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Socioeconomic determinants of neonatal mortality in Nigeria

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Abstract

The need to reduce the rate of neonatal mortality should be of concern to the government and people of Nigeria, considering the fact it is the span of life with the highest risk of survival. This study examined the determinants of neonatal mortality in Nigeria with a focus on the period spanning from 1970-2022. The article begins by explaining how changes in socioeconomic could affect healthcare outcomes, with particular emphasis on neonatal mortality. Annual data on neonatal mortality rate (NNM), gross domestic product per capita (a proxy for income per capita), life expectancy at birth (LEB), Adolescent female literacy rate rate (AFLR) and under-five mortality rate (UD_5) were obtained from the World Bank Development Indicators. The ARDL approach was employed to analyze the specified regression model. The bound test output suggests a long run relationship between the independent variables and neonatal mortality. In addition, the findings show that GDP per capita and life expectancy at birth were inversely related to neonatal mortality in the long run. The findings show that a unit increase in GDP per capita and LEB will cause neonatal mortality to decline by 19% and 18%, respectively. Moreover, the study found that adolescent female literacy rate was negatively associated with neonatal mortality in the short run and not in the long run period. The study concludes that there is the need for more intervention in the area of education for adolescent female children to sustainably enhance its impact on neonatal mortality in the long run. Consequently, the study advocates for targeted female health literacy programmes for adolescent female pupils in low-income urban and rural areas of the country to ensure sustainable reduction in neonatal mortality.

Keywords: Adolescent female literacy rate, ARDL, Life expectancy at birth, Mortality, Neonatal.

1. Introduction

Neonatal mortality refers to the number of deaths during the first 28 days of life per 1000 live births (WHO, 2024). Neonatal birth describes a phase of infant life that is crucial to the survival of the child and happiness of the family. In fact, given its importance to the family as a unit and the well-being of the population, the crucial need to reduce the rate of neonatal mortality is a significant part of the United Nations Sustainable Development Goals (SDGs). In particular, SDG goal number three, designed to promote healthy lives and well-being for all, has as an integral aspect the reduction of neonatal mortality.

Neonatal mortality cannot be completely divorced from socioeconomic and demographic factors that negatively affect maternal and child health outcomes in a country. Girum and Wasie (2017) opined that there is a significant correlation between maternal mortality and the changing socioeconomic conditions of countries. Deteriorating socioeconomic conditions have a profound impact on women and children more than other categories of people in society. For instance, poor families confronted by economic hardships may be forced to prioritize spending on essential needs, such as food and clothing, over maternal and child healthcare. In fact, with declining disposable income, pregnant women who have the responsibility of managing family nutrition may be forced to adopt strategies that are stressful to their health and the well-being of their children.

Moreover, in rural communities, economic hardship may increase the opportunity cost faced by pregnant women in the choice between accessing skilled birth attendants and unorthodox childbirth practitioners. UNAIDS (2012) has documented the impact of economic crisis on women and communities across the world. However, changing socioeconomic conditions are not the only correlates of neonatal mortality.

Souza et al (2019) opine that the determinants of neonatal mortality are multiple and represent a complex interaction with sociodemographic, healthcare, and biological variables. Examples of these non-income factors i insufficient immunization, mother's level of maternal literacy, early age of fertility, poor access to qualitative healthcare, infections, rural location, and lack of skilled birth attendants (Yakhelef, et al., 2021; Tamir, 2024).

Provision of qualitative healthcare is capital-intensive. Consequently, in many countries, healthcare services are provided by the government and the private sector. Accordingly, the situation in the Nigerian health sector is no different, as public investment in healthcare is on the concurrent list of government expenditures. Therefore, public healthcare spending is carried out by the national, state, and local government authorities, albeit with differing scopes and scales of operation.

However, in Nigeria, the twin problems of sluggish economic growth rates and low health sector budgets have been confronting the domestic economy in recent times. Although the former can be partly attributed to dynamic shifts in the geopolitical environment, its impact on the domestic economy, with particular reference to the health sector, where a trend of low budgetary allocation has persisted for a long time, is quite obvious, and it may affect the progress towards achieving the Sustainable Development Goals. Statistics of budgetary allocation to health suggest that the sector received its highest share (6.51%) of the total budget in 2007. Successive allocations to the health sector in the national budget have staggered between 4.2% (2000), 4.76% (2022), and 5.75% in 2023 (Budget office, 2023). In essence, the study argues that though growth has been sluggish, such low national budgetary expenditure on healthcare can affect government health investment objectives. Moreover, it could raise the probability of a mixed outcome in the rate of progress towards ameliorating the effect of diseases and sickness that lead to the death of children in the country.

Theoretically, economic growth is expected to enhance the share of income available to households for health consumption. In addition, economic prosperity is expected to positively influence socio-demographic factors such as the level of adolescent female literacy, life expectancy at birth, and the number of skilled birth attendants, which are core determinants of neonatal mortality. Also, beyond the ability of economic prosperity to enhance the capacity of national healthcare management systems, it can lead to sustainable improvement in household income and their capacity to seek better healthcare services for women and children. Moreover, it would also positively influence the status of other non-income determinants of neonatal mortality. Thus, the imperative of understanding how economic and socio-demographic factors influence neonatal mortality cannot be overemphasized.

The determinants of neonatal mortality have been investigated by scholars in several countries. For instance, Sidi-Yakhlef, et al (2021) examined the socio-demographic correlates of neonatal mortality in Algeria. The study observed that adolescent female fertility rate, level of education of the mother, area of residence, and the income status of households were determinants of neonatal mortality in the country. Tamir (2024) employed a panel data approach to investigate the determinants of neonatal mortality in low and middle-income countries. The findings suggest that factors such as low and high birth weight, short successive birth intervals, high adolescent female fertility rates, and low female literacy rates are some of the causes of neonatal mortality.

However, in Nigeria, studies on the determinants of neonatal mortality are scanty. Nevertheless, they indicate that the determinants of neonatal mortality in the country are the mother's age and level of education, religion, lack of antenatal care, birth asphyxia, and low birth weight. ( ). Consequently, the present study contributes to these sets of studies that have investigated the determinants of neonatal mortality in two ways: first, the study employs data sequences spanning from 1970 to 2020 to investigate the determinants of neonatal mortality in Nigeria. The study employed a long period to unravel how changes in socioeconomic factors correlate with neonatal mortality. Secondly, the study assesses the magnitude of impact that income per capita, life expectancy at birth, under-five mortality, and adolescent female literacy exerts on neonatal mortality.

Accordingly, the study proposed the following hypotheses:

Ho1: *Income, life expectancy at birth, adolescent female literacy rate, and neonatal mortality are not correlated.*

Neonatal mortality may be mitigated through the positive socioeconomic improvement in the economic conditions prevalent in a country. Where economic growth translates to an increase in per capita income levels and better life expectancies at birth, it could reduce the risk of maternal and child mortality, which are often associated with poor socio-economic conditions. Moreover, an increase in adolescent female literacy rates could translate to better maternal and child care, which are essential in reducing the risk of neonatal mortality.

H_{02}: *Income and neonatal mortality are negatively correlated.*

Theoretically, it is expected that when household disposable income is adequate, pregnant women should be able to access qualitative healthcare services before and after delivery, to ensure their safety, as well as that of the child. However, for pregnant mothers in poor families with low incomes, this could put a heavy price on the choice between expenditure on the family's necessities and maternal care.

H_{03}: *Life expectancy at birth and neonatal mortality are negatively correlated.*

The organization for economic cooperation and development (OECD) defined life expectancy at birth as the average lifespan a newborn can be expected to live, assuming that age-specific mortality levels remain constant (OECD, 2024). Life expectancy at birth is determined by socioeconomic factors such as improved per capita health expenditure, lifestyle, standard of living, physician density ratio and quality of health services. Improvement in the life expectancy is will engender lower neonatal mortality rates.

Ho3: *Adolescent female literacy rate and neonatal mortality are negatively correlated.*

The importance of education for the girl-child cannot be overemphasized, especially as it pertains to maternal and child care. An increase in adolescent female literacy rate can lead to a better understanding of the causes of neonatal mortality and strategies to prevent the death of a child. Moreover, enhancing adolescent female literacy can improve awareness of the importance of personal hygiene during pregnancy and after childbirth for mothers.

The rest of the paper is laid out as follows. Section 2 summarizes the conceptual and prior empirical studies on this topic. Section 3 introduces the econometric methodology adopted. Section 4 is the result and discussion of findings, while Section 5 contains the conclusion and recommendations of the study.

2. Literature Review

2.1. Conceptual Literature

Socioeconomic Factors as Determinants of Neonatal Mortality

Studies show that several socioeconomic variables can influence the rate of neonatal mortality at a particular time. Faruk et al (2025) have documented how socioeconomic, demographic, and cultural factors affect child mortality. A key socioeconomic indicator is the income level of the family. The income level of a family affects neonatal mortality through pathways such as the ability of the pregnant mother to afford quality maternal and child care services. Moreover, it determines the capacity of mothers to access postnatal health care services and the quality of nutrition obtained by infants.

Although it may be argued that a family's income level is not isolated from the influence of business cycles that affect the economy, nevertheless, it is expected that when a household is financially stable, it could help lower the risk of neonatal mortality occasioned by poverty. So, it can be deduced that income is an important correlate of child survival (O’Hare, et al, 2013).

The rate of female education is also an important determinant of neonatal mortality. Studies suggest that educated mothers are more likely to understand the importance of promoting healthy behaviour before and after the delivery of their child. Moreover, education promotes the fluidity of health communication during pregnancy, as educated mothers can easily detect early signs of sickness and better communicate their experiences to the medical personnel. In effect, the greater the extent of education received by adolescent females, the lower the risk of teenage pregnancies and incidents of death of a newborn by an adolescent mother (Mitiku, 2021).

Furthermore, an inverse relationship is theoretically expected for life expectancy at birth and neonatal mortality. OECD (2022) defined life expectancy at birth as the average lifespan a newborn child is expected to live, assuming that the age-specific mortality rates do not change. Thus, while the rate of life expectancy at birth is reflective of mortality levels across the age categories in a population, neonatal mortality is indicative of the death of newborn babies within the first 28 days of life. Consequently, it can be deduced that when life expectancy at birth is high, the neonatal mortality rate would be low. Conversely, a high life expectancy at birth rate implies a low rate of neonatal mortality. These relationships are reinforced by factors such as the improvements in income per capita, government expenditure on health, as well as other non-income variables like female education levels, sanitation, and lifestyle practices (Gazilas, 2024). Many of these variables are positively correlated with life expectancy and also affect neonatal mortality. Thus, for example, it is expected that countries with higher per capita income levels should have lower rates of neonatal mortality and higher life expectancy at birth.

2.2. Theoretical Framework

Modernization theory and Child mortality

The modernization theory was a major theory of thought during the 1950s to 1960s. A decade that saw the emergence of newly independent nations. The theory of modernization broadly asserts that as society transitions from traditional production systems to modern means of production and individuals become more educated, it will become economically more prosperous and wealthier. The theory suggests that through industrialization and its attendant benefits to the national revenue, a country could invest more sustainably in its health and education sectors, and build the capacity of healthcare personnel and institutions. The outcome will then lead to a decline in child mortality. Modernization theories are used to explain changing patterns of child mortality and fertility across societies (Frank & Kovacs, 2021; Mejia, 2024).

2.3. Empirical Literature

Research on the determinants of neonatal mortality continues to interest scholars in developing and developed countries. Hence, several studies have been carried out to unravel factors that cause neonatal mortality. For instance, Shiferaw et al (2020) investigated the determinants of neonatal mortality in Ethiopia. The study utilised a community-based panel data approach. The findings revealed that neonates born to women residing in rural areas have a higher risk of neonatal mortality. Moreover, the mother's age and level of education were also significant determinants of neonatal mortality. The study echoed the need for tailored health intervention schemes in rural areas to focus on improving the literacy levels of women and late-age pregnancy.

Sidi-Yakhlef, et al (2021) examined socio-demographic determinants of neonatal mortality in Algeria. The study employed the Multiple Indicator Cluster Survey (MICS 4) carried out between 2013 and 2014 by the Algerian Ministry of Health, Population and Hospital reforms, in collaboration with the United Nations Children's Fund (UNICEF). The outcome of the study suggests that adolescent female fertility rate, level of education of the mother, area of residence, and income status were determinants of neonatal mortality in the country. The study therefore suggested the need for sustained health assistance for people in disadvantaged and high-risk areas of the country.

Zilidis and Hadjichristodoulou (2020) investigated the impact of economic crisis and socio-economic factors on perinatal and infant mortality in Greece. The scope of the study is from 2000 to 2016. The study employed both correlation and multiple regression methods in the estimation of the data. The findings indicated that neonatal mortality, perinatal mortality, and infant mortality were negatively correlated with GDP and per capita disposable income. In addition, neonatal mortality, infant mortality, and low birth weight were found to be positively correlated with long-term unemployment.

Tamir (2024) investigated the determinants of neonatal mortality among mothers at extreme ages of reproductive life in several low and middle-income countries. The study utilised reports from demographic and health surveys between 2015-2022. The findings show that factors that engender high neonatal mortality include low and high birth weight, short successive birth intervals, high adolescent female fertility rates, low female literacy rates, lack of post-natal checkups, and multiple deliveries. Moreover, the findings revealed that male babies as well as low and high-birth-weight babies faced elevated risks of neonatal mortality.

The analytical approach used Garcia et al (2023) is quite different. Their study employed a machine learning analytical approach to analyze the impact of public health expenditure and its allocation on neonatal and child mortality from 2012 to 2019 in 147 countries. The study calculated the Generalised propensity scores for each of the countries and then estimated the expenditures associated with each of these dimensions of mortality. The findings showed that a 1% variation in the international purchasing power parity per capita in total public health spending, expenditures in health as well as in other sectors was associated with a variation of -0.635 (95% CI -1.176, -0.095), -2.17 (95% CI -3.051, -1.289) -0.632 (95% CI -1.169, -0.095) in neonatal mortality rates, respectively. The same variation in public expenditures in sectors other than health was associated with a variation of -1.772 (95% CI -6.219, -1.459) on neonatal and under-five mortality, respectively. The study concluded that public health expenditure impacts under-five mortality rates. Moreover, the findings suggest that allocating public revenue to health and other social sectors has different effects on the dimensions of mortality.

Dwomoh (2021) employed geospatial analysis to investigate the determinants of neonatal mortality in Ghana. The study relied on data from the Ghana demographic and health survey and the Ghana maternal health survey conducted between 1998 to 2017. The findings show that population density, smaller household size, low birth weight, and mothers who have multiple births were correlates of neonatal mortality in the country. The study concluded that improving support for women who have multiple deliveries would lead to a reduction in neonatal mortality.

Mitiku (2021) investigated neonatal mortality and its associated factors in Ethiopia. The study was based on the 2016 Ethiopian Demographic and Health Survey. The findings of the study revealed that women with multiple births and male neonates have a higher risk of neonatal mortality. Moreover, breastfeeding of babies after one hour of delivery reduced the risk of neonatal mortality compared to delayed initiation of breastfeeding. The study concluded that there is a need to encourage mothers to use postnatal healthcare services and for pregnant women to deliver in health institutions. In the same vein, Souza, et al (2019) investigated the determinants of neonatal mortality in Brazil. The study followed a case-control approach in the analysis of the cause of death of neonates from 2012 to 2016. The findings showed that newborn characteristics such as fetal congenital anomaly, low birth weight, and poor prenatal care were factors that were significantly associated with neonatal mortality.

3. Methodology

The objective of this study is to investigate the socioeconomic determinants of neonatal mortality in Nigeria. Historical data sequence from 1970 to 2022 on neonatal mortality (NNM), per capita income (GDPC), adolescent female literacy rate (AFLR), life expectancy at birth (LEB), and under-five mortality rate (UD_5) were obtained from the World Bank Development Indicators, 2022. The functional form of the neonatal mortality model is specified as:

$$NNM = f(GDPC, LEB, UD\_5, AFER) \qquad 1$$

Where:
NNM = Neonatal mortality
GDPC = Per-capita Income
LEB= Life expectancy at birth
UD_5 = Under five mortality rate
AFER= Adolescent female Fertility rate

The econometric specification of the neonatal mortality model in equation 1 is stated as

$$LNNM_t = \propto_0 + \propto_1 LGDPC_t + \propto_2 LEB_t + \propto_3 UD\_5_t + \propto_4 LAFER_t + \propto_5 \mu_t \quad (2)$$

The theoretical expectation for the coefficients of equation 3.2 are $\propto_1 < 0$; $\propto_2 < 0$; $\propto_3 > 0$; $\propto_4 > 0$

4. Result and Discussion

4.1 Descriptive Statistics

As a summary of the basic properties of the variables used in the model specification, Table 1 shows the descriptive statistics. The table shows that the variables have positive mean and median values, respectively. Per capita income has the highest maximum value at 379251.6, while the value of under-five mortality rate (UD_5) is the smallest. In addition, the standard deviation of each variable in the model highlights their level of dispersion, and shows that under-five mortality rate has the lowest (3.395223) standard deviation points close to the mean. Per capita income has the largest dispersion (99451.75) from the mean. Moreover, the probability values of the Jarque Bera statistic at a 5% level of significance suggest the non-rejection of the null hypothesis of normal distribution for all the variables.

Table 1. Basic Statistics

	NEONATAL	GDP_P	LEB	UD_5	AFLR
Mean	47.14717	249685.5	47.58177	184.5774	139.5224
Median	49.50000	250500.9	46.51300	201.1000	133.7790
Maximum	66.40000	379251.6	53.63300	284.0000	190.1580
Minimum	34.30000	5410.694	39.71300	107.2000	87.26000
Std. Dev.	8.741757	99451.75	3.395223	46.98729	26.17469
Skewness	0.345159	-1.101118	-0.066191	0.043457	-0.012980
Kurtosis	2.274860	3.959285	2.471325	2.103685	2.585129
Jarque-Bera	2.213560	12.74224	0.655924	1.790814	0.381582
Probability	0.330622	0.001710	0.720390	0.408441	0.826305
Sum	2498.800	13233330	2521.834	9782.600	7394.689
Sum Sq. Dev.	3973.752	5.14E+11	599.4322	114805.9	35625.95
Observations	53	53	53	53	53

Source: Author's Computation, 2025.

4.1.2 Covariance and Correlation Matrix

Correlation and covariance matrix is a useful method for the preliminary assessment of the degree and direction of relationship between variables in a model. The result of the correlation matrix is highlighted in Table 2. The correlation matrix as shown in Table 2 suggests that a weak correlation between neonatal mortality (NNM) and per capita income (GDP_P) (8%). Also, the correlation as between neonatal mortality (NMM) and adolescent female literacy rate (AFLR) is positive and significant (88%).

Table 2 Covariance and Correlation Matrix

Covariance Correlation	NEONATAL	GDP_P	LEB	UD_5	AFLR
NNM	74.97645				
	1.000000				
GDP_P	73363.59	9.70E+09			
	0.086009	1.000000			
LEB	-28.25165	-49100.99	11.31004		

	-0.970173	-0.148212	1.000000		
UD_5	399.1186	455719.7	-154.5578	2166.149	
	0.990365	0.099398	-0.987449	1.000000	
AFLR	199.2734	768515.8	-71.90649	1057.241	672.1877
	0.887650	0.300906	-0.824690	0.876163	1.000000

Source: Author's Computation, 2025.

The covariance matrix shows that the direction of movement as well as the correlation between life expectancy at birth (LEB) and adolescent female literacy rate (AFLR) is negative and significant at 72% and 82%, respectively. In addition, the covariance of neonatal mortality and life expectancy is also weak and negative.

4.1.3 Unit Root Test

The result of the KPSS and ADF unit root tests at levels and first difference are shown in Table 3 below. The KPSS and ADF tests were conducted at intercept, and the result shows the test statistic and critical values/P.values (in brackets) of variables in the model. The output of the KPSS test suggests that the test statistic is greater than the critical value, for all the variables at levels except GDP per capita that has a critical value that is higher than the test statistics at I (0). Moreover, all the model variables are stationary at first difference. Thus, the KPSS tests shows a mixed order of integration. In the same vein, the ADF unit root test shows that the variables (NNM, UD_5, AFLR) were stationary at first difference, except for GDPC that was stationary at levels.

Table 3. KPSS and ADF Unit Root Tests

TEST	*NNM*	GDPC	*LEB*	*UD_5*	*AFLR*
$KPSS_I^*$	0.955194 (0.463000)	0.105978 (0.463000)	0.903975 (0.463000)	0.963275 (0.46300)	0.891916 (0.463000)
$\Delta KPSS_I^*$	0.257191 (0.463000)	0.202975 (0.463000)	0.154866 (0.463000)	0.164158 (0.463000)	0.176225 (0.463000)
ADF_I^*	-2.925169 (0.5931)	-2.502373 (0.0198)	-2.919952 (0.9138)	-2.922449 (0.9560)	-2.918718 (0.9964)
ΔADF_I^*	-2.925169 (0.0033)	-2.919952 (0.0000)	-2.919952 (0.0783)	-2.922449 (0.0000)	-2.919952 (0.0002)

Source: Author's Computation, 2024. N/B: Critical values/P. values ().

Accordingly, since the Autoregressive Distributed Lag approach (ARDL) permits estimation of variables with mixed order of integration, it is employed in the econometric analysis of the neonatal mortality model. Pesaran and Shin (1999) developed the ARDL for the cointegration analysis of models with variables having mixed unit root properties. Improvements in the ARDL method ensures the estimation of the dependent and explanatory variables with different lags as well as the use of fixed regressors, which is impossible in other conventional methods used for the test of cointegration. Moreover, the ARDL gives robust estimates even for small data sets, and is therefore suitable for the present study that spans from 1970 to 2022.

The general specification of the ARDL(p,q) is as follows:

$$\Delta y_t = a_0 + \sum_{i=1}^{p} a_{1i}\Delta\gamma_{t-1} + \sum_{j=1}^{q} \gamma_j X_{t-j} + \varepsilon_t$$
3

where y_t is the dependent variable, X_t is a vector of the dynamic explanatory variables which and ε_t is the error term that should be normally distributed with zero mean and constant variance $\varepsilon_t \sim N(0, \sigma^2)$, p and q are the number of lags for dependent and explanatory variables; respectively.

To test for whether there is long-run relationship (cointegration) between y_t and X_t, the bound test equation is specified as follows:

$$\Delta y_t = \beta_0 + \sum_{i=1}^{p} \beta_{1i}\Delta\gamma_{t-1} + \sum_{j=1}^{q} \varphi_{1i}\Delta X_{t-j} + \omega_0\gamma_{t-1} + \omega_1 X_{t-1} + \vartheta_t$$
4

where β_1, and φ_1 are the parameters of the short-run relationship; ω_0 and ω_1 are the parameters of long-run relationship. Accordingly, cointegration between y_t and X_t exists if the null hypothesis, H_0: $\omega_0 = \omega_1 = 0$ is rejected against the alternative H_1: $\omega_0 \neq \omega_1 \neq 0$.

In addition, the existence of cointegration relationship in the models, also necessitates an evaluation of the error correction model (ECM). The equation of the ECM is specified as follows:

$$\Delta y_t = \beta_0 + \sum_{i=1}^{p} \beta_{1i}\Delta\gamma_{t-1} + \sum_{j=1}^{q} \varphi_{1i}\Delta X_{t-j} + \emptyset_0 ECM_{t-1} + \vartheta_t$$
5

In actual fact, the term of the ECM_{t-1} is derived from the lagged value of the error term (μ_{t-1}) of the following long-run relationships:

$$y_t = a_0 + \sum_{j=1}^{q} \gamma_j X_t + \mu_t$$
6

$$ECM_{t-1} = \mu_{t-1} = y_{t-1} - \sum_{j=1}^{q} \gamma_j X_{t-1}$$

7

and $\emptyset_0 < 0$ is the parameter of the error correction model ECM_{t-1} that measures the speed of adjustment from any shocks in the short-run back towards the long-run.

4.1.2 Lag Order Criteria

The mixed levels of integration suggested by the unit root test attest to the applicability of the ARDL cointegration approach. However, as a prerequisite for the application the ARDL cointegration approach, the optimal lag length of the specified model must be verified. Accordingly, Figure 2 is the result of the optimal model selection as chosen by the Akaike Information Criteria (AIC). Accordingly, the model with the lowest AIC is more preferred. Figure 2 shows that ARDL model 3.0.0.0 is preferred to other models.

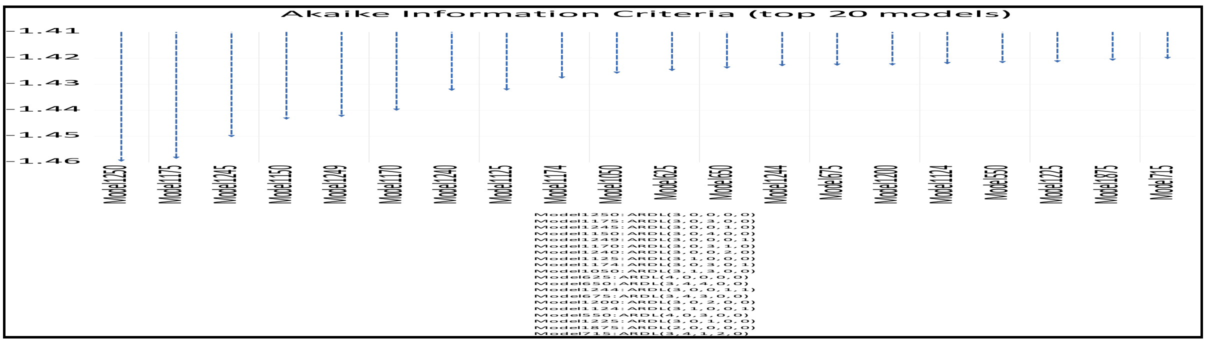

Figure 2. Akaike Information Model Order Selection

4.2. ARDL Bound Test Output

The study investigated the existence of cointegration between variables in the neonatal mortality model. Table 4 is the output of the bound test.

Table 4 ARDL Bound Test Output

Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	7.425859	10%	2.2	3.09
k	4	5%	2.56	3.49
		2.5%	2.88	3.87
		1%	3.29	4.37

Source: Author's Computation, 2025.

The null hypothesis of the bound test posits no level relationship among the variables in the neonatal mortality model. This hypothesis could be rejected if the computed F-statistic exceeds the critical lower I(0) and upper I(1) bounds at all the conventional significance levels. Accordingly, Table 4 show that the F-statistic value (7.425859) exceeds values at the critical values of the lower I(0) and upper I(I) bounds at the 10%, 5%, 2.5% and 1% significant levels. Hence, this indicates evidence of a cointegration relationship between neonatal mortality (NNM), percapita income (GDP_P), life expectancy at birth (LEB), under-five mortality (UD_5) rate and adolescent female literacy rate (AFLR) over the study period.

4.2.1 ARDL Long run Output

Table 3 presents the long run coefficients of the ARDL neonatal mortality model. The result indicates that per-capita income depresses neonatal mortality, and the outcome is statistically significant. Specifically, a 1% change in per capita income is associated with 19% decline in the rate of neonatal mortality. This outcome implies that improvement in percapita income (GDP_P) could lead to a decrease in the number of deaths among new born babies in the long run. Moreover, the outcome shows that improvement in life expectancy (LEB) index is inversely related with the neonatal mortality rate. The result suggests that a unit rise in life expectancy will lead to *18%* decrease in neonatal mortality. In addition, the study shows that the coefficient of under-five mortality is positive and statistically significant at the 5% level significance level. This outcome supports the proposition of that the rise in the mortality of children under five years may not imply a fall in the number of deaths of children who die within their first 28 days of birth. The coefficient of under-five mortality shows that a unit rise in the under-five mortality rate will cause neonatal mortality to increase by 0.17%. Furthermore, the sign of the coefficient of adolescent female literacy rate is not in accordance with the apriori expectation.

Table 4. Long-run Output of Neonatal Mortality Model

Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
LOG(GDP_P)	-0.018884	0.005004	-3.773611	0.0007
LEB	-0.017828	0.008326	-2.141302	0.0405
UD_5	0.001710	0.000794	2.152574	0.0395
LOG(AFLR)	0.324091	0.085039	3.811068	0.0006
C	2.998979	0.321440	9.329824	0.0000

Source: Author's Computation, 2025.

4.2.2 ARDL Short-run Output

Table 5. Short-run Output of Neonatal Mortality Model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLOG(GDP_P)	-0.001150	0.000493	-2.330264	0.0267
DLOG(GDP_P(-1))	0.001486	0.000505	2.943834	0.0062
DLOG(GDP_P (-2))	0.001754	0.000439	3.991530	0.0004
D(LEB)	0.000929	0.001261	0.736498	0.4671
D(UD_5)	0.003683	0.000702	5.243801	0.0000
D(UD_5(-1))	-0.003819	0.000822	-4.646309	0.0001
DLOG(AFLR)	-0.007974	0.010016	-0.796086	0.4322
DLOG(AFLR(-1))	-0.044199	0.013969	-3.164056	0.0036
DLOG(AFLR(-2))	-0.035089	0.012147	-2.888599	0.0071
DLOG(AFLR(-3))	-0.034663	0.011421	-3.034968	0.0049
CointEq(-1)*	-0.230097	0.031915	-7.209786	0.0000
R-squared	0.977992	Mean dependent var		-0.012245
Adjusted R-squared	0.969818	S.D. dependent var		0.009235
S.E. of regression	0.001604	Akaike info criterion		-9.797114
Sum squared resid	9.01E-05	Schwarz criterion		-9.256594
Log likelihood	254.0293	Hannan-Quinn criter.		-9.592041
Durbin-Watson stat	2.168638			

Source: Author's Computation, 2025.

Table 5 shows the result of the ECM and short-run estimates of the ARDL neonatal mortality model. The findings show that the parameters are statistically significant at various lags and the coefficient of the error correction mechanism (ECM) is correctly signed. The value of the ECM suggests that a deviation from long run equilibrium in one year will be corrected the next year at a speed of 23%. This outcome implies that the system might oscillate for some time before equilibrium is restored. Interestingly, the table also shows the mixed impact of in per-capita income on neonatal mortality in the short run. It could be deduced that a higher percapita incomes, pregnant women and households may probably respond to child health services more positively and this will cause the decline in neonatal mortality. However, the outcome could be counteracted in succeeding years, if there is a deterioration in the percapita of households. In addition, the table shows that increasing adolescent female literacy rate (AFLR) could cause the decline of neonatal mortality. Table 5 shows that a unit change in AFLR would probably lead to a 0.079% and 3.4% fall in the rate of neonatal mortality in the current lag and third lags, respectively. Moreover, Table 5 shows that 97% of variation in the dependent variable is explained by the independent variables employed in the ARDL model. The Durbin Watson (D.W) statistic value (2.168638) attests to the absence of serial correlation in the estimated regression model.

4.2.3 Diagnostic Tests

Tests for Serial correlation, Heteroscedasticity and Normality

Breusch-Godfrey (LM) Test for Serial Correlation			
F-statistic	0.940691	Prob. F(2,28)	0.4023
Obs*R-squared	3.085123	Prob. Chi-Square(2)	0.2138
Breusch -Pagan-Godfrey Test for Heteroscedasticity			
F-statistic	0.376643	Prob. F(18,30)	0.9835
Obs*R-squared	9.032156	Prob. Chi-Square(18)	0.9590
Scaled explained SS	3.587755	Prob. Chi-Square(18)	0.9999

Table 6. Diagnostic Test Output

Source: Author's Computation, 2025.

Table 5 displays the findings from the Breusch-Godfrey (BG) serial correlation LM test and the heteroscedasticity test. Highlights from Table 5 indicate that the null hypotheses of no serial correlation in the residuals cannot be rejected as the p-values of the F-statistic and Obs*R-squared tests are greater than the 5% significance level. Moreover, the result shows that the absence of heteroscedasticity in the model.

Figure 3 shows that the Jarque-Bera (J.B) test for normality. The J.B. probability value (0.91) exceeds the 5% significance threshold and affirms the apriori expectations for normality**.**

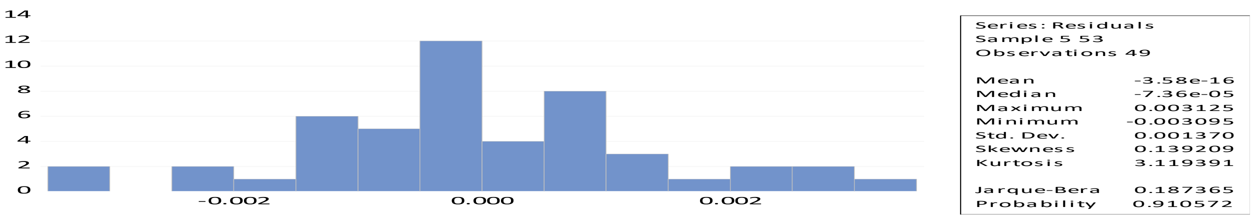

Figure 3. Normality Test Output

Stability Tests

Figure 3. shows the output of the cumulative sum of squares (CUSUM) and the cumulative Squares (CUSUM of Square) tests for parameter stability. The output indicates that the CUSUM and CUSUM of Squares are largely within the 5% critical values. Although in certain periods they move slightly beyond the band lines, they return to the critical bandwidths. Therefore, Figure 4 suggests that the model parameters are stable over time.

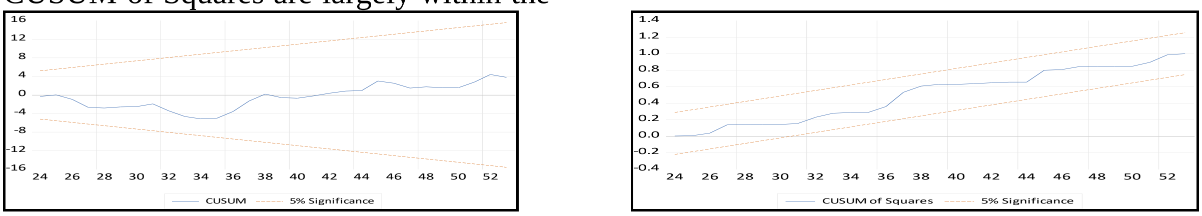

Figure 4. CUSUM and CUSUM OF Squares output

4.3 Discussion of Findings

The neonatal mortality rate is a critical indicator of the well-being of a society. Hence, it is expected that the number of death of neonates should be insignificant in countries with qualitatively high economic and socio-demographic indices. The bound test output suggests that there is a long run relationship between neonatal mortality, per capita income, adolescent female literacy rate, under five mortality and life expectancy during the period under review. This outcome implies that neonatal mortality rate could be determined by both economic and socio-demographic factors. Consequently, the study rejects the null hypothesis of no relationship between per capita income, adolescent female literacy rate, under five mortality, life expectancy at birth and neonatal mortality in Nigeria.

Moreover, the long run estimates show that income depresses the growth rate of neonatal mortality. This outcome may not be farfetched because the survival of a new born baby could be connected to the ability of the pregnant woman and/or household to afford quality maternal healthcare services and qualified skilled birth attendants. In Nigeria, maternal and child health care services are supported by both the federal and state governments. Accordingly, the study argues that, depending on the level of income of the household, the risk of child death occasioned by delays in seeking health services by pregnant women can be mitigated, ceteris paribus. In the short run, the findings show the mixed influence of per capita income on the rate of neonatal mortality. The findings revealed that improvement in income may lead to a decline in neonatal mortality in the current period, but this is counteracted in successive periods. The outcome in the short run shows how a change in the performance of the economic through its impact on household income can affect the rate of neonatal mortality. Moreover, the findings suggests that since the first 28 days of life portend a high-risk span in the life of infants, the risk in the case of low-income countries is exacerbated by the number of families below the poverty line who may be unable to afford expensive medical maternal and child health care expenses. Interestingly, this outcome is consistent with the findings of Zilidis and Hadjichristodoulou (2020). Consequently, the study rejects the proposition that percapita income has no significant impact on neonatal mortality.

The findings also show that the index of life expectancy at birth (LEB) is a significant predictor of neonatal mortality in Nigeria in the long run period. The coefficient of LEB is negative and statistically significant, suggesting that a unit change in the index of LEB will cause a 17% decline in the neonatal mortality rate. Roffia, et al (2023) observed that life expectancy is determined by several socioeconomic factors. Hence, the findings suggest that improvements in the socioeconomic that enhance the well-being of pregnant women and infants could lead to a decline in neonatal mortality rates. For instance, improvements in the rate of per capita health expenditure, GDP, social spending and the physician density ratio as correlates of life expectancy at birth would cause a fall neonatal mortality Consequently, the study does not accept the null hypothesis, which asserts that life expectancy at birth is not a significant determinant of neonatal mortality.

Interestingly, the results show the mixed impact of adolescent female literacy rate (AFLR) on neonatal mortality in the short and long run periods. The coefficients of AFLR in the short run align with theoretical expectations, as they indicate an inverse relationship between the adolescent female literacy rate and neonatal mortality. This result implies that improving access to education for women, pregnant women, and adolescents could lead to better health-seeking behaviours, improved care for pregnancy and children after delivery. Similar findings on the importance of female education to child health were obtained by Sidi-Yakhlef, et al (2021) and Shiferaw et al (2020). However, the long-run coefficient of AFLR is positive, and is not in conformity with the a priori expectations. This outcome suggests the need to sustained improvement on the number of the girl child that have access to education across the country. These would result to better knowledge of reproductive health care decisions and pregnancy care. This finding negates the proposition that adolescent female literacy rate has no significant impact on neonatal mortality.

5.Conclusion and Recommendations

A micro-analysis of events at the level of the household in Nigeria shows that the loss of a newborn child disturbs the family unit and throws the immediate community into a mournful mood. Consequently, the present study is indicative of the imperative of reducing neonatal mortality in the country. The outcome shows how changes in income, life expectancy at birth, adolescent female literacy rate and under-five mortality rate as quality-of-life indicators can contribute to the variation in neonatal mortality. The study concludes that given that Nigeria is a low-income country, by examining how changes in income and socio-demographic factors influence the birth and survival of new born babies, it provides vital insights on effective policy solutions that could be proffered, especially in the areas of girl-child education, improving life expectancy and household disposable income. Consequently, the study advocates for the stabilization of the macroeconomy in such ways that would grow the domestic economy and improve per capita income. Moreover, the study recommends the use of targeted education intervention programmes for adolescent female children in low income rural and urban areas as an effective long-term mechanism to enhance improvement in child health outcomes.

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