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Statistical analysis of socio-economic determinants on newborn birth weight in Nigeria

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Abstract. This study identifies the main factors which were significantly associated with Low Birth Weight (LBW) as a socioeconomic condition. Using logistic regression, the variables that are statistically significant are antenatal, residence status, smoking status and sex. So, we conclude that there is a significant effect of socioeconomic factors in determining weight at birth in Nigeria and Cochran's test reveals that the proportions at which socioeconomic factors affect weight at birth in Nigeria are statistically significantly different across the independent variables in the study.

Keywords: analysis; birth weight; newborn; determinants; socio-economic factors

1 Introduction

Birth weight serves as a fundamental marker of neonatal health, influencing survival, growth trajectories, and long-term developmental outcomes. It is not merely a biological measure but a reflection of broader maternal health, socioeconomic conditions, and the efficacy of healthcare systems [6]. Globally, low birth weight (LBW), defined as less than 2.500 grams, remains a significant public health challenge, associated with heightened risks of neonatal mortality, cognitive impairments, and chronic diseases in adulthood. In Nigeria, where neonatal mortality rates are among the highest worldwide, addressing the determinants of birth weight is critical to improving child health outcomes and advancing progress toward the Sustainable Development Goals (SDGs) related to health and well-being [4].

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The interplay between socioeconomic factors and birth outcomes is well-documented, with maternal education, household income, healthcare access, and nutritional status emerging as key determinants of birth weight [5]. In Nigeria, stark disparities in healthcare access and educational attainment exacerbate the vulnerability of mothers and newborns, particularly in rural and underserved regions. These inequities underscore the importance of understanding how socioeconomic status (SES) shapes birth outcomes, as well as the need for evidence-based interventions to mitigate adverse effects [1].

Beyond socioeconomic factors, maternal age, parity, and pre-existing health conditions also play pivotal roles in determining birth weight. For instance, adolescents and older mothers, as well as those with limited access to antenatal care, are at greater risk of delivering LBW infants [3]. Additionally, regional and cultural variations across Nigeria further complicate the landscape, necessitating localized studies to inform context-specific health policies and programs [7]. These complexities highlight the need for a nuanced understanding of the multifaceted determinants of birth weight.

While existing research on birth weight determinants in Nigeria has provided valuable insights, many studies have focused on isolated factors or specific geographic areas, limiting their generalizability and policy relevance [2]. There is a pressing need for comprehensive analyses that integrate multiple socioeconomic variables and employ robust statistical methodologies to unravel the intricate interactions influencing birth weight. Such an approach can offer a holistic perspective, enabling the design of targeted interventions to improve neonatal outcomes.

This study seeks to address this gap by conducting a statistical analysis of the socioeconomic determinants of newborn birth weight in Nigeria. By examining the impact of SES on birth weight, the research aims to provide actionable insights for policymakers and healthcare practitioners. The findings will contribute to the development of evidence-based strategies to reduce LBW rates, enhance neonatal survival, and promote long-term health and well-being in Nigeria. In doing so, this study aligns with global efforts to achieve equitable health outcomes and sustainable development.

2 The data

This research was undertaken at the University of Abuja Teaching Hospital, situated in Gwagwalada, Abuja, Nigeria's Federal Capital Territory. Gwagwalada, with a population estimated at around 452.000 in 2003, is a diverse community comprising various ethnic and tribal groups, mirroring the multicultural nature of Abuja as the country's capital. The investigation was designed as a hospital-based, cross-sectional analysis conducted within the labor room and postnatal ward of the Obstetrics and Gynecology Department at the aforementioned hospital. The study period extended over a decade, from 2008 to September 2018. Participants were briefed on the study's aims, and written consent was secured from the mothers. In cases where participants were below 18 years of age, consent was additionally obtained from their spouses or family heads.

Mothers were enrolled in the study before delivery using a systematic random sampling approach. All infants were weighed within the first hour after birth using a calibrated infant scale (with a maximum capacity of 10 kg and a precision of 10 g, produced by the Docobel Company). Low birth weight (LBW) was categorized as a birth weight below 2.500 grams. Direct interviews were conducted with mothers at their bedside to gather data on various study parameters, such as maternal age, residential location, religious affiliation, educational attainment, gestational age, smoking habits, birth status, birth order, and antenatal care utilization. Data collection was carried out daily over a nine-month period until the target sample size was achieved.

The study utilized data from the 2008 Nigerian Demographic and Health Survey, which indicated a low birth weight (LBW) prevalence of 14% (655 per 1000 live births). Based on this prevalence, with a 10% margin of error and a 95% confidence level, the sample size was calculated. This methodological rigor ensured the robustness and precision of the study's outcomes.

2.1 Response (dependent) variable

The response variable in this study is birth weight, which is categorized into two distinct groups: low birth weight (LBW) and normal birth weight. Birth weight is a vital health indicator for newborns and serves as the primary outcome measure in this research. Low birth weight is defined as a weight below 2.500 grams at birth, while normal birth weight is 2.500 grams or above. This binary variable reflects the health status of newborns, with the analysis focusing on identifying the factors that influence birth weight. As the central focus of the study, birth weight provides critical insights into neonatal health outcomes and the determinants that contribute to variations in these outcomes.

2.2 Explanatory variables

The explanatory variables in this study are the factors hypothesized to influence birth weight. These variables include:

i **Birth Order**: This variable distinguishes whether the child is a firstborn or not.

ii **Antenatal Care Attendance**: This measures whether the mother utilized antenatal care services during pregnancy.

iii **Residence Status**: This categorizes the mother's residence as either rural or urban.

iv **Education Status**: This evaluates whether the mother has formal education or not.

v **Smoking Status**: This identifies whether the mother smokes, a known risk factor for adverse birth outcomes.

vi **Sex of the Baby**: This variable captures the gender of the newborn (male or female).

3 Methods

3.1 Cochran's Q test

Suppose we have k binary measurements on each of N subjects (where the "subject" may be a set of matched individuals). Let Y_i be the binary response from subject i in category j ($i = 1$ to N, $j = 1$ to k), with success = 1 and failure = 0. Let the proportions, $\pi_1, \pi_2, \ldots, \pi_k$, represent the proportion of "successes" in each of the k groups.

Cochran's Q is used to test the null hypothesis

$H_0 : \pi_1 = \pi_2 = \cdots = \pi_k$ (i.e. the treatments are equally effective)

versus the alternative

$H_A : \pi_a \neq \pi_b$ (i.e. is a difference in effectiveness between treatments) for at least one pair π_a, π_b, with $a \neq b$ and $1 \leqslant a, b \leqslant k$.

3.2 Assumptions of Cochran's Q Test and Associated Multiple Comparisons

The following are the assumptions that must be satisfied:

1. Responses are binary and from k matched samples.
2. The subjects are independent of one another and were selected at random from a larger population.
3. The sample size is sufficiently "large". (As a rule of thumb, the number of subjects for which the responses are not all 0's or 1's, n, should be $\geqslant 4$ and n_k should be $\geqslant 24$. This assumption is not required for the exact binomial McNemar test.)

The Cochran's Q test statistic is

$$T = k(k-1)\frac{\sum_{j=1}^{k}(X_{.j} - \frac{N}{k})^2}{\sum_{i=1}^{b} X_{i.}(k - X_{i.})},$$

where:

$b =$ the number of blocks,

$k =$ the number of treatments,

$X_{.j} =$ column total for the jth treatment,

$X_{i.} =$ row total for the ith block,

$N =$ the grand total.

The p-value or the critical region for the test is computed as:

For significance level α, the critical region is $T > X^2_{1-\alpha,k-1}$, where $X^2_{1-\alpha,k-1}$ is the $(1-\alpha)$-quantile of the chi-squared distribution with $k-1$ degrees of freedom. The null hypothesis is rejected if the test statistic is in the critical region. If the Cochran test rejects the null hypothesis of equally effective treatments, pairwise multiple comparisons can be made by applying Cochran's Q test on the two treatments of interest.

3.3 Multiple comparisons

When the null hypothesis of success proportion equality is rejected by Cochran's Q test, you can proceed to determine which of the groups are different by computing multiple pair wise comparisons. Pairwise tests between groups "a" and "b" test the null hypothesis

$$H_0 : \pi_a = \pi_b$$

versus the alternative

$$H_A : \pi_a \neq \pi_b.$$

3.4 Logistic regression

Let:

$$P_i = Pr(Y = 1|X = x_i).$$

Then we can write the model:

$$\log\left(\frac{P_i}{1-P_i}\right) = \log it(P_i) = \beta_0 + \beta_1 x_i.$$

We can write the model in terms of odds as:

$$\frac{P_i}{1-P_i} = \exp(\beta_0 + \beta_1 x_i).$$

Or in terms of the probability of the outcome occurring as:

$$P_i = \frac{\exp(\beta_0 + \beta_1 x_i)}{(1 + \exp(\beta_0 + \beta_1 x_i))}.$$

Conversely the probability of the outcome not occurring is

$$1 - P_i = \frac{1}{(1 + \exp(\beta_0 + \beta_1 x_i))}.$$

Specifically, in this study:
P_i is the probability of a newborn having normal birth weight (as opposed to low birth weight).
$1 - P_i$ – the probability of low birth weight for the same observation.
$\frac{P_i}{1-P_i}$ – this is the odds of the outcome (normal birth weight) occurring for the ith observation.

Notation

Term	Description
P_i	probability of a success for the ith row in the data
β_0	intercept coefficient
β_1	coefficient for predictor x
x_i	the data point for the ith row

4 Results

The variables in this study were coded dichotomously (0 and 1) to facilitate analysis, with each category representing distinct groups. Specifically, SEX was coded as 0 for female and 1 for male, SMOKING STATUS as 0 for non-smoker and 1 for smoker, BIRTH ORDER as 0 for not firstborn and 1 for firstborn, ANTENATAL CARE ATTENDANCE as 0 for no antenatal care and 1 for attended antenatal care, RESIDENCE STATUS as 0 for rural and 1 for urban, and EDUCATION STATUS as 0 for no formal education and 1 for formal education.

The data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 25.0, employing various statistical tests to examine the relationships

Table 1. Socio demographic characteristics of respondents.

Variable	Responses	Frequency	Percent
Sex of respondents	Male	529	49.3
	Female	544	50.7
	Total	**1073**	**100.0**
Age interval	15–19	284	26.5
	20–24	216	20.1
	25–29	137	12.8
	30–34	138	12.9
	35–39	112	10.4
	40–44	130	12.1
	45–49	56	5.2
	Total	**1073**	**100.0**
Smoking status	Non smoker	788	73.4
	Smoker	285	26.6
	Total	**1073**	**100.0**
Birth Order	Not first Born	756	70.5
	First Born	317	29.5
	Total	**1073**	**100.0**
Birth delivery method	Normal delivery	559	52.1
	CS	514	47.9
	Total	**1073**	**100.0**
Antenatal	Did not attend	642	59.8
	Attend	431	40.2
	Total	**1073**	**100.0**
Birth Status	Low birth weight	559	52.1
	Normal birth weight	514	47.9
	Total	**1073**	**100.0**
Residential	Rural	724	67.5
	Urban	349	32.5
	Total	**1073**	**100.0**
Educational Status	No formal education	518	48.3
	Formal education	555	51.7
	Total	**1073**	**100.0**
Baby weight Interval	1.6–2.0	463	43.2
	1.8–2.2	5	0.5
	2.3–2.7	309	28.8
	2.8–3.2	94	8.8
	3.3–3.7	14	1.3
	3.8–4.2	24	2.2
	4.3–4.7	122	11.4
	4.8–5.2	42	3.9
	Total	**1073**	**100.0**

between the variables under investigation. The results of these analyses are presented in Table 1.

Binary Logistic Regressions Results

Hypothesis

H_0: there is no effect of socioeconomic factors in determining weight at birth in Nigeria.

H_1: there is an effect of socioeconomic factors in determining weight at birth in Nigeria.

Table 2. Variables in the equation.

Variable	Estim.	Std. er.	Wald stat.	DF	Sig.	Odds ratio	95% C.I. for Odds ratio
BIRTH ORDER	−0.235	0.165	2.027	1	0.155	0.790	0.572–1.093
ANTENATAL	1.608	0.162	98.094	1	0.000	4.993	3.632–6.863
RESIDENCE STATUS	−0.405	0.158	6.527	1	0.011	0.667	0.489–0.910
EDUCATION STATUS	0.162	0.149	1.186	1	0.276	1.176	0.878–1.575
SMOKING STATUS	−3.161	0.244	167.709	1	0.000	0.042	0.026–0.068
SEX	−0.308	0.150	4.254	1	0.039	0.735	0.548–0.985
Constant	0.186	0.157	1.405	1	0.236	1.205	–

The Table 2 shows that, using our model we have six (6) independent variables and one (1) dependent variable.

In initial model we modeled probability of low-weight on newborn sex, birth order, antenatal status, residence status, education status and smoking status

$$\frac{P_i}{1-P_i} = \exp(\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots).$$

Thus, the initial logistic model is given as:

$$= \exp(\beta_0 + \beta_1 \text{ birth order } + \beta_2 \text{ antenatal } + \beta_3 \text{ residence status } + \beta_4 \text{ education status } + \beta_5 \text{ smoking status } + \beta_6 \text{ sex}).$$

After removing non-significant variables we get the following final model:

$$\frac{P_i}{1-P_i} = \exp(\beta_0 + \beta_2 \text{ antenatal } + \beta_3 \text{ residence status } + \beta_5 \text{ smoking status } + \beta_6 \text{ sex}),$$

$$\frac{P_i}{1-P_i} = \exp(0.186 + 1.608 \text{ antenatal } - 0.405 \text{ residence status } - 3.161 \text{ smoking status } - 0.308 \text{ sex}).$$

The coefficient for antenatal care attendance is 1.608, indicating a strong positive relationship with normal birth weight. The odds ratio of 4.993 suggests that mothers who attended antenatal care have nearly five times higher odds of having a baby with normal birth weight compared to those who did not attend. This finding is highly significant, with a p-value of <0.001, and the 95% confidence interval for the odds ratio ranges from 3.632 to 6.863, reinforcing the strength of this result.

The coefficient for residence status is 0.405, indicating a negative relationship with normal birth weight. The odds ratio of 0.667 suggests that mothers residing in rural areas have 33.3% lower odds of having a baby with normal birth weight compared to those in urban areas. This result is statistically significant, with a p value of 0.011, and the 95% confidence interval for the odds ratio ranges from 0.489 to 0.910, highlighting the adverse impact of rural residence on birth outcomes.

The coefficient for smoking status is 3.161, indicating a strong negative relationship with normal birth weight. The odds ratio of 0.042 suggests that mothers who smoke have 96% lower odds of having a baby with normal birth weight compared to non smokers. This finding is highly significant, with a p value of <0.001, and the 95%

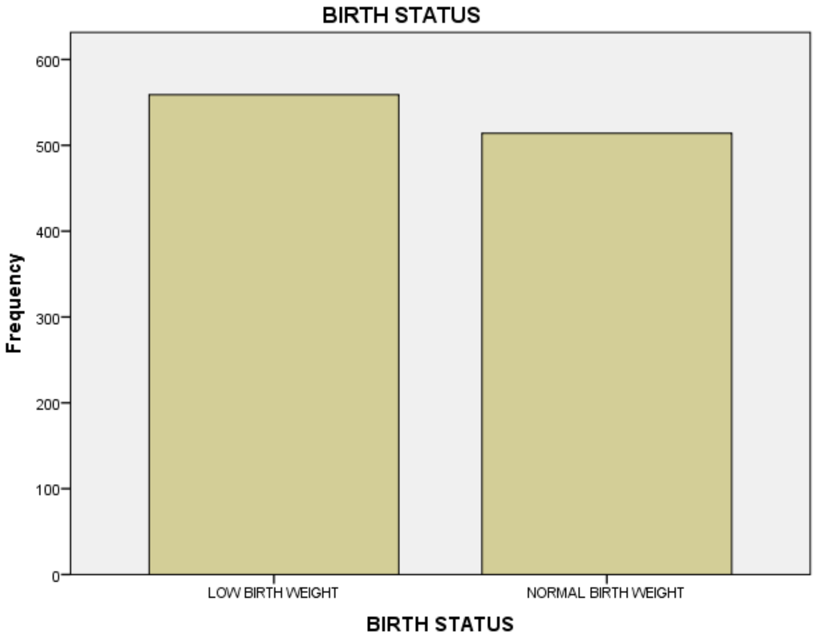

Fig. 1. Distribution of respondents by Birth weight.

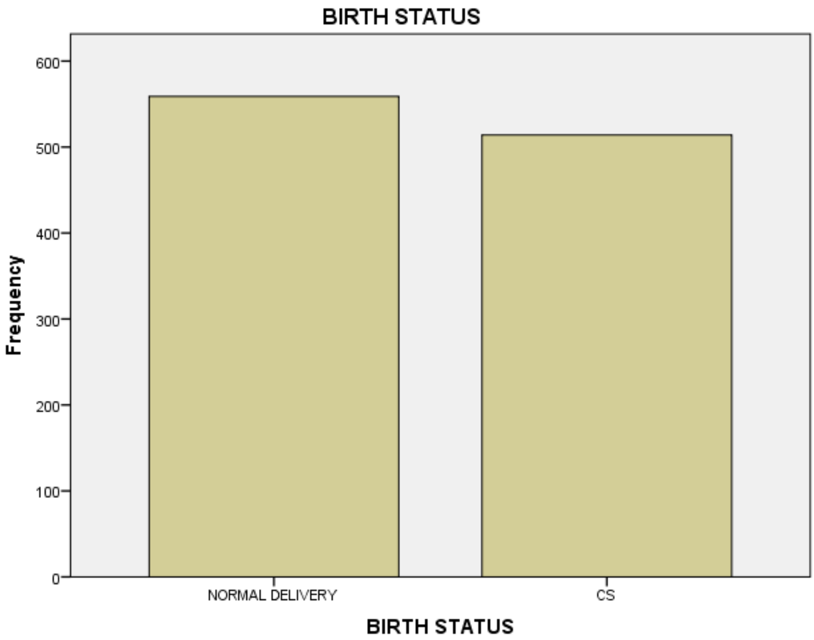

Fig. 2. Distribution of respondents by Birth delivery status.

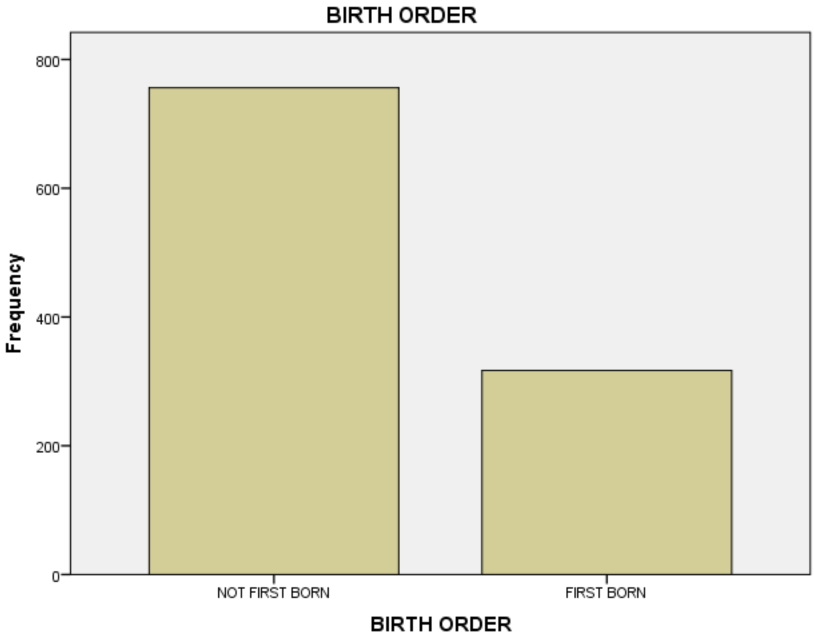

Fig. 3. Distribution of respondents by Birth Order.

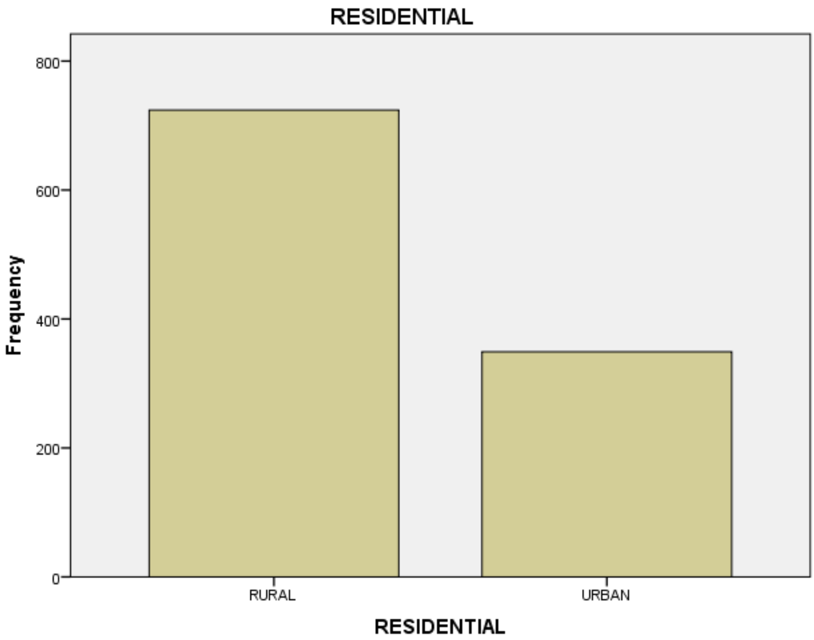

Fig. 4. Distribution of respondents by residence.

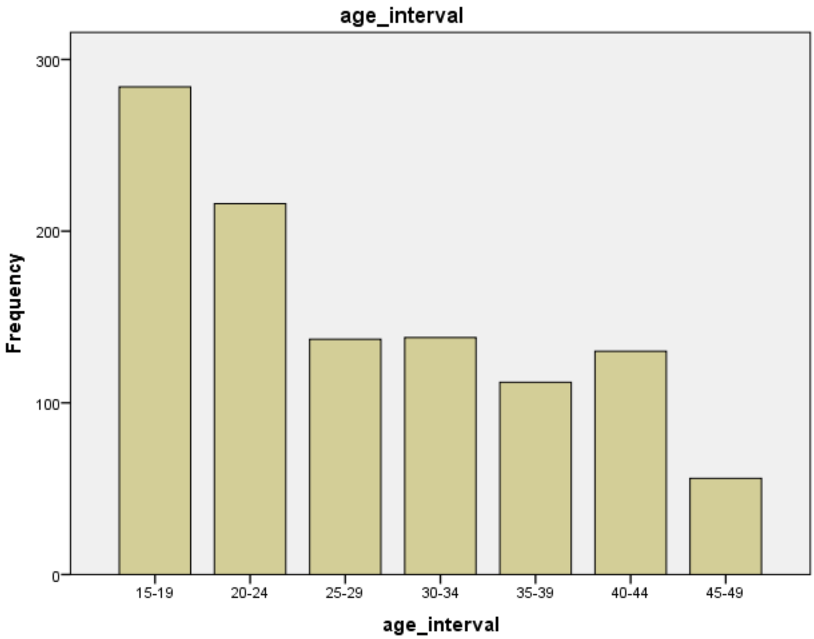

Fig. 5. Distribution of respondents by age.

confidence interval for the odds ratio ranges from 0.026 to 0.068, underscoring the detrimental effect of smoking on birth weight.

The coefficient for the sex of the baby is 0.308, indicating a negative relationship with normal birth weight. The odds ratio of 0.735 suggests that female babies have 26.5% lower odds of having normal birth weight compared to male babies. This result is statistically significant, with a p value of 0.039, and the 95% confidence interval for the odds ratio ranges from 0.548 to 0.985, suggesting a gender based disparity in birth weight outcomes.

The coefficient for birth order is 0.235, suggesting a slight negative relationship with normal birth weight. The odds ratio of 0.790 suggests that firstborn babies have 21% lower odds of normal birth weight compared to non firstborn babies. However, this effect is not statistically significant, with a p value of 0.155, and the 95% confidence interval for the odds ratio ranges from 0.572 to 1.093.

The coefficient for education status is 0.162, suggesting a slight positive relationship with normal birth weight. The odds ratio of 1.176 suggests that mothers with formal education have 17.6% higher odds of having a baby with normal birth weight compared to those without formal education. However, this effect is not statistically significant, with a p value of 0.276, and the 95% confidence interval for the odds ratio ranges from 0.878 to 1.575.

Thus, the null hypothesis (H_0) is rejected based on the significant effects of antenatal care attendance, residence status, smoking status, and sex of the baby on birth weight. These findings provide strong evidence that socioeconomic factors significantly influence birth weight outcomes in Nigeria.

Table 3. Cochran test frequencies.

	Value	
	0	1
SEX	544	529
SMOKING STATUS	788	285
BIRTH ORDER	756	317
ANTENATAL	642	431
RESIDENCE STATUS	724	349
EDUCATION STATUS	518	555

Table 4. Test statistics.

N	1073
Cochran's Q	249.736[a]
Df	5
Asymp. Sig.	0.000

Cochran's Q test

Hypothesis

H_0: The proportions at which socioeconomic factors affect weight at birth in Nigeria are the same.

H_1: The proportions at which socioeconomic factors affect weight at birth in Nigeria are not the same.

Table 4 shows that we have a statistically significant result and also the proportions of having babies with low birth weight and normal birth weight is statistically significantly different across the independent variables in study.

Discussion

This study investigated the influence of socioeconomic factors on birth weight outcomes in Nigeria, utilizing data from the University of Abuja Teaching Hospital over a ten year period (2008–2017). The findings reveal that maternal, environmental, and socioeconomic factors play a significant role in determining birth weight, with antenatal care attendance, residence status, smoking status, and sex of the baby emerging as key predictors. The analysis employed binary logistic regression and Cochran's Q test, both of which yielded statistically significant results, providing strong evidence to reject the null hypothesis and conclude that socioeconomic factors significantly affect birth weight outcomes in Nigeria.

The results demonstrate a strong positive relationship between antenatal care attendance and normal birth weight. Mothers who attended antenatal care had nearly five times higher odds of having a baby with normal birth weight compared to those who did not attend. This finding is highly significant ($p < 0.001$), with a 95% confidence interval for the odds ratio ranging from 3.632 to 6.863. This underscores the critical role of antenatal care in promoting healthy birth outcomes. Antenatal care provides opportunities for early detection and management of pregnancy related complications, nutritional counseling, and health education, all of which contribute to improved fetal growth and development. The significant impact of antenatal care highlights the need for increased access to and utilization of these services, particularly in underserved areas.

Residence status was found to have a significant negative relationship with normal birth weight. Mothers residing in rural areas had 33.3% lower odds of having a baby with normal birth weight compared to those in urban areas. This result is statistically significant ($p = 0.011$), with a 95% confidence interval for the odds ratio ranging from 0.489 to 0.910. The adverse impact of rural residence on birth outcomes may be attributed to limited access to healthcare facilities, poorer infrastructure, and lower socioeconomic status in rural areas. These findings emphasize the need for targeted interventions to improve healthcare access and living conditions in rural communities, thereby reducing disparities in birth weight outcomes.

Smoking status exhibited a strong negative relationship with normal birth weight. Mothers who smoked had 96% lower odds of having a baby with normal birth weight compared to non-smokers. This finding is highly significant ($p < 0.001$), with a 95% confidence interval for the odds ratio ranging from 0.026 to 0.068. Smoking during pregnancy is a well-established risk factor for low birth weight, as it restricts fetal growth by reducing oxygen and nutrient supply to the developing baby. The study's results reinforce the importance of public health campaigns aimed at reducing smoking rates among pregnant women and providing support for smoking cessation.

The sex of the baby was also a significant predictor of birth weight, with female babies having 26.5% lower odds of normal birth weight compared to male babies. This result is statistically significant ($p = 0.039$), with a 95% confidence interval for the odds ratio ranging from 0.548 to 0.985. This sex-based disparity in birth weight may be linked to biological differences in fetal growth patterns between males and females. However, further research is needed to explore the underlying causes of this disparity and its implications for neonatal health.

While birth order and education status showed slight relationships with birth weight, these effects were not statistically significant. Firstborn babies had 21% lower odds of normal birth weight compared to non-firstborn babies, but this result was not significant ($p = 0.155$). Similarly, mothers with formal education had 17.6% higher odds of having a baby with normal birth weight compared to those without formal education, but this effect was also not significant ($p = 0.276$). These findings show no strong evidence to suggest that birth order and maternal education may have an influence on birth weight outcomes in this context.

Cochran's Q test further validated the findings by demonstrating statistically significant differences in the proportions of low birth weight and normal birth weight across the independent variables ($p < 0.001$). This indicates that the socioeconomic factors under investigation have varying effects on birth weight outcomes, reinforcing the importance of addressing these factors through targeted public health interventions.

Implications for Policy and Practice

The study's findings have important implications for policy and practice in Nigeria. The significant impact of antenatal care attendance underscores the need for policies that promote universal access to antenatal services, particularly in rural areas. Public health campaigns should focus on educating pregnant women about the benefits of antenatal care and addressing barriers to access. Additionally, interventions aimed at reducing smoking rates among pregnant women are critical for improving birth outcomes. The disparities between rural and urban areas highlight the need for equitable distribution of healthcare resources and infrastructure development in rural communities.

Conclusion

This study highlights the profound impact of socioeconomic factors on birth weight outcomes in Nigeria, offering valuable insights into the challenges many mothers and newborns face. Key factors such as antenatal care attendance, where mothers live, whether they smoke, and the baby's sex were found to play significant roles in determining birth weight. For instance, mothers who attended antenatal care were nearly five times more likely to have babies with normal birth weights, showcasing the life-changing benefits of proper prenatal care. On the other hand, mothers living in rural areas or who smoked during pregnancy faced much higher risks of having babies with low birth weights. Additionally, the study revealed a concerning trend: female babies were less likely to have normal birth weights compared to males, a finding that calls for deeper exploration to understand why this disparity exists. These results paint a clear picture of how socioeconomic and health-related factors shape the well-being of mothers and their babies.

The findings from this study carry important messages for policymakers, healthcare providers and communities. To improve birth outcomes, it is crucial to ensure that all mothers, especially those in rural areas, have access to quality antenatal care. Public health campaigns should also focus on educating mothers about the dangers of smoking during pregnancy and provide support to help them quit. Addressing the gap between rural and urban healthcare access is another critical step, as it can help reduce the inequalities that put rural mothers and their babies at a disadvantage. By tackling these issues, we can take meaningful steps toward reducing low birth weight rates and giving every child a healthier start in life. This study not only sheds light on the challenges but also points the way toward solutions that can make a real difference for families across Nigeria.

Recommendations

In order to reduce low birth weight in Nigeria, the following recommendations were made:

i. Government hospitals should ensure that they have all equipment and facilities for antennal services

ii. Due to residence status, women living in rural area sometimes cannot access hospitals, hence we suggest every community should have health care centers that can provide proper antenatal services so that pregnant women will not have to go through long journeys probably with Motor Cycle (Okada) to receive hospital services.

iii. Government should repair the roads in rural areas because they can affect pregnant women too.
iv. Intending mothers should not see smoking as a way of life or having fun and mothers smoking should quit because of the future of their unborn child; low birth weight tends to result in a poor health trap for the child.

Conflict of Interests

The authors declare that there is no competing interest among them when writing this paper.

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REZIUMĖ

Naujagimio gimimo svorio socialinių ir ekonominių veiksnių statistinė analizė Nigerijoje

A.A. Ayenigba, D.A. Afariogun, S.O. Lawal

Šiame tyrime nustatyti pagrindiniai veiksniai, kurie buvo reikšmingai susiję su mažu gimimo svoriu (MSW) kaip socialine ir ekonomine būkle. Naudojant logistinę regresiją, statistiškai reikšmingi kintamieji yra prenatalinis amžius, gyvenamosios vietos statusas, rūkymo įpročiai ir lytis. Taigi, darome išvadą, kad socialiniai ir ekonominiai veiksniai turi reikšmingą įtaką gimimo svoriui Nigerijoje, o Cochrano testas rodo, kad socialinių ir ekonominių veiksnių įtakos gimimo svoriui Nigerijoje proporcijos statistiškai reikšmingai skiriasi tarp nepriklausomų kintamųjų tyrime.

Raktiniai žodžiai: analizė; gimimo svoris; naujagimis; lemiantys veiksniai; socialiniai ir ekonominiai veiksniai