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# Maternal Determinants of Low Birth Weight in Yemen: A Case-Control Study at Al- Sabeen Hospital, Sana'a City

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## Abstract

# Background

Low birth weight (LBW) remains a major contributor to neonatal morbidity and mortality, particularly in low-resource settings such as Yemen.

# Objective

To identify maternal determinants of LBW in Sana'a City, Yemen.

# Methods

An unmatched case–control study was conducted among 110 mothers (37 cases and 73 controls) at Al-Sabeen Hospital. Participants were selected using convenience sampling. Data were collected via face-to-face interviews using a structured questionnaire. Binary logistic regression was performed using SPSS. Variables with $p < 0.20$ in bivariable analysis and clinically relevant factors were included in the multivariable model. Adjusted odds ratios (AOR) with 95% confidence intervals (CI) were reported.

# Results

In multivariable analysis, low maternal income (< 80,000 YER) (AOR = 24.2, 95% CI: 2.04–88.67), inadequate antenatal care (ANC) (< 8 visits) (AOR = 16.6, 95% CI: 2.32–119.34), preterm delivery (AOR = 9.62, 95% CI: 1.31–70.47), and short birth spacing (< 2 years) (AOR = 7.87, 95% CI: 1.91–32.48) were significant obstetric and socio-demographic predictors of LBW. Tobacco use (AOR = 11.2, 95% CI: 1.63–87.74) and khat chewing (AOR = 11.9, 95% CI: 1.57–64.70) were significant behavioral factors. Occasional intake of protein (AOR = 19.7, 95% CI: 1.11–350.96) and vegetables (AOR = 48.1, 95% CI: 2.45–942.84) and caesarean delivery (AOR = 41.7, 95% CI: 3.18–54.61) were also associated with increased odds of LBW.

# Conclusion

LBW is influenced by multiple socio-demographic, obstetric, behavioral, and nutritional factors. Strengthening ANC and improving maternal nutrition while reducing tobacco and khat use may reduce LBW in Yemen.

## Introduction

LBW defined by the World Health Organization (WHO) as a birth weight of less than 2,500 grams regardless of gestational age, remains a major global public health concern due to its strong association with neonatal morbidity, mortality, and long-term developmental complications. Normal birth weight at term is considered to range between 2,500 and 4,200 grams [1]. Birth weight is widely recognized as a sensitive indicator of neonatal and intrauterine health status, reflecting maternal, nutritional, and environmental conditions during pregnancy [1].

According to UNICEF, LBW is associated with a wide range of adverse outcomes, including increased risk of neonatal death, impaired physical and cognitive development, stunting, and a higher likelihood of chronic diseases such as obesity and diabetes later in life. It is also closely linked to intrauterine growth restriction, preterm birth, and maternal factors such as malnutrition, substance use, and inadequate ANC [2].

Globally, LBW remains highly prevalent. In 2020, an estimated 19.8 million (14.7%) live births were classified as LBW, representing a decline from 22.1 million (16.6%) in 2000; however, this reduction is insufficient to meet global nutrition targets [4]. Earlier estimates also indicate that approximately 20.5 million newborns were born with LBW in 2015, with nearly 90% occurring in low- and middle-income countries [3]. South Asia and sub-Saharan Africa alone account for more than three-quarters of global LBW cases, reflecting persistent inequalities in maternal health, nutrition, and healthcare access [1, 5].

Despite global reductions, progress remains slow and uneven. The WHO Global Nutrition Target aims to reduce LBW prevalence by 30% by 2025, equivalent to reducing annual LBW births from approximately 20 million to 14 million. Achieving this goal requires integrated interventions addressing maternal nutrition, ANC utilization, environmental exposures, and social determinants of health such as poverty and education [6].

Evidence shows that LBW is a multifactorial outcome influenced by maternal biological, behavioral, and contextual factors. These include inadequate ANC, poor nutritional status, comorbidities, and exposure to harmful substances during pregnancy [7, 8]. In addition, sociodemographic characteristics, obstetric history, maternal health conditions, and healthcare utilization behaviors play critical roles in determining birth weight outcomes [9]. In low-resource settings such as Yemen, these risk factors are likely compounded by ongoing socioeconomic instability, limited healthcare access, and widespread nutritional challenges, highlighting the need for context-specific evidence to guide interventions.

**Objective**

To identify maternal determinants of LBW in Sana’a City, Yemen.

## Methods and analysis

## Study design and setting

An unmatched case–control study was conducted to identify risk factors for LBW among mothers delivering at Al-Sabeen Hospital in Sana'a City, Yemen. This design was chosen to enable detailed assessment of maternal socio-demographic, obstetric, behavioral, and dietary factors associated with LBW.

## Study population and sampling

The study population comprised all women who delivered at Al-Sabeen Hospital during the study period. A total of 110 participants were included: 37 cases (mothers of LBW neonates) and 73 controls (mothers of normal birth weight (NBW) neonates), yielding a case-to-control ratio of 1:2.

Participants were selected using a convenience sampling technique. Neonatal birth weight was measured using a calibrated digital neonatal scale. Cases were defined as neonates weighing < 2,500 g at birth, regardless of gestational age, while controls were term neonates with birth weights between 2,500 g and 4,200 g (10). Cases and controls were not matched to allow inclusion of a broader range of exposures and to facilitate multivariable analysis. Exclusion criteria for both groups included mothers with known acute or chronic diseases, complicated pregnancies, dystocic labour, stillbirths, neonates with congenital malformations, and mothers who declined participation.

## Sample size determination

The sample size was calculated using Epi Info version 7.2.6.0 (StatCalc). Assumptions included a two-sided confidence level of 95%, statistical power of 80%, and a control-to-case ratio of 2:1. The calculation was based on an expected odds ratio of 0.27, with the proportion of khat chewing during pregnancy estimated at 84.7% among controls and 60% [11] among cases, derived from previous literature. The minimum required sample size was 37 cases and 73 controls, resulting in a total sample of 110 mother–neonate pairs.

## Data collection and instruments

Data were collected between 1 February to 30 April 2025 using two approaches: (1) review of medical records and (2) face-to-face interviews with mothers using a structured questionnaire.

Cases were recruited upon admission to the delivery ward, while controls were selected from the same hospital during the same period. Neonatal weight was measured within the hospital using a digital neonatal scale to the nearest 0.1 kg. The questionnaire was developed based on previously published [11–14] studies and consisted of closed-ended questions organized into five sections: Socio-demographic characteristics (e.g. maternal age at marriage and delivery, education, occupation, residence, income, consanguinity, mode of delivery). Obstetric history (e.g., parity, birth spacing, gestational age, ANC visits, history of abortion, previous history of LBW). Maternal medical conditions

(e.g. anemia, hypertension, cardiac conditions, infections/fever, placental problems). Maternal nutrition during pregnancy (e.g. dietary supplement intake, consumption of coffee/tea, fruits, vegetables, protein, whole grains, and dairy products) and maternal behaviour (e.g. khat chewing, frequency and duration, tobacco use, frequency and duration).

Data quality was ensured through regular supervision, on-site checking for completeness, and immediate correction of inconsistencies. Content validity of the questionnaire was assessed by a panel of experts. A pilot study conducted on 10% of the sample demonstrated good internal consistency (Cronbach's α = 0.811).

# Data analysis

Data were analyzed using IBM SPSS Statistics. Descriptive statistics were used to summaries participant characteristics. Categorical variables were presented as frequencies and percentages. Associations between LBW and potential risk factors were assessed using bivariate and multivariable logistic regression. CORs with 95% CIs were calculated. Variables with $p < 0.20$ were included in a multivariable logistic regression model to identify independent predictors of LBW. AORs with 95% CIs were reported. A Forward Stepwise (Likelihood Ratio) selection method was applied to construct the final model. The final model demonstrated adequate goodness-of-fit based on the Hosmer–Lemeshow test ($p = 0.998$), indicating good model calibration. Multicollinearity was assessed using the variance inflation factor (VIF), with values < 5 considered acceptable. Statistical significance was set at $p < 0.05$.

## Results

# Maternal socio-demographic factors and risk of LBW

Table 1 presents the bivariate logistic regression analysis of maternal socio-demographic factors associated with LBW. Early age at marriage (< 18 years) was more frequent among LBW cases (8.1%) compared to controls (2.7%), but was not significantly associated with LBW (COR = 3.13; 95% CI: 0.50–19.63; $p = 0.22$). Maternal age at delivery showed a significant association with LBW ($p = 0.014$). Women aged < 30 years had higher odds of delivering LBW infants (COR = 3.02; 95% CI: 1.25–7.98). Caesarean delivery was strongly associated with LBW, with a markedly higher proportion among cases (75.7%) compared to controls (8.2%) (COR = 34.74; 95% CI: 11.29–106.81; $p < 0.001$). Consanguineous marriage significantly increased the odds of LBW (COR = 5.19; 95% CI: 2.02–13.33; $p < 0.001$). Lack of maternal education was strongly associated with LBW (COR = 11.76; 95% CI: 3.53–39.15; $p < 0.001$). Unemployment was also associated with increased odds of LBW (COR = 9.31; 95% CI: 1.17–73.52; $p = 0.034$). Rural residence significantly increased the risk of LBW (COR = 5.43; 95% CI: 2.24–13.11; $p < 0.001$). Low household income (< 80,000 YER) showed the strongest association among socio-demographic variables, with markedly increased odds of LBW (COR = 21.1; 95% CI: 7.11–62.55; $p < 0.001$).

Table 1
Bivariate logistic regression analysis of maternal socio-demographic factors associated with LBW at Al-Sabeen Hospital, Yemen

| Socio-demographic factors | Cases (LBW) F (%) | Controls (NBW) F (%) | COR | 95% CI | | *p*-value |
|---|---|---|---|---|---|---|
| | | | | *Lower* | *Upper* | |
| **Age at marriage** | | | | | | |
| < 18 years | 3(8.1%) | 2 (2.7%) | 3.13 | .50 | .223 | 0.223 |
| ≥ 18 years | 34(91.9%) | 71 (97.3%) | Ref. | — | — | — |
| **Age at delivery** | | | | | | |
| < 30 years | 28(75.7%) | 37 (50.7%) | 3.02 | 1.25 | 7.98 | 0.014 |
| ≥ 30 years | 9 (24.3%) | 36 (49.3%) | Ref. | — | — | — |
| **Mode of delivery** | | | | | | |
| Vaginal | 9 (24.3%) | 67 (91.8%) | Ref. | — | — | — |
| Caesarean | 28(75.7%) | 6 (8.2%) | 34.7 | 11.29 | 106.81 | < 0.001 |
| **Consanguinity** | | | | | | |
| Yes | 30(81.1%) | 33 (45.2%) | 5.19 | 2.02 | 13.33 | < 0.001 |
| No | 7 (18.9%) | 40 (54.8%) | Ref. | — | — | — |
| **Education** | | | | | | |
| Uneducated | 15(40.5%) | 4 (5.5%) | 11.76 | 3.53 | 39.15 | < 0.001 |
| Educated | 22(59.5%) | 69 (94.5%) | Ref. | — | — | — |
| **Occupation** | | | | | | |
| Unemployed | 36(97.3%) | 58(79.5%) | 9.31 | 1.17 | 73.52 | 0.034 |
| Employed | 1 (2.7%) | 15 (20.5%) | Ref. | — | — | — |
| **Place of residency** | | | | | | |
| Rural | 20(54.1%) | 13 (17.8%) | 5.43 | 2.24 | 13.11 | < 0.001 |
| Urban | 17(45.9%) | 60 (82.2%) | Ref. | — | — | — |
| **Family income monthly (YER)** | | | | | | |
| < 80000 | 32(86.5%) | 17 (23.3%) | 21.1 | 7.11 | 62.55 | < 0.001 |
| ≥ 80000 | 5 (13.5%) | 56 (76.7%) | Ref. | — | — | — |

*Significant at p < 0.05; Ref = Reference category; COR = Crude odds ratio; CI = Confidence interval; LBW = Low birth weight; NBW = Normal birth weight.*

## Maternal obstetric history factors and risk of LBW

Table 2 presents the bivariate logistic regression analysis of maternal obstetric history factors associated with LBW. Twin pregnancies were significantly associated with LBW (COR = 6.871; 95% CI: 1.31–35.95; p = 0.022). parity (< 3 deliveries) was not significantly associated with LBW (p = 0.46). A history of abortion was strongly associated with LBW (COR = 12.02; 95% CI: 4.70–30.70; p < 0.001). Preterm delivery (< 37 weeks) significantly increased the odds of LBW (COR = 12.88; 95% CI: 4.23–39.24; p < 0.001). Short birth interval (< 2 years) was associated with higher odds of LBW (COR = 18.42; 95% CI: 6.79–49.98; p < 0.001). Inadequate ANC (< 8 visits or none) showed a strong association with LBW (COR = 40.40; 95% CI: 13.01–125.57; p < 0.001). A previous history of LBW was significantly associated with recurrence of LBW (COR = 6.87; 95% CI: 1.31–35.95; p = 0.022).

Table 2
Bivariate logistic regression analysis of maternal obstetric history factors associated with LBW at Al-Sabeen Hospital, Yemen

| Obstetric history factors | Cases (LBW) F(%) | Controls (NBW) F(%) | COR | 95% CI | | p-value |
|---|---|---|---|---|---|---|
| | | | | *Lower* | *Upper* | |
| **Number of fetuses** | | | | | | |
| Singleton | 31(83.8%) | 71 (97.3%) | Ref. | — | — | |
| Twins | 6 (16.2%) | 2 (2.7%) | 6.87 | 1.31 | 35.95 | 0.022 |
| **Parity** | | | | | | |
| < 3 deliveries | 21(56.8%) | 36 (49.3%) | 1.34 | .60 | 2.99 | 0.461 |
| ≥ 3 deliveries | 16(43.2%) | 37 (50.7%) | Ref. | — | — | — |
| **History of abortion** | | | | | | |
| Yes | 26(70.3%) | 12 (16.4%) | 12.01 | 4.70 | 30.70 | < 0.001 |
| No | 11(29.7%) | 61 (83.6%) | Ref. | — | — | — |
| **Gestational age at delivery (week)** | | | | | | |
| Preterm | 18(48.6%) | 5 (6.8%) | 12.88 | 4.23 | 39.24 | < 0.001 |
| Term | 19(51.4%) | 68 (93.2%) | Ref. | — | — | — |
| **Birth spacing** | | | | | | |
| < 2 years | 29(78.4%) | 12 (16.4%) | 18.42 | 6.79 | 49.98 | < 0.001 |
| ≥ 2 years | 8 (21.6%) | 61 (83.6%) | Ref. | — | — | — |
| **ANC visits during pregnancy** | | | | | | |
| < 8 visits/or no | 30(81.1%) | 7 (9.6%) | 40.40 | 13.01 | 125.47 | < 0.001 |
| ≥ 8 visits | 7 (18.9%) | 66 (90.4%) | Ref. | — | — | — |
| **Previous history of LBW delivery** | | | | | | |
| Yes | 6 (16.2%) | 2 (2.7%) | 6.87 | 1.31 | 35.95 | 0.022 |
| No | 31(83.8%) | 71 (97.3%) | Ref. | — | — | — |

*Significant at p < 0.05; Ref = Reference category; COR = Crude odds ratio; CI = Confidence interval; LBW = Low birth weight; NBW = Normal birth weight.*

# Maternal medical factors and risk of LBW

Table 3 presents the bivariate logistic regression analysis of maternal medical conditions during pregnancy associated with LBW. Maternal anemia was significantly associated with LBW (COR = 3.99; 95% CI: 1.67–9.52; p = 0.002). Hypertensive disorders increased the odds of LBW (COR = 5.444; 95% CI: 1.31–22.49; p = 0.019). Cardiac conditions were significantly associated with LBW (COR = 8.28; 95% CI: 1.62–42.20; p = 0.011). Infections or fever during pregnancy showed a strong association with LBW (COR = 11.41; 95% CI: 2.31–56.14; p = 0.003). Placental complications were also significantly associated with LBW (COR = 9.79; 95% CI: 1.96–48.92; p = 0.005).

Table 3
Bivariate logistic regression analysis of maternal medical factors associated with LBW at Al-Sabeen Hospital, Yemen

| **Maternal medical factors** | **Groups** | | **OR** | **95% CI** | | ***p*-value** |
|---|---|---|---|---|---|---|
| | **Cases (LBW) F (%)** | **Controls (NBW) F (%)** | | ***Lower*** | ***Upper*** | |
| **Anemia** | | | | | | |
| Yes | 18 (48.6%) | 14 (19.2%) | 3.99 | 1.67 | 9.52 | 0.002 |
| No | 19 (51.4%) | 59 (80.8%) | *Ref.* | — | — | — |
| **Hypertension** | | | | | | |
| Yes | 7 (18.9%) | 3 (4.1%) | 5.44 | 1.31 | 22.49 | 0.019 |
| No | 33 (81.1%) | 70 (95.9%) | *Ref.* | — | — | — |
| **Cardiac problems** | | | | | | |
| Yes | 7 (18.9%) | 2 (2.7%) | 8.28 | 1.62 | 42.20 | 0.011 |
| No | 30 (81.1%) | 71 (97.3%) | *Ref.* | — | — | — |
| **Infection or fever** | | | | | | |
| Yes | 9 (24.3%) | 2 (2.7%) | 11.41 | 2.31 | 56.14 | 0.003 |
| No | 28 (75.7%) | 71 (97.3%) | *Ref.* | — | — | — |
| **Placenta problems** | | | | | | |
| Yes | 8 (21.6%) | 2 (2.7%) | 9.79 | 1.96 | 48.92 | 0.005 |
| No | 29 (78.4%) | 71 (97.3%) | *Ref.* | — | — | — |

*Significant at p < 0.05; Ref = Reference category; COR = Crude odds ratio; CI = Confidence interval; LBW = Low birth weight; NBW = Normal birth weight.*

# Maternal nutrition during pregnancy and risk of LBW

Table 4 presents the bivariate logistic regression analysis of maternal nutrition during pregnancy and their association with LBW. Lack of dietary supplement intake (iron, folate, or vitamin A) significantly increased LBW risk (COR = 13.14; 95% CI: 2.70–63.93; $p < 0.001$). Habitual coffee or tea consumption was associated with higher odds of LBW (COR = 4.91; 95% CI: 1.06–22.66; $p = 0.041$). Occasional consumption of fruits, vegetables, and protein was strongly associated with LBW (fruit: COR = 8.27; vegetable: COR = 9.27; protein: COR = 14.35; all $p < 0.001$). Occasional dairy consumption was also associated with LBW (COR = 6.871; 95% CI: 1.31–35.95; $p = 0.022$). Whole grain consumption was not significantly associated with LBW ($p = 0.255$).

Table 4
Bivariate logistic regression analysis of maternal nutrition associated with LBW at Al-Sabeen Hospital, Yemen

| Maternal nutrition during pregnancy | Groups | | COR | 95% CI | | *p*-value |
|---|---|---|---|---|---|---|
| | Cases (LBW) F (%) | Controls (NBW) F (%) | | *Lower* | *Upper* | |
| **Dietary supplement intake** | | | | | | |
| No | 10(27.0%) | 2 (2.7%) | 13.14 | 2.70 | 63.93 | < 0.001 |
| Yes | 27(73.0%) | 71 (97.3%) | *Ref.* | — | — | — |
| **Coffee or tea consumption** | | | | | | |
| Habitual | 35(94.6%) | 57 (78.1%) | 4.91 | 1.06 | 22.66 | 0.041 |
| Occasional | 2 (5.4%) | 16 (21.9%) | *Ref.* | — | — | — |
| **Fruits consumption** | | | | | | |
| Habitual | 23(62.2%) | 68 (93.2%) | *Ref.* | — | — | — |
| Occasional | 14(37.8%) | 5 (6.8%) | 8.27 | 2.68 | 25.50 | < 0.001 |
| **Vegetables consumption** | | | | | | |
| Habitual | 22(59.5%) | 68 (93.2%) | *Ref.* | — | — | — |
| Occasional | 15(40.5%) | 5 (6.8%) | 9.27 | 3.02 | 28.43 | < 0.001 |
| **Protein consumption** | | | | | | |
| Habitual | 18(48.6%) | 68 (93.2%) | *Ref.* | — | — | — |
| Occasional | 19(51.4%) | 5 (6.8%) | 14.3 | 4.71 | 43.72 | < 0.001 |
| **Whole grain consumption** | | | | | | |
| Habitual | 35(94.6%) | 72 (98.6%) | *Ref.* | — | — | — |
| Occasional | 2 (5.4%) | 1 (1.4%) | 4.11 | .36 | 46.93 | 0.255 |
| **Dairy products consumption** | | | | | | |
| Habitual | 31(83.8%) | 71 (97.3%) | *Ref.* | — | — | — |
| Occasional | 6 (16.2%) | 2 (2.7%) | 6.87 | 1.31 | 35.95 | 0.022 |

*Significant at p < 0.05; Ref = Reference category; COR = Crude odds ratio; CI = Confidence interval; LBW = Low birth weight; NBW = Normal birth weight.*

# Maternal behaviors during pregnancy and risk of LBW

Table 5 presents the bivariate logistic regression analysis of maternal behavioral factors during pregnancy associated with LBW. Khat chewing during pregnancy was significantly associated with LBW (COR = 6.62; 95% CI: 2.46–17.79; p < 0.001). Habitual use showed a stronger association, while occasional use was not significant. Longer duration of khat chewing was associated with a dose–response increase in LBW risk (≤ 4 hours: COR = 4.60; >4 hours: COR = 22.77; both p < 0.033). Tobacco use during pregnancy was strongly associated with LBW (COR = 17.85; 95% CI: 5.84–54.54; p < 0.001). Long-term tobacco use (≥ 2 years) significantly increased LBW risk (COR = 21.25; 95% CI: 6.37–70.81; p < 0.001), while short-term use was not significant. Higher daily frequency of tobacco use was also associated with increased odds of LBW (≥ 3 times/day: COR = 38.25; 95% CI: 8.04–181.85; p < 0.001).

Table 5
Bivariate logistic regression analysis of maternal behavioral factors associated with LBW at Al-Sabeen Hospital, Yemen

| Maternal behaviors factors | Groups | | COR | 95% CI | | *p*-value |
|---|---|---|---|---|---|---|
| | Cases (LBW) F (%) | Controls (NBW) F (%) | | *Lower* | *Upper* | |
| **Khat chewing during pregnancy** | | | | | | |
| Yes | 31 (83.8%) | 32 (43.8%) | 6.62 | 2.46 | 17.79 | < 0.001 |
| No | 6 (16.2%) | 41 (56.2%) | *Ref.* | — | — | — |
| **Frequency of khat chewing** | | | | | | |
| Habitual | 27 (73.0%) | 25 (34.2%) | 7.38 | 2.67 | 20.36 | < 0.001 |
| Occasional | 4 (10.8%) | 7 (9.6%) | 1.89 | .49 | 7.24 | 0.353 |
| Never | 6 (16.2%) | 41 (56.2%) | *Ref.* | — | — | — |
| **Length of khat chewing session/hours /day** | | | | | | |
| No | 6 (16.2%) | 41 (56.2%) | Ref. | — | — | — |
| ≤ 4 hours | 21 (56.8%) | 29 (39.7%) | 4.60 | 1.12 | 18.80 | 0.033 |
| > 4 hours | 10 (27.0%) | 3 (4.1%) | 22.77 | 4.84 | 107.18 | < 0.001 |
| **Tobacco used** | | | | | | |
| Yes | 21 (56.8%) | 5 (6.8%) | 17.85 | 5.84 | 54.54 | < 0.001 |
| No | 16 (43.2%) | 68 (93.2%) | *Ref.* | — | — | — |
| **Duration of tobacco used /year** | | | | | | |
| No smoking | 16 (43.2%) | 68 (93.2%) | *Ref.* | — | — | — |
| < 2 years | 1 (2.7%) | 1 (1.4%) | 5.00 | .25 | 97.69 | 0.289 |
| ≥ 2 years | 20 (54.1%) | 4 (5.5%) | 21.25 | 6.37 | 70.81 | < 0.001 |
| **Frequency of tobacco used/day** | | | | | | |
| No smoking | 16 (43.2%) | 68 (93.2%) | *Ref.* | — | — | — |
| < 3 times | 3 (8.1%) | 3 (4.1%) | 9.00 | 1.03 | 78.57 | 0.047 |
| ≥ 3 times | 18 (48.6%) | 2 (2.7%) | 38.25 | 8.04 | 181.85 | < 0.001 |

*Significant at p < 0.05; Ref = Reference category; COR = Crude odds ratio; CI = Confidence interval; LBW = Low birth weight; NBW = Normal birth weight.*

# A multivariable logistic regression analysis

A Table 6 multivariable logistic regression analysis was conducted to identify independent predictors of LBW after adjusting for potential confounders. The results showed that mothers with a monthly family income of less than 80,000 YER had significantly higher odds of delivering LBW infants compared to those with higher income (AOR = 24.2, 95% CI: 2.04–88.67, p = 0.003). Similarly, inadequate ANC attendance (< 8 visits) was a strong independent predictor of LBW, with affected mothers showing increased odds compared to those who had ≥ 8 visits (AOR = 16.6, 95% CI:2.32–119.34, p = 0.005).

Obstetric factors also demonstrated significant associations. Preterm birth was significantly associated with LBW (AOR = 9.62, 95% CI: 1.31–70.47, p = 0.026), and short birth spacing (< 2 years) increased the likelihood of LBW compared to longer intervals (AOR = 7.87, 95% CI: 1.91–32.48, p = 0.004). Regarding maternal behavioral factors, tobacco use during pregnancy was independently associated with higher odds of LBW (AOR = 11.2, 95% CI: 1.63–87.74, p = 0.002). Similarly, khat chewing during pregnancy was significantly associated with increased odds of LBW (AOR = 11.9, 95% CI: 1.57–64.70, p = 0.015).

In terms of dietary factors, occasional protein consumption was significantly associated with increased odds of LBW compared to habitual intake (AOR = 19.7, 95% CI: 1.11–350.96, p = 0.042). Likewise, occasional vegetable consumption was associated with higher odds of LBW (AOR = 48.1, 95% CI: 2.45–94.84, p = 0.011). Additionally, mode of delivery was significantly associated with LBW. Mothers who delivered by caesarean section had higher odds of having LBW infants compared to those who had vaginal deliveries (AOR = 41.7, 95% CI: 3.18–54.61, p = 0.004).

Table 6
Multivariable logistic regression analysis of factors associated with LBW at Al-Sabeen Hospital-Yemen

| Variables | AOR | 95% CI | p-value |
|---|---|---|---|
| **Family income (YER)** | | | |
| ≥ 80,000 | Ref | — | — |
| < 80,000 | 24.2 | 2.04–88.67 | 0.003 |
| **ANC visits** | | | |
| ≥ 8 visits | Ref | — | — |
| < 8 visits | 16.6 | 2.32–119.34 | 0.005 |
| **Gestational age at delivery (week)** | | | |
| Term | Ref | — | — |
| Preterm | 9.62 | 1.31–70.47 | 0.026 |
| **Birth spacing** | | | |
| ≥ 2 years | Ref | — | — |
| < 2 years | 7.87 | 1.91–32.48 | 0.004 |
| **Tobacco use during pregnancy** | | | |
| No | Ref | — | — |
| Yes | 11.2 | 1.63– 87.74 | 0.002 |
| **Khat chewing during pregnancy** | | | |
| No | Ref | — | — |
| Yes | 11.9 | 1.57–64.70 | 0.015 |
| **Protein consumption** | | | |
| Habitual | Ref | — | — |
| Occasional | 19.7 | 1.11-350.96 | .042 |
| **Vegetable consumption** | | | |
| Habitual | Ref | — | — |
| Occasional | 48.1 | 2.45–94.84 | 0.011 |
| **Mode of delivery** | | | |
| Vaginal | Ref | — | — |

| Variables | AOR | 95% CI | p-value |
|---|---|---|---|
| **Family income (YER)** | | | |
| Caesarean | 41.7 | 3.18–54.61 | 0.004 |

*AOR= Adjusted Odds Ratio; CI = Confidence Interval; Ref = Reference category. Statistical significance was set at p < 0.05.*

# Discussion

This case-control study conducted at Al-Sabeen Hospital, Sana'a, identified multiple independent determinants of LBW, spanning socio-demographic, obstetric, medical, nutritional, and behavioral domains. The findings demonstrate that LBW is primarily driven by a combination of obstetric, pregnancy complications socioeconomic disadvantage, inadequate maternal care, and modifiable behavioral and dietary risk factors. One of the strongest associations found in this study was the significant link between caesarean delivery and LBW (COR = 34.7; p < 0.001). This result is consistent with findings from [15], who reported that women with anemia and pregnancy complications were more likely to deliver via caesarean delivery, particularly in cases involving LBW neonates. Similarly, [16] highlighted that the mode of delivery influenced weight regain in preterm neonates, implying reflect underlying perinatal complications contributing to LBW. Therefore, while caesarean delivery itself may not be a direct cause of LBW, it could serve as a clinical marker of high-risk pregnancies. Low socioeconomic status emerged as a dominant predictor of LBW, particularly low family income, which showed one of the strongest effects in the adjusted model. This aligns with extensive evidence linking poverty to poor maternal nutrition, reduced healthcare access, and adverse perinatal outcomes [17, 18]. Similarly, low education, unemployment, and rural residence were associated with increased risk, reinforcing the established role of maternal socioeconomic position as a structural determinant of fetal growth [19, 17]. These findings underscore that LBW remains strongly socially patterned in low-resource settings. Multiple gestation and history of LBW twin pregnancies were significantly associated with LBW, a well-established risk supported by [15] and [20]. Moreover, mothers with a history of LBW were over six times more likely to deliver another LBW baby, consistent with the recurrence patterns noted by [21] and [22]. Short interpregnancy interval and preterm birth were also strongly associated with LBW, reflecting maternal depletion and reduced gestational growth time, respectively [21, 22]. Poor maternal dietary intake showed strong associations with LBW, particularly low consumption of protein, fruits, and vegetables and lack of supplementation. These findings are consistent with evidence demonstrating that inadequate dietary diversity and micronutrient deficiency adversely affect fetal growth [23, 24, 25, 26]. Similarly, [27] also reported a correlation between maternal nutrition (including food group diversity) and neonatal birth weight. The results emphasize the critical role of maternal nutrition in pregnancy outcomes, particularly in resource-limited settings. Inadequate ANC (< 8 visits) was a key independent predictor of LBW, consistent with global evidence that insufficient ANC limits early detection and management of pregnancy complications [24, 27]. These results highlight the importance of both

reproductive planning and continuity of ANC in reducing LBW risk. Maternal medical conditions, including anemia, hypertension, infection, and placental disorders, were significantly associated with LBW. These conditions are known to impair uteroplacental perfusion, oxygen delivery, and fetal nutrient transfer, leading to intrauterine growth restriction [28, 18]. The consistency of these findings with prior studies reinforces the biological plausibility of maternal health status as a central pathway to LBW. Maternal substance use, particularly khat chewing and tobacco consumption, demonstrated strong independent associations with LBW. These findings align with regional evidence reporting dose-dependent effects of khat on fetal growth and established global evidence linking tobacco exposure to fetal hypoxia and growth restriction [29, 30, 12, 13]. These behaviors represent highly modifiable risk factors and major targets for maternal health interventions in Yemen and similar settings.

# Strengths and limitations

This study employed a case-control design, which is a robust analytical approach for investigating multiple potential risk factors associated with a single outcome—in this case, LBW. The study adhered strictly to established research methodology guidelines, thereby enhancing the quality, reliability, and consistency of the reported findings. This study has certain limitations. A major concern is the reliance on self-reported data, which is susceptible to recall bias. This may could affect the accuracy of information regarding variables such as the number of ANC visits and the frequency and duration of khat or tobacco use during pregnancy.

## Conclusion

Overall, LBW in this population is determined by an interplay of structural socioeconomic disadvantage, inadequate ANC, maternal morbidity, poor nutrition, and harmful behavioral practices. The strongest modifiable drivers include ANC utilization, maternal diet, and substance use, suggesting priority intervention areas for maternal and newborn health programs.

## Abbreviations

LBW
low birth weight
NBW
normal birth weight
ANC
antenatal care
CI
confidence interval
AOR
adjusted odds ratio
COR

crude odds ratio
YER
Yemeni riyals
WHO
world health organization
UNICEF
united nations international children emergency funds
VIF
variance inflation factor

## Declarations

# Clinical trial number:

Not applicable.

# Ethics approval and consent to participate:

The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. The research protocol was approved by The Research Ethics Committee of the Faculty of Medical and Health sciences, AL-Razi University, Sana'a Yemen **[Approval No: RU/01/FMHS/2025].** All participants provided informed consent prior to inclusion in the study.

**Consent for publication:**

Not applicable. This study does not contain any individual person’s data in any form (including individual details, images, or videos).

**Competing interests:**

the authors declared no conflict of interest.

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# Author Contribution

L.A (First author) conceived and designed the study, collected data, and drafted the main manuscript text. N.A. supervised the research process, performed statistical analysis, provided critical guidance, and contributed to manuscript revision. A.A., G.I., and E.H. were responsible for data entry and data collection. All authors reviewed and approved the final manuscript

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# Data Availability

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

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