REVISITING THE ASYMMETRIC IMPACT OF INCOME INEQUALITY AND HEALTH OUTCOMES IN NIGERIA:
The Role of Climate Risk

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ABSTRACT

Using a non-linear ARDL model, this study investigates the asymmetric relationship between health outcomes and wealth disparity in Nigeria. It confirms *that there is a consistent association between the variables being studied. In the short term, income inequality (GINI_POS and GINI_NEG) affects life expectancy negatively and positively respectively, with only GINI_NEG being significant. In the long term, both GINI_POS and GINI_NEG significantly influence life expectancy positively. For maternal mortality, GINI_POS and GINI_NEG show significant effects both in the short and long term. Regarding infant mortality, GINI_POS and GINI_NEG have insignificant short-term positive effects, while in the long term, they exhibit significant negative and insignificant positive effects respectively. Climate risk negatively affects life expectancy in the short term, but its interaction with income inequality positively affects health outcomes, albeit only for a short period. The study concludes that income inequality significantly impacts health outcomes in Nigeria and highlights the need for equitable income distribution to mitigate the adverse effects of climate risks on health.*

1. Introduction

The relationship between distribution of income and public health outcome is more intricate than previously thought (Lynch et al., 2004; Wiederspan et al., 2015; Avancena et al., 2021; Zheng et al., 2024). Despite this complexity, it is generally accepted that the wellbeing of society has suffered as a result of the rising income inequality in many nations (Atkinson et al., 1995; Lindert, 2000; Bor et al., 2017; Chancel et al., 2023; Oluwaseun & Idowu, 2025). There is evidence that income inequality causes individuals to experience some forms of health challenges, and inevitably leads to worse health outcomes in advanced economies (Mathew & Brodersen, 2018; Vilda et al., 2019; Gugushvili et al. 2020; Alexiou & Trachanas 2021; Wildman, 2021; Sanders, 2023; Oluwaseun & Idowu, 2025). Also, analysis has revealed that most minor illnesses worsen because people cannot afford to get immediate medical attention (World Health Organization, 2001; Hayward & Ayeb-Karlsson, 2021). Income inequality may have an impact on health through influencing the adoption of specific social and health-related policies (Neckerman & Torche, 2007; Schwabish et al. 2006; Alexiou & Trachanas, 2021; Nahian, 2023). For example, some studies discovered that there is a higher direct impact of wealth disparity on birth weight life expectancy (World Bank, 2022; Alvaro et al. 2010).

From a scholarly perspective, economic disparity poses a significant risk to population health through multiple processes. These mechanisms include the psychological, absolute, relative, and neo-materialism hypotheses, which highlight the adverse consequences of income inequality on health outcomes. Chronic stress, a lack of social capital, limited access to healthcare services, and a general state of poor health are all linked to higher income inequality (Laporte, 2002; Deaton, 2003; Babones, 2008; Mayer & Sarin, 2005; Wilkinson, 1997; Kawachi & Kennedy, 1997; Bobak et al. 2000; Coburn, 2000; Lynch et al., 2000; Sanders, 2023; Oluwaseun & Idowu, 2025). Furthermore, there is a correlation between financial inequality and environmental deterioration (Mumtaz & Theophilopoulou, 2023; Matthew & Brodersen, 2018; Drabo, 2010), and environmental quality is a significant factor of health status. This could be because environmental quality is a general need and demand for it is expanding faster than supply of money (Baumol & Oates, 1988; Mesagan & Nwachukwu, 2018). According to

Grossman and Krueger (1995), the Environmental Kuznets Curve (EKC) theory has several explanations, one of which is as follows: As a nation's economic development rises, Kuznets (1955) argues, the distribution of income becomes less equitable, and growth only leads to greater equality after per capita income surpasses a benchmark.

The literature confirms that widening wealth gaps exacerbate environmental degradation and health decline (Baloch et al., 2020), with climate change costing $383 million daily globally (WMO, 2021; Chancel et al., 2023). Nigeria's vulnerability is acute due to limited adaptation capacity (Albu & Albu, 2020; Sarkodie & Strezov, 2019), as reflected in rising temperatures (27.37°C in 2020), severe flooding (Ogbeide-Osaretin et al., 2022; Caretta et al., 2022), and a poor ND-GAIN Index ranking (160/181) (Climate Risk Profile: Nigeria, 2021). Extreme heat alone causes thousands of deaths annually (Chancel et al., 2023; Ebi et al. 2021), while climate risks deepen inequality by reducing productivity and income (Ogbeide-Osaretin et al., 2022; Dasgupta et al., 2020), disproportionately affecting vulnerable groups (Khan & Yahong, 2021). Health outcomes are further strained by climate indicators like temperature, humidity, and extreme weather (Xu et al., 2020); Ray et al., 2019; WHO, 2018; Uzzoli, 2016), compounded by income inequality's inverse ties to health metrics (Fatukasi & Ayeomon, 2015; Odusanya & Agboola, 2017; Oburota & Olaniyan, 2020). In Nigeria – home to Africa's highest income disparity (Oburota & Olaniyan, 2020) – inequality asymmetrically impacts infant and child mortality (Ajefu & Bada, 2021).

Also, because of rising temperatures, population migration brought on by rising sea levels and food shortages, as well as other factors influencing human mobility, climate change may reduce labour capacity in sensitive occupations (McMichael et al., 2020; Schwerdtle et al., 2020). Unfortunately, sub-Saharan African countries, including Nigeria, incur a higher proportion of unfavourable health effects from increased climatic variability (Rublee et al., 2021; Di Napoli et al. 2022). Numerous factors including weak healthcare systems, poor infrastructure, food insecurity, and a large labour force in challenging conditions, contribute to this predicament (USAID, 2022; NIH, 2022). Studies conducted in Nigeria indicate that climate risk amplifies the adverse impact of inequality on access to healthcare and health-seeking behaviours (Otu et al. 2022; Adepoju & Salami, 2023). Despite government

commitment to bridging the gap between the rich and the poor through fiscal and monetary policies using budgetary allocation and interventions to enhance socio-economic activities and the well-being of the populace for more than a decade, a sizeable number of the population is still trapped in poverty and this negatively affects health outcomes (Oxfam, 2018; Fatukasi & Ayeomon, 2015).

Stylized facts reveal that average temperatures in Nigeria have increased by around 1°C over the last 60 years, with projections of further warming of up to 3.2°C by 2060 (USAID, 2021). The frequency and intensity of heat waves have increased, posing significant health and agricultural risks (Olusegun & Abiodun, 2022). Nigeria's life expectancy of 55.2 years in 2021 remains lower than the sub-Saharan African average of 61.2 years (World Bank, 2022b). Nigeria's infant mortality rate is still higher than the sub-Saharan African average of 48.4 deaths per 1,000 live births (World Bank, 2022a). The ratio of maternal mortality of 556 deaths per 100,000 live births in 2017 is still one of the highest in the world and is significantly higher than the global average of 211 deaths per 100,000 live births (WHO, 2019). The facts on temperature increase, climate variability, and persistent health disparities in Nigeria pose significant challenges to the country's sustainable development and the well-being of its population. Empirical studies in Nigeria (Angbas et al., 2018; Aluko & Aluko, 2017; Fatukasi & Ayeomon, 2015) have not taken cognizance of the various indicators of health outcomes (life expectancy, maternal mortality, & infant mortality), thus the need for this study. Also, given the rising challenge of climate change, it becomes necessary to interact with climate risk regarding its impact on income inequality to see how it affects health outcomes. In the relationship between income inequality and health outcomes in Nigeria between 1990 and 2023, this study aims to determine the asymmetry and moderating effect of climate risk.

The paper is structured as follows: section 2 presents a brief literature review; in section 3 the materials and method of the research are developed, and section 4 presents the results and discussion, while section 5 gives the conclusion and policy remarks.

2.   Brief Literature Review

This first section dwells on the scholarly concepts of income inequality and health outcomes such as life expectancy, maternal mortality, and infant mortality rate. Income inequality, according to Bakare (2012), is the state in which funds obtained over a given time period, such as compensation for labour or interest on investments, differ in amount, type, or situation, especially in an unfair ranking disparity. Graham (1995) defined income inequality as the gap that separates the rich from the poor. According to literature, income inequality is the negative element of income distribution, meaning that indices of income inequality reveal an unequal allocation of income within a society (Mdingi & Ho, 2021).

Literature on health outcomes has primarily focused on establishing the correlation between specific causal factors such as morbidity rates, life expectancy, and infant mortality in society (Oluchukwu et al., 2019; Kim & Lane, 2013; World Health Organization, 2012). To Hajebi and Razmi (2014), the World Health Organization (WHO) defines health as an individual's complete condition of mental, physical, and social well-being. Health status measures the physical and emotional well-being of an individual or a defined population (Aluko & Aluko, 2017). Thus, measuring quality of life "health" in Africa goes beyond growth and its per capita measure (Ekpo, 2020). Climate vulnerability or risk is the degree to which people or communities are at risk of experiencing the negative impacts of climate change (IPCC, 2014). Climate shocks tend to cause a greater loss of income and wealth in lower-income countries (and among poorer households) (Cevik & Jalles, 2022). Climate vulnerability refers to a system's potential for suffering damage or ill effects as a result of climate change (Allen Consulting Group, 2005). According to Resetar et al. (2020), the consequences of climate change could pose the greatest risks, including flooding, heat, drought, severe thunderstorms, severe winter weather, and tornadoes. Different economic sectors, including agriculture, health, water resources and energy, are impacted by fluctuations in climate factors. Human activity has been identified as the primary cause of climate change.

Theoretically, there are four ways that wealth inequality might negatively impact population health (Mayer & Sarin, 2005). First, the absolute income hypothesis suggests that income is crucial for population health, enabling better nutrition, medical care, and stress reduction. Transferring wealth from

the rich to the poor could improve general health status, despite the typical economic model prediction that health gains would reduce as income rises (Laporte, 2002; Deaton, 2003; Babones, 2008). This implies that health is a concave function of income, where redistributing income could benefit the aggregate population's health. Second, the relative income hypothesis proposes that economic inequality affects health, particularly when individuals compare their income to those of others in their community (Mayer & Sarin, 2005; Wilkinson, 1997). This comparison can lead to feelings of low control, insecurity, and loss of self-esteem, which can result in chronic stress, lowered resistance to diseases, and early death. Third, the psychosocial hypothesis – which posits that social comparisons and diminished social capital result in inferior health outcomes – may have an effect on population health due to financial inequality (Kawachi & Kennedy, 1997; Bobak et al. 2000). Wilkinson (1996) further states that low social standing brought on by wealth disparity sets off unpleasant feelings like guilt and mistrust, which in turn cause unhealthy neuroendocrine processes and stress-related behaviours like drinking and smoking (Mayer & Sarin, 2005). Lynch et al. (2001) found a strong association between economic inequality and infant mortality, suggesting that economic inequality plays a significant role in health outcomes. Finally, according to the neo-materialism theory, healthcare disparities are caused by wealth inequality, which also affects how material resources are distributed (Coburn, 2000; Lynch et al., 2000). A decrease in governmental funding for health care and services for the impoverished due to rising wealth disparity may have a negative impact on public health outcomes (Coburn, 2000).

Furthermore, the framework for the human capital-related aspects of health care development was provided by the human capital theory (Schultz, 1961; Becker, 1964; Grossman, 1972; Mincer, 1974). Understanding a variety of health and healthcare-related phenomena has been greatly aided by the health-based human capital model, which has been the cornerstone of the health economics model (Van Kippersluis & Galama, 2013). The substantial influence that health has on wealth, incomes, and labour force involvement is a noteworthy conduit, which connects health, health outcomes, and economic conditions (Oluchukwu et al., 2019). For instance, those who suffer from health issues are more likely to lose money by leaving the workforce earlier

(Deaton, 2006; Møller, 2005). Health outcomes are affected in a manner similar to how income inequality limits access to health care services.

In this study, we consider certain empirical results relating to health outcomes and income disparity. Income inequality was found to have an inverse influence on death rate by Fatukasi and Ayeomon (2015), who used the co-integration test and dynamic ordinary least squares (DOLS). Yet in the Nigerian model, there was a clear correlation between the rate of life expectancy and income inequality. Hajebi and Razmi (2014) conducted a study using panel data and fixed effects to determine whether economic disparity and public health status were significantly correlated negatively in a group of middle- and low-income nations. Using a non-parametric estimating approach termed kernel regression, Oburota and Olaniyan (2020) found that health care financing options were linked to a worsening of income inequality in Nigeria at both the national and sectoral levels. Using random effects (GLS) estimates, Angbas et al. (2018) found that income disparity has a detrimental impact on health outcomes in Nigeria. Using the one-way error component panel modelling technique, Aluko and Aluko (2017) found that the amount of individual income had a negative impact on child mortality in Nigeria.

Matthew and Brodersen (2016) adopted the ordinary least squares (OLS) analysis and the probit analysis, and results show that Gini coefficient had significant positive relationships with physical and behavioural health outcomes in the United States. Alexiou and Trachanas (2021) found strong evidence of the significant impact of income on health outcomes in 47 high-income countries based on the World Bank's national income classifications, which employs a panel fixed-effects approach, as well as the nonparametric covariance matrix estimator created by Driscoll and Kraay (1998). The results clearly show that income has a strong impact on health outcomes. Oluwaseun and Idowu (2025) employed the ARDL approach in a country-specific study conducted in Nigeria, and their findings reveal that income inequality negatively affects life expectancy in both the short and long term, but the impact is only statistically significant in the long run. Also, there is a one-way causal relationship between life expectancy and the Gini coefficient.

Momoh et al. (2024) used panel Granger causality tests on data from 44 sub-Saharan African countries (2000–2021), finding bidirectional causality

between life expectancy and real GDP, education, and carbon emissions. Esseau-Thomas et al. (2022) applied global cross-country analysis, and their findings reveal that epidemic deaths, particularly during COVID-19, significantly increased the Gini coefficient. Momoh and Okwu (2022), using World Bank and WHO data (2000–2019), found that income level, out-of-pocket payments, and health spending significantly influenced health outcomes in anglophone West Africa. Ibukun (2021) employed governance-quality-adjusted panel regressions and found that health expenditure significantly reduced child mortality and improved life expectancy in West Africa. Ogu (2023) applied time-series analysis for Nigeria (1990–2021), and found that while life expectancy positively affects economic growth, other health inequality indicators have adverse effects.

In developed economies, climate change vulnerability has no statistically significant impact on income distribution; however, in developing nations, where the coefficient on climate change vulnerability is seven times greater and has statistically higher significance, it is positively correlated with rising income inequality (Cevik and Jalles, 2022). Standard panel regression analysis and a panel vector autoregression (VAR) model were employed in the investigation. Income disparities have a detrimental impact on health status, as Drabo (2010) shows using the two-step least squares (2SLS) approach and the GMM system estimation. Furthermore, the research validates the idea that the quality of the environment plays a significant role in mediating the impact of wealth inequality on the population's health. The study by Mumtaz and Theophilopoulou (2023) uses panel structural VAR, and the results show that in 17 developed nations, measures of income inequality rise in response to unfavorable climate shocks. Using content analysis, Paavola (2017) discovered that people who are already severely impacted by climate change will see a worsening of their current health problems as well as a reduction in their capacity to withstand future risks to their well-being.

2.1 Gap in the Literature

Apart from traditional pathways, income inequality can impact health through climate risk. Lower-income communities, often residing in hazard-prone areas, face greater exposure to climate-related disasters due to limited access to safe housing and infrastructure. This exacerbates health disparities as these

communities have less capacity to adapt and recover. Addressing income inequality is vital for enhancing resilience to climate risks and safeguarding public health. This approach is lacking in the empirical studies reviewed in this study.

3. Materials and Method

The section details the model specification to test the hypothesis of the study alongside the method of analysis, kinds of data, and sources. This study is country-specific to Nigeria. Concerning the data, the study employed the health outcome components of life expectancy, maternal mortality rate, and infant mortality rate. In addition, it contributes to the extant literature by exploring options on different measures of income inequality such as Gini Coefficient and consumption expenditure alongside other germane variables of health expenditure, inflation, out-of-pocket health expenditure, and crime rate proxied by the absence of violence index. In this direction, we adopted alternative methodological frameworks comprising linear ARDL and non-linear ARDL in order to ascertain the direction in terms of asymmetric impact of income inequality to health outcomes in Nigeria. The study employs yearly data from 1990 to 2023 from the Central Bank of Nigeria Statistical Bulletin, World Health Organization database, National Bureau of Statistics, and World Bank's Development Indicators. It also focuses on Nigeria because of its distinct trends in health outcomes and income disparity. Health outcomes, specifically life expectancy, infant death rate, and maternal mortality rate, are the study's dependent variables. The Gini coefficient, which measures income inequality, is the relevant independent variable. The modelling of the relationship between income inequality and health outcomes is supported by additional variables such as health expenditure, inflation, and out-of-pocket medical expenses. By defining suitable models, the inquiry was conducted.

3.1 Model specification

This section focuses on a number of models, including that of Nejadlabbaf et al. (2013), who proposed that health status in Nigeria is influenced by per capita income, education level, savings level, and income inequality distribution. According to Fatukasi and Ayeomon (2015), per capita income,

savings, education, and income inequality all affect health outcomes including life expectancy and maternal mortality. The distribution of income among nations is often influenced by political regimes and institutional factors (Cevik & Jalles, 2022). As a result, the political stability index and absence of violence index were taken into account in this study (Pulok, 2012). This is due to Rodrik's (1999) suggestion that nations with democratic systems of government tend to have more equitable wealth distribution. According to Diffenbaugh and Burke (2019), institutional and geographic barriers to adaptation cause low-income nations to deteriorate over time. Furthermore, Islam and Winkel (2017) discovered that the negative impacts of climate change led to increased income distribution inequality. The functional form of the model is expressed in equation (1):

$$HLO = f(GINI, OPE, HXP, INF) \tag{1}$$

where: HLO represents health outcomes decomposed into maternal mortality rate (modeled estimate: per 100,000 live births), infant mortality rate (per 1,000 live births), and life expectancy at birth, total (years). GINI coefficient measures income inequality; OPE stands for out-of-pocket expenditure (% of current health expenditure) health expenditure, HXP represents government health expenditure (₦' Billion) while INF is inflation (consumer price index).

In order to model the association between economic inequality and health outcomes, we take into consideration the NARDL technique of Shin et al. (2014). Some of the benefits of applying the NARDL technique as listed by Van Hoang et al. (2016) are as follows. First, the cointegration link between the independent and dependent variables may be modelled in the first place, thanks to this. Second, it also makes it possible to test for nonlinear as well as linear cointegration. Third, it differentiates between the impacts of the independent variable on the dependent variable over the short and long terms. Fourth, the NARDL model relaxes this requirement and permits merging data series with multiple integration orders, in contrast to conventional error correction models that require the time series under consideration to have the same integration order. However, we take into account both symmetric and asymmetric ARDL for robustness. We consider each of these requirements separately.

3.2 Symmetric ARDL (Linear ARDL)

The following is the standard framework of Pesaran et al. (2001), where the symmetric ARDL model is specified using:

$$\Delta HLO_t = \alpha_0 + \alpha_1 HLO_{t-1} + \alpha_2 GINI_{t-1} + \alpha_3 X_{t-1} + \sum_{i=1}^{N_1} \lambda_1 \Delta HLO_{t-i}$$

$$+ \sum_{j=0}^{N_2} \lambda_2 \Delta GINI_{t-j} + \sum_{j=0}^{N_3} \lambda_3 \Delta X_{t-j} + \varepsilon_t \ldots \ldots [2]$$

where: HLO_{t-1} is the logarithm of health outcome proxied by maternal mortality rate, infant mortality rate, and life expectancy; $GINI_{t-1}$ is the logarithm of the GINI coefficient measuring income inequality; X_{t-1} is the logarithm of additional correlates that are included in the model for the relationship study, such as inflation, out-of-pocket costs, and government health costs. The intercept and slope coefficients' long-run parameters are calculated as $-\dfrac{\alpha_0}{\alpha_1}$ *and* $-\dfrac{\alpha_2}{\alpha_1}$ respectively, since in the long run, it is assumed that $\Delta HLO_{t-i} = 0$ and $\Delta GINI_{t-j} = 0$.

However, the short-run estimates are obtained as λ_1 and λ_2 for health outcomes and the GINI coefficient respectively. Since the first difference variables can support several lags, figuring out the best lag combination for the ARDL becomes essential. Applying the Akaike Information Criterion (AIC), the Hannan-Quinn Information Criterion (HIC), or the Schwartz Information Criterion (SIC) will yield the optimal lag leg. According to the chosen criterion, the lag combination with the lowest value among the competing lag orders is the optimum lag. In order to investigate long-term relationships within the model, the ARDL model of choice is utilized. The use of upper and lower constraints in this cointegration test method is why it is called bounds testing. Because the test is distribution-based, cointegration exists when the computed value is greater than the upper bound; there is no cointegration when the value is less than the lower bound, and a value in the middle of the two bounds indicates that the test is inconclusive. In the spirit of

our model, the null hypothesis of no cointegration can be expressed as follows, whereas the cointegration option is represented by the symbol (λ). The following is a new specification of Equation (1) that adds an error correcting term:

$$\Delta HLO_t = \delta v_{t-1} + \sum_{i=1}^{N_1} \lambda_i \Delta HLO_{t-i} + \sum_{j=0}^{N_2} \lambda_j \Delta GINI_{t-j} + \varepsilon_t \qquad (3)$$

where: v_{t-1} is the symmetric error correction term; the parameter δ is the speed of adjustment.

The GINI coefficient does not break down into positive and negative changes in equations (2) and (3), which supports the symmetric behaviour of the GINI coefficient on health outcomes in this case.

3.3 Asymmetric ARDL (NARDL) model

The likely asymmetric behaviour of the GINI coefficient on health outcomes can be represented by breaking down the variable into positive and negative changes (see Ogbonna, 2023; Efayena & Olele, 2023). The idea behind the GINI coefficient asymmetry analysis is that households in Nigeria might react differentially to both positive and negative changes in the GINI coefficient. Previously, but not particularly for the connection between the GINI coefficient and health outcomes, emphasis was placed on research that addressed imbalances. This approach is based on the NARDL by Shin et al. (2014), which appears to use less computing power than earlier asymmetric models and does not require the same order of integration (I(1)) for every series in the model. The provided NARDL is:

$$\Delta HLO_t = \alpha_0 + \alpha_1 HLO_{t-1} + \alpha_2 GINI_{POS_{t-1}} + \alpha_3 GINI_{NEG_{t-1}} + \alpha_4 X_{t-1}$$

$$+ \sum_{i=1}^{N_1} \lambda_1 \Delta HLO_{t-i} + \sum_{j=0}^{N_2} (\lambda^+ \Delta GINI\_POS_{t-j} + \lambda^- \Delta GINI\_NEG_{t-j}) +$$

$$\sum_{j=0}^{N_3} \lambda_3 \Delta X_{t-j} + \varepsilon_t \qquad (4)$$

The GINI coefficient variable (〖GINI〗_t) in Equation (4) can now be broken down into two parts: positive and negative changes in the GINI coefficient . Theoretically, these broken pieces are described as:

$$GINI\_POS_t = \sum_{j=1}^{t} \Delta GINI_{POS_j} = \sum_{j=1}^{t} \max(\Delta GINI_{j,} 0) \qquad (5)$$

$$GINI\_NEG_t = \sum_{j=1}^{t} \Delta GINI\_NEG_j = \sum_{j=1}^{t} \min(\Delta GINI_{j,} 0) \qquad (6)$$

We then respecify Equation (4) to include an error correction term thus:

$$\Delta HLO_t = \tau \xi_{t-1} + \sum_{i=1}^{N_1} \lambda_1 \Delta HLO_{t-i} + \sum_{j=0}^{N_2} (\lambda^+ \Delta GINI\_POS_{t-j}^+$$

$$+ \lambda^- \Delta GINI\_NEG_{t-j}^-) + \sum_{j=0}^{N_3} \lambda_3 \Delta X_{t-j} + \varepsilon_t \qquad (7)$$

It is noteworthy that, akin to the linear ARDL, the estimation of the long run is contingent upon the existence of cointegration. Therefore, even under NARDL, pre-testing for cointegration is required, and this entails F-distributed bounds testing. To further determine if the asymmetry matters in the short and long terms, we also use the Wald test for testing limits. The null hypothesis that there are no asymmetries for the Wald test- $H_0 : \alpha_2 = \alpha_3$ (for the long run) and $H_0 : \sum_{j=0}^{N1} \lambda_j^+ = \sum_{j=0}^{N2} \lambda_j^-$ (for the short run) is tested against the alternative presence of asymmetries - $H_1 : \alpha_2 \neq \alpha_3$ for the long run and $H_1 : \sum_{j=0}^{N1} \lambda_j^+ \neq \sum_{j=0}^{N2} \lambda_j^-$ for the short run.

4. Results and Discussion

In this section, we provide the analysis for the study beginning with the pre-estimation, followed by the main estimation, and finally, the post-estimation analysis.

4.1 Summary statistics

Table 1 displays the summary statistics for the variables under examination highlighting the mean, standard deviation, skewness, kurtosis, Jarque-Bera, maximum, and minimum values. The mean values account for the average of each variable considered. Comparably, the standard deviation shows the degree to which the series are spread or crowded around their averages. The skewness indicates the direction of the movement/fluctuations (either right positive or left negative); whereas the kurtosis indicates how heavy the tail is relative to a normal distribution. The Jarque-Bera emphasizes the distribution of the series, while the maximum and minimum values indicate the extreme magnitudes of the variables under consideration.

Table 1: Descriptive Statistics

	Mean	Std. Dev	Skew	Kurt	J-Bera	Max	Min
LXP	48.66994	2.763271	0.321235	1.443473	5.198499	52.91000	45.48700
MMR	1217.068	162.0865	0.735071	2.220110	5.077497	1562.000	993.0000
IMR	101.9220	20.68972	-0.23384	1.432137	4.907699	126.0000	67.37000
GINI	39.71023	5.163135	0.826469	2.495568	5.475537	51.90000	33.76667
HXP	103.4928	140.9844	1.243852	3.215924	11.43138	437.5212	0.041315
INF	89.52811	118.8477	1.650551	4.976008	27.13680	464.4665	0.405047
CR	87.37669	60.11234	0.705221	3.351850	3.874105	225.4132	0.000012
Obs	44	44	44	44	44	44	44

Note: Standard deviation, skewness, kurtosis, Jarque-Bera, maximum, and minimum are shortened as Std. Dev, Skew, Kurt, J-Bera, Max, and Min respectively.
Source: Authors' computation using E-views 12.

The table shows that for the period under review, the mean life expectancy (LXP) for a Nigerian is 46 years, with maximum and minimum values of 52 and 45 years respectively. Also, the series exhibits a 2.8 dispersion around the mean, and it shows that the series is positively skewed at 0.3, implying that the majority of the data points are concentrated on the left side of the distribution, which is a kurtosis value of 1.4, indicating that the data series is platykurtic. For maternal mortality rate (MMR), the series exhibits a mean value of 1217, a deviation away from the mean of 162, a positive skewness of 0.7 and a kurtosis of 2.2, implying the data series is platykurtic in nature. The infant mortality rate (IMR) measure of health outcome renders a mean value of 101, implying that out of 1000 births

slightly above 10% of the children die at birth. It further shows the tendency of 20.6 infants to deviate away from the mean values of the series. The series also indicates a negative skewness with a platykurtic kurtosis of -0.23 and 1.4 respectively. The measure of income inequality (GINI coefficient) has a mean value of 39.7, with a deviation away from the mean of 5.2 and a positive skewness of 0.8 and a platykurtic kurtosis of 2.50, indicating fewer outliers. In a similar light, health expenditure (HXP) reveals a mean value of 103, with a high dispersion away from the mean of about 140, a positive skewness of 1.2, with a kurtosis of 3.2. Inflation (INF) on the other hand indicates a mean value of 89, with a higher level of dispersion away from the mean of 118, and a skewness and kurtosis of 1.6 and 4.9 respectively. Climate policy uncertainty (CPU) equally gives similar results, indicating a mean value of 87, with a standard deviation away from the mean of about 60, amidst a skewness and kurtosis of 0.7 and 3.8 respectively in Nigeria, and ranges between -0.33604 and 2.50069 for Australia and Japan respectively.

4.2 Unit root test

Non-stationarity is a key concern when dealing with issues of time series. Hence, this study conducts a unit root test to ascertain the validity of the variables for the proposed methodology. We conducted both the Augmented Dickey-Fuller and the Philip-Perron unit root tests for the purpose of robustness. The results, as presented in Table 2, indicate that the maternal mortality rate (MMR) and the infant mortality rate (IMR) which are health outcome measures are stationary with order of integration I(0). In contrast, life expectancy (LXP), Gini coefficient (GINI) – which is the measure of income inequality, health expenditure (HXP), inflation (INF), and climate risk (CR) are all integrated of order one I(1) for the two test methods. These findings are consistent with the requirements for the application of the ARDL modelling framework, which necessitates that variables should be either I(0) or I(1) but not I(2).

Table 2: Unit Root Test Results

Variables	Augmented Dickey-Fuller			Philip Perron		
	Level	First Diff.	I(d)	Level	First Diff.	I(d)

LXP	-0.03549	-2.45174***	I(1)	0.374095	-2.31849**	I(1)
MMR	-4.60934***	-	I(0)	-4.07595***	-	I(0)
IMR	-3.84491***	-	I(0)	-3.27069***	-	I(0)
GINI	-0.55857	-1.96504**	I(1)	-0.19492	-2.06202**	I(1)
GINI_POS	-2.547588	-6.1985***	I(1)	-3.55937**	-	I(0)
GINI_NEG	-1.141673	-6.13091**	I(1)	-0.323814	-5.166953	I(1)
HXP	1.112721	-7.16929***	I(1)	3.170522	-7.17816***	I(1)
INF	6.348170	-4.242157*	I(1)	3.596625	-6.228023*	I(1)
CR	-0.32781	-6.71938***	I(1)	-0.35514	-6.71892***	I(1)

Note: ***, **, and * indicate statistical significance at 1%, 5% and 10% respectively.
Source: Authors' computation using E-views 12.

4.3 Main results

Given the behaviour of our data series as shown by the outcome of the unit root test results, whereby we established the presence of a mixed order of integration among variables and the need to ascertain the existence of a long-run linear association among the variables, we proceed to conduct a cointegration test using the ARDL bounds testing approach as presented in Table 3. The results show an F-statistic value of 8.401939, which is above the lower and upper bounds of 3.29 and 4.37 at a 1% significance level. The result indicates the presence of a long-run linear combination among the variables, hence appropriate to model both the short and long-run dynamics of the relationship.

Table 3: Autoregressive Distributed Lag Bounds Test Results

Test Statistics	Value	Significance	I(0)	I(1)
			Asymptotic n= 1000	
F-statistics	8.401939	10%	2.2	3.09
K	4	5%	2.56	3.49
		2.5%	2.88	3.87
		1%	3.29	4.37

Source: Authors' computation using E-views 12.

We conduct the main analysis using three variables (life expectancy, maternal mortality, and infant mortality) as indicators of health outcomes and as dependent variables separately, in order to enable us capture unique characteristics inherent in each of the health outcomes indicators. The results

are presented in Tables 4, 5, 6. Also, to account for the role of climate change we present the results in Table 7.

The result of the impact of income inequality on health outcomes proxied by life expectancy is presented in Table 4. From the results, the first period lag of life expectancy has a positive but insignificant impact on the current life expectancy. The second period lag however exhibits a negative and significant impact on the current lifespan. This implies that a 1% change in life expectancy in the previous two years in Nigeria will impact the life expectancy in the current year by 26% in the short run. In a similar manner, positive changes in income inequality exert a negative but insignificant impact on life expectancy, while the negative changes have both a positive and significant impact on the life expectancy of Nigerians. This finding highlights the role and the need to account for asymmetric analysis in a bid to capture these salient features in the behaviour of macroeconomic variables. This implies that a 1% negative change in the income inequality of Nigerians will result in a 14.2% positive change in the life expectancy of Nigerians in the short run. However, in the long run, both positive and negative changes in income inequality render positive and significant effects on health outcomes. This result acknowledges the significant role of income status as a driver of health outcomes, which is in line with the finding of Hajebi and Razmi (2014). The result further establishes both positive and significant associations among health expenditure, inflation and health outcomes in the short run. However, inflation dynamics account for negative impact in the long run. The speed of adjustment of the model value of -0.357582 is both negatively and statistically significant and accounts for the extent to which disequilibrium among the variables in the model will revert to equilibrium position.

Table 4: Short-run and Long-run Results of ARDL (2,0,0,0,0) Model using Life Expectancy

Variable	Coefficient	Std. Error	t-statistics
Short-run estimates			
LXP(-1)	0.079226	0.134062	0.590967
LXP(-2)	-0.267017*	0.147969	-1.804550
GINI_POS	-0.014800	0.010317	-1.434535
GINI_NEG	0.141800***	0.025941	-5.466340
HXP	0.001985**	0.000903	2.198918
INF	-0.001597**	0.000802	-1.990195

C	16.49628	3.261579	5.057758
ECM(-1)	-0.357582***	0.046735	-7.651310
Long-run estimates			
GINI_POS	0.041390*	0.023839	-1.736214
GINI_NEG	0.396551***	0.028290	-14.01746
HXP	0.005551**	0.002003	2.770984
INF	-0.004466**	0.002085	-2.142515
C	46.13282***	0.275867	167.2287

Source: Authors' Computation using E-views 12

The impact is contingent upon the particular health outcome and time horizon, as can be seen by closely examining the dynamics of the asymmetric impact of income inequality on the three proxies of health outcomes (life expectancy, infant mortality, and maternal mortality), as presented in Tables 5, 6, and 7. It is observed that for maternal mortality, positive and negative changes in income inequality impact the mortality rate significantly both for the short and long run time frame. In a similar vein, life expectancy equally exerts significant impact for all the changes except for the short run positive changes where an insignificant impact is observed. However, for infant mortality the significance of the impact is only observed on the positive changes in the income inequality in the long run. The findings of the results hold and establish the presence of asymmetry in the relationship and further prove that the choice of a particular health outcome matters in explaining the asymmetric impact of income inequality.

Table 5: Short-run and Long-run Results of ARDL (1,1,1,1,0) Model using Maternal Mortality Rate (MMR)

Variable	Coefficient	Std. Error	t-statistics
Short run estimates			
MMR(-1)	0.177357*	0.103921	1.706647
GINI_POS	4.313205**	2.150107	2.006042
GINI_NEG	-3.776975**	1.465519	-2.577228
HXP	-0.526082***	0.102253	-5.144894
INF	0.191420*	0.106093	1.804262
C	-288.7371*	161.0172	-1.793207
ECM(-1)	-0.177357***	0.031343	5.658523
Long run estimates			
GINI_POS	-24.31936***	6.042789	-4.024526
GINI_NEG	21.29591**	9.314379	2.286348
HXP	1.791318*	0.871525	2.055385
INF	-1.079292**	0.596892	-1.808185
C	-28.73711**	12.61396	-5.594167

Source: Authors' computation using E-views 12

Table 6: Short-run and Long-run Results of ARDL (2,1,0,0,0) Model using Infant Mortality Rate (IMR)

Variable	Coefficient	Std. Error	t-statistics
Short run estimates			
IMR(-1)	0.776696***	0.044634	17.40133
GINI_POS	0.095109	0.074266	1.280646
GINI_NEG	0.026269	0.040295	0.651911
HXP	9.282505	0.000833	-0.111459
INF	-0.001998**	0.000838	-2.385264
C	4.703015**	2.173058	2.164238
ECM(-1)	-0.034864***	0.002909	-11.98683
Long run estimates			
GINI_POS	-2.132524**	1.072450	-1.988459
GINI_NEG	0.753458	0.792185	0.951114
HXP	-0.002663	0.023410	-0.113743
INF	-0.057310*	0.029690	-1.930291
C	4.703015***	0.398826	11.79215

Source: Authors' computation using E-views 12.

Table 7 shows the results of our analysis of how climate risk influences the relationship between income inequality and health outcomes. To achieve this, we used life expectancy as a proxy for health outcomes. According to our research, the environment affects Nigerians' life expectancy in the short run, but when it comes to health outcomes, it also significantly improves them when it interacts with income inequality. This suggests that reducing the impact of climate risk requires a careful consideration of economic distribution. Nevertheless, this effect is transient because it has negligible long-term effects; this is consistent with the literature (Cevik & Jalles, 2022).

Table 7: Short-run and Long-run Results of ARDL (2,1,0,0,0) Model for the Role of Climate Risk

Variable	Coefficient	Std. Error	t-statistics
Short-run estimates			
LXP(-1)	0.032276	0.028126	1.147543
GINI	-0.114794	0.060675	-1.891955
CR	-0.015109**	0.008187	-1.845577
GINI*CR	0.000395**	0.000229	1.721405
C	-0.761008	1.843141	-0.412886
ECM(-1)	-0.032276***	0.012825	2.516654
Long run-estimates			
GINI	0.521835	0.961190	0.542905
CR	0.468137	0.473479	0.988717
GINI*CR	-0.012238	0.013083	-0.935438
C	-0.761008**	0.362260	-2.100722

Source: Authors' computation using E-views 12.

Table 8 presents the diagnostic result for the estimated model. It reveals that the model is correctly specified with respect to its functional form and the inclusion of relevant variables given that the F-statistic for the Ramsey Reset test is statistically insignificant. We further conducted the serial correlation test where both the F-statistic and the probability of the Chi square were not statistically significant, hence, the absence of serial correlation in the model. In a similar way, the Breusch-Pagan-Godfrey test for heteroscedasticity was conducted and we found that the residuals are homoscedastic. We therefore presented the model stability test in Figure 1.

Table 8: Diagnostics Test Results

	Value	Df	Probability
	Results of Ramsey Reset Test		
F-Statistics	0.013016	(1, 27)	0.9100
	Breusch-Godfrey Serial Correlation LM Test		
F-Statistic	2.919486	Prob. F(2,26)	0.1718
Obs*R-squared	7.519019	Prob Chi2	0.2233
	Heteroscedasticity Test: Breusch-Pagan-Godfrey		
F-statistic	1.114628	Prob. F(12,28)	0.3872
Obs*R-squared	13.25414	Prob. Chi-Square	0.3508

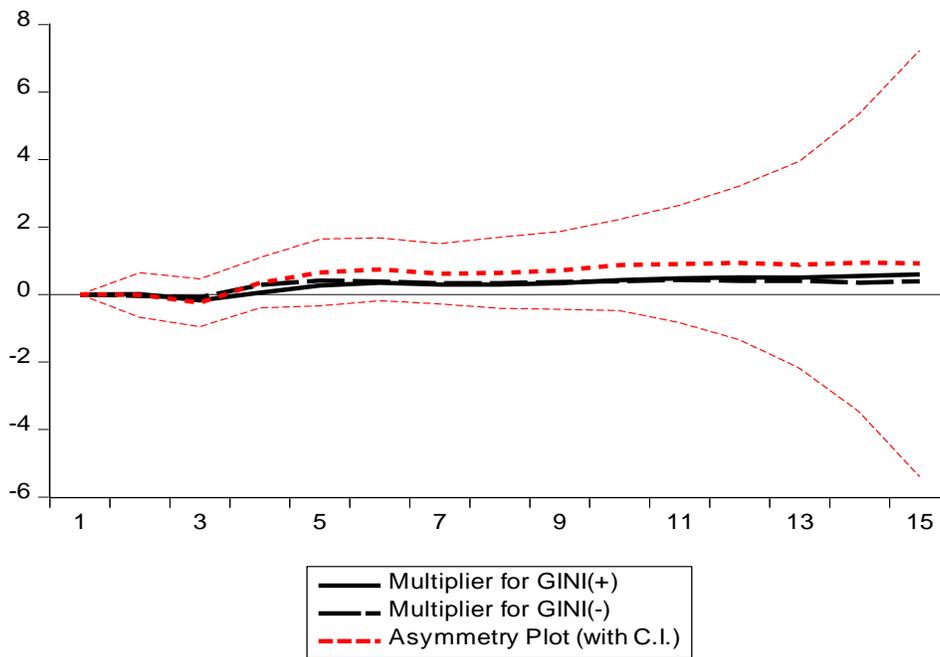*Source:* Authors' computation using E-views 12.

Figure 1: Asymmetry Multiplier Plot
Source: Extract from E-view 12.

5. Conclusion

This study examines the asymmetric impact of income inequality and health outcomes in Nigeria, also accounting for the role of climate risk in the relationship, using the Nonlinear Autoregressive Distributed Lag modeling

approach. We found that among the three health outcomes considered, positive and negative changes in income inequality have a significant impact on health outcomes in most instances for the short and long run dynamics. We equally accounted for the role of climate risk in the analysis and found that income distribution matters for issues of climate risk resilience and adaptation as it appears to cushion the impact on health outcomes when they interact.

We therefore recommend that progressive fiscal policies – including equitable taxation and targeted social investments – can redistribute resources to communities experiencing the greatest health burdens. By expanding access to universal healthcare, implementing conditional cash transfers, and supporting nutritional programmes, governments can directly address the immediate health needs of vulnerable populations. Simultaneously, strategic investments in education and vocational training provide pathways to economic mobility, addressing the root causes of health disparities rather than merely treating symptoms.

Climate adaptation must be seamlessly integrated into public health infrastructure to protect at-risk communities from environmental threats. This requires developing resilient healthcare facilities capable of withstanding extreme weather events, deploying mobile health units to reach displaced populations, and establishing robust early warning systems for climate-related health emergencies. Community-based climate-health education further ensures that underserved populations maintain access to care despite increasing environmental pressures and geographic barriers. To effectively address the interconnected challenges of inequality, climate risk, and health outcomes, intersectoral collaboration is essential. Governments, the private sector, the academia, and NGOs must unite their expertise and resources through coordinated partnerships. Initiatives like public-private green job programmes and integrated policy task forces can drive progress on multiple fronts – boosting equitable economic growth, strengthening climate resilience, and improving public health.

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