Jurnal Jaminan Kesehatan Nasional
Volume 5 Number 1, (June, 2025). Page 1 - 13
DOI: 10.53756/jjkn.v5i1.268
ISSN : 2798-6705 (online) | 2798-7183 (print)

Research Paper

Lifestyle Factors of Low Birth Weight: Evidence from the 2023 Indonesian Health Survey

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Abstract: The stagnant prevalence of low birth weight (LBW) in Indonesia poses challenges for the National Health Insurance (Jaminan Kesehatan Nasional/JKN), due to increased medical care needs, higher inpatient claim costs, and long-term developmental implications for future generations. This study aimed to identify significant maternal lifestyle factors associated with LBW by analyzing data from the Indonesian Health Survey (SKI) 2023. A total of 30,516 mothers who had given birth within the past five years were included. Bivariate and multivariable logistic regression analyses identified key maternal factors. Living in urban areas (AOR: 1.228; 95% CI: 1.038–1.453), exposure to second-hand smoke (AOR: 1.383; 95% CI: 1.149–1.664), infrequent consumption of energy drinks (AOR: 2.501; 95% CI: 1.015–6.161), and frequent vegetable consumption (AOR: 1.217; 95% CI: 1.030–1.437) were significant contributors. The effect of low-frequency instant food consumption was more pronounced among mothers with only primary education (AOR: 4.740; 95% CI: 1.438–15.623). To reduce LBW prevalence, healthcare providers should educate expectant mothers on risks of second-hand smoke and unbalanced nutrition through improved antenatal care.

Keywords: Low Birth Weight; Maternal Health; Lifestyle Factors; 2023 SKI

Introduction

Babies represent the future generation of a nation, and their well-being plays a pivotal role in shaping a country's long-term development. A healthy baby contributes to a stronger society by minimizing future health complications and enhancing population quality.

Low birth weight (LBW), defined as a birth weight below 2,500 grams regardless of gestational age (UNICEF & WHO, 2019), is a significant concern, especially in developing countries. It is linked to both short- and long-term health issues, including cognitive delays, cardiovascular and respiratory diseases, and autoimmune disorders (Shahani et al., 2021; Song et al., 2022).

Globally, LBW prevalence is influenced by socioeconomic disparities, healthcare accessibility, and cultural norms (Blencowe et al., 2019). In Indonesia, however, LBW

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prevalence has remained relatively unchanged—6.2% in 2018 (Riskesdas, 2018) and 6.1% in 2023 (Badan Kebijakan Pembangunan Kesehatan, 2024). The country has yet to meet the WHO target of a 30% LBW reduction by 2025 (Doherty & Kinney, 2019).

Beyond health outcomes, LBW impacts Indonesia's health system, particularly JKN. For instance, the INA-CBG tariff for LBW babies (P-8-13-X) is 50.01% higher than for normal-weight babies (P-8-17-X) (Permenkes RI No. 3/2023).

Some LBW risk factors, such as genetics or maternal age, are unmodifiable, while others—smoking, diet, or physical activity—are modifiable (Johnson et al., 2017). Yet, Indonesia lacks large-scale studies assessing the impact of maternal lifestyle behaviors on LBW.

This study is the first to examine the association between maternal lifestyle factors and low birth weight (LBW) using nationally representative data from the 2023 Indonesian Health Survey (SKI). By integrating interaction terms across demographic and behavioral variables, this research provides a more nuanced understanding of modifiable maternal risk factors that can inform targeted antenatal interventions under the JKN program.

Method

Study Design

This cross-sectional study was designed using secondary data from the 2023 SKI. The National Institute of Health Development Policy within the Ministry of Health of the Republic of Indonesia conducted this survey nationally, covering 38 provinces and 514 districts/cities.

Data Sources and Samples

The research population from the 2023 SKI served as the sample for data cleaning, specifically focusing on women with infants born within the last five years prior to the survey. The infants' birth weights were documented in written records or reported by their mothers. During the data cleaning process, any responses with missing information (indicated as "#NULL!") or ambiguous answers (coded as 8 for yes/no questions and 8888 for birth weights) were excluded.

The initial dataset consisted of 189,800 infants (IDART_BALITA) and corresponding data for their mothers (IDART_IBU). Only 30,581 included actual birth weight data, and after excluding 65 entries with incomplete information, the final sample comprised 30,516 participants.

Data Management and Statistical Analysis

Microsoft Excel was used for cleaning and coding to ensure the dataset was accurate, consistent, and ready for statistical examination. SPSS version 25 (IBM, NY, USA) was used for statistical analysis, applying weights to account for the unequal selection probabilities inherent in the nationwide survey design. These weights were critical for ensuring that the results accurately reflected Indonesia's population.

Weighted Logistic Regression

We used weighted logistic regression to investigate the factors linked to low birth weight (LBW). This approach accounted for the survey's design and helped correct any biases due to sampling. For the dependent variable, infants weighing less than 2,500 grams were classified as "low birth weight." In comparison, those weighing 2,500 grams or more were classified as having "normal birth weight (UNICEF & WHO, 2019).

Selection of Independent Variables

Independent variables were included based on their theoretical relevance, prior empirical evidence, and findings from the bivariate analysis. Variables that demonstrated a statistical significance level of ≤0.25 in the bivariate analysis were included in the multiple logistic regression model to ensure no potentially important confounders were excluded prematurely, as recommended in epidemiological research (Grant et al., 2019).

The independent variables were categorized into demographic and lifestyle characteristics (Figure 1). Demographic characteristics included the mother's place of residence, education level, and household wealth index. Residence was classified as rural or urban, while education levels were divided into no education, primary, secondary, and higher education. Based on household assets, the wealth index was ranked as richest, rich, middle, poor, and poorest, following guidelines from Indonesia's National Institute of Health Development Policy (BKPK Kemenkes, 2024).

A variety of lifestyle factors were examined, including maternal smoking (both active and passive), alcohol consumption, physical activity level (low, moderate, vigorous), and dietary habits (sweetened foods, sweetened beverages, oily foods, grilled foods, preserved foods, flavor enhancers, energy drinks, instant foods, vegetables, and fruit). Dietary habits were further divided into two categories: "<1 time/day" and "≥1 time/day".

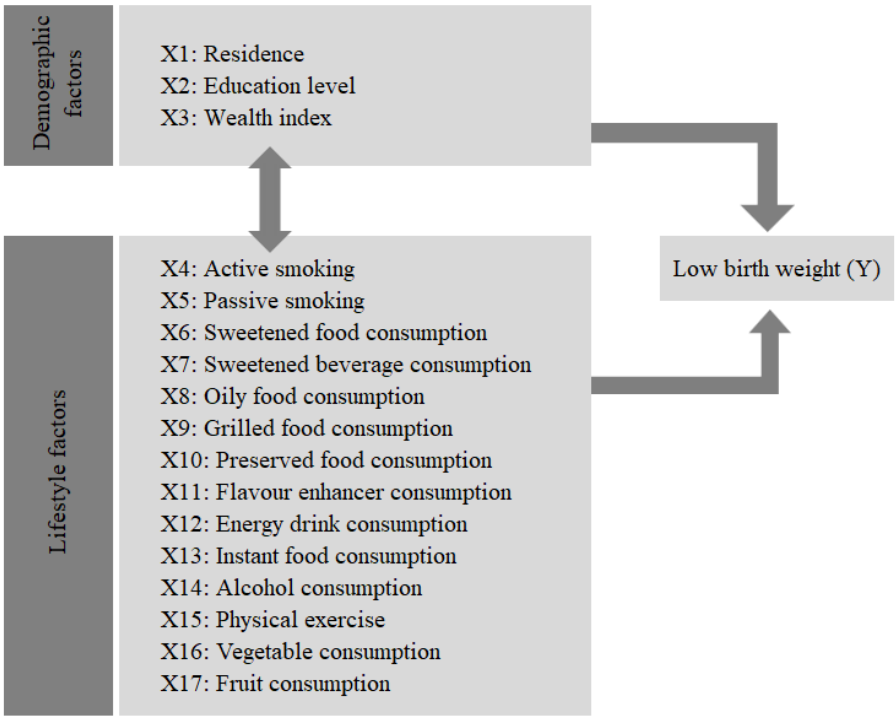

Figure 1. Framework of Demographic and Lifestyle Factors

Model building and adjustment

We used a stepwise approach to create the final model. All potential variables from the bivariate analysis were initially included in the model. Adjusted odds ratios (AORs) and 95% confidence intervals (CIs) were reported to describe the strength and direction of relationships between lifestyle factors and LBW.

We also tested how different factors worked together by including interaction terms in the model. For example, we examined how a mother's education level interacted with smoking habits or how living in rural versus urban areas affected dietary habits. Only interactions with a p-value ≤0.05 were included in the final model. The performance of the final model was evaluated using multiple pseudo-R-squared measures, such as Cox & Snell, Nagelkerke, and McFadden.

Results

Description of Study Respondents

In this study, we presented national survey data representing Indonesia. Among the respondents, 50.4% were urban women, and 81.3% had attained at least secondary education. As for socioeconomic factors, most women who gave birth (61.6%) were from the middle to poorest wealth quintiles (Table 1).

Table 1. Bivariate Analysis of LBW Determinants in Indonesia

Variables	N (%)	LBW		χ^2
		Yes (weighted %)	No (weighted %)	
Birth weight (grams)				
Low birth weight (<2500)	1,732 (5.7)	1,732 (6.1)	-	
Normal birth weight (≥2,500)	28,784 (94.3)	-	28,784 (93.9)	
Residence				0.092*
Urban	15,382 (50.4)	896 (58.4)	14,486 (55.0)	
Rural	15,134 (49.6)	836 (41.6)	14,298 (45.0)	
Education level				0.640
No education	1,682 (5.5)	113 (4.4)	1,569 (4.7)	
Primary education	4,018 (13.2)	253 (15.0)	3,765 (13.8)	
Secondary education	17,984 (58.9)	990 (61.9)	16,994 (63.9)	
Higher	6,832 (22.4)	376 (18.7)	6,456 (17.7)	
Wealth index				0.681
Poorest	5,036 (16.5)	315 (14.0)	4,721 (12.4)	
Poor	6,966 (22.8)	414 (18.2)	6,552 (18.9)	
Middle	6,792 (22.3)	383 (22.5)	6,409 (22.6)	
Rich	4,879 (16.0)	282 (20.9)	4,597 (20.1)	
Richest	6,843 (22.4)	338 (24.4)	6,505 (26.1)	
Active smoking				0.166*
Yes	209 (0.7)	14 (1.7)	195 (0.9)	
No	30,307 (99.3)	1,718 (98.3)	28,589 (99.1)	
Passive smoking				<0.001**
Yes	20,888 (68.4)	1,231 (75.0)	19,657 (68.2)	
No	9,628 (31.6)	501 (25.0)	9,127 (31.8)	
Sweetened food consumption				0.461
<1 time/day	20,323 (66.6)	1,159 (65.9)	19,164 (67.4)	
≥1 time/day	10,193 (33.4)	573 (34.1)	9,620 (32.6)	

Variables	N (%)	LBW		χ^2
		Yes (weighted %)	No (weighted %)	
Sweetened drink consumption				0.982
<1 time/day	18,490 (60.6)	1,052 (61.6)	17,438 (61.7)	
≥1 time/day	12,026 (39.4)	680 (38.4)	11,346 (38.3)	
Oily food consumption				0.115*
<1 time/day	20,833 (68.3)	1,126 (58,2)	19,707 (61.4)	
≥1 time/day	9,683 (31.7)	606 (41.8)	9,077 (38.6)	
Grilled food consumption				0.032**
<1 time/day	28,864 (94.6)	1,618 (94.0)	27,246 (95.8)	
≥1 time/day	1,652 (5.4)	114 (6.0)	1,538 (4.2)	
Preserved food consumption				0.515
<1 time/day	27,920 (91.5)	1,571 (91.2)	26,349 (91.9)	
≥1 time/day	2,596 (8.5)	161 (8.8)	2,435 (8.1)	
Flavor enhancer consumption				0.017**
<1 time/day	8,689 (28.5)	422 (18.8)	8,267 (22.6)	
≥1 time/day	21,827 (71.5)	1,310 (81.2)	20,517 (77.4)	
Energy drink consumption				0.166*
<1 time/day	29,974 (98.2)	1,711 (99.1)	28,263 (98.5)	
≥1 time/day	542 (1.8)	21 (0.9)	521 (1.5)	
Instant food consumption				0.280
<1 time/day	28,544 (93.5)	1,607 (93.2)	26,937 (94.3)	
≥1 time/day	1,972 (6.5)	125 (6.8)	1,847 (5.7)	
Alcohol consumption				0.047*
Yes	64 (0.2)	8 (0.6)	56 (0.2)	
No	30,452 (99.8)	1,724 (99.4)	28,728 (99.8)	
Physical exercise				0.272
Low	4,537 (14.9)	261 (15.1)	4,276 (14.9)	
Moderate	20,271 (66.4)	1,167 (70.5)	19,104 (68.2)	
Vigorous	5,708 (18.7)	304 (14.4)	5,404 (16.9)	
Vegetable consumption				0.009**
<1 time/day	13,624 (44.6)	717 (37.6)	12,907 (42.9)	
≥1 time/day	16,892 (55.4)	1,015 (62.4)	15,877 (57.1)	
Fruit consumption				0.940
<1 time/day	23,914 (78.4)	1,364 (76.7)	22,550 (76.5)	
≥1 time/day	6,602 (21.6)	368 (23.3)	6,234 (23.5)	
Interaction terms				
Education*Active smoking	30,516 (100)	1,732 (6.1)	28,784 (93.9)	0.024**
Education*Sweetened food	30,516 (100)	1,732 (6.1)	28,784 (93.9)	0.225*
Wealth index*Sweetened food	30,516 (100)	1,732 (6.1)	28,784 (93.9)	0.515
Education*Instant food	30,516 (100)	1,732 (6.1)	28,784 (93.9)	0.140*
Wealth index*Alcohol	30,516 (100)	1,732 (6.1)	28,784 (93.9)	0.035**
Education*Physical exercise	30,516 (100)	1,732 (6.1)	28,784 (93.9)	0.006**

*p <0.25, **p <0.05.

In terms of lifestyle factors, active smoking and alcohol consumption during pregnancy were uncommon, with each reported by fewer than 1% of respondents. However, exposure to second-hand smoke was quite common, impacting 68.4% of participants. Furthermore, 66.4% of participants indicated moderate physical activity during their pregnancy.

Regarding dietary practices, most respondents consumed sweetened foods, sweetened drinks, oily foods, grilled foods, preserved foods, energy drinks, and instant foods less than once daily. Conversely, flavor enhancer usage was more frequent, with most reporting consumption more than once daily. While more than half of the

respondents (55.4%) reported eating enough vegetables, only a quarter (21.6%) consumed sufficient fruit.

Prevalence of LBW

The mean birth weight of infants in this study was 3,061.74 grams, ranging from 1,000 to 6,000 grams. The prevalence of LBW in the cleaned 2023 SKI dataset was 5.7%. After applying sample weighting, the estimated national prevalence of LBW was 6.1% (553,670 cases/9,115,665 live births).

Key Determinants of LBW

As shown in Table 1, bivariate analysis identified several maternal and lifestyle factors significantly associated with LBW ($p \leq 0.25$), warranting inclusion in multivariable regression modeling. These factors included maternal residence, active smoking, passive smoking, oily food consumption, grilled food consumption, flavor enhancer consumption, energy drink consumption, vegetable consumption, and alcohol consumption.

Additionally, significant interaction effects ($p \leq 0.25$) were observed. Several interaction terms were identified between education and active smoking, education and sweetened food consumption, education and instant food consumption, wealth index and alcohol consumption, and education and physical activity. These interaction terms highlight the potential modifying influence of socioeconomic and educational factors on lifestyle determinants of LBW.

Multivariable Analysis of LBW Determinants

A summary of the results of the logistic regression analysis is provided in Table 2. Once other predictors were considered, only the maternal residence (*p*-value: 0.016), passive smoking (*p*-value: <0.001), grilled food consumption (*p*-value: 0.035), energy drink consumption (*p*-value: 0.046), and vegetable consumption (*p*-value: 0.021) showed significant risk for LBW. There was an increase in the odds of experiencing an LBW pregnancy among urban mothers (AOR: 1.228; 95% CI: 1.038-1.453), mothers who experienced second-hand smoke (AOR: 1.383; 95% CI: 1.149-1.664), and drank energy drink less than once a day (AOR: 2.501; 95% CI: 1.015-6.161). A reduction in the odds of having a newborn with LBW was found among respondents who consumed grilled food and vegetables less than once a day.

Mothers with primary education and sweet food consumption less than once a day have lower odds (around 51% less) of having an LBW baby compared to mothers with no education and sweet food consumption more than once a day (AOR: 0.486; 95% CI: 0.266-0.887). For mothers consuming sweetened food more than once a day, education level has no discernible impact on LBW incidence, as the odds ratios for all groups are fixed at one.

Middle-wealth mothers consuming sweetened food less than once a day have almost 15 times the odds of having an LBW baby than the wealthiest group consuming sweet food more than once a day (AOR: 14.847; 95% CI: 1.123-196.298). Both for <1 time/day and ≥1 time/day (AOR: 12.518; 95% CI: 0.924-169.618), mothers in the middle wealth quintile demonstrate higher odds of LBW compared to the richest group consuming sweet food ≥1

time/day. This suggests that middle-wealth status might pose unique vulnerabilities, although the significance varies.

Table 2. Multivariate Analysis of LBW Risk Factors

Variables	AOR	95% CI
Residence		
Rural	Ref	Ref
Urban	1.228*	1.038-1.453
Passive smoking		
Yes	1.383**	1.149-1.664
No	Ref	Ref
Oily food consumption		
<1 time/day	Ref	Ref
≥1 time/day	1.040	0.869-1.245
Grilled food consumption		
<1 time/day	Ref	Ref
≥1 time/day	1.498*	1.029-2.180
Flavor enhancer consumption		
<1 time/day	Ref	Ref
≥1 time/day	1.158	0.949-1.411
Energy drink consumption		
<1 time/day	2.501*	1.015-6.161
≥1 time/day	Ref	Ref
Vegetable consumption		
<1 time/day	Ref	Ref
≥1 time/day	1.217*	1.030-1.437
Education*Active smoking		
No education*Non smoker	Ref	Ref
Primary*Non smoker	0.998	0.234-4.256
Secondary*Non smoker	1.239	0.369-4.162
Higher*Non smoker	1.773	0.412-7.639
No education*Smoker	0.340	0.036-3.169
Primary*Smoker	0.126	0.010-1.606
Secondary*Smoker	3.388	0.702-16.358
Higher*Smoker	0.217	0.017-2.756
Education*Sweet food consumption		
No education*<1 time/day	1.599	0.770-3.323
Primary*<1 time/day	0.486*	0.266-0.887
Secondary*<1 time/day	0.809	0.531-1.234
Higher*<1 time/day	0.940	0.564-1.567
No education*≥1 time/day	Ref	Ref
Primary*≥1 time/day	1.000	1.000-1.000
Secondary*≥1 time/day	1.000	1.000-1.000
Higher*≥1 time/day	1.000	1.000-1.000
Wealth index*Sweet food consumption		
Poorest*<1 time/day	5.419	0.297-98.783
Poor*<1 time/day	4.268	0.308-59.165
Middle*<1 time/day	14.847*	1.123-196.298
Rich*<1 time/day	0.064	0.003-1.381
Richest*<1 time/day	1.000	1.000-1.000
Poorest*≥1 time/day	3.734	0.198-70.408
Poor*≥1 time/day	2.184	0.155-30.727
Middle*≥1 time/day	12.518	0.924-169.618
Rich*≥1 time/day	0.057	0.003-1.281
Richest*≥1 time/day	Ref	Ref
Education*Instant food consumption		
No education*<1 time/day	Ref	Ref

Variables	AOR	95% CI
Primary*<1 time/day	4.740*	1.438-15.623
Secondary*<1 time/day	2.263	0.822-6.231
Higher*<1 time/day	1.059	0.291-3.859
No education*≥1 time/day	2.646*	1.048-6.683
Primary*≥1 time/day	2.646*	1.048-6.683
Secondary*≥1 time/day	2.646*	1.048-6.683
Higher*≥1 time/day	2.646*	1.048-6.683
Wealth index*Alcohol consumption		
Poorest*Non Drinker	0.283	0.034-2.388
Poor*Non Drinker	0.339	0.059-1.955
Middle*Non Drinker	0.083*	0.014-0.488
Rich*Non Drinker	19.117*	1.455-251.206
Richest*Non Drinker	1.051	0.143-7.719
Poorest*≥1 time/day	1.000	1.000-1.000
Poor*≥1 time/day	1.000	1.000-1.000
Middle*Drinker	1.000	1.000-1.000
Rich*Drinker	1.000	1.000-1.000
Richest*Drinker	Ref	Ref
Education*Physical exercise		
No education*Low	Ref	Ref
Primary*Low	1.000	1.000-1.000
Secondary*Low	1.000	1.000-1.000
Higher*Low	1.000	1.000-1.000
No education*Moderate	1.665	0.755-3.673
Primary*Moderate	0.758	0.428-1.340
Secondary*Moderate	0.969	0.716-1.312
Higher*Moderate	1.672	0.940-2.975
No education*Vigorous	1.155	0.470-2.841
Primary*Vigorous	1.588	0.793-3.181
Secondary*Vigorous	0.714	0.495-1.029
Higher*Vigorous	0.908	0.456-1.808

Ref: reference group; *statistically significant at p <0.05; **p <0.001.
Cox and Snell R square: 0.009
Nagelkerke R square: 0.025
McFadden R square: 0.020

Frequent instant food consumption (≥1 time/day) is consistently associated with higher odds of LBW, regardless of education level, with similar effect sizes (AOR: 2.646; 95% CI: 1.048-6.683 for all education levels). For low-frequency instant food consumption (<1 time/day), the association with LBW appears to depend on education level, being most significant for mothers with primary education (AOR: 4.740; 95% CI: 1.438-15.623). Mothers in the middle wealth quintile who do not consume alcohol are significantly less likely to have LBW babies (AOR: 0.083; 95% CI: 0.014-0.488), but mothers in the rich wealth quintile who do not consume alcohol have substantially higher odds of LBW (AOR: 19.117; 95% CI: 1.455-251.206) compared to the richest wealth quintile. This is a striking finding and suggests an elevated risk.

The pseudo-R squared values (Cox and Snell: 0.009, Nagelkerke: 0.025, McFadden: 0.020) indicated the model's modest explanatory power. However, the statistically significant results highlight the meaningful contribution of the predictors and interaction terms to explaining LBW.

Discussion

The magnitude of LBW in this study was reasonably consistent with the earlier report of the 2018 Riskesdas survey (Riskesdas, 2018) and the recent publication of the SKI main result for 2023 (Badan Kebijakan Pembangunan Kesehatan Kemenkes RI, 2024). The slight variation in results may be attributed to how the respondents were selected. This excluded infants with unclear birth weights that needed corresponding maternal data, which could lead to an underestimation of the actual number of LBW cases in our population.

Observations of this study are consistent with those from the global literature that emphasize the adverse effects of tobacco smoke exposure during pregnancy due to passive parental smoking (Handriani et al., 2022). The presence of a smoking spouse at home doubles the risk of LBW and triples it when combined with high levels of outdoor air pollution (Delcroix et al., 2023).

A critical component of interventions targeting household smoke-free environments is to reduce passive smoking in Indonesia, where tobacco use is highly prevalent among men (CDC et al., 2022). Public health campaigns and policy enforcement can address this risk factor by reducing secondhand smoke exposure, including expanding the reach of smoking bans in public and private spaces.

Frequent consumption of vegetables leads to higher chances of LBW, which raises important issues regarding maternal nutrition. Imbalanced diets that are high in vegetables but low in protein, fats, and other essential nutrients during pregnancy can hinder fetal growth due to nutritional imbalance (Sebastiani et al., 2019). These eating habits are often associated with convenience and cost, especially among rural mothers from lower-income households, but they may also indicate a lack of nutritional knowledge. Healthcare professionals should educate pregnant mothers to avoid overconsumption without a balance of calorie-dense foods, which may restrict fetal growth, especially in women with high energy needs during the later stages of pregnancy.

It emerged in this study that mothers drinking specific dosages of energy drinks had a higher risk of delivering LBW babies. The main ingredients of energy drinks are caffeine with added sugars, other additives, and legal stimulants such as guarana, taurine, and L-carnitine (Costantino et al., 2023). The adverse effects of excess caffeine have been proven (James, 2021). Still, the effects of other additives remained inconclusive, as did the combined effect of the ingredients in energy drinks.

Consuming grilled food more than once a day increases the risk of LBW. Overindulging in grilled, barbecued, or smoked meat may pose health risks because harmful compounds, such as polycyclic aromatic hydrocarbons, may be formed (Parada et al., 2017). More research is necessary to clarify the complex relationship between food preparation methods and fetal health outcomes.

The interaction between maternal education and lifestyle factors provides important insights. Mothers with only primary education who consumed sweetened foods less often were less likely to have LBW infants. This highlights the importance of education in

improving maternal health behaviors. Generally, higher education correlates with better health literacy and reduced adverse health events (Bayati et al., 2018; Sudhakar et al., 2020), which helps mothers make informed choices about nutrition and lifestyle during pregnancy. Initiatives to enhance education for women, especially in underserved rural areas, could significantly improve maternal and child health outcomes.

It was also found that the wealth index significantly influenced the relationship between lifestyle factors and birth weight. Mothers from middle-class families who frequently consumed instant foods were more likely to experience birth weight loss (LBW) than their wealthiest peers, possibly because of a difference in access to quality prenatal care and healthier food options. Research has shown that poor maternal healthcare service utilization is associated with adverse maternal and neonatal outcomes, particularly in populations with low educational and economic status (Sheikh et al., 2024). Comprehensive maternal health services should be included in the scope of the JKN program to address these inequities.

To reduce the number of babies with LBW in Indonesia, JKN antenatal services can be improved by adding programs that help mothers make healthier lifestyle choices. These could include programs to help mothers quit smoking, teach about healthy eating, and monitor nutrition during pregnancy. Local health departments should enforce smoke-free areas in public and residential spaces and offer community programs to educate pregnant women about the dangers of smoking. Promoting better nutrition by encouraging affordable, healthy eating with local ingredients is also important, especially for lower-income people. Community programs, like offering subsidies for healthy foods and getting local health workers and volunteers involved, can help change behaviors and improve the health of both mothers and babies.

The strength of this study was that it examined a wide range of maternal lifestyle risk factors, including substance use. However, the use of a retrospective questionnaire in 2023 SKI limited the study, which had the potential to introduce recall bias and frequency misclassification. The logistic regression model's modest explanatory power suggests unmeasured factors influencing LBW, such as genetic predispositions or environmental exposures. Future studies should employ longitudinal designs and incorporate biomarkers to better understand the complex interplay between maternal lifestyle and LBW.

The findings of this study offer practical insights for improving antenatal care under Indonesia's JKN scheme. Health promotion efforts should prioritize education about the risks of second-hand smoke, promote balanced maternal nutrition, and discourage the consumption of energy and instant foods during pregnancy. These results also support the integration of lifestyle screening into routine antenatal visits, especially for women with lower education levels or those in vulnerable socioeconomic groups. Policymakers should consider expanding nutritional assistance and smoke-free campaigns as part of national maternal health strategies.

This study has several limitations. First, it relies on self-reported data from the 2023 SKI, which may introduce recall bias, especially in dietary frequency and smoking exposure. Second, the cross-sectional design prevents the establishment of causality. Third, potential confounding factors such as gestational age, maternal weight gain, or environmental pollutants were not captured in the SKI dataset. Future longitudinal studies incorporating clinical biomarkers and environmental data are recommended to validate and expand on these findings.

Conclusion

The challenge of LBW has remained unchanged in recent years despite increased funding for nutritional supplementation. This finding underscores the importance of multifaceted, focused, evidence-based dietary support programs for pregnant women. Several lifestyle risk factors identified in this study contributed to the development of LBW in Indonesia. They should be addressed by enforcing smoke-free areas in public and residential spaces, as well as promoting healthier dietary choices, particularly for low-income groups. Pregnant women should be aware of the adverse effects of second-hand smoke and imbalanced nutrition on their pregnancy. Healthcare providers should improve communication to raise awareness of pregnant mothers and the content quality of existing antenatal care services. By enhancing the quality of antenatal care and increasing access to health services, JKN can play a key role in reducing LBW rates and improving the health of mothers and babies in Indonesia.

Acknowledgments

We sincerely thank the 2023 Indonesian Health Survey program for generously providing the dataset utilized in this study. We also extend our heartfelt appreciation to Prof. Dr. Dra. Dumilah Ayuningtyas, MARS, in her capacity as the editor of Jurnal Jaminan Kesehatan Nasional, and to the journal's reviewers for their invaluable and constructive feedback, which significantly enhanced the quality of this work.

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