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HEALTH OUTCOMES AND ENVIRONMENTAL QUALITY NEXUS: AN ARDL APPROACH TO COINTEGRATION ANALYSIS FOR THE CASE OF NIGERIA

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Abstract

Environmental degradation and pollutants have, over the years, deteriorates health outcomes through decline in life expectancy and rising mortality, notably from cardiovascular and respiratory-related diseases in less developed countries. This study adds to the existing literature on the environmental quality-health nexus within the context of Nigeria using the data from 1980 to 2021 sourced from World Bank's World Development Indicators. Using autoregressive distributed lag (ARDL) approach to cointegration, the findings of the study revealed the presence of long-run relationship between environmental quality and health outcomes proxied by carbon emission and life expectancy respectively as well as foreign direct investment (FDI) and labour force as control variables. Specifically, carbon emission per capita is found to have negative and statistically significant impact on life expectancy where a unit increase in carbon emission reduces life expectancy by 0.6872 and 0.7030 in both the short and long-run respectively. While FDI is reported to have significant impact on life expectancy in both short-run and long-run, labour force has no significant impact. These findings call for swift response from Nigeria's government to treat pollution-induced health challenges as matter of urgent concern. In view of this, the study recommends, among others, transition from traditional energy sources of cooking fuels, notably solid fuels such as wood and charcoal which are among the major sources of respiratory illnesses to a cleaner source like LPG, ethanol, and improved cook stoves which minimizes indoor carbon emissions. This can be achieved by incorporating clean energy access in the social protection programmes and partnership with the leadership of local communities for the distribution of clean energy equipment at subsidized rate as well as massive awareness campaigns about the health effects associated with the traditional cooking energy sources. Also, establishing air quality sensors in major cities and industrial zones in order to enhance air quality monitoring cannot be over emphasized.

Keywords: Environmental quality, health outcomes, carbon emission, life expectancy, ARDL
JEL Classification Codes: I0, I15, I18, C32

1.0 Introduction

Achieving improved population health by the year 2030 across the globe, regardless of geographical boundaries as well as socioeconomic and cultural barriers, remains a core pillar in the Sustainable Development Goals (SDGs) as outlined by the United Nations (UN, 2015). This buttresses the view of health by World

Health Organization (WHO) as a fundamental human right that must be accorded to individuals without any discrimination. However, the pervasive incidence and prevalence of diseases, particularly in less developed countries, despite interventions from public, private, and donor agencies remain disturbing which calls for a re-think and deep investigation of various factors that influence the health of the population. A key among these factors is the environment in which people live. As rightly stated by Rahman, Alam and Velayutham (2021), the inability to recognize the effect of energy, environment, sanitation and hygiene have been the source of increased health crisis and poor health status in many parts of the world. This, consequently, deteriorates health outcomes through decline in life expectancy and rising mortality, notably from cardiovascular and respiratory-related diseases due to environmental degradation and pollutants (Babajide et al., 2020; Ogbonna et al., 2018). For instance, at macro level, environmental pollution from carbon dioxide emission on one hand, and point pollutants such as suspended particulate matters, changes in rainfall and temperature in specific locations on the other, have been documented to exert devastating effects on environmental quality which in turn, affects the health status of the population. According to Badulescu et al. (2019), the costs of environmental degradation on human health has been evidenced in incidence and prevalence of diseases, and this has influenced not only the quality of life but also widens the economic burden of increased healthcare spending in low-income countries. This supported the assertion of Jerrett et al. (2003) that developing countries with higher pollution-related cases were reported to spend higher on healthcare and vice-versa. Conversely, improving the quality of the environment is equally expected to improve the quality of life which can be seen in rising life expectancy and decrease in mortality and incidence of illnesses. Hence, judging whether a particular population is healthy or not, strongly depends on the environment in which such population lives.

In Nigeria, over-reliance on environment for livelihood by individuals on one hand, and pursuit of economic growth by government on the other, has resulted to unbearable environmental damages with consequences on quality human life and healthcare spending. As a result, various policies and interventions aimed at ensuring environmental quality for human development without compromising the pursuit for sustainable economic growth and development have been made. In

addition to Environmental Impact Assessment (EIA) Act of 1992, and the establishment of National Environmental Standards and Regulations Enforcement Agency (NESREA) in 2007, notably recent policies include National Climate Change Policy (2021-2030) aimed at mitigating greenhouse gas (GHG) emissions and curtailing the effect of climate change on socioeconomic status of Nigerians; Petroleum Industry Act of 2021 which provides measures for reducing GHG emissions as well as managing fugitive methane associated with oil and gas explorations and exploitations. Notwithstanding these efforts, health outcomes and environmental quality in the country remain worrisome, and this is largely attributed to limited or poor implementation of the enacted policies. For example, in a comparative analysis conducted by Manchikanti (2025) on Environment Protection Index (EPI) for Kenya, Nigeria, and South Africa, it was reported that GHG emissions in Nigeria are projected to reach as peak as 900 million tons of carbon dioxide (CO2) by 2030 if remain unchecked. This is not surprising Nigeria with a view to protecting population health without compromising the need for sustainable economic growth and development. This study therefore, aims at investigating the relationship between environmental quality proxied by given the heavy reliance of the country's economy on petroleum resources whose exploitation causes tremendous air pollution and exposure of the population to deadly toxic substances. Furthermore, WHO (2021) reported that GHG emissions in major cities of Nigeria such as Lagos, Kano, and Port Harcourt have been more than what is safe for a decent life. This is worsened by emissions from vehicles, and widespread use of generators for domestic and industrial use with complicated mix of pollutants that hurt respiratory health, heart health, and death rates in different demographic groups.

However, Nigeria's fast-growing population and urbanization trend, together with government desire for industrialization and sustained economic development will undoubtedly aggravate environmental pressures in years to come based on the current business-as-usual scenario (Oguntoke et al., 2019). Within this context, it is worthwhile to offer more insight on the relationship between the quality of the environment and the health outcomes in

CO2 and health outcomes proxied by life expectancy. However, the rest of the paper is structured as follows: section two dwells on theoretical framework and review of empirical studies, and section three explains the methodology. While section

four presents the results, the last section concludes the study and offers policy recommendations.

2.0 Literature Review

2.1 Theoretical Framework

This study centres on Socio-Ecological Model (SEM) developed by Urie Bronfenbrenner which explains different levels of interaction between human beings and the environment in which they live as well as how this interaction influences human behaviour and health outcomes. The model stresses that in public health, a bidirectional influence exists between individual behaviour and socio-physical environment through five levels - individual, interpersonal, organizational, community, and structures and systems as demonstrated in Figure 2.1 below.

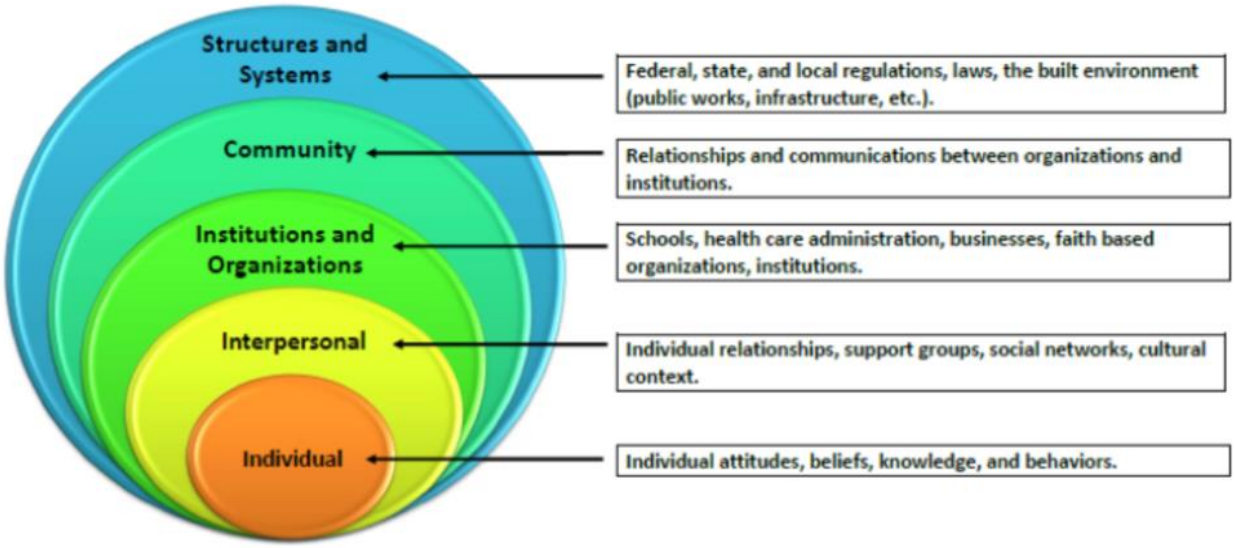

Figure 2.1: Five Levels of Socio-Ecological Model
Source: Centre for Disease Control and Prevention (cdc.gov).

Environmental quality is a composite and multi-dimensional concept that is measured in terms of either the level of air pollution, water pollution, soil contamination, or exposure to toxic substances in the society which has a direct effect on population health outcomes via complex and often inter-related pathways (Prüss-Ustun, et al., 2019). According to the WHO (2021), about 24% of the World's disease burden is caused by environmental factors, with low and middle-income countries, where environmental regulations are often not strong enough and enforcement mechanisms are weak, taking the highest share.

2.2. Empirical Literature

A study conducted by Beyene and Kotosz (2021) on African countries from 2000 to 2016 to investigate the impact of environmental quality on life expectancy revealed that in the long-run, life

expectancy significantly increases with the improvement in environmental quality based on panel ARDL and Dynamic Fixed Effect modeling techniques.

Within the context of Nigeria, Nwankwo and Ogagarue (2020) posited that exposure to environmental toxic substances has been the major cause for acute and chronic health challenges at varying levels. Empirically, studies on the connection between environmental quality and population health have also received much attention in the field of health economics and epidemiological research. For instance, Adebayo, Kirikkaleli, and Adeshola (2021) investigated the correlation between environmental degradation and health outcomes in Nigeria from 2000 to 2018. Using fixed-effects panel regression models, the study revealed that carbon dioxide emissions, particulate matter pollution, and water pollution as proxies for environmental degradation have significant negative effect on life expectancy and infant mortality rates as health outcomes variables across Nigerian states.

In another cross-sectional study, Ogundipe, Akintola and Ogunlana (2021) examined how industrial pollution affects respiratory health outcomes in communities situated close to industrial zones in Lagos State, Nigeria. The study sampled 2,400 people from eight communities to compare the respiratory health status between exposed communities defined to be located within 5 kilometres away from industrial zones and unexposed communities that are at least 15 kilometres away from the industries. The results of air quality assessments indicated that particulate matter (PM2.5), sulphur dioxide, and nitrogen dioxide were extremely higher in exposed communities. In specific term, the average PM2.5 values in exposed and non-exposed communities were 85 μg/m³ and 35 μg/m³ respectively. It is worth noting that both values surpassed the minimum acceptable level outlined by WHO. Also, prevalence of respiratory symptoms and illnesses were reported to be higher in exposed communities, with prevalence of asthma and chronic cough being 2.3 times and 1.8 higher than unexposed communities.

Similarly, Babajide et al. (2020) investigated the correlations between environmental quality indices and mortality rates in Nigerian. The study used aggregated data of air quality, water quality, and waste management indicators across 12 major cities as well as mortality data from 2015 to 2019. The results revealed a significant difference in environmental quality among the studied cities, with Lagos, Kano, and Port Harcourt recording the lowest scores. In addition, a significant inverse relationship is found to exist between environmental quality and mortality rate, indicating that cities with

high score of environmental quality have lower mortality rate and vice versa. Specifically, when quality of the environment declines by a unit, overall mortality rate, and in particular, respiratory death rate rises by 12% and 18% respectively.

Similarly, in a study conducted on 31 Chinese cities, Li, Chiu and Lin (2019) posited that carbon emissions significantly worsened not only the air pollution and population health but also imperiled environmental governance. To them, carbon emissions rise with increase in the volume of production which consequently deteriorates health conditions and living standard of the population including rise in cardiovascular and respiratory disorders. Furthermore, Matthew et al. (2019) investigated the impact of emissions from construction and manufacturing industries on population health in Nigeria. Based on the autoregressive distribution lag (ARDL) approach to co-integration analysis, the study revealed that carbon emissions significantly affect the health conditions of Nigeria's population.

Based on the above review, it is obvious that many studies employed cross-sectional research designs to investigate the correlations between health outcomes and environmental quality (Ogundipe et al., 2021; Babajide et al., 2020) but fail to establish causality or evaluate the cumulative impacts of prolonged environmental exposures. Only few studies were reported to take this challenge (Osabohien et al., 2019). However, the fact that interaction between human beings and their environment is an inevitable phenomenon, the need to be investigating, at regular interval, how variations in environmental quality influence the trends in health outcomes over prolonged periods cannot be over stressed.

3.0 Data and Methods

This study employs time series data spanning from 1980 to 2021, obtained from the World Bank's World Development Indicators (2024). Life expectancy (LEXP) is used as a proxy for health outcomes following the works of Modibbo, Muktar and Inuwa (2015), Arthur and Oaikhenan (2020), Modibbo and Idris (2020); while CO2 emissions per capita (CO2P) is used to proxy environmental quality.

To empirically account for the impact of environmental quality on health outcomes over long period of time, the study sought for autoregressive distributed lag (ARDL) approach to Cointegration developed by Pesaran et al. (2001). The use of this approach is to acknowledge the cumulative and dynamic effects among the variables over time, which cross-sectional studies fail to. In addition, ARDL approach is relatively simple and applicable regardless of whether the variables are integrated of

order one [I(1)]; order zero [I(0)]; or a mixture of both (Pesaran et al., 2001). In its level form, the functional model of this study is presented as follows:

$$LEXP_t = f(CO2P_t, FDI_t, LBRF_t) \quad (3.1)$$

However, equation 3.1 is replicated in an ARDL model as shown below:

$$\begin{aligned}\Delta LEXP_t &= \varphi_0 + \varphi_1 LEXP_{t-1} + \varphi_2 CO2P_{t-1} \\ &+ \varphi_3 FDI_{t-1} + \varphi_4 LBRF_{t-1} \\ &+ \sum_{t=1}^{m} \varphi_5 \Delta\, LEXP_{t-1} + \sum_{t=1}^{n} \varphi_6 \Delta\, CO2P_{t-1} \\ &+ \sum_{t=1}^{p} \varphi_7 \Delta\, FDI_{t-1} + \sum_{t=1}^{q} \varphi_8 \Delta\, LBRF_{t-1} \\ &+ \varepsilon_{t1} \qquad (3.2)\end{aligned}$$

$$\begin{aligned}\Delta CO2P_t &= \theta_0 + \theta_1 CO2P_{t-1} + \theta_2 LEXP_{t-1} \\ &+ \theta_3 FDI_{t-1} + \theta_4 LBRF_{t-1} \\ &+ \sum_{t=1}^{m} \theta_5 \Delta\, CO2P_{t-1} + \sum_{t=1}^{n} \theta_6 \Delta\, LEXP_{t-1} \\ &+ \sum_{t=1}^{p} \theta_7 \Delta\, FDI_{t-1} + \sum_{t=1}^{q} \theta_8 \Delta\, LBRF_{t-1} \\ &+ \varepsilon_{t1} \qquad (3.3)\end{aligned}$$

Where Δ stands for the difference notation, while $LEXP_t$ and $CO2P_t$ stand for life expectancy and carbon emissions per capita respectively. FDI_t and $LBRF_t$ represent foreign direct investment and labour force respectively and they were employed as control variables. The null hypothesis for equation 3.2 is given as $H_0 = \phi_1 = \phi_2 = 0$, while that of equation 3.3 is $H_0 = \theta_1 = \theta_2 = 0$. To investigate the existence of long-run relationship among the variables, the significance of the lagged level variables is determined based on the F-statistics for the cointegration denoted as $F_{LEXP}(LEXP / CO2P_t, FDI_t, LBRF_t)$ for equation 3.2, and $F_{CO2P}(CO2P_t / LEXP_t, FDI_t, LBRF_t)$ for equation 3.3. However, FDI and LBRF have been included in the estimation as control variables. Finally, in order to avoid having spurious results, unit root test is conducted to examine the stationarity properties of the variables using Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) test procedures.

4.0 Presentation of Results and Discussion of Findings

Descriptive analysis of the data

Before conducting the above estimations, the behaviour of the data is examined using descriptive statistical techniques, and the result is presented in Table 4.1.

Table 4.1: Results of Descriptive Statistics

Time Period: 1980 – 2021					
Variables	Observation	Mean	Std. Deviation	Maximum	Minimum
LEXP	42	48.54836	2.803809	53.45500	45.48300
CO2P	42	0.741365	0.140425	1.214217	0.501456
FDI	42	1.211571	1.001323	4.282088	-1.150856
LBRF	42	52.54839	0.793303	54.61496	51.27999

Source: Author's computation using Eviews, version 13.

The descriptive analysis of the data shows that the average life expectancy in Nigeria over the period of this study stood about 49 years, assuming the health conditions at the time of given birth to a child remain unchanged, with a standard deviation of about 3 years. However, the maximum number of years, a person is expected to live in Nigeria is reported to be around 53 years while the minimum stood at 45 years. This, compared to other developing countries in the world, remain at lower level justifying how the prevalence of poor health conditions undermines standard living conditions among Nigeria's population. Carbon emission per capita has a mean of 0.74 with a standard deviation of 0.14, while the maximum and minimum stood at 1.21 and 0.50 respectively

Estimation of Unit Root Test

Unit root test is conducted to examine the stationarity properties of the variables using Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) test procedures. This result is presented in Table 4.2.

Table 4.2: Results of unit root test

	Augmented Dickey-Fuller		Phillips-Perron	
Variables	Level	First Difference	Level	First Difference
LEXP	-3.558589 **	-	-1.681440	-2.982354
CO2P	-5.120729 ***	-	-5.051759 ***	-
FDI	-4.108974 ***	-	-4.085529 **	-
LBRF	-0.128820	-3.622094 **	-1.836433	-1.283037

*Note: ***, and ** indicate level of significance at 1% and 5% respectively.*

Source: Author's computation using Eviews, version 13.

Based on the results above, a mixture of I(1) and I(0) stationery processes is observed among the variables either at level or first difference using ADF test procedure. Specifically, life expectancy, carbon emission and foreign direct investment are found to be stationery at level, while labour force at first difference. However, while CO2P and FDI are stationery at level using PP test approach, LEXP and LBRF were neither stationery at level nor at first difference.

Bound Test for Cointegration

Having established the stationarity process of the variables, a test for the existence of long-run relationship is conducted using the

ARDL bounds test procedure for cointegration test, and the results are shown in Table 4.3.

Table 4.3: Results of Bounds Test

F-Statistics	Critical values (at 5%)	Lower bound	Upper bound
F_{LEXP} (LEXP/CO2P,FDI,LBRF)	6.7383	4.568	5.795
F_{CO2P} (CO2P/LEXP,FDI,LBRF)	7.0345		
F_{FDI} (FDI/LEXP,CO2P,LBRF)	13.3358		
F_{LBRF} (LBRF/LEXP,CO2P,FDI)	**6.1892**		

Source: Author's computation using Eviews, version 13.

Interestingly, cointegration is found to exists among all the variables as shown by the F-statistics critical values which are higher than the upper bound critical value of 5.795 at 5 percent level of significance. This indicates the existence of long-run relationship between life expectancy and environmental quality in Nigeria. This also warrants the estimation of both long-run and short-run impact of carbon emission on life expectancy, and the results are presented in Table 4.4.

Table 4.4: Results of long-run and short-run impact

Dependent variable: LEXP		
Result of long-run impact		
Independent variables	Coefficient	Standard error
CO2P	-0.7030	0.3989 *
FDI	-0.0482	0.0258 **
LBRF	1.0342	0.3349
Result of short-run impact		
CO2P	-0.6872	0.0144 **
FDI	0.0618	0.0006 ***
LBRF	-1.82167	0.0983 *
ECT(-1)	-0.1306	0.0000 ***

*Note: ***, and **, * indicate level of significance at 1%, 5% and 10% respectively.*

Source: Author's computation using Eviews, version 13.

In both short and long-run, the results revealed that carbon emission has negative and statistically significant effect on life expectancy in Nigeria, where a 1-unit increase in carbon emission shortens life expectancy by about 0.7 years in the long-run and 0.69 years in the short-run. This result aligns with the findings of Adebayo et al. (2021) who found that carbon dioxide emissions, particulate matter pollution, and water pollution as proxies for environmental degradation have significant negative effect on life expectancy and infant mortality rates as health outcomes variables across Nigerian states. It further buttressed the findings of Meyene and Kotosz (2021) that improvement in the quality of environment significantly

enhances the life expectancy in African countries. This, however, is not unexpected given the high level of unregulated industrial activities taking place in the country and the rampant use of environmentally-unfriendly equipment in the production processes. In the short-run, however, the result showed that FDI has positive and statistically significant impact on life expectancy. This conforms to the a priori expectation because in the early stage of capital inflow, it is expected that more employment opportunities as well as goods and services will be provided thereby improving the short-term living conditions of the population. In the long-run, however, FDI has negative and significant effect on life expectancy in Nigeria. This can be connected with the use of heavy equipment that emit high level of carbon dioxide by foreign companies operating in the country. For instance, oil producing companies, cement manufacturing industries, use of solid fuels such as wood and charcoal, as well as trucks and machineries used in the country's transportation systems remain the major sources of air pollution and environmental degradation which are harmful to the long-term living condition of the population. However, labour force is found to have positive but insignificant effect on life expectancy in the long-run.

5.0 Conclusion and Policy Recommendations

This study examined the impact of environmental quality proxied by carbon emission on health outcomes represented by life expectancy in Nigeria using time series data from 1980 to 2021. ARDL bound test cointegration technique was employed to investigate both the short and long-run impact, and based on the overall results, the study concludes that health outcomes are significantly and negatively affected by poor environmental quality in Nigeria. Thus, in line with the major findings, the need for Nigeria to mitigate the effects of carbon emission in order to improve the health conditions of its population cannot be over emphasized. To achieve this, the study recommends for transition from traditional energy sources of cooking fuels, notably solid fuels such as wood and charcoal which are among the major sources of respiratory illnesses to a cleaner source like LPG, ethanol, and improved cook stoves which minimizes indoor carbon emissions. This can be achieved by incorporating clean energy access in the social protection programmes and partnership with the leadership of local communities for the distribution of clean energy equipment at subsidized rate as well as massive awareness campaigns about the health effects associated with the traditional cooking energy sources. Also, establishing air quality sensors in major cities and industrial zones in order to enhance air

quality monitoring. This can be achieved by developing Air Quality Index (AIQ) information system using media channels such as radio and mobile applications. Also, companies must be mandated to report and disclose the level of their industrial carbon emissions. This allows government and vulnerable groups to take protective measures and also hold such companies accountable.

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