

Exploring the association between low birth weight prevalence and socioeconomic factors: A cross-country gender-related analysis

Düşük doğum ağırlığı prevalansı ile sosyoekonomik faktörler arasındaki ilişkinin incelenmesi: Ülkeler arası toplumsal cinsiyetle ilişkili istatistiksel bir analiz

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doi.org/10.35232/
estudamhds.1860537

Abstract

Low birth weight (LBW), defined as the weight at birth of less than 2500 grams measured within the first hour of birth, is an important indicator of public health since it is connected with countries' mortality rates, life expectancy, nutrition, and healthcare services. This paper examines the multifaceted socioeconomic factors associated with LBW with a particular focus on gender-related factors. The analyses were based on country-level data collected from publicly open-access sources. 138 countries were included in the correlation analyses on the gender inequality index (GII) and LBW, and 86 countries in the regression analysis due to data availability. Multiple linear regression analysis, including nine variables, reveals that the adolescent fertility rate (AFR) emerges as a critical factor; the rate is positively linked to LBW. Similarly, higher female unemployment (FU), vulnerable employment (FVE), and share of youth not in education, employment, or training (FNEET) are associated with higher LBW prevalence, potentially due to the association between LBW prevalence and gender disparity. Conversely, for the same reason, the proportion of seats held by women in national parliaments (PSWNP), and women business and the law index score (WBLI) are inversely related to LBW. The statistical analysis reveals the strong connections between LBW prevalence and multiple socioeconomic factors, highlighting the important role of gender-related indicators in relation to LBW. The prevalence of LBW is remarkably higher in countries where gender inequality scores are higher. With concerns about the health of babies worldwide, further attention should be given to gender inequality and related factors. Comprehensive policies, strategies, and coordinated efforts should be put into force to mitigate LBW rates effectively.

Keywords: Women's health, low birth weight babies, socioeconomic factors, gender disparity, regression analysis

Özet

Düşük doğum ağırlığı (LBW), doğumdan sonraki ilk bir saat içinde ölçülen ve doğumda 2500 gramın altında olan ağırlık olarak tanımlanmakta olup ülkelerin ölüm oranları, beklenen yaşam süresi, beslenme durumu ve sağlık hizmetleriyle ilişkili olması nedeniyle önemli bir halk sağlığı göstergesidir. Bu çalışma, LBW'nin çok boyutlu sosyoekonomik belirleyicilerini, özellikle toplumsal cinsiyete ilişkin faktörlere odaklanarak incelemektedir. Analizler kamuya açık erişimli kaynaklardan toplanan ülke düzeyindeki verilere dayandırılmıştır. Veri mevcudiyeti nedeniyle cinsiyet eşitsizliği endeksi (GII) ile LBW arasındaki korelasyon analizine 138 ülke, regresyon analizine ise 86 ülke dahil edilmiştir. Dokuz değişkeni içeren çoklu doğrusal regresyon analizi, ergen doğurganlık oranının (AFR) kritik bir faktör olarak öne çıktığını ve bu oranın LBW ile pozitif ilişkili olduğunu göstermektedir. Benzer şekilde, daha yüksek kadın işsizliği (FU), güvencesiz istihdam (FVE) ve eğitimde veya istihdamda yer almayan gençlerin oranı (FNEET), potansiyel olarak LBW prevalansı ile toplumsal cinsiyet eşitsizliği arasındaki ilişkiden dolayı daha yüksek LBW prevalansı ile ilişkilidir. Buna karşılık, ulusal parlamentolarda kadınların sahip olduğu sandalye oranı (PSWNP) ile kadınlar, iş dünyası ve hukuk endeksi (WBLI) puanı, aynı gerekçeyle LBW ile ters yönlü bir ilişki sergilemektedir. İstatistiksel analiz, LBW prevalansı ile çok sayıda sosyoekonomik faktör arasındaki güçlü bağlantıları ortaya koymakta ve cinsiyetle ilişkili göstergelerin LBW ile bağlantılı önemli rolünü vurgulamaktadır. Toplumsal cinsiyet eşitsizliğinin daha yüksek olduğu ülkelerde LBW yaygınlığı belirgin biçimde daha yüksektir. Dünya genelinde bebek sağlığına ilişkin endişeler göz önüne alındığında, toplumsal cinsiyet eşitsizliği ve buna bağlı faktörlere daha fazla önem verilmesi gerekmektedir. LBW oranlarını etkili biçimde azaltmak için kapsamlı politikaların, stratejilerin ve eşgüdümlü çabaların hayata geçirilmesi önem arz etmektedir.

Anahtar Kelimeler: Kadın sağlığı, düşük doğum ağırlıklı bebekler, sosyoekonomik faktörler, cinsiyet eşitsizliği, regresyon analizi

ESTUDAM Public Health
Journal.
2026;11(3):194-207.

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Geliş Tarihi / Received:
10.01.2026

Kabul Tarihi / Accepted:
23.06.2026



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Introduction

Globally, more than 19.8 million infants per year (14.7% of all infants) are born with a weight of less than 2500 grams (5.5 pounds) (1). This threshold value is determined because of the short- and long-term risks of several adverse health conditions of LBW infants compared to normal birth weight babies. LBW infants face significantly higher risks of neonatal mortality rate, delayed motor and cognitive development, and non-communicable diseases in adulthood, such as diabetes, cardiovascular disease, and hypertension. That makes it a significant global health problem and an indicator of health status.

According to UNICEF, the main causes of LBW are poor nutrition during pregnancy and maternal health and malnutrition (2). Although intrauterine growth restriction (fetal growth restriction) and preterm birth (low gestational age) are the major factors, it can be due to many other issues, such as maternal high blood pressure, acute infections, hard physical work, multiple births, stress, anxiety, other psychological factors, genetic composition of the mother, and maternal nutrition status (3,4).

Besides, many multifaceted indirect causes are associated with these factors. For instance, LBW is more prevalent in low- and middle-income, high-population countries, and higher gender disparities in healthcare and socioeconomic conditions.

In the existing literature, a wide range of socioeconomic factors has been studied extensively. Many combinations of the factors have been investigated from different perspectives. While some studies have addressed the issue from a country-level view, others have investigated it within the context of a specific country or region. Country-level studies are particularly important because they allow for the assessment of

structural factors and enable international comparisons.

In this context, several cross-country studies have modeled LBW prevalence as an outcome variable using regression frameworks. For example, Erasun et al. analyzed LBW rates across OECD countries and examined their association with economic, demographic, and health-system factors such as health care coverage, public health system coverage, hospitals per million inhabitants, and ratios of health care workers, physicians, midwives, and nurses (5). Similarly, Hadaro et al. investigated regional and sub-regional determinants of LBW across 44 low- and middle-income countries using multilevel mixed-effects regression models. They found that factors such as health insurance, household wealth, maternal age, access to healthcare facilities, maternal education, neonate's sex, prenatal care, and antenatal iron supplementation were statistically associated with LBW (6). In addition, macro-level indicators such as the GII (7) and gross domestic product (GDP) growth (8, 9) have also been linked to LBW outcomes in previous studies.

Within this broader framework, the occupational status of women, particularly during pregnancy, is correlated not only with their financial status and ability to access nutrition and necessary maternal services but also with their mental and physical health. For example, unemployment during pregnancy (7) and women in vulnerable employment, reducing financial status or causing financial instability, can contribute to adverse pregnancy outcomes. Global evidence from the International Labor Organization 2019 report highlights persistent gender disparities in labor market indicators. Female unemployment, labor force participation, and own-account workers rates are significantly lower than those

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Pekin Alakoç N. Exploring the association between low birth weight prevalence and socioeconomic factors: A cross-country gender-related analysis. *ESTUDAM Public Health Journal*. 2026;11(3):194-207

of men (10). Similarly, the share of youth not in education, employment, or training (NEET) rates in 2018 was observed as 30%, and 13% for young women and men, respectively (10). This big gender gap causes their needs to be typically addressed in isolation, which affects the quality of their life, well-being, health, and nutrition.

In addition, adolescent pregnancy represents another important gender-related factor, as adolescents are more likely to experience health complications since they may not be fully physically prepared for pregnancy, which increases the probability of having a premature baby (11).

Despite the growing literature on LBW, a considerable proportion of the existing studies are geographically limited, mostly focusing on a specific country or region, such as West Ethiopia (3), Mexico (12), Iran (13,14), Los Angeles (15), Indonesia (16), Brazil (17), and Bangladesh (18). Moreover, the literature is typically based on survey or case-based data, which are valuable for contextual understanding, but their findings are often restricted to producing generalizable conclusions at the global level due to differences in socioeconomic and health system structures.

Furthermore, several reviews have combined evidence on LBW factors in a specific country or region. For example, González-Jiménez and Rocha-Buelvas reviewed the studies and classified the risk factors in the Americas into sociodemographic, environmental risks, behavioral factors, prenatal or coverage controls, and others (19). Similarly, studies in Mexico (12), India (20), Bangladesh (18), Brazil (17), Madrid (21), and Iran (13) have identified a wide range of factors. Torres-Arreola et al. examined the associations with socioeconomic factors in Mexico (12). They mentioned that production, nutrition, smoking, morbidity during pregnancy, accessibility to health services, and prenatal care are related to LBW. In India, maternal characteristics such as educational attainment, body mass index (BMI), and short stature have been linked to adverse birth outcomes (20). Home environment and hygiene factors, unimproved toilet facilities in Bangladesh (18), as well as smoking, alcohol, high systolic blood pressure, and GDP growth in Brazil (17), adolescent pregnancy in Madrid (21), and unemployment during pregnancy

in Iran (13) have been investigated for their potential effects.

Against this background, this study provides statistical evidence about the relationship between socioeconomic factors and LBW rates at the country level, with a particular focus on gender disparity and associated factors. The cross-sectional ecological study includes several variables that were identified in the literature as potentially linked to both LBW rates and GII.

The gender related factors are presented by AFR, female unemployment rate (FU), female vulnerable employment rate (FVE), female share of youth not in education, employment, or training (FNEET), PSWNP, and WBLI. In addition to gender related metrics, population density (PD) and annual GDP growth (GDPG) are also included to provide a more comprehensive conclusion.

Although many studies connect socioeconomic factors with mothers' and infants' health outcomes, relatively few studies have used globally comparable datasets incorporating multiple gender-related indicators.

To the best of the author's knowledge, this is one of the few studies that analyzes LBW prevalence using global country-level data while integrating a comprehensive set of gender inequality-related variables. Therefore, this study not only highlights the importance of LBW but also contributes to the literature by providing a broader country-level perspective and generating evidence that may inform global health and gender-sensitive policy interventions.

Material and Method

Study Design

This study was designed as a cross-sectional ecological analysis using country-level data from the year 2022. The unit of analysis is the country. To maximize data availability and effectively conduct the analyses, two distinct data sets, which consist of 138 and 86 countries from the year 2022, were analysed.

Data Source

The indicators were collected from open-access data sources, the World Bank Group, and the United Nations Development Reports. The variables and the year (2022) were selected to ensure maximum

data availability across countries. Countries with missing data for any of the variables included in the analysis were excluded. Therefore, the first data set consists of GII, Human Development Index (HDI), and LBW ratio data for 138 countries. The second data set, used for regression analysis, includes 9 variables (including LBW ratio) for 86 countries. The lists of countries included in each data set are provided in the Appendix (Data sets 1 and 2). Thus, no missing values remain in the complete data sets, and ethical approval was not required.

Variables

The detailed definitions of the variables obtained from the data source are provided below:

LBW (% of births): Low-birthweight babies are newborns weighing less than 2,500 grams (5.5 pounds), with the measurement taken within the first hour of life, before significant postnatal weight loss has occurred.

GII (scale 0-1): GII is a composite metric of gender inequality using three dimensions: reproductive health, empowerment, and the labour market. The indicators used in the index are maternal mortality ratio, adolescent birth rate, female and male population with at least secondary education, female and male shares of parliamentary seats, and female and male labor force participation rates. The index shows the loss in potential human development due to inequality between female and male achievements in these dimensions. It ranges from 0, where women and men fare equally, to 1, where one gender fares as poorly as possible in all measured dimensions.

HDI (scale 0-1): HDI is a summary measure of average achievement in key dimensions of human development: a long and healthy life, measured by life expectancy at birth; being knowledgeable, measured by mean years of schooling and expected years of schooling; and having a decent standard of living, measured by GNI per capita in PPP terms in US\$. The HDI is the geometric mean of normalized indices for each of the three dimensions. The United Nations classifies the countries into four categories by HDI: Low human development (LHD) ($HDI < 0.550$), medium human development (MHD) ($0.550 < HDI < 0.699$), high human development (HHD) ($0.700 < HDI < 0.799$), and very high human development (VHHD) ($HDI > 0.800$) (22).

AFR (births per 1,000 women ages 15-19): The rate is the number of births per 1,000 women ages between 15 and 19. It is based on data on registered live births from vital registration systems or, in the absence of such systems, from censuses or sample surveys.

FU (% of female labor force): Unemployment refers to the share of the labor force that is without work but available for and seeking employment. FU is the proportion of unemployed females to the total unemployed labor force. It is calculated by expressing the number of unemployed females as a percentage of the total number of females in the labor force. The labor force (formerly known as the economically active population) is the sum of the number of persons employed and the number of persons unemployed.

FVE (% of female employment): Vulnerable employment is contributing family workers and own-account workers as a percentage of total employment.

FNEET (% of female youth population): It is the proportion of female young people who are not in education, employment, or training to the population of the corresponding age group. Youth not in education are those who were neither enrolled in school nor in a formal training program. For the purposes of this indicator, youth is defined as all persons between the ages of 15 and 24 (inclusive). The female NEET rate is calculated as follows: $FNEET = (\text{female youth} - \text{female youth in employment} - \text{female youth not in employment but in education or training}) / \text{female youth} \times 100$.

PSWNP (%): It is the number of seats held by women members in single or lower chambers of national parliaments, expressed as a percentage of all occupied seats. It is derived by dividing the total number of seats occupied by women by the total number of seats in parliament.

WBLI (scale 1-100): The index measures how laws and regulations affect women's economic opportunities. Overall scores are calculated by taking the average score of each index (mobility, workplace, pay, marriage, parenthood, entrepreneurship, assets, and pension), with 100 representing the highest possible score.

PD (people per sq. km of land area): It is calculated by dividing the midyear population by land area in

square kilometers, people per sq. km of land area. GDPG (annual %): GDP is the total income earned through the production of goods and services in an economic territory during an accounting period. This indicator denotes the percentage change over each previous year of the constant price (base year 2015) series in United States dollars.

These independent variables were selected by considering the literature as well as the data sets' availability, accuracy, and structure. As an interdisciplinary field, gender related studies constitute a very wide area in literature. It has deep interactions with many disciplines such as sociology, law, public health, education, etc. So that researchers have employed many different variables to indicate, measure, or analyse gender related disparities. In this study, to capture the different dimensions of gender inequality, the existing indicators of the literature were considered in the selection of potential factors of LBW.

Statistical Analysis

As the first step of the statistical analysis, scatterplots and the correlation coefficient were used to show the association between the variables. Then, relative frequency histograms were plotted for all variables to examine their distributions, and numerical summary statistics were calculated to identify data structures, central tendencies, variabilities, and potential outliers necessary for further robust analysis.

The analyses are structured into two complementary components. First, the association between the GII and LBW was investigated to provide a perspective on gender disparities. Second, multiple regression analyses were used to examine the joint associations between LBW and selected gender-related and socioeconomic indicators.

The first component was included to address the study's objective of examining gender-related disparities by using a composite index that reflects an overall association and supports the regression-based joint association findings. To examine the connection between GII and LBW, correlations were calculated.

The second component examined the factors associated with LBW using multiple linear regression analyses, where LBW was modeled as

a function of country-level independent variables. The data set includes 86 selected countries and 8 independent variables

Although LBW was expressed as a percentage, the use of multiple linear regression with LBW as the dependent variable was considered appropriate. As shown in Table 2, the observed LBW values were distributed within a moderate range and were not concentrated near the theoretical boundaries of 0% and 100%. Moreover, expressing LBW as a percentage enables meaningful comparisons across countries with substantially different population sizes and numbers of births. Similar approaches have also been adopted in the existing literature, where LBW percentages have been analyzed as the dependent variable using linear regression models (5, 6). Diagnostic analyses also indicated that the assumptions of linear regression, including linearity, homoscedasticity, and approximately normally distributed residuals, were reasonably satisfied.

The model-building process followed a structured multi-stage approach. First, a broader set of candidate variables identified from the literature was considered covering health, education, living conditions, and economic structure factors, such as immunization coverage (%), female school enrollment rates (%), under-5 mortality rate (per 1,000 live births), fertility rate (births per woman), number of maternal deaths, rural population (% of total population), access to basic sanitation (% of population), food production index, imports and exports of goods and services (% of GDP), prevalence of undernourishment (%), and current health expenditure (% of GDP). Variable selection was guided by theoretical relevance to LBW and gender-related factors. Second, a correlation analysis was conducted to examine associations with LBW. Variables exhibiting substantial limited theoretical relevance and multicollinearity were excluded. Subsequently, multiple regression models with different combinations of candidate independent variables were systematically estimated and compared. The final model was selected based on a combination of criteria, including theoretical interpretability, model fit (R^2 and adjusted R^2), mean squared error (MSE),

and the satisfaction of regression assumptions. Moreover, the contribution of each variable was assessed by individual t-tests. The final model, which includes AFR, FU, FVE, FNEET, PSWNP, WBLI, PD, and GDPG, is presented.

Following the regression analysis, the model assumptions were evaluated to ensure the validity and accuracy of the conclusions. The normality assumption was checked by using the Kolmogorov-Smirnov test, given that the sample size exceeds 50. The assumption of homoscedasticity was assessed by using the Breusch-Pagan test. The Durbin-Watson test was performed to detect the presence of autocorrelation. To measure the amount of multicollinearity, variance inflation factors (VIFs) were calculated for each independent variable. In addition to the tests, the assumptions

were validated visually by scatter plots, histogram of the residuals, and residual plots.

Results

Initially, to present the correlation between GII and LBW, a scatterplot of GII versus LBW was created by using the data collected from 138 countries. The scatterplot given in Figure 1 demonstrates a clear positive association between the two variables, indicating that as gender inequality increases, the incidence of observing LBW babies increases significantly. The correlation coefficients were also calculated to assess the strength of the relationship. Pearson and Spearman correlation coefficients (0.6805 and 0.7118, respectively) support the scatterplot.

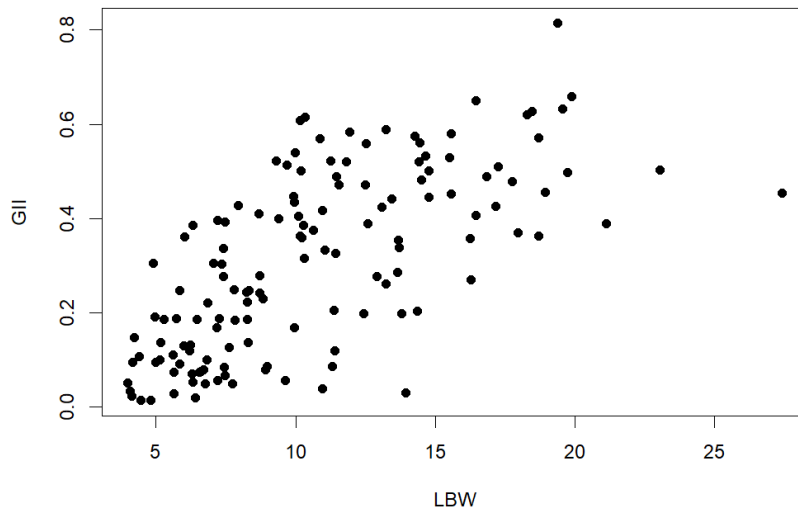


Figure 1: Scatterplot of LBW (%) versus GII

The scatterplot also highlights several countries with notable values of GII and LBW. Papua New Guinea exhibits the highest GII value (0.815) among the countries included in the analysis and is also characterized by a relatively high LBW prevalence (19.38%). India has the highest LBW prevalence (27.44%), followed by Bangladesh (23.05%) and the Philippines (21.14%). In contrast, the United Arab Emirates presents an interesting pattern, with one of the lowest GII values (0.030) but a relatively high LBW prevalence (13.94%) compared with countries exhibiting similar levels of gender inequality. At the other end of the distribution, countries characterized by low GII also exhibited low LBW prevalence such as Norway (GII: 0.014,

LBW: 4.443%), Iceland (GII: 0.051, LBW: 3.993%), Denmark (GII: 0.013, LBW: 4.808%), Finland (GII: 0.032, LBW: 4.069%), and Sweden (GII: 0.023, LBW: 4.122%).

Türkiye is positioned close to the center of the distribution, with a GII value of 0.277, an LBW prevalence of 12.90%, and a high HDI value of 0.835. These examples illustrate that, although the overall association between GII and LBW is positive, country-specific socioeconomic and health-system characteristics may contribute to deviations from the general trend.

Using the same data set, the percentage of countries falling into each specific HDI category was calculated along with their average LBW and

GII values, as summarized in Table 1. The data indicate that, on average, 10.6538% of infants are born with LBW worldwide. As the HDI increases, the average of LBW rates decreases significantly. VHHD countries have the smallest average LBW, which is 8.0394%, and the value approximately doubles for LHD countries. A similar relationship

can be observed for GII: More developed countries have less GII.

In the rest of this study, 86 countries' data were used and statistical methods were applied to these data. Table 2 gives the key descriptive statistics of the variables.

Table 1: Averages of LBW (%), and GII for four classes of countries

Class	Percentage of Countries (%)	Average LBW (%)	Average GII
LHD	0.12	15.19	0.57
MHD	0.19	13.22	0.48
HHD	0.26	10.94	0.34
VHHD	0.43	8.04	0.14
Total		10.65	0.31

Table 2: Descriptive statistics and Pearson correlation coefficients with LBW

Data sets	Min	Max	Median	Mean	Std. Dev.	Kurtosis	Skewness	Pearson Corr.
LBW	3.99	23.05	8.72	10.14	4.58	-0.43	0.73	
AFR	1.81	165.14	26.92	38.10	35.98	1.38	1.28	0.64
FU	0.69	30.51	5.06	7.16	5.81	4.33	1.97	0.30
FVE	2.65	91.22	27.96	35.61	28.50	-1.07	0.56	0.63
FNEET	2.78	51.86	18.15	20.76	12.58	-0.50	0.63	0.70
PSWNP	5.33	61.25	28.47	29.63	11.77	-0.67	0.08	-0.34
WBLI	46.88	100.00	87.19	84.91	12.267	0.95	-0.96	-0.62
PD	2.20	1660.97	89.85	148.53	235.76	25.75	4.69	0.13
GDPG	-20.54	20.02	4.05	3.96	4.50	11.45	-1.54	-0.14

Table 2 and the relative frequency histograms can be summarized as follows: PD and GDPG have extreme points, but these points are not too far from the remaining data. Since kurtosis values are greater than 1, the distributions of AFR, FU, PD, and GDPG can be defined as leptokurtic. On the other hand, FVE has platykurtic and the distributions of LBW, PSWNP, FNEET, and WBLI have approximately similar tailedness to that of a normal distribution. As can be observed from the skewness, mean, and median, AFR, FU, and PD have highly positively skewed distributions. LBW, FNEET, and FVE are also positively distributed but moderately. The distribution of PSWNP is almost symmetric. Besides, GDPG has a highly negatively

skewed distribution and WBLI has a moderately negative distribution.

Additionally, the relationships between the LBW and the eight independent variables were examined by scatterplots and Pearson correlation coefficients. Linear relationships were observed for all the pairs. The correlation coefficients of the eight variables versus LBW are listed in Table 2, last column. The coefficients of AFR, FU, PD, FNEET, and FVE indicate positive relationships, while PSWNP, GDPG, and WBLI are negatively correlated with LBW. The strength of the correlation between PD and GDPG can be interpreted as weak, while FU and PSWNP are moderate, and the others are strong.

The following equation gives the fitted multiple linear regression model for LBW. (1)

$$\text{LBW} = 11.9703 + 0.0386 * \text{AFR} + 0.1798 * \text{FU} + 0.0327 * \text{FVE} + 0.0766 * \text{FNEET} - 0.0677 * \text{PSWNP} - 0.0587 * \text{WBLI} - 0.2202 * \text{GDPG} + 0.0035 * \text{PD} \quad (1)$$

This regression model is statistically significant with an F-value of 29.00 and a corresponding p-value of $2.2\text{e-}16$. The R^2 of the model was found

to be 0.7508, indicating that the independent variables explain 75.08% of the variability of LBW. Similarly, the regression model produced a high R^2_{adj} value of 0.7249, suggesting a strong model fit. The MSE, which is 2.4, indicates a relatively low average squared difference between observed and predicted values. Moreover, individual significance tests of regression coefficients were performed and the test results are summarized in Table 3.

Table 3: Individual t-test results and 95% confidence intervals for multiple linear regression coefficients

Parameters	Estimate	Std. Error	t value	95% CI	p-value
Intercept	11.97	2.68	4.46	6.6300, 17.3100	2.72e-05 ***
AFR	0.04	0.01	3.14	0.0201, 0.0599	0.0024 **
FU	0.18	0.06	3.25	0.0605, 0.2995	0.0017 **
FVE	0.03	0.02	1.93	-0.0098, 0.0698	0.0574 .
FNEET	0.08	0.03	2.29	0.0202, 0.1398	0.0246 *
PSWNP	-0.07	0.03	-2.64	-0.1298, -0.0102	0.0100 *
WBLI	-0.06	0.03	-2.00	-0.1198, -0.0002	0.0489 *
PD	0.004	0.001	3.04	0.0020, 0.0060	0.0032 **
GDPG	-0.22	0.06	-3.72	-0.3395, -0.1005	0.0004 ***

Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.

The test statistics and p-values reveal that seven of the eight independent variables are statistically significant at the 0.05 significance level, while the remaining variable (FVE) is marginally significant at the 0.1 level with a p-value of 0.057, which is close to the 0.05 threshold. The 95% confidence intervals are consistent with the p-values. Only one variable, FVE, has a confidence interval that includes zero, which is consistent with its marginal statistical significance.

The estimates of the regression coefficients of the AFR, FU, FVE, FNEET, and PD are positive, indicating that these variables are associated with higher LBW rates, whereas PSWNP, WBLI, and GDPG exhibit negative estimates, indicating an inverse association with LBW. For all the coefficients, the signs of the confidence interval bounds are in agreement with the signs of the corresponding estimates.

The diagnostic results suggest that the regression assumptions are reasonably satisfied. The

Kolmogorov-Smirnov test yielded a test statistic of 0.10 and a p-value of 0.36, which is greater than the significance level, 0.05, meaning that the residuals follow a normal distribution. The Breusch-Pagan test resulted in a p-value of 0.25, confirming the assumption of homoscedasticity and indicating that the residuals have constant variance. For the autocorrelation assessment, the Durbin-Watson test statistic and the corresponding p-value were 1.84 and 0.18, respectively, proving the absence of significant autocorrelation, indicating that autocorrelation does not exist. Regarding measuring the amount of multicollinearity, all calculated VIFs were below the threshold of 5, with a maximum value of 3.45 for the FVE variable, suggesting moderate multicollinearity, which is not severe and acceptable. These statistical findings were further supported by visual inspections of the scatter plots, histogram, and residual plots, all of which validated the model's accuracy.

Discussion

Understanding the causes and the factors associated with LBW is crucial for both clinical and public health contexts. The LBW is not only an indicator of infants' health but also a critical reflection of socioeconomic conditions. It has significant short- and long-term consequences for infant health, population well-being, and socioeconomic development.

The primary focus of the study is to determine the connection between LBW and gender-related disparities. Investigating the issue from a country-level perspective is also important because it is a public health issue both between and within countries. Although the prevalence, causes, and consequences of LBW vary across regions and countries, it is a shared global health problem. Thus, a global perspective allows researchers and policymakers to compare the country-based patterns as well as collaborate on solutions.

The results reveal positive correlations between GII and LBW, indicating that countries with higher levels of gender inequality tend to experience higher LBW prevalence. This significant correlation should be interpreted as reflecting a general association at the aggregate level and may not fully capture country-specific conditions.

In general, more developed countries exhibit lower levels of GII, which aligns with improved maternal and child health outcomes. However, some countries deviate from the overall pattern. For example, the United Arab Emirates exhibits a relatively low GII despite a comparatively higher LBW prevalence, whereas Papua New Guinea shows high GII and relatively low LBW. Countries such as India, Bangladesh, and the Philippines show high LBW rates in line with higher levels of gender inequality. Conversely, countries with very low levels of GII tend to report lower prevalence rates of LBW, representing the opposite end of the observed distribution.

These deviations suggest that structural and contextual factors beyond gender inequality may also influence LBW outcomes at the country level. In particular, differences in health system performance, maternal health behaviors, access to prenatal care, and socioeconomic development may contribute to variations in LBW prevalence

across countries with similar GII levels.

Through the regression analyses, the study links the gender related factors (AFR, FU, FVE, FNEET, PSWNP, and WBLI) along with two socioeconomic factors (PD and GDPG) with LBW. Some variables included in the regression model may conceptually overlap with GII dimensions.

The regression coefficient of AFR shows the positive connection between AFR and LBW. That is, as the AFR increases, LBW tends to increase. The same connection can be observed from the correlation coefficient, which is 0.64. As it is mentioned by Makinson (23) and De Cao et al. (24), teenage mothers are at a higher risk of giving birth to babies with LBW. It is clear that this can be due to biological, social, and economic factors, which can result in complications such as preterm birth and intrauterine growth restriction. Moreover, compared to adult mothers, adolescent mothers may have less access to healthcare, education, and limited economic resources. Understanding the associations with AFR can help policymakers and healthcare providers identify vulnerable populations and implement interventions to prevent LBW.

The regression and correlation coefficients of FU and FVE are also positive, indicating the positive contribution of FU and FVE to LBW. This can be explained as: FU is associated with financial inadequacy, which in turn is correlated with access to sufficient prenatal care and nutrition. This result is in line with the findings of Lindo, who used a longitudinal household survey in the United States (25). They also showed the negative influence of husbands' job losses on infant health and birth weight, which is reduced by approximately 4.5%. However, the findings of the existing literature demonstrate diversity. For example, De Cao et al. identified two cases in the United Kingdom: unemployment has the strongest negative association with infants conceived in low-to-middle-socioeconomic areas, whereas the link is reversed for those conceived in the higher areas (24). Aparicio et al. showed that when the unemployment rate is high in Spain, the newborns have considerably enhanced health outcomes, including reductions in LBW (26). The mixed findings in the literature can be explained by differences across countries.

The effect may vary depending on economic conditions, labor market structure, the strength of social protection systems, and the compositional differences among individuals. In countries with stronger unemployment protection or more flexible labor markets, where new job opportunities are more readily available, the association tends to be negative. In such settings, unmarried and younger individuals, who are generally at higher risk of adverse birth outcomes, are less likely to have children during periods of higher unemployment. In contrast, maternal behaviors such as alcohol consumption and smoking, along with delayed initiation of antenatal care, combined with parental income loss, are found to contribute to poorer birth outcomes in some countries.

Women working in vulnerable situations often face limited job security, social protections, and working conditions, all of which are adversely associated with their health during pregnancy and maternity. Statistical analysis of the relationship between FU, FVE, and LBW can shed light on the importance of labor policies that protect women's health and promote economic stability.

Young women who are not engaged in education, the workforce, or any training are at greater risk of having equal access to various social, political, and economic rights, resources, and opportunities. The positive connection between FNEET and LBW can be translated into lower levels of health literacy, healthy pregnancies, and access to healthcare services.

The regression analysis reveals the negative effect of PSWNP and WBLI on LBW. As the number of women in national parliaments increases or women's economic opportunities improve, gender-sensitive policies that promote pregnancy, maternal, and children's health are more likely to be implemented. Reducing legal barriers to women's opportunities can affect the incidence of LBW. The analyses on the correlation between FNEET, PSWNP, WBLI, and LBW provide insight into the broader socioeconomic factors that may affect children's health and LBW. Although it is well recognized and clearly observable that factors such as FVE, FNEET, PSWNP, and WBLI exert an indirect negative influence on low birth weight (LBW), to our knowledge, these variables have been relatively

less examined as the factors associated with LBW in the existing literature. In most of the previous studies, the focus has been placed on more direct health or socioeconomic factors.

Moreover, similarly, PD and GDPG have also not been included as factors related to LBW in existing studies. While both factors are indirectly associated with LBW, they have primarily been treated as variables influencing general health indicators such as non-communicable diseases (27) and maternal and under-5 mortality rates (28).

The statistical analyses about PD can be summarized as follows: Higher PD may have adverse effects on LBW. A dense population means more crowded living conditions, which might be associated with limited access to healthcare facilities and fewer social and economic opportunities. PD is linked to multiple factors that may also be associated with LBW. Some of these factors may have adverse effects, such as poor air quality and drinking water availability, while others may have positive effects, such as improved access to healthcare services in more urbanized places. The observed positive association of this study likely reflects the combined influence of these competing mechanisms.

The economic indicator, GDPG, is closely associated with public health outcomes, including low birth weight. The negative correlation and regression coefficient indicate that higher economic growth is associated with lower levels of LBW prevalence. That can be explained by higher investments and expenditures on health and so that, better access to healthcare infrastructure, nutrition, and enhanced maternal care services, which are linked to lower LBW prevalence. By examining the connection between GDPG and LBW, researchers and policymakers can gain deeper insights into how economic fluctuations influence maternal and child health.

Based on the findings of this study, investigating the socioeconomic, particularly gender-related, factors associated with LBW at a global level carries significant practical and social implications. From a practical perspective, examining how gender related factors such as FU, FVE, FNEET, PSWNP, and WBLI are associated with LBW can provide evidence for governments, international organizations, and policy-makers to develop

targeted interventions. Such efforts allow the design of preventive strategies, such as campaigns that emphasize the importance of maternal birth and infant and child care education, maternal health programs, and nutritional support for mothers. Moreover, understanding the global pattern enables more effective allocation of resources and directs attention to high LBW regions or countries. Socially, the implications of studying the factors of LBW extend into a wide range of inequality issues. As shown by the analysis, the negative effects of the gender related factors on LBW reflect the disadvantages and inequalities faced by women. Highlighting these inequalities underscores the need for structural reforms that empower women socially and economically and eliminate barriers to accessing health and education. Therefore, investigating the socioeconomic factors of LBW is not only a scientific necessity but also an important social responsibility to create healthier, more equitable, and more resilient societies worldwide. Inevitably, this study has some limitations that need to be declared. Since the study is a data-based work, the key limitations are due to the data. One limitation is the availability of complete data for the selected indicators. World Data Bank reports 217 countries in the world, but most of them have missing data, or the most recent data are older than 5 years. Another limitation is the accuracy of the data and its suitability for use in comparing countries. While some countries' data are based on limited observations or registration systems, others include all the relevant regions with high accuracy. The measurement or estimation method of the indicators may have shown variability. Although the variables are convenient to use and are expected to have a strong relationship with LBW, they may not be significant in the model because the regression model shows the simultaneous effect of the variables. Besides, this is an ecological study; the observed associations are at the country level and can be interpreted as only country-level relationships. The results may be affected by potential confounding factors and cross-country heterogeneity. Although multicollinearity was assessed using VIF and no serious issues were detected, some independent variables may represent overlapping constructs, such as gender inequality and socioeconomic

development. Although the model specification was guided by the literature and the theoretical relevance of the variables, multiple combinations of potential predictors were examined during the modeling process. The final model was selected based on statistical significance, overall model fit, and the satisfaction of regression assumptions. Therefore, the analysis has an exploratory component, and alternative model specifications may yield different results. The findings may be sensitive to model specification and different combinations of variables could potentially lead to alternative results.

Literature on LBW mostly focuses on the causes and consequences of LBW, mainly the diseases. This study adds to the limited body of cross-national evidence that deals with the occurrence of LBW from a socioeconomic factors perspective, specifically gender disparities. Children's health, socioeconomic indicators, and gender disparity are each very rich and diverse concepts in their fields. Being in the intersection of these topics reflects the complexity and necessity of this study. Thus, this study can contribute to the existing literature and fill the gap in this area. It may shed light on the gender disparity and its effects on infants from a global perspective and provide a more holistic understanding.

Conclusions

The findings of the cross-sectional ecological study reveal a remarkable relationship between LBW and various socioeconomic factors through a gender-focused perspective. Despite the limitations, the results indicate the opinion that higher levels of LBW are particularly observed in countries with higher GII and lower HDI. This pattern suggests that disparities in access to healthcare, economic opportunities, and empowerment may be linked to differences in LBW across countries. With this knowledge, addressing gender inequality and understanding its causes and implications is essential for fostering a healthier population, ultimately improving both short-term and long-term well-being for mothers and newborns. Hence, by integrating these insights into policy decisions, governments and healthcare institutions can work toward reducing LBW rates and fostering healthier futures for both mothers and children. It is expected

that this study will contribute to future studies and shed light on LBW and gender disparities. Future research should continue exploring the complex interactions between these factors, incorporating longitudinal data to better understand the long-term implications of LBW and reduce the burden of LBW. How socioeconomic inequalities in cultural and regional variations shape birth outcomes over time should also be examined through statistical analysis. Country- or region-specific mechanisms should also be further explored.

Data Availability Statement

The data that supported the findings of this study are openly available in the World Bank Group at: <https://databank.worldbank.org/> and the United Nations Development Report at <https://hdr.undp.org/data-center/thematic-composite-indices/gender-inequality-index#/indicies/GII>. Accessed on 24 February 2025.

Conflict of Interest

The author declares no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Financial Support

The study did not receive any financial support.

Ethical Declaration

The study relies on publicly available open-access data. No human or animal subjects were involved; therefore, ethical approval was not required.

Author Contribution

The author confirms the sole responsibility for the conception of the study, presented results, and the manuscript preparation.

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Appendix

Data set 1: Countries included in the GII-LBW correlation analysis (n = 138)

Albania, Algeria, Angola, Argentina, Armenia, Australia, Austria, Azerbaijan, Bahrain, Bangladesh, Belarus, Belgium, Belize, Benin, Bhutan, Bolivia, Bosnia and Herzegovina, Botswana, Brazil, Brunei Darussalam, Bulgaria, Burkina Faso, Burundi, Cambodia, Cameroon, Canada, Chile, China, Colombia, Congo Democratic Republic, Congo Republic, Costa Rica, Cote d'Ivoire, Croatia, Cuba, Czechia, Denmark, Dominican Republic, Ecuador, El Salvador, Estonia, Eswatini, Fiji, Finland, France, Gabon, Gambia, Georgia, Germany, Ghana, Greece, Guatemala, Guinea-Bissau, Guyana, Honduras, Hungary, Iceland, India, Indonesia, Iraq, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Korea

Republic, Kuwait, Kyrgyz Republic, Latvia, Lebanon, Lesotho, Liberia, Lithuania, Luxembourg, Madagascar, Malawi, Malaysia, Maldives, Malta, Mauritius, Mexico, Moldova, Mongolia, Montenegro, Morocco, Mozambique, Myanmar, Namibia, Nepal, Netherlands, New Zealand, Nicaragua, North Macedonia, Norway, Oman, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Portugal, Qatar, Romania, Russian Federation, Rwanda, Senegal, Serbia, Sierra Leone, Singapore, Slovak Republic, Slovenia, Spain, Sri Lanka, St. Lucia, Suriname, Sweden, Switzerland, Tajikistan, Tanzania, Thailand, Togo, Trinidad and Tobago, Tunisia, Türkiye, Ukraine, United Arab Emirates, United Kingdom, United States, Uruguay, Uzbekistan, Venezuela, RB, Viet Nam, Zambia, Zimbabwe.

Data set 2: Countries included in the regression analysis (n = 86):

Albania, Angola, Armenia, Australia, Austria, Bangladesh, Belarus, Belgium, Benin, Bolivia, Botswana, Brazil, Bulgaria, Burkina Faso, Cameroon, Chile, China, Colombia, Costa Rica, Czechia, Denmark, Ecuador, El Salvador, Estonia, Fiji, Finland, France, Gambia, The, Georgia, Germany, Ghana, Greece, Guatemala, Honduras, Hungary, Iceland, Ireland, Italy, Jamaica, Japan, Jordan, Kyrgyz Republic, Lao PDR, Lithuania, Luxembourg, Madagascar, Malawi, Malaysia, Malta, Mexico, Moldova, Mongolia, Morocco, Mozambique, Namibia, Nepal, Netherlands, Norway, Panama, Paraguay, Peru, Poland, Portugal, Romania, Russian Federation, Rwanda, Senegal, Slovak Republic, Slovenia, South Africa, Spain, Sri Lanka, Sweden, Switzerland, Tajikistan, Tanzania, Thailand, Timor-Leste, Togo, Tunisia, Türkiye, United Kingdom, Uruguay, Uzbekistan, Viet Nam, Zimbabwe.