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Research article

The design of body mass index and its relationship with weight gained pregnancy and weight of a newborn baby in Alor District East Nusa Tenggara Indonesia

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ABSTRACT

This research provides valuable insights into the factors influencing weight gain during pregnancy and its implications for newborn health. Women with anemia are encouraged to gain more weight during pregnancy than those without anemia to mitigate risks associated with low weight gain, such as intrauterine growth retardation and prenatal death. Pre-pregnancy nutritional status (indicated by BMI) also plays a crucial role in determining weight gain during pregnancy, highlighting the importance of addressing nutrition prior to conception. Pregnant women, particularly those with low hemoglobin levels or low pre-pregnancy BMI, should receive targeted nutritional support to enhance weight gain and overall health. Regular monitoring of hemoglobin levels and nutritional status is essential for early identification of women at risk of inadequate weight gain or anemia. Health practitioners should provide personalized weight gain targets based on individual BMI and nutritional status, promoting optimal health outcomes for both mother and baby. This study underscores the critical relationship between maternal nutritional status, anemia, and weight gain during pregnancy. Ensuring adequate weight gain through improved nutrition can significantly reduce the risks of intrauterine growth retardation and prenatal death, thereby enhancing maternal and neonatal health outcomes.

Keywords: Body Mass Index (BMI), Pregnancy Weight Gain, East Nusa Tenggara, Indonesia.

INTRODUCTION

Multiple lines of evidence have established that maternal nutritional factors are important determinants of pregnancy outcomes, and there is growing evidence suggesting that maternal nutritional status is a significant determinant of preterm birth [1]. Poverty and malnutrition are interrelated phenomena; therefore, improving the nutritional status of a society is closely related to efforts to improve the economy [2]. Several studies in many countries show that the proportion of infants with LBW decreases as national income increases [3]. The intake picture of pregnant women in Indonesia is still alarming. The population of pregnant women with energy adequacy levels still less than 70% of the energy adequacy rate (AKE) is slightly higher in rural areas at 52.9% compared to urban areas at 51.5%[4]. Meanwhile, the protein adequacy rate (AKP) is also higher in rural areas at 55.7% compared to urban areas at 49.6%. As an area with extreme climate conditions and highly threatened by climate change, which is related to food insecurity and the high disparity between regions, causes a high prevalence of CED pregnant women, reaching 16.24%[5]. In reality, several studies have shown that both low and high gestational weight growth is linked to adverse fetal-neonatal outcomes. Gestational weight gain is essential for the correct development of the fetus [6]. The high rate of malnutrition in pregnant women can have an impact on the high rate of LBW which is estimated to reach 350,000 babies each year [4]. So, evidence on the optimal gestational weight gain across the ranges of the pre-pregnancy maternal body mass index is necessary. Currently, the number of LBW in Kalabahi reaches 142 out of 8360 live-born babies (Health Department of Alor District, 2020).

Additional harmful health effects for the mother, child, and future pregnancies can be caused by excessive GWG and/or PPWR in the short- and long term- [7].

The "first 1000 days" of life, span roughly from conception to one's second birthday. It is a unique period for fetal programming where foundations of optimum health, growth, and development across the lifespan are established. A woman who is healthy at the time of conception is more likely to have a healthy pregnancy and child. Long-term results for moms and newborns are improved when women's nutritional status is improved before getting pregnant [8]. One of the most significant markers of the health of a community and a major contributor to infant mortality is low birth weight. When compared to newboms of similar weight, the majority of these neonates have significant functional or developmental limitations, and they are more susceptible to delays in cognitive, linguistic, motor, and sensory processing abilities [9].

The lower the BMI that the mother has before the conception period, the higher the expected weight gain. Birth weight was favorably connected with total body water gain, total body potassium gain, and fat-free mass gain (P .01), but not with fat mass gain. Although there was a positive correlation between postpartum weight and fat retention and gestational weight gain (P =.001) and fat mass gain (P =.001), there was no correlation with total body water, total body potassium, or fat-free mass gain [11]. Prenatal mortality and intrauterine growth retardation are both risk factors for low weight gain [12]. The focus of this study is to predict the model of weight gain during pregnancy based on BMI and its impact on the baby's birth weight so that interventions need to be carried out through counseling pregnant women, especially in dryland island communities which are often synonymous with low quality food consumption and nutrition. The quality of food consumption and nutrition in NTT in NTT is still not diverse both in quality and quantity so that the risk of chronic energy deficiency (SEZ) of pregnant women in 2020 is 24.3%, women of childbearing age have a small bone mass so that weight gain during pregnancy based on pre-pregnancy body mass index is very important to study related to the impact on birth weight.

MATERIALS AND METHODS

Research Design

This research is a descriptive study, using a quantitative and qualitative research design with a cross-sectional study because independent and dependent variables are observed at the same time (period) [13]. The research was carried out with a system analysis approach by breaking down the components of the maternal weight gain system during pregnancy based on the body mass index before pregnancy the baby's growth and development system and the nutritional status of children up to 2 years old into their respective components.

Respondents and location

Sample registration was done through interviews with officers at the hospitals and health centers using maternal medical records (height, initial and final weight, body mass index) and infant growth as the outcome of the causative factor, namely BMI and maternal weight gain during pregnancy. The samples were taken from the population purposively that meet the following criteria: mothers aged 20-35 years and have given birth for the last 4 months, not the first or above sixth pregnancy, healthy (not suffering from chronic pain), have medical records of births (weight newborn babys)) as well as medical records of maternal pregnancy (weight, height at early and late pregnancy, and pregnancy care), control during pregnancy at least 2 times (both 1st and 3rd trimester and in trimeters 2 and 3), giving birth to a single baby living, not smoking and drinking alcohol, several family members ≤ 7 people.

Research Instrument

The statistical test used is multiple linear regressions. This study used pure experimental design, randomizing Pretest-Posttest Control Groups [14], namely this study was conducted in the population by providing nutritional counseling in the treatment group, as well as measurements before and after counseling.

The first stage is the collection of basic, descriptive exploratory data, carried out on the family of examples intended to determine the general state of the family example and nutritional status of pregnant women so that nutrition education strategies can be developed in the form of counseling [15]. The second stage is in the form of giving intervention to the treatment group, namely through nutritional counseling.

RESULT AND DISCUSSION

Maternal BMI and Weight Gain During Pregnancy

Weight gain during pregnancy in this study was more concentrated on mothers who give birth to babies with normal birth weight. Sample weight gain ranged from 5-20 kg (12.6 ± 2.4 kg). As recommended the weight gain during pregnancy is in the range of 10-12.5 Kg. Based on these recommendations, the category of maternal weight gain during pregnancy was made according to weight and height before pregnancy. Weight gain during pregnancy both according to weight and height before pregnancy shows that most of the samples have normal height and weight before pregnancy, which was 39-55 Kg and 144-156 Metres with weight gain ranging from 10-12.5 Kg and more than 12.5 Kg. The average sample weight gain according to BMI is as follows: very thin (14.3 ± 5.1); thin (13.5 ± 3.6); Normal (12.9 ± 2.2); fat (11.6 ± 1.4); and obese (11.7 ± 3.4). The median GWG outside the IOM recommendations was 3.1 kg above and 2.7 kg below. In comparison to GWG within the IOM recommendations, GWG above was associated with increased odds of cesarean section (OR 1.50; 95%CI 1.25, 1.80), LGA (2.00; 1.58, 2.54),

and reduced odds of SGA (0.66; 0.50, 0.87); no significant effect on preterm birth was detected. [12]The results of this study were in line with several studies that show that the total body weight gain during pregnancy is in the range of 8-14 Kg. The wide range of total weight gain is due to the very wide variety of maternal conditions such as height, socioeconomic conditions, and level of food consumption [16]. One of the main non-obstetric causes of maternal morbidity and death is intimate partner violence (IPV).7–11 IPV includes patterns of conduct intended to acquire or hold onto power and control, as well as physical, emotional, and sexual aggression [17]. Weight gain during pregnancy both according to pre-pregnancy BW and TB showed that most of the samples were more spread normal in pre-pregnancy BW and TB of 39-55 kg and 144-156 with weight gain ranging from 10-12.5 kg and more than 12.5 kg. The average weight gain of the samples according to BMI was as follows: very thin (14.3 ± 5.1); thin (13.5 ± 3.6); normal (12.9 ± 2.2); fat (11.6 ± 1.4); and obese (11.7 ± 3.4).

Figures 1: The results of this study are in line with several studies that show that the total weight gain of the mother during pregnancy is in the range of 8-14 kg.

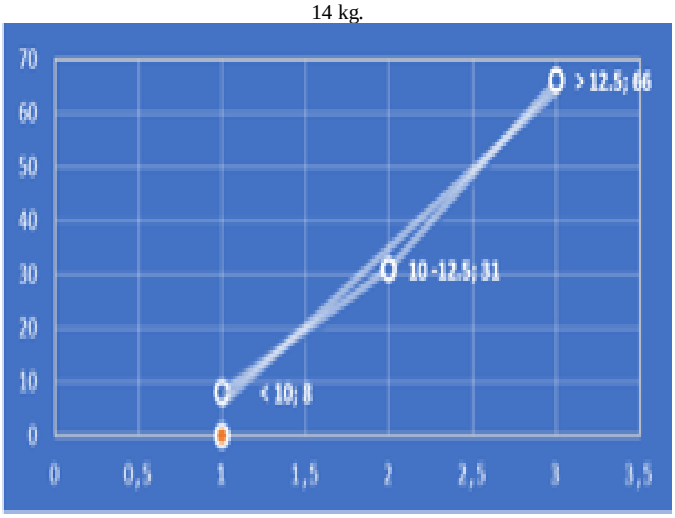


Figure 2: Weight gain of pregnant women based on body mass index (BMI) before pregnancy. Most (62.86%) had normal nutritional status with weight gain of 10.6-15 kg

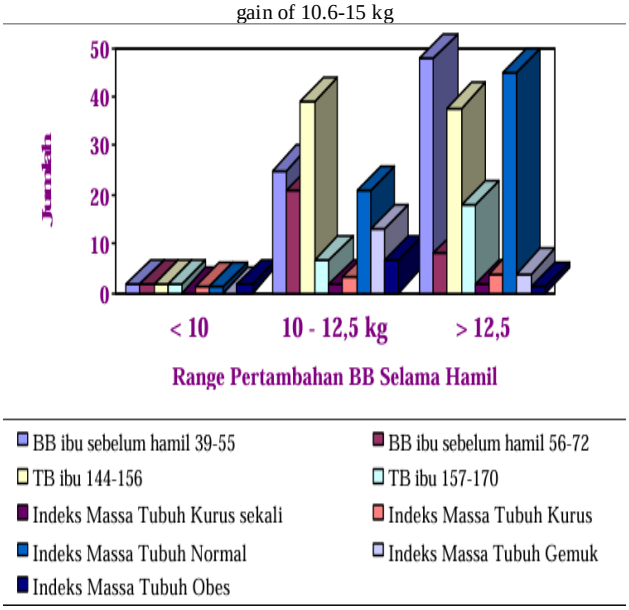
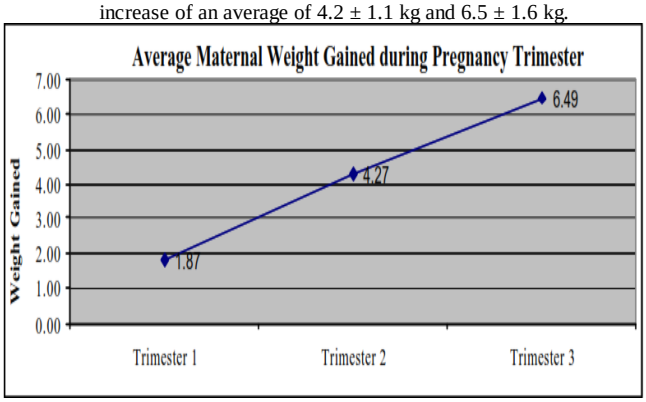


Table 1: Samples distribution based on weight gain during pregnancy according to BMI

BMI before pregnancy	Weight Gain (kg)	Total (n)	Percentage (%)
Thin	8-20 (13.73 ± 3.80)	11	10.47
Normal	5-20 (12.88 ± 2.15)	66	62.86
Fat	10-13 (11.44 ±1.20)	18	17.14
Obese	8-20 (11.60 ± 3.24)	10	9.5
Total		105	100

Figures 3: Weight gain during pregnancy in the first trimester averaged 1.9 ± 0.6 kg and in the second and third trimesters respectively experienced an increase of an average of 4.2 ± 1.1 kg and 6.5 ± 1.6 kg.



Data sources (Weight, Height, and Weight Gain): Health Card of Pregnant women, sample & interview. Sample weight gain during first trimester pregnancy averaged 1.9 ± 0.6 Kg and in the second and third trimesters each gain weight of 4.2 ± 1.1 Kg and 6.5 ± 1.6 Kg (Figure 6). Thus, it can be predicted that in the first trimester, the average maternal weight gain is 0.1 Kg per week, then it starts to increase in the second and third trimesters, 0.3 Kg and 0.5 Kg per week, respectively, while weight gain at each trimester of pregnancy was 1.4 ± 2.4 Kg; 3.7 ± 2.9 Kg; and 4.8 ± 2.6 Kg. According to the multinomial logistic regression model, pre-pregnancy overweight or obese women were 4.09 times more likely than normal-weight women to have an excessive incidence of GWG (AOR = 4.09, 95% CI: 1.38–12.12, p = 0.011) [18]. An additional constraint was that the first trimester PP BMI data were gathered, and the expectant mothers were required to recall their body weight [19]. Most samples, especially those who have a normal BMI before pregnancy gain weight in the second and third trimesters. This is because of an increase in appetite for both staple foods and intermittent foods. Conversely, in The samples that experience a decrease in appetite or do not experience changes in the quantity of food, weight gain tends to be lower.

The facts indicate that mothers who experience a weight gain of 5-9 Kg on average give birth to babies with relatively low birth weight, which is 2600 grams, but in this study, only a small percentage of the samples experienced this (1.9%). On the other hand, mothers with weight gain as recommended by the Ministry of Health tend to give birth to babies with an average birth weight of ≥ 3000 gr [20]. Weight gain of <1 kg during the second trimester, especially the third

trimester will pose a high risk of low birth weight, retardation in uterine growth, and prenatal death. Excessive weight gain after week XX implies the occurrence of water retention, which is simultaneously associated with a large fetus, and the risk of complicating pelvic head disproportion (PHD), where excessive retention is also an early sign of preeclampsia [21]. The findings imply that, particularly in poor nations, a low degree of maternal nutritional diversification during pregnancy may be linked to an increased risk of low birth weight. Diversity in diet may be a useful indicator of a mother's nutrition throughout pregnancy and her likelihood of giving birth to a baby who is born before full term[22]. Although the rate of weight gain in the second and third trimesters is the same, the accumulation of maternal proportions and fetal tissue growth does not occur simultaneously. Increased components in the mother's body occur throughout the second trimester. The growth of the fetus and placenta and the increase in amniotic fluid is very fast during the third trimester. Nutritional deficiencies and unfavorable pregnancy outcomes continue to be global public health issues. Throughout pregnancy, adequate intake of protein, energy, and minerals is still crucial [23]

Nutritional Status of Pregnant Women

An indicator of the nutritional status with anthropometric assessment is based on both weight and MUAC (mid-upper arm circumference) size. For pregnant women, malnutrition (malnourished or over-nourished) leads to edema but rarely affects the upper arm. According to the Ministry of Health (1994), the measurement of MUAC for a group of women of childbearing age (WCA) is one of the easy ways of early detection and can be carried out by the general public, to find out the groups at risk of chronic energy deficiency (CED), the amount of hemoglobin (Hb) and blood pressure. In this study, the MUAC size of the samples ranged from 20-27.5 cm (23.3 ± 2 cm) where 52.5% of the samples had MUAC size of ≥ 23.5 cm, while the others (47.5%) had MUAC of <23.5 cm.

One characteristic of iron nutritional anemia is the reduction of hemoglobin. The sample hemoglobin values ranged from 8.4-14 g / dL (11.6 ± 1.7 g / dL). 38.2% of samples have Hb levels <11 g / dL, whereas 61.8% of samples have Hb levels> 11 g / dL. However, the sample conditions classified as anemia (Hb <11 g / dL) before becoming pregnant until the first trimester have normal Hb counts (Hb> 11 g / dL) and most of them experience a decrease in HB blood count after entering the last trimester of pregnancy. In addition to the size of MUAC and the amount of hemoglobin, this study also used blood pressure indicators as an assessment of the nutritional status of pregnant women. Most of the samples (57.5%) had normal blood pressure (<140/90 mmHg), low blood pressure (32.5%), and the rest (20%) had high blood pressure.

Table 2: Sample distribution according to nutritional status indicators

Nutritional Status Indicators	* n	%	Weight gain of pregnant women (kg)	Weight of newborn baby(gr)
The size of mid upper arm circumference (MUAC) :				
A. Normal (≥ 23.5 cm)	76	72,3	12.55 ± 2.41	3160.00 ± 395.80
B. CED (< 23.5 cm)	29	27,6	10.35 ± 1.60	2200.00 ± 382.18
Hemoglobin level :				
A. Normal (≥ 11 gr/dL)	76	72,3	12.38 ± 2.34	3.32.66 ± 447.22
B. Anemia (< 11gr/dL)	29	27,6	10.08 ± 1.48	2167.76 ± 463.88
Blood Pressure (TD) :				
A. Low (< 140/90 mmHg)	10	9,52	10.43 ± 1.42	2175.38 ± 444.95
B. Normal (140/90 mmHg)	76	72,3	12.26 ± 2.62	3081.74 ± 452.06
C. High (> 140/90 mmHg)	16	15,2	10.65 ± 0.99	2250.00 ± 264.08

Data sources (MUAC, Hemoglobin, TD): Health Card of Pregnant women samples. The average increase in knowledge in the counseling group was 5.98 higher than the control group's 3.15. This is in line with research that states direct counseling is more effective and more motivating for targets to adopt extension materials.

Most of the samples, especially those who have a normal BMI before pregnancy experience weight gain in the second and third trimesters, this is because of an increase in appetite for both staple foods and intermittent foods. Conversely, in the samples that experience a decrease in appetite or do not experience changes in the quantity of food, weight gain tends to be lower. The facts show that mothers who experience a weight gain of 5-9 Kg on average give birth to babies with relatively low birth weight, which is 2600 grams, but in this study, only a small percentage of the samples experienced this (1.9%). These findings point to a crucial opportunity for public health education that emphasizes how excessive GWG affects all mothers' risk of having obese children, regardless of their pre-pregnancy weight status [24]. The accumulation of maternal proportions and fetal tissue growth does not happen at the same time, even though the pace of weight gain in the second and third trimesters is essentially the same. Throughout the second trimester, the mother's body contains more components. While the fetus and placenta expand quickly throughout the third trimester, so does the amount of amniotic fluid. The development and maintenance of prenatal overweight and obesity, as well as recurrent food cravings and compulsive consumption of highly appetizing foods, might hurt the offspring's health [25].

Another factor that was significantly associated with maternal weight gain during pregnancy was pre-pregnancy nutritional status (BMI) ($r = 0.154$; $P < 0.05$), where mothers who had a low BMI (very thin or thin) needed adequate weight gain to guarantee fetal growth and development in the womb and the mother's health. It is clear that the samples who are thin (low BMI) gained weight ranging from 8-20 (13.5 ± 3.6 kg). The pace of gestational weight increase is independently related with preterm delivery in Peruvian pregnant women who begin prenatal care at or before 12 weeks of gestation, mostly due to its association with idiopathic preterm birth. The shape of these correlations differs depending on pre-pregnancy BMI [26].

The recommendations for weight gain during pregnancy recommended by IOM that mothers with a BMI classified as thin are recommended to gain weight by 14-20 kg. Thus, BMI can be used as a benchmark for determining weight gain during pregnancy. Pregnancy weight gain can be used as an index to determine the nutritional status of pregnant women because there are similarities in the amount of weight gain during pregnancy in all pregnant women. Inadequate weight gain during pregnancy is the impact of low BMI, low education, and low economic status [27]. Factors that influence the weight gain of pregnant women are nutritional knowledge, the distance of the last two pregnancies, the frequency of the disease (fever, typhus, and diabetes), BMI, MUAC, and anemia status. This can be seen through the following regression equation: Y = 3.884 + 0.231x1 + (-0.325x2) + (-0.500x3) + (-1.026x4) + (-1.579x5) + (-0.347x6) + 0.340x7 + 0.672x8 + 0.459 ($R2 = 0.489$ and $\alpha = 0.05$). These elements have contributed to a 48.9-pound weight gain during pregnancy. Compared to women in East Asia, women in the USA and Western Europe have greater prepregnancy BMIs and higher rates of GWG above recommended levels. However, rates of GWG above recommendations are comparable on all three continents when utilizing regional BMI categories in East Asia. Across all regions, GWG outside guidelines are linked to negative results [28]. In various Asian groups, the cut-off threshold for observed risk ranges from 22 kg/m2 to 25 kg/m2, while for high risk it ranges from 26 kg/m2 to 31 kg/m2 [29].

At the research stage, the results obtained after the implementation of counseling showed a significant increase in the value of the average knowledge of mothers in the counseling group. The statistical results showed a significant effect ($p < 0.05$) between the counseling group and the control group in terms of improving health nutrition knowledge before and after the intervention. However, socioeconomic status affected the perinatal outcomes even within a similar setting of universal access to health care. Differential access to good-quality obstetric services and neonatal care is another main reason for socioeconomic disparities in perinatal health [30]. Adjustment for behavioral and lifestyle factors abolished, accentuated, attenuated, or unmasked the crude relations between socioeconomic status and perinatal outcomes. These results reveal some of the mechanisms underpinning socioeconomic effects. The stark socioeconomic disparities in postnatal mortality point to a relative lack of social and other forms of support for socioeconomically disadvantaged mothers and families in the first year following childbirth. The second concern is knowledge of healthy lifestyle choices, particularly with smoking, increased weight before becoming pregnant, and older maternal ages [31].

The average increase in calories was 301.57, which was statistically significantly different from the control group's 148.45 calories. There are disparities in food consumption and increased body weight between pregnant women who receive nutrition education and those who do not [32], according to research. The statistical results show that there is an influence of nutritional counseling on increasing protein consumption in the group of pregnant women after receiving nutrition counseling. The number of pregnant women classified as KEK (Chronic lack of energy) in this study was 27%, this is seen in the level of energy and protein consumption still below the recommended nutritional adequacy of pregnant women. A healthy diet and calcium supplementation during pregnancy have been associated with a decreased incidence of low birth weight (LBW) newborns. The low consumption of energy and protein in the low economic group is generally caused by limited economic access in the form of income and other physical resources in reaching food and socio-cultural factors that always tie the local community to marriage parties and family gatherings so as not to prioritize food expenditure rather than non-food. Pregnant women who take calcium supplements and eat a sufficient diet are linked to a lower risk of low birth weight (LBW) babies.

The average difference in body weight that occurred in the counseling group was probably due to an increase in maternal knowledge about the importance of ANC (antenatal care) or K1-K4 visits for health checks during pregnancy. Based on profile data of Mebung and Kenarilang Health Center, the achievement of K1-K4 has reached 80%. This shows that providing information about nutrition and health to pregnant women during pregnancy through nutritional counseling can be practiced well, as seen in increasing energy and protein intake. An increased risk of unfavorable pregnancy outcomes was linked to both greater GWG and rising GWG trajectories. In order to reduce the risk of unfavorable pregnancy outcomes, prenatal care should place a strong emphasis on promoting GWG within the indicated range [26][32]. Dietary counseling significantly improved the frequency of consumption of different food items and knowledge, attitude, and practice mean scores of the intervention group in comparison with the control group (P-value <0.001). For the health of both the mother and the growing fetus, women's nutritional status is crucial. Body mass index (BMI) before pregnancy and weight growth throughout pregnancy are two independent variables that have a significant impact on the pregnancy's outcome [6].

CONCLUSION

The average sample weight gain according to BMI is as follows: very thin (14.3 ± 5.1); thin (13.5 ± 3.6); Normal (12.9 ± 2.2); fat (11.6 ± 1.4); and obese (11.7 ± 3.4). Factors that influence the weight gain of pregnant women are nutritional knowledge, the distance of the last two pregnancies, the frequency of illness (fever, typhus, and

diabetes), BMI, MUAC, and anemia status. Nutritional status (BMI) before pregnancy is an index of determining maternal weight gain during pregnancy and has an impact on reducing LBW babies in Kalabahi City, Alor Regency. The intervention to improve the nutritional status of pregnant women through the counseling program showed significantly different results between the control and case groups in terms of weight gain during pregnancy. Pre-pregnant mothers need to pay attention to nutritional status from the beginning of pregnancy and pay attention to weight gain during pregnancy because it will be related to the nutrition of the baby who will be born, especially in dryland communities that are food insecure and at high risk of stunting in NTT.

Limitations

This research can be used as additional material in handling existing nutritional problems. Apart from that, it is hoped that officers can utilize health promotion media such as leaflets and stickers to help maternal and Neonatal remember the information provided, while for sub-district agencies it is hoped that government awareness will be made in efforts to overcome and repair roads in Kalabahi Subdistrict so that the people there, especially mothers with toddlers, can easily go to posyandu or community health center because of adequate road access.

Author Contributions

Writing original draft preparation, A.H.T.; Writing—review and editing, A.H.T; Visualization, A.H.T., M.L., and R.L.; Supervision, M.L. and R.L. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement: The study was conducted in accordance with the Declara tion of Helsinki, and approved by the Ethics Committee of Public Health Faculty, Nusa Cendana University with number: 2021019-KEPK.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Written informed consent for publication must be obtained from participating patients who can be identified (including the patients themselves). Please state "Written informed consent has been obtained from the patient(s) to publish this paper" if applicable.

Conflicts of Interest

The authors declare no conflicts of interest.

Appendix A

The appendix is an optional section that can contain details and data supplemental to the main text—for example, explanations of experimental details that would disrupt the flow of the main text but nonetheless remain crucial to understanding and reproducing the research shown; figures of replicates for experiments of which representative data is shown in the main text can be added here if brief, or as Supplementary data. Mathematical proofs of results not central to the paper can be added as an appendix.

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