutritional intake and nutritional status are two main modifiable factors influencing birth weight [9]. Abu-Saad and Fraser 2010 also found that maternal dietary influences on birth outcomes [13]. It can reduce the adverse outcome like LBW [13]. Therefore, pregnancy is time to ensure adequate dietary intake for optimal birth weight due to maintain the growth of maternal and fetal tissue especially in the third trimester [14]. In addition, the largest increment of energy requirement occurs in the late pregnancy [15].

Efforts to improve maternal and fetal nutrition have focused on achieving appropriate energy, protein, vitamins, minerals, and other nutrients [2], because multiple nutrient deficiencies are more likely to occur than single deficiencies [13] and it has generally been successful to increased fetal growth [16]. Therefore, consuming a wide variety of food among and within food group is a recommended strategy to ensure adequate intake [2].

Pregnant woman is one of the vulnerable groups where the problem of them will be particularly critical [17]. They need to provide the nutrient demands for both mother and the fetus [17]. In other side, to conduct and analyze dietary assessment using conventional quantitative dietary assessments are costly and cumbersome [18, 19]. However, there is a simple indicator that can be measured quickly and easily, which is dietary diversity [18].

Dietary diversity as a proxy of quantitative dietary intake is used to assess the quality of the diet. Dietary diversity scores (DDS) as a method is based on the number of different foods or food groups consumed over a given reference period [18]. It can capture the overall adequacy of nutrient intake [18]. Studies in different age showed that an increase in individual dietary diversity scores (IDDS) was related to increased nutrient adequacy of the diet [20]. Furthermore, positive associations between DDS and nutritional status among both children [21, 22] and women had been documented previously [23, 24].

Study from developing country among women showed that DDS was correlated with nutritional status of women include BMI, mid upper arm circumference (MUAC), waist-hip-ratio (WHR), and skin fold thickness [25]. Interestingly, the study on dietary diversity related to pregnant women in Northen Ghana has been examined. They found that DDS could serve as useful predictive indicator of maternal nutrition and the likelihood of delivering LBW babies [19].

Therefore, this study is aiming to investigate the association between DDS which can provide the indicator of dietary intake among pregnant women and infant weight at birth needed especially in developing countries. It will also identify the determinants of birth weight among pregnant women in East Jakarta.

1.2. Problem Statement

According to WHO, Indonesia had the prevalence of LBW in 2010 around 11.1% [4]. In other site, based on the National Health Survey in 2013, the prevalence was 10.2% [8]. This number has been reducing from previous year in Indonesia, but it is still above the target of "The World Summit for Children" which is below 10% for LBW [4]. Adequate dietary intake during pregnancy is an important point that can affect fetal growth such as birth weight [17]. Jakarta as capital city of Indonesia had availability of food to meet the requirement of nutrient during pregnancy, better health facilities and care services, but the prevalence of LBW in Jakarta was not far from National level around 10% [8]. Moreover, there was an increment of LBW's incidence nationally during five years (from 5.3% in 2006 to 5.8% in 2010) and Jakarta had also higher incidence around 5.4% [26]. It concludes that unsolved problem occurred in Jakarta.

Dietary Diversity Scores (DDS) had showed to be valid proxy indicators of good quality diets. It also related to nutrient adequacy of both macronutrients and micronutrients intake [20, 23]. Not only the nutrient adequacy, but also DDS associated with nutritional status which has also been demonstrated among children and women [21, 25]. As to whether DDS can serve as a reliable indicator of dietary intake that can predict birth outcomes such as birth weight has received little attention. Moreover, there was less evidence on examining the dietary diversity in Urban area [24]. Therefore, further research in Indonesia as developing country, especially in East Jakarta needed where measurement of nutrient intake was problematic.

1.3. Research Question

How is the relationship between maternal dietary diversity particularly in third trimester and birth weight in East Jakarta?

1.4. Objectives of the Study

The general objective is to examine the association between maternal dietary diversity at third trimester and birth weight in East Jakarta. The specific objectives are:

1. To measure the infant weight at birth.
2. To develop the indicator of food group which can determine the minimum dietary diversity of pregnant women at third trimester.
3. To measure the determinants that may contribute to the dietary diversity scores (DDS) at third trimester.
4. To measure other predictors that may have a relationship with infant weight at birth such as socioeconomic-demographic, maternal factors, behavioural factors, maternal nutritional status, and gestational aged at birth.

1.5. Benefit of the Study

The benefits of the study are:

1. To contribute the body of knowledge on maternal DDS at third trimester in related to child health, especially in urban area.
2. To provide the recommendation related to dietary diversity among pregnant women on increasing the child health.

CHAPTER II
LITERATURE REVIEW

2.1 Birth weight

2.1.1 Definition of Birth Weight

Birth weight is the first weight of the newborn which is measured within the first hour of life before the significant postnatal weight loss occurred [9]. Birth weight is one of the most accessible and reliable indicators and universally measured. In general, birth weight is an indicator of fetal growth and developmental processes that influence long-term health [27].

2.1.2 Classification of Birth Weight

The normal birth weight has been defined as newborn baby who has 2,500–4,000g without calculate the gestational age [28]. According to the definition, birth weight of newborn less than 2,500g is classified as low birth weight (LBW). Other categories of LBW are very low birth weight (baby who has birth weight 500–1499g) and extreme low birth weight (baby who has birth weight less than 500g). Moreover, newborn baby who has weight at birth more than 4,000g is categorized as high birth weight [29].

Birth weight and gestational age have independent effects on fetal mortality. LBW is either the result from preterm birth and or fetal growth restriction [30]. Preterm birth is defined as low gestational age at birth (<37 weeks of gestation) [30]. It is commonly caused by the baby's born too early, which indicates the babies are likely having a small weight [30, 31]. And the definition of fetal growth restriction is that the babies born in the full term or small for gestational age (SGA) whiles the birth weight is less than the normal weight. It might be because of slow growth in uterus [30, 31].

In developing countries, the majority of LBW babies are SGA but are not born prematurely. LBW babies caused by preterm birth are more prevalence in developed countries. Nevertheless, 6.7% of LBW babies are born preterm in developing countries [30, 32].

2.2 Determinants of Birth Weight

2.2.1 Socioeconomic-demographic Factors

Socioeconomic status such as maternal education, household income, wealth has been found as a predictor on birth weight. The previous study explained that maternal education is found to be positively correlated with birth weight on several mechanisms [33]. More educated people are known can improve the financial resources available through increased earnings [34]. Additionally, higher birth weight is found on high family status such as mothers and father's employment, education, and social class [33]. It can determine the availability and affordability to get food, especially healthy and variety food.

Moreover, maternal education will contributes her ability and capacity to process and use medical information [35] for instance, information on maternal health and nutrition. Another study has also similar result that more educated mothers are more ability and has the willingness then the awareness of changed their health behaviour [36, 37]. In the conclusion, maternal education can either, become a proxy indicator for an income effect or affects maternal health.

Wealth has been consistently demonstrated to be associated with better pregnancy outcomes [11]. In multivariate analysis, the odds of having LBW were lower for women in higher wealth index [38]. It may result of affordability of the mother to access food, education, health care and prenatal care during pregnancy, which reduce the adverse outcome. Women in low socioeconomic status are more likely to have inadequate food intake, inappropriate house condition, inability to get health care facilities and sanitation which increase the adverse pregnancy outcome [39].

2.2.2 Maternal factors

2.2.2.1 Obstetric history

Genetic factors play a significant role in determining birth size. Epidemiological studies showed that 38–80% of birth weight variance is influenced by genetic factors [40]. The significant correlation of parental birth weight and the newborn weight at birth has also been observed. The Scandinavian study found that maternal and paternal birth weights were significantly lower in families with two small for gestational age (SGA) births compared with families with no SGA births [41]. The similar result was found in the United States [42].

Furthermore, a previous history of preterm birth or delivery of low birth weight infant is a major predictor of subsequent preterm delivery. The study found that women with a prior spontaneous preterm delivery carried 2.5 increased risk of preterm delivery compared with those with no have history [14]. However, finding on birth weight cannot be explained by recognized genetic factors alone [43].

2.2.2.2 Maternal age

Maternal age has been identified as factors influence the birth weight of newborn baby. Pregnancy at an earlier age and older women has the same risk on having low birth weight [31]. Increased risk of low birth weight in some adolescents is because the blood supply to the cervix and uterus has not completely, which leads poor supply of nutrients to the fetus. This condition tends to increased risk of infection which triggers the preterm births [44]. Previous study indicated that in young mothers, incomplete physical growth might also contribute to adverse outcomes due to maternal-fetal competition for nutrients [45].

Among older women, possible reason can be explained for having the risk on birth outcomes. For instance, they might be having a higher prevalence of any chronic disease which can contribute the birth outcomes like preterm birth and SGA [46]. Low uteroplacental dysfunction caused by poor uterine vasculature may be related to fetal growth restriction in older women [47]. These results lead to the possibility of a lower mean birth weight of newborn.

2.2.2.3 Parity

There is an association between parity and birth weight. Parity is defined as number of previous pregnancies of the mother whether the child was born alive or stillbirth [48]. The result from Shah in 2010 shown that nulliparity was associated with reduction in birth weight [49]. Inconsistency, the study in Vietnam concluded that birth weight was associated with the parity, which indicated women who birth more than two have led to lower mean birth weight than the normal weight [50].

In another concern, primigravidae are more likely to give birth to small for gestational age babies than multigravidae.The mechanism is in a normally grown fetus, the maternal plasma volume increases by about 50% with possibly an additional 5% in multigravidae [51]. Thus, the increase in plasma volume will be influenced by multigravidae.

2.2.2.4 Birth Spacing

Short interval (<18 months) and long interval (>60 months) between pregnancies are associated with LBW, preterm birth, and SGA. The study hypothesized that short interval may result in inadequate replenishment of maternal nutrient stores in the body [52]. Women with a short interval are likely to have risk of obstetric complications [53]. Another hypothesis related to long interval between pregnancies is that mother's ability to facilitate growth to the fetus declines and it may cause secondary infertility [54]. Both short and long intervals can reduce the fetal growth and therefore its result is the birth weight.

2.2.3 Maternal Disease and Infections

An estimated 5–10% of all IUGR cases are caused by infection. Preeclampsia, diabetes mellitus, renal disease are all common cause of IUGR. Thus, it is associated with the fetal growth including the birth weight. While mothers have an infection, the supply of maternal nutrients may be less available to the fetus. It will reduce the blood flow and fetoplacental circulation [43]. Moreover, the structure of the placenta can be damaged due to nutrient transfer is impaired. The problem of reduced appetite is often during an infection. It has an impact by increased cytokines and decreasing intestinal reabsorption, which is related to requiring more energy, protein, and micronutrient intake [43].

2.2.4 Maternal Behaviour

2.2.4.1 Cigarette Smoking and Alcohol Habit

Maternal smoking and alcohol consumption result in low birth weight deliveries due to it can limit the fetal growth. Smoking is one of the maternal behaviour which most affects fetal growth, including exposure to passive smoking [55].

Second-hand smoke (SHS) exposure is often in working place, public transportation, and even in home. The condition of pregnant women can be dangerous when the toxic compound exhaled [56]. Several studies approved that an increased risk of preterm birth and IUGR was observed among smokers [57, 58].

The mechanisms of cigarette smoking are reduced expansion of plasma volume, increased maternal plasma carbon monoxide and blood viscosity where its consequences affect into the fetal directly [57]. Not only smoking, alcohol consumption has a several consequences on birth outcomes include fetal growth and development [9]. The effect of this lifestyle can increase an adverse effect on fetal alcohol effects (FAE) such as fetal alcohol syndrome and neuro developmental disorders of the fetus [31].

2.2.5 Maternal Nutritional Status

2.2.5.1 Maternal Weight

Study found that the risk of giving birth SGA significantly increases with mothers who have pre-pregnancy weight below 50kg [43]. It may also increase the risk of IUGR [14]. The mechanism is reflected on adequacy and inadequacy of nutrients in the mother's pre-pregnancy weight which can determine the fetal growth, include the birth weight of newborn [14, 43].

2.2.5.2 Maternal Height

Maternal height is an important determinant of birth weight. Several studies found that smaller babies are delivered by women who are short compare with tall mothers [59, 60]. It reflects an association between height, uterine size, and blood flow [9]. Previous study from Bisai, 2010 revealed the cut-off that short mothers (≤145 cm) had greater risk on having LBW compare to mothers who had height average 146–155 cm and more than 155 cm [61]. These affects are associated with genetic factors, physical limitations imposed on the growth of the placenta, uterus, and the fetus.

2.2.5.3 Maternal Gestational Weight Gain

Gestational weight gain is a unique and complex biological mechanism that contributes the functions of growth and development of the fetus [14].What studies have established is that women who are extremely thin are also more likely to have smaller infants[43]. Consistently, women who tend to have successful outcome is that the women who have better nutritional status due to meet the demands imposed by the pregnancy [9, 14]. Therefore, body mass index (BMI) may become a better indicator of maternal nutritional status than is weight alone.

Pre-pregnancy BMI is calculated to determine the optimal weight gain [14]. It has implications for both mother and fetus. Additionally, its implications are associated with the pregnancy outcome and birth outcome [2]. Gestational weight gain during the second and third trimesters in the pregnancy is an important determinant of fetal growth [2, 15]. IUGR has been also associated with low gestational weight gain [14]. Mother who has appropriate gestational weight gain during pregnancy can give the contribution of fetal growth. It will ensure that mother can provide the nutrient availability to foetus for growth [14]. It means that gestational weight gain is associated with an increased rate of birth weight as birth outcome during pregnancy.

2.2.5.4 Chronic Energy Deficiency (CED)

Mid upper arm circumference (MUAC) is recognized as one of measurement on malnutrition. It is also one of the proxy indicators which are used to see whether mother has a risk of LBW and infant mortality during pregnancy [62]. The previous study also found that pregnant women who had MUAC less than 23.0 cm had risk of delivering LBW [63]. Moreover, the similar finding has been examined in Lombok, Indonesia where there was association between CED among pregnant women and infant birth weight [11].

2.2.5.5 Anaemia

Haemoglobin status of pregnant women is very important. Anaemia affects a high proportion of pregnant women in the developing countries. In the worldwide, 42% of pregnant women are anaemic [64]. Haemoglobin level in the different trimester is become fluctuated due to haemoglobin diluted. In the end of second trimester, haemoglobin concentration is decrease then the concentration will rises during third trimester [62].

Pervious study explained that women had higher haemoglobin concentration when delivered in the full-term compare to women who delivered in preterm period [65]. Multiple effects of anaemia are association with fetal growth and perinatal outcomes. Several studies has been examined that anaemia increased the risk of preterm deliveries and LBW [66].

2.2.6 Maternal Nutrition

2.2.6.1 MacronutrientsIntake (Energy, Protein, Fat, Carbohydrate)

Mothers who are able to increase their body weight can improve the birth weight [9]. It can describe that maternal nutrition has a direct impact on fetal growth [67]. Energy intake which is influenced by macronutrient intake such as protein, carbohydrate, and fat is a determinant of gestational weight gain during pregnancy [9, 13]. The importancy of energy intake is that it can provide the availability of nutrient which is needed for foetus during pregnancy [17].

There is an increament of energy requirement for each trimester.Energy, Protein, Fat, and Carbohydrate Recommended Dietary Allowance (RDA) for pregnant women in Indonesia describes in the table below.

Table 2.1 RDA of Energy, Protein, Fat, and Carbohydratefor Pregnant Women

Age (years old)	E (kcal)	P (g)	F (g)	n-6	n-3	CHO (g)
16 – 18	2125	59	71	11	1.1	292
19 – 29	2250	56	75	12	1.1	309
30 – 49	2150	57	60	12	1.1	323
Additional pregnancy stage						
1st Trimester	+180	+20	+6	+2.0	+0.3	+25
2nd Trimester	+300	+20	+10	+2.0	+0.3	+40
3rd Trimester	+300	+20	+10	+2.0	+0.3	+40

(Permenkes No.75 tahun 2013)

The significant increament in energy demand occurs in the third trimester due to the fetal growth is more complex [17]. Inadequate nutrient intake of pregnant women can lead the illness due to inavailability of nutrient demand. It will influence the fetal growth in determining birth weight [13, 67]. During pregnancy, additional energy is required to support metabolic demands of fetal growth, which increase by 15% in pregnancy [17].

Protein requirement is also needed, not only to contribute energy but also to support the synthesis of maternal and fetal tissues. The requirement of carbohydrate and fat as macronutrients are also recommended to provide enough calories in the diet [17]. Growth of the fetus and placenta also needs protein demands on pregnant women. Therefore, additional protein is essential to maintenance of a successful pregnancy [15]. Requirement of protein increases throughout gestation and maximum during the third trimester due to support the synthesis of maternal and fetal tissues. RDA of 0.66 g/kg/day of protein are recommended by IOM. Adverse consequences will increase when protein deficiency occurred during pregnancy [17].

IOM recommends 135 to 175 g/day is the recommended amount of carbohydrate [15]. It can provide enough calories, prevent ketosis and maintain appropriate blood glucose during pregnancy [17]. Fiber is one of type CHO which is important during pregnancy. The DRI for fiber is 28 g/day [17].Fat is one of macronutrients that there is no DRI for it. The amount should be depending on energy requirements for proper weight. However, to meet the demand of n-6 and n-3 polyunsaturated, there is a recommendation of it in the first time around 13 g/day (linoleic acid) and 1.4 g/day (α-linolenic acid) in the diet [14].

2.2.6.2 Micronutrients Intake (Vitamins and Minerals)

Micronutrients including vitamins and minerals have been identified as an important role to increase the birth weight and decrease the risk of preterm birth and SGA [13, 68].

Table 2.2 RDA of Vitamins for Pregnant Women

Age (years old)	Vit.A (mcg)	Vit.D (mcg)	Vit.E (mg)	Vit.K (mcg)	Vit.C (mg)	Vit.B1 (mg)	Vit.B2 (mg)	Vit.B3 (mg)	Vit.B5 (mg)	Vit.B6 (mg)	Folic Acid (mcg)	Vit. B12 (mcg)
16 – 18	600	15	15	55	75	1.1	1.3	12	5.0	1.2	400	2.4
19 – 29	500	15	15	55	75	1.1	1.4	12	5.0	1.3	400	2.4
30 – 49	500	15	15	55	75	1.1	1.3	12	5.0	1.3	400	2.4
1st Trimester	+300				+10	+0.3	+0.3	+4	+1	+0.4	+200	+0.2
2nd Trimester	+300				+10	+0.3	+0.3	+4	+1	+0.4	+200	+0.2
3rd Trimester	+300				+10	+0.3	+0.3	+4	+1	+0.4	+200	+0.2

(Permenkes No.75 tahun 2013)

Vitamin A plays a role in gene expression. In human cord blood vitamin A concentrations correlated with birth weight, head circumference, length, and gestation duration. However, women who have high vitamin A in the diets need to be closely evaluated due to high risk for fetal anomalies [17]. Moreover, vitamin D is related to positive effects on calcium balance during pregnancy. Thus, vitamin D and its metabolites cross the placenta and appear in fetal blood in the same concentration. It also enhanced immune function and brain development. The deficiency of vitamin D is associated with hypertensive condition of pregnancy, neonatal hypocalcaemia and hypoplasia of tooth enamel [17].

Vitamin E deficiency in human is rare due to the deficiency has not been linked with reduced fertility or fetal malformations as it have in animals. However, the requirements are increased during pregnancy to meet the amount of α-tocopherol [14]. Adequate amount of vitamin K has a role in bone health. It is important during pregnancy because the deficiency of vitamin K has been reported [17].An additional 10mg/day of vitamin C is recommended to prevent preeclampsia as known as preeclampsia can increase risk of IUGR and deliver the baby [17]. During pregnancy, the demands of maternal erythropoiesis and fetal and placental growth will increase folic acid requirements. It is important the prevention of Neural Tube Defects (NTDs). Folic acid deficiency reduce rate of deoxyribonucleic acid (DNA) synthesis and mitotic activity in individual cells [17].

There is a differentiation recommendation between Indonesian RDA and IOM around 0.6 mg. Vitamin B6 has a role in manage severe nausea and vomiting in pregnancy. It also provides for increased needs associated with synthesis of non-essential amino acids on growth and vitamin B dependent niacin synthesis from tryptophan [17].

Table 2.3 RDA of Minerals for Pregnant Women

Age (years old)	Ca (mg)	P (mg)	Mg (mg)	Na (mg)	K (mg)	Iron (mg)	Zn (mg)	I (mg)	F (mg)
16 – 18	1200	1200	220	1500	4700	26	10	150	2.5
19 – 29	1100	700	310	1500	4700	26	10	150	2.7
30 – 49	1000	700	320	1500	4700	26	10	150	2.7
1st Trimester	+200		+40				+2	+70	
2nd Trimester	+200		+40				+4	+70	
3rd Trimester	+200		+40				+10	+70	

(Permenkes No.75 tahun 2013)

Hormonal changes can increase the absorption and use of calcium. Thus, the amount of 150 mg additional calcium is recommended during pregnancy due to human chorionic somatomammotropin from the placenta increases the rate of maternal bone turnover[17]. Phosphorus is associated with hyperemesis gravidarum. There is no additional recommendation for phosphor but it is important in energy metabolism as a component of adenosine triphosphate (ATP) [69].

Increase in the maternal blood supply is also increases the demand for iron. Pregnant women must consume an additional 700 to 800 mg of iron due to hematopoiesis, fetal, and placental tissue. Therefore, iron supplementation is became a national program to prevent iron deficiency anemia. Because it can increase risk of hemorrhage and develop puerperal infection [17].Anemia during pregnancy can inhibits fetal growth which causes fetal stress with increased production and circulation of fetal corticotrophin-releasing hormone and oxidative damage to erythrocytes [43].Additionally, iron deficiency was associated with a tripling of the incidence of low birth weight [13, 67].

Zinc deficiency can result in abnormal brain development in the fetus and abnormal behavior in the newborn. Women with low plasma zinc concentrations are 2.5 times more at risk for delivering an infant weighing less than 2000 g. the additional amount of intake zinc is recommended due to plasma zinc level in the mother correlates with plasma zinc level in the offspring [17]. The study from Scholl explained that women with low serum concentration of iron, folate or zinc are more likely to experience preterm births compare with those who has normal range [70].

Forty to fifty (40–50) mg amount of magnesium is recommended in pregnancy. It can reduce the incidence of preeclampsia and IUGR as a cause of low birth weight [17]. Another mineral such as fluoride and iodine also has important role. The role of fluoride in prenatal development is controversial which involves the extent to which fluoride is transporter across the placenta and its value in utero in the development of caries-resistant permanent teeth [17].

Moreover, the role of iodine is in the thyroxine molecule which has critical roles in metabolism of macronutrients. Iodine deficiencies have been demonstrated as a cause of neonatal cretinism [71]. Another consequence of maternal iodine deficiency is may compromise fetal development. The most important of insufficient iodine intakes has been associated with increased miscarriage rates and spontaneous abortion [72].

A study conducted in Japan aimed to examine the fetal growth and its relation with micronutrients in maternal serum, placental, and fetal blood found that reduced intakes of zinc, cooper, magnesium, and selenium might be related to intraurine growth restriction [73]. In the conclusion, maternal dietary intake includes macronutrients and micronutrients have an important role in determining pregnancy status and birth outcomes.

2.2.7 Maternal Dietary Diversity

Pregnant woman is in the condition on high demand of both quality and quantity of the nutrient [2]. Available evidence suggested that maternal intake of macronutrient and micronutrient has an important effect on fetal growth [13, 14, 67]. Therefore, pregnant women need to consume variety of food to meet the requirement. Dietary diversity is essential to nutrient adequacy. It is also as predictor on nutritional status in several studies [23]. Related to pregnancy, Saaka also found that maternal dietary diversityas measured by individual dietary diversity score scores (IDDS) was significant independent predictor for mean birth weight and LBW [19].

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2.3 Dietary Diversity

2.3.1 Definition of Dietary Diversity

Dietary diversity is a qualitative measure of food consumption, which is designed to capture information over a reference period. It is also a proxy for nutrient adequacy on the diet of individuals [18].

2.3.2 Dietary Diversity Methods

2.3.2.1 Dietary Diversity Level

Dietary diversity can be measured in household level using household dietary diversity score (HDDS) and individual level using individual dietary diversity score (IDDS) [18]. IDDS and HDDS have a different approaches for collecting information on dietary diversity.At the individual level, the respondent is asked about all foods that they consumed on the previous day (inside and outside the home), whereas at the household level, the respondent should be the person who has responsible for meal preparation for the household and collect the all foods eaten inside the home by any member of the household during the previous day and night [18]. Nowadays, habitual in eating outside is increase, so that consumption the foods eaten outside the home must be collected to gather the data of household level [18].

2.3.2.2 Reference Period of Dietary Diversity

There are various reference period to measure the dietary diversity. A reference period of 24 hours is most commonly used as it limits recall bias and is more accurate [18, 74]. However, it cannot provide an indication of an individual's habitual diet [18, 75]. Other valid timeframes that can be used is more than 24 hour period such as 3 or 7 days [18]. Length of reference period depends on what information will be used [23]

2.3.2.3 Number and Definition of Food Groups

Number of food groups is important to consider the questionnaire of DDS. Depending on the purposes and objectives of the study, there are several food group indicators (FGI) to gather the data of dietary diversity score [23]. The amount of intake on each of food group is also considered to collecting data of DDS [75].There is no international standard on which food groups included in the scores due to different purposes of the study [18].

2.3.3 Dietary Diversity and Balanced Diet

A food guideline in Indonesia has been established in 2014 [76]. There were ten messages of balanced diets, which were:

1. Thankful and enjoy the diversity of the food
2. Many eating enough vegetables and fruits
3. Get used to eat the side dishes that contain high protein
4. Get used to consume the diversity of staple foods
5. Limit the consumption of sweet, salty and fatty foods
6. Familiarize breakfast
7. Make it a habit to drink water that is sufficient and safe
8. Make a habit of reading the labels on food packaging
9. Wash hands with soap with clean waters flow
10. Perform enough physical activity and maintain a normal body weight is applied to the entire Indonesian Balanced Diets ages, including infants, to include breastfeeding as constituent components.

There was a figure which describes the message of balance diets.

Figure 2.1 Indonesian Balanced Diets

According to the message of balanced diets in Indonesia, there were some messages regarding to the dietary diversity. Balanced diet had a relationship with the dietary diversity due to the regulation of balanced diet refer to the requirement of adequate intake with adding other message on healthy life style. Since there was no single food or food group supplies the all nutrient that we need [17], therefore the intervention on increasing the diversity of food as a part of balanced diet should have attention to be applied.

2.3.4 Findings of Dietary Diversity

Dietary diversityscores (DDS) is relatively quite simple to apply and it has been shown to reflect dietary intake [18]. Quality of nutrient can be reflected by dietary diversity in where more diverse the diet is more fulfill the nutrient requirements. Findings on nutritional status related to dietary diversity scores have been examined.

Value of a diverse diet has long been recognized in some studies [21]. Dietary diversity scores (DDS) has been validated as a proxy to measure both macronutrient and micronutrient intake, which is related to nutrient adequacy among pregnant women. Previous study approved that there was a strong significantly positive relationshipbetween the Nutrient Adequacy Ratios (NAR) of respective micronutrients (as well as Mean Adequacy Ratios/MAR) with the DDS [77]. On average, 26 foods and 7 food groups were consumed. All micronutrients were positively significantly associated with the dietary diversity score rather than the food variety score. Increasing the number of food group has a greater impact on nutrient adequacy than increasing the number of individual foods in the diet [77]. The table 2.4 showed the findings on dietary diversity related to nutrient adequacy below.

Table 2.4 Studies on Dietary Diversity and Nutrient Intake or Nutrient Adequacy

Country	Age group	Dietary diversityapproach (indicator)	Method and reference period	Descriptive dietary diversity findings	Type of validation or association study	Against which outcome	Main findings
Kenya[78]	12-36 months	No. of foods	Average daily intake from 3days, 24 h-recalls	Mean 5 for BF children; 6 for non-BF children	Association between low ≤5 and high :≥5 diversity&%RDA	RDA for energy, protein, vitamin A, C, B1, B2, B3, iron, calcium	Diversity >5 associated with greater intake of all nutrients
Niger[79]	24-48 months	Diversity score (DS): 11 food groups over 3 days: cereals, green leafy vegetables, other vegetables, pulses/nuts, roots/tubers, fat, fruits, legumes, milk/eggs, meat, sugar	3-day modified weighed intake	DS: mean=4.8, 5.3 (3 seasons)	Association between DS and Nutritional Quality Score (NQS)	NQS: energy, protein, vitamin A, and zinc	Diversity ≤5 significantly lower NQS in all 3 seasons compared to DS :≥6
Indonesia[80]	24–59 moths	1) FVS: all foods in 2 non-consecutive days 2) DDS: 9 food groups (cereals and tubers; all flesh food; dairy products; eggs; legumes and nuts; vit.A rich fruits and vegs.;other fruit;other vegs.;oils and fats	2 non-consecutive days using 24HR	Mean MAR of 7 nutrients (71.6%) DDS: 6 FVS: 9	Sensitivity and specificity of DDS related to nutrient intake adequacy	MAR for energy, protein, vtaim A, vitamin C, calcium, iron, zinc cut off:75% RDA	1) Correlation between MAR with DDS and FVS. 2) Correlation between NAR and DDS for all nutrients 3) Correlation between NAR and FVS for all nutrient except vitamin A and zinc 4) Cut-off points: DDS=6;Se:59.7%, Spe :68.7%. FVS=9; Se: 55.2%, Spe: 63.9%
Ghana and Malawi[81]	36-72 months	1) No. food items consumed on average/day 2) Some analyses grouped foods into: 13 groups: citrus fruits, non-citrus fruits, kenkey, bread, banku (corn or cassava), fufu (cassava or plantain), fish, meat, bush meat, cassava, sweet potatoes, other corn, groundnuts	Average over 3-day from direct weighing	Total no. foods items recorded: Malawi: 62, Ghana: 76. Mean daily intake ranged from 6.4 to 7.1 in Malawi: 7.1 to 8 in Ghana.	Correlation between dietary diversity and nutrient densities (results only briefly reported)	Nutrient densities (protein, fat, calcium, zinc, iron)	1) No correlation with protein, fat, calcium density in either country 2) Ghana: no correlation with zinc or iron density 3) Malawi: negative correlation with iron and zinc density during food shortage season 4) Malawi: correlation with energy

Country	Age group	Dietary diversityapproach (indicator)	Method and reference period	Descriptive dietary diversity findings	Type of validation or association study	Against which outcome	Main findings
Mali[82]	< 5 y. average age: 36 months	1) Food Variety Score (FVS): no. foods (n=75) 2) Dietary Diversity Score (DDS): 8; staples, vegetables, fruits, meat, milk, fish, egg, green leaves	Direct weighing for 2-3 days. Total consumed over 2-3 days.	Mean FVS: 20.5 DDS: 5.8	Validation against NAR and MAR Calculated sensitivity and specificity of different cutoff points for FVS and DDS	NAR for: energy, % energy from fat, protein, iron, vitamin A, B1,B2, B3, calcium folic acid MAR for allnutrients: cutoff:75% RDA	1) Correlation FVS and DDS with NAR: significant for % fat, vitamin C, A 2) Correlation MAR with FVS = 0.33; with DDS = 0.39 3) DDS = stronger determinant of MAR than FVS (regression) 4) Cutoff points:DDS = 6: Se 77%, Spe=33% FVS=23: Se: 87%, Spe: 29%
Bangladesh, Mali, Burkina Faso, Philipines, Mozambique[75]	Adult women aged 15-49 years	8 food group diversity indicators (FGI) that:1) were based on FG, not individual food items; 2) varied in level of aggregation of foods into groups; 3) varied in the minimum quantity of consumption required for a food group to "count" in the score (1 or 15g) FGI-6, FGI-9, FGI-13, FGI-21	Recall of a single day	For FGI-6 across sites, scores ranged from 2 to 6, whereas FGI-2 from 2 to 15. MPA for NPNL (0.34-0.35), lactating women (0.24-0.25)	Associations between all 8 FGI and MPA in all sites poor setting (controlling for energy intake)	Mean Probability of Adequacy (MPA) for 11 micronutrients (vit A, B1, B2,B3, B6, B12, folate,C, calcium, iron, zinc)	The moderate strength of associations between FGI and MPA was reflected in indicator performance (AUC, sensitivity, specificity&misclassification).For NPNL women, correlations were highestfor FGI-21R in 3 sites but were highest for FGI-6R&FGI-9R
Urban Mali[23]	Adult women aged 15-49 years	Food group combinations based on 6 and 21 FG	Two 24-HR from non-consecutive days with 2-11 day separating the recall period	There is no cut-off of DDS, however the PA was <0.25 for vit B12 and folate; ranged between 0..25 and 0.49 for B2, Ca, and B3; and was ≥0.50 for iron, vit A, B6, B1, Zn, C.	Correlation between a set of 6 and 21 food groups (g/d) and micronutrient intakes or MPA	Micronutrient intakes, probability of adequacy (PA)& mean probability of adequacy (MPA) for 11 micronutrient	The overall MPA for the composite measure of 11 micronutrients was 0.47±0.18. grams of intake from the nuts/seeds, milk/yogurt, vitamin A-rich dark green leafy vees (DGLV), and vitamin C-rich vegetables food groups were correlated (0.20-0.36; p<0.05) with MPA.

Country	Age group	Dietary diversityapproach (indicator)	Method and reference period	Descriptive dietary diversity findings	Type of validation or association study	Against which outcome	Main findings
Tehran[83]	Adult women aged 18-80 years	23 subgroups of 5 food groups: Bread-grains (7), fruits (2), vegetables (7), milk (2), and meat (4) with consumed at least one-half serving. Calculation: Number of subgroups consumed by the total number of subgroups of each main group and multiplied by 2. Total score is sum of the scores of the five groups.	2 day survey period using 24-HR. 2 separate 24 HR, spaced approximately 10 days apart and selected randomly	Grain (0.87 ± 0.28), vegetable (1.34 ± 0.29), fruit (1.42 ±0.50), meat (1.00±0.37), dairy (1.38 ± 0.50). DDS (6.01 ± 1.01)	Correlation between DDS and nutrient adequacy	Probability of Adequacy for 14 nutrients (vit A, B1, B2, B6, B12, Calcium, iron, zinc, phosphorus, magnesium, protein, niacin, cooper)	Whole grain DS is correlated with protein and vit B2 intake (r=0.35), fruit DS with vitC (r=0.44), dairy DS with calcium (r=0.54), meat DS with protein (r=0.34). Dietary diversity score is a useful indicator of specific nutrient adequacy in Tehranian women.
Gauteng, South africa[77]	Adult women aged 19-69 years	9 food groups by FAO, 80 subgroup food: flesh foods (9), egg (1), dairy (9), vegetables (17), cereals (14), legumes (4), vit A rich foods (7), fruits (15), fat/oil (4)	DDS from FFQ 1 week period	On average, 26 foods and 7 FG were consumed.	Correlation between dietary diversity and micronutrient intake and variability between age groups	Nutrient Adequacy Ratio (NAR) and Mean Adequacy Ratio (MAR) for calcium, iron, zinc, vit A, B1, B2, B3, B6 , folate, B12, vit C	There was a strong significantly positive relationship (p<0.001) between the NAR of respective micronutrients (as well as MAR) with the DDS, the relationship was negative with food variety and diversity within food groups; except for vitamin C.
Vietnam[84]	Adult women	1)FVS: all foods in 7-d (n>120) 2)DDS: 12 food groups' cereals, starch, green leafly vegetables, other vegetables, fish/seafood, meat, eggs, nuts/legumes, fruits/juice. Oil/fats, sauces, beverages/biscuits/sweets	7-d food frequency	FVS: range: 6-39; mean=18 and 20 (2 regions); DDS: mean=8 and 9 (range 5-11)	Validation against: 1)Intake of 13 nutrients 2)Nutrient density Created terciles of FVS: low ≤5 and high:≥21	Measured: 1) Nutrient intake; 2) Nutrient intake relative to energy density	1)FVS>21: significantly greater intake of most nutrients than FVS≤15 2)FVS≤15: also consumed higher variety of foods from most food groups 3)DDS≥8: significantly higher MAR of energy, protein, niacin, vitamin C, zinc.
Mozambique[85]	Households	HH level: info on all HH members, all foods consumed at all meals in 1 day. Each food receives score of 1-4 based on nutrient density, availability, size of portion. e.g.: vegetables, fruits, oils, sugars, some condiments=1cereals, bread, tubers=2 beans, nuts=3 meat, fish, milk, egg=4	Qualitative recall of all foods consumed by all individuals in 1 day	Very low scored: (0-12: 11%); average (12-19: 35%); adequate (≥20: 54%)	Association with quantitative dietary quality index (DQI) based on quantitative dietary assessment (24-h reall at HH level)	Diet Quality Index: 10 points, based on nutrient adequacy for: energy (2), vitamin A (2), iron (2), proteins (2) 7 other nutrients combined (2)	1) Rapid assessment too; (MDAT) associated with Diet Quality Idex (DQI) for all nutrients except vitamin A 2) Changing cutoff points that define low, average and adequate scores improved performance of MDAT

Table 2.5 Studies on Dietary Diversity and Nutritional Status

Country	Age group	Dietary diversityapproach (indicator)	Method and reference period	Descriptive dietary diversity findings	Type of validation or association study	Against which outcome	Main findings
11countriess: Benin, Mali,Cambodia, Volomia, Ethiopia, Haiti,Nepal,Malawi, Peru,Rwanda,Zimbabwe[21]	6-23 months	1) 7-point DDS:1) starchy saples (grain, roots, or tubers); 2) legumes; 3) dairy milk (milk other than breastmilk, cheease, yoghurt); 4) meat, poultry, fish, or eggs; 5) vit A-rich fruits and vegetables; 6) other fruits and vegetables; 7) foods made with oil, fat, or butter Calculation: Foods/FG that child had consumed on ≥3 d in the previous week received a score of "1" and <3times in the past week were scored "0".	7-days recall	Mean diversity score (range 0-7): benin(3.2), Ethiopia (2.2), Malawi (2.4), Mali (1.7), Rwanda (2.9), Zimbabwe (3.1), Cambodia (2.8), Nepal (2.8), Colombia (4.8), Haiti (3.8), Peru (4.5).	Bivariate association between dietary diversity and HAZ	HAZ (Heigh for Age Z-score)	Dietary diversity was significantly associated with HAZ, either as a main effect or in an interaction, in all but one of the countries analyzed. 1) Significant associations between HAZ and dietary diversity terciles were found in bivariate analyses in 9 of the 11 countries, but not in Benin or Cambodia. 2) Associations between dietary diversity and HAZ were significant as a main effect in 7 of the countries studied
Mali[86]	6-59 months	1) Household level FVS 2) DDS (same as above: Hatloy, orheim, and Oshaug 1998)	HH-level 24-h food freq. (104 food items)	FVS: 19.6 (urban), 14.3 (rural) DDS: 6.7 (u), 6.1 (r)	Association with nutritional status (controlling for SES)	Stunting, underweight, wasting	In urban areas: lower FVS or DDS has twice risk of stunted or underweight; rural areas: no association (controlling for SES)
Kenya[78]	12-36 months	Number of foods	Average daily intake from 3 days 24-h recalls	Mean: 5 for BF children; 6 for non-BF children	Association with nutritional status control (multivariate analysis, but no for SES)	HAZ, WAZ, WHZ, triceps skinfold (TS), mid-upper arm circumference (MUAC)	1) Diversity associated with HAZ, WAZ, WHZ, TS and MUAC; 2) Diversity >5 more important for HAZ among non-BF children (difference between diversity groups: 0.9 HAZ among non-BF vs. 0.2 among BF
Ethiopia DHS[22]	12-36 months	1) 24-h food group diversity: 8 groups: grains, roots/tubers, milk, vit A-rich fruits/vegetables, other fruits/vegetables, meat/poultry/fish/cheese/eggs/yoghurt, legumes, fats/oils 2) 7-day food group diversity (same as above except grains combined with roots/tubers (n=7)	24-h food group recall; 7-day food group recall	Mean 24-h diversity: 2.25 Mean 7-day diversty: 2.86	Association with HAZ (controlling for SES) Created terciles of 24-h diversity and 7d diversity	Height-for-age Z-score (HAZ)	1) Both 24-h and 7-day food group diversity strongly associated with HAZ, controlling for child, maternal and household socioeconomic factors 2) Differences in adjusted mean HAZ between lowest and highest tercile of 24-hour diversity; 0.65 Z-scores. 7-day diversity: 0.67 Z-scores

Country	Age group	Dietary diversityapproach (indicator)	Method and reference period	Descriptive dietary diversity findings	Type of validation or association study	Against which outcome	Main findings
China[87]	12-47 months	Food group scale (0-7): rice, egg, vegetables, fruits, soybeans, meat, other	Recall of usual intake at 12 months	Mean number of food groups: 4.8	Bivariate association with nutritional status	HAZ, WAZ, WHZ	Significant difference of 0.20 HAZ between children who consumed < 3 groups and rest of sample
Niger[79]	24-48 months	Diversity Score (DS): 11 food groups over 3 days	3-day modified weighed intake	DS: mean = 4.8, 5.3 (3 seasons)	Association between DS and growth	Growth: mean HAZ, WAZ, WHZ	Association DS and growth not significant (low correlations, significant only for WHZ in one round)
Iran and India[88]	457 children aged 6-9 years	Main food group between Iranian and Indian were similar (11 FG) but the items within groups were different. The frequency of consumption for the different food items and using simple count without weighing. Number of time consumed Daily (7), 2-3times/week(3), once/week (1), fortnight (0.5), monthly (0.25), occasionally (0)	Food intake frequencies	There is no specific dietary diversity finding on this study.	Assess the effect of dietary score and nutritional status	Weight for age, height for age, weight for height	Total DDS were significantly higher for Indian children who had normal weight orwho were overweight (F=32.197, p=0.000) and lowest for underweight children. Similar trends were observed for thechildren from Iran (F=9.345, p=0.000). Stunted children had lower total mean scores than those who had normal. Increasing weight was associated with higher scores for almost all food groups in India
Ogun State, Nigeria (rural village)[25]	204 women	Eight food group: cereals and grains, seeds, nuts and legumes, starchy roots and tubers, vegetables, fruits, meat and meat products, fish and sea foods, oil/dairies are classified by FANTA with little modification	24 hour-recall	Total DDS on season 1 was 3.55±7.6 and total DDS on season 2 was 3.93±4.3.	Correlation DDS and nutritional status of women (BMI, MUAC, WHR, skin fold thickness) in two seasons in rural areas	Nutritional status: BMI, MUAC, waist-hip ratio (WHR), Skin fold thickness	The DDS of the subjects was low. Protein, energy and fat intakes of the subjects increased significantly during the rainy season (p<0.05). 2% of the subjects gainedweight, 4% had weight reduction from overweight and obese category. The result of the WHR showed that 78% had normal WHR, 14% had overweight, and7% were obese.

Eventually, DDS also has relationship with nutritional status. Positive associations between dietary diversity and nutritional status of children [89, 21] and women [25, 90] are documented previously. Recently, the study between DDS and birth outcome (nutritional status of the newborn baby) among pregnant women had been examined [19]. This study found that the women who receive the minimum dietary diversity (receive foods from 8 or more food groups in seven days) was 85.5% and the mean DDS was 9.1 ± 1.4. Moreover, the IDDS was associated with reduced risk of LBW (OR=0.43, 95% CI=0.22 – 0.85, p = 0.014) [19].

There are many considerations to determine the method of dietary diversity scores which can represent the purpose of the study such as, the number and definition of food group, the reference period of assessment dietary diversity. Twelve food groups are listed for the HDDS while nine food groups are listed for the WDDS [18]. WDDS is reflected to individual scores which are meant to reflect the nutritional quality of the diet and to reflect the probability of micronutrient adequacy of the diet [18]. Therefore food groups included in the score are listed towards this purpose [18]. The aggregation of food groups between HDDS and WDDS from FAO is described in the table below.

Table 2.6 Aggregation of food groups from HDDS and WDDS

Question number	Food Group HDDS
1	Cereals
2	White tubers and roots
3,4,5	Vegetables[1]
6,7	Fruits[2]
8,9	Meat[3]
10	Eggs
11	Fish and other seafood
12	Legumes, nuts and seeds
13	Milk and milk products
14	Oils and fats
15	Sweets
16	Spices, condiments and beverages

[1] The vegetable FG is a combination of vitamin A rich vegetables and tubers, dark green leafy vegetables and other vegetables

[2] The fruit group is combination of vitamin A rich fruits and other fruits

[3] The meat group is a combination of organ meat and flesh meat

Question number	Food Group WDDS
1,2	Starchy staples[1]
4	Dark green leafy vegetables
3,6 and red palm oil	Other vitamin A rich fruits and vegetables[2]
5,7	Other fruits and vegetables[3]
8	Organ meat
9,11	Meat and fish[4]
10	Eggs
12	Legumes, nuts and seeds
13	Milk and milk products

[1] The starchy staples food group is a combination of Cereals and White roots and tubers.

[2] The other vitamin A rich fruit and vegetable group is a combination of vitamin A rich vegetables and tubers andvitamin A rich fruit.

[3] The other fruit and vegetable group is a combination of other fruit and other vegetables.

[4] The meat group is a combination of meat and fish.

According to table 4.5, the food groups considered in the score for the WDDS put more emphasis on micronutrient intake than on economic access to food as like as HDDS[18]. These result is based on the Women's Dietary Diversity Project tested the ability of simple dietary diversity scores to predict micronutrient adequacy of women reproductive age's diet. This was carried out in 5 diverse settings in developing countries which are urban areas of Burkina Faso and Mali, rural areas of Bangladesh and Mozambique, and an urban/per-urban area in the Philippines [18, 75, 24].

Four different food group combinations consist of 8 FGI such as FGI-6, FGI-6R, FGI-9, FGI-9R, FGI-13, FGI-13R, FGI-21, and FGI-21R. Food Group Indicator Restriction (FGI-R) considered the minimum quantity of consumption required for a food group to count the score (1g or 15g) [24]. The result found that using 15g restriction of minimum quantity (FGI-6R, FGI-9R, FGI-13R, FGI-21R) had slightly better performance and better correlation with individual micronutrient intakes than 1g restriction [24, 75]Furthermore, for all dietary diversity indicators, mean total energy intake increased consistently with the number of food groups eaten, except for FGI-9R, FGI-13 and FGI-21 where energy intake did not increase [24]. The table of food group indicator summarized into the table below.

Table 2.7 Food Groups Summed in Diversity Indicators

6-GI	9-GI	13-GI	21-GI
All starchy staples	All starchy staples	All starchy staples	Grains and grain product All other starchy staples
All legumes and nuts	All legumes and nuts	All legumes and nuts	Cooked dry beans and peas Soybeans and soy products Nuts and seeds
All dairy	All dairy	All dairy	Milk/yoghurt Cheese
Other animal source foods	Organ meet Eggs Flesh foods and other miscellaneous small animal protein	Organ meat Eggs Small fish eaten whole with bones All other flesh foods and miscellaneous small animal protein	Organ meat Eggs Small fish eaten whole with bones Large whole fish/dried fish/shellfish and other seafood Beef, pork, veal, lamb, goat, game meat Chicken,duck,turkey,pigeon, guinea hen, game birds Insects, grubs, snakes, rodents and other small animals
Vitamin A-rich fruits and vegetables	Vitamin A-rich dark green leafy vegetables Other vitamin A-rich vegetables and fruits	Vitamin A-rich dark green leafy vegetables Vitamin A-rich deep yellow/orange/red vegetables Vitamin A-rich fruits	Vitamin A-rich dark green leafy vegetables Vitamin A-rich deep yellow/orange/red vegetables Vitamin A-rich fruits
Other fruits and vegetables	Other fruits and vegetables	Vitamin C-rich vegetables Vitamin C-rich fruits All other fruits and vegetables	Vitamin C-rich vegetables Vitamin C-rich fruits All other vegetables All other fruits

The validation study concluded that all DDS were significantly correlated with micronutrient adequacy. However, 21 FG performed best in several countries due to it was more disaggregated indicators [18, 75]. In other site, FAO develops the WDDS that 9 food groups for WDDS are enough to predict the nutrient adequacy of the women of reproductive age. The important point to develop number of food group is depending on the purpose or location of the survey [18].

Nine, thirteen, and twenty one food groups of individual dietary diversity questionnaire (IDDQ) can be chosen at the WDDP sites [23], even guidelines for measuring households and individual dietary diversity by FAO used 9 food groups for women's of reproductive age [18]. However, there is no study or reference which can be used to determine the standard food group indicator for pregnant women. As known, pregnant women need both the quantity and quality of the diet during pregnancy to provide the nutrient demands [14, 17]. Therefore, 21 food groups will be adopted to reflect the nutritional quality of the diet of pregnant women by considering which food groups to be included in the IDDS questionnaire. One of several considerations why 21 food groups are chosen is thatJakarta as capital city of Indonesia, as center of economy and trade of foodstuffs can describe the available food is wider than other city of Indonesia. Market survey, review locally an available food items, gather information on ingredients used in local dishes and local meal customs, and terminology of local food need to be conducted to develop the food group.

Reference period of dietary diversity is must be considered due to represent the dietary intake of individual. FAO suggested that 24 hours period can limits recall bias but it cannot indicate the individual's habitual diet [18]. Several studies on dietary diversity demonstrated using more than single 24 hours period in determining nutritional status (see the table 2.4). Thus, based on previous study on dietary diversity and birth outcome that using 7 days 24HR and the literature described that dietary diversity score itself is not direct factor in determining birth weight, 3 days 24 hour recalls is may be appropriate reference period of this study.

Previous study in among pregnant women used 24-hour food frequency questionnaire and included 11 food groups. Previous study found that there is limitation methods used in assessing dietary diversity due to depended on memory and their ability to recall accurately [19]. Therefore, 24 hour recall period will be used in this study to represent the dietary diversity scores.

CHAPTER III
METHOD

3.1 Study Design

The study was part of big prospective cohort study namely, "Role of Nutrition and Antenatal Care on Fetal Programming that Influence Infant Birth Weight in East Jakarta". This study was designed for a cross-sectional study to examine the association between maternal dietary diversity and infant birth weight in East Jakarta.

3.2 Area and Time of the Study

The study was conducted from February to Mei, 2015. Public Health Centers (PHC) or *Puskesmas* and referral hospitals in East Jakarta involved in this study, which were *Puskesmas Kecamatan* Pulogadung, Kramat Jati, Matraman, Jatinegara, Ciracas, PasarRebo, Cakung, Makassar, Duren Sawit, Cipayung, *RSUD* Budi Asih and *RSUD* Pasar Rebo. Description of study area was presented in the figure below:

Figure 3.1 Description of Study Area

3.3 Material of the Study

3.3.1 Population and Subject

Pregnant women at 3rd Trimester who conducted antenatal care (ANC) in *Puskesmas* within East Jakarta municipality were population of this study. The study subject was the paired pregnant women and their infant who required the inclusion and exclusion criteria of the subject.

3.3.2 Criteria of Subject

Inclusion and exclusion criteria of the study subject are described below:

Table 3.1 Inclusion and exclusion criteria of subject

Inclusion Criteria	Exclusion Criteria
a) Pregnant woman aged 19–44 years old b) Gestational aged at 3rd Trimester (>32 weeks) c) Residing in East Jakarta region d) Registered and visited ANC at targeted CHC and referral hospital e) Planned to deliver their babies at targeted CHC and referral hospital	a) Twin babies b) Suffered from infectious diseases (Tuberculosis and HIV-AIDS) and pregnancy complications (Gestational Diabetes Mellitus, pre-eclampsia)

Pregnant women who fulfill the inclusion and exclusion criteria confirmed by screened test (registered and visited ANC in PHC, planned to deliver at PHC, and the age of mothers) and medical record (gestational aged at recruitment, gestational aged at birth, and diseases who suffered by pregnant women).

3.3.3 Sample Size and Sampling Procedure

3.3.3.1 Sample Size Calculation

The sample size was calculated by using a formula for population proportion (Lwanga and Lemeshow, 1991).

$$n = \frac{{Z_{1\ \alpha/2}}^2}{[\log_e(1-\varepsilon)]^2}\left[\frac{1-P_1}{P_1}+\frac{1-P_1}{P_1}\right]$$

In where:

- n = sample size
- RR = P1/P2
- $Z_{1-\alpha/2}$ = Z statistic for a level confident (95%)
- $Z_{1-\beta}$ = Power of the test (80 – 90%)
- P_2 = probability of outcome among unexposed

Table 3.2 Sample size calculation by previous study

Exposure	Outcome	Study design	Minimum sample size	***Total sample (Non response rate* 10%)**	Literature
Chronic Energy Deficiency (CED)	Low Birth Weight (LBW)	Cohort $P_2 = 0.112$ RR = 2.32	105/group (210)	231	Saraswati &Sumarno , 1998
Chronic Energy Deficiency (CED)	Low Birth Weight (LBW)	Cross-sectional $P_2 = 0.35$ RR = 2.55	131/group (262)	288	Sebayang et al., 2012
Anemia	Low Birth Weight (LBW)	Cohort $P_2 = 0.112$ RR = 2.55	82/group (164)	181	Saraswati &Sumarno , 1998
Mother's Height (<145 cm)	Low Birth Weight (LBW)	Cross-sectional $P_2 = 0.25$ OR = 1.93	65/group (130)	143	Sebayang et al., 2012
Parity	Low Birth Weight (LBW)	Cross-sectional $P_2 = 0.18$ OR = 2.26	83/group (166)	183	Samiran et al., 2006
Short interpregnancy interval	Low Birth Weight (LBW)	Cohort $P_2 = 0.09$ OR = 1.9	120/group (240)	264	Adam et al., 2009
DDS (no minimum DDS)	Low Birth Weight (LBW)	Cross-sectional P2 = 0.12 OR = 2.33	130/group (260)	282	Saaka, 2013

A power of 80% with 95% confidence interval was used in this study. Total sample was multiplied by non-response rate 10%. The higher sample size on several calculation of each variable was considered as sample size of the study. Finally, 288 pregnant women were needed to detect proportion in the group of birth weight.

3.3.3.2 Sampling Procedure

East Jakarta was purposively selected due to its largest area in Jakarta with population density in 4^{th} ranked. All Public Health Center (PHC) or 10 *Puskesmas* of each Sub District in East Jakarta was included in the study area. The sampling procedure was conducted by using consecutive sampling method. Pregnant women who visited in *Puskesmas* at the data collection period were screened consecutively. Finally, the subject was pregnant women who met the inclusion and exclusion criteria. The flow chart of sampling procedure presented below:

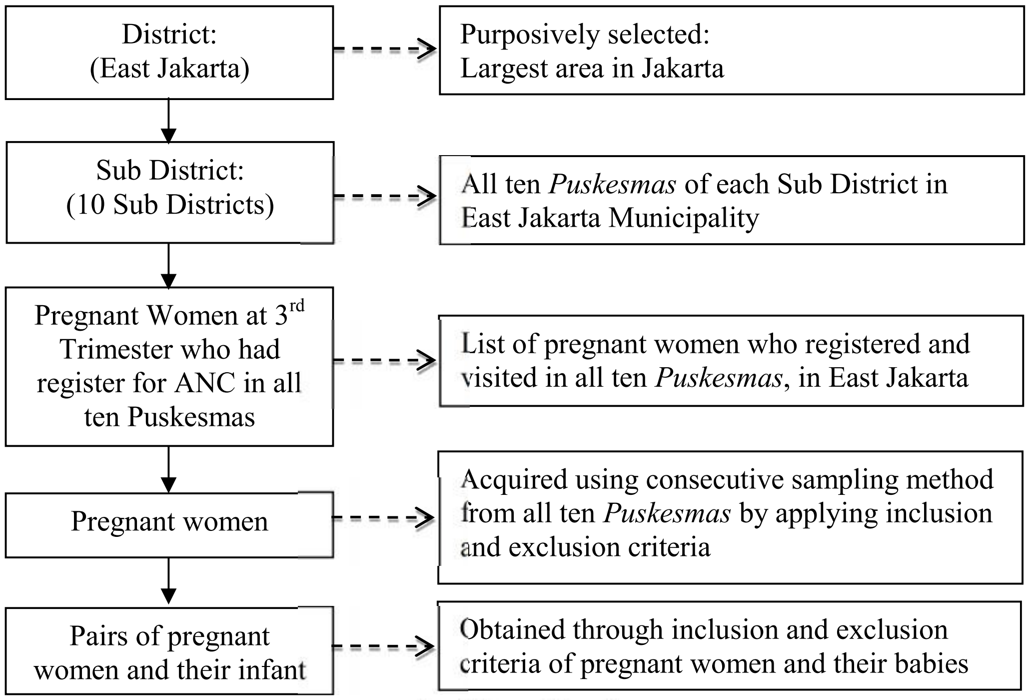


Figure 3.2 Flow chart of Sampling Procedure

3.4 Instruments of the study

There were several instrument of the study to gather the information and data. The instruments and purposes of this study were described in the table below.

Table 3.3 Instrument of the study

Instruments	Purposes
Structured Interview Questionnaire	To assess socioeconomic-demographic information (maternal education, working status, and HH income), maternal factor (mother's age, parity, birth spacing, history of deliver LBW baby and premature delivery), and maternal behavior (passive smokers).
24 Hour Recall Form	To assess individual dietary diversity scores (IDDS)
Shorr Board	To measure the maternal height
SECA 767 Weighing scale	To measure the maternal body weight at recruitment
SECA 201 MUAC Tape	To measure the maternal mid-upper arm circumference
Serenity Infant Weighing Scale	To measure the infant birth weight
Hemocue Portable Unit	To measure the maternal hemoglobin concentration
Medical Record	To assess the gestational age of pregnant women and infectious disease (tuberculosis and HIV-AIDS) and pregnancy complication (Gestational Diabetes Mellitus, pre-eclampsia)

3.5 Data Collection Procedure

3.5.1 Structured Interview

The interview was conducted by trained enumerators and was taken approximately 30 minutes to one hour for each respondent. It was collected in the *Puskesmas* while respondent wait to have the service on ANC. The content of questionnaire consisted of socioeconomic-demographic information (education, working status, and HH income), maternal factors (maternal age, parity, birth spacing, history of delivery premature baby or LBW), maternal behavior (passive smokers) and dietary assessment (24 hour-recall).

3.5.2 Dietary Assessment

Participants was interviewed at third trimester (>32 weeks gestation) by the investigator. The investigator included all team member and ten enumerators from the health and nutrition's background. Participants was asked all foods consumed during previous 24 hours which started at the previous morning.

The data was collected using a form 24 hour-recall in some phase. Firstly, respondent was asked about all meals, foods, and or beverages consumed in the previous day during 24 hours. Then, the food ingredient of locally food and meals consumed by them was asked completely including the recipe (food made by respondent), the price (kind of street food), brand, and label of food (fortification food). After that, enumerator estimated the amount of each food by using food photograph and household portion size.

There were two non-consecutive days available data of dietary intake in the big cohort study including workday and weekday of assessing the intake. However in this study, information for dietary diversity scores was derived from single 24 hour recall. Determinations of which day was used in the study was through random selection, with these priorities below:

1. Availability of data intake of respondent due to there were some respondent who had only one day recall
2. The long period between the measurement of dietary intake and anthropometric measurement within more than three weeks, the data recall at recruitment being a priority therefore.

3.5.3 Anthropometric Assessment

3.5.3.1 Maternal Height

Height was measured to the nearest 0.1 cm using Shorr Board. Respondent were asked to stand of straight position where heel, calf, buttocks, shoulder and head attached to wall with hands hanging loosely. The examiner asked the respondent's head into "Frankfurt plane position), then the result was determined by two measurement [62].

3.5.3.2 Attained Maternal Weight

The SECA 767 digital adult scale was used to measure body weight of participants at the recruitment to the nearest 0.05 kg. SECA must be placed on flat surface area and to get the validity of the measurement. The air bubble indicator determined the tools whether it was in the right position or not. Then, we asked the mothers to remove any accessories of them. Then, mother must stand in the middle of the weighing scale and looking straight ahead. Body weight was recorded and the measurement was done in two measurements [62].

3.5.3.3 Maternal MUAC

MUAC was measured using non-stretch and flexible SECA 201 insertion tape. The examiner stand sideways facing inactive arm of the subject (the subject with right-handed, the arm was measured and vice versa). The examiner must ensure that the subject's head at Frankfurt plan position with arms relaxed; legs apart and sleeved garment was rolled up; hanging loosely by the side with the palm facing inward. The measurement was examined at the midpoint of the upper arm between the tip of olecranon and acromion process. The tape was wrapped gently but firmly around the arm at midpoint. The result was determined by two measurements to the nearest 0.5 cm [62].

3.5.3.4 Infant Birth Weight

Birth weight with naked neonate in supine position was obtained within two hours of delivery by standard baby weighing Serenity to the nearest 1.0g. The measurement was taken by a personal trained including the team project member, midwives or doctor in PHC and hospital. The examiner must ensure that the infant's position and condition were placed on the right position. The infant was measured twice to the nearest 10 g [62].

3.5.4 Biochemical Assessment

Biochemical examination was conducted to capture the hemoglobin concentration of respondent. It was measured in a finger prick blood samples by Cyanomethemoglobin method. Then the result was read two times to see the difference to the nearest 0.1g/dl. When the difference was more than 0.2g/dl, third reading was conducted. The result of hemoglobin concentration was obtained by average of two reading [62]. Assessment was examined at recruitment >32 weeks to determine hemoglobin level of respondent before the respondent deliver the baby at full term condition.

3.5.5 Secondary Data

3.5.5.1 Gestational Age

Measurement of gestational aged was measured twice; gestational aged at recruitment or weight measurement and gestational aged at birth. Gestational age at recruitment of respondent was assessed on their first visit to the antenatal clinic. Last menstrual period (LMP) approach was used to determine the gestational age. The dates for the assessment of gestational age were taken from medical record/maternal health records booklet.

Gestational aged at birth was measured using the date of infant birth confirmed by medical record data. It determined the status of gestational age whether the baby was delivered in preterm (gestational age <37 weeks) or full term (gestational age ≥ 37weeks or higher).

3.5.5.2 Infectious Disease and Pregnancy Complication

Infectious disease (tuberculosis, HIV-AIDS) and pregnancy complication (GDM and pre-eclampsia) was taken from medical record data. These data was used to determine whether the respondent suffered from serious illness or not.

3.6 Data Management

3.6.1 Pre-testing Questionnaire

Pre-testing questionnaire including questions of socioeconomic-demographic and maternal factors was conducted in five PHC to increase the quality of the data. 30 pregnant women who were not the respondent were included to do pre-testing questionnaire. The pre-testing was aimed to ensure the similar understandibility and perception such as wording, options, the sentencing, and the meaning of each question to cover the barriers and flow of the interview process. Then, based on the finding of pre-testing, the questionnare was evaluated and revised.

3.6.2 Market Survey

Market survey was conducted in the beginning before collecting the dietary intake data to get the information of food available in the study area. Not only the food available, but also the food ingredients of some kind of meals or food could be known due to the market survey. As a result, food items consumed by respondent were more clearly to categorize into food groups due to the recipe of meals or beverages had been known during the market survey.

3.6.3 Training

The training was conducted before colleting the data. Enumerators and research team training conducted the training in two days for questionnaire introduction, interview, dietary assessment, and anthropometry and hemocue techniques. Ten enumerators involved in this study had education and background from health and nutrition. The training consisted of several principal, such as introduction to objective of study, introduction to the tools including how to use and calibrate the tools, and practices in last day of training. Besides the enumerators, the refreshment was also conducted among health care professional in PHC and referral hospital regarding the measurement of infant birth weight. The purpose was that all enumerator had the similar competency and perception. Therefore, error and bias could be minimalized to maintain the validity and quality of the data.

3.6.4 Calibration of tools

Calibration of tools was conducted in the morning before started to collection data, to ensure the tools were used and on the right value. Each of the tools (SECA 767 weighing scale, pediatric weighing scale, and Hemocue) had the standard of calibration. The result of calibration was noted on the calibration book daily.

3.6.5 Data Quality Assurance, Entry, and Cleaning

The quality of data was ensured by daily check in the field by supervisor. Parallax error, intra or inter-observer variation was reduced with the daily calibrating of tools, training enumerators before collecting data, and dividing the job desk in appropriately. All of person in charge in the big cohort study had their own responsibility during data collecting. Ten enumerators from health and nutrition's background involved in this study who only having the job desk on collecting the structured questionnaire and dietary assessment. The anthropometric measurement (height, body weight, MUAC of pregnant women) and biochemical examinations (hemoglobin concentration) were only measured by research team member. Moreover, the infant birth weight was measured by personal trained including the research team member, midwives, doctors, and nurse in the Public Health Center or referral hospital.

Data was checked daily to reduce the error and loss of important data. After data collection, the data was checked for data distribution, under or over reporting dietary intakes, and the presence of extreme or error values. Moreover, coding the data from dietary intake into DDS was conducted by only the researcher to minimize the bias and different perception in assigning the food items into food groups (IDDS). Double coding of food groups was conducted to prevent the plausible error about 30 respondents by trained enumerators.

3.7 Variables of Identification Matrix (VIM)

The variables of Identification Matrix (VIM) in this study were explained in the table 3.3 below.

Table 3.3 Variables of Identification Matrix

No	Variable	Indicator	Method	Reference
1	Socio-economic and Demographic	Maternal education Maternal working status Household income	Interview	Riskesdas, 2013[8]; Sebayang *et al.,* 2012[11]
2	Maternal Factor	Maternal age Parity Birth spacing History of LBW History of premature delivery	Interview	Riskesdas, 2013[8]
3	Behavior factor	Passive smokers	Interview	Oberg *et al.,* 2010[56]
4	Mother's nutritional statuses	Attained body weight Maternal height Maternal MUAC Hemoglobin concentration	Anthropometric measurement	IOM, 2009[14]; Bisai, 2010[61]; WHO, 2012[4]; WHO, 2012[4]
5	Maternal DDS	21 Food Groups	Single 24 hour-recall	FANTA, 2009[24]
6	GA at birth	Preterm (<37 weeks) Aterm (37–40 weeks) Post term (>40 weeks)	Medical record	Riskesdas, 2013[8]
7	Infant birth weight	LBW (<2,500 g) Normal BW (2,500–4,000 g) High BW (>4,000 g)	Anthropometric measurement	WHO, 2004[9]; Gibson, 2005[62]

3.8 Data Analysis and Presenting

3.8.1 Data Analysis

Data was analyzed using SPSS version 20.0 software for all statistical analysis. Descriptive analysis was presented to provide general information on the characteristics of the study populations including socioeconomic-demographic, maternal factors, obstetric history, maternal nutritional status, and birth outcome.

The Kolmogorov-Smirnov test was performed to test the normality of the continuous data including mother's age, household income, parity, birth spacing, mother's height, body weight, MUAC, hemoglobin concentration, gestational aged at recruitment and at birth, birth weight. Pearson correlation was used to describe the relationships between dietary diversity scores and birth weight using best linear unbiased predictors. Spearmen correlation was used when either the dependent or independent variables were not normally distributed.

Bivariate analysis was performed using Chi-Square analysis to examine the association between maternal dietary diversity, birth weight and its determinants. In addition, binary logistic regression was examined to see the relationship between infant birth weight and its determinants. The potential variables were identified as a predictor of birth weight when the result showed significant association below than 0.25 ($p<0.25$). Finally, all predictors influenced the birth weight were assessed using binary logistic with the 95% confidence interval (CI) and p value <0.05.

3.8.1.1 Development of Food Group Indicators on DDS

Information of dietary diversity scores was coming from data intake analyzed by Nutrisurvey for Windows 2004. Furthermore, food items consumed by respondents were defined as source of food groups based on nutrient containing of food. Indonesia Food Composition Table (FCT) was used to determine nutrient content of food items per 100 gram. For instance, food items classified as vitamin A-rich fruits and vegetables when the food items containing >120 retinol equivalent (RE) or vitamin A per 100 gram. Moreover, fruits and vegetables were determined as vitamin C-rich fruits and vegetables if the food containing > 9mg vitamin C per 100 gram [18, 24]. A score of one (1) was assigned if the pregnant women consumed the food groups and zero (0) was assigned if they did not consume in the past 24 hours. The total score was number of food groups consumed by respondent.

There were several food group indicators (FGI) developed by FANTA and FAO. FANTA has four FGI such as FGI-6, FGI-9, FGI-13, and FGI-21 and FAO has two FGI such as food group indicators of households dietary diversity scores (HDDS) and women dietary diversity scores (WDDS). In this study, we tried to develop food group indicator which suitable for pregnant women and started from the higher number of food groups which was FGI-21. In the original FGI-21, there were seven food groups containing animal source protein, such as organ meat, eggs, small fish eaten whole with bones, large whole fish/dried fish/shellfish/other seafood, beef/pork/lamb/goat, chicken/duck/bird, and insects/grubs/snakes/rodents/other small animals. However, food group containing insects/grubs/snakes/rodents/other small animals was unusual consumed by pregnant mother in Indonesia. For that reason, it was replaced with the new food group, which was composite food from animal source protein. Food items in this group were nugget, sausage, meat ball, *siomay*. These kinds of food could not be classified into another food group like flesh food, because it seemed like respondent diverse in animal source protein though meat ball containing more flour and other material than the flesh food. Kind of food items consumed by pregnant women of each food groups was showed below.

Table 3.4 Food Items of Food Groups

No	Food Groups	Food Items
1	Cereals	*Beras putih, beras merah, beras ketan putih, bihun, roti, mie, pasta*
2	White roots and tubers	*Kentang, singkong putih, ubi jalar putih*
3	Cooked dry beans and peas	*Kacang hijau*
4	Soybeans and soy product	*Tempe, tahu, susu kedelai*
5	Nuts and seeds	*Kacang tanah, kacang mete, kuaci*
6	Milk/yoghurt	*Susu hamil berbagai merk, susu bubuk, susu cair, yoghurt, ice cream*
7	Cheese	*Keju*
8	Organ meet	*Hati ayam, ampela ayam, jantung ayam, hati sapi*
9	Eggs	*Telur ayam, telur bebek, telur puyuh*
10	Small fish eaten whole with bones	*Ikan teri segar, ikan teri medan, ikan asin*
11	All small and large fish, shellfish and other seafood	*Ikan kembung, ikan tongkol, ikan mas, ikan gurame, ikan mujair, ikan selar, ikan tuna, udang, cumi, kerang, kepiting, lobster*
12	Beef, pork, veal, lamb, goat	*Daging sapi, daging kambing, daging babi*
13	Chicken, duck, bird	*Daging ayam, daging bebek, daging burung*
14	Composite food from animal protein	*Bakso, siomay, pempek, batagor*
15	Vitamin A-rich dark green leafy vegetables	*Bayam, daun melinjo, daun pepaya, daun singkong, kangkung, katuk, lettuce, sawi hijau*
16	Vitamin A-rich vegetables	*Wortel, tomat, buah bit*
17	Vitamin A-rich fruits	*Mangga, papaya*
18	Vitamin C-rich vegetables	*Bayam, daun melinjo, daun pepaya, daun singkong, kangkung, katuk, sawi hijau, bit, brokoli, buncis, kacang panjang, kol, kembang kol, labu siam, lobak, tomat, wortel*
19	Vitamin C-rich fruits	*Mangga, pepaya, alpukat, belimbing, durian, jambu biji, jeruk, kiwi, lemon, melon, nanas, pir, rambutan, sawo, stroberi*
20	All other vegetables	*Nangka muda, toge kacang hijau, sawi putih, jamur*
21	All other fruits	*Semangka, pisang, buah naga, salak, kedondong, bengkuang, jambu air, apel*

Furthermore, to determining the cut-off of food group indicators used the receiver operating characteristics (ROC) test. Area under curve (AUC) was presented to determine the acceptable discrimination. Moreover, the cut-off was determined from sensitivity and specificity of the analysis. The categorization on determining the result of area under curve were divided into four categories, which were not acceptable (<0.5), poor discrimination (0.5–0.6), moderate discrimination (0.6–0.8), and high discrimination (0.9–1.0).

3.8.2 Data Presenting

Data was presented as means ± standar deviation (SD) if the data has normal distribution whereas the data was not normally distribution, median (inter-quartile range) was showed in the table. The categorization of each variable which was used to chi-square analysis was explained below.

Mother's age was divided into three categories ≤25 years, 26–35 years, and ≥36 years [8]. The income was categorized based on Regional Minimum Salary/*Upah Minimum Regional (UMR)* in Jakarta (IDR 2,700,000). Nulliparous and multiparous were the category of parity due to the first pregnancy had higher risk on birth outcome. There was a government program on relating the health of pregnant women that birth interval might be not less than 2 years from previous pregnancy. Therefore, birth spacing was categorized into two, which were <24 months, and ≥24 months.

Mother's height was categorized into two, which were below 150 cm and above 150 cm. Moreover, mid upper arm circumference of mothers below 23.5 cm was categorized as Chronic Energy Deficiency (CED), so the category was divided into two below 23.5cm and more than 23.5 cm. Hemoglobin status was divided into two categories, which were anemia (<110 g/l) and non-anemia (≥110 g/l).

Birth weight was divided into two categories. Based on the systematic review and meta-analysis study showed that higher mortality for individuals born relatively small (birth weight <3,000 g) with reference category 3,000–4,000 g. Therefore, with expecting higher birth weight as the indicator of survival infant, we made the cut-off into two categories (infant weight at birth <3,000 g and ≥3,000 g) [27]. Furthermore, the dietary diversity scores was categorized into two levels (low DDS and high DDS) based on the result of ROC test, median and considering other study on DDS.

3.9 Operational Definition

Working status	:	Maternal activities to obtain income with minimally six working hours in a day
Education	:	Level of formal education experienced by the respondent
Passive smokers	:	Produced from burning cigarette or any other tobacco products and from smoke exhaled by smokers [56]
Parity	:	Number of pregnancy (life/death delivery, singleton ortwin) which women experienced.
Birth spacing	:	Interval of current first week of current pregnancy towards previous pregnancy which counted in months
Gestational aged at birth	:	Time range from the first formation of fetus until delivery based on medical record data
Infant birth weight	:	Birth weight of newborn which measured within hour after delivery by trained person
Dietary Diversity Score (DDS)	:	Total number of unique food groups consumed by pregnant women in the 24 hour period [18].

3.10 Organization of the Study and Ethical Consideration

Researcher : Nursyifa Rahma Maulida

Advisor : 1. DR. dr. Fiastuti Witjaksono, MSc., MS., SpGK
2. Ir. Siti Muslimatun, MSc., PhD

We had collaboration with District Health Office (DoH) and health workers (midwives, nurses, doctor) to ensure the successfulness of data collection activities and community acceptance. The commitment was established in the form of permission letter and personal approach informally. Structure of management and the responsibility within the team were made to clarify the role and task of each person during study, including the enumerators.

Due to this study was part of big cohort study, there was an organization of that. The organization of the big prospective cohort study described below:

- Principle Investigator and Co-PI:
  - Dr. dr. Fiastuti Witjaksono, MSc., MS., SpGK
  - dr. Rina Agustina, MSc., PhD
  - Dr. dr. Inge Permadi, MS., SpGK
  - dr. Erfi Prafiantini, MKes.
- Research Team Member:
  - dr. Alexander Halim Santoso
  - dr. Christoper Andrian
  - Dudung Angkasa, S.Gz
  - dr. Grentina Dwi Prawesti
  - dr. Kristina Joy Herlambang
  - dr. Liliana Mulia
  - dr. Marisa
  - dr. Merdina Manik
  - Miftahul Jannah, S.Gz
  - dr. Mutia Winanda
  - dr. Nesyana Nurmadilla
  - Nursyifa Rahma Maulida, S.Gz
  - dr. Theresia Indrawati
  - Trikorian Ade Sanjaya, S.Gz
  - Witri Priawantiputri, S.Gz
  - dr. Zalela

Each of PHC had one person in charge (PIC) to manage and organize the time schedule, respondent, tools, and others on relating the data collection. The PIC of each PHC was responsible to make a daily report and summarize the data collection to field supervisor. The, field supervisor had responsibility on checking the completeness of data, arranging the job desk and schedule of the examiners/enumerators, and making daily progress report to the principle investigators.

The study was conducted after receiving the ethical approval from Ethical Committee of Faculty of Medicine, University of Indonesia. Then the permission from the local government in the province, District Health Office, and Community Health Centers or Puskesmas, and referral hospitals was established. Signed inform consent was obtained by those who had willingness to joint the study. Any invasive and non–invasive method to collect data was conducted under the agreement of the respondent. They were allow withdrawn at anytime as will without punishment. All of data and information was treated confidentially for only the purpose of this study.

CHAPTER 4
RESULT

The present study was conducted in Public Health Centers (PHC) of ten sub districts which located in East Jakarta. Since this study was part of big study, there were certain things which should be considered including the inclusion and exclusion criteria. In the big study, 315 pregnant women recruited. Due to there were respondent who did not met the inclusion and exclusion criteria in the specific study such as the age, gestational aged at recruitment, tuberculosis, pre-eclampsia, and other infectious disease, seven of 315 respondents were excluded.

Moreover, five of pregnant women who were willing to participate in the beginning, they refused suddenly to continuing data collection. The rest delivered their babies in elsewhere (hospital, traditional shaman, and other health centers). Then, during cleaning the data, there were some extreme value on gestational aged at birth and hemoglobin concentration. The flow was described in the figure below.

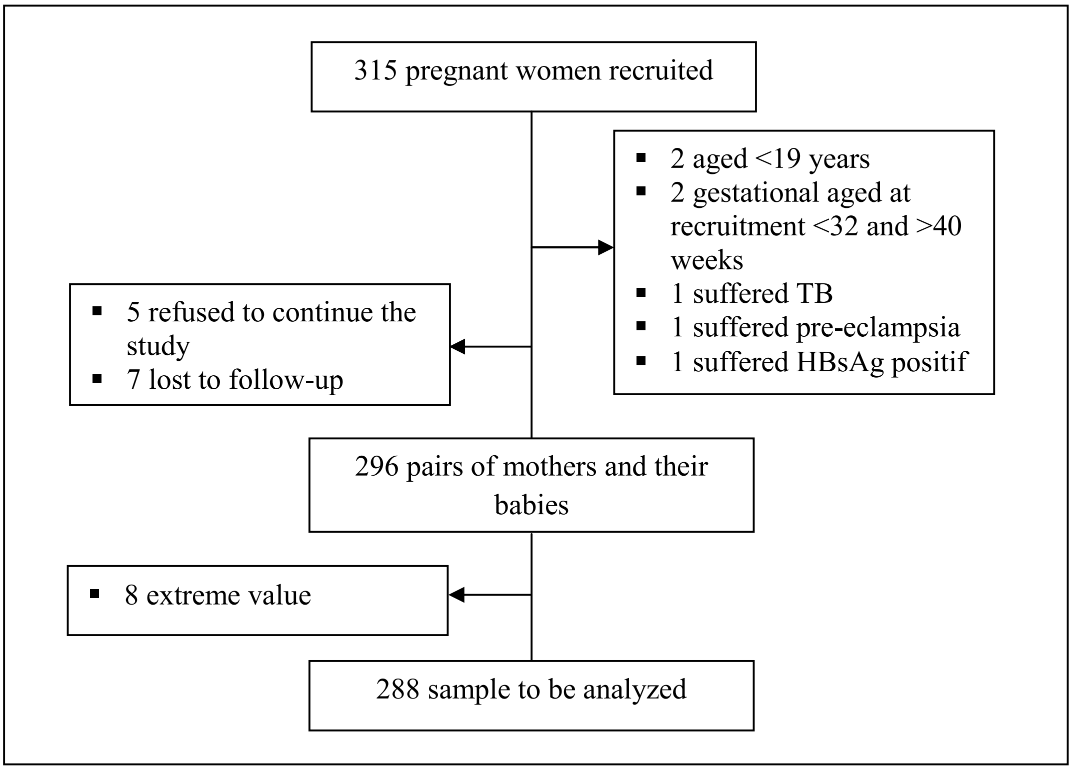


Figure 4.1 Result of sample selection

4.1 General Characteristics of the Study

The higher proportion of respondent came from the three districts such as Jatinegara, Kramat Jati, and Pasar Rebo due to these three districts had larger coverage area in East Jakarta. Moreover, schedule of antenatal care was more frequent than others, which were four days a week in Kramat Jati's and Pasar Rebo's district, and five days a week in Jatinegara's district. Contrarily in Cipayung, because the location of Puskesmas was recently moving to the new location and there was no public transportation available, so the pregnant women who did antenatal care were very rare in that location. Data on socioeconomic-demographic of respondent was presented in the table 4.1 below.

Table 4.1 General characteristics of respondent at recruitment (n=288)

Variables	Total[1]	n (%)
Gestational aged at recruitment, *weeks*	35 (34–37)	
32 – 34		103 (35.8)
35 – 37		153 (53.1)
38 – 40		32 (11.1)
Education, *years*		
≤ 9		87 (30.2)
> 9		201 (69.8)
Working status		
Working mother		85 (29.5)
Housewife		203 (70.5)
Household income, *(IDR)*	2,500,000 (2,000,000 – 3,500,000)	
< 2.700.000		151 (52.4)
≥ 2.700.000		137 (47.6)

[1]median (IQR) or mean ± SD, [a]n=180

Socioeconomic status showed by household's income, where the median of income was around IDR 2,500,000, thus the income had been categorized based on Regional Minimum Salary/*Upah Minimum Regional (UMR)* in Jakarta (IDR 2,700,000). Since the mandatory program from government, Healthcare Insurance managed by the newly established Healthcare and Social Security Agency/*Badan Penyelenggara Jaminan Sosial Kesehatan (BPJS Kesehatan)*, public should had BPJS card for using health care facilities in the Community Health Centers. Therefore, respondents from different socioeconomic involved in this study and could describe the real condition affecting the birth weight.

4.2 Maternal Factors and Maternal Behavior

Generally, the age of pregnant women was 28 years. The respondents who could be analyzed for birth spacing, history of deliver prematurity and history of LBW were 180 respondents due to there were some pregnant women in the first pregnancy condition at recruitment and some of them had a history of abortion in the previous pregnancy. Therefore, the sample size of those variables was less than a total sample size.

In addition, there was a similar percentage between mothers who had history of deliver LBW babies and deliver prematurity (12.2%). Based on the observation of the data, the cause of having LBW baby previously of respondent was not clearly whether it was the result from preterm birth or fetal growth restriction since not almost respondent who had history of LBW was also have history of deliver prematurity. The description of proportion was showed in the table below.

Table 4.2 Maternal factors and maternal behavior of respondent (n=288)

Variables	Total[1]	n (%)
Mother's age, *years*	28 (24–32)	
≤ 25		99 (10.1)
26 – 35		160 (55.6)
≥ 36		29 (10.1)
Parity, *children*	2 (1–3)	
Nulliparous (0)		97 (33.7)
Multiparous (≥1)		191 (66.3)
Birth spacing [a], *months*	51 (30 - 83)	
< 24		31 (17.2)
24–60		71 (39.5)
> 60		78 (43.3)
History of deliver prematurity[a]		
Yes		22 (12.2)
No		158 (87.8)
History of deliver LBW baby[a]		
Yes		22 (12.2)
No		158 (87.8)
Passive smokers		
Yes		121 (42.0)
No		167 (58.0)

[1]median (IQR), [a]n=180

About 43% of respondent experienced to second-hand smoke exposure which increased an adverse outcome of birth outcome, especially birth weight. It was also indicating the poor household environment among pregnant women.

4.3 Maternal Nutritional Status

Table 4.3 showed the nutritional status of respondent in term of anthropometric and biochemical assessment. Mothers who had more risk on birth weight regarding the stature were 6.3%. Moreover, chronic energy deficiency occurred among pregnant women were around 11%. However, the prevalence of anemia was high about 43.4%. As a result, the prevalence of anemia was still high in East Jakarta.

Table 4.3 Maternal nutritional status of respondent (n=288)

Variables	Total[1]	n (%)
Attained body weight by gestational aged, *weeks*		
32 – 34	63.1 ± 10.6	103 (35.8)
35 – 37	64.5 ± 9.4	153 (53.1)
38 – 40	63.5 ± 10.7	32 (11.1)
Mother's height, *cm*	153.5 ± 5.5	
At risk (< 145.0)		18 (6.3)
145.0–149.9		54 (18.8)
≥ 150.0		216 (75.0)
Mid upper-arm circumference, *cm*	27.5 (25.1–29.5)	
Chronic Energy Deficiency (< 23.5)		31 (10.8)
Normal (≥ 23.5)		257 (89.2)
Hemoglobin level, *g/l*	111.6 ± 13.5	
Anemia (< 110.0)		125 (43.4)
Non-anemia (≥ 110.0)		163 (56.6)

[1]median (IQR) or mean ± SD, [a]n=180

4.4 Birth Outcome

The result of birth outcome included the gestational aged at birth, mode of delivery, infant sex, and birth weight. According to the result, baby born on the pre-term condition was 1.7%. These numbers were the same with the prevalence of LBW baby which was 1.7%. One third of respondent deliver their baby with caesarian method (27.4%). It related on some problem which occurred among respondent before deliver the baby such as premature rupture of the membranes (PROM), cranio pelvic disproportion (CPD), oblique position, pre-eclampsia, post term, and others. Result showed that 14.6% of respondent was post term which tend to deliver with caesarian method for prevent complication in this study. Furthermore, most of respondent deliver the normal birth weight, whereas baby with high birth weight was 1.1%. The result was showed in the table 4.4 below.

Table 4.4 Birth outcome (n=288)

Variables	Total[1]	n (%)
Gestational aged at birth, *weeks*	39 (38 – 40)	
Pre-term (< 37)		5 (1.7)
Aterm (37–40)		241 (83.7)
Post-term (> 40)		42 (14.6)
Mode of delivery		
Vaginal		209 (72.6)
Caesarian section		79 (27.4)
Infant sex		
Boys		138 (48.9)
Girls		150 (52.1)
Birth weight, gram	3138 ± 366	
Low birth weight (< 2,500)		5 (1.7)
Normal (2,500–2999)		100 (34.7)
Normal (3000–4000)		180 (62.6)
High birth weight (> 4,000)		3 (1.0)

[1]median (IQR) or mean ± SD, [a]n=180

4.5 Maternal Dietary Diversity

Dietary Diversity is number of food group consumed by respondent in the reference period. There were several food groups summed in diversity indicators developed by FANTA, 2009. We explored the food group consumed by respondent from different Food Groups Indicator (FGI). Some food groups in FGI-21 were merged into FGI-13, FGI-9, and FGI-6. FGI-21 which had more list of FG, generally, the percentage of each FG consumed by respondent was few, whereas when FG was merged into less aggregation FG (FGI-13, FGI-9, and FGI-6), the percentage of each FG became higher. For instance, FG as source of energy in FGI-21 was divided into two FG which were cereals and white roots and tubers; the result showed that cereals were consumed by all respondents and 40.6% of them also consumed white roots and tubers. However, when FG was merged into less aggregation FG (FGI-13, FGI-9, and FGI-6), the result showed that the entire respondents consumed all starchy staples.

Moreover, the results also appeared in other FG of FGI-21 such as the animal source protein food. It was divided into seven FG (organ meat, eggs, small fish eaten whole with bones, large whole fish/dried fish/shellfish and other seafood, beef/pork/lamb/goat, chicken/duck/bird, and composite food from animal protein), there were only FG of eggs and chicken/duck/bird that half of respondent consumed these two FG, while the other FG showed that the percentage was less than 40%. However, when these FG of animal source of protein was merged into the less aggregation such as FGI-6, the percentage became higher that almost respondents consumed the FG of other animal source foods. It seemed that variety of FG consumed by respondent was more than one FG. The proportion of each FGI consumed by respondent was described in the table below.

Table 4.5 Proportion of FG consumed by respondent according to different FG (n=288)

<table>
<tr><th>FGI-22</th><th>%[1]</th><th>FGI-13</th><th>%[1]</th><th>FGI-9</th><th>%[1]</th><th>FGI-6</th><th>%[1]</th></tr>
<tr><td>Cereals</td><td>100</td><td rowspan="2">All starchy staples</td><td rowspan="2">100</td><td rowspan="2">All starchy staples</td><td rowspan="2">100</td><td rowspan="2">All starchy staples</td><td rowspan="2">100</td></tr>
<tr><td>White roots and tubers</td><td>40.6</td></tr>
<tr><td>Cooked dry beans and peas</td><td>17.7</td><td rowspan="3">All legumes and nuts</td><td rowspan="3">75.7</td><td rowspan="3">All legumes and nuts</td><td rowspan="3">75.7</td><td rowspan="3">All legumes and nuts</td><td rowspan="3">75.7</td></tr>
<tr><td>Soybeans and soy products</td><td>68.1</td></tr>
<tr><td>Nuts and seeds</td><td>19.4</td></tr>
<tr><td>Milk/yoghurt</td><td>51.4</td><td rowspan="2">All dairy</td><td rowspan="2">53.8</td><td rowspan="2">All dairy</td><td rowspan="2">53.8</td><td rowspan="2">All dairy</td><td rowspan="2">53.8</td></tr>
<tr><td>Cheese</td><td>6.6</td></tr>
<tr><td>Organ meat</td><td>11.5</td><td>Organ meet</td><td>11.5</td><td>Organ meet</td><td>11.5</td><td rowspan="7">Other animal source foods</td><td rowspan="7">96.2</td></tr>
<tr><td>Eggs</td><td>59.4</td><td>Eggs</td><td>59.4</td><td>Eggs</td><td>59.4</td></tr>
<tr><td>Small fish eaten whole with bones</td><td>4.9</td><td>Small fish eaten whole with bones</td><td>4.9</td><td rowspan="5">Flesh fcoods and other miscellaneous small animal protein</td><td rowspan="5">91</td></tr>
<tr><td>Large whole fish/dried fish /shellfish and other seafood</td><td>41.7</td><td rowspan="4">All other flesh foods and miscellaneous small animal protein</td><td rowspan="4">90.3</td></tr>
<tr><td>Beef, pork, lamb, goat</td><td>13.2</td></tr>
<tr><td>Chicken, duck, bird</td><td>58.3</td></tr>
<tr><td>Composite food from animal protein</td><td>28.5</td></tr>
<tr><td>Vitamin A-rich dark green leafy vegetables</td><td>48.3</td><td>Vitamin A-rich dark green leafy vegetables</td><td>48.3</td><td>Vitamin A-rich dark green leafy vegetables</td><td>48.3</td><td rowspan="3">Vitamin A-rich fruits and vegetables</td><td rowspan="3">74</td></tr>
<tr><td>Vitamin A-rich deep yellow/orange/red vegetables</td><td>39.9</td><td>Vitamin A-rich deep yellow/ orange/red vegetables</td><td>39.9</td><td rowspan="2">Other vitamin A-rich vegetables and fruits</td><td rowspan="2">44.4</td></tr>
<tr><td>Vitamin A-rich fruits</td><td>8.7</td><td>Vitamin A-rich fruits</td><td>8.7</td></tr>
<tr><td>Vitamin C-rich vegetables</td><td>79.5</td><td>Vitamin C-rich vegetables</td><td>79.5</td><td rowspan="4">Other fruits and vegetables</td><td rowspan="4">95.1</td><td rowspan="4">Other fruits and vegetables</td><td rowspan="4">95.1</td></tr>
<tr><td>Vitamin C-rich fruits</td><td>52.4</td><td>Vitamin C-rich fruits</td><td>52.4</td></tr>
<tr><td>All other vegetables</td><td>31.3</td><td rowspan="2">All other fruits and vegetables</td><td rowspan="2">41.3</td></tr>
<tr><td>All other fruits</td><td>41.7</td></tr>
</table>

[1] food group consumed by respondent

Finally, 21 food groups were chosen as indicator of dietary diversity scores to determine the birth weight. There were some considerations to determine the FGI-21. Based on the explanation above, it showed that Jakarta as capital city had more available food, thus the more aggregation food groups could represent the real condition in urban area. Moreover, the previous study found that FGI-21 showed a strongest correlation with intakes of micronutrients than other FGI [24], since pregnant women need to provide the nutrient demands not only the macronutrients, but also the micronutrients. It could influence the birth outcome like birth weight [2].

The cut-off of dietary diversity to determine the birth weight with categorization <3,000 g and ≥3,000 g was performed using receiver operating characteristics (ROC) curve. The result showed in the figure and the table below.

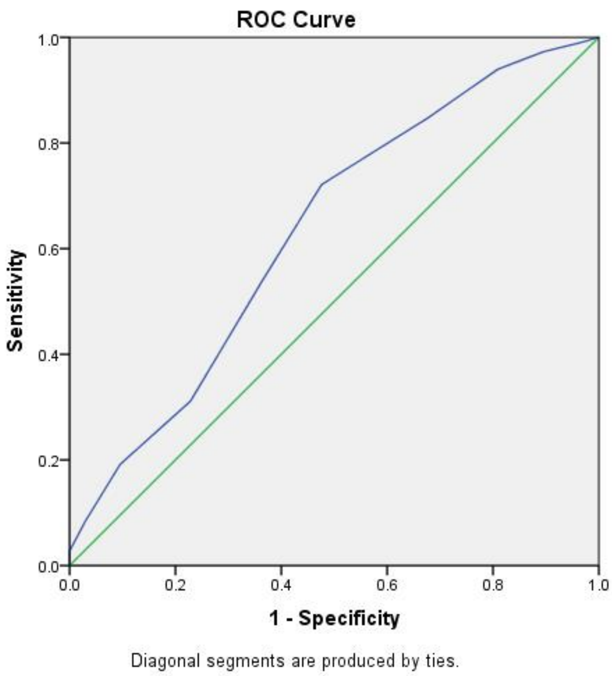


Figure 4.2 Receiver operating characteristics (ROC) curve of maternal DDS

The explanation of cut-off was showed in the table below.

Table 4.6 Cut-off of maternal DDS

Area Under Curve (AUC)	95% CI	p-value	Se	Spe	Cut-off value
0.634	0.566–0.701	0.000	0.721	0.476	7.50

According to the figure 4.2 and table 4.6, the cut-off of FGI-21 was 7.5. However, we concluded the total score of eight as a cut off of FGI-21. As a result, Low DDS was defined as respondent who consumed total FG less than eight score of 21 scores, whereas pregnant women who consumed eight and or higher than eight was categorized as high DDS. Furthermore, the cut-off of DDS was classified as moderate performance to discriminate the birth weight based on the result of area under curve (AUC) (AUC>0.6). The result was also linear with median (*IQR*) of FGI-21, which were 8 (5–10).

4.6 Maternal Dietary Diversity (DDS) and its Determinants

To explore the factors influencing maternal dietary diversity of pregnant women, the table showed the result below:

Table 4.7 Associations between maternal DDS and its determinants (n=288)

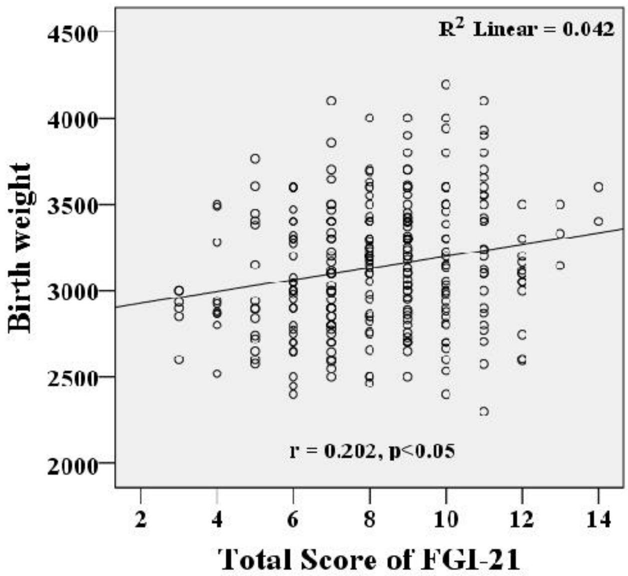
Variable		N	Low DDS n (%)	High DDS n (%)	Crude OR (95% CI)	p-value
Socioeconomic-demographic						
Education, *years*	≤ 9	87	40 (46)	47 (54)	1	
	> 9	201	66 (32.8)	135 (67.2)	1.74 (1.04–2.91)	0.034*
Working status	Working	85	28 (32.9)	57 (67.1)	1	
	Housewife	203	78 (38.4)	125 (61.6)	0.79 (0.46–1.34)	0.380
Household income, *(IDR)*	< 2.700.000	151	59 (39.1)	92 (60.9)	1	
	≥ 2.700.000	137	47 (34.3)	90 (65.7)	1.29 (0.76–1.99)	0.402
Maternal Nutritional Status						
Height, *cm*	< 150	72	31 (43.1)	41 (56.9)	1	
	≥ 150	216	75 (34.7)	141 (65.3)	1.42 (0.83–2.45)	0.204
Attained body weight, *kg*	< 60	106	49 (46.2)	57 (53.8)	1	
	≥ 60	182	57 (31.3)	125 (68.7)	1.89 (1.15–3.09)	0.011*
Hemoglobin status, *g/l*	Anemia (<111)	125	47 (37.6)	78 (62.4)	1	
	Non-anemia (≥ 111)	163	59 (36.2)	104 (63.8)	1.06 (0.65–1.72)	0.807
Maternal MUAC, *cm*	CED (< 23.5)	31	13 (41.9)	18 (58.1)	1	
	Normal (≥ 23.5)	257	93 (36.2)	164 (63.8)	1.27 (0.59–2.72)	0.531

*[a]n=180, *Chi-square, significantly correlated (p<0.05)*

There was a significantly association between maternal education and dietary diversity. It showed that mothers with high education had 1.7 times higher odds for having high DDS compared to low educated mothers. Additionally, mother's body weight in late pregnancy was associated with dietary diversity scores. There were more high DDS mothers among those who had body weight in late pregnancy more than 60 kg compared to those who had smaller body weight.

4.7 Maternal Dietary Diversity Scores (DDS) and Infant Birth Weight

The correlation between maternal DDS and infant birth weight was presented in the figure below:



Spearman correlation, significantly correlated ($p<0.05$)

Figure 4.3 Correlations between maternal DDS and infant birth weight (n=288)

Based on the result, there was positive correlation ($p<0.05$) between maternal DDS of FGI-21 and infant birth weight, however the correlation coefficients was categorized as low correlation ($r<0.3$). Furthermore, Chi-square analysis was examined to see the association between maternal DDS and infant weight at birth. Birth weight was divided into two categories (<3,000 g and ≥3,000 g), while the dietary diversity scores of FGI-21 was categorized into two levels (low DDS and high DDS).

Table 4.8 Associations between maternal DDS and infant birth weight (n=288)

Variable	N	< 3,000 g n (%)	≥ 3,000 g n (%)	OR (95% CI)	p-value
IDDS (21 FG)					
Low DDS (< 8 FG)	106	55 (51.9)	51 (48.1)	1	
High DDS (≥ 8 FG)	182	50 (27.5)	132 (72.5)	2.85 (1.73–4.69)	0.000*

Chi-square, significantly correlated ($p<0.05$)

Chi-square analysis remained a significant difference in birth weight (<3,000 g and ≥3,000 g). With regard to maternal DDS, there were more high infant weight at birth (≥3,000 g) among mothers with high DDS than low DDS (72.5% vs. 48.1%, $p<0.000$). In summary, pregnant women with high DDS had 2.85 times higher odds of having infant birth weight more than 3,000 g compared to low DDS.

4.8 Infant Birth Weight and its Determinants

Based on the observation, 63.2% of pregnant women consumed supplement. In this study, kind of supplements consumed by them were IFA tablet, calcium lactate, vitamin B complex, vitamin C, omega-3, and others multivitamin. Intake of supplement was important to assess whether it had an impact on birth weight or not. There was a government program support for pregnant women that IFA tablet must be consumed minimally 90 tablets during pregnancy. Therefore, the supplement was included in the analysis due to it was important to assess the micronutrient intervention even though the assessment of supplement was only from previous day.

The results presented that mother's age, history of deliver LBW baby, dietary diversity, attained body weight of mothers at recruitment, and mother's height had association with birth weight. There were more respondent who had high infant weight at birth among reproductive age (26–35 years) than older women ($p<0.05$). Moreover, there was a significant association between experience of having LBW babies previously and infant weight at birth in the next pregnancy. Sample on the history of deliver LBW baby's variable was more less than total sample due to there were respondent with the primigravida's condition at recruitment. So, they had no experience yet to deliver the baby previously. Therefore, total sample analyzed in history of having LBW and birth weight was only 180 pregnant mothers.

Nutritional status was matters in this study where mother who had good nutritional status during pregnancy had 2.3 times of mother's height variable and 3.0 times of mothers body weight higher odds of becoming infant weight at birth more than 3,000 g compared to mothers who had inadequate nutritional status during pregnancy as well as DDS. The association between infant birth weight and other determinants was showed on the table 4.10 below.

Table 4.9 Associations between birth weight and its determinants (n=288)

Variable		N	< 3,000 g n (%)	≥ 3,000 g n (%)	OR (95% CI)	p-value
Socioeconomic-demographic Variables						
Education, *years*	≤ 9	87	35 (40.2)	52 (59.8)	1	
	> 9	201	70 (34.8)	131 (65.2)	1.26 (0.75–2.11)	0.38
Working status	Working	85	31 (36.5)	54 (63.5)	1	
	Housewife	203	74 (36.5)	129 (63.5)	0.99 (0.59–1.69)	0.99
Household income, *(IDR)*	< 2.700.000	151	55 (36.4)	96 (63.6)	1	
	≥ 2.700.000	137	50 (36.5)	87 (63.5)	0.99 (0.62–1.61)	0.99
Maternal Factors Variables						
Mother's age, *years*	≤ 25	99	52 (32.5)	108 (67.5)	1.72 (0.75–3.96)	0.20
	26–35	160	38 (38.4) 15	61 (61.6)	2.22 (1.00–4.95)	0.050[*]
	≥ 36	29	(51.7)	14 (48.3)	1	
Parity, *children*	Nulliparity (0)	97	33 (34)	64 (66)	1	
	Multiparity (≥1)	191	72 (37.7)	119 (62.3)	0.85 (0.51–1.42)	0.54
Birth spacing [a], *months*	< 24	31	9 (29)	22 (71)	1	
	≥ 24	149	58 (38.9)	91 (61.1)	0.64 (0.28–1.49)	0.30
History of deliver LBW baby[a]	Yes	117	13 (59.1)	104 (65.8)	1	
	No	68	54 (34.2)	14 (63.6)	2.78 (1.12–6.92)	0.024[*]
History of premature delivery[a]	Yes	22	8 (36.4)	14 (63.6)	1	
	No	158	59 (37.3)	99 (62.7)	0.96 (0.38–2.42)	0.93
Maternal Behavior Variables						
Passive smokers	Yes	167	55 (32.9)	112 (67.1)	1	
	No	121	50 (41.3)	71 (58.7)	0.69 (0.43–1.13)	0.14
Maternal Dietary						
21 Food Groups	Low DDS (<8)	106	55 (51.9)	51 (48.1)	1	
	High DDS (≥8)	182	50 (27.5)	132 (72.5)	2.85 (1.73–4.69)	0.000[*]
Consumption of supplement	No	106	42 (39.6)	64 (60.4)	1	
	Yes	182	63 (34.6)	119 (65.4)	1.24 (0.76–2.03)	0.395
Maternal Nutritional Status						
Height, *cm*	< 150	72	37 (51.4)	35 (48.6)	1	
	≥ 150	216	68 (31.5)	148 (68.5)	2.30 (1.33–3.96)	0.002[*]
Attained body weight, *kg*	< 60	106	56 (52.8)	50 (47.2)	1	
	≥ 60	182	49 (26.9)	133 (73.1)	3.04 (1.84–5.03)	0.000[*]
Hemoglobin status, *g/l*	Anemia (<111)	125	39 (31.2)	86 (68.8)	1	
	Non-anemia (≥ 111)	163	66 (40.5)	97 (59.5)	0.67 (0.41–1.09)	0.10
Maternal MUAC, *cm*	CED (< 23.5)	31	13 (41.9)	18 (58.1)	1	
	Normal (≥ 23.5)	157	92 (35.8)	165 (64.2)	1.29 (0.61–2.76)	0.50
Gestational aged at birth, *weeks*	≤ 40	246	91 (37)	155 (63)	1	
	> 40	42	14 (33.3)	28 (66.7)	1.17 (0.59–2.34)	0.65

[a]n=180, [*]Chi-square, significantly correlated (p<0.05)

Furthermore, logistic regression was conducted to assess predictors of birth weight among pregnant women including mother's age, mother's history of

LBW baby, passive smokers, mother's height, mother's attained body weight, hemoglobin status, and maternal DDS. The model correctly predicted 45.7% of the birth weight (<3,000 g) and 89.1% of the high birth weight (≥ 3,000 g), and overall correctly predicted 73.3% of the birth weight among the pregnant women. The results were shown on the table 4.7 below:

Table 4.10 Predictors for infant birth weight among pregnant women (n=288)

Variable		**Exp(B)**	**95% CI for Exp(B)**	**p-value**
Mother's age, *years*	≤ 25	2.14	0.85 to 5.38	0.106
	26–35	2.53	1.07 to 5.98	0.035*
	≥ 36			
Passive smokers	Yes			
	No	0.66	0.38 to 1.13	0.130
IDDS (21 FG), *food groups*	Low DDS (< 9)			
	High DDS (≥ 9)	2.81	1.64 to 4.79	0.000*
Height, *cm*	< 150			
	≥ 150	1.58	0.84 to 2.96	0.158
Attained body weight, *kg*	< 60			
	≥ 60	2.65	1.49 to 4.71	0.000*
Hemoglobin status, *g/l*	Anemia (<110)			
	Non-anemia (≥ 110)	0.62	0.62 to 0.36	0.090

**Logistic regression, significantly correlated (p<0.05)*

After adjusting with other variables, maternal DDS still had association with the birth weight. For this model, approximately 20.2% of the variance in accelerated birth weight can be predicted by the significant predictors, which were mother's age, body weight at third trimester, and maternal dietary diversity scores. Variable of history of deliver LBW baby was not included in this model. While there was a significantly association with the birth weight, the power of the result might be less due to the sample size to be analyzed was only 180 respondent.

The results showed that hemoglobin status among pregnant women was tend to the birth weight (p=0.078). However, it seemed that non-anemia mothers had 1.39 higher odds to reduce the birth weight. In conclusion, hemoglobin status might be a predictor for birth weight, although in this study the association was not present.

CHAPTER 5
DISCUSSION

The proportion of study sample was presenting the similar proportion on population of pregnant women in each district. Jatinegara, Kramat Jati, and Pasar Rebo's districts were the highest contributor for study sample.

5.1 Infant Birth Weight

In the present study, the prevalence of low birth weight (LBW) baby was 1.7%. This number was lower than either from national prevalence (10.2%) or LBW prevalence in Jakarta (10%). The possible explanation was that in my eligible subject, the range of age was 19–44 years. While in the Basic Health Survey, there was no limitation of age. Thus, the younger age group (≤18 years) as strong predictor of LBW gives the contribution of higher LBW nationally [8]. Moreover, other factors influencing LBW such as infectious disease had been controlled of this study.

Additionally, 1.7% of respondent delivered their baby prematurely. This number was similar with the number of LBW baby (1.7%). However, the data showed that only one respondent who had LBW baby delivered prematurely. Then the rest, (four respondents) showed that the babies born in the full term while the birth weight was less than the normal weight (<2,500 g). This finding approved that LBW in infants was largely attributed to intrauterine growth retardation (IUGR) occurred in the developing country [91], which was concentrated mainly in Asia nearly 75% affected infants [91].

5.2 Maternal Dietary Diversity Scores

In the present study, 21 food groups had been chosen to determine the birth weight. It was more representing to capture the quality of nutrient intakes of pregnant women in this study.

Food groups available in FGI-21 contributed some important nutrients. The largest contributor for energy and carbohydrate intake was FG of all starchy staples (cereals and white roots and tubers). Not only as contributor for energy and carbohydrate, but also it provided about half of the total protein intake especially on grain/grain products [24, 92]. Although starchy staples were not FG of nutrient dense, they were source of micronutrients intake. Moreover, FG of all legumes and nuts provided the plant protein source as well as principle source of most micronutrient intakes such as vitamin B1, B2, B3, B6, iron, and zinc [24].

Intake of animal source proteins such as organ meat, eggs, flesh food and other miscellaneous small protein had higher contribution for adequate protein. Furthermore, they contained some micronutrients including vitamins and minerals (vitamin B complex, calcium, iron and zinc) [18, 24, 92]. In the present study, products of formula milk for pregnant women were commonly consumed by pregnant women. These products were dairy product with fortified some vitamins and minerals. Thus, when pregnant women consumed the milk product, indirectly they had been consumed the source of some micronutrients including vitamins and minerals.

In addition, FG of vitamin A-rich fruits and vegetables were also source of micronutrients intakes, especially for FG of vitamin A-rich dark green leafy vegetables, it contained the nutrient of calcium[24]. Another food groups contributing the calcium intake were FG of dairy milk and small fish eaten whole with bones.

The important nutrient during pregnancy was iron due to the blood volume increased as well as increasing gestational age. FG of beef/pork/lamb/goat was source of iron food especially the source of heme iron[92]. Organ meat's FG was also the source of heme iron; however the containing on protein of that FG was not higher. Bioavailability of iron will be higher if the consumption accompanied with protein rich food [17]. Therefore, dietary diverse was important to make sure the requirement of nutrients can be fulfilled.

Based on the explanation above, dietary diversity can support the balanced diet especially among pregnant women where some message on guideline of balanced diet can improve the health and nutritional status. Regarding to this study, five messages of balance diet (number one into number five) can be reflected through dietary diversity[76].

According to the result of determinants on DDS, there was two factors contributing the maternal DDS, which were maternal education and maternal body weight in late pregnancy. The finding showed that the number of more educated mothers were higher in high DDS group compared to low DDS group. The previous study found that dietary diversity was associated with socioeconomic status [77]. In addition, food security was a strong predictor on dietary diversity scores [93], while in the present study, food security was not assessed. However, mother's education as one of the indicators of socioeconomic status could explain the relationship on dietary diversity. The explanation was that educated mothers had ability and capacity to process and use the information [35]. Another study had similar result that people with higher education had more ability and had the awareness of their health behavior[36]. In other words, well-educated mothers will have more consideration to choose and consume the food. In this case, they were more diverse in the consumption.

As a result, maternal nutritional status especially body weight in late pregnancy had association with dietary diversity. The finding indicated that more higher the DDS, it had more an increment of body weight. The linearity with the previous study on DDS supported the finding that DDS were positively and significantly correlated with energy intake[24]. The study in Tehran presented that correlation between DDS and nutrient adequacy among females aged 18-80 years was examined[83]. It approved that quality of nutrient can be reflected by dietary diversity. Additionally, the relationship between DDS and nutritional status of women (BMI, MUAC, waist-hip-ratio, and skin fold thickness) was also found in developing country, Nigeria[25]. Thus, the finding can support the present study that the nutrient intake can be captured by dietary diversity scores [18]. More diverse among pregnant women was more correlate with the energy intake[17]. Hence, it could reflect the increment of body weight due to there was availability of nutrient stores in the body which needed for foetus during pregnancy.

5.3 Maternal DDS and Infant Birth Weight

Findings of this study showed that there was a positive correlation between maternal DDS and infant birth weight even though the correlation coefficient was very weak (r<0.3). It was not surprising due to maternal DDS was a proxy indicator for nutrient adequacy [18]. It measured the quality of nutrient intake where more diverse the diet was more fulfill the nutrient requirements [18, 24]. Therefore, the concept of using DDS as approach of measuring nutrient intake was valid. This issue supported by several studies reported that positive associations existed between dietary diversity and nutrient intake [24, 74, 75].

In the present study, we found a significantly higher rate of infant weight at birth more than 3,000 g among mothers with high DDS. This association confirmed the result of previous study in Northern Ghana that IDDS in maternal was associated with reduced risk of LBW (Adjusted OR=0.43, 95% CI=0.22–0.85, p=0.014) [19]. It revealed that in the developing countries where measuring actual intake was difficult, DDS method offering a quite simple method to measure the quality of nutrient intake [18, 24].

There was an agreement that providing the adequate intake was very important during pregnancy to determine the birth outcome [17]. Moreover, the previous study also reported that dietary composition of pregnant women had an effect on fetal growth [16], especially in developing countries where the multi-micronutrient deficiency occurred [13]. Therefore, dietary diversity could be the indicator on determining the birth weight. Moreover, it could be the strategy to ensure the nutrient adequacy of pregnant women required.

5.4 Factors Affecting the Birth Weight

The findings related to the birth weight and its determinants showed certain factors such as maternal age, history of LBW baby, attained body weight of mothers at recruitment, and maternal height had association with the birth weight. Maternal age was still having an important role affecting the birth weight. A significant association between the age and the birth weight was observed in India[55]. Maternal age ≥35 years had 2 times higher odds on having LBW[55]. The similar result in the present study assessed that mother with reproductive age 26–35 years had 2.2 times higher odds on having the higher birth weight. It means that pregnancy in the reproductive age had opportunity to get the higher birth weight due to physical growth was already complete[14]. Thus, there was no maternal-fetal competition for nutrient between the mother and the feotus [45].

Besides on age, mothers with no experience on having LBW babies previously had higher infant birth weight than those who had history of deliver LBW baby. The present study confirmed the previous literature that LBW baby was a result from the history of deliver LBW infant in the previous pregnancy [14]. It might be related to obstetric history which could increase the risk of preterm delivery or LBW baby. Some references also found that history of deliver LBW baby was related to genetic factors [14, 41]. However, factor affecting birth weight cannot be explained only by recognized genetic factors alone [43].

Maternal nutritional status, as measured by height and body weight at recruitment in this study showed the association with the birth weight. Mothers with height ≥150 cm had significantly increased odds of higher birth weight. The finding was linear with the previous study that smaller babies were delivered by women who were short compared with tall mothers [59, 60]. Study in Lombok showed the similar results that combination of MUAC and body height of the pregnant women increased the likelihood of having a LBW baby [11]. It contributed to impaired fetal growth due to mother's height was correlated with uterine volume and blood flow [2, 9].

Furthermore, when the weight of mothers in the late pregnancy increased to more than 60 kg, they had 3.0 times higher odds on having high infant birth weight than those with inadequate weight. It had the implications for both the mother and the feotus, because it ensured the nutrient availability to feotus for grow [14]. This finding had consistently with the conclusion of a recent review of studies that the risk of giving birth small for gestational age (SGA) significantly increased with mothers who had inadequate nutritional status especially the body weight [11, 43]. Increased the weight during pregnancy had an effect to reduce the risk of IUGR also which occurred in most of developing country [2].

The finding found that the prevalence of pregnant women who suffered from anemia in East Jakarta was higher either than National or Urban area in Indonesia [8]. Based on the result, its prevalence was categorized as severe public health problem due to more than 40% of population suffered from anemia [9]. In other words, anemia was still being the big problem in East Jakarta. Surprisingly, the proportion of group with higher birth weight was higher among anemia mothers than non-anemia mothers, even though the result was not statistically significant.

Anemia is non-nutritional factors that there were several factors contributing the hemoglobin status[9]. Iron deficiency anemia as a factor affecting the birth weight regarding to increase the preterm birth[2]. However, in the present study, the LBW baby was not result of preterm birth but more on the IUGR. Therefore, anemia in this study was not associated with the birth weight due to there was other factors might be more influencing to status of anemia compared to the intake.

There was a program supporting the pregnant women by government, which stated that pregnant women should consume IFA (Iron Folic Acid) tablet minimally 90 tablets during pregnancy. It is one of strategy to reduce the anemia status in Indonesia. However, the present study found that consumption of supplement was not associated with the birth weight. Since the compliance of IFA tablet was not assessed in this study, the effect of micronutrient intervention cannot see clearly whether it had an impact on hemoglobin status or not.

After adjusted by other determinants of birth weight, maternal DDS and infant birth weight revealed the same result that there were associations between those two variables (Adjusted OR=2.81, 95%CI=1.57–4.54, p=0.000). Consistently, maternal age and maternal body weight in the third trimester showed the association with birth weight. In the conclusion, maternal age, maternal weight in late pregnancy, and maternal dietary diversity were the predictors of birth weight in this study.

Previous study revealed that in young mothers, incomplete physical growth might also contribute to adverse outcomes due to there was a maternal-fetal competition for nutrients[45]. The finding explained the similar result with the previous study that mother with reproductive age (26–35 years) at pregnancy had higher infant weight at birth. Since the major influence regulating foetal growth was the supply of nutrients to the foetus, in the reproductive age, they had enough storage for the foetus [14, 44].

Not only the age of the mothers, but also the nutritional status during pregnancy was a strong predictor to increased the birth weight. Actually, the important factor of nutritional status was gestational weight gain since it ensure the fetal growth of the feotus [14]. However, in the present study, the body weight measured in the late pregnancy. Regarding with other previous study, they found that the risk of giving birth small for gestational age (SGA) significantly increased with mothers who had pre-pregnancy weight below 50kg [43]. Study in India revealed the similar result with the present study[55]. They observed that maternal weight at last week of gestation below 45 kg associated with the low birth weight (OR 2.3)[55]. The mechanism was reflected on adequacy and inadequacy of nutrients in the mother's weight which can determine the fetal growth, include the birth weight of newborn [14, 43].

Finally, we found that maternal education was a higher contributor on dietary diversity scores in this study. The result found that well-educated mothers had 1.7 times higher odds on having higher DDS. It explained that mothers with higher education would have the higher knowledge and ability to use the information[36, 37]. It had an impact on mother's decision to choose the healthy food, though it also related to the affordability of mother on purchasing the food [93]. Therefore, mothers with higher education could have an adequate intake through dietary diversity.

Furthermore, the adequate intake of pregnant women had an impact on nutritional status, especially the weight of mothers in late pregnancy. Previous study showed that there were significant correlations between the nutrient intake of the mothers and the weight of newborn in the last trimester of pregnancy[67]. Furthermore, mothers who consumed calories less than the requirement during the last trimester delivered LBW newborns[67]. Other studies revealed the similar conclusion that maternal dietary influencing the birth outcome especially the birth weight[16, 13]. In addition, pregnancy in the reproductive age plays an important role to decrease the adverse outcome and increase the birth weight. It relates with the availability of nutrient stores, so the pregnant women will have the good health and nutritional status which affecting the birth weight. As a result, these factors contribute to the birth weight due to increasing the nutrient intake through dietary diversity and nutritional status could improve the fetal growth during pregnancy.

5.5 Strength and Limitation of the Study

The strength of this study was using dietary diversity scores (DDS) as approach of measuring the nutrient adequacy was valid in urban area especially in East Jakarta, Indonesia. Moreover, DDS among pregnant women might contribute to reduce the problem of intrauterine growth retardation (IUGR) that commonly occurred in developing countries.

There were several limitation of the study that DDS was only examined in the late pregnancy. Thus, it cannot measure the diversity in the early pregnancy (firth and second trimester) due to it also important on fetal development. Moreover, gestational weight gain as a main predictor and an important factor affecting fetal growth such as the birth weight was not assessed.

CHAPTER 6
CONCLUSION AND RECOMMENDATION

6.1 Conclusion

1. The Prevalence of Low Birth Weight (LBW) was 1.7% and mean birth weight was 3138 ± 367 gram.
2. Food Group Indicator (FGI) chosen in this study was FGI-21. Median of dietary diversity scores (DDS) of FGI-21 was 8 (3–14). Cut-off of this indicator was 8. The proportion of respondent with low DDS was 36.8%, whereas in high DDS was 63.2%.
3. Maternal education was associated with maternal dietary diversity scores (DDS) ($p<0.05$).
4. There was a significantly association between maternal DDS and infant weight at birth ($p<0.05$).
5. Maternal age, history of LBW, maternal nutritional status measured by weight and height in late pregnancy were associated with the infant weight at birth ($p<0.05$).
6. The predictors of infant birth weight in this study were maternal age, maternal body weight in late pregnancy and maternal DDS.

6.2 Recommendation

6.2.1 For Program

1. Related with the Dietary Diversity Scores (DDS) measurement, we suggest putting attention and examination on measure the nutrient intake using DDS and recommend the minimum DDS is eight of 21 food groups as an important evidence to prevent the risks for fetal growth and improves infant health in the future.
2. We suggest government to have an improvement on promoting the balanced diet which related to adequate intake of pregnant women.

6.2.2 For Pregnant Women

1. We suggest pregnant women to consume the IFA supplementation regularly regarding to prevent the risk of anemia due to the severe public health problem of anemia was showed in the present study.

6.2.3 For Further Study

1. Further study needs to be undertaken with taking into account the assessment of gestational weight gain (GWG) of pregnant women related with fetal growth (birth weight).
2. Further study also needs to be undertaken with assessing dietary diversity scores (DDS) in the early pregnancy (first and second trimester) to determined a whole picture on dietary related to requirement of important micronutrient in the early pregnancy.

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