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THE IMPACT OF HEALTH INPUTS ON HEALTH OUTCOMES IN NIGERIA: A NARDL APPROACH

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Abstract

This study employs a NARDL technique to examine the intricate relationship between health inputs and health outcomes in Nigeria spanning 2000 to 2023. Drawing on Grossman's health capital theory, the analysis dissects the impact of public and private health expenditures on infant mortality, maternal mortality, life expectancy, and an aggregate health outcome index. Findings reveal unexpected associations, with increases in public health expenditure positively linked to infant mortality rates, while private health expenditure exhibits a negative impact, aligning with theoretical expectations. However, both public and private health expenditures lack significant effects on maternal mortality rates, highlighting the need for targeted interventions in maternal healthcare. Moreover, while private health expenditure significantly contributes to improvements in life expectancy and overall health outcomes, public health expenditure shows no significant effects, indicating potential deficiencies in government healthcare infrastructure and spending allocation. The Granger causality tests reveal no significant causal links between health inputs and health outcomes, except for weak unidirectional causality from infant mortality to private health expenditure and private health expenditure to overall health outcome index. The study recommends targeted public spending, public-private partnerships, improved maternal healthcare, and tailored policies to address regional disparities in healthcare access across Nigeria.

Keywords: Health Inputs, Health Outcomes, Non-linear ARDL, Nigeria.

Jel Classification: H51, I11, P46, N17.

1. INTRODUCTION

Ensuring public and private health is vital for societal prosperity and economic growth, especially in Africa (Bashir, 2016; Ifunanyachukwu & Dauda, 2019). Health, encompassing physical, psychological, and societal health are crucial for both economic and non-economic endeavors (World Health Organization, 2018; Owusu, et al., 2021). Mortality rates for mothers and infants, as well as life expectancy, reflect a nation's health and socioeconomic status (Owusu, et al., 2021). Adequate funding for health plans is crucial for achieving sustainable development goals and societal stability (Blanc, 2015; World Health Organization, 2017, 2019).

The United Nations' Sustainable Development Goal (SDG), particularly Goal 3, aims to improve global health by 2030, targeting reduced maternal and infant mortality rates and increased health funding (WHO, 2016). Maternal mortality, occurring during pregnancy or within 42 days post-termination, impacts socioeconomic development (Boundioa & Thiombiano, 2024). Child survival is crucial for future growth and economic vitality, though challenges like poor sanitation and malnutrition persist, contributing to elevated mortality

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rates (Eboh, et al., 2022). Despite progress, 3.9% of children worldwide pass away before reaching the age of 5 years, with Nigeria facing high rates, necessitating prioritized health expenditure (UNICEF, 2020; United Nations, 2020; Ufere, 2019; World Bank, 2019).

Government investment in healthcare, crucial for reducing child mortality, ensures accessibility and affordability of services, supporting interventions like immunization and disease management (BudgIT, 2018; Raghupathi & Raghupathi, 2020). Nigeria faces high infant mortality rates, emphasizing the need for improved healthcare accessibility and increased government spending (WHO, 2020; UNICEF, 2020; Macrotrends, 2020). However, challenges persist due to reduced support, partially addressed by initiatives like the National Health Insurance Scheme (Eke, 2018).

Nigeria faces healthcare challenges including staff shortages and inadequate infrastructure, resulting in high child mortality rates and malnutrition, impacting cognitive development and productivity (Oluremi, 2019; Pate, 2017). Despite rising health expenditure, which reached 202.36 billion in 2016, allocations remain below WHO's recommended levels, contributing to high infant mortality and maternal deaths (Wasiu, 2020; UNICEF, 2018). With a life expectancy of around 51 years, Nigeria struggles to improve healthcare performance and bridge global health disparities (WHO, 2021).

Recent years have seen an increased exploration of how public health spending affects health outcomes due to demographic shifts, rising healthcare costs, and recognition of public health efficiency (Kiross, et al., 2020). Empirical studies yield inconclusive findings on this connection, with divergent views: some affirm positive impacts, while others find non-significant or negative effects (Boundioa & Thiombiano, 2021). Hence, this paper tends to investigate the effect of government health expenditures on health outcomes in Nigeria between 2000 and 2023, addressing challenges in healthcare infrastructure, funding, and child mortality rates (Arthur & Oaikhenan, 2017; Rizzo, 2019).

Consequently, this study is structured into five distinct sections. The first section functions as an introduction, while the second section examines relevant literature. Sections three and four focus on outlining the research methodology and analyzing empirical findings, respectively. The fifth section concludes the paper and provides policy recommendations.

2. LITERATURE REVIEW

2.1 Health Outcomes

Health outcomes such as mortality rates for children under five, infant mortality, and life expectancy, and maternal mortality reflect population well-being (Mwaura, 2024). They assess overall population health and identify areas needing improved healthcare and public health interventions.

Under-Five Mortality:

Global efforts have resulted in an almost 50% decrease in mortality among children under five years old since 1990, but disparities remain. Studies, including Wang et al. (2017)

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and Nyamuranga & Shin (2019), consistently show a positive association between healthcare expenditure and lower under-five mortality rates. Goryakin, et al. (2017) and Kiross et al. (2020) underscore the critical role of healthcare spending, noting a 1.1% decrease in under-five mortality with every US$1 increase. Challenges persist, with many countries failing to meet the recommended 6% of GDP spending on healthcare (Mwaura, 2024).

Infant Mortality:

Infant mortality, indicating a child's death before their first birthday, reflects a nation's health status (WHO, 2021). Factors like poverty and limited healthcare access contribute to approximately 2.4 million infant deaths annually, primarily in nations with low to moderate incomes. Studies in India (Jain, Singh, & Pathak, 2013) and Ghana (Kiross et al., 2020) consistently link healthcare spending to reduced infant mortality rates. Despite evidence supporting this association, many developing nations like Nigeria struggle to allocate sufficient resources to healthcare (Osakede, 2021).

Maternal Mortality:

Maternal mortality, influenced by various factors, saw approximately 295,000 global deaths in 2017 (Mwaura, 2024). Studies by Akseer et al. (2016) and Hosseinpoor (2012) highlight the positive correlation between healthcare expenditures and improved maternal health outcomes, crucial in countries like Nigeria with limited healthcare access. Aziz et al. (2021) emphasize lower health expenditure's association with higher maternal mortality rates. Public health expenditure, along with investments in women's education, is vital in addressing maternal mortality (Gakidou et al., 2010).

Life Expectancy:

Life expectancy, indicating the average lifespan in a population, is extensively studied concerning healthcare expenditures. Baluran (2023) links increased life expectancy in the US to heightened healthcare costs. Roffia et al. (2023) found a 3.5% rise in healthcare spending per one-year increase in life expectancy across 23 high-income nations. Bunyaminu et al. (2022) noted a 1.2% healthcare spending increase per year of increased life expectancy in low to moderate-income countries. Ikilezi et al. (2021) stress government funding's importance in sustaining immunization programs, despite challenges in maintaining or improving vaccine coverage.

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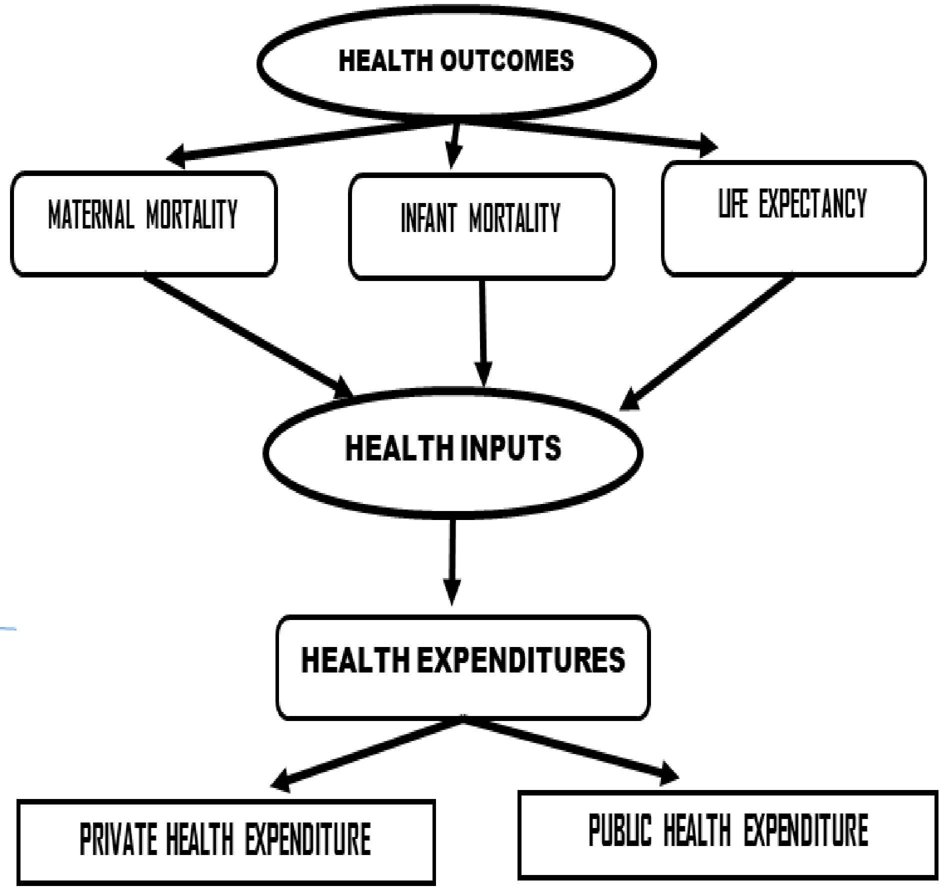

2.2 Health Inputs

Government spending is pivotal in national development, influencing resource allocation and income distribution (Aluthge, et al., 2021). Health inputs, encompassing medical services, infrastructure, and preventive measures, are crucial for public health (Aluthge, et al., 2021). Health expenditure, both public and private, contributes to enhancing national health, with private spending mainly through out-of-pocket expenses (WHO, 2010; OECD, 2010; WHO, 2014). In Nigeria, private health expenditure primarily involves out-of-pocket spending, covering various healthcare costs like medicines and direct household expenses (WHO, 2006; OECD, 2015).

Out-of-pocket payments, as defined by Olatunde (2012), are fees paid for healthcare services, burdening users, especially in regions with limited government health spending (WHO, 2010). This disproportionately affects the poor and vulnerable, emphasizing the need for equitable healthcare financing (OECD, 2015). Public health expenditure, sourced from governmental funds, aims to alleviate individual burdens and create a fairer healthcare system (OECD, 2015). The heavy reliance on out-of-pocket payments underscores the importance of enhancing government healthcare funding to reduce disparities in healthcare access and affordability (Olatunde, 2012).

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2.3 Empirical Review

Nigeria Experience:

An empirical review of studies focusing on the nexus between health inputs and health outcomes in Nigeria reveals varied findings. Anokwuru & Chidinma (2023) found insignificant long-term links between government health spending and infant mortality but noted short-term positive nexus, advocating for meeting the 15% health budget target. Olaitan & Miftahu (2023) identified significant negative effects of both capital and recurrent public spending on child mortality, stressing the importance of increased spending for national development. Chukwuemeka, et al. (2023) highlighted a significant positive impact of public health spending on child mortality, urging improved allocation and monitoring of health funds. Akinbode, et al. (2023) recommended enhanced government health spending and strategic coordination of foreign aid to reduce under-five mortality. Oladosu, et al. (2022) emphasized the need for increased health spending, considering Malaria and HIV/AIDS mortality. Sado & Ogirima (2022) recommended substantial government health expenditure increments to lower infant mortality, emphasizing the need for efficient utilization. Igwe & Uhrie (2022) stressed the need for more nuanced models reflecting real-world complexities when studying health and social issues in Nigeria. Further research by Cyril & Mathias (2021) emphasized collaboration between public and private sectors to improve healthcare and recommended intensified immunization programs. Ochiaka & Akuma (2021) highlighted the positive nexus between increased healthcare spending and higher life expectancy, advocating for increased government budgeting aligned with WHO recommendations. Iwuchukwu, et al. (2021) stressed the positive effect of health education on health outcomes, emphasizing the need for increased awareness and education programs. Adeosun & Faboya (2020) revealed a negative nexus between healthcare spending and infant mortality, proposing targeted expenditure to address healthcare challenges effectively. These studies collectively underscore the critical role of government health expenditure in improving health outcomes, advocating for increased spending, effective utilization, and multi-faceted approaches to address health challenges in Nigeria.

Other Countries Experience:

Studies across various regions underscore the critical role of public health inputs in shaping health outcomes. Boundioa & Thiombiano (2024) highlight that increased public health spending in WAEMU countries correlates with lower maternal mortality rates, contrasting with the adverse trend associated with private expenditure. Mwaura (2024) extends this discussion, revealing significant associations between public health expenditure and health outcomes across different income levels, particularly in middle-income countries where healthcare spending positively impacts infant mortality rates. Ayipe & Tanko (2023) focus on Sub-Saharan Africa's low-income nations, highlighting the negative nexus between domestic health spending and under-five mortality rates, stressing sustained expenditure hikes and improved social conditions. Osei, et al. (2023) analyze government health expenditure's impact on child health indicators in West African

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nations, noting a long-term negative effect on under-five mortality rates and stunting rates. Bayero, Safiyanu, & Gurin (2022) corroborate these findings, showcasing the varied impact of health expenditure on maternal and child mortality across income levels in African countries. Similarly, Logarajan, et al. (2022) emphasize the necessity of robust health financing safety nets to safeguard child health outcomes in Malaysia, highlighting the negative impact of out-of-pocket expenses on under-five mortality. Bajer (2022) and Alfred & Metiboba (2021) emphasize the importance of government and external health funding in reducing infant and child mortality rates across African nations, urging increased investment and immunization efforts. Mustapha, et al. (2021) further stress the indirect impact of public health spending on infant mortality in West Africa, underlining the significance of sustained health expenditure and policy prioritization for improved child health outcomes. These studies collectively underscore the paramount importance of public health expenditure in improving maternal and infant health outcomes and life expectancy across diverse geographical and socioeconomic contexts.

3. METHODOLOGY

3.1 Theoretical Framework

Grossman's (1972) health capital theory revolutionized understanding health investment dynamics, conceptualizing health as capital, akin to financial or human capital, yielding improved quality of life and productivity (Grossman, 1972). Central to the model is rational decision-making in health investment, allocating resources to activities promoting health and preventing illness (Adhiambo, 2017). Grossman's model operates through three components: health demand, production, and medical care demand, influenced by personal preferences, socio-economic status, lifestyle, genetics, environment, and healthcare-seeking behavior (Grossman, 1972). Active investment can help maintain or enhance health capital (Boachie & Ramu, 2016).

$$H_t = f(X_t) \quad (1)$$

Health outcomes (H_t) are influenced by diverse inputs (X_t), including health expenditure and healthcare components such as medical services. Recent studies (Edeme et al., 2017; Agbatogun & Opeloyeru, 2020; Olatunde et al., 2019; Salisu et al., 2018) have enhanced the health capital model (eqn. 1) by incorporating health expenditure (HE_t) and supplementary control variables (X_t).

$$H_t = f(HE_t, X_t) \quad (2)$$

$$H_t = \beta_0 + \beta_1 HE_t + \beta_2 X_t + \varepsilon_t \quad (3)$$

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3.2 Model Specification and Theoretical Expectations

The segment examines theories linking Nigeria's health progress to expenditure growth, proposing a model (Equation 4) to analyze how health inputs and health outcomes influence economic advancement. It dissects health expenditures into public and private sectors to decipher their evolving connection to Nigeria's spending narrative.

$$IMR_t = f(PUHE, PRHE)_t \qquad (4)$$

Equation (4) enhances the Grossman (1972) health model by substituting variables, incorporating IMRt for Ht, and PUHEt and PRHEt for HEt. Consequently, the econometric form of the model can be expressed as:

$$IMR_t = \beta_0 + \beta_1 PUHE_t + \beta_2 PRHE_t + \mu_t \qquad (5)$$

Furthermore, by incorporating other health outcome components, the econometric form is given as:

$$MMR_t = \beta_0 + \beta_1 PUHE_t + \beta_2 PRHE_t + \mu_t \qquad (6)$$

$$LEX_t = \beta_0 + \beta_1 PUHE_t + \beta_2 PRHE_t + \mu_t \qquad (7)$$

$$HOI_t = \beta_0 + \beta_1 PUHE_t + \beta_2 PRHE_t + \mu_t \qquad (8)$$

Where IMR = infant mortality, MMR = maternal mortality. LEX = life expectancy, HOI = health outcome index, PUHE = public health expenditure, PRHE = private health expenditure, and μ_t= stochastic error term. Furthermore, the a-priori theoretical expectations establishes the groundwork by forecasting the potential relationships derived from established theories. Consequently, the following theoretical deductions are presumed:

$$\frac{\partial(IMR)}{\partial(PUHE)} < 0, \frac{\partial(IMR)}{\partial(PRHE)} < 0 \qquad (9)$$

$$\frac{\partial(MMR)}{\partial(PUHE)} < 0, \frac{\partial(MMR)}{\partial(PRHE)} < 0 \qquad (10)$$

$$\frac{\partial(LEX)}{\partial(PUHE)} > 0, \frac{\partial(LEX)}{\partial(PRHE)} > 0 \qquad (11)$$

$$\frac{\partial(HOI)}{\partial(PUHE)} > 0, \frac{\partial(HOI)}{\partial(PRHE)} > 0 \qquad (12)$$

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Given the a-priori theoretical expectation for model one, two, and four, a negative impact is expected between public health expenditure and private health expenditure on infant and maternal mortality rate. Conversely, in model three, a positive relationship is expected between the impact of public and private health expenditure on life expectancy.

3.3 Data Measurement, Scope and Sources

The research analyzes time series data from 2000 to 2023, spanning 24 years, ensuring reliability despite proxy challenges. The dataset includes factors like infant mortality, maternal mortality, life expectancy, health outcome index, public health expenditure, and private health expenditure, facilitating credible forecasting and policy insights. The study's dependent variables are infant mortality, maternal mortality, life expectancy, and health outcome index, while explanatory variables include public and private health expenditure, detailed in Table 1.

Table 1: The summary of the Data, interpretation and the Sources

Variable Name	Measurement	Data Source	Variable Source	Expected Sign
Infant Mortality (IMR)	Natural logarithm of mortality rate, infant (per 1000 live births)	World Bank Database	Logarajan, et al. (2022)	Dependent Variable
Maternal Mortality (MMR)	Natural logarithm of maternal mortality rate (per 1000 live births)	World Bank Database and other Journals	Adeosun, et al. (2020)	Dependent Variable
Life Expectancy (LEX)	Total life expectancy at birth	World Bank Database	Adeosun, et al. (2020)	Dependent Variable
Health Outcome Index (HOI)	Computed from three components of health inputs (IMR, MMR, and LEX) using the index of principal component analysis.	Outputs from the Principal Component Analysis (PCA)	Author's computation.	Dependent Variable
Public Health Expenditure (PUHE)	Natural logarithm of domestic general government health expenditure	World Health Organization Database	Logarajan, et al. (2022)	Negative / Positive
Private Health Expenditure (PRHE)	Natural logarithm of domestic private health expenditure	World Health Organization Database	Logarajan, et al. (2022)	Negative / Positive

3.3 Estimation Strategy

Preliminary Analyses

To ensure the robustness of the study, preliminary assessments will be conducted. Firstly, descriptive statistics will be scrutinized to validate the attributes of the variables. Second, multicollinearity (correlation matrix) will be examined to ensure the independence of

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variables. Third, lag selection will be assessed to determine the appropriate time frame for the analysis. Lastly, stationarity or unit root (ADF and PP) will be evaluated to enhance the reliability of the data. These comprehensive assessments aim to guide the selection of a suitable estimation method aligned with the study's objectives, ensuring methodological integrity.

Technique of Analysis

This study adopts the NARDL approach introduced by Shin et al. (2013). The empirical specification starts with Pesaran et al. (2001) symmetric ARDL model. If X and Y lack I(2) stationary variables, the ARDL model is expressed as:

$$\Delta Y_t = \gamma_y Y_{t-1} + \gamma_x X_{t-1} + \varphi K_t + \sum_{i=1}^{u-1} \delta_{iy} \Delta Y_{t-i} + \sum_{i=0}^{v-1} \delta_{ix} \Delta X_{t-i} + e_t \qquad (13)$$

The analysis employs the difference operator (∆) and identifies long (γ) and short (δ) run coefficients in the model. Also, φ is the vector of exogenous regressors, and e_t is the error component. The initial step involves cointegration testing using the Wald test on the H_0 of joint or separate γ_y and γ_x (i.e. $\gamma_y = \gamma_x = 0$). Critical bounds, based on stationarity characteristics, determine significance. Subsequent steps assess short- and long-run impacts with p-values.

The study prioritizes the asymmetric ARDL (NARDL) method, acknowledging its ability to handle cointegration endogenous models better than symmetric ARDL (Enders, 2015). Unlike symmetric models, asymmetric methods account for asymmetric responses to economic changes, ensuring more reliable policy conclusions, particularly when X and Y react asymmetrically. Equation (13) is adjusted accordingly to represent the long-run linear asymmetric model.

$$Y_t = \beta^+ X_t^+ + \beta^- X_t^- + \alpha^+ Z_t^+ + \alpha^- Z_t^- + \mu_t \qquad (14)$$

Where Y_t = health outcome indicators, X_t = public health expenditure, Z_t = private health expenditure, β^+ (β^-) are the long-run coefficient connected to positive or negative changes in public health spending (X_t), while α^+ (α^-) are for private health spending (Z_t) through integration ($X_t = X_t + X_t^- + X_t^+$).

$$X_t^+ = \sum_{j=1}^{t} \Delta X_j^+ = \sum_{j=1}^{t} \max(\Delta X_j, 0) \qquad (15)$$

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$$X_t^- = \sum_{j=1}^{t} \Delta X_j^- = \sum_{j=1}^{t} \min(\Delta X_j, 0) \quad (16)$$

The linear combination (W_t) of equation (14) incorporates asymmetric partial squares.

$$W_t = k + \vartheta_1^+ Y_t^+ + \vartheta_2^- Y_t^- + \theta_1^+ X_t^+ + \theta_2^- X_t^- + \pi_1^+ Z_t^+ + \pi_2^- Z_t^- + e_t \quad (17)$$

Equation (17) attains stationarity when W_t = I(0) and exhibits a linear asymmetric long-run cointegrating relationship rejecting the null hypothesis ($\vartheta_1^+ = \vartheta_2^- = \theta_1^+ = \theta_2^- = \pi_1^+ = \pi_2^-$ = 0). Addressing multicollinearity and endogeneity, equations (14, 15, and 16) are adjusted to dynamic formats for accurate cointegration analysis.

$$Y_t = \sum_{i=1}^{p} \gamma Y_{t-i} + \sum_{i=0}^{q} (\beta^+ X_{t-i}^+ + \beta^- X_{t-i}^- + \alpha^+ Z_{t-i}^+ + \alpha^- Z_{t-i}^-) + e_t \quad (18)$$

Where γ represents the AR parameter, while β and α cause dynamic adjustments in the cointegrating dynamic format, symbolized as:

$$\Delta Y_t = \rho Y_{t-i} + \vartheta^+ X_{t-i}^+ + \vartheta^- X_{t-i}^- + \theta^+ Z_{t-i}^+ + \theta^- Z_{t-i}^- + \sum_{i=1}^{p} \delta_i \Delta Y_{t-i} + \sum_{i=0}^{q} \Delta\tau_i^+ X_{t-i}^+ + \Delta\tau_i^- X_{t-i}^- + \Delta\pi_i^+ Z_{t-i}^+ + \Delta\pi_i^- Z_{t-i}^- + e_t \quad (19)$$

Equation (19) represents the NARDL model by Shin et al. (2014), with $\rho, \vartheta, and\ \theta$ reflecting long-run asymmetric coefficients and $\delta, \tau, and\ \pi$ denoting asymmetric short-run dynamics. Furthermore Y_t are indicators of health outcomes (IMR, MMR, LEX, HOI), X_t is the indicator of public health spending (PUHE), and Z_t is the indicator of private health spending (PRHE). Consequently, the multiplier process is given as:

$$M^+ = \sum_{i=0}^{h} \frac{\partial Y_{t+i}}{\partial X_i^+} = \sum_{i=0}^{h} \beta_i^+ , h = 0, 1, 2, 3, \dots, t \quad (20)$$

$$M^- = \sum_{i=0}^{h} \frac{\partial Y_{t+i}}{\partial X_i^-} = \sum_{i=0}^{h} \beta_i^- , h = 0, 1, 2, 3, \dots, t \quad (21)$$

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$$M^{+} = \sum_{i=0}^{h} \frac{\partial Y_{t+i}}{\partial Z_i^{+}} = \sum_{i=0}^{h} \alpha_i^{+}, h = 0, 1, 2, 3, \ldots, t \qquad (22)$$

$$M^{-} = \sum_{i=0}^{h} \frac{\partial Y_{t+i}}{\partial Z_i^{-}} = \sum_{i=0}^{h} \alpha_i^{-}, h = 0, 1, 2, 3, \ldots, t \qquad (23)$$

Principal Component Analysis (PCA) Framework

Principal Component Analysis is a widely used method in multivariate statistical analysis. It transforms a set of related variables into uncorrelated new variables. Given a vector of random variables ($X = [x_1, x_2 \ldots x_n]^T$) and its mean vector as zero (E[x] = 0), PCA seeks normalized linear combinations that explain the most variability. This is achieved by finding a non-zero vector ($B = [b_1, b_2 \ldots b_n]^T$) that maximizes the variance of the linear combination B'x, which can be written as:

$$var[B'x] = E[B'x]^2 = E[(b_1x_1 + b_2x_2 + \cdots + b_nx_n)^2] \qquad (24)$$

Given that covariance matrix of x = C, then the variance of B'x is:

$$var[B'x] = B'CB \qquad (25)$$

Solving for vector B entails working with the associated Lagrange function.

$$L = B'CB - \tau(B'B - 1) \qquad (26)$$

Consequently, the partial derivative of the first order condition is given as:

$$\frac{\partial L}{\partial B} = 2CB - 2\tau B = 2(C - \tau I)B = 0 \qquad (27)$$

The equation CB = τB simplifies the FOC, representing eigenvalues and eigenvectors for covariance matrix C. Each τi corresponds to eigenvector Bi, explaining total variability in linear combination B_i'x, and forming independent principal components for x.

$$PC_1 = B_1'x = b_{11}x_1 + b_{12}x_2 + \cdots + b_{1n}x_n$$

$$PC_2 = B_2'x = b_{21}x_1 + b_{22}x_2 + \cdots + b_{2n}x_n$$

……………………..

$$PC_n = B_n'x = b_{n1}x_1 + b_{n2}x_2 + \cdots + b_{nn}x_n \qquad (28)$$

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PCA retains key information from x variables, identifying PCs as orthogonal factors, offering a new data perspective.

Granger Causality Test

Granger (1969) laid the groundwork for causal testing through his pioneering work in multivariate regressions, a cornerstone that has profoundly influenced subsequent research endeavors. His innovative approach not only introduced a methodological framework for analyzing causality but also sparked a paradigm shift in how scholars approach the investigation of relationships within datasets.

$$Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \cdots + \alpha_p Y_{t-p} + \beta_1 X_{t-1} + \cdots + \beta_p X_{t-p} + \epsilon_t \quad (29)$$

$$X_t = \alpha_0 + \alpha_1 X_{t-1} + \cdots + \alpha_{p,} X_{t-p} + \beta_1 Y_{t-1} + \cdots + \beta_p Y_{t-p} + \epsilon_t \quad (30)$$

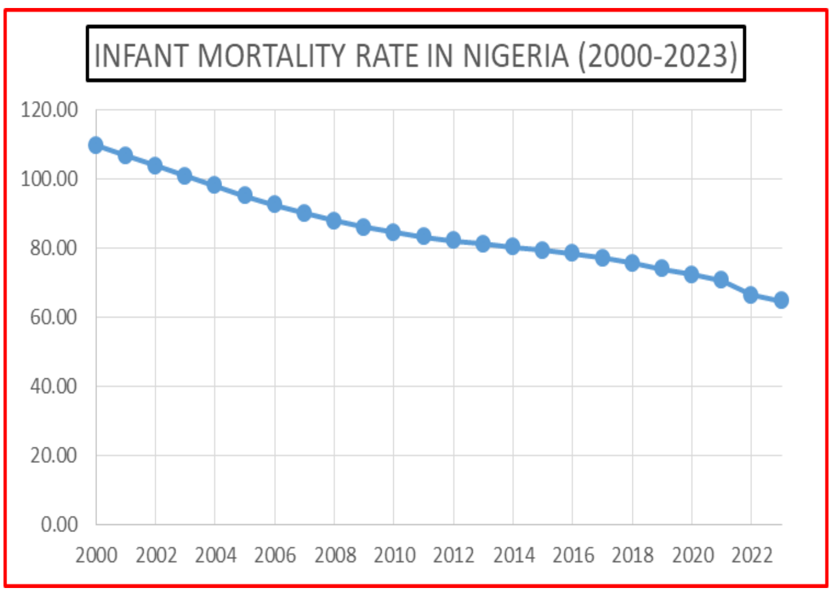
Traditionally, these tests treat data as a single entity, assuming uniform coefficient. By recognizing and accommodating variations across different groups or units, these modern approaches provide a more comprehensive understanding of causality dynamics, enriching the empirical toolkit available to researchers in various fields.

$$\alpha_{0,i} = \alpha_{0,j}, \alpha_{1,i} = \alpha_{1,j}, \ldots, \alpha_{p,i} = \alpha_{p,j}, \varphi_{i,j} \quad (31)$$

$$\beta_{1,i} = \beta_{1,j}, \ldots, \beta_{p,i} = \beta_{p,j}, \varphi_{i,j} \quad (32)$$

4. RESULT AND DISCUSSION

Trend Analysis



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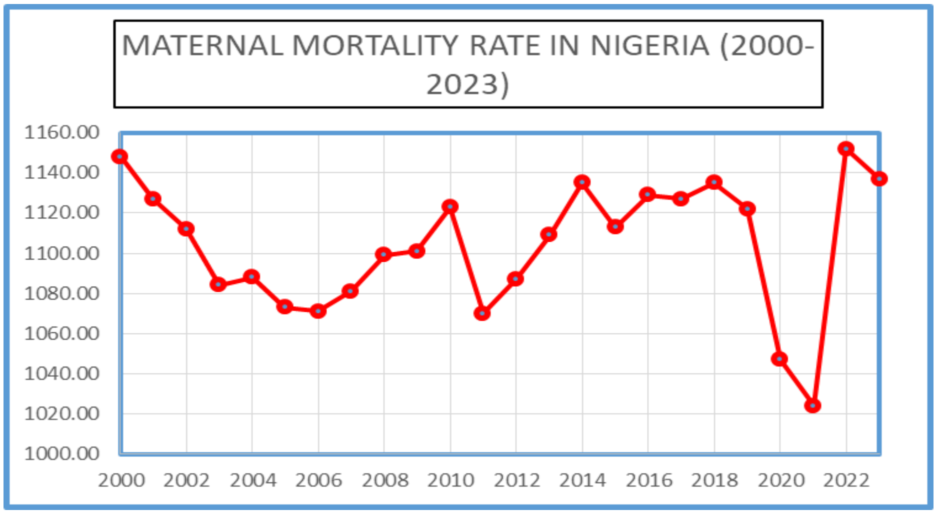

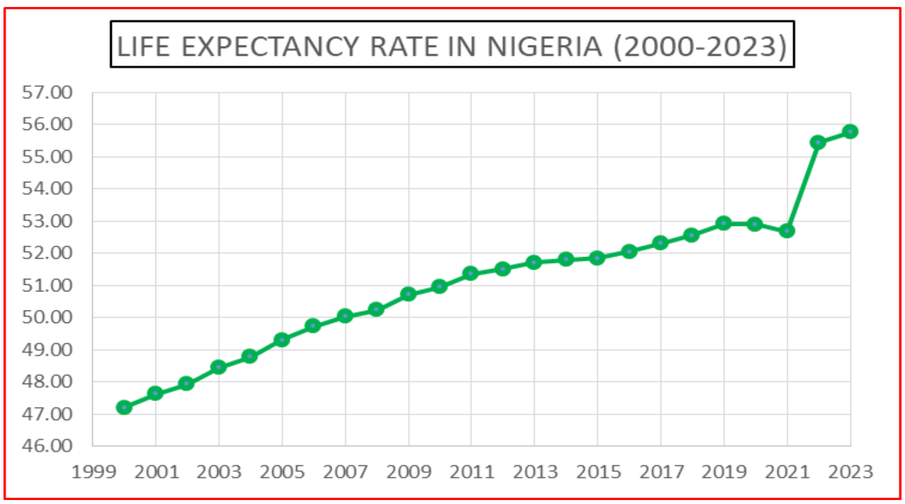

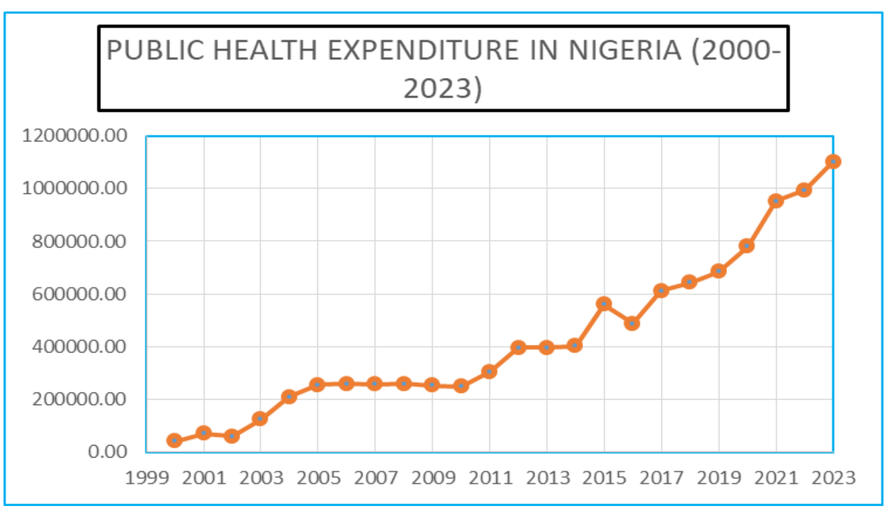

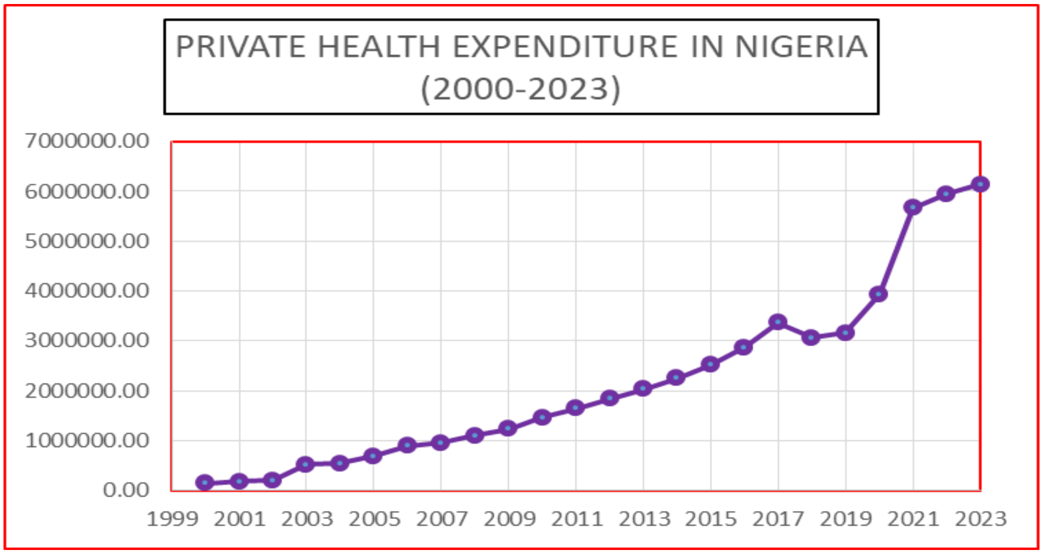

Figure 1: Summary of the Trends of Variables

In Figure 1 above, the infant mortality steadily decreased from 109.60 in 2000 to 64.74 in 2023, reflecting improved infant health outcomes in Nigeria. Maternal mortality varied over the years, declining from 1148.00 in 2000, with fluctuations until 2023, stressing the importance of sustained maternal healthcare efforts. Life expectancy rose from 47.19 in 2000 to 55.75 in 2023, indicating overall population health improvements. Public health expenditure surged from 40,391.25 to 1,102,849.62 from 2000 to 2023, indicating increased investments. Private health spending also rose substantially, from 142,727.56 to 6,142,594.36, suggesting a growing reliance on private funding and the need for public-private partnership policies.

Table 2: Descriptive Statistics

VARIABLE	IMR	MMR	LEX	HOI	PUHE	PRHE
Mean	4.432	7.006	3.932	0.000	12.579	14.163
Minimum	4.170	6.931	3.854	-2.416	10.606	11.869
Maximum	4.697	7.049	4.021	2.812	13.809	15.631
Std. Dev.	0.145	0.030	0.043	1.415	0.866	1.081
Variance	0.021	0.001	0.002	2.001	0.750	1.168
Skewness	0.126	-0.690	0.057	0.053	-0.663	-0.675
Kurtosis	2.236	2.953	2.636	2.419	2.734	2.648
Observation	24	24	24	24	24	24

Descriptive statistics provide insights into health outcomes and expenditures in Nigeria. Infant mortality rate (IMR) averages 4.432, with slight positive skewness (0.126) and moderate kurtosis (2.236). Maternal mortality rate (MMR) averages 7.006, showing negative skewness (-0.690) and higher kurtosis (2.953). Life expectancy (LEX) averages 3.932 years, with minimal skewness (0.057) and kurtosis of 2.636. The health outcome index (HOI) displays variability (-2.416 to 2.812) and leptokurtic distribution (kurtosis = 2.419), derived from IMR, MMR, and LEX using principal component analysis. Public

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health expenditure (PUHE) and private health expenditure (PRHE) average 12.579 and 14.163, respectively, with comparable skewness and kurtosis. While PUHE and PRHE exhibit near-normal distributions, health outcomes deviate slightly.

Table 3: Correlation Matrix

VARIABLE	IMR	MMR	LEX	HOI	PUHE	PRHE
IMR	1					
MMR	-0.031	1				
LEX	-0.991	0.115	1			
HOI	-0.992	0.145	0.998	1		
PUHE	-0.960	-0.111	0.942	0.937	1	
PRHE	-0.979	-0.062	0.961	0.960	0.983	1

The correlation matrix reveals strong negative links between IMR and LEX, health outcome index (HOI), PUHE, and PRHE (ranging from -0.960 to -0.992). Increasing these variables lowers infant mortality. Maternal mortality rate (MMR) weakly correlates positively with LEX and HOI and weakly associates positively with PUHE and PRHE. HOI strongly correlates positively with LEX, PUHE, and PRHE, highlighting health indicators' interdependence. LEX also strongly correlates positively with PUHE and PRHE. High correlations between PUHE and PRHE suggest multicollinearity concerns, urging caution in interpreting their individual effects on health outcomes in Nigeria.

Table 4: Lag Selection Test

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	124.87				5.4E-09	-1.1100	-1.0100	-1.0100
1	163.52	77.30	9	0.000	3.8E-10	-1.3100	-1.3100	-1.2100
2	199.41	71.797*	9	0.000	3.6e-11*	-15.674*	-15.3586*	-14.335*

The lag selection test determines the optimal lag order for the NARDL model studying health inputs' impact on health outcomes in Nigeria. Likelihood ratios (LR) at lags 1 and 2 are significant ($p < 0.001$), with higher likelihood values compared to lag 0. Lag 2 demonstrates the lowest final prediction error (FPE) and information criteria values (AIC, HQIC, SBIC), indicating superior model fit and prediction accuracy. Thus, lag 2 is chosen for robust results.

Table 5: Unit Root Test

UNIT ROOT TESTS:										
Variable	AUGMENTED DICKEY-FULLER:					PHILLIP-PERRON:				
	Constant		Trend		Order	Constant		Trend		Order
	Level	Diff.	Level	Diff.		Level	Diff.	Level	Diff.	
IMR	1.911	-0.630	-2.209	1.170	--------	-0.347	-3.133*	-1.665	-3.048 *	I(1)
MMR	-2.729*	-3.898*	-2.854	-3.774 *	I(0)	-3.332*	-5.176 *	--3.253*	-5.133*	I(0)
LEX	-1.260	-1.744	-2.035	-0.897	--------	0.060	-5.362*	-2.194	-5.284*	I(1)
HOI	-2.300	-2.186	-1.262	-2.606	--------	0.227	-5.141*	-2.326	-5.069*	I(1)
PUHE	-2.747*	-3.011*	-7.273*	-2.608	I(0)	-2.676*	-5.172*	-3.309*	-5.244*	I(0)
PRHE	-3.585*	-4.496*	-7.634*	-3.759*	I(0)	-4.664*	-2.943*	-2.457	-5.369*	I(0)

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Unit root tests (ADF and PP) were conducted to assess stationarity. MMR, PUHE, and PRHE showed stationarity at level, with respective test statistics (-2.729*, -2.747*, -3.585*) indicating integration of order 0 (I(0)). Similarly, the PP test confirmed stationarity. Conversely, IMR, LEX, and HOI exhibited non-stationarity in the ADF test but achieved stationarity in the PP test with the first differencing (I(1)), aligning with the chosen analytical technique (NARDL).

Table 6: Estimation for Model One (1)

ASYMMETRY STATISITCS:							
MODEL ONE (1): IMR = F(PUHE, PRHE)							
		Long-run effect [+]			**Long-run effect [-]**		
Exog.	**var.**	**coef.**	**F-stat**	**P>F**	**coef.**	**F-stat**	**P>F**
	PUHE	0.046**	8.868	0.021	0.651**	18.17	0.004
	PRHE	-0.194***	338.4	0.000	-1.173***	52.44	0.000
		Long-run asymmetry			**Short-run asymmetry**		
		F-stat	**P>F**		**F-stat**	**P>F**	
	PUHE	23.75**	0.002		29.68**	0.001	
	PRHE	71.61***	0.000		14.24**	0.007	
R^2		0.939					
Adj. R^2		0.816					
Cointegration test statistics:					**t_BDM:**	-5.204	
					F_PSS:	12.589	
Model diagnostics:					**stat.**	**p-value**	
Portmanteau test up to lag 9 (chi2):					16.82	0.052	
Breusch/Pagan heteroskedasticity test (chi2):					3.10	0.079	
Ramsey RESET test (F):					33.67	0.003	
Jarque-Bera test on normality (chi2):					0.287	0.867	

Model one examines the intricate relationships between PUHE, PRHE, and IMR in Nigeria. Surprisingly, long-run analysis reveals that increases in PUHE lead to higher IMR, contradicting conventional wisdom, but aligning with Byaro & Musonda (2016). Conversely, PRHE's positive coefficient (-0.194***) indicates lower IMR with increased private expenditure, supported by Mustapha, et al. (2021). Long-run analysis also reveals a negative relationship between PRHE and IMR, consistent with Wang, et al. (2017).

Asymmetries in PUHE and PRHE highlight the need for tailored healthcare financing policies. Cointegration tests confirm a stable long-run relationship between health expenditure and IMR.

However, concerns arise regarding potential autocorrelation and heteroscedasticity in residuals, demanding a resolution for policymakers to access reliable empirical evidence. The model exhibits a high explanatory power, yet borderline significance in autocorrelation and heteroscedasticity tests indicates the need for further refinement.

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Table 7: Estimation for Model Two (2)

ASYMMETRY STATISITCS:							
MODEL TWO (2): MMR = F(PUHE, PRHE)							
		Long-run effect [+]			**Long-run effect [-]**		
Exog.	**var.**	**coef.**	**F-stat**	**P>F**	**coef.**	**F-stat**	**P>F**
	PUHE	-0.001	0.001	0.979	-1.081	1.141	0.321
	PRHE	0.084	1.839	0.217	0.572	0.780	0.406
		Long-run asymmetry			**Short-run asymmetry**		
		F-stat		**P>F**	**F-stat**		**P>F**
	PUHE	1.213		0.307	10.23		0.015
	PRHE	.8927		0.376	8.687		0.021
R^2		0.886					
Adj. R^2		0.657					
Cointegration test statistics:					**t_BDM:**	-2.342	
					F_PSS:	6.775	
Model diagnostics:					**stat.**	**p-value**	
Portmanteau test up to lag 9 (chi2):					31.99	0.00	
Breusch/Pagan heteroskedasticity test (chi2):					0.29	0.59	
Ramsey RESET test (F):					23.44	0.005	
Jarque-Bera test on normality (chi2):					0.8324	0.660	

Model two investigates the relationships between health inputs, particularly PUHE, PRHE, and MMR. Long-run analysis shows non-significant coefficients for PUHE(+) and PRHE(+) on MMR, implying no significant long-term impact. Similarly, negative partial sum coefficients PUHE(-) and PRHE(-) lack significance, indicating a complex relationship with no substantial long-run effects. Asymmetry tests reveal significant short-run asymmetry for PUHE, suggesting public health expenditure increases MMR over shorter periods. PRHE displays non-significant asymmetry. Cointegration tests indicate no long-term relationship between health inputs and MMR. Diagnostic tests highlight autocorrelation issues and potential model misspecification, urging further refinement. These findings deviate from economic theory, suggesting that improved health inputs do not consistently decrease maternal mortality. While autocorrelation is present, heteroskedasticity and abnormality in residuals are absent. Model specification concerns necessitate attention, ensuring robust empirical evidence for policymaking.

Table 7: Estimation for Model Three (3)

ASYMMETRY STATISITCS:							
MODEL THREE (3): LEX = F(PUHE, PRHE)							
		Long-run effect [+]			**Long-run effect [-]**		
Exog.	**var.**	**coef.**	**F-stat**	**P>F**	**coef.**	**F-stat**	**P>F**
	PUHE	-0.016	2.476	0.160	-0.246*	4.221	0.079
	PRHE	0.064***	60.22	0.000	0.290**	7.311	0.030
		Long-run asymmetry			**Short-run asymmetry**		

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		F-stat	**P>F**	**F-stat**	**P>F**
	PUHE	5.236*	0.056	8.24**	0.024
	PRHE	10.29**	0.015	4.183*	0.080
R^2		0.843			
Adj. R^2		0.530			
Cointegration test statistics:				**t_BDM:**	-3.647
				F_PSS:	6.019
Model diagnostics:				**stat.**	**p-value**
Portmanteau test up to lag 9 (chi2):				8.23	0.511
Breusch/Pagan heteroskedasticity test (chi2):				0.32	0.570
Ramsey RESET test (F):				8.99	0.030
Jarque-Bera test on normality (chi2):				3.952	0.139

Model three scrutinizes the intricate connections between public and private health expenditure (PUHE and PRHE) and health outcomes, particularly life expectancy (LEX). In the long run, PUHE(+) shows a non-significant, slightly negative effect on LEX, contrasting previous expectations (Mustapha, et al., 2021). Conversely, PUHE(-) displays a significant negative impact on LEX, opposing earlier research emphasizing public health spending's positive role (Ochiaka & Akuma, 2021). PRHE(+) exhibits a strong positive relationship with LEX, aligning with theoretical expectations, while PRHE(-) also indicates a significant positive effect, emphasizing the importance of private healthcare in improving health outcomes. Significant asymmetries in both PUHE and PRHE underscore the need for tailored healthcare financing policies. Cointegration tests confirm a stable long-run relationship between health expenditure and LEX, despite potential model misspecification concerns highlighted by diagnostic tests. Nevertheless, the model demonstrates strong explanatory power, indicating that PUHE and PRHE explain a substantial portion of LEX variation in Nigeria. Diagnostic tests for autocorrelation, heteroskedasticity, and normality yield non-significant results, enhancing the reliability of estimation results. Overall, the model provides insights into the complex dynamics between health expenditure and life expectancy, emphasizing the importance of nuanced approaches in healthcare financing policies for optimal health outcomes.

Table 8: Estimation for Model Four (4)

ASYMMETRY STATISITCS:							
MODEL FOUR (4): HOI = F(PUHE, PRHE)							
		Long-run effect [+]			**Long-run effect [-]**		
Exog.	**var.**	**coef.**	**F-stat**	**P>F**	**coef.**	**F-stat**	**P>F**
	PUHE	-0.579	3.037	0.125	-9.060*	4.517	0.071
	PRHE	2.218***	67.64	0.000	11.064**	9.427	0.018
		Long-run asymmetry			**Short-run asymmetry**		
		F-stat		**P>F**	**F-stat**		**P>F**
	PUHE	5.57**		0.050	16.55**		0.005
	PRHE	12.72 **		0.009	9.089**		0.020
R^2		0.891					
Adj. R^2		0.673					
Cointegration test statistics:					**t_BDM:**		-4.005

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	F_PSS:	8.315
Model diagnostics:	**stat.**	**p-value**
Portmanteau test up to lag 9 (chi2):	16.75	0.053
Breusch/Pagan heteroskedasticity test (chi2):	0.50	0.480
Ramsey RESET test (F):	20.59	0.010
Jarque-Bera test on normality (chi2):	5.542	0.063

Model four explores the relationship between health inputs and health outcomes in Nigeria, focusing on the health outcome index (HOI) (Boachie et al., 2018). In the long run, increases in public health expenditure (PUHE) show a negative but insignificant effect on HOI, contradicting expectations and previous studies (Igbinedion & Olele, 2018). Conversely, reductions in PUHE exhibit a significant positive association with HOI, contrasting the literature emphasizing the importance of adequate public health financing. Private health expenditure (PRHE) demonstrates a strong positive effect on HOI, suggesting that increases in PRHE significantly contribute to better health outcomes (Mwaura, 2024). Similarly, decreases in PRHE correspond to deteriorations in health outcomes. Significant asymmetries in both PUHE and PRHE highlight the need for tailored healthcare policies. Cointegration tests confirm a stable long-run relationship between health expenditure and health outcomes (Boachie et al., 2018). However, concerns arise regarding potential model misspecification, necessitating further diagnostic checks. Despite challenges, the model exhibits strong explanatory power, explaining a substantial proportion of the variation in health outcomes. Diagnostic tests for autocorrelation and heteroskedasticity yield non-significant results, indicating robustness. Overall, the findings emphasize the complex dynamics between health expenditure and health outcomes, suggesting nuanced approaches to healthcare policymaking in Nigeria.

Discussion of Findings

The findings across the four models provide nuanced insights into the complex relationships between health expenditure and various health outcomes in Nigeria. Model one unravels the intricate relationship between public and private health expenditure and infant mortality rates, revealing surprisingly significant and long-run effects, with increases in public health expenditure leading to higher infant mortality rates, contrary to conventional wisdom, and increases in private expenditure resulting in lower infant mortality, aligning with the theoretical expectation. Model two explores the relationships between health inputs and maternal mortality rates, indicating a lack of significant long-run effects for both public and private health expenditures. In contrast, models three and four delve into the dynamics between health expenditure and life expectancy (LEX) and a health outcome index (HOI) respectively. Both models suggest mixed effects, revealing that increased private health expenditure significantly contributes to improvements in life expectancy and overall health outcomes. However, public health expenditure does not significantly contribute to life expectancy and overall health outcomes, suggesting the need for government intervention in improving health infrastructures and spending. Notably, both models exhibit significant asymmetries, emphasizing the importance of

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tailored healthcare policies. Despite some concerns regarding potential model misspecification, all models demonstrate robust explanatory power, contributing to the understanding of the complex interplay between health expenditure and health outcomes in Nigeria, and warranting further exploration and refinement in future research.

Table 9: Granger Causality

GRANGER CAUSALITY TEST				
MODEL ONE (1): IMR = F(PUHE, PRHE)				
Null Hypothesis:	**Obs**	**F-Statistic**	**Prob.**	**Remark**
PUHE → IMR	22	0.638	0.540	No causal relationship between IMR and PUHE
IMR → PUHE		1.131	0.346	
PRHE → IMR	22	1.549	0.241	Weak uni-causality running from IMR to PRHE
IMR → PRHE		3.312	0.061	
MODEL TWO (2): MMR = F(PUHE, PRHE)				
Null Hypothesis:	**Obs**	**F-Statistic**	**Prob.**	**Remark**
PUHE → MMR	22	0.309	0.738	No causal relationship between MMR and PUHE
MMR → PUHE		0.130	0.879	
PRHE → MMR	22	0.388	0.684	No causal relationship between MMR and PRHE
MMR → PRHE		0.655	0.532	
MODEL THREE (3): LEX = F(PUHE, PRHE)				
Null Hypothesis:	**Obs**	**F-Statistic**	**Prob.**	**Remark**
PUHE → LEX	22	0.807	0.462	No causal relationship between LEX and PUHE
LEX → PUHE		0.829	0.453	
PRHE → LEX	22	1.881	0.183	No causal relationship between LEX and PRHE
LEX → PRHE		2.291	0.132	
MODEL FOUR (4): HOI = F(PUHE, PRHE)				
Null Hypothesis:	**Obs**	**F-Statistic**	**Prob.**	**Remark**
PUHE → HOI	22	1.383	0.278	No causal relationship between HOI and PUHE
HOI → PUHE		0.827	0.454	
PRHE → HOI	22	2.740	0.093	Weak uni-causality running from PRHE to HOI
HOI → PRHE		1.926	0.176	

Granger causality tests across four models investigate the causal links between health input components (PUHE and PRHE) and health outcomes (IMR, MMR, LEX, and HOI) in Nigeria. Results show no significant causal relationship between public health expenditure and health outcomes. Similarly, most cases reject the hypothesis of private health expenditure causing health outcomes, except for weak unidirectional causality from IMR to PRHE and PRHE to HOI. This suggests that improvements in infant mortality may lead to increased private health expenditure, marginally affecting the overall health outcome index. These findings corroborate previous studies like Hamzat et al. (2019) and

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Adeosun & Faboya (2020), highlighting the intricate relationship between health inputs and outcomes in developing countries like Nigeria.

5. CONCLUSION AND POLICY RECOMMENDATIONS

This comprehensive study investigates the nexus between health inputs and health outcomes in Nigeria from 2000 to 2023, employing a Nonlinear Autoregressive Distributed Lag (NARDL) approach. Drawing on Grossman's health capital theory, the research explores the intricate relationships between health expenditure (disaggregated into public and private health expenditures) and health outcomes (infant/child mortality, maternal mortality, life expectancy, and aggregate health outcome index using the principal component analysis). The empirical findings, rooted in a robust methodological framework, reveal nuanced dynamics. Notably, the lag analysis identifies a two-period lag as optimal, ensuring model fit and prediction accuracy. Unit root tests unveil mixed evidence, with some variables demonstrating the integration of order 0 (I(0)), while others exhibit a combination of I(0) and I(1). Correlation analysis illuminates complex interdependencies among health indicators and expenditure categories, emphasizing the need for cautious interpretation. The study's descriptive statistics showcase significant improvements in health outcomes over the study period, alongside escalating public and private health expenditures.

In conclusion, the findings of this study shed light on the intricate relationships between health inputs and various health outcomes in Nigeria, offering valuable insights for policymakers and healthcare practitioners. Contrary to conventional wisdom, increases in public health expenditure demonstrate a surprising positive association with infant mortality rates, while private health expenditure shows a negative relationship, aligning with theoretical expectations. However, the lack of significant effects for both public and private health expenditure on maternal mortality rates suggests the need for targeted interventions in maternal healthcare. Moreover, while private health expenditure significantly contributes to improvements in life expectancy and overall health outcomes, public health expenditure does not exhibit significant effects, highlighting potential deficiencies in government healthcare infrastructure and spending allocation. The significant asymmetries observed underscore the necessity for tailored healthcare policies to address regional disparities effectively. Finally, Granger causality tests reveal no significant causal links between health inputs and health outcomes, except for weak unidirectional causality from infant mortality to private health expenditure and overall health outcome index. Given the robust findings, the study proffers the following policy recommendations:

To address Nigeria's healthcare challenges effectively, policymakers should strategically allocate public health funds to interventions proven to reduce infant mortality, including vaccination programs, maternal and child healthcare services, and nutrition initiatives. Additionally, promoting public-private partnerships through incentives like tax breaks or subsidies can leverage private sector resources to enhance healthcare accessibility and

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quality. Investments in improving maternal healthcare, such as prenatal care, skilled birth attendants, and emergency obstetric services, are crucial for reducing maternal mortality rates. Tailored healthcare policies that consider regional and population-specific needs are essential for ensuring equitable access to quality healthcare services across Nigeria.

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