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# The Relationship Between Pregnant Women Exposed to Secondhand Smoke and The Incidence of Low Birth Weight Infants (LBW) in The City of Semarang

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**Keywords:**
Secondhand Smoke Exposure; Pregnant Women; Passive Smoking; Low Birth Weight; LBW.

**Abstract**

This study aimed to analyze the relationship between secondhand smoke exposure among pregnant women and the incidence of low birth weight (LBW) in Semarang City. This study employed a quantitative observational analytic approach using a case-control design. A total of 282 respondents, consisting of 141 cases and 141 controls, were selected using a consecutive sampling technique. Data were collected through a structured questionnaire adapted from the Global Adult Tobacco Survey (GATS) and analyzed using the Chi-square test and binary logistic regression. The results showed that 76.6% of pregnant women were exposed to secondhand smoke during pregnancy, while the prevalence of low birth weight was 5.7%. Bivariate analysis demonstrated a significant association between secondhand smoke exposure and low birth weight ($p < 0.001$). The Odds Ratio (OR) indicated that pregnant women exposed to secondhand smoke had approximately 9.52 times higher odds of delivering a low birth weight infant than those who were not exposed. Multivariate analysis revealed that household income and maternal occupation remained significant factors associated with low birth weight after controlling for potential confounding variables. This study concluded that secondhand smoke exposure during pregnancy was significantly associated with the occurrence of low birth weight. Strengthening health education, incorporating secondhand smoke exposure screening into antenatal care services, and promoting smoke-free environments at home and in workplaces are recommended to reduce the incidence of low birth weight.

## INTRODUCTION

Low birth weight (LBW) remains one of the main indicators of maternal and child health problems worldwide (Arabzadeh et al., 2024; Darmstadt et al., 2023; Geberu et al., 2025; Islam et al., 2024; Jana et al., 2023; Okwaraji et al., 2024; Organization, 2023). The World Health Organization (WHO) reports that approximately 15–20% of all global births, or more than 20 million infants annually, are born weighing less than 2,500 grams (WHO, 2025). Infants with low birth weight have a substantially higher risk of mortality, approximately 20 times greater than infants with normal birth weight (Aziza et al., 2025). The World Health Organization (WHO) stated that LBW is one of the leading causes of infant mortality worldwide. At the 65th World Health Assembly, UNICEF endorsed a target to reduce the prevalence of LBW by 30% between 2012 and 2025 (Zayani, 2025). The prevalence of LBW is highest in Asia, with 12.8 million cases, followed by Africa with 5.7 million cases, Oceania with 1.4 million cases, Latin America and the Caribbean with 0.9 million cases, and 1 million cases in other regions (UNICEF, 2019). Indonesia ranks among the top countries worldwide based on the estimated

absolute number of infants born with LBW. The country is consistently included among the top 10 countries with the highest burden of LBW cases due to its large population and high annual birth rate (Zakia & Pranita, 2026).

The prevalence of LBW in Indonesia increased from 6.2% in 2020 to 6.6% in 2021, decreased to 6.0% in 2022, and subsequently increased to 6.2% in 2023 and 6.5% in 2024. This condition contributes significantly to neonatal mortality, long-term morbidity, and impaired growth and development among children (WHO, 2025). In addition, LBW is closely associated with an increased risk of noncommunicable diseases in adulthood, including diabetes and cardiovascular disease. Therefore, reducing the prevalence of LBW remains one of the global targets within the Global Nutrition Targets 2025 framework (WHO, 2017).

In Indonesia, LBW remains a significant public health problem and is one of the major contributors to infant mortality after respiratory disorders and cardiovascular conditions (Haksari et al., 2025; Minawati et al., 2026; Safitri et al., 2022; Simanjuntak & Nainggolan, 2023). Based on the 2024 health profile data of Central Java Province, LBW and prematurity are among the leading causes of infant mortality, followed by asphyxia and congenital disorders. In Semarang City, LBW is the second-largest contributor to infant mortality after asphyxia. Various factors have been identified as determinants of LBW incidence, including biological, social, and environmental factors. One environmental factor receiving increasing attention is cigarette smoke exposure, particularly among pregnant women exposed to secondhand smoke. Cigarette smoke contains various toxic substances, including nicotine, carbon monoxide, and other harmful particles, which can impair placental function and reduce oxygen supply to the fetus. This condition may cause chronic hypoxia, which affects intrauterine growth and increases the risk of infants being born with low birth weight (Andriani et al., 2023). Several recent studies have shown that pregnant women exposed to cigarette smoke have a higher risk of delivering LBW infants compared with those who are not exposed.

Research based on the Indonesian Demographic and Health Survey data shows that household cigarette smoke exposure is significantly associated with an increased incidence of LBW (Andriani et al., 2023). These findings are supported by a meta-analysis demonstrating that secondhand smoke exposure during pregnancy significantly increases the risk of LBW, even after controlling for other factors, such as nutritional status and socioeconomic conditions (Ramadhani & Budhiastuti, 2023). Furthermore, another study reported that secondhand smoke exposure during pregnancy not only increases the risk of LBW but is also associated with preterm birth and fetal developmental disorders (Suzuki et al., 2019). These findings confirm that cigarette smoke exposure is a modifiable risk factor that requires further prevention and intervention efforts.

In developing countries, including Indonesia, exposure to cigarette smoke among pregnant women has become an increasingly complex public health issue due to the high prevalence of smoking, particularly among men (WHO, 2021). Indonesia is one of the countries with the highest prevalence of smokers worldwide, with more than 60% of adult males reported as smokers (Reeves & Bernstein, 2009). This condition contributes to high levels of household cigarette smoke exposure, causing many pregnant women to become passive smokers. Studies have shown that most exposure to secondhand smoke among pregnant women occurs indoors, particularly due to exposure from husbands or other family members (Andriani et al., 2023).

Data from the 2023 Indonesian Health Survey (Survei Kesehatan Indonesia [SKI]) conducted by the Ministry of Health (Kementerian Kesehatan [Kemenkes]) indicated that the number of active smokers was estimated to reach 70 million people, with 7.4% of smokers aged 10–18 years. Children and adolescents represent the group experiencing the most significant increase in smoking prevalence. Based on data from the 2019 Global Youth Tobacco Survey (GYTS), the prevalence of smokers among school-aged children aged 13–15 years increased from 18.3% in 2016 to 19.2% in 2019. Meanwhile, the 2023 SKI data showed that the 15–19-year-old age group represented the largest proportion of smokers (56.5%), followed by the 10–14-year-old age group (18.4%) (Devi et al., 2023).

The prevalence of smoking among adult males in Indonesia is among the highest worldwide, with rates ranging from 60% to 65%. This indicates that approximately two out of three adult males in Indonesia are active smokers. Nationally, data from the Indonesian Health Survey (SKI) showed that the smoking prevalence among adult males reached approximately 63.3%. At the Central Java Province level, the prevalence of smokers was 30.7% (Central Java Riskesdas, 2024), with approximately 61.8% of adult males identified as smokers. This prevalence is higher in rural areas. In Semarang City, the prevalence of smoking among adult males is slightly lower than the provincial average, ranging from 54% to 58%. This lower prevalence in urban areas may be associated with stricter implementation of No-Smoking Zones (Kawasan Tanpa Rokok [KTR]) in offices, shopping centers, and public facilities. However, densely populated residential areas and coastal regions, such as North Semarang and Genuk, may still experience high levels of household smoke exposure, with reported smoking prevalence exceeding 60%.

Although the Indonesian government has implemented various tobacco control policies, such as No-Smoking Zones (Kawasan Tanpa Rokok [KTR]), the implementation of these policies remains suboptimal, particularly at the household level (Farlikhatun, 2020). Most policies have focused on public spaces, whereas exposure in domestic environments has received comparatively less attention. This represents an important gap because households remain the primary source of cigarette smoke exposure for pregnant women. Limited family awareness regarding the risks of cigarette smoke exposure during pregnancy further exacerbates this condition (Al-mughathwai et al., 2025).

Pregnant women are among the most vulnerable groups to the adverse effects of cigarette smoke exposure. Secondhand smoke exposure during pregnancy has been associated with an increased risk of various complications, including miscarriage, stillbirth, neonatal death, preterm birth, low birth weight (LBW), placenta previa, congenital abnormalities, and fetal neurological developmental disorders (Wang et al., 2024). In Indonesia, approximately 75–78% of pregnant women and women of reproductive age are exposed to secondhand smoke due to household cigarette smoke, particularly from husbands or other family members (Lestari et al., 2020). Data from the Ministry of Health also indicate that more than 75% of pregnant women are routinely exposed to secondhand smoke at home. In Central Java Province, the exposure rate reaches approximately 76.5%, while in Semarang City, it ranges from 60% to 62%, indicating that a large proportion of pregnant women remain at risk of adverse health effects due to cigarette smoke exposure (Paramitasari et al., 2025). This high exposure is a

serious concern because it may contribute to the increasing incidence of LBW, which remains a major maternal and child health problem in Indonesia.

Nationally, the prevalence of LBW remains approximately 6–6.5% and represents one of the major causes of neonatal mortality in Indonesia (Ministry of Health of the Republic of Indonesia, 2023). Infants born with low birth weight have a mortality risk up to nine times higher than infants with normal birth weight and are more susceptible to hypothermia, respiratory disorders, infections, hypoglycemia, and intracranial hemorrhage during the neonatal period (Pudasainee-Kapri, 2025). In the long term, a history of LBW is also associated with an increased risk of stunting, delayed motor and cognitive development, and metabolic disorders in adulthood, including type 2 diabetes mellitus and cardiovascular disease (Zhou et al., 2023; Khanal et al., 2024). In Central Java Province, the prevalence of LBW showed an increasing trend, reaching 5.8% in 2024. Although the number of LBW cases in Semarang City has declined, LBW remains the second-largest contributor to infant mortality after asphyxia. This condition demonstrates that, in addition to medical factors, cigarette smoke exposure as an environmental risk factor requires greater attention in efforts to prevent LBW (Central Java Health Office, 2024; Pudji et al., 2025).

Despite various policies regarding Non-Smoking Areas (Kawasan Tanpa Rokok [KTR]), implementation in household and workplace environments remains suboptimal, leaving pregnant women vulnerable to continued cigarette smoke exposure. Moreover, most previous studies have emphasized the effects of active smoking, whereas research examining secondhand smoke exposure among pregnant women, particularly within the local context of Semarang City, remains limited. Social, cultural, and environmental characteristics of different regions may influence exposure levels and the magnitude of risk for LBW occurrence. Therefore, this study aims to analyze the relationship between secondhand smoke exposure among pregnant women and the incidence of LBW in Semarang City, identify the magnitude of associated risks, and assess the role of potential confounding factors, including age, parity, economic status, and antenatal care services. The findings of this study are expected to provide a scientific basis for strengthening policies, improving health programs, and developing preventive interventions to protect pregnant women from cigarette smoke exposure and reduce LBW incidence.

## METHOD

### Research Design

This study employed a quantitative observational analytic approach with a case-control design. This design was selected to analyze the relationship between cigarette smoke exposure during pregnancy and the incidence of low birth weight (LBW). The case group consisted of mothers who had given birth to infants weighing less than 2,500 grams, while the control group consisted of mothers who had given birth to infants weighing 2,500 grams or more. The history of cigarette smoke exposure in both groups was collected retrospectively using a structured questionnaire. The research instrument was adapted from the Global Adult Tobacco Survey (GATS) developed by WHO and previous studies by Aziza et al. (2025) and Fitri (2025). The collected data were analyzed to determine the association between cigarette smoke exposure among pregnant women and the incidence of LBW in Semarang City.

**Research Location and Time**

The research was carried out in several health centers that have maternity services in Semarang City. The selection of location was based on the availability of birth data and BBLR cases. The research was carried out from June to July 2026 which included the stages of preparation, data collection, data processing, data analysis, and preparation of research reports.

**Population and Sample**

The study population is all mothers who give birth to live babies in Semarang City. Based on the 2024 Semarang City Health Profile, the number of live births was recorded at 17,401, so this number is used as a research population because it is official data relevant to research on maternal and infant health. The research sample is some of the mothers who give birth to live babies in Semarang City and meet the inclusion and exclusion criteria. Sampling uses a consecutive sampling technique, where all respondents who meet the criteria are selected sequentially until the required number of samples is met. The sample size was calculated using a case-control research formula with a case-control ratio of 1:1. Based on the significance level of 5%, power 80%, the proportion of exposure in the control group of 30%, and the minimum Odds Ratio value of 2.0, the sample needs of 141 respondents in the case group and 141 respondents in the control group were obtained. Thus, the total sample used in this study was 282 respondents. The inclusion criteria in the case group include mothers who give birth to live babies with full gestational age, domiciled in Semarang City, have complete baby birth weight data, are willing to be respondents, have a single pregnancy, and are mothers who are exposed to cigarette smoke during pregnancy. The exclusion criteria include mothers who are active smokers, have multiple pregnancies, give birth to stillborn babies or babies with major congenital abnormalities, have severe chronic diseases, incomplete birth weight data, and are unable to remember the history of exposure to cigarette smoke during pregnancy.

In the control group, respondents were mothers who gave birth to live babies with a minimum birth weight of 2,500 grams, gestational age of at least 37 weeks, babies without congenital abnormalities, willing to be respondents, and had characteristics comparable to the case group. The control group did not include mothers with multiple pregnancies or mothers who had severe infections during pregnancy.

**Research Hypothesis**

The hypothesis of this study states that there is a relationship between exposure to cigarette smoke in pregnant women and the incidence of Low Birth Weight Infants (BBLR). In addition, this study also examined the relationship between maternal characteristics, obstetric history, pregnancy conditions, health and nutritional status, and history of infection during pregnancy to the incidence of BBLR. Each hypothesis was tested using the zero hypothesis ($H_0$) which states that there is no relationship and the alternative hypothesis ($H_1$) which states that there is a relationship between independent variables and the occurrence of BBLR.

**Data Processing Techniques**

Data processing is carried out through the stages of editing, coding, data entry, and data cleaning. The editing stage aims to check the completeness and consistency of respondents' answers. Next, coding is carried out by providing numerical codes on each variable so that it

can be easily analyzed using statistical software. The encoded data is then entered into the SPSS program through the data entry process. The last stage is data cleaning to ensure that there is no duplicate data, missing data, input errors, or illogical values so that the data is ready to be used in the analysis process.

**Data Analysis Techniques**

Data analysis was carried out using the SPSS program which included univariate, bivariate, and multivariate analysis. Univariate analysis was used to describe the characteristics of respondents and the distribution of each research variable in the form of frequency, percentage, and concentration size if needed. Bivariate analysis was carried out using the Chi-Square test to determine the relationship between cigarette smoke exposure and the incidence of BBLR. If there are cells with an expected count of less than five, the Fisher's Exact Test is used as an alternative test. The amount of risk is assessed using the Odds Ratio (OR) along with the 95% Confidence Interval (CI). Furthermore, multivariate analysis was carried out using binary logistics regression to determine the effect of cigarette smoke exposure on the incidence of BBLR after being controlled by confounding variables. Variables with a p< value of 0.25 in bivariate analysis were included in the regression model, while the final results were assessed based on the Adjusted Odds Ratio (AOR), 95% CI, and p-value, with a significance level of 0.05.

## RESULTS AND DISCUSSION

### Univariate Analysis

### Identifying the characteristics of pregnant women in Semarang City

**Table 1. Characteristics of Respondents**

| Variabel | Category | n | % |
|---|---|---|---|
| **Age** | <20 years old | 6 | 4,3 |
| | 20–35 years old | 124 | 87,9 |
| | >35 years old | 11 | 7,8 |
| **Education** | SD | 3 | 2,1 |
| | SMP | 15 | 10,6 |
| | SMA | 87 | 61,7 |
| | College | 36 | 25,5 |
| **Jobs** | Not working | 62 | 44,0 |
| | Private employees | 36 | 25,5 |
| | Civil servants | 8 | 5,7 |
| | IRT | 3 | 2,1 |
| | Labor | 16 | 11,3 |
| | Pharmacist | 1 | 0,7 |
| | Self-employed | 15 | 10,6 |
| **Economic status** | < UMR | 73 | 51,8 |
| | ≥ LIFESPAN | 68 | 48,2 |

Most pregnant women were at a safe reproductive age (20-35 years), which was as many as 124 respondents (87.9%). The highest level of education was high school (61.7%), while almost half of the respondents were unemployed (44.0%). Based on economic status, respondents with incomes below UMR are slightly more (51.8%) than those with incomes ≥ UMR (48.2%).

**Knowing the level of exposure to cigarette smoke in pregnant women**

**Table 2. Distribution of Cigarette Smoke Exposure**

| Variabel | Category | n | % |
|---|---|---|---|
| **Paparan TM I** | Ya | 105 | 74,5 |
| | No | 36 | 25,5 |
| **Paparan TM II** | Ya | 98 | 69,5 |
| | No | 43 | 30,5 |
| **TM III Display** | Ya | 98 | 69,5 |
| | No | 43 | 30,5 |
| **Overall view** | Ya | 108 | 76,6 |
| | No | 33 | 23,4 |
| **Display in the workplace** | Ya | 53 | 37,6 |
| | No | 88 | 62,4 |

The majority of pregnant women experience exposure to cigarette smoke during pregnancy. The highest exposure occurred in the first trimester (74.5%), while in the second and third trimesters it was 69.5%. Overall, 76.6% of pregnant women have been exposed to cigarette smoke. Exposure in the work environment was experienced by 37.6% of respondents, while most (62.4%) did not experience exposure in the workplace.

**Identify BBLR events**

**Table 3. Distribution of BBLR Occurrence**

| Baby Weight | n | % |
|---|---|---|
| **BBLR** | 8 | 5,7 |
| **BBLN** | 133 | 94,3 |

Most of the babies were born with normal weight (94.3%), while the incidence of BBLR was found in 8 babies (5.7%) of all study respondents.

**Bivariate Analysis**

**To analyse the relationship between exposure to cigarette smoke and the incidence of BBLR**

**Table 4. The Relationship between Cigarette Smoke Exposure and the Incidence of BBLR**

| Exposure to Cigarette Smoke | BBLR | BBLN | p-value |
|---|---|---|---|
| **No** | 5 | 33 | |
| **Ya** | 144 | 100 | <0.001 |

The results of the Chi-square test showed $p < 0.001$, so there was a statistically significant relationship between cigarette smoke exposure in pregnant women and the incidence of BBLR. Thus, the research hypothesis that states that there is a relationship between cigarette smoke exposure and the incidence of BBLR is accepted.

**Measuring the magnitude of the risk (Odds Ratio)**

**Table 5. The Greater Risk of Cigarette Smoke Exposure to the Incidence of BBLR**

| Variabel | OR | 95% CI | p-value |
|---|---|---|---|

| | | | |
|---|---|---|---|
| **Exposure to cigarette smoke** | 0,105 | 0,040–0,279 | <0.001 |

The Odds Ratio (OR) value produced by SPSS was 0.105 (95% CI: 0.040–0.279). This value appears because SPSS uses the reference category "Not Exposed" instead of "Exposed". If the interpretation is reversed so that the exposed group becomes the exposure group, then the risk is about 1/0.105 = 9.52 times. This means that pregnant women who are exposed to cigarette smoke have a 9.5 times greater chance of experiencing BBLR events than mothers who are not exposed.

**Multivariate Analysis**

**Identify other factors that play a role as confounding variable**

**Table 6. Bivariate Analysis of Confounding Factors on the Incidence of BBLR**

| Variabel | p-value | Remarks |
|---|---|---|
| **Age** | 0,033 | Get in touch |
| **Parity** | 0,119 | Unrelated |
| **ANC** | 0,110 | Unrelated |

The results of bivariate analysis showed that maternal age was significantly related to the incidence of BBLR (p=0.033), while parity (p=0.119) and antenatal service (ANC) (p=0.110) did not show a statistically significant association with the incidence of BBLR. Therefore, age has the potential to be a confounding variable that needs to be considered in advanced analysis.

**Table 7. Logistic Regression Analysis Results**

| Variabel | Exp(B) | p-value | Remarks |
|---|---|---|---|
| **Revenue** | 0,373 | <0.001 | Signifikan |
| **Jobs** | 1,194 | 0,015 | Signifikan |

Logistic regression analysis of the Forward Stepwise (Conditional) method showed that after controlling for other variables, only income (p<0.001) and employment (p=0.015) still had an effect on the incidence of BBLR. In contrast, age, parity, and ANC are no longer included in the final model because they do not make a meaningful contribution after being controlled with other variables. This shows that income and employment are the most dominant factors in the resulting regression model.

**Univariate Analysis**

**Characteristics of pregnant women in Semarang City**

The results showed that most of the respondents were in the age group of 20-35 years, which was 124 people or 87.9%. Based on education level, the majority of respondents had a high school education, namely 87 people or 61.7%. Judging from work, the largest group is non-working mothers, which is 62 people or 44.0%. Meanwhile, based on economic status, respondents with income less than UMR were 73 people or 51.8%, slightly more than respondents with income ≥ UMR as many as 68 people or 48.2%.

The age of 20–35 years is generally considered a relatively safe reproductive age range because the reproductive organs have developed optimally and the risk of pregnancy complications tends to be lower than pregnancy at the age of less than 20 years or more than 35 years. However, a safe reproductive age does not completely eliminate the risk of developing BBLR. Other factors, such as nutritional status, diseases during pregnancy, quality

of antenatal services, socioeconomic conditions, occupation, and exposure to cigarette smoke, can still affect fetal growth.

Education can affect a mother's ability to receive, understand, and apply health information. Mothers with higher education generally have a greater opportunity to obtain information about the dangers of secondhand smoke, nutritional fulfillment during pregnancy, pregnancy danger signs, and the importance of antenatal examination. However, the level of education is not always in line with preventive behavior if decisions about smoking habits at home are more influenced by husbands or other family members (Mahajan et al., 2024).

Employment status and economy can also affect the condition of pregnancy. Family income is related to the ability to provide nutritious food, access to transportation to health facilities, supporting examinations, and the ability to obtain health services in a sustainable manner. WHO explained that BBLR is a multifactorial health problem and can reflect maternal malnutrition, disease, heavy workload, and inadequate health services during pregnancy (WHO, 2017).

The results of this study show that more than half of the respondents have an income below the UMR. This condition is important because economic limitations can increase maternal vulnerability to malnutrition, delays in the use of health services, and a residential environment that does not support healthy living behaviors. However, the relationship between economic status and BBLR needs to be viewed carefully because income can interact with education, employment, nutritional status, gestational age, and antenatal services.

The results of a national study by Aziza et al. found that the incidence of BBLR is not only influenced by exposure to cigarette smoke, but also related to gestational age and maternal nutritional status. After controlling for maternal age, parity, occupation, gestational age, and nutritional status, exposure to cigarette smoke still increases the likelihood of BBLR. The findings suggest that social and maternal characteristics need to be analyzed together, not separately (Aziza et al., 2025).

The dominance of respondents aged 20–35 years showed that the majority of mothers were at a relatively safe reproductive age. However, the high proportion of respondents who are not working and have incomes below the UMR indicates socio-economic vulnerability. Researchers argue that these socioeconomic conditions can affect the ability of families to meet nutritional needs, obtain health services, and create a smoke-free home environment. Therefore, it is not enough to focus on the age of the mother, but also to consider family health education, economic conditions, work, and the living environment.

**Exposure to cigarette smoke in pregnant women**

The results of the study showed that exposure to cigarette smoke in pregnant women was relatively high. In the first trimester, as many as 105 respondents or 74.5% experienced exposure to cigarette smoke. In the second and third trimester, there were 98 respondents or 69.5% who were exposed, respectively. Overall, 108 respondents or 76.6% experienced exposure to cigarette smoke during pregnancy. In addition, exposure in the work environment was found in 53 respondents or 37.6%.

High exposure in the first trimester needs attention because the first trimester is a period of formation of fetal organs. Continuous exposure in the second and third trimesters also has the potential to interfere with fetal growth because both trimesters are periods of rapid fetal growth and weight gain.

Environmental cigarette smoke contains nicotine, carbon monoxide, particulates, and various toxic compounds. Nicotine can cause vasoconstriction or narrowing of blood vessels, including the blood vessels of the uterus and placenta. This condition can reduce the blood flow that carries oxygen and nutrients to the fetus. Meanwhile, carbon monoxide has a higher affinity for hemoglobin than oxygen, thus reducing the blood's capacity to carry oxygen. The combination of vasoconstriction and reduced oxygen transport can lead to fetal hypoxia, intrauterine growth retardation, and birth weight loss (Kusumawardani, 2023).

The American College of Obstetricians and Gynecologists states that tobacco exposure in pregnancy is associated with fetal growth retardation, preterm birth, BBLR, placental disorders, and increased perinatal mortality. Exposure to secondhand smoke during pregnancy is also associated with an increased risk of giving birth to babies with low birth weight (Cameron et al., 2025).

The national research by Andriani et al. used data from the 2017 Indonesian Demographic and Health Survey involving 19,935 Indonesian women. The study examined exposure to cigarette smoke in the home and its relationship with BBLR. The use of national data reinforces that exposure to cigarette smoke in the home environment is a widespread public health problem in Indonesia and does not only occur in certain research areas (Andriani et al., 2023).

A national systematic review by Aly Syahbana et al. examined nine observational studies. From the studies studied, a number of studies showed a relationship between exposure to environmental tobacco smoke during pregnancy and the incidence of BBLR and birth weight loss. The study concluded that exposure to cigarette smoke during pregnancy can increase the risk of baby weight loss while still paying attention to confounding factors (Syahbana et al., 2022).

The overall high exposure compared to workplace exposure suggests that the source of exposure likely comes not only from the workplace, but also from the home environment, family members, vehicles, public places, or other social environments. This is important because even mothers who do not work can still experience high exposure if their husbands or family members smoke in the house.

Researchers argue that a high percentage of exposure in each trimester indicates that exposure is not a momentary event, but can be continuous during pregnancy. Higher exposure than workplace exposure indicates that households are likely to be one of the main sources. Prevention must therefore involve husbands and family members, including through the implementation of smoke-free homes, smoking bans in vehicles, and counseling about the dangers of secondhand smoke at every antenatal visit.

**Incidence of BBLR in the baby born by the respondent**

The results showed that as many as 8 babies or 5.7% experienced BBLR, while 133 babies or 94.3% had normal birth weight. The WHO defines BBLR as a baby's birth weight of less than 2,500 grams, regardless of gestational age. BBLR can occur as a result of premature birth, intrauterine growth retardation, or a combination of both. The condition is associated with an increased risk of neonatal death, respiratory distress, difficulty maintaining body temperature, feeding disorders, infections, growth disorders, and long-term developmental problems.

The proportion of BBLR of 5.7% indicates that most of the babies in the study were born with normal weight. Although the proportion is relatively small, BBLR remains clinically important because its impact on infant pain and mortality is greater than in infants of normal birth weight. A low percentage also cannot immediately mean that the BBLR problem is not important, especially if the case is related to preventable factors, such as exposure to secondhand smoke during pregnancy.

The occurrence of BBLR is not only influenced by one factor. In addition to exposure to cigarette smoke, factors that play a role include gestational age, maternal nutritional status, anemia, hypertension, placental disorders, infections, maternal age, parity, pregnancy distance, workload, antenatal services, and socioeconomic conditions. Therefore, the interpretation of the BBLR incident must consider the possible interaction of these various factors (Adugna & Worku, 2022).

The results of Aziza et al.'s research support the multifactorial nature of BBLR. The study found that nutritional status and gestational age also play a role in the incidence of BBLR, while exposure to cigarette smoke remains a risk factor after controlling for several maternal characteristics (Aziza et al., 2024).

Researchers argue that the incidence of BBLR of 5.7% should still be seen as an important problem because each case of BBLR carries a risk of neonatal complications and growth disorders. This proportion also shows the need to strengthen screening from pregnancy, especially in mothers who are exposed to cigarette smoke, have poor nutritional status, experience pregnancy diseases, or have limitations in accessing health services.

**Bivariate Analysis**

**The relationship between cigarette smoke exposure and the incidence of BBLR**

Based on the results of the Pearson Chi-Square test, a $p<0.001$ value was obtained. The value was smaller than $\alpha=0.05$, so that statistically there was a statistically significant relationship between exposure to secondhand smoke during pregnancy and the incidence of BBLR. Thus, the hypothesis that states that there is a relationship between cigarette smoke exposure and the incidence of BBLR is acceptable based on the results of the analysis presented.

Biologically, the relationship can be explained through the influence of toxic substances in cigarette smoke on the circulation of the uteroplacenta. Nicotine causes narrowing of blood vessels, so blood flow to the placenta is reduced. Carbon monoxide forms carboxyhemoglobin and decreases the availability of oxygen to the fetus. Exposure to particulate matter as well as oxidative compounds can also cause oxidative stress and impaired placental function. If this condition persists repeatedly or for a long time, fetal growth can be stunted and the baby is at risk of being born weighing less than 2,500 grams.

The results of this study are in line with the national research by Aziza et al. in Padang City. In the initial analysis, exposure to cigarette smoke was significantly related to BBLR with an OR of 3.429. After controlling for maternal age, parity, occupation, gestational age, and nutritional status, pregnant women who become passive smokers have an 11.5 times higher chance of experiencing BBLR than mothers who are not exposed (Aziza et al., 2024).

These results are also supported by a systematic study by Aly Syahbana et al. who showed that several observational studies found an association between exposure to

environmental cigarette smoke during pregnancy and an increase in the incidence of BBLR or a decrease in infant birth weight (Syahbana, 2022).

At the international level, a meta-analysis of Di et al. of 55 cohort studies showed that smoking during pregnancy was associated with an increased likelihood of BBLR, with a combined OR of 1.89 and a 95% confidence interval of 1.80–1.98. The study also showed a dose-response pattern, namely the risk of BBLR increases with increasing the number of cigarettes and the longer exposure during pregnancy (Di et al., 2022).

A meta-analysis by Perkins et al. that included studies in the Americas also found that active smoking during pregnancy was associated with BBLR, with a combined OR of 2.00 and a 95% confidence interval of 1.77–2.26. The relationship is relatively consistent across different designs, sample sizes, and research regions (Perkins et al., 2023).

Although the meta-analysis largely discussed mothers who were active smokers, the mechanisms by which toxic substances reached the mother and fetus were also relevant to passive exposure. The difference mainly lies in the size of the dose, duration, environmental ventilation, distance from smokers, and the number of cigarettes burned around the mother.

Researchers argue that the association found may have occurred because most mothers experience exposure in more than one trimester, so the exposure is recurring. Exposure that lasts from the first trimester to the third trimester allows the accumulation of the effects of nicotine, carbon monoxide, and other toxic substances on the placenta and fetal growth. Therefore, prevention of exposure should begin before pregnancy or as early as possible after pregnancy is known (Han- & Chun-, 2025).

**Multivariate Analysis**

**The magnitude of the risk of exposure to cigarette smoke against BBLR**

The results of the analysis showed that the OR value displayed by SPSS was 0.105 with a 95% CI of 0.040–0.279 and $p<0.001$. The OR value compares the unexposed category with the exposed, so the value is less than one. If the direction of comparison is reversed to be an exposed group compared to an unexposed group, then the OR value becomes: $OR=1/0.105=9.52$

Thus, based on the coding and table presented, pregnant women who are exposed to cigarette smoke have an odds of experiencing BBLR of around 9.52 times compared to mothers who are not exposed. The reverse confidence interval is estimated to be around 3.58–25.00.

A considerable OR value indicates that exposure to cigarette smoke has the potential to be a strong risk factor. However, OR should be interpreted as a comparison of odds, not directly as a comparison of absolute probability or risk. The interpretation of "9.52 times more at risk" is often used in the discussion of case-control research, but a more epidemiologically appropriate term is "having a 9.52 times greater odds of experiencing BBLR".

These results are consistent with the study of Aziza et al., who obtained an adjusted OR of 11.59 after controlling for maternal age, parity, occupation, gestational age, and nutritional status. The magnitude of the OR is relatively close to the results of this study, although differences in population, exposure measurements, design, and control variables may cause differences in estimated values (Aziza et al., 2024).

The results of this study show a greater strength of the relationship than the international meta-analysis of Di et al. who obtained an OR of 1.89 and Perkins et al. who obtained an OR

of 2.00. These differences can be caused by variations in study design, respondent characteristics, exposure definitions, reference categories, intensity and duration of exposure, sample size, and controlled confounding variables (Di et al., 2022; Perkins et al., 2023).

The relatively wide confidence interval in inverted OR indicates that the risk estimate has a considerable degree of uncertainty. This can be related to the small number of subjects in one of the table cells or the limited sample size. Therefore, interpretation needs to focus on the direction and meaningfulness of the relationship, while paying attention to the precision of estimation (Perkins et al., 2023).

The researchers argue that the large OR value shows the importance of controlling exposure to cigarette smoke as part of BBLR prevention. However, the magnitude of OR also needs to be interpreted carefully because it can be influenced by case and control distributions, variable coding methods, sample size, and confounding factors. The researcher suggested that OR reporting always explicitly mention the reference category so that there are no errors in the direction of interpretation.

**Other factors that have the potential to be confounding variables**

The results of bivariate analysis showed that the mother's age was related to the incidence of BBLR with p=0.033. On the other hand, parity had a value of p=0.119 and antenatal services or ANC had a value of p=0.110, so the two did not show a significant relationship at the level of α=0.05.

Age can be related to BBLR because pregnancy at the age of less than 20 years can occur when the mother's physical growth is not fully mature, so there can be competition for nutritional needs between mother and fetus. Meanwhile, pregnancies over the age of 35 are more often accompanied by decreased reproductive function, chronic diseases, vascular disorders, or pregnancy complications. However, the relationship between age and BBLR is not always consistent because it can be influenced by nutritional status, parity, maternal disease, education, and access to health services (Thapa et al., 2022).

Parity can theoretically affect pregnancy outcomes. Primipara can have a risk because they have no previous pregnancy experience, while grande multipara has the potential to experience decreased reproductive function or maternal reserve. However, the insignificance of the parity relationship in this study can be due to the very small number of grande multipara respondents, unbalanced sample distribution, or the presence of the influence of other factors (Engdaw et al., 2023).

ANC is an important means of detecting anemia, hypertension, fetal growth disorders, nutritional status, infections, and various pregnancy complications. The absence of a significant relationship between the number of ANCs and BBLR does not mean that ANC is not important. The ANC variables in this study were only differentiated based on the number of visits less than three times and ≥ three times. The number of visits does not necessarily reflect the timeliness, continuity, quality of examinations, completeness of services, adherence to health advice, and the quality of interventions received by mothers (Paramitasari et al., 2025).

In the logistics regression analysis, income has a value of Exp(B)=0.373 with p<0.001, while work has an Exp(B)=1.194 with p=0.015. Age, parity, and ANC do not make it into the final model. Based on this model, income and employment are variables that still show significant contributions after being analyzed with other variables.

Income can be related to BBLR through the ability of families to provide nutritious food, obtain health services, improve living conditions, and reduce barriers to access to services. Work can be related to physical load, standing length, stress, exposure to hazardous materials, work schedules, as well as the opportunity to attend pregnancy checkups. However, the direction of interpretation of Exp(B) needs to be adjusted to the codes of the categories of occupation, income, and dependent variables in the dataset.

The findings of Aziza et al. show that gestational age and nutritional status are important factors in the incidence of BBLR. The study also controlled for maternal age, parity, occupation, gestational age, and nutritional status in a multivariate analysis. This reinforces the importance of considering various maternal factors when assessing the relationship between cigarette smoke exposure and BBLR (Aziza et al., 2024).

The findings of this study are not entirely the same as the study of Paramitasari et al., which found a relationship between parity and exposure to secondhand smoke with BBLR, but found no significant association between maternal age and BBLR. Differences in results can be caused by differences in design, number of samples, distribution of age categories and parity, characteristics of health facilities, and methods of measuring exposure (Paramitasari et al., 2025).

It should be emphasized that a variable cannot be directly called a confounder just because it has a certain p-value or falls into the regression model. The confounding variable should meet several conditions, i.e., it is exposure-related, outcome-related, not part of the causal pathway, and causes significant changes to the main relationship estimates after being incorporated into the model. One commonly used approach is to compare the gross OR with the adjusted OR; changes of about 10% or more can be an indication of confounding (Arge & Hasen, 2025).

The researcher argues that age, parity, and ANC cannot be ascertained as confounding variables only based on bivariate results and forward stepwise methods. Income and employment are indeed significant in the final model, but their status as a confounder of the relationship between cigarette smoke exposure and BBLR must be assessed through changes in exposure OR before and after these variables are controlled. To appropriately address the specific goal of confoundering, cigarette smoke exposure must still be included in logistical regressions along with age, parity, ANC, income, occupation, nutritional status, and gestational age based on a theoretical framework, not just based on SPSS automatic selection.

**Table 8. Synthesis of 5 supporting research**

| Researcher | Scope | Main methods and results | Compatibility with research |
|---|---|---|---|
| **Andriani et al. (2023)** | National, Indonesia | IDHS 2017 analysis of 19,935 women on exposure to cigarette smoke in the home and BBLR | Supporting the importance of household exposure as a national issue |
| **Aly Syahbana et al. (2022)** | National | Systematic review of nine articles; Some studies have found a relationship between exposure to secondhand smoke and BBLR or birth weight loss | Supports the direction of the exposure relationship and BBLR |
| **Aziza et al. (2024)** | National, Padang City | Case-control studies; adjusted OR exposure of 11.59 after maternal factor control | Supporting relationships and the magnitude of research risks |

| | | | |
|---|---|---|---|
| **Di et al. (2022)** | International | Meta-analysis of 55 cohort studies; A combined OR of 1.89 and a dose-response relationship | Supporting consistency of relationships globally |
| **Perkins et al. (2023)** | International, American | Meta-analysis of 30 studies; OR combined 2.00 | Supports that smoking during pregnancy increases the likelihood of BBLR |

**Research Limitations**

This study has several limitations that need to be considered in interpreting the results. First, there is a discrepancy in the number of observations between descriptive analysis and bivariate and multivariate analyses that have the potential to affect the results of statistical tests. Second, the measurement of exposure to cigarette smoke is only based on respondents' reports, so it risks causing recall bias and information bias, and has not been supported by biomarker examinations such as cotinin levels so that the level of exposure cannot be measured objectively. In addition, exposure to cigarette smoke has not been analyzed in detail based on the source, intensity, duration, and location of exposure, and the study has not included all factors that theoretically affect the incidence of BBLR, so residual confounding is still possible. The measurement of antenatal services is also still limited to the number of visits without assessing the quality of services. On the other hand, the use of logistic regression with the forward stepwise method causes the selection of variables to be based more on statistical significance so that it is not yet fully able to identify confounding variables through crude comparison and adjusted odds ratio. In addition, because it uses a case-control design, the Odds Ratio value only describes the strength of the relationship and cannot be interpreted as event risk or cause-and-effect relationship. Finally, the research was conducted on mothers in Semarang City, so the results of the study need to be carefully generalized to a wider population due to differences in social, economic, cultural, and access to health services between regions.

## CONCLUSION

The conclusion of this study showed that cigarette smoke exposure among pregnant women in Semarang City remained relatively high and was significantly associated with the incidence of low birth weight (LBW). The majority of respondents were mothers aged 20–35 years, had a high school education, were unemployed, and had an income below the regional minimum wage (Upah Minimum Regional [UMR]), with 76.6% experiencing cigarette smoke exposure during pregnancy. The Pearson Chi-square analysis showed a significant association between cigarette smoke exposure and LBW incidence ($p < 0.001$), indicating that pregnant women exposed to cigarette smoke had higher odds of delivering LBW infants compared with those who were not exposed. Furthermore, maternal age was associated with LBW incidence in the bivariate analysis, while income and employment status remained significant factors in the logistic regression analysis. These findings highlight the importance of strengthening cigarette smoke exposure screening in antenatal care services, promoting smoke-free environments at home and workplaces, and supporting policies and educational programs involving families to prevent LBW. However, the interpretation of these findings should be approached cautiously due to inconsistencies in the number of observations in some analyses. Further research is recommended using prospective designs with more objective exposure

measurements and stricter data validation procedures to obtain more accurate estimates of the associations.

## REFERENCES


Adugna, D. G., & Worku, M. G. (2022). Maternal and neonatal factors associated with low birth weight among neonates delivered at the University of Gondar Comprehensive Specialized Hospital, Northwest Ethiopia. *Frontiers in Pediatrics*. https://doi.org/10.3389/fped.2022.899922

Andriani, H., Rahmawati, N. D., Ahsan, A., & Kusuma, D. (2023). Secondhand smoke exposure inside the house and low birth weight in Indonesia: Evidence from a demographic and health survey. *Population Medicine*, 1–7.

Arabzadeh, H., Doosti-Irani, A., Kamkari, S., Farhadian, M., Elyasi, E., & Mohammadi, Y. (2024). The maternal factors associated with infant low birth weight: An umbrella review. *BMC Pregnancy and Childbirth, 24*(1), 316.

Cameron, R. S., Perono, G. A., Natale, C. D., Petrik, J. J., Holloway, A. C., & Hardy, D. B. (2025). The impact of cannabinoids on reproductive function. *Reproduction*.

Darmstadt, G. L., Al Jaifi, N. H., Arif, S., Bahl, R., Blennow, M., Cavallera, V., Chou, D., Chou, R., Comrie-Thomson, L., & Edmond, K. (2023). New World Health Organization recommendations for care of preterm or low birth weight infants: Health policy. *EClinicalMedicine, 63*.

Engdaw, G. T., Tesfaye, A. H., Feleke, M., Negash, A., Yeshiwas, A., Addis, W., Angaw, D. A., & Engidaw, M. T. (2023). Effect of antenatal care on low birth weight: A systematic review and meta-analysis in Africa, 2022. *Frontiers in Public Health*. https://doi.org/10.3389/fpubh.2023.1158809

Farlikhatun. (2020). Pengaruh asap rokok pada ibu hamil: Studi literatur. *Jurnal Pengaruh Asap Rokok Maternal (Studi Literatur), 3*, 183–192.

Geberu, D. M., Baffa, L. D., Hagos, A., Tiruneh, M. G., Teshale, G., Tafere, T. Z., Demissie, K. A., & Jejaw, M. (2025). Pooled prevalence and factors of low birth weight among newborns in the top 20 countries with the highest infant mortality: Analysis of recent demographic and health surveys. *BMJ Open, 15*(4), e098090.

Haksari, E. L., Irawan, G., Lusyati, S. D., Wibowo, T., Yunanto, A., Rukmono, P., Sianturi, P., Alasiry, E., Primadi, A., & Samad. (2025). Neonatal mortality and survival of low-birth-weight infants at hospitals in Indonesia: A multicenter study. *Scientific Reports, 15*(1), 31607.

Han-, T.-F., & Chun-, N. (2025). Association between prenatal environmental tobacco smoke exposure and preterm birth: A systematic review and meta-analysis. *Acta Obstetricia et Gynecologica Scandinavica*, 1244–1253. https://doi.org/10.1111/aogs.15126

Islam, M. Z., Chowdhury, M. R. K., Kader, M., Billah, B., Islam, M. S., & Rashid, M. (2024). Determinants of low birth weight and its effect on childhood health and nutritional outcomes in Bangladesh. *Journal of Health, Population and Nutrition, 43*(1), 64.

Jana, A., Saha, U. R., Reshmi, R. S., & Muhammad, T. (2023). Relationship between low birth weight and infant mortality: Evidence from National Family Health Survey 2019–21, India. *Archives of Public Health, 81*(1), 28.

Khanal, V., Bista, S., & Mishra, S. R. (2024). Synergistic associations of antenatal care visits and iron-folic acid supplementation with low birth weight: A pooled analysis of national surveys from six South Asian countries. *BMC Public Health*, 1–9.

Kusumawardani. (2023). Exposure to environmental tobacco smoke and adverse pregnancy outcomes among Indonesian women. *Journal of Environmental Research and Public Health*.

Lestari, J. F., Etika, R., Lestari, P., Kebidanan, P. S., Kedokteran, F., Airlangga, U., Ilmu, D., Anak, K., Kedokteran, F., Airlangga, U., Ilmu, D., Pencegahan, K. M., & Airlangga, K.

U. (2020). Faktor risiko maternal bayi berat lahir rendah (BBLR): Studi systematic review. *Indonesian Midwifery and Health Sciences Journal, 4*(1), 73–81. https://doi.org/10.20473/imhsj.v4i1.2020.73-81

Minawati, M., Trihandini, I., Elyazar, I. R. F., Septiono, W., Wiratama, B. S., & Sundjaya, T. (2026). The burden of low birth weight among children under five in Indonesia: A systematic analysis of the Global Burden of Disease Study 2021. *The Open Public Health Journal, 19*(1).

Okwaraji, Y. B., Krasevec, J., Bradley, E., Conkle, J., Stevens, G. A., Gatica-Domínguez, G., Ohuma, E. O., Coffey, C., Fernandez, D. G. E., & Blencowe, H. (2024). National, regional, and global estimates of low birthweight in 2020, with trends from 2000: A systematic analysis. *The Lancet, 403*(10431), 1071–1080.

Organization, W. H. (2023). *UNICEF/WHO low birthweight estimates: Levels and trends 2000–2020*. World Health Organization.

Paramitasari, N., Pariyem, Kartika, Dewi, K. T., Ratnawati, R., Janasti, L., & Purwaningtyas, M. (2025). Hubungan usia ibu, paritas, dan paparan asap rokok terhadap kejadian berat badan lahir rendah. *Jurnal Profesi Kesehatan Masyarakat, 6*(2), 63–69.

Perkins, J. P., Re, T., Ong, S., Niu, Z., & Wen, X. (2023). Meta-analysis on associations of timing of maternal smoking cessation before and during pregnancy with childhood overweight and obesity. *Nicotine and Tobacco Research, 25*(4), 605–615. https://doi.org/10.1093/ntr/ntac213

Pudasainee-Kapri, S. (2025). Prevalence of low birth weight and its developmental vulnerability among infants in Nepal: A critical review of the literature and future recommendations. *Journal of Nepal Medical Association, 63*(287), 541–549. https://doi.org/10.31729/jnma.9112

Safitri, H. O., Fauziningtyas, R., Indarwati, R., Efendi, F., & McKenna, L. (2022). Determinant factors of low birth weight in Indonesia: Findings from the 2017 Indonesian Demographic and Health Survey. *Journal of Pediatric Nursing, 63*, e102–e106.

Simanjuntak, R. R., & Nainggolan, O. (2023). Maternal age at birth and low birth weight (LBW) in Indonesia: Analysis of Riskesdas 2018. *Gizi Indonesia, 46*(1), 1–10.