# Does Greenhouse Gas Emission Have Any Relevance to Per Capita Health Expenditure? Empirical Evidence from Nigeria

***Amaka G. METU, Chris KALU, Uju EZENEKWE, Olisaemeka D. MADUKA**

Department of Economics, Faculty of Social Sciences,

Nnamdi Azikiwe University, Awka, Nigeria

*Corresponding email: ag.metu@unizik.edu.ng

**Abstract**

The quest to achieve sustainable development in the world has led to higher energy consumption which invariably leads to increasing environmental pollution through greenhouse gas emissions. Environmental pollution poses dangers to human health and the need to protect human health increases pressure on health care expenditure. Human capital development is necessary for any economy to achieve sustainable development. This study is an attempt to examine if greenhouse gas emissions have any impact on per capita health expenditure in Nigeria, using data from 1990 to 2015. The study is anchored on the Environmental Kuznets' Curve Hypothesis that postulates an inverted u-shaped relationship between the environment and income. The bounds test technique was used to estimate the long-run relationship between the dependent and the explanatory variables while the error correction method within the ARDL model was used to estimate the speed of adjustment. The paper found that greenhouse gas emissions have negative but statistically significant influence on health expenditure in Nigeria. Gross domestic product, population density and mortality rate were all statistically significant suggesting that these variables were important in influencing health expenditure in Nigeria in the long run. The paper therefore recommends that companies that emit gases should be taxed for these emissions and the revenue directed towards environmental management.

**Keywords:** ARDL, Environment, Greenhouse gases, Health expenditure, Pollution

**JEL classification:** H51, C32, Q56

## Introduction

The issue of sustainable development has led to wider discussions on the environment as well as energy consumption. In developing countries, increase in energy consumption is often associated with pollution from different gas emissions (Nwokoye & Metu, 2014). Pollution is known to affect human health and eventually reduce the effectiveness and well-being of people in their efforts to participate in economic activities(Graff Zivin & Neidell, 2012 as cited in Nwokoye & Metu, 2014). The damage to human health resulting from pollution in turn increases demand for healthcare services.

Environmental pollution is one of the things that affect the health of people apart from diet, sanitation, and in some cases, lifestyle. Yazdi, Tahmasebi and Mastorakis (2014) opined that the main source of environmental damage is air pollution. Air pollution is caused by consumption of fossil fuels and carbon dioxide and sulphur dioxide emissions; all combined are known as greenhouse gas emissions. Greenhouse gases are gases in the atmosphere that absorb radiation and hold heat in the atmosphere leading to global warming, climate change and deterioration of the environment. Carbon dioxide emissions and sulphur dioxide emissions from use of energy and industrialisation contribute to air pollution, and are major contributors to global climate change; they are recognised as causing serious health problems (Balan, 2016). Hoelller, Dean and Nicolaisen (1991) warned that the cost of limiting greenhouse gas emissions is likely to be much higher in developing countries such as Nigeria and other sub-Saharan African countries due to the faster underlying growth rate of the emissions.

Deterioration of air quality contributes to different types of illnesses which invariably affect individuals as well as government health care expenditure. The pattern of the health care budget should affect human health status. If government allocates a reasonable percentage of its budget to health care, it is expected that health outcome will improve and vice versa. The demand for health care in developing countries is increasing at an alarming rate while health care expenditure is not. For instance, the United Nations Environmental Programme (2016) stipulates that the financial implication of outdoor pollution in developing countries is about 5% of the gross domestic product. This is also applicable to Nigeria.

Sources of greenhouse gas emissions in developing countries are not different from those of developed countries; the only difference is the extent of management activities. The developed countries have strict environmental laws and acts with which they regulate environmental activities. The weak environmental regulations in developing countries, including Nigeria, attract polluting industries that discharge contaminated chemicals and gases which deteriorate the quality of the environment (Nwokoye & Metu, 2014). Poor environmental quality is responsible for so many heart-related illnesses. The need to meet the demand for health care services increases the share of government spending on health. The quality of health care delivery affects health outcome which is capable of influencing the achievement of the long-term goal of economic development. As health care is one of the most important determinants of human capital development, there is the need for provision of qualitative healthcare delivery.

Literature on health care expenditure due to environmental degradation, proxied by $CO_2$ emissions, abound (for instance, Narayan and Narayan, 2008; Assadzadeh, Bastan and Shahverdi, 2014; Abdullah, Azam and Zakariya, 2016) but studies examining the impact of greenhouse gas emissions, life expectancy and health expenditure are relatively rare and recent. Therefore, the aim of this study is to examine the extent of the influence of greenhouse gas emissions on per capita health expenditure in Nigeria using annual data from 1990 to 2015. This period captures the period of industrial revolution in Nigeria because the quest for economic growth through industrialisation led to increase in air pollution from greenhouse gas emissions.

The present study also examined the link between health expenditure and other determinant factors such as population density, mortality rate and gross domestic product, within the specified period. This is necessary because as population density and mortality rate increase, they are bound to affect health expenditure by increasing pressure on health care services. It is expected that the findings of this study will provide valuable policy inputs for environmental managers in designing appropriate specific policies for environmental management and control. This study is presented in five sections. Following the introductory section is a section which reviews the theoretical and empirical literature. The next section outlines the method used for the study. The empirical analysis follows while the concluding remarks and recommendations end the paper.

**Review of Related Literature**

Greenhouse gases are gaseous compounds in the atmosphere that absorb infrared radiation and hold heat in the atmosphere; in other words, they are gases that trap heat in the atmosphere and consist of carbon dioxide ($CO_2$), water vapour ($H_2O$), nitrogen dioxide ($NO_2$), methane ($CH_4$) and other fluorinated gases (United States Environmental Protection Agency (USEPA) (n.d). These trappings of heat lead to global warming and climate change but this depends on how long the trappings stay in the atmosphere and the abundance of the gases in the atmosphere.

Health is a dynamic state of physical, social, spiritual and mental well-being of the population that translates to quality of life (Center for Disease Control and Prevention (CDCP, 2013). It does not necessarily mean the absence of disease. Health expenditure is the ratio of total health expenditure to gross domestic product. It covers services by both public and private providers.

The present study is rooted in the Environmental Kuznets' Curve Hypothesis that postulates an inverted U-shaped relationship between environmental quality and economic development (Nemat, 1994). The Kuznets' curve hypothesis was postulated by Simon Kuznets in the 1950s and 1960s. It is based on the hypothesis that as an economy develops economic inequality decreases as a result of increase in market forces. The Kuznets curve was later extended to the environmental curve hypothesis. The Environmental Kuznets' curve has been used to explain the relationship between economic activities and the use of natural resources which leads to the emissions of pollutants such as sulphur oxide, nitrogen oxide, lead, greenhouse gases, sewage and chemicals previously released into the air or water. When a country's gross domestic product (GDP) is low, economic activities initially lead to deterioration in the environment, but over time as the level of economic activity begins to grow, the economy begins to improve its relationship with the environment thereby reducing the level of degeneration. The emissions affect heath status leading to increase in demand for health care and health care expenditure. This results in an inverted u-shaped relationship between income and emissions; people are also willing to pay more to have better environmental standards. Also with proper law and environmental regulation, the level of air emissions harmful to human health will decline.

Many scholars have carried out different researches on the determinants of health expenditure in different countries, but for the purpose of clarity, this study reviewed works on greenhouse gas emissions and health expenditure. Gerdtham et al. (1992) examined the relationship between per head expenditure in 19 Organisation for Economic Cooperation and Development (OECD) countries using cross sectional data. The variables used for the study include income per head, amount of doctors, women labour force and part of the population that are above 65 years. Their findings showed that income and the population above 65 years have a direct substantial effect on per head health spending while the amount of doctors available has an indirect significant effect on health expenditure in the studied countries. This study was carried out in developed countries where human welfare is of utmost importance, whereas the present study is on a developing economy, where economic development is still a problem.

Achike, Onoja and Agu (n.d.), examined the determinants of carbon dioxide ($CO_2$) emissions in Nigeria from 1970 to 2009. The data were analysed using Zellner's Seemingly Unrelated Regression (SURE) model. The result of their study indicated that fossil energy consumption, agricultural land area expansion, rents from forestry trade and farm technology were significant determinants of green house gas (GHG) emissions in Nigeria within the study period. They recommended that the government should put in place policies that will tax companies that are emitting GHGs and utilize such tax proceeds for research and building the capacity of farmers.

Jerret et al. (2003) employed cross-sectional data collected from 49 counties to examine the relationship between health expenditure and $CO_2$ emissions in Ontario, Canada. The study showed that countries with more pollutant emissions have higher per head health expenditure while those with enough environmental protection spend less on health. In as much as their study used air pollutants to proxy environmental quality, they could not capture all air pollutants and so the need to use total greenhouse gas emissions which is more robust in capturing air pollutants.

Odusanya et al. (2014) examined the effects of environmental quality proxied by $CO_2$ emissions on health care expenditure in the long and short run periods. The study employed autoregressive distributed lag (ARDL) bound test technique to analyse the data. Their findings showed that $CO_2$ emissions and expenditure on health are negatively related in Nigeria; that is, as $CO_2$ emissions increased, expenditure on health reduced. Just like other similar studies, the use of carbon dioxide emissions to capture greenhouse gas emissions is not enough to capture emissions that degenerate the environment, especially in Nigeria where air pollution is on the increase.

From the study by Yazdi, Tahmasebi and Mastorakis (2014), which studied the role of environmental quality on health expenditure in Iran; some greenhouse gases such as sulphur dioxide, carbon dioxide and particular matter were used to capture environmental quality. The study was conducted using time series data from 1976 to 2010. The data were analysed using co-integration and auto-regressive distributed lag in order to estimate both the short run and long run impact of environmental quality on health expenditure. The study found that expenditure on health, sulphur dioxide, carbon oxide was co-integrated; and also suspended particular matter emissions had a statistically significant positive effect on health spending during the period under study. Their study used more robust variables to capture environmental quality but their study was carried out in Iran with a different socio-economic environment from Nigeria. Their results may not be applicable in Nigeria taking into consideration the differences between both countries.

Abdullah, Azam and Zakariya (2016) examined the impact of greenhouse gas emissions on public health expenditure in Malaysia. Time series data on health expenditure, gross domestic product, nitrogen dioxide, carbon dioxide, sulphur dioxide, mortality rate and fertility rate were analysed using auto-regressive distributed lag. The findings of the study reveal that the explanatory variables have a long-run relationship with health expenditure, which is the dependent variable. Also infant mortality, sulphur dioxide and fertility rate had the most statistically significant effect on health expenditure in Malaysia.

From the result of the study by Yahaya et al. (2016), carbon dioxide had the highest explanatory power on per capita health expenditure which is greater in the long run than in the short run. The study was conducted using 125 developing countries and the data were analysed using panel co-integration framework from 1995 to 2012. According to their findings per capita health expenditure and carbon monoxide emissions, sulphur nitrous and carbon dioxide emissions were co-integrated. The study concludes that environmental quality is relevant in determining health expenditure in developing countries. Nigeria is one of the countries studied by Yahaya et al., but the use of pooled data makes it possible to study different countries at the same time without consideration to the differences in their environments.

Mutizwa and Makochekanwa (2015) estimated the impact of environmental quality on health status in 12 Southern African Development Community (SADC) countries between 2000 and 2008. The environmental proxies are improved sanitary facilities, access to improved water resources and carbon emission, while health status was measured by infant mortality rate. From the result, about 38% of infant mortality rate was accounted for by environmental quality factors. The study concluded that carbon emission does not have an impact on health status in SADC countries while access to improved water sources and improved sanitary facilities have greater impact on infant mortality rate. The study therefore recommended that environmental regulations should be strengthened so as to improve sanitary facilities as well as access to quality water sources.

Yazdi and Khanalizadeh (2017) in their study in the Middle East and North African region (MENA) countries found that health expenditure and carbon dioxide, income, particulate matters ($PM_{10}$) emissions are co-integrated. The long run elasticity showed that $PM_{10}$ emissions, income and $CO_2$ have statistically significant positive effects on health expenditure. The study concluded that health expenditure is not sensitive to income.

Most of the previous studies were conducted outside Nigeria and they used carbon dioxide ($CO_2$) to proxy greenhouse gas emissions; there are still divergences in their results. The present study however used total greenhouse gas emissions, which is a more encompassing air pollutant. Yahaya et al. (2016) used different gas emissions to capture greenhouse gas emissions; but the study used panel data from 125 developing countries from 1995 to 2012. They collected data from Emission Data Base for Global Atmospheric Research (EDGER) and data from EDGER were not available beyond 2008 by the time the study was conducted, hence some of the data used were extrapolated. Moreover, studying different countries together may have some limitations because of socio-demographic differences. Therefore the present study contributes to knowledge by estimating the impact of greenhouse gas emissions on per capita health expenditure in Nigeria from 1990 to 2015. The study also looked at the link between health expenditure and some socio-economic determinants of health expenditure in Nigeria as control variables to make the study more robust.

**Methodology**

The study adopted the Yahaya et al. (2016) model which included some greenhouse gases (nitrogen dioxide, carbon dioxide, carbon monoxide and sulphur dioxide). The present study modified the model by including other factors that influence health expenditure such as gross domestic product, mortality rate, and population density. Therefore, our model is specified thus:

$$lnHEPC = \beta_0 + \beta_1 lnRGDP + \beta_2 lnTGHG + \beta_3 lnPOD + \beta_4 lnMR + U \quad (1)$$

where:

*HEPC* = health expenditure per capita in real terms (US$PPP)

*RGDP* = real gross domestic product per capita

*TGHG* = total greenhouse gas emission

*POD* = population density

*MR* = infant mortality rate

*U* = error term

$B_1$ to $B_4$ are the slope coefficients.

*Ln* shows that the variables are logged in order to interpret the results as elasticities.

The apriori expectation is that the slope coefficients $\beta_1, \beta_2, \beta_3, \beta_4, > 0$. According to theory, it is expected that as infant mortality increases, there should be an increase in per capita health expenditure. Similarly, population density, real gross domestic product and greenhouse gas emissions are expected to have positive relationships with health expenditure. As more emissions are released in the atmosphere, health status deteriorates leading to increase in demand for health care expenditure by the people.

Data were collected from World Development Indicators and Central Bank of Nigeria (CBN) *Statistical Bulletin* (various issues). The paper employed the Bounds Test for Co-integration and the Auto-regressive Distributed Lag (ARDL) model for estimating the long-run and short-run relationships among the variables of interest. This method avoids the classification of variables as *I(1)* and *I(0)* by developing critical values which identified the variables as stationary or non-stationary. The ARDL technique can distinguish between dependent and explanatory variables making it possible to avoid the problems that may arise in the presence of serial correlation and endogeneity. Note also that the ARDL procedure allows for uneven lag orders, while the Johansen's VECM does not. However, Pesaran, Shin and Smith (2001) argued that appropriate modification of the orders of the ARDL model is sufficient to simultaneously correct for residual serial correlation and the problem of endogenous variables. In summary, it can be seen that the ARDL bounds test can be used with a mixture of *I(0)* and *I(1)* data. It involves just a single-equation set-up, making it simple to implement and interpret; and different variables can be assigned different lag-lengths as they enter the model. The ARDL bounds testing procedure consists of estimating an unrestricted error correction model with the following generic form:

$$\Delta \ln HEPC_t = a + \Sigma\beta_i \Delta \ln HEPC_{t-i} + \Sigma\delta_j \Delta \ln RGDP_{t-j} + \Sigma\lambda_k \Delta \ln TGHG_{t-k} + \Sigma\varphi_l \Delta \ln POD_{t-1} + \Sigma\gamma_m \Delta \ln MR_{t-m} + \eta_1 \ln HEPC_{t-1} + \eta_2 \ln RGDP_{t-1} + \eta_3 \ln TGHG_{t-1} + \eta_4 \ln POD_{t-1} + \eta_5 \ln MR_{t-1} + \mu_t \quad (2)$$

The above equation shows the unrestricted ECM version of ARDL specification. The bounds test is mainly based on the joint *F*-statistic whose asymptotic distribution is non-standard under the null hypothesis of no co-integration. The first step in the ARDL bounds test approach is to estimate equation (2) by OLS, which tests for the existence of a long-run relationship among the variables by conducting an *F*-test for the joint significance of the coefficient of the lagged level of the variables. Thus, the null and alternative hypotheses are stated as follows:

$H_0: \eta_1 = \eta_2 = \eta_3 = \eta_4 = \eta_5 = \eta_6 = 0$, (no long-run relationship)

$H_1 : \eta_1 \neq \eta_2 \neq \eta_3 \neq \eta_4 \neq \eta_5 \neq \eta_6 \neq 0$, (long-run relationship exists)

Then we estimate the bounds test bearing in mind that two sets of critical values are reported in Pesaran et al. (2001). One set is calculated assuming that all variables included in the ARDL model are *I*(0) and the other is estimated considering that the variables are *I*(1). The null hypothesis of no co-integration is rejected when the *F*-statistic exceeds the upper critical bounds value, this means that there exits a long-run relationship between government expenditure on health and the explanatory variables. However, we do not reject the null hypothesis if the *F*-statistic is lower than the lower bounds, meaning that government expenditure on health and the explanatory variables are not co-integrated. But if the calculated *F*-statistic lies between critical values, the result becomes inconclusive at that level of significance.

With a long-run relationship confirmed from the ARDL bounds test, the short-run dynamic coefficient was estimated using the following error correction model:

$$\Delta lnHEPC_t = a + \Sigma\beta_i \Delta lnHEPC_{t-i} + \Sigma\delta_j \Delta lnRGDP_{t-j} + \Sigma\lambda_k \Delta lnTGHG_{t-k} + \Sigma\varphi_l \Delta lnPOD_{t-l} + \Sigma\gamma_m \Delta lnMR_{t-m} + \Psi ECM\ (-1) + \mu t \quad (3)$$

where: $ECM_{t-1}$ is the error correction term resulting from the verified long-run equilibrium relationship and Ψ is a parameter indicating the speed of adjustment to the equilibrium level. The sign of the $ECM_{t-1}$ must be negative and significant to ensure convergence of short run dynamics to long-run equilibrium.

## Results and Empirical Analysis

### Descriptive statistics

The empirical analysis started with the examination of the characteristics of the variables that were to be estimated and the result is presented in Table 1. The standard deviation shows that the most volatile variable in the series was gross domestic product (263063.9) while infant mortality (20.18520) was the least volatile variable. The skewness statistic shows that health expenditure per capita, infant mortality and total greenhouse gas emissions were negatively skewed while gross domestic product and population density were positively skewed. For the kurtosis statistic, the distribution of the series is platykurtic relative to normal. The major concern here is to examine the normality of the distribution of the data-set. Using the Jarque-Bera probability value, the null hypothesis of normal distribution for the variables was accepted at 5% critical value.

**Table 1: Descriptive Statistics**

| | HEPC | GDP | IMR | PODE | TGHGE |
|---|---|---|---|---|---|
| Mean | 159.6793 | 526483.4 | 99.92949 | 150.8360 | 274000.3 |
| Std. Dev. | 97.31136 | 263063.9 | 20.18520 | 29.78955 | 64942.85 |
| Skewness | -0.202368 | 0.658152 | -0.163410 | 0.269281 | -0.553617 |
| Kurtosis | 2.052007 | 2.085854 | 1.596798 | 1.871942 | 1.838338 |
| Jarque-Bera | 1.151044 | 2.782347 | 2.248768 | 1.692777 | 2.790046 |
| Probability | 0.562411 | 0.248783 | 0.324852 | 0.428961 | 0.247827 |
| Observations | 26 | 26 | 26 | 26 | 26 |

*Source:* Authors' Computation using E-views 9.

## Unit Root Test Analysis

Augmented Dickey-Fuller (ADF) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) unit root test was used to ascertain the time series properties of the variables. Unit root test is important in the estimation of time series data because incorporating unit root variables when using the OLS technique gives misleading results. The structural break test was estimated using Zivot Andrew breakpoint unit test and the result is presented in Table 2.

**Table 2: Zivot Andrew Breakpoint Unit Root Result**

| Variable | ZA Statistic | Break Date | Remark |
|---|---|---|---|
| *lnHEPC* | -6.174650** | 2003 | Reject H0 |
| *lnRGDP* | -2.685669 | 1997 | Accept H0 |
| *lnTGHG* | -7.314969** | 1998 | Reject H0 |
| *lnMR* | -7.452719** | 2003 | Reject H0 |
| *lnPOD* | -14.67398** | 2006 | Reject H0 |

*Note:* *(**) implies significant at 1% (5%) level of significance.

*Source:* Authors' Computation using E views 9.

Table 2 shows that the null hypothesis of unit root with structural break is rejected for all the variables except for *RGDP*. This implies that the other variables such as *HEPC*, *TGHG*, *MR* and *POD* had structural break dates but no structural break problems. Having confirmed that only *RGPD* has a structural break problem, the breakpoint unit root is applied in testing for its unit root while ADF was used to determine the order of integration for other variables and the results are presented in Table 3.

**Table 3: Results of ADF and KPSS Unit Root Test**

| Variable | ADF Statistic | I(d) | KPSS Statistic | *I(d)* |
|---|---|---|---|---|
| *lnHEPC* | -5.778038** | *I(1)* | 0.077813** | *I(1)* |
| *lnRGDP* | -4.565570** | *I(1)* | 0.381699* | *I(1)* |
| *lnTGHG* | -6.093761** | *I(1)* | 0.133505* | *I(0)* |
| *lnMR* | -4.359588** | *I(0)* | 0.370055* | *I(I)* |
| *lnPOD* | -6.093761** | *I(1)* | 0.139919* | *I(1)* |

*Note:* ** (*) implies significant at 1% (5%) levels, for ADF result.

While ** (*) denotes acceptance of stationarity at 10% (5%) levels, for KPSS result

*Source:* Authors' Computation using E views 9.

Table 3 presents the results of the unit root test. The result of the ADF test shows that the logs of per capita health expenditure, real gross domestic product, total greenhouse gas emission and population density are non-stationary at level *I(I),* while log of mortality rate is stationary at level *I(0).* The KPSS result shows that the null hypothesis of stationarity is accepted for the logs of all the variables at their first difference *I(1)* except the log of total greenhouse gas emission which is stationary at level *I(0).* However, the logs of non-stationary series were all stationary after first difference. The results justify the use of the ARDL bounds technique in determining the long-run relationships between the dependent variable and independent variables.

## The Bounds Test Analysis

**Table 4: Bounds Test Result (with Intercept and Trend)**

| F-statistic | 5% critical value | | 1% critical values | |
|---|---|---|---|---|
| | I(0) | I(1) | I(0) | I(0) |
| 17.90956** | 2.86 | 4.01 | 3.74 | 5.06 |

*Note:* The notation** indicates significant at 1% level.

*Source:* Authors' Computation using E views 9.

Table 4 shows the ARDL bounds testing for co-integration. Assuming an unrestricted intercept and trend, the null hypothesis states that there is no co-integration among the variables of interest. The value of the calculated *F*-statistic 17.90956 was greater than the upper bound critical value at 1% level of significance. We reject the null hypothesis of no co-integration using the bound testing approach. Therefore, we conclude that a long-run relationship exists between health expenditure, real gross domestic product, total greenhouse gas emission, mortality rate and population density.

**ARDL Model Analysis**

The long-run coefficient is estimated and presented using Table 5.

**Table 5: Estimated Long-Run Model**

| Determinants | *lnRGDP* | *lnTGHG* | *lnMR* | *lnPOD* | *C* |
|---|---|---|---|---|---|
| Coefficient | 4.0512* | -2.6945* | 156.323* | 169.379* | -1630.705* |
| t-statistic | (3.179) | (-5.965) | (16.332) | (22.392) | (-16.532) |
| Probability | 0.0098 | 0.0001 | 0.0000 | 0.0000 | 0.0000 |

Note: The notation* indicates significant at 1% level.

**Source:** Authors' Computation using E views 9.

From Table 5, the estimated long-run coefficient shows that the real gross domestic product (RGDP) has a coefficient of 4.0512, meaning that a 1% increase in income causes expenditure on health to increase by 4.05% in Nigeria in the long run. The result shows a positive statistically significant influence on health expenditure in Nigeria. This conforms to expectation because health expenditure is sensitive to income. The percentage of the budgetary allocation to health depends on the total gross domestic product. Total greenhouse gas emission proxy had a coefficient of -2.694 with a significant influence on health expenditure. That means a 1% increase in greenhouse gas emission reduces health expenditure by 2.69% in Nigeria. This does not conform to apriori expectation where increase in greenhouse emission is expected to increase expenditure on health in order to cushion the effects of gas emissions on human health. This result supports the study by Odunsanya et al. (2014) that found a negative relationship between environmental quality proxied by $CO_2$ emissions and health care spending in Nigeria. But the result is in contrast to the study by Abdullah et al. (2016) which found a positive relationship between emissions and health expenditure in Malaysia. The divergence in results may be as a result of the difference in the variables used to capture greenhouse gas emissions. Most previous studies used only carbon monoxide to proxy greenhouse gas emissions. Greenhouse gas emissions consist of emissions from carbon dioxide, methane, sulphur oxide, nitrous oxide and water vapour. The entire emissions combine to pollute the environment. The coefficient of mortality rate is 156.323 meaning that a 1% increase in mortality rate in Nigeria increases health expenditure by as much as 156.3%. Also, population density (POD) has a positive statistically significant effect on health expenditure with a coefficient of 169.379. This conforms to theory because as population density increases, demand for health services will increase leading to a large increase in health expenditure. In terms of magnitude, the log of population density exerts the highest influence on per capita health expenditure, more than mortality rate and gross domestic product.

**Error Correction Model**

The result of the ECM is presented in Table 6.

**Table 6: Error Correction Mechanism (Short-Run Relationship)**

| Variable | Coefficient | t-Statistic | (Probability) |
|---|---|---|---|
| *D*(*LHEPC*(-1)) | 0.805781 | 6.895 | (0.0000) |
| *D*(*LHEPC*(-2)) | 0.345592 | 3.927 | (0.0028) |
| *D*(*LRGDP*) | -6.011767 | -1.41598 | (0.1877) |
| *D*(*LRGDP*(-1)) | -8.252480 | -1.8469 | (0.0945) |
| *D*(*LMR*) | 394.107585 | 9.5395 | (0.0001) |
| *D*(*LTGHGE*) | -3.565092 | -3.788 | (0.0000) |
| *D*(*LPOD*) | -6.198.54 | -2.893 | (0.0036) |
| *D*(*LPOD*(-1)) | 11690.05 | 3.222 | (0.0160) |
| *CointEq*(-1) | -2.521 | -12.17 | (0.0000) |
| *Adjusted R-Squared* | 0.896 | *F-Stat.*= 29.79763 | (0.0000) |

*Source:* Authors' Computation using E views 9.

Table 6 presents the short-run relationship between health expenditure per capita and total greenhouse gas emissions. It provides the proportion of disequilibrium error that is accumulated in the previous period, which is corrected in the current period. The result confirms the existence of a long-run equilibrium relationship between health expenditure per capita and total greenhouse gas emissions as the coefficient of the error correction term has the expected negative sign and is statistically significant at 99% confidence level. The coefficient of error term is 2.52% indicating that health expenditure corrects its previous disequilibrium at a speed of 2.52% annually. The short-run coefficient of total greenhouse gas emissions is negative and statistically significant at 5%, meaning that a unit percent increase in total greenhouse gas emissions decreases per capital health expenditure in Nigeria by 3.67%.

The short-run coefficient of infant mortality is positive and statistically significant at 5% level. This shows that an increase in infant mortality by a unit percent influences heath expenditure in Nigeria. This conforms to expectation as an increase in infant mortality increases health expenditure. Improvement in health facilities to take care of maternal health will reduce the number of deaths in children below five years. The short-run coefficient of real gross domestic product is negative and statistically not significant at 5%. This is not in conformity with the expected behaviour that an increase in income should be one of the major contributors to health expenditure. This is not surprising because the single digit budgetary allocation to health in Nigeria is far less than the 13% recommended by the World Health Organisation (WHO) (2003).

Finally, population density significantly contributes to health expenditure in Nigeria in the short run. This conforms to the expected behaviour as an increase in population density increases health expenditure. Expansion of cities with a growing manufacturing sector (especially the informal sector) leads to influx of people into the cities thereby increasing environmental degradation as well as need for health care (Metu, Kalu & Ezenekwe, 2015). In summary, only real gross domestic product did not have a significant short-run effect on health expenditure in Nigeria within the examined period. The variation in the dependent variable exhibited by the adjusted R-Squared (0.896) is desirable and implies that the variation in health expenditure is explained by the explanatory variables. Examining the combined effect of the explanatory variables, the F-Statistic (29.798, p = 0.0000) shows significance in per capita health expenditure within the study period.

**Table 7: Residual Diagnostic Test for ARDL Model**

| S/N | Tests | F-Stat | Prob. |
|---|---|---|---|
| 1 | DW- Statistic | 2.42 | |
| 2 | Breusch-Godfrey Serial Correlation LM Test | 1.849 | 0.2187 |
| 3 | Heteroskedasticity Test: BPG | 0.208 | 0.9926 |
| 4 | Normality Test: Jarque Bera Statistic | 1.1426 | 0.565 |

*Source:* Authors' Computation using E views 9.

Diagnostic tests were conducted to examine the plausibility of the model and the result is presented in Table 7. The Durbin-Watson statistic of 2.42 leads to the acceptance of the null hypothesis of no auto-correlation. The values of the F-Statistic obtained from the Breusch-Godfrey Serial Correlation LM test also show that the model has no serial correlation and is justified by the Durbin-Watson statistic which is approximately 2. The values of the F-Statistic obtained from the heteroskedasticity test (Breusch-Pagan-Godfrey) are not statistically significant at 5% level implying the residual is homoskedastic. The value of the Jarque-Bera statistic is also not statistically significant at 5% level indicating that the error term is normally distributed. We can then conclude that the model is plausible and can be used for the prediction and forecasting of lifetime behaviour.

## Conclusion and Recommendations

This paper estimated the impact of greenhouse gas emissions on per capita health expenditure in Nigeria. The data used for the analysis were annual data from 1990 to 2015 collected from *World Development Indicators* and *Central Bank of Nigeria Statistical Bulletin*. The auto-regressive distributed lag (ARDL) model was used to estimate the influence of greenhouse gas emissions on per capita health expenditure while real gross domestic product (*RGDP*), infant mortality rate *(MR*) and population density (*POD*) were the control variables.

The result shows that there is a long run relationship between health expenditure and the explanatory variables. Greenhouse gas emissions have negative significant influence on health expenditure both in the short and long runs. Real gross domestic product has positive statistically significant influence on health expenditure in the long run but does not exact any influence on health expenditure in the short run. The error correction term

(ECM) was found to be statistically significant at 1% level of significance and also had the expected negative sign.

The results of this study have useful policy implications. For instance, population density and mortality rate all have positive relationships with health expenditure and are statistically significant. It shows that socio-economic factors influence health expenditure in Nigeria, therefore policies that will promote the socio-economic well-being of the citizens will also encourage investments in health care expenditure. Also greenhouse gas emission was expected to have a positive relationship with per capita health expenditure but the result shows a negative relationship. This indicates that allocation to health expenditure alone is not sufficient to handle environmental pollution caused by greenhouse gas emissions.

Based on the findings of this study, it is recommended that the Nigerian government should tax companies for environmental pollution and the acruing revenue be channelled towards protecting the environment. Environmental laws and policies on the control and management of air pollution should be stringently implemented because increase in environmental degradation through pollution will lead to health problems and high mortality rates. Population density was found to induce the highest influence on health expenditure in Nigeria. The Nigerian government should therefore improve infrastructural facilities in the rural areas so as to reduce overcrowding in the urban areas.

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