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Pollution's Hidden Toll: Examining the Health Effects of Environmental Pollution in Adamawa State, Nigeria

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ABSTRACT: As the world faces increasing problem of environmental pollution and public health challenges, it is evident that health of individuals and associated economic prosperity are unavoidably linked to the environment. To understand this link, the study examined the effects of environmental pollution on health status in Adamawa state, Nigeria. The study was carried out in Adamawa state in three Senatorial Districts across 55 communities where 440 questionnaires were administered. Ordered Logistic Regression was used to analyzed the results. Key findings show a negative coefficient between health status and environmental pollution. By Marginal effect, a one-unit increase in environmental pollution reduces the log odds of being in a higher health status (Excellent) category by 53% (OR: 1-0.470), holding other variables constant. This means that increase in environmental pollution likely increases the probability of being in lower health status (that is, those who perceived their health as poor). This result is significant at the 1% level ($p < 0.01$), thus emphasizing the critical role pollution plays in suppressing poor health. The result is in line with scholarly researches in public health, which shows that pollution carries vectors of disease and other harmful agents that affect quality of health of individuals. This outcome generally demonstrates how environmental and workplace conditions interact with availability of infrastructure to influence health status. Policymakers and stakeholders should prioritize inclusive measures that address environmental quality in addition to improvements in health and public infrastructures. Furthermore, public health campaigns should emphasize the collective responsibility of communities in maintaining conducive environments and hygienic practices.

KEYWORDS: Environmental pollution, Health Status, Ordered Logistic Regression and Adamawa state, Nigeria.

1.0 INTRODUCTION

As the world faces increasing problem of environmental pollution and public health crises, it is becoming clearer that health of individuals and their economic prosperity are unavoidably linked to the environment. According to the Office of Disease Prevention and Health Promotion Environmental Quality (2020), a healthy environment includes air, water and land that is safe for human health, supports healthy lifestyles and is free from hazards that can reduce quality of life and create health problems (Office of Disease Prevention and Health Promotion (ODPHP), 2020). The physical environment therefore can be regarded as a necessary habitat for hosting and supporting the continuous survival of ecosystem and its interaction in a safe and healthy space. The efficacy and functionality of human being are thus achieved in a healthy environment where the major risk factors that can cause problems in human health are eliminated or minimized. Albeit, the environment has been contaminated and harmful substances are introduced by unwholesome and unregulated economic activities that have made the physical environment a major concern for promoting human health.

Richard et al (2022) report that pollution remains responsible for approximately 9 million deaths worldwide annually. Specifically, air pollution has caused the greatest number of deaths, (6.7 million deaths), while 1.4 million premature deaths have occurred due to water pollution, thus making it the world's largest environmental risk factor for disease and premature death worldwide (Parvez et al 2021). The World Health Organization (2016) have estimated that 12.6 million people had died as a result of living or working in an unhealthy environment. The report indicated that exposures to environmental risk factors such as polluted air, water and land have also contributed to diseases and injuries in young children under 5 and older people 50-75 years. By these numbers, everyone is affected by environmental pollution, both children and elderly people including young ones.

In Nigeria, environmental pollution has become a serious problem to every human endeavors. For instance, Chinedu, Ezeibe, Anijiofor-Ike, and Daud (2018) observed that solid waste management is a major environmental challenge in most Nigerian cities. The Health Effect Institute (HEI, 2019) reports that air quality in Nigeria is worse compared to other countries in Africa and ranks 6th in the world, as the country continues to exceed the WHO Air Quality Guideline. The report indicates that Lagos residents are

ranked as the highest population likely to be exposed to hazardous air followed by Port Harcourt and Kano respectively. Furthermore, the report indicates that 150 per 100, 000 deaths had occurred attributable to air pollution in 2019. Wolf, Emerson, Esty, de Sherbinin and Wendling (2022) opined that environmental pollution in Nigeria is among the worst in environmental performance index (EPI) in the world. This scenario is further buttress by the Clean Up Nigeria (CUN, 2021) Cleanliness Performance Index rating where it shows 172.7 million Nigerians living in unclean environment in 2021, compared to 170 million in 2020.

According to CUN (2022) report on environmental performance that covers refuse dump in open places, streets and roads cleanliness, personal hygiene and sanitation and open defecation, Adamawa state ranks 12th dirtiest State in Nigeria. This shows that environmental pollution is growing and constitute a major risk to environmental degradation. In Adamawa state, the problem of pollution is majorly attributed to bad sanitary habits and poor management of waste. It is common to see people dumb refuse indiscriminately and this has caused serious environmental problems. Open defecation is still prevalent and adds to the worsening problem. According to National Demographic and Health Survey (2019), 22.8 percent of the population in Adamawa State defecated in the open in 2018. Open defecation has consequences of increasing the cases of diarrhea, cholera and dysentery in the State. The incidence and prevalence of sanitation related diseases are therefore likely to increase the spread of environmentally induced diseases in human health. United Nation Environment Programme Agency (UNEPA, 2006) observed that wastes that are not managed properly, especially solid waste from households and the community, are a serious health hazard and can lead to the spread of infectious diseases that would likely worsens citizen's health status.

Environmental pollution is a major risk factor to human health which is an important determinant of economic productivity. Day by day, people become sick by the increasing amount of environmental pollution they come in contact with as they pursue their daily lives. Given the prevalence of the effect of environmental pollution, household individuals have to spend their income in preventing and treating diseases that are caused by pollution. In a country where there is high rate of poverty, spending huge amount of money as out-of-pocket expenditure on health can further impoverish citizens and retard human welfare. According to World Bank (2020), healthcare spending in Nigeria per capita is 70 dollars in 2020 equivalent of N53, 025. Aregbeshola and Khan (2018) stated that over 90% of Nigerians pay out-of-pocket payment for healthcare noting that households who live below the poverty line often do not use healthcare services when the need arises because OOP health payments are capable of making households incur catastrophic health expenditure and this can exacerbate the level of poverty.

The incidence of environmental pollution in Adamawa state and its effect on health bear adverse effect on labour force productivity. Studying this relationship is necessary to guide policy interventions in addressing the effect of environmental pollution on health and the low level of productivity in the State. WHO (1986) recognized that health is a resource for everyday living and a tool for determining the level of productivity of a people as well as their standard of living. United Nation (1972) sees the effort to reduce pollution as a way to boost healthy living and enhance economic productivity which should be sustained in order to raise standard of living that is in harmony with the environment.

2.0 Empirical Literatures

Many scholars have examined the effect of environmental pollution on health with varying empirical outcomes. For instance, Ucheje and Ikebude (2024) recognized environmental contamination as a danger to both the ecosystem and public health. Their study examined the impact of air pollution on public health, calling for long-term monitoring of ambient $PM_{2.5}$ and other pollutants in urban areas. While practical recommendations were made, the analytical technique used was not specified. Li, Haoran and Xiaocang (2022) examined the effects of water pollution on human health and disease heterogeneity. The study selected 85 relevant researches based on the keywords of water pollution, water quality, health and cancer. The result revealed that more than 80% of sewage generated by human activities is discharged thus resulting in 80% of diseases and 50% of child deaths worldwide. Yizhen et al (2022) examined the impact of economic level and air pollution on public health in China. Data was analyzed using the multivariate ordered logit and panel data regression models. Part of the results shows negative correlation between air pollution and public health. Urhie, Afolabi, Afolabi, Matthew, Osabohien, and Ewetan (2020) examined economic growth, air pollution and health outcomes in Nigeria. The study found that air pollution and government expenditure have a significant effect on health performance in Nigeria. Sui et al (2021) explored the short-term impacts of Particulate Matter and Ozone ($PM_{2.5}/O_3$) on daily death in Hefei from 2013-2018 using time-series data on daily death of the residents. Meteorological factors and air pollutants collected from January 1, 2013, to December 31, 2018 were used. The study found that an increase in the amount of air pollution increased non-accidental deaths. Specifically, in cold season, air pollution had a stronger effect on the deaths resulting from non-accidental, cardiovascular and respiratory diseases. Also, Becerra-Pérez, Ramos-Álvarez, DelaCruz, García-Páez, Páez-Osuna, Laurent and Boldo (2021) analyzed the impact of Particulate Matter ($PM_{2.5}$) on health status in three northwestern Mexican cities. Specifically, the study provides an economic assessment of the health effects due to exposure to particulate matter $PM_{2.5}$ in Los Mochis, Culiacan and Mazatlán. Results showed that the cost of reducing $PM_{2.5}$ pollution associated with negative health outcomes was based on Official Mexican Standard and World Health Organization environmental standards. Complying with the WHO guideline of 10 µg/m3 in annual $PM_{2.5}$ mean would add up to 15 months of life expectancy at age 30, depending on the city. The mean economic cost per year of the $PM_{2.5}$ effects on human life in these three cities was USD 600 million (NOM scenario) and USD 695 million (WHO scenario). Thus,

effective public health and industrial policy interventions to improve air quality are socially advantageous and cost-saving to promote better health.

Massimo, Giuliano and Sandro (2019) evaluated the impact of ambient air pollution on hospital admission using data from Switzerland admissions. The results showed that ambient air pollution has a substantial impact on hospital admissions. In particular, the study showed that Sulphur dioxide (SO_2) and Nitrogen dioxide (NO_2) are positively associated with admission rates for coronary artery and cerebrovascular diseases. Amos and Adofu (2021) evaluated the impact of ambient air pollution on mortality rate in Nigeria from 1970-2019. Time series data from World Bank Development Indicators were analyzed using Auto Regressive Distributed Lag Model. Results revealed a positive relationship between air pollution and mortality rate in Nigeria. Specifically, air pollution was found to have a negative effect on life expectancy.

Xia et al (2019) examined the relationship between atmospheric pollutants and risk of death caused by respiratory diseases and malignant tumors in Shenyang, China from 2013-2016. The study used data collected in Shenyang from April, 2013 to March, 2016. Results from the study indicated that an increase in the daily average of air pollution increased the risk of death by cardiovascular diseases. Niladri and Bruce (2019) assessed the challenge of pollution and health in Canada. They found that key forms of toxic pollutants in air, water, and soil are still too high with vulnerable populations including the poor, women, children and indigenous peoples are disproportionally affected by pollution. Emife, Adeshina, Elvis and Babatunde (2018) examined public health expenditures, environmental pollution and health outcomes in Nigeria. The study used annual secondary time series data 1981-2017 from Central Bank of Nigeria statistical bulletin and World Development Indicator. Using the ARDL technique the result showed that environmental pollution has a negative and significant effect on health outcome in the country.

3.0 METHODOLOGY

The study was carried out in Adamawa's three Senatorial Districts across 55 communities. Adamawa State was created in 1991 and has an estimated 4,902,100 people (NBS, 2022). It is located in the North-East of Nigeria and it shares international borders with Cameroon to the East. The vast arable land in Adamawa state makes farming and other agricultural activities a thriving business. Its geographical location also is suitable for both local and international trade, facilitating movement of goods and services in commerce. However, the weather conditions in the State can be extremely harsh which makes it easy for the spread of diseases especially during both the harmattan and rainy seasons.

The Taro Yamane method was used to determine the sample size while Probability Proportional to Sampling technique (PPS) was used to select LGAs and wards where the study took place. By Probability Proportional to Sampling Size (PPS) technique, three LGAs were selected in Northern senatorial and Central Districts while four LGAs in Southern Senatorial district, bringing to ten (10) selected LGAs. These LGAs are Girei, Hong, Yola North, Madagali, Michika, Mubi south, Ganye, Jada, Mayo-belwa and Shelleng.

Table 1.1: Generated sample for selected LGAs by PPS

State	Senatorial District	Number of LGA	Cumulative	Selected LGA	Number of selected LGA
Adamawa	Central	7	7	2, 4, 6	3
	Northern	5	12	8, 10, 12	3
	Southern	9	21	14, 16, 18, 20	4
	Total	21			10

Sampling interval = Cumulative of LGA/cumulative of selected LGA 21/10 ≈ 2; Selected Random start = 2

Table 1.2: Generated sample for selected wards

State	Senatorial District	Number of selected LGA	Number of wards in selected LGA	Selected wards	Number of selected wards
Adamawa	Central	3	33	2, 4, 6, 8, 10, 12 14, 16, 20, 22, 24, 26 28, 30, 32	15
	Northern	3	36	34, 36, 38, 40, 42, 44, 46 48, 50, 52, 54, 56, 58, 60 62, 64, 66, 68	18
	Southern	4	43	70, 72, 74, 76, 78, 80, 82 84, 86, 88, 90, 92, 94, 96 98, 100, 102, 104, 106, 108 110, 112	22
	Total	10	112		55

Sample interval for Ward selection = 2, Random start = 2By Taro Yamane's formular, approximately 400 population size was determined and 55 wards/communities were selected for survey by Probability Proportional to Sample size technique for questionnaire administration. Therefore, 400/55 =7.3 questionnaires per ward/community. Although it is difficult to determine 7.3 questionnaire per ward/community, 1 questionnaire was added for each ward/community making a total of 8 questionnaires per ward/community. Thus, a total of 440 questionnaires, 8 in each ward/community were administered across 55 wards/communities in 10 LGAs.The study utilized primary data generated from survey with the aid of a designed questionnaire. The questionnaire asked simple questions that helped respondents give their opinion on the effect of environmental pollution on health status in Adamawa state. Their personal experiences such as where they reside, the level of exposure to pollution and the severity of the effect of pollution on their health status added richness to the survey. The use of questionnaire provided an opportunity for face-to-face interaction with respondents who are considered relevant to the study. The target population comprises individuals aged 18 and above who are actively engaged in economic activities within the selected LGAs. These include farmers, traders, artisans, and small-scale entrepreneurs.

To evaluate the effect of environmental pollution on health status, Ordered Logistic Regression was used. Health Status is denoted by $HS_i = f(EnvPol_i, ConEnv_i, Facilities_i, Wen_i, WasteDM_i)$. The ordered logistic regression equation models the log-odds of being in or below a specific category of an ordinal dependent variable (in this case, Health Status (HS)) based on the independent variables. The model used in this study was adapted from the empirical work by Urhie et al (2020). The model examined the effect of economic growth and air pollution on health status in Nigeria. According to the model, Life Expectancy at Birth (LEAB, proxy for health status) is a function of economic growth (GDP) and air pollution (CO_2). However, this work includes other variables like facilities, waste disposal method, conducive environment and working environment to account for the contribution of facilities in enhancing health status. In this study, the environmental health theory by Florence Nightingale was used. The ordered logistic regression model is specified as;

$$\text{Log}\,(\Pr(HS_i \leq k) / \Pr(HS_i > k)) = \beta_k + \beta_1 EnvPol_i + \beta_2 ConEnv_i + \beta_3 Facilities_i + \beta_4 Wen_i + \beta_5 WasteDM_i$$

where;

HS_i = health status

$EnvPol_i$ = Environmental pollution

$ConEnv_i$ = Conducive Environment

$Facilities_i$ = Access to facilities

Wen_i = Working Environment

$WasteDM_i$ = Waste Disposal Method

4.0 RESULTS AND DISCUSSION

Table 1.3: Ordered logistic regression for the effect of environmental pollution on health status

Dependent Variable: HS (Health Status)					
	Coef. OR	St.Err.	t-value	p-value	Sig
EnvPol (Environmental pollution)	-0.755 (0.470)	0.207	-3.64	0.0003	***
ConEnv (Conducive Environment)	-0.534 (0.586)	0.175	-3.05	0.002	***
Facilities	0.084 (1.088)	0.138	0.61	0.543	
Wen (Working Environment)	-1.076 (0.341)	0.196	-5.50	0	***
WasteDM (Waste Disposal Method)	0.188 (1.207)	0.085	2.21	0.027	**
Mean dependent var	2.441	.652		0.776	
Pseudo r-squared	0.134	.634		440	
Chi-square	136.583	Prob > chi2		0.000	
Akaike crit. (AIC)	897.561	Bayesian crit. (BIC)		930.255	

*** p<.01, ** p<.05, * p<.1 Odd ratios in Brackets

Source: Authors' computation using Stata 15

From Table 1.3, the negative coefficient between health status and environmental pollution indicates a negative relationship. By Marginal effect, a one-unit increase in environmental pollution reduces the log odds of being in a higher health status (Excellent) category by 53% (OR: 1-0.470), holding other variables constant. This means that increase in environmental pollution likely increases the probability of being in lower health status (that is, those who perceived their health as poor). This result is significant

at the 1% level ($p < 0.01$), thus emphasizing the critical role pollution plays in suppressing poor health. The finding is consistent with public health research, which shows that pollution carries vectors of disease and other harmful agents, reducing overall health quality.

The relationship between conducive environment and health status shows a negative result. Specifically, a one-unit increase in decrease in conducive environmental conditions reduces the log odds of being in a higher health category (Excellent) by 41.4% (OR: 1-0.586) at 1% level of statistical significance keeping all other variables constant. This outcome highlights the importance of a conducive and hygienic environment for maintaining better health outcomes. Conversely, availability of facilities for hygiene has a positive coefficient with health status which shows a positive result. By this result, a one-unit increase in access to facility increases the log odds of better health by 8.8%, but this result is not statistically significant ($p = 0.543$) suggesting that improved facilities might enhance health status. However, this effect is not statistically significant, implying that while facilities are important, they may not independently or substantially influence health outcomes without the interaction of other factors such as habits and functionality of available facilities.

Result further indicates that poor working environments negatively affect health status, with a significant coefficient of -1.076 ($p < 0.01$) which shows a negative relationship. This means that a one-unit increase in poor working environment reduces the log odds of being in a higher health category by 66% (OR: 1-0.341). This suggests that adverse conditions in workplaces, such as exposure to hazards or lack of safety, drastically reduce health status, aligning with global occupational health findings. For waste disposal method, the coefficient is positive which indicates a positive relationship. Marginally, one unit increase in controlled waste disposal method increases the log odds of being in a higher health status category. Specifically, a one unit increase in controlled waste disposal increases the log odds of being in higher health status (Excellent) category by 21% (OR: 1.207-1) at 5% statistical level of significance. This outcome signifies that better waste disposal methods improve the likelihood of being in a higher health status category (that is, those who perceived their health as Excellent or Very Good) showing the importance of effective waste management for public health.

The negative coefficient of environmental pollution indicates that a one-unit increase in environmental pollution decreases the log odds of being in a higher health status category. Given the p-value is less than 0.01, we reject the null hypothesis (H_0) and accept the alternate hypothesis (H_1) that environmental pollution significantly affects health status. The analysis provides strong evidence to reject the null hypothesis for environmental pollution which significantly affect health status. The model indicates an output that is statistically significant with a moderate explanatory power. The Pseudo R-squared value suggests that about 13.4% of the variance in the dependent variable is explained by the predictors in the model. The significant Chi-square statistic confirms the model's overall fit.

The ordered logistic regression results presented in Table 1.3 analyzed the effect of environmental pollution on health status. Result indicates that environmental pollution has a negative effect on health status. The result is consistent with studies carried out by Li, Haoran and Xiaocang (2022) in which they found that more than 80% of sewage generated by human activities resulted in 80% of diseases and 50% of child deaths worldwide. Similarly, Amos and Adofu (2021) found a positive relationship between air pollution and mortality rate in Nigeria. Poor environmental hygiene and severe pollution increase the risk of water-borne and sanitation-related diseases. Contaminated water sources and poor hygiene practices can lead to the spread of diseases like cholera, dysentery, typhoid and hepatitis.

Exposure to pollutants in environmentally unhygienic work place or home can lead to a wide range of health problems such as asthma, heart attack, high blood pressure, cancer, allergies and skin problems such as eczema. Furthermore, consistent exposure to environmental pollutants can suppress the immune system, making individuals more susceptible to infectious diseases and reducing their ability to fight off infections. It is important therefore to note that the severity of the health effects depends on various factors such as the extent of hygiene problems, duration of exposure, individual susceptibility and pre-existing health conditions. Taking measures to reduce environmental pollution at work and improve hygiene in addition to individual measures to protect oneself from exposure can help to mitigate these health risks. Based on the result also, waste disposal method has a positive effect on health status. It is therefore important to encourage and advocate for controlled and proper waste disposal because doing so would increase the chances of achieving health status in an improved environment.

The finding that a one-unit decrease in conducive environmental conditions reduces the likelihood of being in a higher health category underscores the critical role of environmental quality in health outcomes. Poor environmental conditions, such as pollution, inadequate sanitation and overcrowding, can exacerbate the spread of diseases and compromise overall well-being. These results highlight the need for policies and interventions aimed at improving environmental hygiene, reducing pollution and creating cleaner living and working spaces.

Although the availability of facilities for hygiene has a positive association with health status, the lack of statistical significance suggests that simply having facilities may not be enough to guarantee improved health. This finding points to the need for complementary factors, such as community education on proper facility use, maintenance of hygiene infrastructure and ensuring accessibility. It also hints at potential inefficiencies in how facilities are managed or utilized.

The strong negative association between poor working environments and health status emphasizes the detrimental effects of occupational hazards. Unsafe or unsanitary workplace conditions can lead to chronic illnesses, injuries and mental health issues, directly impacting overall health. These findings align with global occupational health research, reinforcing the importance of workplace safety regulations, regular inspections and worker health awareness to mitigate risks and enhance well-being.

The significant positive relationship between controlled waste disposal methods and health status highlights the critical role of effective waste management in public health. Proper waste disposal reduces exposure to harmful pathogens and pollutants, thus preventing the spread of diseases. This finding supports the implementation of robust waste management policies and community-level programs to promote sustainable practices.

5.0 CONCLUSION

Given the results obtained, there is strong evidence to conclude that environmental pollution has a significant negative effect on health status in Adamawa state. These results collectively demonstrate how environmental and workplace conditions interact with available infrastructure to influence health outcomes. Policymakers and stakeholders should prioritize inclusive interventions that address environmental quality, occupational health and public infrastructure development. Furthermore, public health campaigns should emphasize the collective responsibility of communities in maintaining conducive environments and hygiene practices.

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