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Maternal and Environmental Factors Associated with Low Birth Weight: A Systematic Literature Review

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Abstract

This study aims to examine maternal and environmental factors associated with low birth weight through a systematic literature review. The review followed the PRISMA framework to ensure a structured, transparent process for identification, screening, eligibility, and inclusion. Literature searching was conducted using the Directory of Open Access Journals (DOAJ) for studies published between 2022 and 2026. A total of 320 records were identified; after duplicate removal, 308 were screened, and 10 studies were included in the final synthesis. The findings indicate that low birth weight is a multidimensional outcome shaped by the interaction of maternal and environmental determinants. The most consistent maternal factors include preeclampsia, anemia, poor nutritional status, inadequate micronutrient intake, adverse reproductive history, and unhealthy lifestyle behaviors. Environmental determinants such as air pollution, household smoke exposure, solid fuel use, and poor housing conditions were also strongly associated with low birth weight. This review highlights that isolated factors cannot explain low birth weight; rather, it arises from cumulative biological and environmental vulnerabilities. The study contributes to strengthening integrative understanding and supports the development of comprehensive maternal and environmental health interventions.

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Introduction

Low birth weight remains one of the most persistent concerns in maternal and child health because its consequences extend beyond the neonatal period and affect survival, growth, development, and later life health outcomes. In public health and health policy discussions, low birth weight is not only treated as an indicator of fetal vulnerability but also as a marker of broader social, nutritional, environmental, and health system conditions surrounding pregnancy. Recent scholarship

consistently shows that low birth weight is shaped by exposures operating before conception and throughout gestation, especially maternal health conditions, lifestyle patterns, and environmental risks (Arabzadeh et al., 2024; Ruan et al., 2025). This broad relevance makes the topic important not only for clinical medicine but also for epidemiology, nutrition, environmental health, family welfare, and preventive policy.

Conceptually, low birth weight generally refers to a birth weight of less than 2,500 grams, and it is widely used to identify newborns at elevated risk of morbidity and mortality. Within the contemporary literature, maternal factors associated with low birth weight commonly include nutritional status, body size, medical conditions, reproductive history, health behaviors, and psychosocial circumstances, whereas environmental factors include exposure to indoor pollution, biomass fuel, toxic substances, and poor household environmental conditions (Arabzadeh et al., 2024; Lutfia & Farizi, 2024; Nishihama et al., 2022; Ruan et al., 2025). These concepts are analytically related because fetal growth is influenced by both biological processes within the mother and external exposures that shape the quality of the prenatal environment. Accordingly, low birth weight should be understood as a multifactorial outcome emerging from the interaction of maternal, social, and environmental determinants.

A substantial body of research has identified maternal nutritional and anthropometric characteristics as major predictors of low birth weight. Studies have repeatedly shown that underweight status before pregnancy, low pre-pregnancy body weight, inadequate gestational weight gain, short maternal stature, and anemia or mineral deficiencies are associated with a higher likelihood of delivering a low birth weight infant (Diabelková et al., 2022; Hossain et al., 2025; Ivaturi et al., 2025; Jeena et al., 2020; Ruan et al., 2025). These findings suggest that fetal growth is closely linked to maternal nutritional reserves and physiological readiness for pregnancy. From an academic standpoint, this evidence reinforces the view that maternal nutrition is not a peripheral variable but a central explanatory factor in birth outcomes, especially in settings where undernutrition and micronutrient deficiency remain prevalent.

In addition to nutritional conditions, maternal morbidity during pregnancy has been consistently associated with low birth weight. Recent studies and evidence syntheses identify hypertension, preeclampsia, anemia, infections, kidney and blood disorders, tuberculosis, syphilis, and other comorbidities as important risk factors that elevate the probability of low birth weight delivery (Andemariam et al., 2023; Arabzadeh et al., 2024; Devaguru et al., 2023; Handayani et al., 2025; Ruan et al., 2025). The literature further indicates that maternal depression and periodontal disease are also relevant, showing that physical and mental health dimensions both contribute to adverse fetal outcomes (Arabzadeh et al., 2024). This pattern is important because it demonstrates that low birth weight cannot be explained solely through isolated nutritional indicators; rather, it reflects a broader maternal health profile that may involve overlapping clinical and psychosocial vulnerabilities.

The literature also documents the role of maternal behavior and daily living conditions in shaping birth weight outcomes. Smoking, alcohol use, tobacco chewing, and the use of other harmful substances have repeatedly been linked to higher rates of low birth weight across different populations (Arabzadeh et al., 2024; Handayani et al., 2025; Herwanto et al., 2024; Hossain et al., 2025; Ivaturi et al., 2025; Jeena et al., 2020). In addition, caffeine consumption and psychosocial stress have been associated with lower birth weight, while heavy physical work, strenuous activity, and lifting demanding loads during pregnancy are also reported as relevant risks (Arabzadeh et al., 2024; Dola & Valderrama, 2024; Ruan et al., 2025). Collectively, these studies indicate that maternal behavior should not be viewed narrowly as an issue of individual choice, because it is often embedded in occupational demands, social stress, and structural inequalities.

Demographic, social, and care-related factors further complicate the causal landscape of low birth weight. Evidence from recent studies shows that very young maternal age, older maternal age, and high parity are often associated with low birth weight, while low education, low socioeconomic

status, single marital status, and labor-intensive or agricultural work increase vulnerability as well (Andemariam et al., 2023; Devaguru et al., 2023; Diabelková et al., 2022; Hossain et al., 2025; Mizuno et al., 2023). Antenatal care also appears to be a decisive protective factor, as fewer antenatal visits and the absence of folic acid or iron-folate supplementation are consistently associated with a greater risk of low birth weight (Dola & Valderrama, 2024; Herwanto et al., 2024; Vats et al., 2023). This evidence emphasizes that low birth weight is partly shaped by unequal access to knowledge, resources, and preventive care during pregnancy.

Environmental exposure represents another major domain that requires close attention. Recent studies have reported that household conditions such as having the kitchen in the living area and exposure to home renovation pollutants are associated with low birth weight, likely through pathways related to indoor air pollution (Ruan et al., 2025). Other evidence points to the roles of lead and other environmental toxins, while biomass fuel use and broader air pollution exposure have also been implicated in low birth weight (Handayani et al., 2025; Hossain et al., 2025; Ivaturi et al., 2025; Nishihama et al., 2022). These findings are theoretically significant because they shift the discussion beyond maternal biology and toward the ecological conditions of pregnancy. In other words, the prenatal environment is not confined to the maternal body. However, it is shaped by the quality of air, housing, and toxic exposures surrounding the mother in everyday life.

Although the empirical literature is extensive, the evidence remains dispersed across different designs, populations, and analytical emphases. Some studies concentrate on maternal demographic and antenatal variables, others foreground lifestyle and nutritional exposures, and still others examine genetic or environmental influences through predictive or cohort-based models (Jeena et al., 2020; Mizuno et al., 2023; Ruan et al., 2025). This fragmentation creates an interpretive challenge because low birth weight is often studied within partial risk domains rather than within a more integrated framework that brings maternal and environmental determinants into a single synthesis. As a result, the literature offers rich findings. However, these findings are not always organized in a way that makes their relationships, overlaps, and relative significance easy for researchers or decision-makers to understand.

The need for a more integrated synthesis becomes even clearer when existing reviews are considered. Arabzadeh et al. (2024) provide an umbrella review focused primarily on maternal factors, Lutfia and Farizi (2024) review maternal risk factors, and Vats et al. (2023) discuss maternal risks associated with term low birth weight in India. While these works are valuable, they also indicate that the current review landscape still tends to focus on particular subsets of determinants, specific populations, or selected clinical contexts. Environmental exposures are often mentioned but are not always synthesized alongside maternal health, social disadvantage, and care-related variables within a single, clearly structured review framework. Consequently, there remains a meaningful research gap: Existing reviews primarily focus on maternal risk factors or specific clinical contexts, while limited evidence synthesis integrates maternal and environmental determinants within a single analytical framework. Consequently, there remains insufficient understanding regarding how these interacting domains collectively shape low birth weight risk across recent studies.

For these reasons, a Systematic Literature Review is needed to review, analyze, map, and synthesize prior findings on maternal and environmental factors associated with low birth weight. This article aims to identify the major determinants reported in recent academic studies, examine how those determinants are conceptually and empirically linked, and clarify the dominant patterns, inconsistencies, and practical implications emerging from the literature. The contribution of this article is twofold. Theoretically, it strengthens the knowledge base on the multidimensional determinants of low birth weight by bringing fragmented findings into a more coherent analytical structure. Practically, it provides an evidence-based reference for researchers, academics, educators,

maternal and child health practitioners, and policymakers who require a clearer synthesis of modifiable risks and contextual factors to support more effective prevention strategies.

Beyond its relevance for prevention during pregnancy, a clearer synthesis of maternal and environmental determinants is also important for informing postnatal responses, particularly home-based care for infants born with low birth weight. In this regard, understanding the conditions that contribute to low birth weight may help families and health practitioners strengthen thermal protection, breastfeeding support, household hygiene, smoke-free care, and early recognition of neonatal danger signs after discharge.

Low birth weight is commonly understood as a birth weight below 2,500 grams. It is widely treated in the literature as a critical indicator of neonatal vulnerability because it is associated with higher risks of illness, mortality, and adverse developmental outcomes. In recent scholarship, the determinants of low birth weight are generally organized into two closely related domains: maternal and environmental factors. Maternal factors include nutritional status, pre-pregnancy body size, gestational weight gain, anemia, maternal illness, substance use, psychosocial stress, and the adequacy of antenatal care, while environmental factors include household pollution, biomass fuel exposure, air pollution, and toxic substances such as lead (Arabzadeh et al., 2024; Jeena et al., 2020; Nishihama et al., 2022; Ruan et al., 2025). These concepts are theoretically linked by the idea that fetal growth is shaped not only by maternal biological readiness and health behaviors, but also by the quality of the physical and social environments in which pregnancy occurs. In this perspective, low birth weight is best viewed as a multifactorial outcome resulting from the interaction among maternal health, social disadvantage, access to care, and environmental exposure, rather than a single isolated cause.

Several recent studies provide the empirical foundation for this perspective. Arabzadeh et al. (2024), through an umbrella review, demonstrate that maternal conditions such as anemia, hypertension, mental health problems, periodontal disease, smoking, alcohol use, and inadequate nutrition consistently increase the risk of low birth weight, thereby contributing to a broad synthesis of maternal determinants across prior studies. Jeena et al. (2020), using data from the Mother and Child in the Environment birth cohort in South Africa, show that maternal demographic and antenatal factors such as age, parity, and limited antenatal care are strongly associated with low birth weight and preterm birth, highlighting the importance of care-related and reproductive variables. Ruan et al. (2025), in a prospective cohort study, further confirm that maternal health and lifestyle patterns, including poor nutritional status, low weight gain during pregnancy, and unhealthy daily exposures, significantly affect birth weight outcomes. In the environmental domain, Nishihama et al. (2022) identify the attributable contribution of environmental risk factors to low birth weight in the Japan Environment and Children's Study, while Mizuno et al. (2023) show that early prediction models of low birth weight are strengthened when both genetic and environmental variables are considered. Together, these studies make an important contribution by confirming that low birth weight is shaped by overlapping maternal and environmental pathways rather than by purely clinical or demographic explanations.

Even so, the literature still reveals an important theoretical and empirical gap. Much of the recent evidence remains fragmented because some studies focus primarily on maternal medical and behavioral risks, whereas others emphasize demographic, socioeconomic, or environmental exposures in relative isolation (Devaguru et al., 2023; Handayani et al., 2025; Herwanto et al., 2024). Existing reviews also tend to privilege maternal determinants over the combined interaction between maternal and environmental conditions. Hence, the field still lacks a sufficiently integrated synthesis that maps how these domains jointly explain low birth weight across recent studies. This gap is important because separated findings can obscure the cumulative and interconnected nature of risk. Therefore, the conceptual focus of this article is an integrative framework that positions low birth weight as the outcome of interconnected maternal health, maternal behavior, social and care-related

circumstances, and environmental exposures. This framework serves as the theoretical basis for the Systematic Literature Review and guides the analysis toward identifying dominant determinants, recurring patterns, and areas of inconsistency in the contemporary literature.

Therefore, this study aims to conduct a systematic literature review to identify, analyze, and synthesize maternal and environmental factors associated with low birth weight, with a particular focus on understanding their interaction and combined influence.

Materials and Methods

Research Design

This study employed a Systematic Literature Review (SLR) to examine maternal and environmental factors associated with low birth weight. The review was designed to identify, analyze, map, and synthesize findings from previous studies concerning the roles of maternal health conditions, nutritional status, reproductive history, health behaviors, psychosocial burden, and environmental exposures in shaping low birth weight outcomes. Following the PRISMA guided review process, the identification stage yielded 320 records from database searching. After 12 duplicate records were removed, 308 records remained for title and abstract screening. During this stage, 290 records were excluded because they fell outside the publication period, were not journal articles, lacked adequate full-text access, or did not directly address maternal and environmental determinants of low birth weight. This process resulted in 18 reports being assessed for full-text eligibility. After further evaluation using predefined inclusion and exclusion criteria, 8 reports were excluded because their analytical focus was broader than the review question, their emphasis was not sufficiently centered on maternal and environmental determinants of low birth weight, or their contribution was not sufficiently comparable for the final synthesis. As a result, 10 studies were retained and included in the final review. The article selection process is presented in the PRISMA flow diagram below.

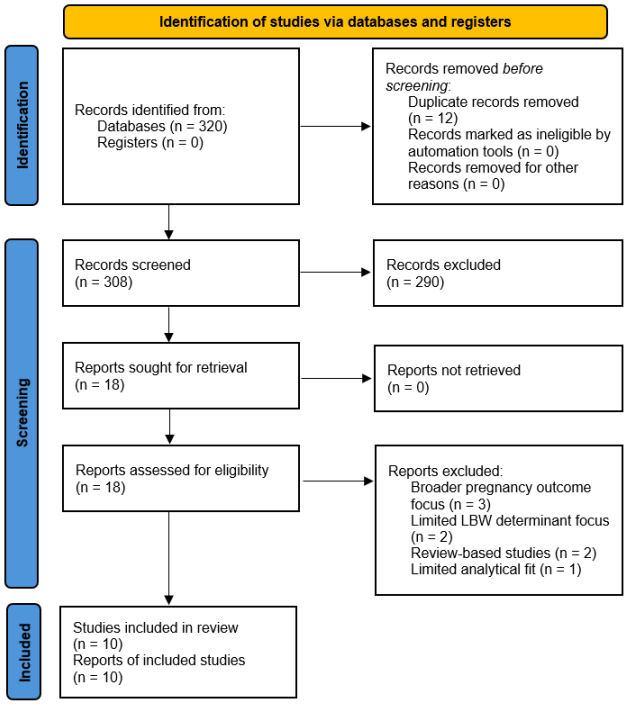

Figure 1. The PRISMA flow diagram detailing the screening and selection process of the literature

Inclusion and Exclusion Criteria

Predetermined inclusion and exclusion criteria were established to ensure consistency in article selection and to maintain alignment with the review objective. Articles were included if they were published in scholarly journals between 2022 and 2026, available in full text, directly relevant to low birth weight in relation to maternal factors and environmental factors, and published in credible scientific outlets. The review prioritized studies addressing maternal determinants, including maternal age, education, nutritional status, anemia, parity, pregnancy complications, antenatal care, smoking, and related variables, as well as environmental determinants such as air pollution, household pollution, solid fuel exposure, particulate matter, and other prenatal environmental exposures. Articles were excluded if they were duplicates, not available in full text, not journal articles, published outside the defined period, or insufficiently relevant to the conceptual focus of the review. The use of predefined eligibility criteria was intended to ensure that the included studies remained closely aligned with the objectives of the review and to minimize inconsistency during screening (Dagher & Khan, 2025; Gusenbauer & Gauster, 2025).

Data Sources and Article Search

The literature search was conducted through the Directory of Open Access Journals, with publications limited to 2022-2026. The search strategy was designed to capture studies that explicitly addressed the relationship between low birth weight and maternal or environmental determinants. The search used combinations of keywords such as ("low birth weight" OR LBW) AND ("maternal factors" OR "maternal risk factors" OR "maternal age" OR "maternal education" OR "maternal nutrition" OR anemia OR "pregnancy complications" OR "antenatal care" OR "prenatal care" OR "maternal smoking" OR parity OR "birth interval") AND ("environmental factors" OR "environmental risk factors" OR "air pollution" OR "ambient air pollution" OR "household air pollution" OR PM2.5 OR PM10 OR "environmental exposure" OR "prenatal environmental exposure" OR "solid fuel exposure" OR "heavy metal exposure"), along with related terms where necessary. Boolean operators were used to broaden or narrow retrieval in a controlled manner, and the search formulation was intended to maximize conceptual relevance while maintaining sufficient sensitivity for potentially eligible studies. This approach is consistent with current methodological guidance emphasizing systematic scoping, searching, screening, and reporting in evidence synthesis (Gusenbauer & Gauster, 2025; Kolaski et al., 2023).

Article Selection Process

All records identified in the initial search were first documented and then screened to remove duplicates. After this stage, titles and abstracts were reviewed to determine their preliminary relevance to the review topic. Articles considered potentially eligible were subsequently examined in full text to assess whether they met all inclusion criteria. During this stage, records were excluded when they did not sufficiently address maternal or environmental determinants of low birth weight, did not meet the publication or source criteria, or lacked adequate substantive relevance to the review focus. The narrowing of records from the initial search to the final body of included studies followed the PRISMA sequence of identification, screening, eligibility, and inclusion, and the study selection process was designed to be transparent and reproducible. In line with methodological guidance, the PRISMA flow diagram can be used to report the number of records retained and excluded at each stage of the review process (Dagher & Khan, 2025; Gusenbauer & Gauster, 2025).

Data Analysis and Quality Assessment

Articles that passed the selection stage were reviewed in depth, and their data were extracted using a structured matrix covering title, author, year of publication, research objective, research

method, substantive focus, and main findings. The extracted information was then analyzed using a descriptive qualitative approach, grouping studies into thematic patterns, comparing results across articles, identifying recurrent determinants, interpreting dominant tendencies, and developing a narrative synthesis of the evidence. In addition, each article was assessed for quality based on its topical relevance, clarity of research objectives, transparency of method, adequacy of analysis, and contribution to understanding maternal and environmental factors associated with low birth weight. Quality assessment was included because critical appraisal is an essential part of evidence synthesis and helps ensure that the final interpretation is built on studies that are methodologically and substantively acceptable. The final synthesis was presented narratively and may be complemented by a summary table to facilitate comparison across studies and to make the review process more transparent and easier to follow (Brackett & Batten, 2022; Dagher & Khan, 2025; Lindsay et al., 2025).

Results and Discussions

The study selection process was conducted systematically in accordance with PRISMA and was based on the compiled literature corpus for this review. At the identification stage, 320 records were retrieved from the database search. After 12 duplicate records were removed, 308 records remained for title and abstract screening. During screening, 290 records were excluded because they fell outside the publication period, were not journal articles, lacked adequate full-text access, or did not directly address maternal and environmental factors associated with low birth weight. This left 18 reports for full-text assessment. All 18 reports were successfully retrieved and examined for eligibility. At the eligibility stage, 8 reports were excluded because their analytical focus was broader than the review question, their emphasis was not sufficiently centered on maternal and environmental determinants of low birth weight, or their contribution was not sufficiently comparable for the final synthesis. Consequently, 10 studies met all inclusion criteria and were included in the final qualitative review. This sequence reflects the core PRISMA stages of identification, screening, eligibility, and inclusion.

Table 1 presents the analytical matrix of the 10 studies included in the review. The matrix was developed by extracting the title, study purpose, methodological design, analytical focus, indicators, and main findings from each article in the source corpus. This arrangement enabled systematic comparison of studies and identification of recurring patterns in how recent scholarship explains low birth weight through maternal and environmental pathways.

Table 1. Summary of Articles Included in the Review

No.	Author and year	Title	Objective	Method	Main focus or variables	Instrument or indicators	Main findings
1	Ruan et al. (2025)	*The impact of maternal health and lifestyle on low birth weight: a prospective cohort study*	To identify pregestational and periconceptional factors associated with low birth weight	Prospective cohort study of 34,104 pregnant women	Maternal demographics, disease history, obstetric factors, nutrition, behavior, and environmental exposure	Modified Poisson regression, relative risk, LBW incidence	Advanced age, lower education, multiparity, prior preterm birth, infection, preeclampsia, lack of folic acid, underweight status, low weight gain, alcohol use,

							high physical activity, and renovation pollutants increased LBW risk. Modifiable factors accounted for 40.92% of cases.
2	Lu et al. (2024)	*Interpregnancy interval, air pollution, and the risk of low birth weight: a retrospective study in China*	To examine whether the interpregnancy interval and air pollution jointly affect LBW	Retrospective cohort study of 10,512 singleton births	Interpregnancy interval, PM2.5, PM10, O3, NO2, SO2, CO	Logistic regression, air pollution score, interaction indices	Short interpregnancy interval and high PM2.5 exposure had a synergistic association with LBW, especially in the first trimester.
3	Rumrich et al. (2025)	*The association of low-level air pollution with birth weight in a register-based study: potential effects below WHO AQ guidelines*	To estimate the impact of low-level air pollutant exposure on birth weight	Register-based cohort study of 226,551 singleton births	PM2.5, PM10, PMcoarse, NO2, NOx, CO, SO2, O3	Multiple regression, change in birth weight in grams	PM2.5 had the strongest negative association with birth weight, and effects were observable even below the WHO guideline values.
4	Wang et al. (2025)	*The impact of air pollution exposure on adverse pregnancy outcomes: a time series study*	To estimate the lagged effects of air pollutants on LBW and PTB	Time series study of 44,727 live births	PM2.5, PM10, SO2, NO2, CO, O3	Distributed Lag Nonlinear Models, Generalized Additive Models, relative risk	PM10 at lags 0-11 weeks showed the strongest effect on LBW, while NO2 and O3 also contributed to adverse outcomes.
5	Sinsamala et	*Pregnancy outcomes as*	To assess the relationship	Prospective cohort	PM2.5, PM10, NO2,	Mixed effects	Air pollution decreased

	al. (2024)	*related to in utero exposure to air pollution and greenness: The Life-GAP Project*	between air pollution and greenness with birth outcomes	study of 4,286 singleton births	O3, black carbon, greenness	regression, IQR-based estimates	birth weight, with the strongest effect for PM2.5, while greenness increased birth weight, and O3 showed an opposite pattern.
6	Tamene et al. (2023)	*Using household survey data to explore the effects of the domiciliary environment on weight at birth*	To examine domiciliary environmental predictors of LBW	Multilevel mixed effects analysis of 12,125 participants	WASH, fuel type, housing conditions, sanitation, region	Multivariable multilevel logistic regression, adjusted odds ratio	Poor water treatment, solid fuel use, natural wall covering, shared latrine, and peripheral residence significantly increased LBW risk.
7	Budha et al. (2025)	*Contributing Factors for Low Birth Weight among Newborns in a Maternity Hospital, Kathmandu*	To identify contributors to LBW among hospital births	Case control study of 129 mothers	Birth interval, nausea and vomiting, folic acid, calcium, tobacco, passive smoke, rest	Structured questionnaire, antenatal chart review, inferential statistics	Short birth interval, severe nausea and vomiting, non-use of folic acid, non-use of calcium, tobacco use, smoke exposure, preterm birth, and inadequate daytime rest were associated with LBW.
8	Zuvarcan et al. (2024)	*Correlation between Preeclampsia and Infant Low Birth Weight at Dr Moewardi Hospital, Surakarta,*	To determine the relationship between preeclampsia and LBW	Retrospective case-control study of 120 live births	Preeclampsia, maternal age, gestational age, parity, anemia, asthma	Medical records, multiple logistic regression	Preeclampsia substantially increased LBW risk, and gestational age functioned

		Central Java, Indonesia					as an important confounder.
9	Yamamoto et al. (2023)	*Investigating associations between maternal stress, smoking, and adverse birth outcomes: evidence from the All Our Families cohort*	To examine the independent and joint effects of stress and smoking on LBW and PTB	Cohort study of 3,388 pregnant women	Active smoking, environmental tobacco smoke, perceived stress, and anxiety	Perceived Stress Scale, Spielberger inventory, regression analysis	Smoking and stress had independent adverse associations with LBW and PTB, while the interaction for LBW was only marginally significant.
10	Buciu et al. (2025)	*The Compounded Risk of Maternal Anemia and Preeclampsia: Neonatal Outcomes and Predictive Modeling in a Low-Resource Tertiary Center*	To examine neonatal outcomes in preeclamptic pregnancies complicated by anemia	Retrospective cohort study of 3,517 singleton births	Anemia severity, preeclampsia, birthweight, gestational age, NICU admission	Logistic regression, ROC analysis	Moderate to severe anemia in preeclamptic pregnancies was associated with lower birthweight, shorter gestation, and higher preterm birth risk.

The included literature demonstrates that recent research on low birth weight is dominated by observational epidemiological designs, particularly cohort, retrospective cohort, case-control, time-series, and multilevel regression studies. The selected studies span Asia, Europe, Africa, and North America, with Asian settings more strongly represented than those in other regions. In substantive terms, the studies cluster around two broad domains. The first concerns maternal determinants, including disease conditions, nutritional status, reproductive history, lifestyle, and psychosocial burden. The second concerns environmental determinants such as ambient air pollution, household smoke exposure, housing conditions, sanitation, and neighborhood environment. This distribution indicates that current scholarship increasingly treats low birth weight as a multifactorial outcome rather than a single-cause problem.

A clear pattern emerging from the maternal domain is the recurring importance of clinical and nutritional vulnerability. Ruan et al. (2025) showed that infection, preeclampsia, underweight status before conception, low pregnancy weight gain, and lack of folic acid supplementation significantly contributed to low birth weight. This finding is reinforced by Zuvarcan et al. (2024), who found that preeclampsia substantially increased the likelihood of low birth weight, and by Buciu et al. (2025), who demonstrated that the severity of maternal anemia worsened neonatal outcomes in pregnancies complicated by preeclampsia. Budha et al. (2025) also linked non-consumption of folic acid and

calcium with low birth weight. Taken together, these studies suggest that maternal physiological readiness and nutritional sufficiency remain central to fetal growth, and that low birth weight often emerges where maternal medical complications and nutritional inadequacy overlap rather than occur in isolation.

The literature also shows that maternal behavior and psychosocial exposure are important complementary pathways. Ruan et al. (2025) identified alcohol use and moderate to high physical activity as significant contributors, while Budha et al. (2025) found tobacco use, passive smoke exposure, and inadequate daytime rest to be associated with low birth weight. Similarly, Yamamoto et al. (2023) reported that active smoking, total smoke exposure, and maternal stress were independently associated with adverse birth outcomes, even though the interaction between smoking and stress in relation to low birth weight was only marginally significant. These studies do not merely add more risk factors to the list. Rather, they indicate that health behavior, psychological burden, and daily living conditions are closely intertwined with maternal biological risk, making low birth weight a product of cumulative vulnerability across physical, behavioral, and emotional dimensions.

Environmental exposure constitutes the second major pillar of the synthesis, and the evidence within this domain is notably consistent. Rumrich et al. (2025), Wang et al. (2025), Sinsamala et al. (2024), and Lu et al. (2024) all found that prenatal exposure to air pollutants was associated with reduced birthweight or increased low birthweight risk. PM2.5 and PM10 were the most frequently harmful pollutants, with Rumrich et al. (2025) showing that even exposure levels below current WHO guideline thresholds were associated with measurable reductions in birthweight. Sinsamala et al. (2024) also reported that PM2.5 had the strongest negative association with birth weight. In contrast, Wang et al. (2025) demonstrated that early gestational PM10 exposure exerted the clearest effect on low birth weight risk. These convergent findings strengthen the argument that environmental pollution should be treated as a direct determinant of fetal growth rather than merely a contextual background variable.

An important extension of the environmental literature is the recognition that risk is not confined to ambient pollution. Tamene et al. (2023) demonstrated that the domiciliary environment, including untreated water, solid fuel combustion, shared sanitation, and poor housing materials, independently predicted low birth weight. Budha et al. (2025) and Yamamoto et al. (2023) further highlighted smoke exposure and the maternal domestic context as meaningful contributors. These results are especially significant because they broaden the analytical scope from urban air quality to the immediate living environment of pregnant women. In this sense, the home emerges as a critical site of environmental risk, particularly in settings where fuel use, ventilation, sanitation, and housing quality remain uneven. The reviewed evidence, therefore, supports a more ecologically grounded understanding of low birth weight, one that includes both outdoor exposure and the everyday material conditions surrounding pregnancy.

The synthesis also reveals that recent scholarship is increasingly attentive to interaction effects and critical exposure windows. Lu et al. (2024) found that a short interpregnancy interval and high PM2.5 exposure had a synergistic effect, with the highest risk in the first trimester. Wang et al. (2025) similarly showed that lag-specific exposure mattered, especially during the early weeks of gestation. Sinsamala et al. (2024) introduced an additional dimension by showing that greenness was positively associated with birth weight, suggesting that environmental protection may involve not only reducing harmful exposure but also promoting beneficial surroundings. These findings move the literature beyond static factor listing and toward a more dynamic interpretation in which timing, cumulative exposure, and the interaction of reproductive and environmental conditions all shape birth outcomes.

From a comparative perspective, the reviewed studies largely reinforce one another, particularly regarding the harmful roles of preeclampsia, anemia, nutritional inadequacy, smoking exposure, particulate pollution, and poor household conditions in increasing low birth weight risk.

Nevertheless, some variation remains across environmental findings, especially regarding the magnitude and timing of exposure effects. These inconsistencies may reflect differences in geographical settings, pollutant composition, exposure assessment methods, gestational periods examined, and population characteristics. For example, Sinsamala et al. (2024) and Rumrich et al. (2025) reported an inverse relationship between ozone and particulate matter, whereas Wang et al. (2025) still found that ozone contributed to adverse outcomes. Likewise, interaction evidence was more robust for interpregnancy interval and air pollution than for smoking and stress. These differences do not undermine the overall synthesis. Instead, they suggest that low birth weight arises through multiple pathways that may vary by population, exposure level, analytical model, and gestational timing.

Theoretically, the results support an integrated framework in which low birth weight is understood as the outcome of interconnected maternal, behavioral, and environmental processes. The maternal domain explains how disease burden, poor nutrition, and reproductive risk reduce the fetus's developmental resilience. The environmental domain explains how polluted air, household smoke, poor sanitation, and substandard housing intensify that vulnerability. When these domains intersect, the probability of low birth weight becomes stronger and more difficult to interpret through single-factor models. The contribution of this review lies in showing that the current literature does not merely identify parallel risk factors. However, it increasingly points toward a combined explanatory structure in which maternal and environmental determinants operate simultaneously and often interactively.

The practical implications of the synthesis are equally important. The reviewed evidence suggests that reducing low birth weight requires a combined preventive strategy involving stronger antenatal screening, nutritional supplementation, adherence to folic acid and calcium, management of hypertensive and anemic pregnancies, reduction of smoking and passive smoke exposure, workload and rest management, rational birth spacing, and improvement of residential environmental quality. Public health responses, therefore, need to move beyond clinic-centered care and also address fuel use, housing conditions, water and sanitation infrastructure, and urban air quality.

These implications also extend to the postnatal period, because infants born with low birth weight often require sustained home-based care after leaving health facilities. In practical terms, the present synthesis suggests that family-centered education should emphasize maintaining thermal stability, supporting frequent and adequate breastfeeding, protecting infants from household smoke and poor sanitation, closely monitoring infant growth, and promptly recognizing danger signs requiring medical attention. From this perspective, home care should not be viewed as separate from prevention, but rather as a continuation of risk reduction within the domestic environment where maternal and environmental vulnerabilities may persist.

Nevertheless, the review also identifies several gaps. Most studies were observational, exposure assessment remained heterogeneous, and relatively few studies modeled maternal and environmental determinants within the same integrated framework. This means that future research should further strengthen longitudinal designs, refine exposure measurement, and examine how maternal and environmental risks accumulate across diverse contexts, especially in low and middle-income settings where such risks are likely to overlap more strongly.

Conclusion

This systematic literature review shows that low birth weight is best understood as a multifactorial outcome shaped by the combined influence of maternal and environmental determinants. Across the studies included in the final synthesis, the most consistent maternal factors were preeclampsia, anemia, inadequate nutritional status, insufficient micronutrient

supplementation, adverse reproductive history, smoking exposure, and other unfavorable health and lifestyle conditions. At the same time, the environmental literature consistently demonstrated that ambient air pollution, household smoke exposure, solid fuel use, poor housing conditions, and inadequate domestic sanitation were associated with reduced birth weight or increased low birth weight risk. The synthesis also indicates that these determinants do not operate independently in all cases, since several studies identified interaction effects and critical exposure windows, particularly during early pregnancy. Overall, the review strengthens the theoretical understanding that low birth weight emerges through interconnected biological, behavioral, and environmental pathways rather than through a single isolated cause.

From a practical perspective, this review underscores the importance of integrated prevention strategies that combine maternal health monitoring, nutritional support, management of hypertensive and anemic pregnancies, smoking reduction, and environmental risk control in both household and community settings. The findings may also serve as an evidence-based reference for strengthening home-based care of low birth weight infants, particularly through family education on thermal care, breastfeeding practices, household environmental safety, hygiene, and early detection of neonatal complications. The review also contributes to the literature by bringing together findings that are often discussed separately and by clarifying the dominant patterns linking maternal vulnerability to environmental burden. At the same time, the synthesis reveals that the current evidence base remains dominated by observational studies, heterogeneous exposure assessments, and still limited integration of maternal and environmental variables within unified analytical models. Future reviews should therefore expand database coverage, include a broader range of comparable studies, and deepen synthesis of specific contexts, exposure windows, and interaction mechanisms to refine the evidence base on maternal and environmental factors associated with low birth weight.

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