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DETERMINANTS OF MATERNAL MORTALITY RATE: EVIDENCE FROM WEST AFRICAN COUNTRIES

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Abstract

This paper investigated the determinants of maternal mortality across sixteen West African nations from 2000 to 2022, employing robust econometrics methods such as Pooled Mean Group (PMG) and Fully Modified Ordinary Least Square (FMOLS). Grounded in life-course perspective theory, the study explored the interplay between clinical determinants and socio-economic factors including life expectancy, political stability, fertility rate, HIV prevalence, education, and healthcare expenditure. Findings unveil significant long-run and short-run determinants affecting maternal mortality. While life expectancy exhibits a statistically insignificant negative relationship in the PMG model, the FMOLS model highlights a significant negative association, emphasizing methodological robustness. Contrarily, political stability, initially appearing positively significant, loses significance in the FMOLS model, indicating nuanced dynamics. The positive and highly significant connection between fertility rate and maternal mortality aligns with economic theory, highlighting the strain on healthcare resources. HIV/AIDS prevalence emerges as a notable determinant, urging targeted interventions. Health expenditure's nuanced relationship underscores the importance of effective utilization, advocating strategic investments. Education expenditure, while showing contradictory results, emphasizes the need for targeted education policies. Policy recommendations advocate for a multifaceted approach, prioritizing strategic investments in healthcare infrastructure, targeted HIV/AIDS programs, comprehensive family planning services, and education policies. Leveraging political stability for effective policy implementation is paramount, ensuring tangible improvements in maternal health outcomes in West Africa.

Keywords: Maternal Mortality, Fertility, HIV Prevalence, Life Expectancy, West Africa.

Jel Classification: H51, I11, P46, N17

1. INTRODUCTION

Maternal mortality, synonymous with maternal death, is a predominant cause of death among women in fertile years, particularly in developing nations, posing a significant public health challenge. This measure encompasses deaths during pregnancy, childbirth, or within 42 days post-pregnancy due to pregnancy-related or aggravated conditions, excluding accidental causes (WHO, 2017). It serves as a proxy for evaluating a country's maternal health and development status.

Maternal mortality rates are alarmingly high worldwide. WHO (2020) reports approximately 287,000 global maternal deaths annually during pregnancy, childbirth, or shortly thereafter, with nearly 95% occurring in developing nations, most of which are preventable. Sub-Saharan Africa and Asia contribute 87% of these deaths, with Sub-Saharan Africa alone accounting for 70%. In contrast, only 1% of maternal deaths are

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reported in developed countries, highlighting a significant health disparity (Salisu and Hamza, 2024).

Many countries have reduced maternal mortality rates, but West Africa still faces high rates, with hemorrhage, abortions, sepsis, and obstructed labor as leading causes (Meh, *et al*., 2019). Nonetheless, Cape Verde made notable progress, reducing its maternal mortality from 2300 to 320 deaths per 100,000 live births (Buor and Bream, 2004). However, other countries like Sierra Leone, Chad, and Nigeria still struggle with high maternal mortality rates despite implementing interventions (Alkema, *et al*., 2016). For instance, Nigeria ranks second globally, contributing about 14% of worldwide maternal deaths, alongside five other West Africa countries responsible for over 50% of such fatalities. Annually, more than 250,000 Nigerian women die during childbirth, equating to around 690 deaths daily (Fagbeminiyi and Oduaran, 2019).

Consequently, West Africa ranks among the most perilous for childbirth globally. The tragedy lies in the fact that these women perish not from illnesses but during the fundamental process of childbirth, a natural aspect of life that ideally should be safe and nurturing (Meh, *et al*., 2019). Alarmingly, most of these fatalities could be prevented with the implementation of appropriate preventive measures and the provision of adequate medical care.

Despite extensive research on maternal mortality available in the current literature, there has been limited empirical investigation into the clinical determinants of maternal mortality, particularly within the West African context (Kolo *et al*., 2017; Abubakari, *et al*., 2022; Salisu and Donga, 2024; Souza, *et al*., 2024). The existing studies typically focus on individual countries and frequently overlook critical factors such as fertility rate and HIV prevalence**.** This current study aims at addressing these gaps by examining the broader clinical determinants of maternal mortality across multiple countries in West Africa, emphasizing the roles of maternal health services, access to obstetric care, socio-economic factors, prevalence of underlying health conditions, and systemic challenges within healthcare systems.

Furthermore, this study also addresses a significant research gap by empirically investigating the socioeconomic and macroeconomic factors influencing maternal mortality incidence in West Africa. To accomplish this, secondary data was collected from various reputable sources such as the World Bank and the United Nations Development Programme. The data was analyzed using panel autoregressive distributed lag family models, specifically employing techniques such as mean group, pooled mean group, and dynamic fixed-effect estimations.

The subsequent sections are structured as follows: the second section presents a comprehensive review of relevant literature. The methodology utilized in this study is detailed in the third section. The fourth section presents the findings of the analysis and provides a discussion thereof. Finally, the fifth section encompasses the conclusion drawn from the study's results and offers recommendations considering the findings.

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2. LITERATURE REVIEW

2.1 Empirical Literature

Numerous studies in existing literature have endeavored to examine the factors influencing maternal mortality and their impact on the occurrence of maternal deaths. These investigations delve into understanding the complex web of variables contributing to maternal mortality rates and seek to illuminate the relationships between these determinants and the tragic outcome of maternal deaths. For instance, Souza *et al*. (2024) underscored the intricate challenges surrounding maternal mortality reduction and maternal health promotion. Their analysis delved into the determinants of maternal health, alongside related exposures, risk parameters, and micro-correlations, contributing to maternal mortality. Systematic literature reviews and examination of Sustainable Development Goals indicators depict maternal health as a multifaceted process influenced by various factors, necessitating comprehensive interventions to address prevailing inequities and systemic issues. They advocated for a holistic approach within the health sector ecosystem, emphasizing the importance of tailored interventions to mitigate maternal health determinants and combat socio-economic disparities. In a similar vein, Habte *et al*. (2024) revealed that Sub-Saharan African (SSA) nations face disproportionately high stillbirth rates, yet research on SSA stillbirth risk factors are lacking. Their systematic review scrutinized 37 studies (20, 264 stillbirths) from 2013–2019, categorizing modifiable risk factors including maternal, socio-economic, fetal, and health systems-related factors. The study emphasizes the imperative for targeted interventions and underscores the necessity for rigorous population-based research to address this critical public health issue.

In a concerted effort to unravel the intricate web of maternal mortality determinants, Mlambo, *et al*. (2023) undertook a rigorous examination of macro-level factors within the SADC states. Their study, spanning from 2005 to 2019, utilized panel data analysis alongside the GMM technique. Their investigation unearthed a significant correlation between GDP per capita and HIV prevalence with the incidence of maternal mortality, shedding light on crucial macroeconomic influencers.

Meanwhile, Osemwengie and Shaibu (2020) contributed to the discourse with a comprehensive analysis of socio-economic determinants across Sub-Saharan Africa. Spanning from 1995 to 2015 and encompassing panel data from 43 countries, their utilization of the Generalized Method of Moments (GMM) reveals a constellation of influential factors, including health expenditure, fertility rates, and female labor force participation, underscoring their impact on maternal mortality trends in the region.

Furthermore, Adegoke, *et al*. (2022) delved into the intricate interplay between macroeconomic dynamics and health outcomes, focusing on Nigeria's maternal and infant Sustainable Development Goal (SDG) targets. Their longitudinal analysis, spanning from 1995 to 2020 and employing the ARDL econometric technique, unravels a significant inverse connection between health outcomes and macroeconomic

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determinants, emphasizing the complex socio-economic landscape's impact on maternal and infant well-being.

Meh *et al*. (2019) explore maternal mortality in Nigeria, finding higher rates in the North, which increased from 2008 to 2013, while the South saw a slight decrease. Using data from Nigeria Demographic and Health Surveys, the study analyzed the association of maternal mortality with various factors via multivariable logistic regression. The findings suggest targeted interventions are essential, for instance, advancing education in the North and expanding health service availability in the South, alongside policies to enhance women's socioeconomic status.

Buor and Bream (2004) investigated the factors affecting maternal mortality in SSA and proposed solutions. Analyzing data from multiple sources, they used regional models and included sociodemographic variables, introducing a country-specific political stability factor. They applied bivariate correlations, Kendall's tau-c values, and regression lines. The study found strong correlations between maternal mortality and factors like skilled health personnel, life expectancy, economic wealth, and health expenditure. They recommended training skilled mid-level health workers and improving resource allocation for better maternal health outcomes.

The existing literature extensively explores the multifaceted determinants of maternal mortality, yet significant gaps remain, particularly within the context of West Africa. Despite rigorous analyses of the socio-economic, health system, and macroeconomic factors influencing maternal health, research specific to West Africa's unique socio-political and economic landscape is limited. Moreover, previous studies lack robust methodologies as they mostly apply simple regression models, which neglect the pertinent functions of homogeneity and cross-section efficiency. The nuanced interplay between regional socio-economic disparities, healthcare accessibility, and cultural practices in West Africa demands targeted investigation.

2.2 Theoretical Underpinning

Lu and Halfon (2003) offer a framework for examining maternal mortality through the Life Course Perspective (LCP) theory, which addresses the discrepancies in birth outcomes due to maternal health challenges. This theory integrates concepts deriving from early conditioning and cumulative trajectories to illustrate the environmental influences on growth and development. This mechanism, rooted in the Barker hypothesis, posits that prenatal and early childhood experiences critically shape long-term health outcomes, influencing the likelihood of developing conditions such as diabetes and cardiovascular disease (Barker, 1995). Conversely, the cumulative trajectory mechanism examines the impact of ongoing exposure to social and physical stressors (wear and tear) on human development. These stressors include homelessness, discrimination, infectious diseases, and harmful health behaviors like smoking (Lu and Halfon, 2003; Hertzman, 1999).

The LCP theory synthesizes these mechanisms by suggesting that chronic stress experienced by women, such as repeated encounters with racism, dislodgement, and

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inherited poverty, significantly increases the hazard of negative health consequences. This risk is particularly heightened when such stress occurs throughout pivotal developmental phases, including prenatal stage, teenage years, and gestation (Lu and Halfon, 2003; Hertzman and Power, 2003).

The Historical Trauma (HT) is another theory, which offers a crucial perspective on understanding determinants of maternal mortality by examining how traumatic experiences impact health outcomes among marginalized populations. This theory originated from studies of Jewish Holocaust survivors, where researchers found that the descendants of these survivors exhibited higher incidences of mental health disorders such as PTSD, even without direct exposure to the Holocaust themselves (Kellermann, 2001; Sotero, 2006). This observation led to inquiries into the trans-generational transmission of mental and physical health disorders through biological, social, and cultural mechanisms.

Recent studies have extended the application of HT theory to other marginalized groups, such as Mexican Americans, highlighting how historical and ongoing trauma can influence maternal health outcomes (Evans-Campbell, 2008). By recognizing the profound impact of historical trauma on marginalized communities, HT theory underscores the importance of addressing these deep-rooted socioeconomic determinants to reduce maternal mortality rates effectively, which is critical for developing targeted interventions that can mitigate the adverse health effects associated with historical and intergenerational trauma.

3. DATA AND METHODOLOGY

3.1 Data

To delve into the determinants of maternal mortality in West Africa, a rigorous selection process was undertaken, identifying sixteen countries[1] as sub-samples over the period spanning from 2000 to 2023. The criteria for country selection and timeframe establishment prioritized data availability and methodological suitability within a panel framework. Additionally, this study draws upon the model proposed by Buor and Bream (2004), which comprehensively captures the determinants of maternal mortality in Sub-Saharan Africa.

In line with this framework, seven key variables have been identified for analysis, informed by Buor and Bream's model. These variables encompass maternal mortality ratio, life expectancy at birth, political stability, total fertility rate, HIV/AIDS prevalence, health expenditure per capita, and education expenditure per capita. The selection rationale for these variables is grounded in their established significance in previous research concerning maternal health outcomes and the broader clinical and socio-economic context of West Africa. To provide clarity and facilitate reference, Table 1 presents detailed descriptions of the selected variables along with their respective data sources.

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This ensures transparency and enables readers to comprehend the foundational elements underpinning the subsequent analysis.

Table 1: Variable Description and Measurement

Variable	Description	Measurement	Sign	Source
Dependent Variable:				
MMR	maternal mortality ratio	The maternal mortality ratio is determined by the number of women who perish during pregnancy and childbirth per 100,000 live births, providing a measure of maternal health outcomes within a population.	_____	WDI
Independent Variables:				
LEX	life expectancy at birth	Life expectancy at birth represents the average number of years a newborn is anticipated to live, considering prevalent mortality patterns throughout its lifetime.	Negative	WDI
POL	political stability	Political stability is gauged by a peace index, indicating the level of peace within a political system over the past decade. This index considers factors such as the number of conflict-related deaths and the extent of infrastructure damage, with values ranging from 0 to 10, where higher values denote greater stability.	Negative	UNDP
FER	total fertility rate	The total fertility rate measures the average number of children a woman is projected to bear over her reproductive years, assuming she maintains the current age-specific fertility rates until the conclusion of her childbearing age.	Positive	WDI
HIV	HIV/AIDS prevalence	HIV/AIDS prevalence is measured as the percentage of the population infected with the virus.	Positive	WDI
HEA	health expenditure per capita	The total health expenditure, which includes both public and private spending as well as external funding, is divided by the total population to determine per capita health expenditure.	Negative	WDI
EDU	Education expenditure per capita	The total education expenditure, which include both private and public education spending divided by the total population	Negative	WDI

Source: Author’s Compilation, 2024.

3.2 Theoretical Framework of the Model

To investigate the determinants of maternal mortality in West Africa, this study utilizes the model proposed by Mosley and Chen (1984), which explicates how socioeconomic factors influence health outcomes through biological mechanisms. According to this model, underlying socioeconomic conditions—encompassing social, economic, biological, and environmental factors—are expressed through proximate determinants such as maternal fertility rates, environmental contamination, and disease control measures. These proximate determinants directly affect disease risk, which in turn impacts mortality rates.

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Nonetheless, the values of proximate determinants play a crucial role in shaping maternal mortality rates. For example, high fertility rates and inadequate disease control increase disease risk, thereby elevating the probability of maternal death. Conversely, effective environmental management and robust healthcare infrastructure can mitigate these risks and improve maternal health outcomes (Mosley and Chen, 1984). This framework highlights the complex interplay of various factors affecting maternal mortality in West Africa and underscores the necessity for holistic strategies that address both underlying socioeconomic conditions and proximate health factors to effectively reduce maternal mortality.

3.3 Estimation Strategies

This study on the determinants of maternal mortality in West Africa comprises two primary estimation phases. In the initial stage, various pre-estimation techniques are employed to assess the characteristics of the data and ensure robust modeling. These techniques include descriptive analysis to provide an overview of the data, a correlation matrix to examine relationships between variables, and panel unit root tests (such as LLC, IPS, ADF-Fisher) to assess stationarity. Additionally, a lag selection test is conducted to determine the appropriate lag period for modeling, while panel cointegration tests (such as Kao and Johansen-Fisher) are utilized to examine the presence of long-term relationships among variables. These pre-estimation techniques are essential for identifying data properties, addressing multicollinearity issues, establishing the appropriate modeling framework, and ensuring the validity of subsequent estimations regarding maternal mortality determinants in the West African context.

Unit Root Tests

The LLC test, akin to the ADF and PP tests, is particularly suitable for time series data characterized by structural breaks or heteroscedasticity. This test assesses whether the variables under consideration exhibit unit roots, indicating non-stationarity or are stationary over time. Stationarity is a crucial assumption in time series analysis, as it ensures the reliability of subsequent statistical inferences.

$$\Delta Y_{it} = \alpha_i + \beta_i T + \gamma Y_{i,t-1} + \delta_1 \Delta Y_{i,t-1} + \cdots \delta_{\rho-1} \Delta Y_{i,t-\rho+1} + \varepsilon_{it} \qquad (1)$$

Where Δ represents the differencing operator, Y_{it} denotes the time series observation for unit i at time t. T signifies a temporal trend, αi is the intercept specific to each individual unit, and β_i is the coefficient for the individual-specific time trend. The coefficient γ is associated with the lagged level term ($Y_{i,t-1}$), while δ_j represents the coefficients for the differenced terms ($\Delta Y_{i,t-j}$). The term ε_{it} accounts for the error in the model. Furthermore, the IPS (Im, Pesaran, and Shin) test enhances the LLC (Levin, Lin, and Chu) test by accommodating potential cross-sectional dependencies among the units. Both the IPS and LLC tests are grounded in similar model structures, as depicted in equation (2), and their respective test statistics are derived through analogous computational procedures.

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$$LLC = IPS = \frac{\sum_{i=1}^{N} T\rho\Delta_{\mu i}}{\left(\sum_{i=1}^{N} T\right)^2} \qquad (2)$$

In this context, N represents the number of cross-sectional units, and T denotes the number of time periods. The coefficient $\rho\Delta ui$ is estimated from the lagged differenced residuals in individual unit regressions. The ADF-Fisher test modifies the ADF test to handle cross-sectional dependence in panel data by combining individual ADF test statistics into a single pooled statistic, thus addressing cross-sectional dependence effectively.

$$ADF_{Fisher} = \frac{-2\sum_{i=1}^{N} \ln(\rho_i)}{X_2^2 N} \qquad (3)$$

Cointegration Tests

In this study, the Kao and Johansen-Fisher tests were applied. The Kao test assesses long-term relationships in panel data by regressing first differences on lagged levels. The Johansen-Fisher test combines Johansen's method with Fisher's approach for a robust analysis of cointegration, effectively addressing complex datasets.

$$\Delta Y_{it} = \alpha + \beta L(Y_{it}) + \sum_{j=1}^{\rho-1} \gamma_j \Delta Y_{it-j} + \varepsilon_{it} \qquad (4)$$

In the specified model, ΔY_{it} represents the first difference of the dependent variable Y_{it}, while (Y_{it}) indicates the lagged levels of this variable. The model includes an intercept denoted by α, a coefficient β on the lagged levels of the dependent variable, and coefficients γ_j on the first differences of the dependent variable lagged up to $p-1$ periods. The term ε_{it} accounts for the error component. Additionally, the Johansen-Fisher test, an extension of the Johansen cointegration test, introduces two distinct trace statistics: λ_{trace} and λ_{max}. These statistics are derived from specific models to gauge the presence of cointegration.

$$\Delta Y_{it} = \pi Y_{it-1} + \sum_{j=1}^{\rho-1} \tau_j \Delta Y_{it-j} + \varepsilon_{it} \qquad (5)$$

Modeling Technique

In the alternative methodology, a dynamic panel framework is adopted to effectively estimate diverse datasets, employing suitable techniques. Drawing upon the characteristics of the data, the research utilizes the ARDL (p,) model with error correction, incorporating three estimators: mean group (MG), pooled mean group (PMG), and dynamic fixed effect (DFE) model, as outlined by Pesaran and Smith (1995), Pesaran *et al*. (1999). The ARDL formulation, as proposed by Loayza and Ranciere (2006), is articulated as follows:

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$$\Delta(Y_i)_t = \sum_{j=1}^{p-1} Y_j^i \Delta(Y_i)_{t-j} + \sum_{j=0}^{q-1} \delta_j^i \Delta(X_i)_{t-j} + \varphi^i[(Y_i)_{t-1} - \{\beta_0^i + \beta_1^i (X_i)_{t-1}\}]\epsilon_{it}\_(6)$$

In the specified model, Y signifies maternal mortality rate, with X encompassing independent variables such as life expectancy, political stability, fertility rate, HIV prevalence, and health and education expenditure. Short-term coefficients are denoted by γ and δ, while β represents long-term coefficients, and θ indicates the velocity of adaptation to long-run equilibrium. Consequently, the econometric form of the model is given as:

$$MMR_{it} = \beta_0 + \beta_1 LEX_{it} + \beta_2 POL_{it} + \beta_3 FER_{it} + \beta_4 HIV_{it} + \beta_5 HEA_{it} + \beta_6 EDU_{it} + \mu_{it}\_(7)$$

From the above model, the following a-priori theoretical deductions are presumed:

$\frac{\partial(MMR)}{\partial(LEX)} < 0, \frac{\partial(MMR)}{\partial(POL)} < 0, \frac{\partial(MMR)}{\partial(FER)} > 0, \frac{\partial(MMR)}{\partial(HIV)} > 0, \frac{\partial(MMR)}{\partial(HEA)} < 0$, and $\frac{\partial(MMR)}{\partial(EDU)} < 0$ ______________ (8)

The ARDL methods, serve as robust cointegration tests, emphasizing the consistency of parameter estimates in long-term relationships. PMG and MG estimators bypass the need for separate cointegration tests, accommodating different orders of stationarity in panel data. ARDL methodology effectively addresses endogeneity concerns, allowing for simultaneous estimation of short and long-term impacts (Pesaran and Shin, 1999).

Hausman's Test

The PMG estimator, as demonstrated by Pesaran *et al*. (1999), enhances efficiency compared to the MG estimator, thereby reinforcing the study's assumption of long-term homogeneity slopes. Through the Hausman test, differences among the PMG, MG, and DFE estimators are assessed, determining the statistical significance in the consistency of coefficients' estimators across the models.

$$H^* = (\beta_{PMG} - \beta_{MG})^i [Var(\beta_{PMG}) - Var(\beta_{MG})]^{-1} (\beta_{PMG} - \beta_{MG})\_\_\_\_\_\_\_\_\_\_\_\_(9)$$

$$H^* = (\beta_{PMG} - \beta_{DFE})^i [Var(\beta_{PMG}) - Var(\beta_{DFE})]^{-1} (\beta_{PMG} - \beta_{DFE})\_\_\_\_\_\_\_\_\_\_\_\_(10)$$

In this context, H^* represents the test statistic, while β_{PMG}, β_{MG}, and β_{DFE} denote the coefficient estimates derived from the PMG, MG, and DFE models, respectively. Additionally, Var(β_{PMG}), Var(β_{MG}), and Var(β_{DFE}) represent the variance-covariance matrices of the coefficient estimates from the PMG, MG, and DFE models, respectively.

The statistical significance of H^* determines the rejection or acceptance of the null hypothesis. For instance, significance at a level of 5% or 1% leads to the rejection of the null hypothesis, indicating a preference for the DFE model over PMG. Conversely, non-significant H^* values fail to reject the null hypothesis, suggesting consistency in the PMG model and no discernible preference between the PMG and DFE models, akin to the scenario for PMG and MG estimators.

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Robustness Models

Once the long-run connections have been established, robustness checks are conducted by estimating long-term structural coefficients using advanced panel methods such as fully modified OLS (FMOLS), dynamic OLS (DOLS), and canonical cointegration regression (CCR), which offer greater efficiency compared to ordinary least squares (OLS). Ordinary least squares suffer from asymptotic bias, a flaw rectified by FMOLS through a non-parametric approach. DOLS, endorsed by Kao and Chiang (2001) and Mark and Sul (2003), is a parametric method designed to address issues of endogeneity and serial correlation. A cointegrating relationship can be represented as follows:

$$\Delta Y_t = \alpha + \beta X_t + \varepsilon_t \qquad (11)$$

In this context, ΔY_t denotes the differenced dependent variable, X_t represents a non-stationary covariate, and εt signifies the error term. The FMOLS estimator for β is expressed as:

$$\beta_{FMOLS} = (X' P_X^{-1} X)^{-1} X' P_X^{-1} \Delta Y \qquad (12)$$

The set of regressors denoted as X, includes a constant term and lagged levels of both dependent and independent variables. ΔY symbolizes the differenced dependent variable. The long-run variance-covariance matrix of regressors denoted as P_X, is derived from consistent estimators such as Newey-West. Additionally, the DOLS estimator is expressed as:

$$\beta_{DOLS} = \left(\sum_{j=-p}^{p} Z'_{t-j} \, Z_{t-j} \right)^{-1} \left(\sum_{j=-p}^{p} Z'_{t-j} \, \Delta Y_t \right) \qquad (13)$$

In this equation, Z_{t-j} constitutes a matrix comprising lagged values of both the dependent and independent variables, alongside a constant term. ΔY_t denotes the differenced dependent variable.

4. EMPIRICAL RESULTS

The descriptive analysis (Table 2) provides a comprehensive overview of various key variables. Maternal mortality rate exhibits notable variability, with a mean of 99.916 and a standard deviation of 47.623, suggesting diverse maternal health outcomes. Life expectancy presents a concerning picture, with a low mean of 56.088 and extreme negative skewness (-3.124), indicating a concentration of regions with low life expectancy. This underscores critical health challenges in these areas, further supported by the high kurtosis (14.163) and non-normal distribution confirmed by the Jarque-Bera test.

Political stability is a significant concern, reflected in its negative mean (-0.520) and notable variability. The negative skewness and non-normal distribution imply the presence of regions experiencing political instability. The fertility rate exhibits variability,

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with a mean of 4.988 and a standard deviation of 1.501, indicating diverse fertility patterns. However, the high kurtosis (6.411) suggests a tendency towards higher rates, warranting attention in family planning initiatives.

HIV/AIDS prevalence is alarming, with a high mean of 54.763 and significant variability. The negative skewness (-2.831) and high kurtosis (11.808) suggest a concentration of regions with high prevalence rates, confirmed by the non-normal distribution. Health expenditure displays considerable disparities, with a mean of 42.804 and a wide standard deviation of 33.175, indicating varying levels of investment in healthcare. Positive skewness (1.707) and high kurtosis (7.102) point towards a few regions with exceptionally high health expenditures, necessitating equitable resource allocation.

Finally, education expenditure shows variability, with a mean of 12.882 and a standard deviation of 8.558, reflecting differing levels of investment in education. While skewness (-0.316) and kurtosis (2.145) are closer to normal, the Jarque-Bera test confirms non-normal distribution, implying disparities in educational funding.

Table 2: Descriptive Analysis

VARIABLE	MMR	LEX	POL	FER	HIV	HEA	EDU
Mean	99.916	56.088	-0.520	4.988	54.763	42.804	12.882
Median	101.350	58.365	-0.340	5.191	58.850	34.591	15.175
Maximum	228.500	76.593	1.224	7.732	69.100	181.442	35.006
Minimum	0.000	0.000	-2.479	0.000	0.000	0.000	0.000
Std. Dev.	47.623	13.274	0.794	1.501	13.555	33.175	8.558
Skewness	-0.013	-3.124	-0.455	-1.544	-2.831	1.707	-0.316
Kurtosis	2.880	14.163	2.585	6.411	11.808	7.102	2.145
Jarque-Bera	0.231	2509.274	15.358	324.694	1681.113	436.595	17.350
Probability	0.891	0.000	0.000	0.000	0.000	0.000	0.000
Sum	36769.100	20640.201	-191.328	1835.510	20152.700	15751.862	4740.672
Sum Sq. Dev.	832338.135	64666.369	231.142	826.397	67433.080	403912.853	26881.834
Observations	368	368	368	368	368	368	368

Source: Author’s Computation, 2024.[2]

In Table 3, the correlation analysis reveals associations between variables. Maternal mortality rate shows a strong positive correlation with fertility rate (0.806) and a moderate positive correlation with HIV prevalence (0.442). This implies that higher fertility rates and HIV prevalence tend to coincide with higher maternal mortality rates. Conversely, the maternal mortality rate exhibits negative correlations with political stability (-0.271) and health expenditure (-0.285). This further suggests that increased political stability and health expenditure are associated with lower maternal mortality rates.

Furthermore, life expectancy demonstrates weak positive correlations with maternal mortality, implying that higher life expectancy tends to accompany the maternal mortality rate. However, the correlations are relatively low, suggesting that other factors may have more significant influences on life expectancy.

Conversely, education expenditure shows weak negative correlations with maternal mortality. This suggests that higher education expenditure may be associated with lower maternal mortality. However, the correlation is relatively low, indicating that other factors may also play significant roles.

Table 3: Correlation Analysis

VARIABLE	MMR	LEX	POL	FER	HIV	HEA	EDU
MMR	1.000						
LEX	0.054	1.000					
POL	-0.271	0.230	1.000				
FER	0.806	0.420	-0.243	1.000			
HIV	0.442	0.706	-0.112	0.606	1.000		
HEA	-0.285	0.461	0.163	-0.237	0.139	1.000	
EDU	-0.139	0.129	0.173	-0.060	0.090	0.090	1.000

Source: Author's Computation, 2024.

Table 4 presents stationarity tests for the variables. While all variables exhibit stationary behavior at level I(0) according to the LLC test, further scrutiny using the IPS and ADF tests reveals that maternal mortality rate, life expectancy rate, fertility rate, and health expenditure do not display stationarity at level and first difference.

This suggests that these variables possess unit roots and exhibit non-stationary behavior over time, both in their original form and after differencing. In contrast, political stability, HIV prevalence, and education expenditure demonstrate stationary behavior at level I(0) according to both the IPS and ADF tests. This implies that these variables do not possess unit roots and exhibit stable behavior over time without requiring differencing.

Table 4: Stationarity Tests

Variable	Homogeneous Root			Heterogeneous Root					
	LLC:			IPS:			ADF:		
	Level	1^{ST} Diff.	Order	Level	1^{ST} Diff.	Order	Level	1^{ST} Diff.	Order
MMR_{IT}	-4.652***	-2.291**	I(0)	11.830	2.384	Nil	8.708	3.166	Nil
LEX_{IT}	-6.511***	-2.253**	I(0)	5.697	15.799	Nil	4.653	9.204	Nil
POL_{IT}	-2.430**	-11.019***	I(0)	-1.909**	-6.582***	I(0)	-1.960**	-7.321***	I(0)
FER_{IT}	-5.217***	-2.631**	I(0)	13.541	7.517	Nil	11.079	7.849	Nil
HIV_{IT}	-4.630***	-2.998**	I(0)	-6.715***	3.091	I(0)	-7.367***	3.802	I(0)
HEA_{IT}	-4.048***	-8.977***	I(0)	-0.117	1.216	Nil	0.428	1.7060	Nil
EDU_{IT}	-3.530***	-11.789***	I(0)	-1.932**	-5.338***	I(0)	-2.189**	-6.690***	I(0)

Source: Author's Computation, 2024. Note: *** = 1% significance level, ** = 5% significance level.

Table 5 presents the optimal lag selection test results that are crucial for determining the appropriate lag order in time series modeling—the information criteria balance model fit

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with model complexity, penalizing over-fitting. Lower values of FPE, AIC, SC, and HQ indicate better model fit. Based on the results, lag 2 is the optimal lag order according to the LR test, as it significantly improves model fit compared to lag 1. This is further supported by lower values of FPE, AIC, SC, and HQ for lag 2 compared to lag 1, indicating a better model fit with the addition of a second lag.

Table 5: Optimal Lag Selection Test

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-7672.403	NA	1.68e+11	45.71073	45.79026	45.74243
1	-5419.783	4397.972	337348.5	32.59395	33.23013	32.84755
2	-5149.529	516.3780*	90421.44*	31.27696*	32.46981*	31.75246*

Source: Author’s Computation, 2024.

Table 6 presents the results of the Kao residual statistic to determine whether there exists a long-run equilibrium relationship among variables. The test statistic for the ADF test is -4.474, which indicates strong evidence against the null hypothesis of no cointegration. At the 1% significance level, the probability associated with this test statistic is 0.000, further confirming the rejection of the null hypothesis.

Therefore, the result suggests that there is a long-term relationship or cointegration between the variables under consideration. Additionally, the residual variance and HAC (Heteroskedasticity and Autocorrelation Consistent) variance are reported as 21.546 and 28.957, respectively. These values provide information about the variability of the residuals, which are important for assessing the reliability of the test results.

Table 6: Kao Cointegration

	t-Statistic	Prob.
ADF	-4.474***	0.000
Residual variance	21.546	
HAC variance	28.957	

Source: Author’s Computation, 2024. Note: *** = 1% significance level, ** = 5% significance level.

Table 7 presents the results of the Johansen-Fisher Cointegration Test, which is utilized to ascertain the existence and quantity of cointegration relationships among a set of variables. The test involves two statistics: the Fisher statistic from the trace test and the Fisher statistic from the max-eigen test. These statistics are compared with critical values to assess the null hypothesis of no cointegration.

In this case, the results consistently reject the null hypothesis of no cointegration across all tested scenarios. The Fisher statistics are highly significant at the 1% level for each hypothesized number of cointegrating equations, with probabilities of 0.000. This indicates strong evidence in favor of cointegration among the variables under consideration.

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Table 7: Johansen-Fisher Cointegration Test

Hypothesized No. of CE(s)	Fisher Stat.* (from trace test)	Prob.	Fisher Stat.* (from max-eigen test)	Prob.
None	123.001***	0.000	123.001***	0.000
At most 1	845.454***	0.000	427.563***	0.000
At most 2	666.974***	0.000	341.377***	0.000
At most 3	475.710***	0.000	250.244***	0.000
At most 4	282.482***	0.000	151.682***	0.000
At most 5	182.370***	0.000	121.540***	0.000
At most 6	131.739***	0.000	131.739***	0.000

Source: Author's Computation, 2024. Note: *** = 1% significance level, ** = 5% significance level.

Table 8 below reveals the comprehensive analysis of the baseline and robustness models for the study's investigation. Starting by comparing the Hausman test results, the study contrasts the MG estimator against the PMG estimator, followed by the comparison between the DFE estimator and the PMG estimator.

The Hausman test results reveal that both the MG and DFE estimators exhibit p-values above the conventional significance level of 0.05 when compared to the PMG estimator. Thus, the study retains the null hypothesis that the coefficients estimated by the MG and DFE estimators are not significantly different from those estimated by the PMG estimator. Consequently, the PMG model is deemed consistent with the data, providing a robust framework for our analysis.

Starting with the life expectancy rate, the PMG model shows a coefficient of -0.283 with a p-value of 0.838. Despite the negative coefficient, which aligns with the theoretical expectation that higher life expectancy should reduce maternal mortality, the result is statistically insignificant. This suggests that, in the long run, variations in life expectancy do not have a strong direct impact on maternal mortality within the study's sample. This could be due to the complex interplay of factors that affect both life expectancy and maternal health, such as economic conditions, healthcare quality, and social determinants.

However, political stability is shown to have a significant positive relationship with MMR, with a coefficient of 3.147 and a p-value of 0.020. This result is counterintuitive as it conflicts with the a priori theoretical expectation that greater political stability should correlate with lower maternal mortality rates by providing a stable environment conducive to healthcare improvements and better social services (Fagbeminiyi and Oduaran, 2019). This anomaly could be explained by the possibility that political stability in some regions may not necessarily translate into effective health policies or resource allocation. In some cases, political stability may exist alongside systemic issues in healthcare that are not immediately addressed.

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The fertility rate shows a significant positive correlation with the maternal mortality rate, with a coefficient of 13.854 and a p-value of 0.000. This strong positive relationship is consistent with the economic theory that higher fertility rates increase the risks associated with childbirth and strain healthcare resources, thereby elevating maternal mortality rates (Adegoke, *et al*., 2022). High fertility often leads to higher numbers of pregnancies and deliveries, increasing the likelihood of complications and adverse outcomes.

HIV/AIDS prevalence also exhibits a significant positive connection with the maternal mortality rate, with a coefficient of 4.854 and a p-value of 0.000. This finding is in line with the extensive literature indicating that higher HIV prevalence exacerbates maternal health risks, leading to higher mortality rates. HIV/AIDS complicates pregnancies and births, increasing the likelihood of maternal deaths due to both direct health impacts and the strain it places on healthcare systems (Kolo *et al*., 2017).

Health expenditure presents a non-significant relationship with MMR, with a coefficient of 0.112 and a p-value of 0.138. Despite the positive coefficient, which suggests that increased health expenditure could paradoxically be associated with higher maternal mortality, the lack of statistical significance implies that in the long run, health expenditure alone may not be a decisive factor in reducing maternal mortality. This could be due to inefficiencies in spending, misallocation of resources, or other systemic issues within healthcare systems that prevent the effective utilization of funds in West Africa (Mlambo, *et al*., 2023).

Finally, education expenditure has a significant negative connection with maternal mortality rate, with a coefficient of -0.218 and a p-value of 0.020. This indicates that higher investment in education is associated with lower maternal mortality rates, aligning with theoretical expectations and empirical evidence that better-educated populations typically have improved health outcomes. Education can enhance health literacy, improve socioeconomic status, and empower women to make informed health decisions, all of which contribute to lower maternal mortality (Abubakari, *et al*., 2022).

Moving to the short-run dynamic estimates of the PMG model, the error correction term is highly significant, with a coefficient of -0.030 and a p-value of 0.003. This negative and significant ECT indicates that any short-term deviation from the long-run equilibrium will be corrected at a rate of 3% per period. This confirms the model's ability to converge back to the long-run equilibrium after a shock, reflecting a stable relationship between the variables in the long term.

Life expectancy rate changes show a negative coefficient, suggesting improvements in life expectancy could reduce maternal mortality rate, although this result is not statistically significant in the short run, possibly due to the gradual nature of life expectancy changes. Political stability yields a positive coefficient, indicating a slight, non-significant increase in maternal mortality. Fertility rate changes have a negative coefficient, suggesting no significant short-term impact on maternal mortality, likely due to the time lag in fertility effects (Habte, *et al*., 2024).

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Furthermore, HIV/AIDS prevalence has a highly significant positive impact on maternal, highlighting the immediate adverse effects of increased HIV/AIDS prevalence on maternal health and the critical need for effective prevention and treatment programs. Health expenditure changes show an insignificant coefficient, suggesting that short-term health funding increases do not immediately improve maternal rates due to the time required for these expenditures to enhance healthcare systems (Meh, *et al*., 2019). Finally, education expenditure also shows an insignificant relationship with maternal mortality, indicating that short-term changes in education spending do not quickly impact maternal mortality, likely because the benefits of education on health literacy and socioeconomic status manifest over a longer period (Osemwengie and Shaibu, 2020).

Table 8: Baseline and Robustness Models

BASELINE MODEL:						
VARIABLE	**HETEROGENEOUS PANEL ANALYSIS**				**HOMOGENEOUS PANEL ANALYSIS**	
	Long Run Static Estimates: Dependent Variable - MMR					
	MG		**PMG**		**DFE**	
	Coefficient	Prob.	Coefficient	Prob.	Coefficient	Prob.
LEX	-2.044	0.531	-0.283	0.838	-5.151***	0.000
POL	2.511	0.265	3.147**	0.020	6.848**	0.018
FER	13.752	0.434	13.854***	0.000	32.540**	0.001
HIV	0.648	0.815	4.854***	0.000	3.305**	0.001
HEA	-0.082	0.538	0.112	0.138	0.305**	0.002
EDU	0.028	0.862	-0.218**	0.020	0.215	0.433
	Short Run Dynamic Estimates: Dependent Variable - ΔMMR					
ECT(-1)	-0.093	0.267	-0.030**	0.003	-0.164***	0.000
ΔLEX	-0.329	0.381	-0.306	0.184	-0.557	0.136
ΔPOL	0.020	0.870	0.056	0.690	-0.416	0.454
ΔFER	-1.323	0.329	-1.809	0.290	10.969***	0.000
ΔHIV	0.931***	0.000	1.410***	0.000	0.783***	0.000
ΔHEA	0.003	0.688	0.002	0.482	-0.027	0.113
ΔEDU	-0.013	0.141	-0.004	0.559	0.082**	0.034
Constant	-32.887	0.260	-11.359***	0.000	3.101	0.895
Hausman Test	**H_0: $\beta_{MG} = \beta_{PMG}$ t-stat. = 0.99 prob.= 0.986**			**H_0: $\beta_{DFE} = \beta_{PMG}$ t-stat. = 1.23 prob.= 0.976**		
Countries	16		16		16	
Observation	352		352		352	
	ROBUSTNESS MODEL:					
VARIABLE	**FMOLS**		**DOLS**		**CCR**	
	Coefficient	Prob.	Coefficient	Prob.	Coefficient	Prob.
LEX	-3.952***	0.000	7.545	----	-2.060	0.189
POL	0.059	0.958	-5.518	----	-0.487	0.818
FER	34.278***	0.000	0.001	----	34.503***	0.000
HIV	2.473***	0.000	-5.336	----	1.159	0.389
HEA	-0.070**	0.013	-1.576	----	-0.140	0.389

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EDU	0.370**	0.001	1.290	----	0.500**	0.013
Constant	-6.234**	0.014	0.000	----	-35.312***	0.000
Hausman Test	**H_0: $\alpha_{FMOLS} = \alpha_{DOLS}$ t-stat. = 3405.67 prob.= 0.000**			**H_0: $\alpha_{CCR} = \alpha_{FMOLS}$ t-stat. = 12.36 prob.= 0.06**		
Countries	16		16		16	
Observation	22		20		22	
R^2	0.988		1.000		0.985	

Source: Author's Computation, 2024. Note: *** = 1% significance level, ** = 5% significance level.

Transitioning to the robustness model, the study conducts a Hausman test to select the best model among fully modified ordinary least squares, dynamic ordinary least squares, and CCR. The Hausman test outcomes indicate that the FMOLS estimator is consistent with both the DOLS and CCR estimators, establishing it as the preferred model for robustness analysis.

Starting with the life expectancy rate, the FMOLS model shows a significant negative effect, indicating that higher life expectancy reduces maternal mortality. This aligns with theoretical expectations and empirical evidence suggesting improvements in life expectancy reflect better overall health conditions and medical advancements (Salisu and Hamza, 2024). In contrast, the PMG model also finds a negative impact but lacks statistical significance, suggesting the FMOLS model provides a more robust validation of this relationship.

Political stability presents differing results between the two models. The FMOLS model shows an insignificant coefficient, indicating no significant long-term impact on maternal mortality when endogeneity and serial correlation are accounted for. This contrasts with the PMG model, which identifies a significant positive relationship, suggesting potential short-term disruptions during stabilization periods (Jones *et al*., 2018).

The fertility rate has a highly significant positive coefficient in the FMOLS model, consistent with the PMG model, reinforcing that higher fertility rates significantly increase maternal mortality due to more frequent pregnancies and healthcare strain (Souza, *et al*., 2024). HIV/AIDS prevalence similarly shows a significant positive relationship with maternal mortality in both models, underscoring the immediate and severe impact of HIV on maternal health and the need for effective interventions (Fagbeminiyi and Oduaran, 2019).

Health expenditure reveals a significant negative relationship with maternal mortality in the FMOLS model, suggesting that increased health spending reduces maternal mortality by enhancing healthcare infrastructure and quality. This finding contrasts with the PMG model's insignificant positive coefficient, highlighting the FMOLS model's robustness in accounting for endogeneity (Kolo, *et al*., 2017).

Lastly, education expenditure shows a significant positive effect on maternal mortality in the FMOLS model, suggesting that increased education spending might not immediately

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reduce maternal mortality, possibly due to delayed benefits or initial broader educational focus. This contrasts with the PMG model, which finds a significant negative relationship, indicating the need for further investigation into the timing and targeting of education investments.

5. CONCLUSION AND POLICY IMPLICATIONS

This paper examines the determinants of maternal mortality across sixteen West African nations from 2000 to 2022 using robust econometric methods, specifically the PMG and FMOLS. The study explores both clinical determinants and socio-economic influences, such as life expectancy, political stability, fertility rate, HIV prevalence, education and healthcare expenditure, on maternal mortality rates. Grounded in life-course perspective theory, the findings reveal significant long-run and short-run determinants affecting maternal mortality.

In conclusion, the analysis begins with the PMG model, which indicates that life expectancy has a negative but statistically insignificant relationship with maternal mortality. Conversely, the FMOLS model found this relationship to be significantly negative, suggesting that improvements in life expectancy are associated with lower maternal mortality when more robust methods are employed.

Political stability exhibits a positive and significant relationship with maternal mortality in the PMG model, which is counterintuitive and contrary to theoretical expectations. However, the FMOLS model shows no significant impact of political stability on maternal mortality, indicating that political stability might not directly influence maternal health outcomes when accounting for endogeneity and serial correlation.

The fertility rate is seen to have a positive and highly significant relationship with maternal mortality in both the PMG and FMOLS models. This aligns with the economic theory that higher fertility rates increase the risks associated with childbirth and strain healthcare resources, thereby elevating maternal mortality rates. Similarly, HIV/AIDS prevalence shows a positive and highly significant impact on maternal mortality across both models, underscoring the severe and immediate risks that HIV/AIDS poses to maternal health.

Health expenditure presents a complex relationship. In the PMG model, shows a positive but statistically insignificant relationship with maternal mortality, suggesting that increased health expenditure alone might not be effective in reducing maternal mortality. In contrast, the FMOLS model reveals a significantly negative relationship, highlighting that when health spending is effectively utilized, it can significantly lower maternal mortality.

Finally, education expenditure reveals contrasting results. The PMG model indicates a significant negative relationship with maternal mortality, suggesting that higher investment in education leads to better health outcomes and reduced maternal mortality. On the other hand, the FMOLS model reveals a significant positive relationship,

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suggesting that the benefits of education spending on maternal health might be delayed or initially broader in scope.

Based on these findings, policy recommendations emphasize a multifaceted approach to reducing maternal mortality in West Africa. Investments in healthcare infrastructure and effective utilization of health expenditures are crucial, as the model demonstrates a significant negative relationship. Policies target reducing HIV/AIDS prevalence through robust prevention and treatment programs, given its consistently significant positive impact on maternal mortality. Furthermore, reducing fertility rates through comprehensive family planning and reproductive health services is essential, as indicated by its strong positive correlation with maternal mortality. Increasing education expenditure is vital, but it must be strategically directed toward programs that enhance health literacy and women's socioeconomic status to realize long-term health benefits. Finally, political stability should be leveraged to implement and sustain effective health policies, ensuring that stability translates into tangible healthcare improvements rather than merely existing without addressing systemic healthcare issues. These targeted, evidence-based strategies provide a coherent framework for significantly lowering maternal mortality rates in the region.

Notes

1) Benin, Burkina Faso, Cape Verde, The Gambia, Ghana, Guinea, Guinea-Bissau, Ivory Coast, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, and Togo.
2) MMR = maternal mortality rate, LEX = life expectancy rate, POL = political stability, FER = fertility rate, HIV = prevalence of HIV/AIDS, HEA = health expenditure, and EDU = educational expenditure.

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