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PUBLIC HEALTH EXPENDITURE AND MATERNAL MORTALITY IN NIGERIA: EVIDENCE FROM THE ARDL BOUNDS TESTING APPROACH (1990–2021)

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ABSTRACT
Maternal mortality remains a critical public health challenge in Nigeria, accounting for approximately 28.5% of global maternal deaths. Paradoxically, this persistent high mortality rate has occurred alongside sustained increases in public health expenditure over the past two decades. This study examines the effect of public health expenditure on maternal mortality in Nigeria, using annual time-series data from 1990 to 2021. The Autoregressive Distributed Lag (ARDL) bounds testing approach was employed to estimate both short-run and long-run relationships, with female education and fertility rate included as control variables. The bounds test confirms the existence of a long-run equilibrium relationship (F-statistic = 5.872 > 4.25 upper bound). The long-run results reveal that public health expenditure significantly reduces maternal mortality with an elasticity of -0.324. Female education exerts the strongest negative effect (-0.467), while fertility rate is positively associated with maternal deaths (0.589). The short-run effects are weaker, with public health expenditure showing a coefficient of -0.287. The error correction term is negative and significant (-0.885), indicating that 88.5% of short-run disequilibria are corrected within one year. The study concludes that public health expenditure is a necessary but insufficient condition for maternal mortality reduction in Nigeria. Recommendations include sustained health financing, targeted investment in female secondary education, and expanded family planning services.
Keywords: Maternal mortality, public health expenditure, female education, ARDL, Nigeria

1.0 INTRODUCTION
Maternal mortality remains a critical metric for assessing the structural integrity of national healthcare systems and broader socio-economic development. According to the World Health Organization (2020), maternal mortality is defined as the death of a woman while pregnant or within 42 days of the termination of pregnancy, irrespective of the duration or site of the pregnancy. Maternal mortality reflects the intersection of clinical efficacy and social equity. While the global Maternal Mortality Ratio (MMR) declined by 34% between 2000 and 2020 (WHO, 2023), this progress is marked by profound regional disparities. Sub-Saharan Africa remains the epicentre of this crisis, accounting for 70% of global maternal deaths with a regional MMR of 536 per 100,000 live births (UNICEF, 2024).

Nigeria's maternal health landscape is particularly precarious. Despite being the continent's largest economy, it accounts for approximately 28.5% of global maternal deaths, with annual fatalities rising from 61,000 in 2000 to 82,000 in 2020, representing a 43.4% increase (World Bank, 2024). The current MMR of 512 per 100,000 live births underscores a stark reality. A

Nigerian woman faces a 1 in 19 lifetime risk of maternal death, compared to just 1 in 4,900 in high-income countries (WHO, 2023).

A significant paradox characterizes the Nigerian healthcare landscape. Maternal mortality has trended upward despite a 39.5% increase in public health expenditure over the last two decades (World Bank, 2024). Although government spending reached 5.05% of Gross Domestic Product (GDP) in 2005 before stabilizing at approximately 3.1%, it remains well below the 15% threshold mandated by the 2001 Abuja Declaration (CBN, 2022). This fiscal gap is compounded by structural bottlenecks, including a doctor-to-population ratio of 0.34 per 1,000, which is far below the WHO recommendation of 1.0, and an inequitable distribution of funds that prioritizes tertiary care over primary and maternal health services (Balogun et al., 2022).

The existing literature on Nigeria's health-expenditure nexus has focused heavily on infant mortality and life expectancy (Ikechukwu, 2019; Oladosu et al., 2022), often overlooking the specific nuances of maternal survival. Furthermore, few studies have empirically accounted for the mediating roles of female education and fertility rates in determining the efficacy of health spending. Consequently, a critical knowledge gap exists regarding whether increased public health expenditure has the elasticity required to reduce maternal mortality in the presence of these socio-demographic constraints.

This study addresses this gap by empirically investigating the short-run and long-run effects of public health expenditure on maternal mortality in Nigeria from 1990 to 2021. The study hypothesizes that public health expenditure exerts a significant, negative effect on maternal mortality (H_1), countering the null hypothesis (H_0) of statistical insignificance. By incorporating variables such as female education and fertility, this study aims to provide a more granular understanding of health-sector fiscal performance, offering evidence-based insights to align Nigerian health policy with SDG 3.1 targets.

2.0 LITERATURE REVIEW

This chapter provides a comprehensive review of the theoretical frameworks and empirical literature relevant to understanding the relationship between public health expenditure and maternal mortality. To establish a robust analytical foundation, the review is structured into four distinct sections. First, the conceptual review clarifies the definitions, metrics, and contextual dynamics of public health spending and maternal mortality, with a particular focus on the Nigerian landscape. Second, the theoretical review explores the foundational models guiding this study, specifically Michael Grossman's Health Capital Theory and Ronald Andersen's Behavioral Model of Health Services Use, to illustrate how public investments and socio-economic factors translate into health outcomes.

Third, the empirical review synthesizes recent global and regional studies, highlighting the methodologies and findings of scholars who have analysed the real-world impact of health spending on maternal survival. Finally, the chapter identifies critical gaps in the existing literature, establishing the methodological and conceptual justifications for the variables and analytical framework adopted in this study.

2.1 Conceptual Review

2.1.1 Public Health Expenditure

Public health expenditure refers to government spending on healthcare services, including preventive, curative, rehabilitative, and administrative health services (World Health

Organization, 2015). It encompasses recurrent expenditure (salaries, drugs, and supplies, among others) and capital expenditure (infrastructure and equipment, among others). Public health expenditure is typically measured as a percentage of GDP or as per capita spending in constant international dollars.

Factors influencing public health expenditure include GDP per capita, population age structure, disease burden, healthcare infrastructure, and government policy priorities (World Bank, 2017; Nketiah-Amponsah, 2019). In Nigeria, public health expenditure has historically been constrained by competing demands from other sectors, low tax revenues, and reliance on volatile oil revenues.

2.1.2 Maternal Mortality

Maternal mortality is defined as the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the duration and site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management, but not from accidental or incidental causes (WHO, 2012). The Maternal Mortality Ratio (MMR) is the number of maternal deaths per 100,000 live births.

The major causes of maternal mortality are classified as direct obstetric complications (haemorrhage, sepsis, eclampsia, obstructed labour, unsafe abortion) and indirect causes (anaemia, malaria, HIV/AIDS, cardiovascular diseases) (Neal et al., 2016; Collier & Molina, 2019). Socio-economic determinants include female education, household income, healthcare access and quality, cultural practices, and family support systems (Oye-Adeniran et al., 2014; Alves et al., 2013).

2.2 Theoretical Review

2.2.1 Health Capital Theory (Grossman, 1972)

The Health Capital Theory, developed by Michael Grossman (1972), provides the primary theoretical foundation for this study. The theory posits that health is a form of capital stock that depreciates over time but can be replenished through deliberate investment. Individuals derive utility from good health (as a consumption good) and benefit economically from improved health through enhanced productivity (as an investment good).

The theory conceptualises health as both a final consumption good and a capital good. The production function can be expressed as:

$$H=f(HC,EDU,NUT,LIF)$$

Where H represents health status, HC represents healthcare inputs (including public health expenditure), EDU represents education, NUT represents nutrition, and LIF represents lifestyle factors. In the context of this study, maternal mortality represents poor or depreciated health capital among women of reproductive age. Public health expenditure on maternal health services (antenatal care, skilled birth attendance, emergency obstetric care) is viewed as investment in health capital. The theory predicts that increased health expenditure should lead to improved health outcomes, including reduced maternal mortality.

2.2.2 Andersen's Behavioral Model of Health Services Use (Andersen, 1968)

The Andersen Behavioral Model, developed by Ronald Andersen (1968), explains factors influencing individuals' utilisation of health services. The model identifies three categories of determinants, which include predisposing characteristics (age, education, occupation, cultural beliefs), enabling resources (income, health insurance, knowledge, accessibility), and need factors (perceived and evaluated health status).

This model is relevant to understanding how female education (a predisposing characteristic) influences maternal health outcomes. Higher educational attainment correlates with greater health literacy, better recognition of danger signs, and increased likelihood of seeking skilled care during pregnancy and childbirth. The model also explains how enabling resources, including public health expenditure that improves healthcare infrastructure and subsidises costs, reduce barriers to accessing maternal health services.

2.3 Empirical Literature Review

2.3.1 Public Health Expenditure and Maternal Mortality

Several empirical studies have examined the relationship between public health expenditure and maternal mortality, with mixed findings across different contexts.

Igbinedion (2016) investigated the causal relationship between public health expenditure and maternal mortality in Nigeria using cointegration and Granger causality analysis. The study employed annual time series data and found a long-run equilibrium relationship where increases in public health expenditure led to reductions in maternal mortality. The study concluded that health expenditure Granger-causes maternal mortality in Nigeria.

Chidinma (2024) analysed the effect of public health expenditure on maternal mortality in Nigeria using ARDL bounds testing with annual data from 1990 to 2022. The study found a significant long-run inverse relationship between public health expenditure and maternal mortality, although the short-run effect was statistically insignificant. The error correction term was negative and significant, confirming long-run equilibrium adjustment.

Makuta and O'Hare (2015) conducted a panel study of 43 Sub-Saharan African countries from 2000 to 2011 using fixed-effects and interaction models. The study found that higher public health spending is significantly associated with lower maternal mortality, but only in countries with strong governance quality. This suggests that institutional effectiveness mediates the spending-outcome link.

Nicholas, Edward, and Bernardin (2016) employed panel regression analysis across selected Sub-Saharan African countries using fixed effect estimators. The study found that both total and public health expenditure significantly reduced maternal mortality across the region. The study emphasised the need for increasing public health budgets to improve maternal outcomes.

Rezaei, Matin, Karyani, Woldemichael, and Soofi (2016) employed panel data from 1990 to 2010 using random-effects regression to study determinants of maternal mortality across low, middle, and high-income countries. Controlling for fertility, female education, and urbanisation, the study found that higher per-capita public health expenditure has a significant inverse relationship with MMR.

Gao et al. (2023) examined the influence of household socio-economic factors on maternal survival in Nigeria using descriptive and regression analysis. Their findings revealed that GDP per capita and maternal education levels significantly reduced maternal mortality, although the study did not directly evaluate health expenditure.

2.3.2 Literature Gaps

The empirical literature reviewed reveals several gaps. First, most studies have focused on infant mortality or life expectancy rather than maternal mortality specifically. Second, existing studies have paid inadequate attention to the mediating role of female education and fertility in the health expenditure-maternal mortality nexus. Third, few studies have employed the ARDL bounds testing approach which is appropriate for small samples and mixed order of integration. This study addresses these gaps by focusing specifically on maternal mortality, incorporating female education and fertility as control variables, and employing the ARDL methodology.

3.0 METHODOLOGY

3.1 Theoretical Framework

This study is anchored in Grossman's (1972) Health Capital Theory, which provides the theoretical foundation for modelling the relationship between health expenditure and health outcomes. According to the theory, health capital (H) is produced using healthcare inputs (HC), education (EDU), and other factors. The production function can be expressed as:

$Ht=f(HCt,EDUt,Xt)$

Where X represents other determinants of health. In the context of this study, Maternal Mortality Rate (MMR) is an inverse indicator of health capital. Public Health Expenditure (PHE) represents the healthcare input. Female Education (EDU) and Fertility rate (FER) are included as additional determinants. The theoretical model is specified as:

$MMRt=f(PHEt,EDUt,FERt)$

3.2 Model Specification

Following the empirical specifications of Novignon, Olakojo, and Nonvignon (2012) and Arshad and Malik (2015), the following log-linear model is specified:

$lnMMRt=\beta 0+\beta 1lnPHEt+\beta 2lnEDUt+\beta 3lnFERt+\epsilon t$

3.3 Estimation Technique

The study employs the Autoregressive Distributed Lag (ARDL) bounds testing approach developed by Pesaran, Shin, and Smith (2001). This technique is chosen for several reasons. First, it is applicable regardless of whether the variables are purely I(0), purely I(1), or mutually cointegrated. Second, it is appropriate for small sample sizes, such as the 32 observations in this study. Third, it provides unbiased estimates of both short-run and long-run relationships. Fourth, it addresses potential endogeneity issues by including appropriate lags of both dependent and independent variables.

The ARDL representation of the model is specified as:

$$\Delta \ln MMR_t = \alpha_0 + \sum_{i=1}^{p} \alpha_1 \Delta \ln MMR_{t-i} + \sum_{i=0}^{p} \alpha_2 \Delta \ln PHE_{t-i} + \sum_{i=0}^{p} \alpha_3 \Delta \ln EDU_{t-i} + \sum_{i=0}^{p} \alpha_4 \Delta \ln FER_{t-i} + \delta_1 \ln MMR_{t-1} + \delta_2$$

The bounds test for cointegration involves testing the null hypothesis of no long-run relationship:

$$H_0 : \delta_1 = \delta_2 = \delta_3 = \delta_4 = 0$$

against the alternative hypothesis:

$$H_1 : \text{At least one } \delta_i \neq 0$$

The computed F-statistic is compared against the critical value bounds provided by Pesaran et al. (2001). If the F-statistic exceeds the upper bound I(1) critical value, the null hypothesis of no cointegration is rejected. If cointegration is established, the long-run coefficients are derived from the ARDL model, and the error correction representation is estimated as:

$$\Delta \ln MMR_t = \alpha_0 + \sum_{i=1}^{p} \beta_1 \Delta \ln MMR_{t-i} + \sum_{i=0}^{p} \beta_2 \Delta \ln PHE_{t-i} + \sum_{i=0}^{p} \beta_3 \Delta \ln EDU_{t-i} + \sum_{i=0}^{p} \beta_4 \Delta \ln FER_{t-i} + \lambda ECM_{t-1} + \nu_t$$

Where λ is the error correction coefficient, expected to be negative and statistically significant, indicating the speed of adjustment back to long-run equilibrium following a short-run shock.

3.4 Data and Variable Measurement

The study employs annual time-series data spanning 1990 to 2021, yielding 32 observations. The choice of this period is guided by data availability and alignment with global development goals. All data were sourced from the World Development Indicators (WDI) database of the World Bank and the Global Health Observatory of the World Health Organization.

Table 1: Variable Definitions and Measurements

Variable	Code	Definition	Measurement	Source
Maternal Mortality Ratio	MMR	Number of maternal deaths per 100,000 live births	Ratio	WHO
Public Health Expenditure	PHE	Government health expenditure as % of GDP	Percentage	WDI
Female Education	EDU	Female secondary school enrollment (% gross)	Percentage	WDI
Fertility Rate	FER	Total fertility rate (births per woman)	Rate	WDI

All variables are transformed into natural logarithms to normalise the distribution, reduce heteroscedasticity, and allow the coefficients to be interpreted as elasticities.
Source: Computed by the author using the data collected.

3.5 Analytical Procedure

The empirical analysis proceeds in five stages. First, descriptive statistics and correlation analysis are conducted to understand the basic properties of the data and preliminary relationships among variables. Second, unit root tests (Augmented Dickey-Fuller and Phillips-Perron) are performed to determine the order of integration of each variable and ensure that no variable is I(2). Third, the ARDL bounds test is conducted to determine whether a long-run cointegrating relationship exists. Fourth, the ARDL model is estimated to

obtain short-run and long-run coefficients. Fifth, diagnostic tests (autocorrelation, heteroscedasticity, normality, and stability) are conducted to validate the model.

4.0 RESULTS AND DISCUSSION

4.1 Descriptive Statistics

Table 2 presents the descriptive statistics for all variables in both level and logarithmic forms over the period 1990 to 2021.

Table 2: Descriptive Statistics (1990-2021, N = 32)

Variable	Mean	Std. Dev.	Minimum	Maximum
MMR	972.59	113.43	814.00	1200.00
PHE (%)	3.10	0.72	2.00	5.05
EDU (%)	34.20	9.95	20.67	50.33
FER	5.60	0.54	4.64	6.46
lnMMR	6.876	0.116	6.702	7.090
lnPHE	1.088	0.286	0.693	1.620
lnEDU	3.501	0.310	3.029	3.919
lnFER	1.715	0.096	1.534	1.866

Source: Researcher's computation, 2025

The descriptive statistics reveal several important patterns. The mean maternal mortality ratio of 973 deaths per 100,000 live births is exceptionally high by global standards, though the standard deviation of 113.43 indicates considerable variation over the period. The minimum value of 814 and maximum of 1,200 indicate that maternal mortality has fluctuated rather than showing consistent decline.

Public health expenditure averages only 3.10% of GDP, far below the 15% Abuja Declaration target. The standard deviation of 0.72 indicates relative stability, though the range from 2.00% to 5.05% shows some variation. Female secondary school enrolment averages 34.20%, indicating that only one-third of eligible girls attend secondary school. The minimum of 20.67% and maximum of 50.33% show improvement over time, though starting from a very low base. The total fertility rate averages 5.60 births per woman, which remains high despite declining from 6.46 to 4.64 over the period.

The correlation matrix presented in Table 3 reveals that MMR is negatively correlated with PHE (-0.424) and EDU (-0.514), and positively correlated with FER (0.628). These preliminary correlations align with theoretical expectations.

Table 3: Pearson Correlation Matrix

Variables	lnMMR	lnPHE	lnEDU	lnFER
lnMMR	1.000			
lnPHE	-0.424	1.000		
lnEDU	-0.514	0.356	1.000	
lnFER	0.628	-0.287	-0.582	1.000

Source: Researcher's Computation (2025).

Table 4.2 shows that maternal mortality is negatively correlated with public health expenditure (-0.424) and female education (0.514) but positively correlated with fertility rate (0.628). This suggests that higher health spending and better female education are associated with lower maternal mortality, whereas higher fertility tends to increase maternal deaths. Furthermore, the relatively low correlations among the explanatory variables indicate that multicollinearity is unlikely to be a concern for the ARDL estimation.

4.2 Unit Root Tests

Before estimating the ARDL model, the stationarity properties of all variables are examined using the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests. The ARDL approach requires that no variable be integrated of order two, I(2). **Table 4 presents the unit root test results.**

Table 4: Augmented Dickey-Fuller Unit Root Tests

Variable	Level	First Difference	Order		
	Test Statistic	p-value	Test Statistic	p-value	
lnMMR	-1.245	0.823	-4.876***	0.001	I(1)
lnPHE	-2.456	0.147	-4.543***	0.002	I(1)
lnEDU	-2.134	0.421	-3.876***	0.007	I(1)
lnFER	-2.478	0.314	-3.987***	0.005	I(1)

*Notes: ***, **, * indicate significance at 1%, 5%, and 10% levels respectively. Critical value at 5% is -2.981.*

The ADF test results indicate that all variables are non-stationary at level, as the test statistics are less than the critical value in absolute magnitude and p-values exceed 0.05. However, after first differencing, all variables become stationary at the 1% significance level. The PP test results that is shown in Table 5 confirm these findings. Therefore, all variables are

integrated of order one, I(1). No variable is I(2), satisfying the precondition for the ARDL bounds testing approach.

Table 5: Phillips-Perron (PP) Unit Root Test Results

Variable	Level	First Difference	Order of Integration
lnMMR	-1.198 (0.801)	-4.912*** (0.001)	I(1)
lnPHE	-2.512 (0.134)	-4.598*** (0.002)	I(1)
lnEDU	-2.198 (0.398)	-3.912*** (0.007)	I(1)
lnFER	-2.543 (0.287)	-4.032*** (0.005)	I(1)

Source: Researcher's Computation (2025).

4.3 Bounds Test for Cointegration

Table 6 presents the ARDL bounds test results for cointegration among the variables.

Table 6: ARDL Bounds Test Results

F-Statistic	Significance	I(0) Bound	I(1) Bound	Decision
5.872	10%	2.45	3.52	Cointegrated
	5%	2.87	4.25	Cointegrated
	2.5%	3.19	4.29	Cointegrated
	1%	3.65	4.66	Cointegrated

Critical values are from Pesaran et al. (2001) for k = 3 (number of regressors) with n = 31.

The computed F-statistic of 5.872 exceeds the upper bound I(1) critical value at all significance levels, including the 1% level (4.66). Therefore, the null hypothesis of no cointegration is rejected. This finding confirms the existence of a stable long-run equilibrium relationship among public health expenditure, maternal mortality, female education, and fertility rate in Nigeria from 1990 to 2021.

This result has important implications. It indicates that the variables do not drift arbitrarily apart; rather, maintain a systematic association over time. Policy interventions targeting any of these variables will have sustained, predictable effects on maternal mortality in the long run.

4.4 Long-Run and Short-Run Estimates

Table 7 presents the ARDL (2,1,1,1) estimates for both the long-run and short-run relationships.

Table 7: ARDL (2,1,1,1) Estimates

Variable	Short-Run Coefficient	Std. Error	t-Statistic	Long-Run Coefficient	Std. Error	t-Statistic
Constant	8.4523***	1.2341	6.848	-	-	-
lnPHE	-0.2874**	0.1045	-2.751	-0.3241**	0.1214	-2.671
lnEDU	-0.4153***	0.1204	-3.450	-0.4672***	0.1387	-3.368
lnFER	0.5231***	0.1382	3.786	0.5894***	0.1621	3.634
ECM(-1)	-0.8847***	0.1243	-7.121	-	-	-

*Notes: ***p<0.01, **p<0.05, *p<0.10. Dependent variable: lnMMR. Lag selection based on AIC.*
R-squared = 0.7843, Adjusted R-squared = 0.7521, F-statistic = 24.31*, Durbin-Watson = 2.143**

4.5.1 Long-Run Results
The long-run coefficient for public health expenditure is -0.3241 and is statistically significant at the 5% level. This implies that, in the long run, a 1% sustained increase in public health expenditure as a percentage of GDP is associated with a 0.324% reduction in the maternal mortality ratio in Nigeria. This finding confirms the Health Capital Theory prediction that investment in health capital yields improved health outcomes. The result is consistent with Igbinedion (2016), who found a long-run relationship between health expenditure and maternal mortality in Nigeria, and with Makuta and O'Hare (2015), who reported similar findings across Sub-Saharan Africa.

The long-run coefficient for female education is -0.4672 and is statistically significant at the 1% level. This indicates that a 1% increase in female secondary school enrolment reduces maternal mortality by 0.467% in the long run. Notably, the magnitude of this effect is larger than that of public health expenditure, suggesting that education is an even more powerful determinant of maternal survival. This finding aligns with Andersen's Behavioral Model, which emphasises that predisposing characteristics such as education fundamentally shape healthcare-seeking behaviour. Educated women are more likely to recognise danger signs, access skilled birth attendance, and exercise reproductive autonomy. The result is consistent with Gao et al. (2023), who found that maternal education significantly reduces mortality in Nigeria.

The long-run coefficient for fertility rate is 0.5894 and is statistically significant at the 1% level. This implies that a 1% increase in the total fertility rate increases maternal mortality by

0.589% in the long run. This finding is intuitive, as each additional pregnancy carries inherent risks, particularly within a constrained healthcare system. Higher fertility rates also strain the capacity of health facilities and increase the cumulative exposure of women to pregnancy-related complications. This result underscores the importance This result underscores the importance of promoting natural birth spacing methods alongside intensive nutritional support. Specifically, emphasize the Lactational Amenorrhea Method (LAM), where extended, exclusive breastfeeding naturally delays the return of maternal fertility, to support both infant nutrition and optimal maternal recovery intervals.

4.5.2 Short-Run Results

The short-run coefficients are generally smaller in magnitude than their long-run counterparts, indicating that the full effects of policy interventions accumulate over time. The short-run coefficient for public health expenditure is -0.2874, significant at the 5% level. This suggests that a 1% increase in health expenditure in the current year reduces maternal mortality by 0.287% in the same year. The smaller magnitude compared to the long-run coefficient (-0.324) suggests that health expenditure takes time to achieve its full effect.

The short-run coefficient for female education is -0.4153, significant at the 1% level. This strong short-run effect indicates that improvements in female education translate relatively quickly into maternal health benefits, likely through immediate changes in health-seeking behaviour.

The short-run coefficient for fertility rate is 0.5231, significant at the 1% level. The positive effect is somewhat smaller than the long-run coefficient, suggesting that the full mortality burden of high fertility materialises over time as women experience multiple pregnancies.

4.6 Error Correction Mechanism (ECM)

The ECM coefficient is -0.8847 and is statistically significant at the 1% level. The negative sign confirms that short-run deviations from the long-run equilibrium are corrected over time. The magnitude indicates that approximately 88.5% of any disequilibrium in maternal mortality is corrected within one year. This represents a relatively rapid speed of adjustment, suggesting that the Nigerian maternal health system is responsive to policy changes and external shocks.

The rapid adjustment speed has important policy implications. It indicates that temporary disruptions to maternal health services, while harmful, do not create permanent damage to health outcomes provided that underlying determinants remain intact. Conversely, it suggests that policy interventions can produce measurable results within a single budget cycle.

4.7 Diagnostic Tests

Table 8 presents the results of diagnostic tests conducted to validate the ARDL model.

Table 8: Diagnostic Test Results

Test		Test Statistic	p-value	Conclusion
Breusch-Godfrey (autocorrelation)	LM	1.234	0.298	No autocorrelation

Test	Test Statistic	p-value	Conclusion
Breusch-Pagan (heteroscedasticity)	1.876	0.171	Homoscedastic
Jarque-Bera (normality)	3.421	0.181	Normal residuals
Ramsey RESET (specification)	1.543	0.224	Correct specification
CUSUM	Stable	-	Stable parameters
CUSUMSQ	Stable	-	Stable parameters

The diagnostic tests confirm that the model is well-specified and reliable. The Breusch-Godfrey LM test indicates no evidence of serial correlation ($p = 0.298$). The Breusch-Pagan test confirms homoscedasticity ($p = 0.171$). The Jarque-Bera test indicates that the residuals are normally distributed ($p = 0.181$). The Ramsey RESET test confirms that the model has no omitted variable bias ($p = 0.224$).

4.8 DISCUSSION OF FINDINGS

4.8.1 Public Health Expenditure and Maternal Mortality

The finding that public health expenditure significantly reduces maternal mortality in the long run, but with a weaker short-run effect, aligns with the Health Capital Theory (Grossman, 1972). Health is conceptualised as a capital stock that requires sustained investment over time to yield returns. The weak short-run effect reflects the reality that health systems require time to translate financial resources into improved service delivery. Funds must be budgeted, allocated, disbursed, and then converted into tangible inputs such as trained personnel, drugs, equipment, and facility upgrades. Each of these steps involves time lags.

The elasticity of -0.324 implies that a sustained 10% increase in public health expenditure (from 3.1% to 3.41% of GDP) would reduce maternal mortality by approximately 3.24%. While statistically significant, this magnitude suggests that health expenditure alone is insufficient to achieve the dramatic reductions needed to meet SDG target 3.1. This finding is consistent with Chidinma (2024), who found a significant long-run but insignificant short-run effect in Nigeria, and with Makuta and O'Hare (2015), who found that the effect of health expenditure is conditional on governance quality.

The relatively small elasticity also reflects inefficiencies in Nigeria's health expenditure. A substantial proportion of the health budget is allocated to tertiary care and administrative costs rather than to primary and maternal healthcare services. Additionally, leakages, corruption, and poor procurement practices may reduce the effective resources reaching service delivery points.

4.8.2 Female Education as the Dominant Determinant

The finding that female education exerts a stronger effect on maternal mortality than public health expenditure is both striking and instructive. An elasticity of -0.467 means that a 10% increase in female secondary enrolment (from 34% to 37.4%) would reduce maternal mortality by 4.67%, a larger effect than an equivalent increase in health spending.

This finding is consistent with Andersen's Behavioral Model (1995), which posits that predisposing characteristics such as education fundamentally determine healthcare utilisation. Education operates through multiple channels. First, educated women have greater health literacy and are better able to recognise danger signs during pregnancy and childbirth. Second, education enhances women's decision-making power within households, enabling them to allocate resources for healthcare and to choose skilled attendance. Third, educated women are more likely to seek antenatal care, deliver in health facilities, and accept postnatal follow-up. Fourth, education delays marriage and childbearing, reduces fertility, and increases spacing between births, all of which reduce maternal risk. The result aligns with Gao et al. (2023), who found maternal education to be a significant predictor of maternal survival in Nigeria. Rezaei et al. (2016) reported similar findings across multiple countries. The stronger effect of education compared to health expenditure suggests that investments in girls' secondary education may yield higher returns in maternal health outcomes than equivalent investments in healthcare infrastructure, at least in the Nigerian context.

4.8.3 Fertility Rate and Maternal Mortality

The positive and significant relationship between fertility rate and maternal mortality is consistent with clinical and epidemiological evidence. Each pregnancy carries inherent risks, including haemorrhage, eclampsia, sepsis, and obstructed labour. Higher fertility increases the cumulative probability of experiencing these complications. Additionally, high fertility strains the capacity of health facilities, reduces the quality of care per patient, and increases competition for scarce resources.

The elasticity of 0.589 implies that a 10% reduction in fertility (from 5.6 to 5.0 births per woman) would reduce maternal mortality by 5.89%. This suggests that family planning programmes should be considered maternal health interventions, not merely population control measures. The finding aligns with Neal et al. (2016), who identified high fertility as a major risk factor for maternal mortality in Sub-Saharan Africa.

4.8.4 Speed of Adjustment

The error correction coefficient of -0.885 indicates rapid adjustment to long-run equilibrium. This finding suggests that the Nigerian health system, despite its challenges, retains a functional capacity for self-correction. When maternal mortality deviates from its long-run path due to short-run shocks such as economic downturns, health worker strikes, or disease outbreaks, the system returns to equilibrium within approximately 13 to 14 months.

This rapid adjustment has positive implications for policy effectiveness. It suggests that well-designed interventions can produce measurable improvements within a single budget cycle or electoral term, which is politically significant for sustaining commitment to maternal health programmes. It also indicates that temporary disruptions, while harmful, do not create permanent damage to the trajectory of maternal health outcomes.

4.8.5 Comparison with Previous Studies

The findings of this study are broadly consistent with the existing literature while extending it in several respects. Consistent with Igbinedion (2016) and Chidinma (2024), this study confirms a long-run relationship between health expenditure and maternal mortality in Nigeria. Consistent with Makuta and O'Hare (2015), the effect of health expenditure is significant but modest. Consistent with Rezaei et al. (2016), female education emerges as a powerful determinant of maternal survival.

However, this study extends the literature by explicitly comparing the magnitudes of the effects of health expenditure and female education, revealing the latter to be larger. This finding has not been emphasised in previous Nigerian studies. Additionally, the study provides a precise estimate of the speed of adjustment (88.5% annually), which has important policy implications that were not previously quantified for Nigeria.

5.0 CONCLUSION

This study concludes that public health expenditure is a significant determinant of maternal mortality in Nigeria, but only in the long run. The weak short-run effect suggests that health spending alone is insufficient. Female education emerges as the most powerful predictor of maternal survival, with an effect larger than that of health expenditure. High fertility rates exacerbate maternal mortality. The rapid speed of adjustment indicates that the Nigerian health system is responsive to policy interventions, and well-designed programmes can produce measurable results within one to two years.

The persistent paradox of high maternal mortality despite increased health spending is explained by three factors. First, the level of spending remains inadequate at 3.1% of GDP, far below international targets. Second, spending is inefficiently allocated, with insufficient focus on primary and maternal healthcare. Third, demand-side barriers, particularly low female education, limit the utilisation of available services.

6.0 RECOMMENDATIONS

Based on the findings, the following policy recommendations are offered:

i. **Sustainable increase in public health expenditure with targeted allocation.** The government should progressively increase health spending to at least 5% of GDP in the medium term and 15% in the long term as pledged in the Abuja Declaration. Crucially, the additional funds should be targeted to primary healthcare and maternal health services, including emergency obstetric care, skilled birth attendance, and antenatal services. Budget release mechanisms should be streamlined to ensure timely disbursement.

ii. **Prioritise female secondary education as a maternal health intervention.** Given that education exerts a stronger effect than health spending, the government should eliminate barriers to girls' education, including school fees, early marriage, and distance to school. Conditional cash transfer programmes that incentivise girls' enrolment and retention should be expanded. Reproductive health education should be integrated into the secondary school curriculum.

iii. **Establish Antenatal Birth and Emergency Preparedness Plans:** Formulate a structured protocol where families collaborate with community health workers to establish a definitive emergency plan well ahead of the due date. This plan should mandate identifying the nearest emergency obstetric care facility, securing a designated driver or community-backed transport fund, and pre-identifying compatible blood donors within the village or neighbourhood.

iv. **Up-Skill Traditional Birth Attendants and Midwives:** Train traditional birth attendants (TBAs) and local midwives in basic, life-saving obstetric interventions. Training should focus on active management techniques during the third stage of labor, early identification of obstructed labor, and the safe administration of low-

cost, essential medications—such as misoprostol tablets to prevent postpartum hemorrhage—when referral hospitals are inaccessible.

v. **Improve the efficiency of health expenditure.** Mechanisms for tracking health expenditure and outcomes should be strengthened to identify inefficiencies and leakages. Performance-based financing arrangements that link facility funding to maternal health outcomes should be piloted and scaled up.

vi. **Strengthen data systems for maternal health.** The rapid adjustment speed indicates that policy interventions yield relatively quick returns. Therefore, timely data on maternal mortality and its determinants should be collected and used for adaptive management. Maternal death surveillance and response systems should be fully implemented in all states of the federation.

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