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IMPACT OF HEALTH INFRASTRUCTURE ON INFANTS AND CHILDREN IN NIGERIA

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Abstract: *Childbirth should be a joyous occasion, yet in Nigeria, it's often shadowed by the grim reality of high child mortality. This study delves into a critical piece of the puzzle: the impact of health infrastructure on the survival of Nigeria's youngest citizens. Between 2000 and 2019, we examined how the availability of healthcare professionals, the strength of primary healthcare centers (PHCs), and the reach of immunization programs influence the chances of a child reaching their fifth birthday. While other research has explored factors like healthcare spending and maternal health, our focus is squarely on the direct contribution of these core elements of health infrastructure. Using data from sources like the World Development Indicators and the Nigerian Demographic Health Survey, we employed a statistical model called the autoregressive distributed lag (ARDL) model to uncover both immediate and long-term connections. We grounded our work in the functionalism theory, which emphasizes the vital role of a robust health system, including its infrastructure, in reducing child deaths. We also looked at the trends in child mortality, the presence of healthcare workers, the state of PHCs, and how many children are being immunized. Our goal is to give policymakers and healthcare providers solid evidence to help them improve child health and move closer to the Sustainable Development Goals for child welfare. Ultimately, this research hopes to shine a light on the often-overlooked importance of health infrastructure in saving children's lives in Nigeria.*

Keywords: *Child Mortality, Health Infrastructure, Nigeria, Primary Healthcare, Immunization*

1.0 INTRODUCTION

Background of the Study

Child health remains a critical issue in Nigeria, as the country continues to experience one of the highest child mortality rates globally. According to the World Health Organization (2015), child health encompasses the physical, mental, and social well-being of children from birth to 18 years. It involves disease prevention, healthy growth promotion, and timely treatment of illnesses. The under-five mortality rate in Nigeria stands at 128 deaths per 1,000 live births, significantly higher than the global average of 41 per 1,000 live births (Okonofua et al., 2016). Reports from the Multiple Indicator Cluster Survey (MICS, 2021) and other studies indicate that child mortality rates vary across different regions of the country (Bello & Joseph, 2014).

One of the major challenges contributing to high child mortality in Nigeria is inadequate health infrastructure. This includes a shortage of healthcare facilities, limited access to medical professionals, and insufficient technological resources. Many Nigerians, particularly in rural areas, have little or no access to healthcare services, with about 63.7% of rural dwellers affected (MICS, 2018). Additionally, children under 15 years make up about 45% of Nigeria's population, with 24 million under the age of five. This highlights the urgent need for child health to be a national priority.

The Sustainable Development Goals (SDGs) emphasize the importance of accessible and affordable healthcare to improve life expectancy. However, achieving this in Nigeria requires significant improvement in health infrastructure. Data from the World Development Indicators (WDI, 2020) show that the number of healthcare professionals available to children remains inadequate. For example, in 2019, one physician attended to 2,625 children, while one midwife served 848 children. This underscores the urgent need for better healthcare infrastructure to reduce child mortality in Nigeria.

Statement of the Problem

While childbirth is a moment of joy, it can also bring sorrow due to high infant mortality. Child health is a key indicator of a country's healthcare system and overall development. Nigeria, with a population of over 200 million, faces a significant challenge in child mortality, with an estimated 132 deaths per 1,000 live births (NDHS, 2018). This means that one in every eight children does not survive beyond the age of five.

The high mortality rate is primarily linked to poor access to quality healthcare. Contributing factors include a shortage of healthcare professionals, inadequate medical facilities, low immunization awareness, lack of clean drinking water, poor sanitation, and socioeconomic factors such as maternal education, age, and income level.

To address these issues, the Nigerian government has introduced several intervention programs, including the National Health Insurance Scheme (NHIS), the Maternal and Child Health Plan, and the National Midwives Service Scheme (NMSS). Other initiatives include free medical treatment for pregnant women and children. However, despite these efforts, child mortality rates remain unacceptably high, with an estimated 117.2 deaths per 1,000 live births as of 2019 (WDI, 2020). This study aims to examine the impact of health infrastructure on child mortality in Nigeria.

Objectives of the Study

The main objective of this study is to assess the impact of health infrastructure on infant and child health in Nigeria. Specifically, it aims to:

Evaluate the impact of healthcare professionals on infant and child health.

Assess the role of Primary Healthcare Centres (PHCs) in improving child health outcomes.

Examine the effect of immunization programs on reducing child mortality.

Significance of the Study

This study is unique in its focus on the direct impact of health infrastructure, particularly healthcare professionals, primary healthcare centers, and immunization programs on child mortality in Nigeria. While previous research has examined factors such as maternal age, health expenditure, and environmental determinants of child deaths, limited studies have provided a comprehensive analysis of how health infrastructure affects child survival rates. By addressing this gap, the study offers a fresh perspective on the role of healthcare accessibility in reducing child mortality, making it a valuable contribution to both academic literature and policy formulation.

The findings of this study is useful for policymakers, healthcare providers, and development agencies in designing targeted interventions to improve child health outcomes. Understanding the extent to which healthcare infrastructure influences child survival will help in prioritizing investments in rural healthcare services, expanding immunization programs, and increasing the availability of medical professionals. Ultimately, the study aims to provide evidence-based recommendations that can support Nigeria's efforts to achieve the Sustainable Development Goals (SDGs) related to health and child welfare.

2.0 LITERATURE REVIEW AND THEORETICAL FRAMEWORK

Theoretical Review

1. Mosley and Chen Model of Child Survival

Mosley and Chen theory of child survival was formally developed as analytical framework to study the factors that determine child survival by Henry Mosley and Lincoln Chen in 1984. The theory concentrates on the hypothesis that social and economic variables affect child mortality. Mosley and Chen identify clearly proximate and socioeconomic factors that determine infants and child deaths. They classified impending factors that affect infant and child deaths into fourteen proximate factors. The theory is of the view that more than 97% of children born alive is anticipated to remain live till their fifth birthday. They assume that closest social and economic factors work together to determine infant and child deaths. Thus, improvement on economic welfare, biology and environment influence infant, and child deaths negatively.

2. Functionalism Theory

Functionalism theory is vital theory in analyzing our subject matter, child mortality. The theory is sourced in classical sociology and was popularized by Talcott Parsons in 1967. The theorist viewed an economy as a complex structure with different components (social organizations) that harmoniously working in agreement for common interest for the whole. The social institution (family, education, and religious) together with economic and political institutions are the societal pivots. The family satisfies the useful biologic requirement for producing a baby to the society. The social institution necessitates the arrangement for the maintenance of the societal health requirements in reducing sicknesses and diseases, with effective policies and programmes. Consequently, high child mortality in a country partly shows system malfunctions, showing health sector incapability to proffer gratifying children healthcare services. This could arise, because of poor accessibility to healthcare, engenderment, poor qualitative and quantitative health resources such as health facilities, education, manpower, skills, training and funding. In Nigeria, chiefly the wealthy have access to quality healthcare.

Thus, parents' socioeconomic status like income, education advancement, amongst others, influences child deaths, life expectancy and economic growth.

Empirical Review

Table 1: Review of Empirical Studies

Year/Date	Location	Purpose of Study	Method of Study	Nature of Data	Major Findings
Adeosun and Faboye (2020)	Nigeria	Health expenses and child mortality	ARDL	Time series	Government expenditure on healthcare possesses a significant negative correlation with child mortality
Okwuwa and Adejo (2020)	Nigeria	Examine access to primary health centers (PHCs) and child mortality	Qualitative and quantitative	NHDS Data	Environment, human capital quality and child mortality have significant relationship
Ude and Ekesiobi (2019)	Nigeria	Impact of government expenditure and child mortality	OLS	Time series Data	Per capita health expenditure and child mortalities have significant inverse relationship.
Liang, Macinko, Dahai and Meng, (2019)	China	The relationship between health professionals and under-5 mortality	OLS Fixed Effect	Panel Data	Reduction in child mortality is negatively associated to health professional and income level.

Oluwaseun (2019)	Nigeria	Impact of health expenditure on health outcomes	OLS Fixed Effect	Panel Data	Health expenditure is significantly negative on child mortality.
Okereke, Ishaku, Unumeri, Mohammed and Ahosi, (2019)	Nigeria	achievement of community health workforce and maternal and child deaths	Qualitative research design	Field survey data	Community midwifery has significant decreasing association on maternal and children deaths.
Makinde, Aboyomi and Olayinka (2018)	Nigeria	Distribution of health facilities		FMH register	Proportion of government health facilities to private health facilities is much higher in the Northern than Southern part of the country
David (2018)	Nigeria	The connection of infant deaths and public health spending	ARDL	Time Series	Health spending, immunization and external resources are significant and influence on child deaths negatively.

Nwankwo (2018)	Nigeria	Nature of maternal mortality and public health spending	Fixed effect	Panel Data	Government health spending has significant negative influence on maternal mortality
Barenberg, Basu and Soylu (2018)	India	Impact of government health spending and infant deaths	Fixed effect	Panel Data	Government and private health expenditure have significant negative impact on infant death rate.
Dhrifi (2018)		determines association of government health expenditure and private health spending on child death rate	3SLS	Panel Data	Public healthcare expenditure in developing economies has greater decreasing effect on child deaths, than private health spending.
Farag, NandaKumar, Wallack, Gaumer, and Erbil, (2018)		measures the connection of government health expenditure and health outcome	OLS	Cross Section Data	Countries with high health spending have more significant negative impact on health outcome, than countries with low health spending

Muntago (2018)	Kenya	studies social, economic and environmental factors determining infant and child deaths	OLS	DHS Data	Sanitation, good water, low pollution are significant, while mother age, education, and birth interval are no significant
Nikoloski and Amendah (2018)		Examined health expenditure on health outcome	OLS	Panel Data	Health expenditure has significant negative influence on infant, neonatal and under-5 deaths
Rhee (2018)		researched effects government health spending and health outcomes	OLS Fixed effect	Panel Data	Public health spending and private healthcare expenditure has significant negative impact on infant and child deaths, but positive on life expectancy.

Gap in literature

Existing studies on child mortality have explored various determinants, including healthcare expenditure (Ude & Ekesiobi, 2019; Oluwaseun, 2019; David, 2018), access to primary healthcare centers (Okwuwa & Adejo, 2020), maternal age at birth (Titilayo et al., 2019), and environmental factors (Mesike & Mojekwu, 2018). While these studies provide valuable insights, they do not comprehensively examine the direct impact of health infrastructure—such as the availability of healthcare professionals, primary healthcare centers, and immunization programs—on child mortality in Nigeria. Studies from other countries, such as Liang et al. (2019) in China and Barenberg et al. (2018) in India, have investigated healthcare professionals and government health spending as determinants of child mortality, but their findings may not be directly applicable to Nigeria due to differences in healthcare systems and socio-economic conditions.

This study fills the existing gap by focusing specifically on the role of health infrastructure in reducing child mortality in Nigeria. Unlike previous research that has primarily concentrated on health expenditures or socio-economic factors, this study takes a holistic approach by analyzing how access to medical professionals, healthcare facilities, and immunization programs contribute to child survival rates. By addressing this overlooked aspect, the research provides a novel contribution to the literature and offers policymakers evidence-based recommendations for improving child health outcomes in Nigeria.

2.3 Theoretical Framework

The theoretical framework adopted in this research is the functionalism theory. The theory views society as a system of interconnected parts. The major assumption of the theory is that health and social institutions are society's pivots. The theory emphasizes that health organizations stipulate strategies in which the health system function to reduce illnesses and diseases. The theory opines that high mortality in countries partly implies systemic disorder, signifying failure of the health institution. This theory is adopted in this research because unlike other theories, functionalism theory can be used to explain a wide range of factors that influence health, including health infrastructure and is relatively easy to understand and use. This makes it a versatile tool for researchers who are interested in understanding the complex relationship between health and infrastructure.

3.0METHODOLOGY

Research Design

The research design is ex post facto design, in which the researcher does not have control over the independent variable. Hence, the researcher must use existing data to study the effects of the independent variable. The independent variables are Health professionals, Primary Healthcare Centres, and the immunization of children. The dependent variable is the child mortality rate. The research uses the autoregressive distributive lag bound test method to analyse the data.

Model Specification

The study utilized the knowledge of the theoretical framework. It adapts David (2018) model specification, modified it and incorporates variables relevant to the present study. The study variables are child mortality, availability of health professionals, provision of Primary Health Care (PHC) Centre and immunization of children against diseases.

From the work of David, the relationship between health infrastructure and child mortality was expressed functionally as:

$IMR = f(PHEXP, \text{IMMUN}, \text{EHRES}, \text{PrEXP})$ …………………………………….. (3.1)

Empirically the model is specified linearly as:

$IMR_t = \alpha_0 + b_1 PHEXP_t + b_2 IMMUN_t + b_3 EHRES_t + b_4 PrEXP_t + \mu_t$…………… (3.2)

Theoretically, the expected signs of the partial regression coefficients take negative signs:

$b_1 < 0$, $b_2 < 0$, $b_3 < 0$, $b_4 < 0$.

Where; α_0 is the intercept; $b_1 - b_4$ are the partial regression coefficients; t is the number of time series observations and μ is the error term.

$IMR =$ Infant Mortality Rate, measured by the number of children less than one year of age that died, divided by the number of live births during the year, multiplied by 1,000.

$PHEXP =$ Government Health Expenditure

$IMMUN =$ Immunization, measured as the percentage of children under the age of one immunized against certain diseases and infections.

$EHRES =$ External Health Resources

$PrEXP =$ Private Health Expenditure.

David (2018) used private health expenditure, external health resources and government health expenditure as independent variable, this research, however, uses availability of health professional (AHP), provision of PHCs as independent variables. This study follows David (2018) to used immunization of children as an independent variable, so the model for this study is functionally specified as follows:

$CMR = f(AHP, PHC, IMM)$ ……………………………………………………. (3.3)

Where:

$CMR =$ Child Mortality Rate, measured by the number of children from one year of age that died before the fifth birthday, divided by the number of live children within one and five years of age, multiplied by 1,000.

$AHP =$ Availability of Health Professional, measured as the number of health professionals per 1000 children.

$PHC =$ Provision of Health Facility, measured by government expenditure on health as percentage of gross domestic product.

$IMM =$ Immunization of children against diseases, measured by number of children immunized against diseases, as percentage 1000 children aged 12-23 months.

The model to be estimated is specified as:

$CMR_t = \beta_0 + \beta_1 AHP_t + \beta_2 PHC_t + \beta_3 IMM_t + \mu_t$

…………………………………………….. (3.4)

A priori Expectation

This refers to the required signs of the parameters of the regressors, which shows the effects of the independent variables on the explained variable. The a priori expectations for the covariates in this research are:

$\beta_1 < 0$, $\beta_2 < 0$, $\beta_3 < 0$

Variable description

Accordingly, the variables used in this study are child mortality (CMR_t) as the dependent variable. It is measured as the number of children one year of age that died before their fifth birthday annually, divided by the number of live children within one and five years of age, multiplied by 1,000. The variable is proxied by the under-5 child mortality rate.

The controlled variables are availability of health professionals (AHP_t). This variable is proxied by the number of physicians per 1000 people annually. It is the number of Primary care physician and specialist medical practitioners available for health care need of children. It is measured as the number of health professionals per 1000 children.

Provision of PHC (PHC_t). This variable is proxied by government expenditure on PHC. It is defined as the number of places/locations where healthcare is provided. It is the clinics and doctor's offices to urgent care centers. Provision of health facility is measured as government spending on health as percentage of gross domestic product annually.

Immunization of children against diseases (IMM_t), a child is regarded satisfactorily immunized against disease threatening illnesses after receiving three doses of vaccine. It is measured number of children immunized as percentage of 1000 children ages 12-23 months.

Data Source

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The data utilized for this study is annual time series data. It is secondary data in nature. The sources of the data are World Development Indicator (WDI) data, Nigerian Demographic Health Survey, National Bureau of Statistical, CBN Statistical Bulletin, UNCTAD, Economic and Financial Review of various years and World Bank Statistics and Global Health Expenditure Database (GHED). The data spans from 2000 to 2019, covering a period of 20 years.

Estimation and Evaluation Techniques and Procedure

Pre-Estimation Test

Unit root tests

As a pre-test the study employed Augmented Dickey-Fuller (ADF) unit root test technique to check for the stationarity of the variables employed in the analysis of this research work. This is to guard against producing a false regression result. The Stationarity and order of integration of the series determined the estimation method used in this study. Using, Error Correction Mechanism (ECM). The short-run ECM model is specified as:

$$\Delta CMR_t = \beta_0 = \theta ECM_{t-1} + \sum_{j-i}^{p} \gamma j \Delta CMR_{t-j} + \sum_{j-i}^{q} \lambda j \Delta AHP_{t-j} + \sum_{j-i}^{z} \delta j \Delta PHC_{t-j} + \sum_{j-i}^{n} \varphi j \Delta IMM_{t-j} + \varepsilon_t \quad \ldots \ldots \quad (3.5)$$

Where: β_0 is constant, θ is the coefficient of the error correction term lagged by one period t–1, which captures the speed of adjustment of the series from the short-run to the long-run equilibrium; **γ, λ** δ, and φ, are short-run parameters and ε_t is the error term which is expected to be well behaved. Δ represents the changed identity function.

Besides, we estimate autoregressive distributed lagged (ARDL) model, if the stationarity of the variables are mixture of level I(0) and first differenced I(1).

Estimation Technique

The static cointegration model in equation (1) is associated with the problems of serial correlation and endogeneity. This associated problem of the covariance of the regressor and the residual not equal to zero violates the assumption of ordinary least square method. To address the problems of serial correlation and endogeneity associated with static cointegration as in the model of equation (1), this study adopted Auto-Regressive Distributed Lag (ARDL) bounds test technique created by Pesaran, Shin and Smith (2001).

The ARDL model is modeled for child mortality as:

$$CMR_t = \beta_0 + \sum_{j-i}^{p} \gamma j \Delta CMR_{t-j} + \sum_{j-i}^{q} \lambda j \Delta AHP_{t-j} + \sum_{j-i}^{z} \delta j \Delta PHC_{t-j} + \sum_{j-i}^{n} \varphi j \Delta IMM_{t-j} +$$

ε_t ……………………………………………………………………….... (3.6)

Relatively, the autoregressive distributed lag technique and its bound testing created by (Pesaran et al., 2001) are employed to determine cointegration equilibrium association of the variables regardless of sample size and order of integration of the variables at level I(0), first differenced I(1) or mixture of both I(0) and I(1). Likewise, this technique uses varying optimal lags and single reduced equation form to simultaneously calculate the long run and short run parameters of the model (Abu, 2017).

Post-Estimation Test

Bound Test Co-integration

The autoregressive distributed lag method compares the f-statistic value generated by equating the parameters of the un-differenced variables in the conditional ECM with the critical values provided by Pesaran et al. (2001). The f-statistic value is therefore used to test the null hypothesis, that no cointegration among the study variables against the alternative hypothesis that cointegration exists among the study variables. Thus, if the f-statistic calculated value is greater than the upper bound we reject the null hypothesis that no cointegration or long run equilibrium exists among the variables. In other words, if the f-statistic calculated value is less than the value of the lower bound I(0), we accept the null hypothesis that no cointegration exists among the variables. Agreeably, if the f-statistic calculated value falls between lower bound I(0) value and upper bound I(1) value, our inference would be inconclusive. Thus, the conditional ECM model is specified as:

$$CMR_t = \alpha_0 + \beta_1 \sum_{i=0}^{n} \Delta CMR_{t-1} - \beta_2 \sum_{i=0}^{n} \Delta AHP_{t-1} - \beta_3 \sum_{i=0}^{n} \Delta PHC_{t-1} - \beta_4 \sum_{i=0}^{n} \Delta IMM_{t-1} + \partial_1 CMR_{t-1} - \partial_2 AHP_{t-1} - \partial_3 PHF_{t-1} - \partial_4 IMM_{t-1} + \mu_t \ldots\ldots \quad (3.7)$$

Where; $\partial_1 - \partial_4$ are the parameters of the un-differenced variables in the ECM model used to generate the test statistic for comparing the upper and lower bound. Therefore, if co-integration (long-run relationship) exists between the variables, we estimate equation (3.4) to incorporate the long-run dynamics of the variables, while the ARDL capture the short-run dynamics. The ARDL model specified is equation 3.8:

$$CMR_t = \alpha_0 + \beta_1 \sum_{i=0}^{n} \Delta CMR_{t-1} - \beta_2 \sum_{i=0}^{n} \Delta AHP_{t-1} - \beta_3 \sum_{i=0}^{n} \Delta PHC_{t-1} - \beta_4 \sum_{i=0}^{n} \Delta IMM_{t-1} + \mu_t \ldots\ldots \quad (3.8)$$

Serial Correlation Test

This study employs Breuch-Godfrey Langrage Multiplier test. Our test hypothesis is that there is no serial correlation in the residuals up to the specification order. The decision rule is to reject H_0 if the probability of the Chi-Square calculated is less than 0.05. Alternatively, we reject H_0 if the chi-square (X^2) calculated $n.R^2$ is greater than tabulated X^2 at 5% significant level.

Normality Test

Normality test is used to examine if the residuals are normally distributed. Jacque-Bera normality test is used in this study. The test follows Chi Square distribution. This is given by: JB = $n\left[\frac{s^2}{6}+\frac{(k-3)^2}{24}\right]$. Where S = Skewness which approaches zero (0); K = Kurtosis which approaches three (3); n = Sample size (Number of observation), JB = Jacque-Bera. The test hypothesis is that the residuals are normally distributed. We reject the hypothesis if Jacque-Bera probability value is less than 0.05 or otherwise.

Heteroscedasticity Test

The Heteroscedasticity test is used to check if the variance of the residual of each of the explanatory variables is constant or not. Thus, if the variance of the residual of each of the explanatory variables is not constant, the estimated model may yield biased result. Therefore, to test for heteroscedasticity of the model, Breusch-Pagan-Godfrey heteroskedasticity test was used. The test follows Chi Square distribution. The test hypothesis is no heteroscedasticity. **Decision Rule:** reject the test hypothesis H_0 of no heteroscedasticity if the probability value of the Chi-Square calculated is less than 0.05. Or alternatively, we reject H_0 if n. $R^2 > X^2$ tab at 5% critical value.

Stability Test

The existence of co-integration is not enough tests to establish that the estimated parameters are stable. Therefore, Pesaran, Shin and Smith, (2001) proposed testing the stability of the estimated parameters of the estimated models using cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ). The CUSUM statistic is estimated under the null hypothesis that; no stability of the coefficients of the variables used in the model. If the CUSUM statistic trend falls outside the critical bands of the 5% confidence interval of the parameter stability, we accept the null hypothesis, but reject it if otherwise.

4. DATA ANALYSIS AND DISCUSSION OF RESULTS

Descriptive Statistics of Data

Table 4.1.2: Summary Statistics of the Variables Employed for Estimation

Stat Tools	CMR	AHP	PHC	IMM
Mean	143.230	0.323	3.699	43.500
Median	137.400	0.362	3.615	42.500
Maximum	183.100	0449	5.054	63.000
Minimum	117.200	0184	2.491	25.000
Std. Dev.	19.992	0.084	0.578	11.199
Skewness	0.612	-0.315	0.474	-0.086
Kurtosis	2.167	1.967	3.430	1.915
Jarque-Bera	1.828	1.220	0.904	1.006
Probability	0.401	0.543	0.636	0.605

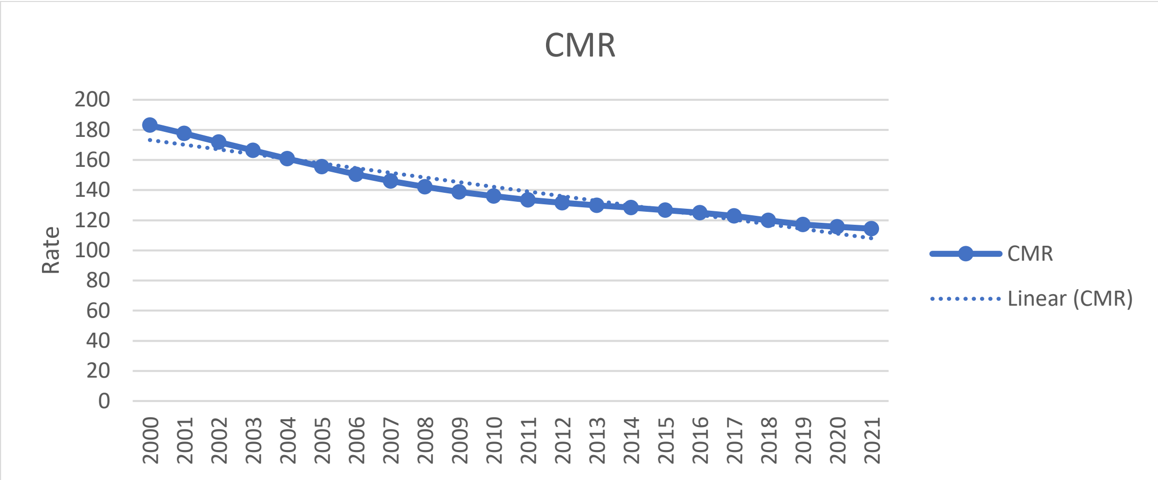
Source: Authors' Computation, 2024.

Table 4.1 depicts the annualized summary statistics for all the variables in the study. The mean values of the variables of interest are greater compared to their standard deviation value indicate generally stability of the variables over the sample period. The skewness value of CMR and primary health care (PHC) are positive, these imply that the right tail of the various distribution is particularly extreme; this also shows that deviations from the mean are positive, but availability of health professional (AHP) are negative, indicating that the left tail is extreme (i.e., it indicates that the deviation from the mean is negative). The kurtosis values of all the variables of interest are less than 3 [excluding primary health care (PHC)] indicating a platykurtic distribution which means that each distribution has tails that are thinner than the normal distribution. The Kurtosis value of primary health care (PHC) is greater than 3 showed a leptokurtic distribution, this implies that the distribution (fatter tails than the normal distribution). The Jarque-Bera probability value are statistically insignificant at 5 percent level of significance for all the variables of interest, this implies that the null hypothesis for normality in the distribution is rejected.

Trend Analysis

For the trend analysis, the individual graphical characterization of the series is first visually examined to determine the presence of a trend factor. An observance of a directional movement of data in the respective graphs of the variables indicates stationarity or not (presence of unit root).

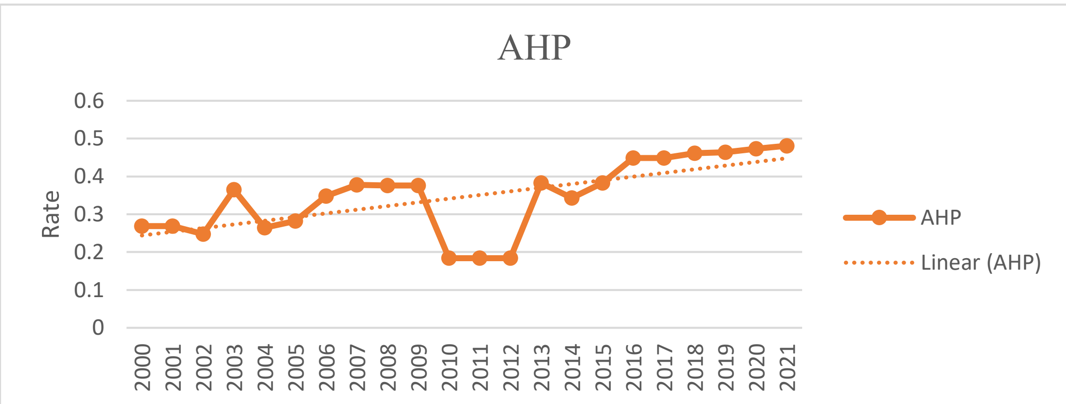
Figure 1: Trend of Child Mortality Rate in Nigeria (2000-2021)



Source: Author's Computation, 2024

Figure 4.1.1 showed upward and downward trending of child mortality rate from 2000 to 2021. Series of child mortality rate attained its highest point in 2000. While its lowest point in the series trend was 2021. The trend analysis revealed that the period between 2004 and 2014 fluctuate steadily below the average trendline indicating a growth rate below average. The period between 2000 to 2003 and 2015 to 2021 fluctuate above the average trend line indicating growth rate above average. The plausible reason for this fluctuation is government effort through the ministry of health and other health agencies to mitigate child mortality rate. The series trend showed that from 2000 child mortality rate has been on the decline.

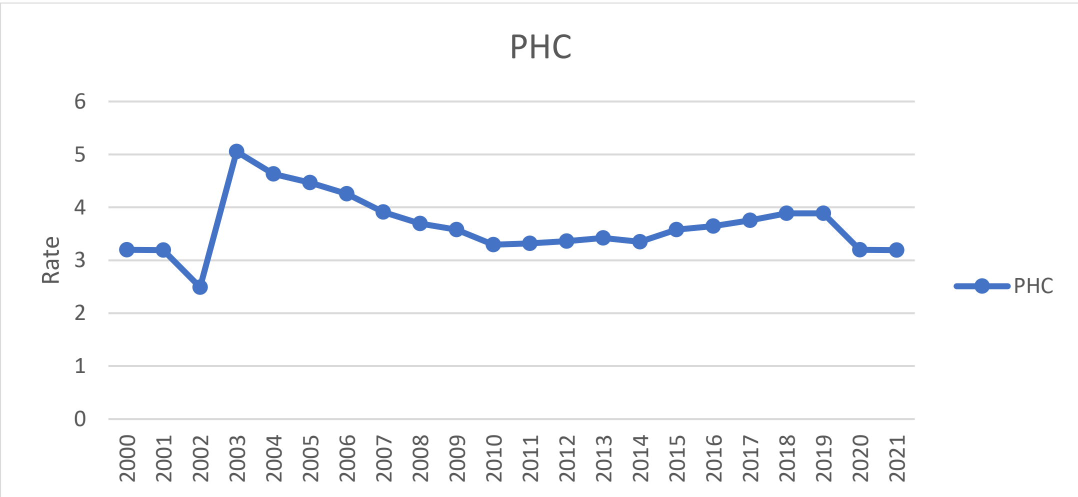
Fig. 2: Trend of Availability of Health Professionals in Nigeria (2000-2021)



Source: Authors' Computation,2024

Figure 2 showed upward and downward trending of availability of health professional from 2000 to 2021. Series of availability of health professional attained its highest point in 2021. While its lowest point in the series trend was 2010 to 2012. The trend analysis revealed that the year 2002, 2004 to 2005, 2010 to 2012 and the year 2015 fluctuate steadily below the average trendline indicating a growth rate below average. The periods from 2000 to 2002, year 2003, 2006 to 2009, 2013 to 2014 and 2016 to 2021 fluctuate above the average trendline indicating growth rate above average. The plausible explanation for this fluctuation is deliberate effort by stake holders, Universities, schools of Health science and NUC to increase the number of medical and health graduates from colleges of health and medical science. The series trend showed that from 2000 child mortality rate has been on the decline.

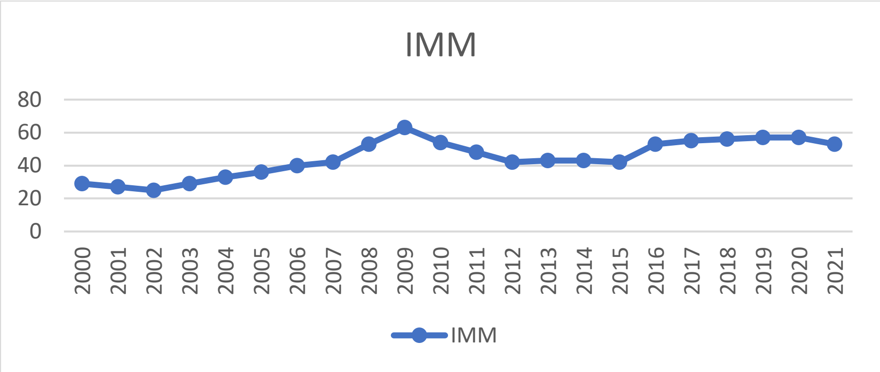
Fig. 3: Trend of Availability of Primary Health Care in Nigeria (2000-2021)



Source: Authors' Computation,2024

Fig. 3 showed upward and downward trending of availability of health professional from 2000 to 2021. Series of availability of health professional attained its highest point in 2021. While its lowest point in the series trend was 2002. Prior to 2002, primary health care has been poorly funded. The advent of democracy increased funding for primary health care, the rate increased tremendously from 2002 to 2003. Subsequent year the rate of primary health care funding declined slightly and has been maintained by other administration. The global economic depression further causes a decline in rate of primary health care funding from 2008 to 2015. The rate increased from the initial level from 2015 up to 2018. the advent of Covid-19 virus saw provision of primary health care decline in a bid to address the challenges of Covid-19 virus.

Fig. 4: Trend of Availability of Immunization of Children in Nigeria (2000-2021)



Source: Authors' Computation

Fig. 4 showed upward and downward trending of immunization of children against diseases from 2000 to 2021. Series of availability of immunization of children against diseases its highest point in 2021. While its lowest point in the series trend was 2002. The plausible explanation for this fluctuation is deliberate effort by the ministry of health, UNICEF and other donor agencies to combat child mortality rate in the Africa. Prior to 2002, there has been mistrust and poor diplomatic relations between the military governments and international organisations controlled by the Western economies culminating in a poor health sector thus poor record on children immunisation. The advent of democracy gave rise to the restoration of cordial diplomatic relation with these international organisations, culminating in improving rate of children immunization from 2003 upward. The global economic depression of 2008 saw the decline in the rate of children immunisation due to poor funding. But as world economies recovered the funding from international health organisation increased culminating in the increasing rate of children immunisation.

Unit Root Test

The stationarity test conducted on the available data generated on availability of health professionals, provision of primary health care health facility and immunization of children against diseases and child mortality in Nigeria is displayed in table 4.3.

Table 3: ADF Unit Root Tests Results

Variables	At level	At first difference	Critical Value (%)			P-Value	Order of Integration
			1	5	10		
CMR	-4.92	-3.78	-3.73	-2.98	-3.21	0.0000	I(0)
AHP	-2.22	-3.73	-3.67	-3.69	-2.62	0.0000	I(1)
PHC	-2.84	-5.52	-3.73	-3.69	-3.22	0.0000	I(1)
IMM	-2.38	-3.81	-3.69	-3.69	-2.94	0.001	I(1)

Source: Authors' computation from E-views 12, 2024. Note: *, ** and *** imply significance at 1%, 5% and 10% respectively.

Table 4. shows the Augmented Dickey-Fuller (ADF) statistic results for the unit root test. The tests statistic demonstrates that the variables are integrated at levels I(0) and first difference, validating the use of ARDL model. Before the ARDL model was estimated the cointegration test and lag selection was carried out.

Data Analysis and Results

Lag Length Selection

Table 5: Lag Length Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	0	-141.32	NA	24.057	14.532	14.731
1	1	-34.76	159.833	0.003	5.4761	6.472
2	2	-15.01	21.72098	0.003	5.102	6.894

Source: Author's computation, 2024. Indicates lag order selected by the criterion. LR: sequential modified LR test statistic (each test at 5% level).

As a first step of the ARDL procedure, the appropriate lag length for the model is determined using the lag length criteria approach of restricted VAR estimate. The result of table 4.2.1 revealed that a maximum lag two is the lag order selected by four of the criteria at 5 percent level. Thus, we proceed to estimate the bound test, long run from and short run dynamics of the model using a lag length of order two.

The Bound Test for Cointegration

Table 6: Bound Test for Cointegration

TEST STATISTIC	VALUE	LAG LENGTH	SIGNIFICANCE LEVEL	CRITICAL VALUE OF BOUNDS	
				I(0)	I(1)
F-Statistic	46.00	2	10	2.72	3.09
			5	3.23	3.35
			1	4.29	5.61

Source: Author's computation, 2023

The ARDL bound test cointegration result of the variables employed is presented in table 4.2.2. Thus, from the autoregressive bound test result displayed in table 4.5; the estimated F-statistic 46.00 is greater than the upper bound I(1) statistic amid 1%, 2.5%, 5% and 10% significant levels. Hence, we reject the test hypothesis of no co-integration among child mortality rate, availability of health professionals, provision of health facilities, and immunization of children against diseases. This implies that a long-run equilibrium relationship exists amid among the variables (CMR, AHP, PHC and IMM). However, with the existence of co-integration relationship among the variables, equation 4 and 8 are estimated for the long-run and short-run respectively.

4.2.3 ARDL Long run Result

Table 4.2.3: Long run ARDL Result

Dependent Variable: CMRGR				
Independent Variable	Coefficient	Std. Error	t-Statistic	Prob.
CMR (-1)	-0.924159	0.372087	-2.146360	0.0984
AHP	-4.8718	95.22727	-0.387117	0.0063
AHP(-1)	-6.10193	143.3241	-0.454319	0.0132
PHC	-0.43054	3.111400	-0.156374	0.0014
PHC(-1)	4.5452	3.304245	1.375587	0.2410
IMM	-0.4187	0.188838	-0.786143	0.0075
IMM(-1)	-0.2203	0.337279	-0.653354	0.0542
C	-17.71576	35.02238	-1.933500	0.01253

R^2 = 0.940590 **R^2 Adjusted** =0.910885 **F-Statistics** = F-Stat. 31.66448 **(0.0000)**				
Durbin-Watson Statistics = 1.846414				

Note: Statistical Significance at 1%; Statistical Significance at 5%, Statistical significance at 10% Critical values are obtained from Pesaran et al. (2001).

Source: Authors' computation using E-views 12, 2024.

Table 3 shows the long run form of the ARDL result. The coefficient of health professionals availability is -48.4883 with a probability of 0.0063. This indicates that availability of health professionals is negative and statistically significant on child mortality in Nigeria, in the long run. The coefficient of provision of Primary Health Care health facility is -9.3800 with a probability of 0.0014. This depicts that provision of Primary health care health facility is significant and has decreasing relationship on child mortality in Nigeria, in the long run. Also, the coefficient of immunization of children against diseases is -0.4187 with a probability of 0.0075, which shows that immunization of children against diseases is statistically significant reducing child mortality in Nigeria in the long run.

Short Run Dynamics

Table 7: The Short Run Result

Dependent Variable: D(CMRGR)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(CMR(-1))	0.717028	0.186983	3.834726	0.0000
D(AHP)	-4.2718	35.45241	-1.039820	0.0129
D(AHP(-1))	-24.4909	54.28129	-4.504148	0.0108
D(PHC)	-0.4054	1.148570	-3.997856	0.0513
D(PHC(-1))	-6.007540	1.836679	-3.270871	0.0308
D(IMM)	-0.0272	0.120659	-1.230360	0.33168
D(IMM(-1))	0.498161	0.136811	3.641238	0.0219

C	17.9507	-7.972000	-8.494200	0.000
ECM1(-1)	-0.1004	0.296414	-8.486978	0.0000

Note: Statistical significance at 1% level; statistical significance at 5%; statistical significant at 10%

Source: Authors' Computation from E-views 12

The result shown in table 4.2.4 is the short run ARDL result. In the short run, the coefficient of health professional availability is -4.8718, with a probability value of 0.0129. This shows that availability of health professionals is statistically significant and negatively related to child mortality in Nigeria in the short run. Provision of health facility and immunization of children against diseases are not significant with the coefficient of -0.4054 and 0.0272 on probability value of 0.0513 and 0.3168 respectively, but their lags were significant with -6.007540 and 0.498161 with the probability of 0.0308 and 0.0219 respectively, while provision of health facility decreasing association on child mortality in the short run, the need for immunization of children is positive. The Error Correction Mechanism (ECM) is -0.1004 with probability of 0.0000. It conforms to the *a priori* expectation (i.e., being negative and significant at 5% level of significance). Also, the coefficient of determination R^2 is 0.940590 and the adjusted R^2 is 0.910885. The F-statistic is 31.66448 with a likelihood value 0.0000. The Durbin-Watson statistic is 1.846414.

Post Estimation Diagnostic Test

Breusch-Godfrey LM Test for Serial Correlation

Table 8: Serial Correlation LM Test Result: Breusch-Godfrey

Test Statistic	Value	Probability
F-Statistic	1.2808	0.3197
$Obs * R^2$	3.8745	0.1441

Source: Authors' computation, 2024.

The Breusch-Godfrey serial correlation test in table above shows chi-square X^2 value 3.8745 with the probability of 0.1441. The test statistic is greater than 0.05. The test hypothesis of no serial correlation is accepted.

Breusch-Pagan-Godfrey Test for Heteroskedasticity

Table 9: Heteroskedasticity Test Result: Breusch-Pagan-Godfrey

Test Statistic	Value	Probability
F-Statistic	10.1696	0.0028
$Obs * R^2$	16.8408	0.0780

Source: Authors' computation, 2024.

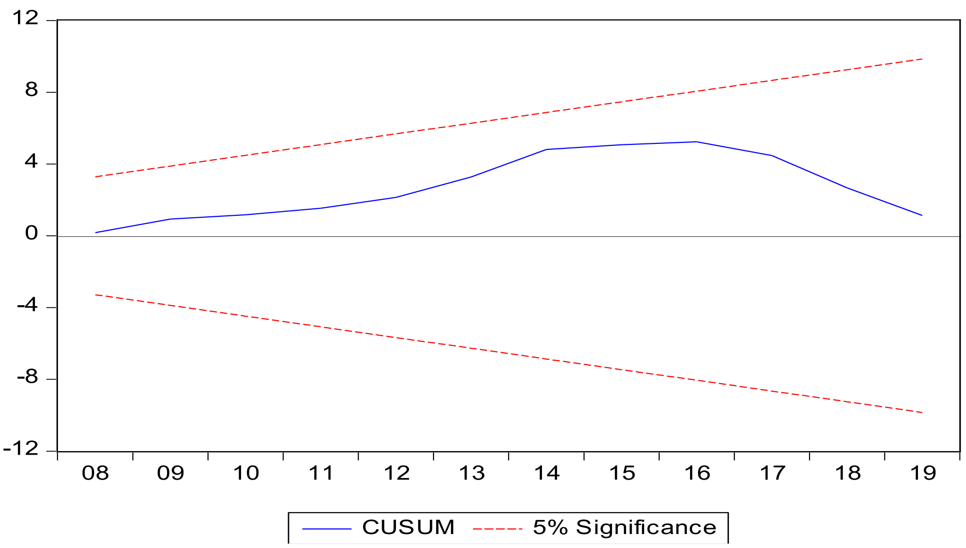
Table 8 shows Breusch-Pagan-Godfrey heteroskedasticity test result. It is estimated as number of observations times R-square $(n.R^2)$. The test statistic of the calculated chi-square is 16.8408, with the probability of 0.0780. Since the probability of the calculated chi-square is greater than 0.05. Hence, the test hypothesis of no heteroskedasticity is accepted. This means that the variance of each residual of our observation in our model is constant.

CUSUM Test for Stability

The equilibrium of the coefficients and the variance of the residual of the model are shown in

Fig. 10: CUSUM Test Result for Stability

Source: Authors' computation, 2024.



Source: Authors' computation, 2024.

The CUSUM trend lies within the two critical lines at 5%, we conclude that coefficients of our model are stable.

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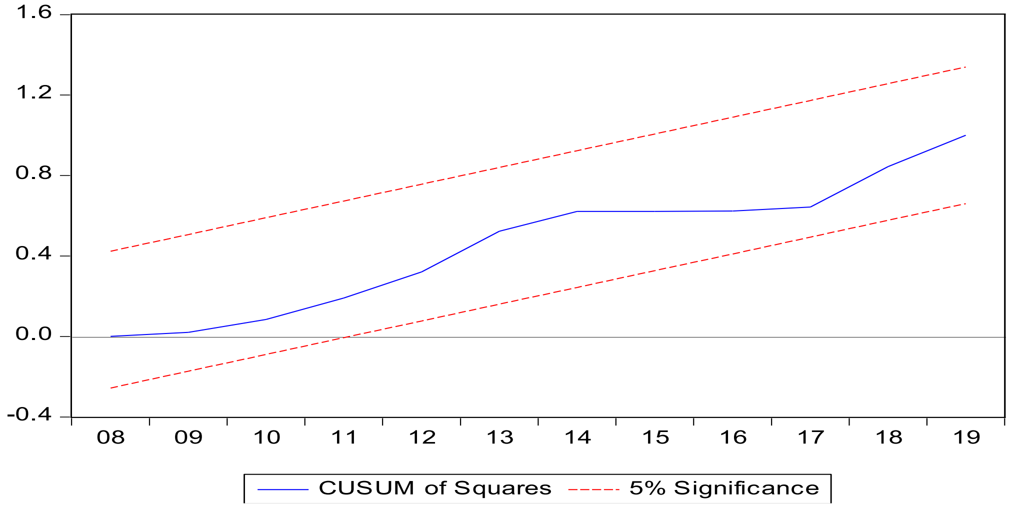
Figure 11: CUSUM SQUARE Test Result for Stability



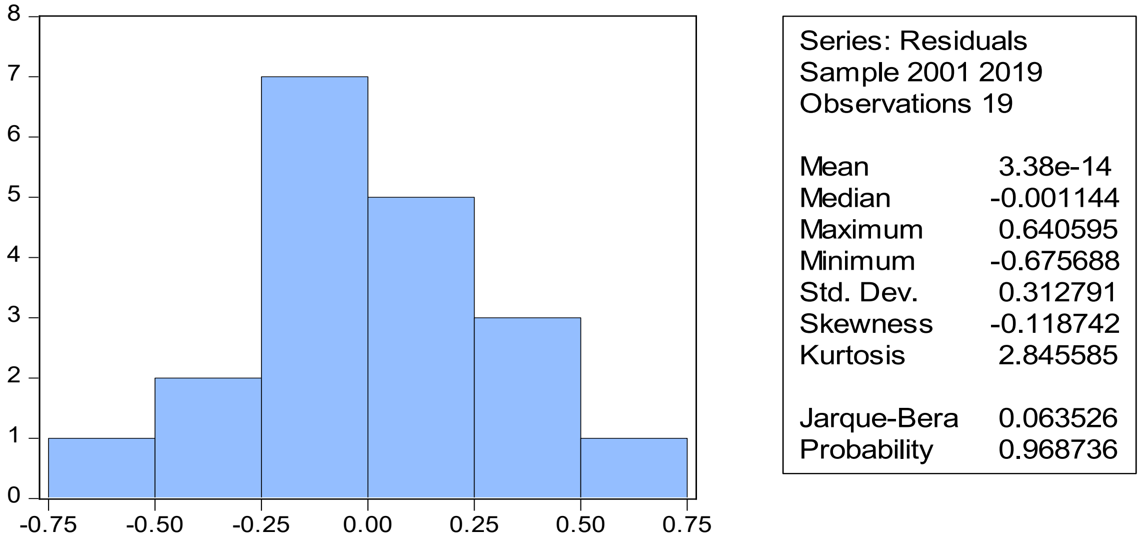
Source: Authors' Computation,2024

The cumulative sum of square lies within the 5% significance lines, it suggests that the variance of the residual is in equilibrium, meaning the residual variance of our model is stable.

Normality Test

The normality test of residual of our model is shown in Figure 4.2.7

Fig. 12 Jarque Bera Normality Test Result



Source: Authors' Computation, 2024

From the Jarque Bera Normality test result, the histogram is bell shaped and the Jarque Bera statistic of 0.0635 with probability 0.9687, requiring acceptance of null hypothesis that the residuals are normally distributed. Thus, the residual of our model is normally distributed.

Discussion of Findings

The findings from the ARDL model analysis provide valuable insights into the relationship between healthcare availability and child mortality in Nigeria, both in the short and long run.

Impact of Healthcare Professionals on Child Mortality

The results reveal that the availability of healthcare professionals significantly reduces child mortality. In the long run, a unit increase in healthcare professionals leads to a 4.87% decrease in child mortality, while in the short run, it reduces child mortality by 4.27%. Additionally, the lagged value of healthcare professionals has a strong negative impact, causing a 24.49% reduction in child mortality. This finding underscores the critical role of healthcare workers in improving child survival rates.

Effect of Primary Healthcare Facilities

The provision of primary healthcare facilities (PHC) also has a significant negative impact on child mortality. In the long run, a unit increase in PHC leads to a 0.43% reduction in child mortality, while in the short run, it results in a 0.40% decline. The lagged value of PHC indicates that an increase in PHC in the previous year leads to a 6.01% decrease in child mortality, highlighting the lasting impact of healthcare infrastructure on child health outcomes.

Role of Immunization

Immunization (IMM) has a notable negative effect on child mortality. A unit increase in immunization coverage leads to a 0.42% reduction in child mortality in the long run. In the short run, a unit increase in immunization results in a 0.03% decline in child mortality, while the lagged value suggests a 0.50% reduction. This confirms the importance of immunization programs in reducing child mortality rates.

Model Performance and Diagnostics

The coefficient of determination (R^2) is 94%, indicating that the explanatory variables—availability of healthcare professionals, primary healthcare facilities, and immunization—account for 94% of the variations in child mortality. The Durbin-Watson statistic (1.846) suggests the absence of autocorrelation, while the F-statistic (31.664) with a probability of 0.0000 confirms that the model is well-specified and significant for forecasting child mortality trends.

The diagnostic tests further validate the robustness of the model:

i. No autocorrelation: The Breusch-Godfrey test result confirms no serial correlation.

ii. Homoscedasticity: The Breusch-Pagan-Godfrey test indicates no heteroscedasticity in the model.
iii. Normality: The Jarque-Bera test suggests that residuals are normally distributed.
iv. Stability: The CUSUM and CUSUM-square tests confirm that the coefficients remain stable over time.

Error Correction Mechanism (ECM)

The error correction term (-0.1004) is negative and statistically significant, indicating that any short-run deviations from equilibrium in child mortality will be corrected at a speed of approximately 10% per year. This means that the system gradually returns to its long-run equilibrium following any short-term shocks.

Finally, the findings highlight the crucial role of healthcare professionals, primary healthcare facilities, and immunization in reducing child mortality in Nigeria. The results suggest that increasing investments in healthcare personnel, expanding access to primary healthcare services, and strengthening immunization programs can significantly enhance child survival rates. The robustness of the model and its strong explanatory power indicate that these factors should be prioritized in policy formulation to achieve better child health outcomes.

5.0 CONCLUSION AND RECOMMENDATIONS

Conclusion

The hypotheses set forth to examine the relationships between health infrastructure factors and child mortality rates have yielded significant insights. This study has found compelling evidence of the impact of healthcare professionals, primary healthcare facilities, and child immunization programs on child mortality in Nigeria.

Specifically, the research has revealed that the availability of healthcare professionals, primary healthcare facilities, and effective child immunization programs significantly influence child mortality rates in Nigeria. These findings underscore the vital role of ongoing efforts to enhance healthcare services and immunization initiatives as effective strategies for reducing child mortality in the Nigerian context.

The robustness of our statistical model and the results of diagnostic tests provide further assurance of the validity and reliability of these findings.

In summary, this study concludes that improving health infrastructure, such as increasing the availability of healthcare professionals, expanding primary healthcare facilities, and strengthening child immunization programs, is imperative for addressing and mitigating the issue of child mortality in Nigeria.

Recommendations

Based on the findings of this study, the study recommends the following actions:

i. Nigeria Government should continue to invest in the training and deployment of healthcare professionals to improve the accessibility and availability of healthcare services, particularly in rural and underserved areas.

ii. The federal Government through the ministry of health should work towards strengthening and expanding primary healthcare facilities should be a priority to ensure that they remain accessible to all segments of the population, thereby reducing child mortality.

iii. Immunization programs for children should be further promoted and expanded to increase the coverage and effectiveness of vaccinations, this can be done through NGOs and International health agencies.

iv. Policymakers, healthcare practitioners, and stakeholders should collaborate to enhance healthcare infrastructure in Nigeria, with a focus on reducing child mortality rates.

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