JHeS (Journal of Health Studies)
Vol. 9, No. 2 (2025), pp.88-97
e-ISSN 2549-3353
p-ISSN 2549-3345
https://doi.org/10.31101/jhes.3976

Original Research Paper

Maternal factors associated with low birth weight infants

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Submitted: January 3, 2025 Revised: March 4, 2025 Accepted: April 14, 2025

Abstract
Indonesia has the second-highest prevalence of low birth weight (LBW) babies in ASEAN countries. Various factors contribute to this high incidence. This study examined the association between gestational weight gain (GWG), pre-pregnancy body mass index (BMI), and antenatal care (ANC) visits frequency towards LBW in a region of Indonesia with a high prevalence of LBW. This is an analytical observational study using cross-sectional design with utilizing medical records data, conducted in June-August 2022. We analyzed 78 medical records of pregnant women who gave term-singleton birth. Main independent variables were gestational weight gain, pre-pregnancy BMI, and ANC frequency. Data analysis was performed using statistical package program, including descriptive statistics, bivariate and multivariate analyses to explore associations between those factors and LBW occurrence. The mean of infant birth weight was 3115.4± 465.2 grams. Low birth weight proportion was 11.5%. More than 90% of subjects follow frequency of ANC visits for K1 and K4, but only a third of participants meet K6 ANC visit recommendation. Approximately half of the subjects (48.7%) had inadequate GWG. Bivariate analysis revealed a strong association between insufficient GWG and LBW (OR = 10.4, 95% CI = 1.233–87.74, p=0.013). However, pre-pregnancy BMI and ANC frequency showed no association with LBW. Inadequate gestational weight gain is significantly linked to an elevated risk of LBW. Emphasizing the appropriate quantity of ANC visits and regular monitoring of maternal weight gain throughout pregnancy is crucial to mitigate the risk of LBW.

Keywords: antenatal frequency; gestational weight gain; low birth weight; maternal BMI

1. Introduction

The term "low birth weight" (LBW) pertains to infants born below 2500 grams, irrespective of their gestational age. LBW occurs when babies are born prematurely or experience restricted growth within the womb, even if they reach full term. Globally, 20.5 million babies have LBW, equal to one in seven live births, marking a decrease from 22.9 million LBW newborns in year 2000 (Blencowe et al., 2019) The most prevalent of LBW is observed in Asia, particularly in South Asia, where it accounts for 48% of cases. However, in various regions, notably in Africa, the prevalence of LBW has not been extensively documented. In Indonesia, LBW cases fluctuated, making Indonesia the second highest country in ASEAN with LBW (Arsyi et al., 2022; Safitri et al., 2022). Low birth weight is associated with a third cause of neonatal deaths in Indonesia (Sari et al., 2022).

LBW can arise from various maternal risk factors, such as maternal age being either adolescent or advanced maternal age, maternal malnutrition, infections and unfavorable obstetric histories like hypertension, anemia, and pre-eclampsia. These multifaceted factors are intricately connected to sociocultural issues, such as maternal education level, teenage marriage and pregnancy, economic

status, as well as the accessibility of health services and information (Anu et al., 2021; Gupta et al., 2019; Manouchehri et al., 2021). Antenatal care (ANC) is widely acknowledged as a highly effective strategy for reducing the occurrence of LBW, especially in countries with limited resources (WHO, 2018). One of the essential components of ANC involves monitoring the weight gain during pregnancy to ensure that it falls within the appropriate range (WHO, 2018). Conversely, excessive gestational weight gain (GWG) can lead to obstetric complications such as gestational hypertension, gestational diabetes, prematurity, and a macrosomia baby (Santos et al., 2019). To address this situation, WHO suggests an increase of ANC frequency from 4 to 8 ANC visits. This approach is designed to enhance the focus on pregnancy nutrition, maternal and fetal health assessment, preventive measures, and the management of common physiological symptoms during pregnancy. However, in populations with low ANC attendance rates or limited healthcare resources, effective monitoring of weight gain and nutritional interventions during pregnancy often fall short of optimal standards (Lattof et al., 2020; WHO, 2018).

In 2021, following the 2016 WHO recommendation, the Indonesian Ministry of Health (MoH) implemented a new policy regarding ANC services. The schedule consists of six encounters, at least one visit during the first trimester (0-12 weeks of pregnancy), two during the second trimester, and three during the third trimester (from 24 weeks of pregnancy until delivery). Additionally, there must be a minimum of two doctor's or specialist's examinations during the first trimester and one during the fifth visit in the third trimester. The ANC service quantities are assessed based on several indicators, including minimum one ANC visit in the trimester one (K1), a total of four ANC contacts during pregnancy (K4), and a minimum of six examinations along the pregnancy with at least two sessions of doctor’s examination in the specified schedule (K6).

The Indonesia national coverage rates for K1, K4, and K6, based on data from 34 provinces, were 96.9%, 68.1%%, and 17.6%%, respectively (Ministry of Health RI, 2023). However, almost half of provinces still had lower ANC coverage in opposed to national achievement. The higher LBW prevalence, along with lower coverage of ANC in some provinces, is crucial to be elaborated, yet the literatures are limited. Additionally, the previous findings about the association of gestational weight gain, maternal anthropometric status, in some regions remains inconclusive (Mulianingsih et al., 2021; Suria et al., 2022). Therefore, the authors aim to explore the association between the frequency of ANC, pre-pregnancy BMI and gestational weight gain with the extent of low birth weight in areas with high rate of LBW infants.

2. Research Methods

This is a hospital-based cross-sectional study conducted at Praya Regency Hospital, Lombok Tengah, West Nusa Tenggara, from June-August 2022. This hospital was chosen for its record as one of the highest-LBW birth rate areas in this province. All data were obtained from medical records in the maternal ward with some specific code and kept anonymous. The data collection was conducted by one of the authors’ team and assisted by a local trained data enumerator. With a statistical significancy of 95%, power of study 80%, the minimum subject estimation was 62. A total of 83 medical records were initially included. The inclusion criteria were mothers who gave birth at Praya hospital between January-July 2021 with singleton pregnancy and term delivery. The exclusion criteria were babies with congenital abnormalities, incomplete maternal anthropometric data, or infant birth weight data were unavailable.

The independent variables were maternal GWG, pre-pregnancy Body Mass Index (BMI), and ANC frequency. The infant birth weight was the dependent variable. We defined the birth weight as low birth weight (<2500 gram), and normal birth weight (> 2500 gram). Due to incompleteness of

sociodemographic data in more than half of subjects' medical records, such as occupations, education level, history of anemia and ferrous supplementary, we did not perform analysis in these variables.

The recorded maternal body weight at the initial ANC visit was used for women without pre-pregnancy or preconception weight data. We determined the pre-pregnancy BMI (body mass index) by dividing the pre-pregnancy weight in kilograms by pre-pregnancy height in square meters. The resulting value was then classified based on the WHO standard cut-off points as listed in Table 1. The pre-pregnancy BMI categories were simplified into underweight and not underweight (including normal weight and overweight). The gestational weight gain (GWG) was the difference between the body weight at the last antenatal care visit at the third trimester and that at the pre-pregnancy or first-trimester visit (<10 weeks of pregnancy). It was then compared to the pre-conception BMI baseline in the first trimester. Our study grouped maternal GWG into adequate and inadequate weight gain. Subjects who gained weight below the recommended range were classified as having inadequate weight gain. In contrast, those in the adequate group gained weight within or exceeded the recommended range according to the 2009 Institute of Medicine (IOM) guidelines for GWG (American College of Obstetricians and Gynecologist, 2013), as outlined in Table 1.

We analyzed the adequacy of ANC frequency based on the 2020 ANC recommendation of the Indonesian MoH by measuring the presence of K1, K4, and K6 during pregnancy. The fulfillment of K1, K4 and K6 frequency is considered into groups of appropriate and inappropriate to standard recommendation of Indonesian Ministry of Health. The K1 coverage represents the total number of pregnant women who had one ANC visit in first trimester. K4 coverage reflects the number of pregnant women who met the minimum standard of four ANC contacts during pregnancy. K6 coverage includes the total number of pregnant women who received ANC with a minimum of six contacts, including two encounters with doctor who performs pregnancy ultrasound (USG) examinations, according to the specified schedule.

Table 1. The 2009 IOM Recommendation for Gestational Weight Gain Based on Pre-pregnancy BMI

Preconception BMI classification	Total gestational weight gain (kg)
Underweight (<18 kg/m^2)	12-18.5
Normal (18-24.9 kg/m2)	11.5-16
Overweight (25 – 29.9 kg/m^2)	7-11.5
Obese (≥ 30 kg/m^2)	5-9

We carried out univariate, bivariate, and multivariate analyses using statistical package program. The findings from the univariate analysis of subject characteristics are displayed in the frequency distribution table. Bivariate analysis was conducted using the chi-square test to evaluate the relationship between independent and dependent variables. Variables with significant association were further examined through binomial logistic regression analysis. The strength of the association was measured using a p-value of < 0.05. Ethical approval was granted from the Ethical Board Faculty of Medicine, Universitas Islam Indonesia, Yogyakarta, Indonesia, with the number 11/Ka.Kom.Et/70/KE/VI/2022.

3. Results and Discussions

A total of 83 maternal hospital records were recruited initially; two subjects were excluded due to unavailable height measurements, and three participants experienced premature delivery. The final dataset for analysis comprised 78 records. The mean age of pregnant women was 28.6 ± 7.5 years, with the youngest participant being 16 years old. The majority of pre-pregnancy BMI fell within the normal range (75.6%), with an equal percentage of obese and underweight individuals (3.8% each).

Table 2. Characteristics of Respondents

Variables	N	%
Mother's age (mean 28.6 + 7.5)		
15-19 years	12	(15.4)
>20 years	66	(84.6)
ANC (K1) following recommendation		
Yes	76	(97.4)
Not	2	(2.6)
ANC K4 following recommendation		
Yes	74	(94.9)
Not	4	(5.1)
ANC K6 following recommendation		
Yes	25	(32.1)
Not	53	(67.9)
Pre-pregnancy BMI (mean 22.93 ± 3.32 kg/m2)		
Underweight	3	(3.8)
Normal	59	(75.6)
Overweight	13	(16,7)
Obese	3	(3.8)
Infants' birth weight (mean 3115.4 ± 465.2 grams)		
Low birth weight	9	(11.5)
Normal	69	(88.5)
Gestational weight gain		
Inadequate	38	(48.7)
Adequate	40	(51.3)

Pre-pregnancy BMI ranged from a 17 kg/m2 to 34.7 kg/m2, with mean 22.93+ 3.32 kg/m2. Nearly half of the subjects had inadequate gestational weight gain (GWG) compared to the guidelines (48.7%). The mean birth weight was 3115.4 ± 465.2 g, ranging from a minimum of 1950 g to a maximum of 4400 g. Only 45.6% of pregnant women attended ANC for a minimum of six times visits. Baseline characteristics are provided in Table 2. Most (of our subjects 75.6%) had a normal pre-pregnancy BMI, and only 3 (3.8%) were underweight. The proportion of LBW in the present study is 11.5%.

Table 3. Bivariate Analysis of Maternal Characteristics and Low Birth Weight

Variable	LBW N=9 (%)	Normal N=69 (%)	OR	95%CI	p
Pre-pregnancy BMI*					
Underweight	1 (33.3)	2 (66.7)	2.75	0.25-29.68	0.394
Not underweight	8 (10.7)	67 (89.3)			
Gestational weight gain*					
Inadequate	8 (21.1)	30(78.9)	10.40	1.23-87.75	0.013
Adequate	1(2.5)	39(97.5)			
Frequency of K1 ANC*					
Not following recommendation	8(10.5)	69(89.5)	8.50	0.48-149.46	0.219
Following recommendation	1(50)	1(50)			
Frequency of K4 ANC*					
Not following recommendation	8(10.8)	66(89.2)	2.75	0.25-29.68	0.394
Following recommendation	1(25)	3(75)			

Variable	LBW N=9 (%)	Normal N=69 (%)	OR	95%CI	p
Frequency of K6 ANC*					
Not following recommendation	2(8)	23(92)	1.75	0.34-9.10	0.710
Following recommendation	7(13.2)	46(86.8)			

*Fischer exact test

In Table 3, we found that the number of LBW babies is more frequent in groups of mothers with inadequate GWG. On bivariate analysis, only inadequate GWG have a significant association (p = 0.013; p <0.05) toward LBW. It is denoted that a mother with inadequate weight gain during their pregnancy had 10 times higher risk to have LBW infant. There was no significant association between pre-pregnancy BMI, K1, K4, and K6 ANC visits toward low birth weight.

In this study, the percentage of LBW infants (11.5%) is higher than the national average number (Ministry of Health RI, 2023). However, this rate decreased compared with the LBW rate (14%) in West Nusa Tenggara Province in 2019 (UNICEF, 2019). Only two participants (2.5%) did not attend ANC in the early trimester (K1). This finding indicates an increasing number of ANC initiations in the primary health care setting, where previous studies reported that the ANC initiation rate in the first trimester is still low, especially in low-income countries (Moller et al., 2017; Wolde et al., 2019). The rate of K4 and K6 ANC attendance among subjects is lower than the national achievement in 2022 (86.2% and 70.9%, respectively) (Kementerian Kesehatan RI, 2023).

The low level of attendance of ANC is one of the challenges for maternal health in countries with low levels of ANC following guidelines (Jiwani et al., 2020). The household welfare and education levels are among the factors affecting the attendance of pregnant women at ANC in Ethiopia (Arefaynie et al., 2022). In Indonesia, factors such as maternal age, history of multiple pregnancies, husband's characteristics, education level, sociodemographic conditions, and regional variations were found to influence the regularity of ANC attendance despite the study focusing exclusively on the age group of 15 to 24 years (Istifa et al., 2021).

Several factors may be attributed to lower ANC attendance rate, such as constrained of access and availability of health services for pregnant women. Factors such as access to health services, whether in urban or rural settings, low educational attainment, and limitations in health financing can significantly impact the capacity of pregnant women to attend ANC (Laksono & Wulandari, 2022; Wulandari et al., 2021). The limited health workers and facilities, limited availability of ultrasound machines and medical personnel for operating the device, are among factors that may affect pregnant mothers to complete K6 visit (Syafriyanti & Achadi, 2024). The ability to play an active role in health workers, especially in primary health care facilities, is essential for pregnant women to receive health checks during ANC (Lattof et al., 2020). Some studies described obstacles to the latest WHO guidelines for ANC (8 contacts), which cannot be fully implemented evenly, especially in populations with inadequate social conditions (Grand-Guillaume-Perrenoud et al., 2022; Seyoum et al., 2021).

Our results documented no significant association between the frequency of both ANC K1, K4 and K6 on LBW. A study of ANC services in some South Asian and ASEAN countries, including Indonesia, revealed that the ANC quantity is not merely sufficient to prevent LBW but must also include good quality ANC (Arsyi et al., 2022; Neupane et al., 2023). In Indonesia, the completeness of ANC quality is the lowest compared with three other ASEAN countries. The ANC services in Indonesia have the lowest lack of routine performance of laboratory tests and provision of counselling about pregnancy complications (Arsyi et al., 2022). This is also supported by national data of SKI 2023, that only 57.8% pregnant women in Indonesia received complete 10 types of ANC service (10

T) as recommended (Ministry of Health RI, 2023). Thus, it may be assumed that neither group with adequate nor inadequate ANC frequency had a good quality of ANC services.

The current study described a strong association between the inadequate GWG and the risk of LBW (OR 10,4; 95%CI 1.23-87.75, p=0.013). Inadequate weight gain has become one of the factors that influence neonatal birth outcomes, which can increase the risk of fetal-maternal complications such as premature birth and small for gestational age (Marshall et al., 2022). This also in accordance to (Arora & Aeri, 2019; Waits et al., 2021) that most pregnant women in Asia experience inadequate GWG. Nutrition intake during pregnancy is essential for gaining a healthy weight. A cohort study reported that 28.23% and 86.23% of pregnant women reported protein and carbohydrate intake below the recommended allowance (Mishra et al., 2020). Another study described a significant positive correlation between the intake of energy, carbohydrates, monosaccharides and saccharose toward pregnancy weight gain (Diemert et al., 2016).

The association of pre-pregnancy BMI with LBW was not statistically significant in our study (p=0.33). Similar findings in Malaysia showed no association between pre-pregnancy BMI and GWG, whereas mid-upper arm circumference does (Ng et al., 2019). Due to minimal subjects with underweight pre-pregnancy BMI, we could not explore further its effects towards GWG. However, another study demonstrated that the GWG cut-off based on Asian-BMI criteria is more reliable for determining adequate GWG among Asian pregnant women rather than the use of IOM recommendation since the latest is primarily based on Caucasoid race data (Choi et al., 2017).

Limited food choices and unhealthy diet choices may increase the risk of complications during pregnancy and childbirth (Kavle & Landry, 2018; Suliga et al., 2018). These results also supported by (Siregar et al., 2022) that only 58% of pregnant women in Padang Sidempuan, North Sumatra, had good knowledge of pregnancy nutrition. Women with lower education levels have limited access to information regarding nutrition for pregnancy, and tend to passively receive information about pregnancy nutrition from midwives, health volunteers or by self-reading the Maternal and Child Health books (Rahmawati, Van Der Pligt, et al., 2021). They often deal with the gap between nutrition information provided by health professionals and their expectations regarding consistent and timely provision (Rahmawati, Willcox, et al., 2021).

This study has several limitations. Because this was a cross-sectional study, we cannot determine the cause and effect of the current study result. In addition, this research analyzes secondary data for which we cannot control the quality of data measurement. However, all subjects included were obstetric referral patients from 25 Community Health Centers under hospital supervision so that they may represent the diversity of maternal characteristics due to variations in sociodemographic conditions in each sub-regency. The subjects' comorbidities themselves also had the potential to influence birth weight outcomes. Therefore, the study findings are shared among conditions frequently encountered in primary health care. The current study is also one of the few scientific reports in Indonesia that explore the impact of ANC using the updated indicators recommended by Indonesian Ministry of Health. Moreover, we used IOM's classification for GWG based on category of pre-conception or initial trimester pregnancy BMI. Further research with more varied data and in-depth methods is needed to determine a more comprehensive relationship between ANC frequency, pre-conception BMI, and GWG on low birth weight.

4. Conclusion

This study found a higher prevalence of LBW among full-term infants compared to the national target. Our findings indicate that inadequate gestational weight gain is associated with an increased risk of LBW. However, no significant association was observed between the frequency of ANC visits or pre-pregnancy BMI and the risk of LBW. These results highlight the importance of emphasizing

adequate GWG during ANC consultations as well as educating mothers on the necessity of monitoring weight gain and consuming adequate nutrition throughout pregnancy. Furthermore, improving the quality of comprehensive ANC visits, for example human resources skills and knowledge, also the availability of good health facilites, rather than focusing solely on the ANC frequency, is essential to ensure that pregnant women receive adequate information for achieving positive pregnancy outcomes. Future prospective research involving a broader range of variables and diverse populations across multiple healthcare facilities may offer deeper insights into the influence of other maternal factors on the risk of LBW.

Acknowledgements

The authors thank the Dean of the Faculty of Medicine Universitas Islam Indonesia, the Director of Praya Regency Hospital and all the staff who help the data preparation.

Authors' Contribution : Conceptualization, EAC, YYP, TK; methodology, EAC, YYP and KAA.; software KAA.; formal analysis, MLA, KAA; writing—original draft preparation, EAC, YYP, TK and MLA.; writing—review and editing to final manuscript EAC, TK, YYP and HSAeQAH. All authors have agreed to the published version of the manuscript.

The authors declared no funding for the reasearch. The authors confirmed no conflict of interest.

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