

**EFFECT OF POPULATION GROWTH AND CLIMATE CHANGE ON
MATERNAL HEALTH OUTCOME IN NIGERIA****Ahmed Malumfashi Halliru¹ & Umaimah Abdullahi Umar²**¹*Department of Economics, Umaru Musa Yar'adua University, Katsina,
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Dutsin-Ma Katsina, Nigeria.**All correspondence to: halliruam77@gmail.com***ABSTRACT**

Reducing maternal mortality is one of the Sustainable Development Goals especially in countries with rapid growing population and climate change. This study investigated the effect of population growth and climate change on maternal health outcome in Nigeria from 2000 to 2022. The pre-estimation tests confirmed the existence of a long run association among the variables. Furthermore, the empirical results revealed that a positive and significant relationship exist between population growth and climate change on maternal mortality in Nigeria both in the short-run and the long-run. The study recommends that, Nigerian government should control population growth within an ideal range by implementing policies that support family planning, education, and healthcare. This will effectively manage the consequences of population expansion while avoiding potential diminishing returns. Government should also fund climate adaptation policies/programmes with the inclusion of maternal health in the larger plans for climate resilience.

Key words: *Maternal Health, Climate Change, Population, ICT, Nigeria*

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INTRODUCTION

One of the most essential aspects of human requirements is health. Health outcome is one of the measures of a nation's overall standard of living. Thus, health is a condition of total physical, mental, and social well-being, rather than the absence of disease or disability, World Health Organization (WHO, 2024). For this reason, nations around the globe strive to improve individuals' health outcomes as primary objective of economic growth and social progress. Sustainable health is based on the complex interrelationship between human well-being particularly maternal health and the condition of our natural environment (Ibimilua and Oluwatoyin, 2023). It is assumed that a mother in good health will give birth to a child in good health; a mother in poor health may give birth to a child in poor health, which could eventually impact the quantity and quality of the labor force. Children of healthy mothers are more likely to grow up to be more educated and later become productive adults.

Consequently, improved maternal condition creates economic gains via social and economic stability, opening up of work opportunities for the expanding population.

The United Nations Department of Economics and Social Affairs (UNDESA, 2015), for example, states that low-income nations like Nigeria are experiencing significant population growth and would have more than 440 million people by 2050. A large population provides an economy with a sizable domestic market and encourages competition that propels inventions and technical breakthroughs. However, whereas population expansion promotes economic progress, it may also increase pressure on resources thereby fuels climate change especially in developing economies with weak environmental policies like Nigeria. For example, the National Bureau of Statistics (NBS, 2024) report that the expanding population makes it harder for Nigeria to pay the rising per capita public spending required to reduce poverty, hunger, and malnutrition, as well as guarantee universal access to healthcare, education, and other utilities. Moreover, the increased population growth contributes to the complexity of achieving Sustainable Development Goals (SDGs) of guarantee equity and inclusion for all groups of people specifically women and other vulnerable groups (Chukwunonso, 2024) as well as reducing climate change. Climate change exacerbates the unique health problems women face particularly during pregnancy when the mother's nutrition and health are crucial. These conditions can eventually lead to long-term respiratory problems, weakened immune systems, and an increased risk of death (Veenema et al., 2023). Every day, approximately 830 women die worldwide (majority of these deaths occur in developing countries) as a result of pregnancy/childbirth complications, unskilled birth attendants and insufficient delivery facilities and these challenges directly are made worse due to increased population growth and climate change.(UN, 2024).

In response to this, Nigeria government came up with initiatives related environment. For example, to ensure a successful national response to the multifaceted effects of population growth and climate change, the nation has established the National Adaptation Strategy and Plan of Action for Climate Change Nigeria (NASPA-CCN) and the Climate Change Policy Response and Strategy (CCPRS). The CCPRS and NASPA-CCN's primary goals are to improve public and private sector involvement in tackling the issues of climate change and to develop mitigation strategies that will encourage low carbon emissions and provide sustainable environmental quality. In the light of the aforementioned, this study examined the impact of population growth and climate change specifically on health in Nigeria. The novelty of this work are: First, we examined the impact of population growth specifically on

maternal health unlike previous studies that focus on general health outcome. Secondly, we captured the role of Information and Communication Technology (ICT) in influencing health which most previous studies failed to account particularly in Nigeria. A nation with more developed ICT tends to have lower energy demands from fossil fuels and help check population growth and climate change and this improve maternal health. In addition, ICT helps in the dissemination of health information even in rural areas and this increase health education and lower mortality. Third, we analyzed the impact of climate change in Nigeria which is the most populous country in African continent. The rest of the paper is design as follows: section two provides the empirical literature, section three is the methodology, section four provides the empirical results while section five concludes the study.

LITERATURE REVIEW

Empirical Studies

Numerous studies have examined the connection between pollution/climate change and health and population growth and health. In the case of climate change/pollution and health, Ayyuba et al. (2024) examined the dynamic effect of pollution on public health in Lahore using the multiple regression and logistic model approaches. The findings from the study reveal that environmental pollution affects public health in Lahore. The study recommends that the government should promote public sector network to improve health condition on the people.

Dauda et al., (2022) seek to contribute to the literature on the determining factors of maternal mortality by examining its linkage to environmental exposures in selected African Countries. The findings revealed that carbon emission, a measure of environmental exposure has a positive impact on maternal mortality. In addition, renewable energy has a negative implication on maternal mortality. Ozten and Keles (2024) analyzed the impacts of climate change on maternal, fetal, and neonatal health in the context of the existing literature in Turkey. The results shows that climate change, leads to increased temperatures, irregular precipitation causing droughts and floods, a rise in infectious diseases and/or the risk of transmission, and air pollution.

Veenema et al., (2023) identified the current peer-reviewed research on the effects of climate change-related environmental exposures on perinatal and maternal health in the United States using Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) approach. High and low temperature extremes were found to negatively influence neonate and maternal health. Significant associations were found between air pollutant exposure and

adverse pregnancy outcomes. Sabel et al. (2016) examined the relationship between Carbon dioxide emissions, health impacting exposures (air pollution, noise and physical activity), health (cardiovascular, respiratory, cancer and leukemia) and wellbeing (including noise related wellbeing, overall wellbeing, economic wellbeing and inequalities) in China. The results reveal that adopting policies to reduce private car use may have benefits for carbon dioxide reduction and positive health impacts through reduced noise and increased physical activity.

Pona et al., (2021) identified environmental health-related risks by discussing the current status and the future needs within Nigeria between 2007 and 2017 using a qualitative approach. The findings shows that Nigeria faces emerging challenges in environmental health, such as climate change, low air quality, water contamination, and natural hazards like floods, storms, and drought. Scheelbeek et al. (2021) examined the impact of health on climate change adaptation responses in low- and middle-income countries (LMICs) using the System GMM estimator. The result shows that reported mal-adaptation was predominantly related to widening of inequalities and unforeseen co-harms.

Soma-Pillay et al., (2022) using qualitative research approach examined the impact of climate change on maternal and child health in South Africa. It shows that climate change has negative impact on maternal and child health. Simane et al. (2016) determined how climate change influences health in Ethiopia. The research was conducted through a comprehensive review of available secondary data and interviewing key informants in various national organizations involved in climate change adaptation and mitigation activities. The study suggests that the monitoring and evaluation efforts exerted on climate change and health activities are not strong enough to address the climate change and health issues in the country.

METHODOLOGY

This study employed the Neo-Malthusian theory which is an updated version of the original Malthusian theory. The Malthusian theory proposed by Reverend Thomas Robert Malthus in the late 18th century argued that population growth tends to outpace food production, leading to famine and disease. However, the Neo-Malthusians still believe that population growth is exponential (i.e., it grows at a constant rate) while resources, grow at an arithmetic rate (i.e., they increase in a linear fashion). This imbalance, according to the theory, will eventually lead to resource scarcity famine and diseases. The mathematical equation of Neo Malthusian model can be written as;

$$MM_t = f(POP_t) \quad (1)$$

Where MM is maternal mortality rate and POP is population measured by urban population. Neo-Malthusians argued that unchecked population growth could lead to the depletion of vital resources thereby becoming a hindrance in all sectors of the economy i.e health, education, infrastructure, mining and others. Equation 1 is expanded to capture other variables that could influence maternal health as:

$$MM_t = f(POP_t, CO_{2t}, GDP_t, ICT_t, EDU_t) \dots \dots \dots (2)$$

Where CO_2 represents environmental degradation, GDP is gross domestic product per capita proxy for income, ICT is information and communication technology and measured by mobile cellular subscriptions per 100 peoples, and EDU is education measured by number of secondary school enrollment per female. Neo-Malthusians argue that rapid population growth exacerbates poverty, inequality, and environmental degradation leading to more pronounced health issues to specifically women of child bearing age and other vulnerable groups. Furthermore, eq. 2 is specified in the base-line ARDL model as follows:

$$\Delta \ln MM_t = \beta_0 + \beta_1 \ln MM_{t-1} + \beta_2 \ln POP_{t-1} + \beta_3 \ln CO_{2t-1} + \beta_4 \ln ICT_{t-1} + \beta_5 \ln EDU_{t-1} + \beta_6 \ln GDP_{t-1} + \sum_{i=0}^p \alpha_1 \Delta \ln MM_{t-1} + \sum_{i=1}^q \alpha_2 \Delta \ln POP_{t-1} + \sum_{i=i}^r \alpha_3 \Delta \ln CO_{2t-1} + \sum_{i=1}^s \alpha_4 \Delta \ln ICT_{t-1} + \sum_{i=1}^u \alpha_5 \Delta \ln EDU_{t-1} + \sum_{i=1}^v \alpha_6 \Delta \ln GDP_{t-1} + \varepsilon_t \dots \dots \dots (3)$$

However, the long run model and the short run models that captured the speed of adjustment are given in equation 4 and 5 respectively:

$$\Delta \ln MM_t = \beta_0 + \beta_1 \ln MM_{t-1} + \beta_2 \ln POP_{t-1} + \beta_3 \ln CO_{2t-1} + \beta_4 \ln ICT_{t-1} + \beta_5 \ln EDU_{t-1} + \beta_6 \ln GDP_{t-1} + \varepsilon_t \dots \dots \dots (4)$$

$$\Delta \ln MM_t = + \sum_{i=0}^p \alpha_1 \Delta \ln MM_{t-1} + \sum_{i=1}^q \alpha_2 \Delta \ln POP_{t-1} + \sum_{i=i}^r \alpha_3 \Delta \ln CO_{2t-1} + \sum_{i=1}^s \alpha_4 \Delta \ln ICT_{t-1} + \sum_{i=1}^u \alpha_5 \Delta \ln EDU_{t-1} + \sum_{i=1}^v \alpha_6 \Delta \ln GDP_{t-1} + ECT_{t-1} + \varepsilon_t \dots \dots \dots (5)$$

In order to achieve the objective of this study we used quarterly time series data from 2000 to 2022 to examine the impact of population and climate change on maternal health in Nigeria. Due to unavailability of annual data for variable like ICT, this study adopted the data interpolation process to get the necessary number of observations needed to run the empirical analysis. However, to tackle the problem of short coverage of data (particularly on ICT), the annual time series data was converted to quarterly data using Gandolfo's techniques of data interpolation. It is suggested that converting annual data to quarterly data gives a high number

of observations. In addition, interpolated series do not lead to bias in the estimates of co-integration vector even in a small sample. Thus, employing Gandolfo's techniques of data interpolation, this study is left with the quarterly data – 2000:Q1 to 2022:Q4 (T=92). Previous empirical studies employed this method to solve the problem of short coverage of data (see Umar and Umar, 2022). After confirming the order of integration we used the bounds testing approach for co-integration based on Autoregressive Distributed Lag (ARDL) model framework, because it is a prerequisite for long-run analysis. It does not impose restriction on the integration order of the variables being all I(1). Also, it can be applied regardless of whether the variables are all I(0), I(1) or mutually co-integrated (Peseran & Smith, 2001).

ANALYSIS AND RESULTS DISCUSSION

Unit root tests are conducted to ensure that none of the variables is I(2) or above. The results of the unit root test in Table 1 indicates that variables like CO₂ emissions, Population, ICT, Education and GDP have unit root or they are not stationary at level. However, after taking their

Table 1: Results of ADF and PP Unit Root Tests

Variables	ADF		PP		
	Level	First Difference	Level	First Difference	Stationarity Status
MM	-3.84081**		-4.43589***		I(0)
LCO ₂	-1.4797	-6.4462***	-2.0670	-4.46151***	I(1)
LPOP	-0.2117	-7.4441***	-1.8659	-10.4577***	I(1)
ICT	-0.1459	-3.8834**	-0.0548	-4.9461***	I(1)
LGDP	-2.1339	-3.3900*	-2.2204	-5.7889***	I(1)
LEDU	-3.02011	-3.99277**	-2.1180	-5.0433***	I(1)

Note: that *, ** and *** symbolize the rejection of null hypothesis at 10%, 5% and 1% level of significance respectively.

First differences each variable turned out to be stationary, implying that they are I(1) since they became stationary only after the first differencing. In addition, maternal health (MH) does not have unit root. This implies that it is stationary in its level I(0).

Table 2: Results of ARDL Co-integration Bounds Test

Estimated model	F-Statistic	
MM(CO ₂ , LGDP,LICT, LPOP,LEDU)	6.80	
Level of significance	Critical bounds	
	I(0)	I(1)
10%	2.68	3.05
5%	3.81	4.01
1%	4.87	5.54

Table 4: Estimated Coefficients (Dependent variable: Maternal Mortality)

Panel A: Long-run coefficients				
Regressor	Coefficient	Standard Error	T-Ratio	Prob.
C	-0.929***	0.189	-4.896	0.000
COPC ₂	1.679***	0.013	125.68	0.000
LGDP	0.130***	0.016	8.124	0.000
LPOP _{t-2}	-0.135**	0.062	-2.179	0.033
LICT _{t-4}	-0.019**	0.001	-2.417	0.018
LEDU	-0.004	0.004	-1.144	0.256
Panel B: Short-run coefficients				
CO ₂	0.604***	0.131	4.611	0.000
LGDP	0.051***	0.011	4.477	0.000
LPOP	-0.109***	0.030	-3.625	0.000
LICT	-0.017**	0.0015	-2.331	0.023
LEDU	-0.004	0.0041	-1.144	0.256
ECT _{t-1}	-0.362***	0.0502	-7.226	0.000
F-statistic	2532.81			0.000
R ² Adjusted	0.997			
D-W Stat.	1.909			

Note: that *, ** and *** symbolize the rejection of null hypothesis at 10%, 5% and 1% level of significance respectively.

The result of bound test given in Table 2 indicates that the value of F-Statistic (6.80) is greater than the upper critical bound at 1% level. This indicates that there is a long-run relationship among the variables during the studied period. The existence of cointegration suggests that the estimated relationship is not spurious. The results of estimation indicate that carbon emission has positive and significant relationship with maternal mortality. It indicates that a 1% increase in carbon emissions will increase maternal mortality by 1.68 and 0.60 percent in the long and short run respectively. This suggests that climate change is one of the major factors affecting women health in Nigeria particularly those with pregnancy. Economic growth has a positive and significant relationship with maternal mortality both in the long run and short run in Nigeria. A one percent increase in GDP will increase maternal mortality by 0.05 percent in the short run, while a one percent increases in GDP increase maternal mortality by 0.13 percent in long run in Nigeria. This demonstrates that rising income in the country does not help in reducing maternal mortality especially because the leading sectors of the

economy are mostly dominated by men with huge income inequality. In addition, some of the growth driven sector like oil and gas are environmentally unfriendly especially in the oil producing areas of Niger-Delta. Studies such as Amiri & Gerdtham (2013) support this finding.

Furthermore, population has a negative yet significant relationship with maternal mortality both in the short run and long run in Nigeria. A one percent increase in population growth rate in the country will lead to a 0.11 percent and 0.14 percent decrease in maternal mortality in short run and long run respectively. Nonetheless, this explains why Nigeria's expanding population makes it harder for the low-income nation to pay the rising per capita public spending required to end poverty, hunger, and malnutrition, as well as guarantee universal access to healthcare, education, and other necessities (Chukwunonso, 2024, Yahaya et al., 2020). Also, another result from the estimation shows that there is negative and significant relationship between maternal mortality and ICT both in the short run and long run. A one percent increase in ICT will decrease maternal mortality in the short run and long run by 0.01 percent and 0.01 percent respectively. Through structural changes, the integration of ICT in the health sector will enhance the fundamental quality of the real sector and the development of human capital in the economy (Iqbal et al., 2019). This will significantly improve maternal mortality and other issues that affect vulnerable populations. In addition, the availability of ICT including rural areas enhances the dissemination of health information easily across the households and this educates women on health issues while pregnant. Lastly Education that was proxied by secondary school enrollment per female had a negative and insignificant relationship with maternal mortality in Nigeria both in the short run and long run.

Moreover, the F-statistic (2532.81) shows that the coefficients of explanatory variables are statistically significant jointly and are able to affect maternal health at 1 percent level. Also, the R^2 reveals that all variables (explanatory) accounted for about 99 percent variation in the model. Lastly, the one-lagged error correction terms (ECT_{t-1}) is negative and statistically significant which shows the adjustment from the short-run leading to the long-run. In addition, the result from the estimation meets our expectation since the coefficient of ECT_{t-1} is negative and significant at 1 percent. The result indicates that 36 percent deviations of maternal mortality issues from the equilibrium will be corrected within the first year

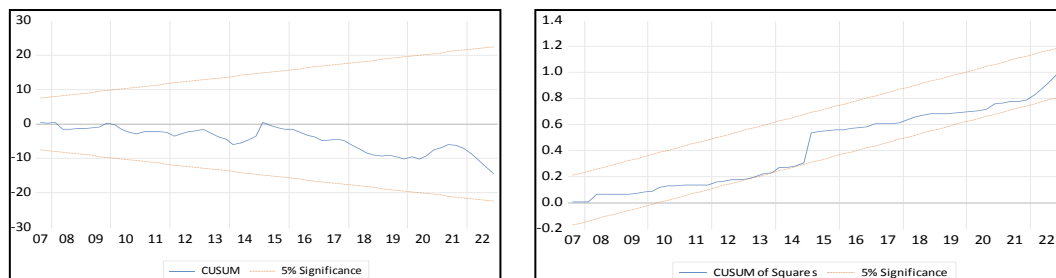
Diagnostic Tests

This study conducted various diagnostics tests including serial correlation, normality and functional form tests. The results reported in Table 5 suggest that the residuals are not correlated; they are independent from each other since the χ^2 value is 0.3809 and the p-value is 0.7. The result L-M test reveals that the error terms are not Heteroscedastic since χ^2 is 1.0173 and p-value is 0.45, respectively (see Table 5).

Table 5: ARDL-ECM Model Diagnostic Tests

Test statistic	Results
Functional Form: Reset F-stat (1, 59)	1.1754.[0.2433]
Serial Correlation:	0.3809[0.6849]
Heteroscedasticity	1.0173[0.4575]
Normality: Jarque-Bera	3.6668 [0.1598]

Note: values in parenthesis [] are probabilities.



CONCLUSION AND RECOMMENDATIONS

Population growth and climate change are among the major drivers of maternal mortality problems in Nigeria. This study examined the impact of population growth and climate change on maternal mortality in Nigeria from 2000 to 2022. Employing ARDL techniques, the results reveal that there is a positive and significant relationship between population growth and climate change on maternal mortality in Nigeria both in the short-run and the long-run. The study recommended that, Nigerian government should control population growth within an ideal range by implementing policies that support family planning, education, and healthcare. This will effectively manage the consequences of population expansion while avoiding potential diminishing returns. Government should also fund climate adaptation policies/programmes with the inclusion of maternal health in larger plans for climate resilience. In addition government should develop maternal health systems in Nigeria;

to highlight the need for increased awareness and international cooperation, with a focus on women's vulnerabilities.

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