

Factors Associated with Malnutrition in Pregnancy: A Principal Component Analysis

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Abstract: Malnutrition during pregnancy in Indonesia is quite high, and has the impact of increasing complications during pregnancy and childbirth as well as in babies who are born. This research aims to analyze factors associated with malnutrition in pregnancy using principal component analysis. This study is an observational analytic using a case-control design. The research started from September to December 2021. The samples for this study were 190 pregnant women in Bandar Lampung City and were taken using a multistage random sampling technique that met the inclusion and exclusion criteria. The independent variables are nutrition intake (energy, protein, carbohydrates, fat, iron), anemia, iron status, protein status, weight gain during pregnancy, age, education, knowledge, occupation, income, parity, food taboo, and BMI before pregnant, and the dependent variable is malnutrition during pregnancy. Nutrition intake data was assessed based on the SQFFQ questionnaire. Data on anemia, iron status, and protein status were assessed based on blood tests. Prepregnancy BMI and weight gain data were measured using anthropometry. Other data with questionnaires. Data were analyzed using principal component analysis. The results of the study showed that based on principal component analysis, 3 categories of factors were found that played a role in the incidence of malnutrition in pregnancy, that were factor 1 (energy intake, protein intake, carbohydrate intake, fat and iron intake) which was named nutrition intake; factor 2 (BMI before pregnancy and weight gain during pregnancy) was named prepregnancy nutritional status and weight gain; and factor 3 (iron status, parity, and food taboo) was named iron reserves and cultural factors.

1 INTRODUCTION

One of the key issues is malnutrition, which impairs a person's physical function to the point where it is unable to support necessary bodily functions like growth, physical labor, and illness resistance or recovery. Low birth weight, intrauterine growth retardation (IUGR), and mother and child mortality and morbidity are frequently caused by poor nutrition during pregnancy, when combined with infections (Serbesa et al., 2019).

Malnutrition is known to increase the risk of poor pregnancy outcomes, including obstructed labor, premature or low-birth-weight (LBW) babies and postpartum hemorrhage (Gebre et al., 2018). Severe anemia during pregnancy is associated with increased maternal mortality. Besides, malnutrition among

mothers has an intergenerational effect, with repeating cycles of malnutrition and poverty in the long run (Saha et al., 2022).

Inadequate maternal nutrition has been linked to an increased risk of complications like intrauterine growth restriction, low birth weight, premature, prenatal and child mortality, and morbidity (Marshall et al., 2022). Inadequate nutrient intake, on the other hand, has been shown to have pathophysiologic effects that manifest as growth and development defects in children and adult chronic disease in adults over time (Norman et al., 2021).

Malnutrition remains one of the world's highest priority health issues, not only because its effects are so widespread and long lasting but also because it can be eradicated best at the preventive stage (Serbesa et al., 2019). Maternal malnutrition is influenced not

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only by lack of adequate nutrition but also influenced by social and psychological factors, nutritional knowledge of mothers, and biological changes that influence perceptions of eating patterns during pregnancies (Dukhi, 2020).

The factors that determine the CED status of a woman of childbearing age, whether pregnant or not pregnant, consist of direct, indirect, basic and main problems. Direct factors include food intake and illnesses suffered (infectious diseases, anemia, protein deficiency). Indirect factors include food availability, environment (family, environmental cleanliness, culture), history of illness/health, health services, obstetric status/parity, mother's education and knowledge (UNICEF, 2015; Ministry of Health of the Republic of Indonesia, 2015).

Of the many factors that play a role or are associated with the incidence of malnutrition in pregnancy, an analysis will be carried out using principal component analysis to reduce a large number of variables into a small number of factors. The purpose of principal component analysis is to explain variations in a set of observed variables on the basis of several dimensions, from variables that change a lot to variables that are few.

2 SUBJECT AND METHOD

This research is an observational analytic study with a cross-sectional research design. The study was conducted at the 12 Public Health Centers in Bandar Lampung City, Indonesia, from September to December 2021. The population in this study were pregnant women in Lampung Province. Based on the results of the sample calculation, the minimum number of samples that must be met were 190 pregnant women in Bandar Lampung City. The sample size calculation uses the sample size formula for unpaired categorical comparative analytics with a 95% confidence value, the power of the test is 80%. Sampling was done by the multistage random sampling method.

The inclusion criteria were pregnant women and willing to take part in the research. The exclusion criteria were having a history of malignant disease, suffering from or having a history of diabetes mellitus, and suffering from or having a history of infectious disease.

The independent variables are nutrition intake (energy, protein, carbohydrates, fat, iron), anemia, iron status, protein status, weight gain during pregnancy, age, education, knowledge, occupation, income, parity, food taboo, and BMI before pregnant,

and the dependent variable is malnutrition during pregnancy. Nutrition intake data was assessed based on the Semiquantitative Food Questionnaire (SQFFQ). Data on anemia, iron status, and protein status were assessed based on blood tests. Prepregnancy BMI and weight gain data were measured using anthropometry. Other data with questionnaires. Data collection was carried out by researchers with the help of 4 enumerators who had been given previous guidance and training. The data was analyzed with a significant degree of 95% ($p < 0.05$) principal component analysis. This research was carried out after obtaining a research ethical clearance letter from the Ethics Committee of the Faculty of Medicine, the University of Lampung with number 3380/UN26.18/PP.05.02.00/2021.

3 RESULTS

The role of the variables that were energy intake, protein intake, carbohydrate intake, fat intake, iron intake, anemia, iron status, protein status, weight gain during pregnancy, age, education, knowledge, occupation, income, parity, food taboo, and BMI before Pregnancy is tested using principal component analysis (PCA) so that factor names can be obtained for all these variables. The results of the first/initial step to carry out factor analysis using the PCA method are presented in table 1. Based on the results of the initial PCA analysis test, it was found that the Kaiser-Meyer-Olkin (KMO) value was 0.692 (greater than 0.5) so that the factor analysis technique could be continued and the Bartlett's test of sphericity value was 0.000 ($p < 0.05$), so the factor analysis in this study could be continued because it met the requirements First.

The Measurement System Analysis (MSA) value for each variable can be seen based on the anti-image matrix value. Based on the results of PCA analysis, not all variables have an MSA value > 0.5 . Variables that have an MSA value > 0.5 are energy intake, protein intake, carbohydrate intake, fat intake, iron intake, anemia, iron status, weight gain during pregnancy, education, income, parity, food taboo, and BMI before pregnancy. Variables that have an MSA value < 0.5 are protein status, age, knowledge, and occupation. Because not all variables have an MSA value > 0.5 , the second requirement for PCA analysis is not fulfilled so the analysis cannot continue. Therefore, the factor analysis process was carried out using the PCA method again only for variables that had an MSA value > 0.5 .

Table 1: Results of Initial Factor Analysis Using the Principal Component Analysis (PCA) Method

Variables	KMO	Bartlett didn't test	Antiimage matrix
	0.692	0,000	
Energy intake			0.725
Protein intake			0.864
Carbohydrate intake			0.723
Fat intake			0.769
Iron intake			0.870
Anemia			0,510
Serum ferritin status			0,522
Serum albumin status			0,484*
Weight gain			0,561
Age			0,456*
Education			0,509
Knowledge			0,497*
Occupation			0,487*
Income			0,519
Parity			0,725
Food taboo			0,612
BMI before pregnancy			0,568

Analysis using the PCA method was carried out a second time by including the variables energy intake, protein intake, carbohydrate intake, fat intake, iron intake, anemia, iron status, weight gain during pregnancy, education, income, parity, occupation, and BMI before pregnancy. Based on the results of the initial PCA analysis test, it was found that the KMO value was 0.733 (greater than 0.5) so that the factor analysis technique could be continued and the Bartlett's test of sphericity value was <0.001 ($p<0.05$), so the factor analysis in this study could be continued because it met the requirements First.

The MSA value for each variable can be seen based on the anti-image matrix value. Based on the results of PCA analysis, not all variables have an MSA value >0.5 . Variables that have an MSA value >0.5 are energy intake, protein intake, carbohydrate intake, fat intake, iron intake, iron status, weight gain during pregnancy, parity, food taboo, and BMI before

pregnancy. Variables that have an MSA value <0.5 are anemia, education and income. Because not all variables have an MSA value >0.5 , the second requirement for PCA analysis is not fulfilled so the analysis cannot continue. Therefore, the factor analysis process was carried out using the PCA method again only for variables that had an MCA value >0.5 .

Analysis using the PCA method was carried out three times by including the variables energy intake, protein intake, carbohydrate intake, fat intake, iron intake, iron status, weight gain during pregnancy, parity, food taboo, and BMI before pregnancy. The results of the two factor analyses using the principal component analysis (PCA) method are presented in table 2. Based on the results of the initial PCA analysis test, it was found that the KMO value was 0.756 (greater than 0.5) so that the factor analysis technique could be continued and the Bartlett's test of sphericity value was <0.001 ($p<0.05$), so the factor analysis in this study could be continued because it met the requirements First.

The MSA value for each variable can be seen based on the anti-image matrix value. Based on the results of the PCA analysis, all variables have an MSA value >0.5 so that the second requirement for this PCA analysis is met and the analysis can continue, and this is the result of the final factor analysis.

The communalities column shows how much the factors formed can explain the variance of a variable. The communalities value for all these variables is the same, namely 1,000, which means that each variable can explain 100% of the variance of the factors formed, thus indicating the close relationship between the variables in question and the factors formed (Delsen, Wattimena & Saputri, 2017).

Table 2: Final Factor Analysis Results Using the Principal Component Analysis (PCA) Method

Variables	KMO	Bartlett didn't test	Anti-image matrix	Communalities	Initial eigenvalue	Eigenvalues
	0.756	0,000				
Energy intake			0.746 0.898	1,000	3,278	3,278
Protein intake			0.757 0.815	1,000	1,635	1,635
Carbo intake			0.882 0.521	1,000	1,095	1,095
Fat intake			0.553 0.754	1,000	0.946	
Iron intake			0.652 0.561	1,000	0.847	
Ferritin status				1,000	0.597	
Weight gain				1,000	0.534	
Parity				1,000	0.480	
Food taboo				1,000	0.365	
BMI Prepregnancy				1,000	0.224	

To determine the number of factors formed, it can be based on the eigenvalue. If there is a total eigenvalue whose value is less than 1, the factor is declared unable to explain the variable well, so it is not included in the formation of the variable (Umar, 2009). The results of the analysis show that the eigenvalue shows that the number of variants obtained in the output results is all three (3) variants, meaning that there are three (3) groups of factors that may be formed. These three variables can explain the variance of the eight items amounting to 60.08%. This figure is quite large because it is proven to explain more than 50% of the variance of the variable.

The number of factors can also be determined from the scree plot. A scree plot is like a broken line. The point where the scree starts to occur shows the number of factors, precisely when the scree starts to flatten, shown by the initial eigen value which is > 1 . The results of the analysis in this study show that the initial eigen value > 1 is component number 1.

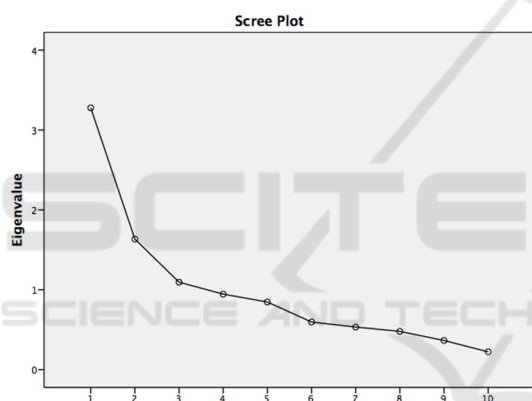


Figure 1. Scree Plot

The results of the analysis then show a component matrix of factors that associated with malnutrition in pregnancy. The component matrix and rotation model are presented in table 3. The matrix component shows the correlation value between a variable and the factors formed. The energy intake variable has the highest variable correlation on factor 1, that was 0.872 compared to the correlation on factors 2 and 3, so that the energy intake variable is on factor 1. The protein intake variable has the highest variable correlation on factor 1, namely 0.764 compared to the correlation on factors 2 and 3 so that the protein intake variable is at factor 1.

The carbohydrate intake variable has the highest variable correlation on factor 1, that was 0.760 compared to the correlation on factors 2 and 3, so that the carbohydrate intake variable is on factor 1. The fat intake variable has the highest variable correlation on factor 1, that was 0.753 compared to the correlation on factors 2 and 3 so that the fat intake variable is in factor 1. The iron intake variable has the highest variable correlation in factor 1, that was 0.710 compared to the correlation in factors 2 and 3 so that the iron intake variable is in factor 1.

The iron status variable has the highest variable correlation in factor 3, that was 0.778 compared to the correlation in factors 1 and 2, so that the iron status variable is in factor 3. The weight gain variable during pregnancy has the highest variable correlation in factor 2, that was 0.821 compared to the correlation in factors 1 and 3 so that the weight gain variable during pregnancy is in factor 2. The abstinence from eating variable has the highest variable correlation in factor 3, that was 0.650 compared to the correlation in factors 1 and 2 so that the abstinence from eating variable is in factor 3.

Table 3. Matrix Components and Rotation Model Results of Application Analysis of Factors Associated with Malnutrition in Pregnancy

Variables	Component			Rotation Model		
	1	2	3	1	2	3
Energy intake	0.872*	0.166	0.054	0.732	0.347	0.286
Protein intake	0.764*	0.099	0.081	0.912	0.223	0.215
Carbohydrate- intake	0.760*	0.207	0.156	0.923	0.154	0.205
Fat intake	0.753*	0.125	0.061	0.921	0.165	0.207
Iron intake	0.710*	0.184	0.013	0.928	0.197	0.210
Ferritin status	0.105	0.054	0.77*	0.000	0.014	0.997
Weight gain	0.272	0.82*	0.053	0.011	0.940	0.042
Parity	0.253	0.158	0.56*	0.025	0.064	0.989
Food taboo	0.225	0.161	0.66*	0.084	0.064	0.992
BMI Pre-pregnancy	0.296	0.80*	0.043	0.024	0.938	0.025

The parity variable has the highest variable correlation on factor 3, that was 0.564 compared to the correlation on factors 1 and 2, so the parity variable is on factor 3. The BMI variable before pregnancy has the highest variable correlation on factor 2, that was 0.808 compared to the correlation on factors 1 and 3 so that the BMI variable before pregnancy is in factor 2. Through the rotation model, 3 rotations of matrix components are produced, according to the number of factors obtained. From the results of the analysis it was found that after rotation there were three variables that were highly correlated (cut off point = 0.55), that were:

- 1) Factor 1: energy intake, protein intake, carbohydrate intake, fat intake and iron intake.
- 2) Factor 2: weight gain during pregnancy, and BMI before pregnancy
- 3) Factor 3: iron status, parity, and food abstinence

4 DISCUSSION

The results of the study show that the factors associated with the incidence of malnutrition in pregnancy consist of 3 factors, that were food intake factors (energy intake, protein intake, carbohydrate intake, fat intake and iron intake), nutritional status factors, that were pre-pregnancy BMI and weight gain during pregnancy, and iron status and cultural factors (parity and food taboo).

The increase in energy in pregnant women is used for growth and development of the fetus, placenta and health maintenance. Pregnant women who consume food with a number of calories below the recommended adequacy for a long time will risk malnutrition which can cause the fetus to grow imperfectly. Energy should be balanced, otherwise it will have detrimental effects on the body (Lowensohn et al., 2016).

When the amount of energy consumed through food is less than the amount of energy used, there is an energy deficit. Body weight is therefore lower than the optimal body weight. It will impede growth in infants and young children if it happens. In the meanwhile, it will cause tissue damage and weight loss if it affects adults (Mahdi et al., 2023).

Insufficient nutritional intake both before and during pregnancy can cause pregnant women to become malnourished. The needs of pregnant women are greater than the needs of non-pregnant women. Pregnant women's energy needs need to be increased according to gestational age (Jouanne et al., 2021). The energy needs of pregnant women in the 1st trimester are increased by 180 kcal/day, in the 2nd

trimester an additional 300 kcal/day and in the 3rd trimester an additional 300 kcal/day.

This increased energy is used for growth and development of the fetus, placenta and health maintenance. Pregnant women who consume food with a number of calories below the recommended intake for many years will risk malnutrition which can cause the fetus to grow imperfectly (Lowensohn et al., 2016).

Protein serves as an enzyme and hormone regulator as well as a building block for the body's structural proteins, such as collagen and elastin. Moreover, proteins serve as immune response mediators and transporters of certain proteins. Pregnant women's protein requirements must be met because the fetus's capacity to grow normally depends on the mother's supply of sufficient protein. Protein is the basic building material needed for the formation of enzymes, antibodies, muscles and collagen. Collagen is used as a framework for skin, bones, blood vessels and other body tissues (Elango & Ball, 2016).

During pregnancy the mother consumes enough protein to meet the increasing needs of herself and the developing fetus. Protein is a source of energy after glycogen, being a catalyst for biochemical reactions in the body, forming the structure of cells and tissues. Therefore, individuals must get sufficient protein intake because protein deficiency will have a negative impact on an individual, especially preconception women, pregnant women and adolescent girls (Elango & Ball, 2016).

Carbohydrates are the main source of energy for humans. Every 1 gram of carbohydrate consumed produces 4 kcal of energy and the results of the carbohydrate oxidation process will then be used by the body to carry out various functions such as breathing, heart contractions, and to carry out various physical activities (Morris & Mohiuddin, 2023).

Carbohydrates perform various important functions for the body, namely as a source of energy, helping fat metabolism, preventing excessive breakdown of body protein. Pregnant women who have a low level of carbohydrate consumption should consume more bread, rice, cereal, etc., including fruit and vegetables that contain carbohydrates (Prasetyo, 2017).

Carbohydrate consumption as the largest energy contributor must be adjusted to the body's needs. Apart from excessive intake which will cause excess weight, if the intake is insufficient then malnutrition will occur. Lack of energy in the body will cause changes in carbohydrates, proteins or fats to become energy sources, so that the main function of these

three nutrients will decrease. If these changes last for a long time, there will be changes in body weight and damage to body tissue. Energy in the human body can arise due to the burning of carbohydrates, proteins and fats, so humans need sufficient food substances to meet their energy requirements (Clemente-Suarez et al., 2022).

Fat functions as a solvent for vitamins A, D, E, and K. Fat also functions as an energy reserve for the mother when she gives birth. The need for fat in pregnant women is very important because it is used as an energy reserve during and after the birth process and breastfeeding. Therefore, pregnant women must consume fat in balanced amounts, neither more nor less (Duttaroy & Basak, 2021).

Fat functions as a source of calories in preparation for childbirth and to metabolize vitamins A, D, E and K. Pregnant women who do not consume enough fat are feared that they will lack energy during pregnancy and childbirth which will affect the baby to be born. Fat also functions in the development of the brain and nerves, so that if there is a deficiency it can result in imperfect growth of the fetus's nerves, whereas if the mother experiences an excess of fat consumption, the baby and the fetus will accumulate energy. Food sources that can produce fat are oil, margarine and butter (Marshall et al., 2022).

Iron requirements increase during pregnancy for maternal and fetal blood formation. In addition, the mother's iron stores are needed for 4-6 months after birth to meet the baby's needs, because the baby's main food in the form of breast milk contains little iron. Additionally, mothers lose a lot of blood during delivery. Sources of iron are animal foods such as liver, meat, chicken, fish and eggs. Plant foods such as cereals, nuts and their processed products, as well as green vegetables but have lower biological availability (Georgieff, 2020).

The role of iron is very essential in pregnancy, in fact various health programs are directed at meeting iron needs during pregnancy, especially through supplementation and fortification programs. Apart from that, information exposure through counseling and various communication media is continuously carried out to provide a comprehensive understanding regarding the importance of meeting iron needs in pregnancy. This causes pregnant women, especially those with higher education, to be able to accept the information and health programs provided in an effort to fulfill their iron needs. Pregnant women with higher education also show better iron consumption (Brannon & Taylor, 2017).

The mother's pre-pregnancy BMI is considered to indicate the quality of the mother's nutrition during

the pre-pregnancy period as well as showing the availability of nutrients in the mother's body tissues before pregnancy, which will have an impact on the mother's health and the growth of the fetus while in the womb. The risk of giving birth to a small baby for gestational age decreases along with an increase in BMI before entering pregnancy. BMI before pregnancy is the most appropriate research to predict the quality of the baby born (Bonakdar et al., 2019).

Maternal nutritional adequacy during pregnancy can also be evaluated through weight gain during pregnancy. Weight gain during pregnancy is the difference between initial body weight and final body weight, where final body weight is the body weight several weeks before giving birth. Another definition, weight gain during pregnancy is the difference between the weight at the end of pregnancy and the weight at the beginning of pregnancy. Final weight is the weight at birth. Meanwhile, initial weight is the weight at the initial pregnancy examination. Under normal circumstances, the mother's weight gain from the beginning of pregnancy is calculated from the first trimester to the third trimester (Mamidi et al., 2017).

Maternal weight gain during pregnancy is directly correlated with the incidence of malnutrition, because both reflect the adequacy of pregnant women's food intake during pregnancy. Insufficient pregnancy weight gain will cause the risk of stunted fetal growth (IUGR, LBW, PBLR) and prematurity (Abubakari et al., 2023).

Iron status in the body can be assessed based on the ferritin indicator, which shows iron stores in the first stage of iron depletion. Ferritin is formed when apoferritin binds to iron. Ferritin, which is the main storage form of iron in the body, is mainly found in the liver, pancreas and spinal cord. In healthy humans, approximately 30% of iron is found in storage form, mainly as ferritin and partly as hemosiderin. If iron reserves are depleted, ferritin in the tissue decreases. Measurement of ferritin concentration is the most sensitive index for detecting iron deficiency before morphological changes are seen in red blood cells, and before anemia occurs (Martinez et al., 2021).

Parity is one of the factors causing malnutrition in pregnant women. Parity is the number of children born to a mother. Parity is divided into nullipara, primipara, multipara and grandmultipara. Nullipara is a woman who has never given birth to a fetus, primipara is a woman who has given birth to a fetus once, multipara is a woman who has given birth to a fetus >1x, and grandmultipara is a woman who has given birth to a fetus >5x (Cunningham et al., 2018).

Parity is a risk factor for malnutrition in pregnancy. Pregnant women who have a parity of more than 4 people are at greater risk of malnutrition compared to mothers who have a parity of less than 4 people. Pregnancies that are too frequent (high parity), that was a mother who already has three children and another pregnancy occurs, her health condition will begin to decline (Karemoi et al., 2020).

Food taboos are foodstuffs or dishes that cannot be eaten by individuals in society for cultural reasons. Some dietary taboo patterns are only adhered to by a certain group of people or by a larger portion of the population. Other patterns only apply to groups within a particular population and at a particular time. If the taboo pattern applies to the entire population and throughout life, nutritional deficiencies are less likely to develop as if the taboo only applies to a certain group of people during one stage of the cycle (Chakona & Shackleton, 2019).

Some dietary restrictions are only adhered to by a certain group of people or by a larger part of the population. Other patterns only apply to certain groups within a population and at certain times. If the pattern of abstinence applies to the entire population and throughout life, nutritional deficiencies are less likely to develop as if the taboo only applies to a certain group of people during one stage of the cycle (Ojo et al., 2023).

REFERENCES

- Abubakari A., Asumah MN., Abdulai NZ. 2023. Effect of maternal dietary habits and gestational weight gain on birth weight: an analytical cross-sectional study among pregnant women in the Tamale Metropolis. *Pan Afr Med J*; 44: 1-19.
- Bonakdar SA., Motlagh ARD., Bagherniya M., Ranjbar G., Khotbehsara RD., Mohajeri SAR, et al. 2019. Pre-pregnancy Body Mass Index and Maternal Nutrition in Relation to Infant Birth Size. *Clinical Nutrition Research*; 8(2): 129–137.
- Brannon PM., & Taylor CL. 2017. Iron Supplementation during Pregnancy and Infancy: Uncertainties and Implications for Research and Policy. *Nutrients*; 9: 1-17.
- Chakona G & Shackleton C. 2019. Food Taboos and Cultural Beliefs Influence Food Choice and Dietary Preferences among Pregnant Women in the Eastern Cape, South Africa. *Nutrients*; 11(11): 1-18.
- Clemente-Suarez VJ., Mielgo-Ayuso J., Martin-Rodriguez A., Ramos-Campo DJ., Redondo-Florez L., Tornado-Aguilera JF. 2022. The Burden of Carbohydrates in Health and Disease. *Nutrients*; 14(18): 1-28.
- Cunningham, Leveno, Bloom, Dashe, Hoffman, Casey, et al. 2018. *Williams Obstetrics*. 25th edition, New York: McGrawHill Education.
- Dukhi N. 2020. *Global Prevalence of Malnutrition: Evidence from Literature*. Ebook. Intechopen, Europe.
- Duttaroy AK., & Basak S. 2021. Maternal Fatty Acid Metabolism in Pregnancy and Its Consequences in the Feto-Placental Development. *Front Physiol*; 12: 1-16.
- Elango R., & Ball RO. 2016. Protein and Amino Acid Requirements during Pregnancy. *Advances in Nutrition*; 7(4): 839S-844S.
- Gebre B., Biadgilign S., Taddese Z., Legesse T., Letebo, M. 2018. Determinants of malnutrition among pregnant and lactating women under humanitarian setting in Ethiopia. *BMC Nutrition*; 4(11): 1-8.
- Georgieff M. 2020. Iron Deficiency in Pregnancy. *Am J Obstet Gynecol*; 223(4): 516–524.
- Jouanne M., Oddoux S., Noel A., Voisin-Chiret AS. 2021. Nutrient Requirements during Pregnancy and Lactation. *Nutrients*; 13(2): 1-17.
- Karemoi TM., Mardiah W., Adistie F. 2020. Factors Affecting Nutritional Status of Pregnant Women: A Literature Study. *Asian Community Health Nursing Research*; 2(2): 39-47.
- Lowensohn RI., Stadler DD., Naze C. 2016. Current Concepts of Maternal Nutrition. *Obstet Gynecol Surv*; 71(7): 413–426.
- Mahdi S., Dickerson A., Solar GI., Caton SJ. 2023. Timing of energy intake and BMI in children: differential impacts by age and sex. *The British Journal of Nutrition*; 130(1): 71–82.
- Mamidi RS., Banjara SK., Manchala S., Babgu CK., Geddam JJB., Boiroju NK., et al. 2022. Maternal Nutrition, Body Composition and Gestational Weight Gain on Low Birth Weight and Small for Gestational Age—A Cohort Study in an Indian Urban Slum. *Children*; 9(10): 1-17.
- Marshall NE., Abrams B., Barbour LA., Catalano P., Christian P., Friedman JE., et al. 2022. The importance of nutrition in pregnancy and lactation: lifelong consequences. *Am J Obstet Gynecol*; 226(5): 607–632.
- Martinez RX., Perez LL., Rosas JPP. 2021. Serum or plasma ferritin concentration as an index of iron deficiency and overload. *Cochrane Database Syst Rev*; 2021(5): 17.
- Ministry of Health of the Republic of Indonesia. 2015. *Guidelines for Managing Chronic Energy Deficiency (CED) in Pregnant Women*. Jakarta: Directorate General of Nutrition Development and Child-Maternal Health, Ministry of Health, Republic of Indonesia.
- Morris AL., & Mohiuddin SS. 2023. *Biochemistry & Nutrients*. StatPearls Publishing, London.
- Norman K., Hab U., Pirlich M. 2021. Malnutrition in Older Adults—Recent Advances and Remaining Challenges. *Nutrients*; 13: 1-20.
- Ojo AS., Nnyanzi LA., Giles EL., Ells LJ., Awolaran O., Okeke SR., et al. 2023. Perceptions of dietary intake amongst Black, Asian and other minority ethnic groups in high-income countries: a systematic review of qualitative literature. *BMC Nutrition*; 9: 1-17.

- Prasetyo D. 2017. The Relationship Between Macronutrient Intake and the Risk of Chronic Energy Deficiency in Pregnant Women in North Pontianak District in 2017. Thesis, Faculty of Health Sciences, Muhammadiyah University of Pontianak, Pontianak.
- Saha S., Pandya AK., Raval D., Wanjari, MB., Saxena, D., 2022. A Study of Maternal Anemia and Utilization of Antenatal and Postnatal Care Services in Devbhumi Dwarka, Gujarat. Cureus; 14(10): 1-14.
- Serbesa ML., Iffa MT., Geleto M. 2019. Factors associated with malnutrition among pregnant women and lactating mothers in Mieso Health Center, Ethiopia. European Journal of Midwifery; 3 (13): 1-5.
- United Nations Children's Fund (UNICEF), 2015. UNICEF's approach to scaling up nutrition for mother and their children. Nutrition Section, Programme Division United Nations Children's Fund (UNICEF). New York: UNICEF.

