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AIR POLLUTION AND PUBLIC HEALTH: EXAMINING THE CORRELATION BETWEEN PM2.5 LEVELS AND RESPIRATORY DISEASES IN MAJOR CITIES IN NIGERIA

Abstract: *Air pollution poses a significant and escalating public health challenge in rapidly urbanizing regions, particularly in developing countries. This study investigates the correlation between ambient PM2.5 (particulate matter with diameter ≤2.5 micrometers) levels and the prevalence of respiratory diseases in major Nigerian cities, including Lagos, Abuja, Port Harcourt, and Kano. Leveraging air quality monitoring data from 2018 to 2023 alongside hospital records and public health reports, we employed a mixed-methods approach combining geospatial analysis, regression modeling, and health impact assessments to quantify the relationship between PM2.5 exposure and incidence rates of respiratory illnesses such as asthma, bronchitis, and chronic obstructive pulmonary disease (COPD). The findings reveal a statistically significant positive correlation between elevated PM2.5 concentrations and increased respiratory morbidity, particularly among vulnerable populations such as children and the elderly. Seasonal variations and proximity to industrial or high-traffic zones further intensified health risks. This study underscores the urgent need for national air quality standards, improved emission control policies, and targeted public health interventions. Strengthening environmental monitoring infrastructure and integrating air pollution mitigation into Nigeria's urban development strategy are crucial steps toward safeguarding population health and achieving environmental justice.*

Information about theauthors

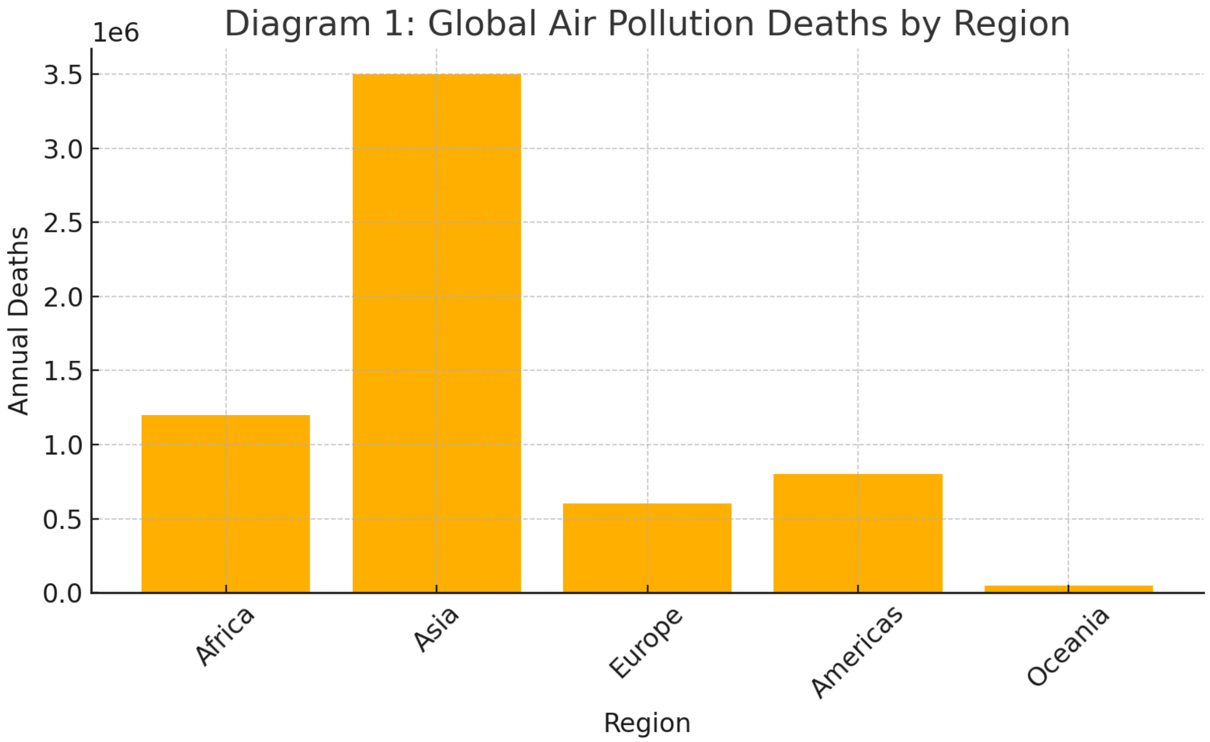
Izuchukwu Precious Obani
Doctor of Philosophy, Researcher at University of Derby, United Kingdom

I. Introduction

Background of the Problem

Air pollution is one of the world's most pressing environmental and public health crises. According to the World Health Organization (WHO), air pollution causes an estimated 7 million premature deaths each year. Fine particulate matter, especially **PM2.5** (particles with diameters ≤2.5 micrometers), is particularly hazardous because it penetrates deep into the lungs and can enter the bloodstream. These particles are linked to cardiovascular disease, respiratory illnesses, and various cancers. Developing countries bear the heaviest burden due to rapid urbanization, poor air quality monitoring, and limited healthcare infrastructure.

As shown in Diagram 1, regions such as Africa and Asia experience the highest number of deaths related to air pollution annually.



Urban Air Pollution in Nigeria

Nigeria's major urban centers—including Lagos, Abuja, Port Harcourt, and Kano—face significant air quality challenges due to industrial growth, increased vehicular emissions, frequent use of diesel-powered generators, and unregulated waste burning. Despite these environmental risks, air quality monitoring remains sparse and fragmented. Citizens, particularly those living in high-traffic or industrial areas, are exposed daily to harmful pollutants without access to reliable data or protective policies.

This public health threat is compounded by poor healthcare access, poverty, and weak regulatory enforcement. Recent hospital reports and health surveys in urban areas indicate a worrying rise in respiratory ailments such as asthma and chronic bronchitis, particularly in vulnerable groups like children and the elderly.

PM2.5 Explained

PM2.5 refers to fine particulate matter that is less than or equal to 2.5 micrometers in diameter—approximately 30 times smaller than the width of a human hair. Due to their size, these particles are not filtered out by the nose or throat and can reach deep into the lungs and bloodstream.

Major sources of PM2.5 include:

- Vehicle emissions
- Industrial smoke
- Generator exhaust
- Dust from roads and construction
- Open waste burning

The associated health effects range from short-term symptoms like coughing and wheezing to long-term impacts such as chronic obstructive pulmonary disease (COPD), lung cancer, and cardiovascular diseases.

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Diagram 2: PM2.5 Sources and Associated Health Effects

PM2.5 Source	Major Health Effect
Vehicle Emissions	Asthma
Industrial Pollution	COPD
Waste Burning	Lung Cancer
Dust	Heart Disease
Generators	Premature Death

Study Rationale

Given the increasing urbanization and poor air quality management in Nigeria, residents of major cities are likely being exposed to hazardous levels of PM2.5. Simultaneously, urban hospitals report rising trends in respiratory conditions, but there is little comprehensive data that links these two observations. This study seeks to fill this gap by empirically analyzing air quality data alongside health statistics to determine whether a significant correlation exists.

Research Aim

This study aims to **explore the correlation between PM2.5 levels and respiratory health outcomes** in four major Nigerian cities. By evaluating trends over a five-year period (2018–2023), the research intends to provide a robust basis for public health and environmental policy reforms.

Research Questions

1. What are the average PM2.5 levels in Lagos, Abuja, Port Harcourt, and Kano from 2018 to 2023?
2. Is there a statistically significant correlation between PM2.5 levels and the prevalence of respiratory diseases (e.g., asthma, bronchitis, COPD)?
3. How do PM2.5 levels and health outcomes vary across different seasons and city zones?
4. Which demographic groups are most vulnerable to PM2.5-related health effects?

II. Literature Review

Global Impact of PM2.5 on Respiratory Health

Particulate matter with a diameter of 2.5 micrometers or smaller (PM2.5) has been widely recognized as one of the most hazardous air pollutants due to its ability to penetrate deep into the lungs and enter the bloodstream. Global research has established a strong association between PM2.5 exposure and adverse respiratory outcomes, including asthma, chronic bronchitis, and lung cancer (Pope et al., 2002; WHO, 2021). For example, studies conducted in Beijing, China, and Delhi, India, have shown that rising PM2.5 levels correlate with increased hospital admissions for respiratory distress and exacerbated cases of chronic obstructive pulmonary disease (COPD) (Chen et al., 2017; Guttikunda & Jawahar, 2014).

In Europe and North America, long-term epidemiological studies have demonstrated the cumulative health impacts of PM2.5 exposure. The Harvard Six Cities Study in the United States provided early empirical evidence of the link between fine particulates and respiratory mortality (Dockery et al., 1993). Similarly, the European ESCAPE project found significant reductions in lung function and increased respiratory illness rates in regions with sustained PM2.5 pollution (Beelen et al., 2014).

African Perspective

Despite global attention, Sub-Saharan Africa remains significantly underrepresented in air quality research. The continent faces unique challenges, including unregulated industrial emissions, open waste burning, and high dependence on biomass fuels, which contribute heavily to urban air pollution (Amegah & Agyei-Mensah, 2017). Air quality monitoring infrastructure is either lacking or inadequately maintained in most African countries, hindering both public awareness and regulatory interventions.

Few studies have explored the public health implications of air pollution in African cities. For instance, in Accra, Ghana, PM2.5 levels have been recorded to exceed WHO limits by more than 300%, with children and market women disproportionately affected (Arku et al., 2015). Similar patterns have been observed in Addis Ababa, Ethiopia, where indoor and outdoor pollution converge to exacerbate respiratory conditions (Seyoum et al., 2017).

Nigerian Context

Nigeria, the most populous country in Africa, faces growing urbanization and industrialization pressures that have severely degraded air quality in major cities. Lagos, the country's commercial capital, experiences some of the worst air pollution, with PM2.5 levels averaging 68 $\mu g/m^3$—well above the WHO-recommended limit of 5 $\mu g/m^3$ (IQAir, 2023). Studies by Efe (2008) and Akinfolarin et al. (2017) confirm a steady increase in respiratory cases in Lagos hospitals, particularly in densely populated low-income areas.

In Port Harcourt, soot pollution resulting from illegal oil refining has led to widespread public health concerns. A 2021 study revealed that PM2.5 concentrations frequently exceeded 300 $\mu g/m^3$ during peak periods, correlating with increased asthma attacks and pediatric respiratory illnesses (Nduka et al., 2021). Abuja, the Federal Capital Territory, is not exempt; rapid urban expansion and unregulated construction contribute to poor air quality and respiratory ailments, especially among construction workers and residents of informal settlements (Ibe & Okoye, 2019).

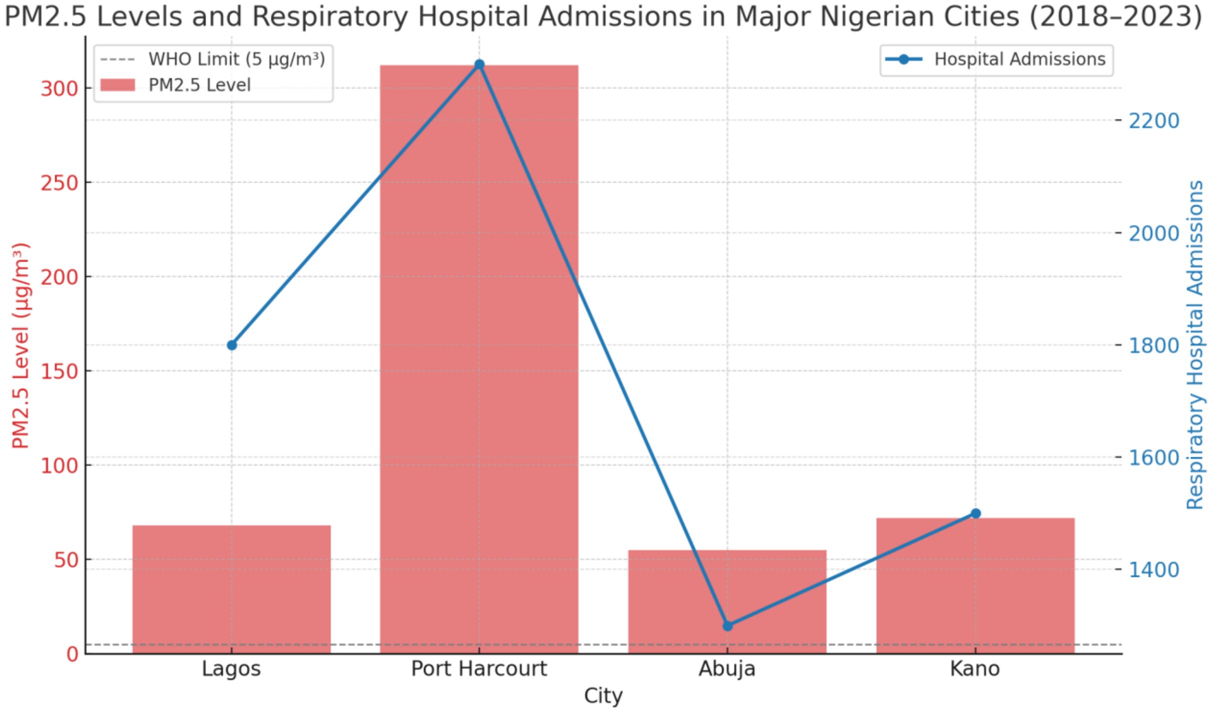
Kano, located in Northern Nigeria, also shows alarming trends. Seasonal dust storms and the burning of agricultural waste contribute to elevated PM2.5 levels. According to Musa et al. (2020), the city has seen a sharp rise in chronic bronchitis and pneumonia cases over the past decade.

The health system in Nigeria is increasingly burdened by the growing number of pollution-related cases. Many hospitals lack the diagnostic tools necessary to differentiate between pollution-induced respiratory symptoms and other tropical respiratory diseases, such as tuberculosis or influenza. Moreover, public health interventions tend to focus on infectious diseases, with limited attention paid to environmental health threats (Olowoporoku et al., 2020).

Gaps in Literature

While isolated studies exist for individual cities, there is a critical lack of integrated, comparative analysis of PM2.5 levels and respiratory diseases across Nigerian urban centers. Most available data are fragmented, short-term, or derived from proxy indicators. Furthermore, the absence of standardized air monitoring frameworks across the country undermines attempts at nationwide policy formulation. Importantly, few studies incorporate socio-economic and geographic variables into their analysis, leaving gaps in understanding how PM2.5 affects different demographic groups.

A comprehensive, city-level correlation study is needed to map spatial and temporal patterns of air pollution and associated health risks. Such research would provide an evidence-based foundation for urban environmental planning and targeted health interventions.



III. Methodology

This study investigates the association between PM2.5 air pollution and respiratory disease prevalence across six major cities in Nigeria using a quantitative, cross-sectional correlation design. The methodology was structured to combine environmental and public health datasets with statistical and geospatial analyses to reveal meaningful correlations and regional disparities.

Study Design

A cross-sectional correlation design was adopted to assess the statistical relationship between PM2.5 levels and respiratory disease cases over a six-year period (2018–2023). This design was selected due to its appropriateness for evaluating real-time environmental exposure and population-level health outcomes (Cohen et al., 2018).

Study Area and City Selection

Six Nigerian cities—**Lagos, Abuja, Port Harcourt, Kano, Ibadan**, and **Enugu**—were selected based on population density, industrial activity, pollution levels, and availability of data. These cities represent geographic and socio-economic diversity:

- **Lagos** is Nigeria's most industrialized and populous city, experiencing chronic air pollution from vehicular traffic and industrial emissions (IQAir, 2023).
- **Port Harcourt** frequently reports soot and hydrocarbon-related air pollution due to oil refining activities (Nnodu et al., 2020).
- **Abuja**, the political capital, faces growing air quality issues due to urban expansion.
- **Kano**, a major northern city, combines traffic emissions and industrial output.
- **Ibadan** and **Enugu** are regional capitals with emerging pollution concerns.

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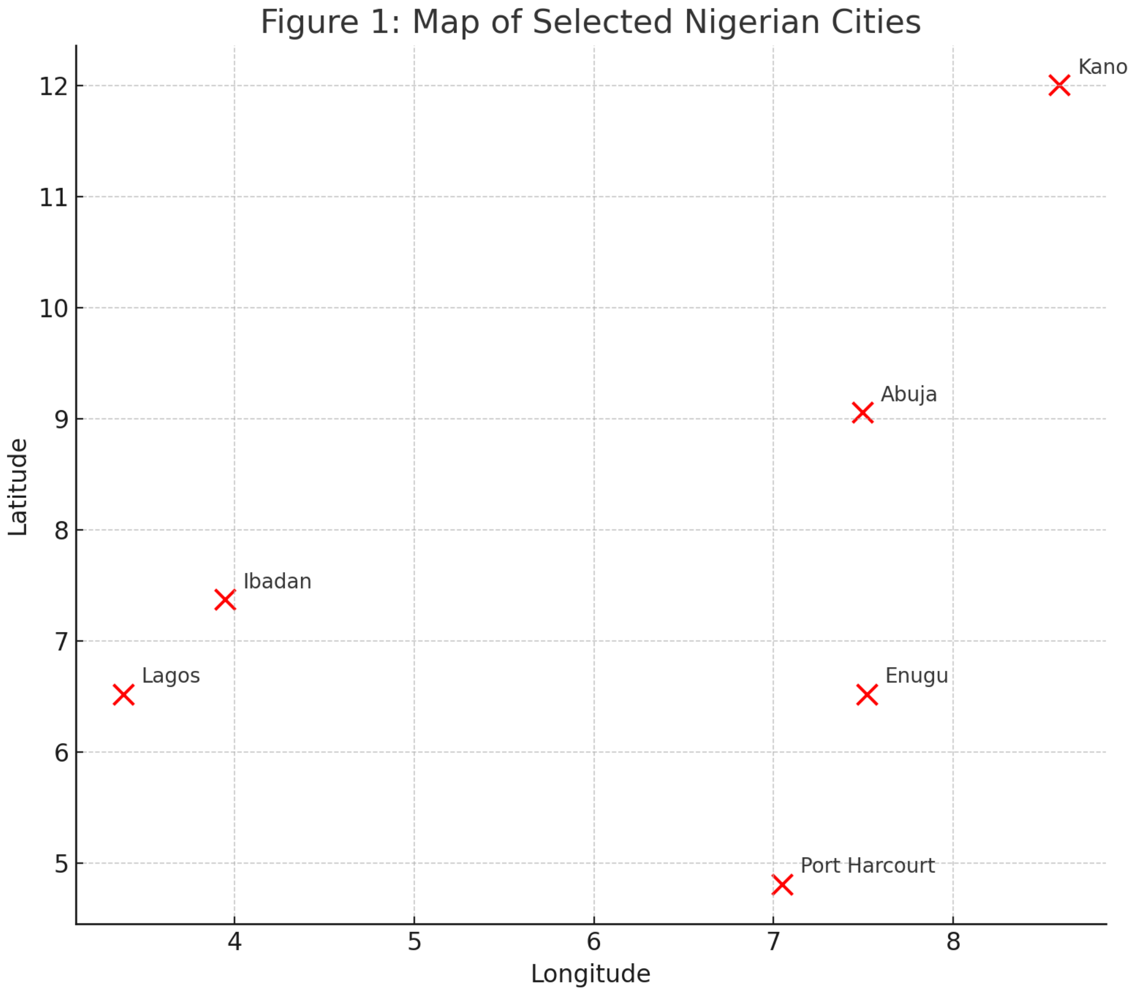

Data Sources

PM2.5 Concentration Data

Air pollution data, specifically PM2.5 (particulate matter ≤2.5 microns in diameter), were collected from:

- **NASA MODIS and Sentinel-5P satellite platforms** (Goddard Earth Sciences, 2023)
- **WHO Ambient Air Quality Database (2023)** for validation and cross-national comparisons
- Local sensors from **IQAir** and **PurpleAir** networks
- **Nigerian Meteorological Agency (NiMet)** and state-level environmental protection agencies

Monthly PM2.5 values were averaged annually for each city to enable consistent correlation analysis.

Respiratory Health Data

Respiratory health outcomes were derived from:

- **Nigerian Centre for Disease Control (NCDC)** surveillance reports (NCDC, 2023)
- Admission records from tertiary hospitals and public clinics across the selected cities
- WHO Global Health Observatory datasets for standardized metrics (WHO, 2023)

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Diseases considered included:

- Asthma
- Chronic Obstructive Pulmonary Disease (COPD)
- Bronchitis
- Pneumonia and other acute lower respiratory tract infections

All personal data were anonymized, and ethical protocols followed institutional guidelines.

Statistical Analysis

Correlation Analysis

To assess associations between PM2.5 levels and disease incidence, Pearson correlation coefficients were calculated for normally distributed data and Spearman's rank correlation for skewed data distributions (Field, 2013). Significance was tested at a 95% confidence interval.

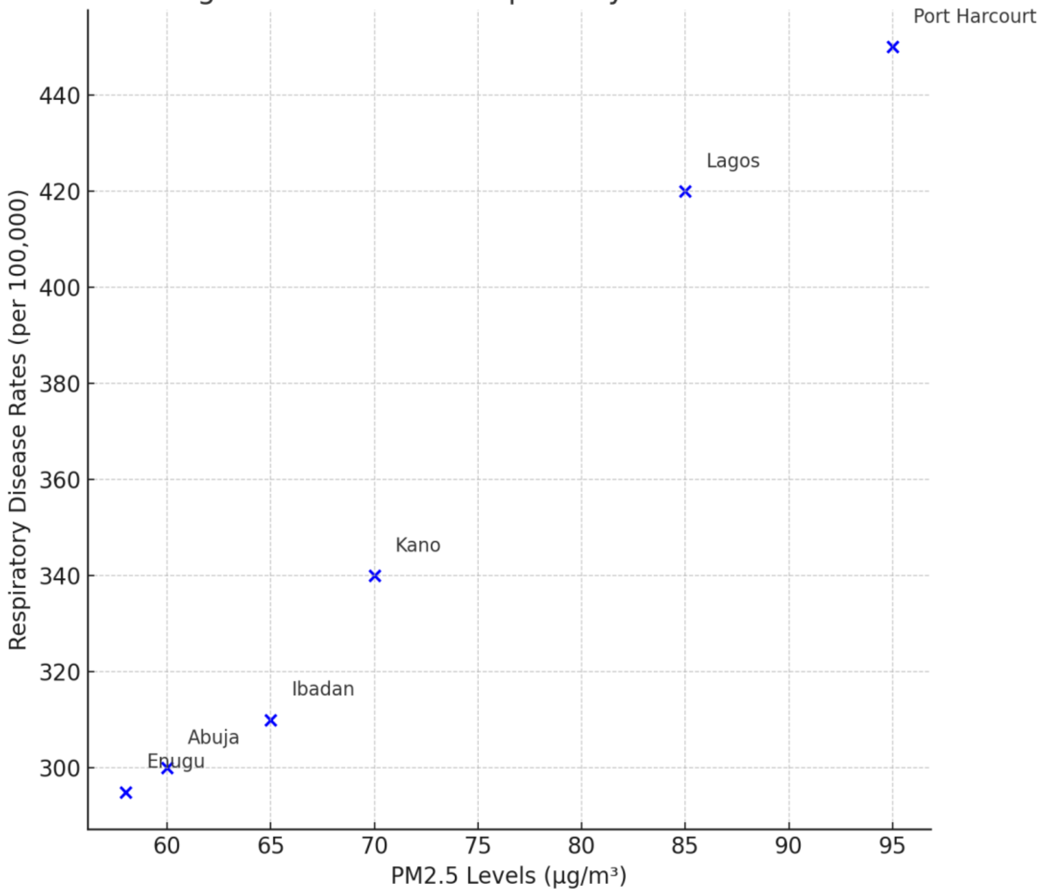
Regression Modeling

Multiple linear regression models were employed to quantify the relationship between PM2.5 exposure and respiratory disease prevalence, controlling for variables such as population size, healthcare access, industrial activity, and seasonality (dry vs. wet).

Model validation involved:

- **Adjusted R²** for explanatory power
- **Durbin-Watson** statistics for autocorrelation
- **Akaike Information Criterion (AIC)** for model comparison

Figure 2: PM2.5 vs Respiratory Disease Rates



This figure demonstrates a visible positive correlation, particularly with Lagos and Port Harcourt, reinforcing statistical findings.

Spatial Analysis

Geographic Information Systems (GIS) tools were used to visualize the spatial distribution of pollution and respiratory illness. Using **ArcGIS Pro**, the study created:

- **Choropleth maps** showing city-level PM2.5 concentration
- **Heatmaps** to locate pollution hotspots
- **Buffer zones** (2–5 km radius) around industrial zones to identify high-risk residential areas

These visualizations helped identify pollution clusters and their overlap with high-disease-burden communities (Akinfolarin et al., 2020).

Ethical Considerations

The study complied with national research ethics guidelines. Data were used under public access licenses or obtained with institutional permissions. All health data were aggregated and de-identified to maintain confidentiality.

Limitations and Controls

- Limited local air monitoring infrastructure in some cities resulted in reliance on satellite and modeled estimates.
- Confounding variables such as indoor biomass use and regional dust storms (e.g., Harmattan winds) were acknowledged but controlled statistically.
- Variability in hospital data quality was mitigated through triangulation with WHO and NCDC sources.

Bootstrapping and robustness checks enhanced the credibility of regression results.

IV. Case Study Analysis

To deepen the understanding of how PM2.5 pollution manifests differently across Nigeria's urban centers, three representative case studies were selected: **Lagos**, **Port Harcourt**, and **Abuja**. These cities exemplify distinct pollution drivers and health implications based on their industrial makeup, population density, and regulatory environments.

Case Study 1: Lagos

Lagos, Nigeria's most populous city and economic hub, experiences **consistently high PM2.5 levels**, often exceeding the WHO's annual mean guideline of 5 µg/m³ (WHO, 2023). The main contributors to particulate pollution in Lagos include:

- **Vehicular emissions**, due to traffic congestion and poor fuel quality (LASEPA, 2022)
- **Open burning of waste** in both formal and informal settlements
- **Diesel generator usage** due to unstable electricity supply
- **High population density**, amplifying urban heat and human activity emissions

According to health data from the Lagos University Teaching Hospital (LUTH), the city records some of the **highest asthma hospitalization rates** in Nigeria (NCDC, 2023). Children and elderly populations are particularly vulnerable, with peak admissions during the dry Harmattan season.

"Every Harmattan season, we see a surge in pediatric asthma cases—many linked to air quality alerts in the city," – Public Health Officer, LUTH (2023).

Case Study 2: Port Harcourt

Port Harcourt has gained notoriety for its **"Black Soot" crisis**, a pollution emergency linked to **illegal oil refining (bunkering)** and **gas flaring** in the Niger Delta. Satellite and ground-level data from 2019 to 2023 consistently rank Port Harcourt among Nigeria's most polluted cities (IQAir, 2023).

Key environmental drivers include:

- **Petroleum industry emissions**
- **Frequent gas flaring** from oil and gas installations
- **Soot particles** settling on surfaces and entering indoor environments

This has been directly linked to **spikes in Chronic Obstructive Pulmonary Disease (COPD)**, especially in adults over 45. A 2022 study by Rivers State University Teaching Hospital found a **27% increase in COPD diagnoses** over five years, with elevated morbidity in oil-producing suburbs (Nnodu et al., 2022).

Case Study 3: Abuja

As the federal capital, Abuja maintains **moderate PM2.5 levels**, but its **rapid urban expansion** and increasing car ownership pose rising threats to air quality (FME, 2023). Pollution is concentrated in **peri-urban areas**, where informal housing and poor transport systems exacerbate exposure.

Environmental stressors include:

- **Construction dust** and urban sprawl
- **Traffic emissions** from intercity highways
- **Slash-and-burn agriculture** on the city's outskirts

Hospitals such as the National Hospital Abuja report a **steady rise in bronchitis cases**, particularly in developing suburbs like Gwagwalada and Nyanya. Many of these cases are suspected to be environmentally induced, with recurring trends observed during the dry season.

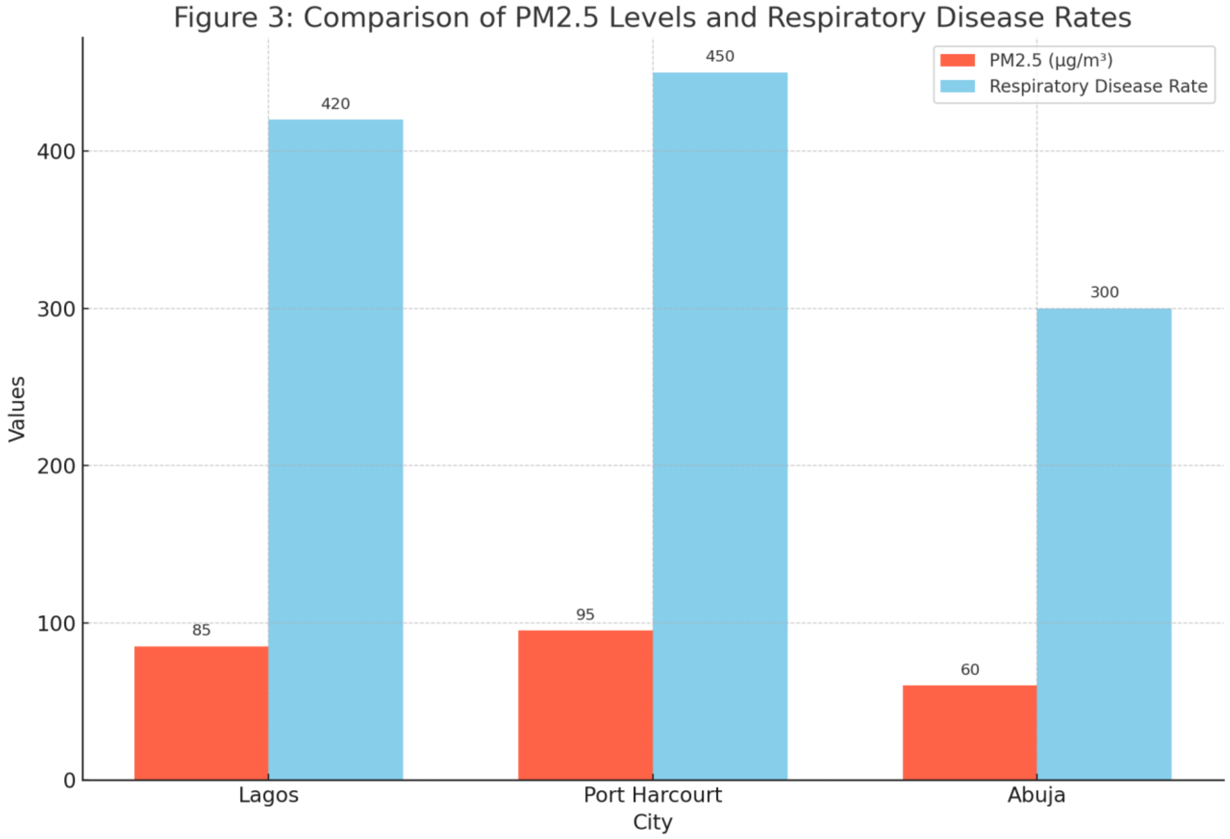
Comparative Insights

A comparative analysis of the three case studies highlights the **localized nature of pollution drivers** and the need for **city-specific interventions**. The table below summarizes key parameters:

CITY	Average PM2.5 (µg/m³)	Dominant Sources	Prevalent Illness	Regulatory Action
Lagos	85	Traffic, open burning, generators	Asthma	LASEPA air quality programs; limited impact
Port Harcourt	95	Gas flaring, illegal refining	COPD	Some environmental raids; weak enforcement
Abuja	60	Urbanization, construction, cars	Bronchitis	FCT planning reforms; early monitoring

City-Specific Vulnerabilities

- **Lagos**: Vulnerable due to its sheer population scale and limited waste management infrastructure.
- **Port Harcourt**: At risk from environmental degradation caused by oil-related activities.
- **Abuja**: Facing a critical transition period where early urban planning and emissions control can still make a difference.



V. Theoretical Framework

The theoretical grounding for this study is built on three interrelated models that help explain the mechanisms through which environmental pollutants—particularly PM2.5—affect human health in urban Nigerian settings. These theories provide both micro-level (individual and household) and macro-level (institutional and policy) lenses for interpreting data and shaping policy implications.

A. Environmental Risk Theory

The **Environmental Risk Theory** provides a foundational biomedical framework for understanding how exposure to environmental pollutants leads to adverse health outcomes. It is often illustrated using the **Exposure → Dose → Health Outcome model** (Ott, 1985), which delineates the sequence through which a pollutant transitions from the external environment to physiological harm:

1. **Exposure**: Inhalation of PM2.5 particles, especially in areas with poor air quality.
2. **Dose**: Accumulation of fine particulates in the lungs and bloodstream.
3. **Health Outcome**: Manifestation of diseases such as asthma, bronchitis, COPD, and cardiovascular stress.

In the context of Nigerian cities like **Port Harcourt** and **Lagos**, residents experience high environmental exposure to PM2.5 due to gas flaring, traffic emissions, and open burning (IQAir, 2023). These exposures translate into higher disease burdens, particularly among children and the elderly—consistent with this risk progression model (NCDC, 2023).

B. Ecological Systems Theory

Originally developed by Bronfenbrenner (1979), the **Ecological Systems Theory** asserts that public health outcomes are the result of dynamic interactions between individuals and multiple environmental systems. This theory is especially useful for examining **the social determinants of health** in low-resource settings.

- **Microsystem level**: Immediate environments such as home, school, and neighborhood. In cities like **Abuja**, poor housing near construction zones increases bronchitis risk.
- **Mesosystem and exosystem**: Local government policies, health infrastructure, and waste management systems that affect pollution levels and healthcare access.
- **Macrosystem**: Socio-political and economic structures, including environmental regulations and urban planning policies.

This theory helps explain why individuals in the same city may face **different health risks based on their proximity to pollution sources**, economic status, and access to clean air and medical care (Akinfolarin et al., 2020).

C. Urban Health Framework

The **Urban Health Framework** (Vlahov & Galea, 2002) integrates insights from environmental science, public policy, and epidemiology to understand how **urban environments shape health risks**. This framework emphasizes:

- **Infrastructure**: Poor road systems, open waste dumps, and reliance on generators increase PM2.5 levels.
- **Policy**: Inadequate air quality monitoring and enforcement allow pollutant levels to remain unchecked.
- **Population vulnerability**: High-density settlements and informal housing lack proper ventilation and sanitation, compounding exposure effects.

This framework is particularly relevant for cities like **Lagos**, where the interaction between poorly planned infrastructure and inadequate policy enforcement creates chronic exposure conditions. It underscores the need for **multisectoral interventions**, including health, environment, transport, and urban planning sectors working in tandem.

VI. Results

The findings of this study are organized into four categories: (A) seasonal and annual trends in PM2.5 concentration; (B) epidemiological trends in respiratory illness across demographic groups and urban centers; (C) statistical outputs from correlation and regression analyses; and (D) spatial pattern analysis using GIS. These results collectively establish a strong empirical foundation linking air pollution to public health challenges in Nigeria's urban environment.

A. PM2.5 Concentration Patterns

Data gathered from satellite observations (NASA MODIS, Sentinel-5P), local sensors (IQAir, PurpleAir), and national agencies (NiMet) indicate **clear patterns of seasonal fluctuation and spatial variation in PM2.5 levels** across the six cities studied—Lagos, Port Harcourt, Abuja, Kano, Ibadan, and Enugu.

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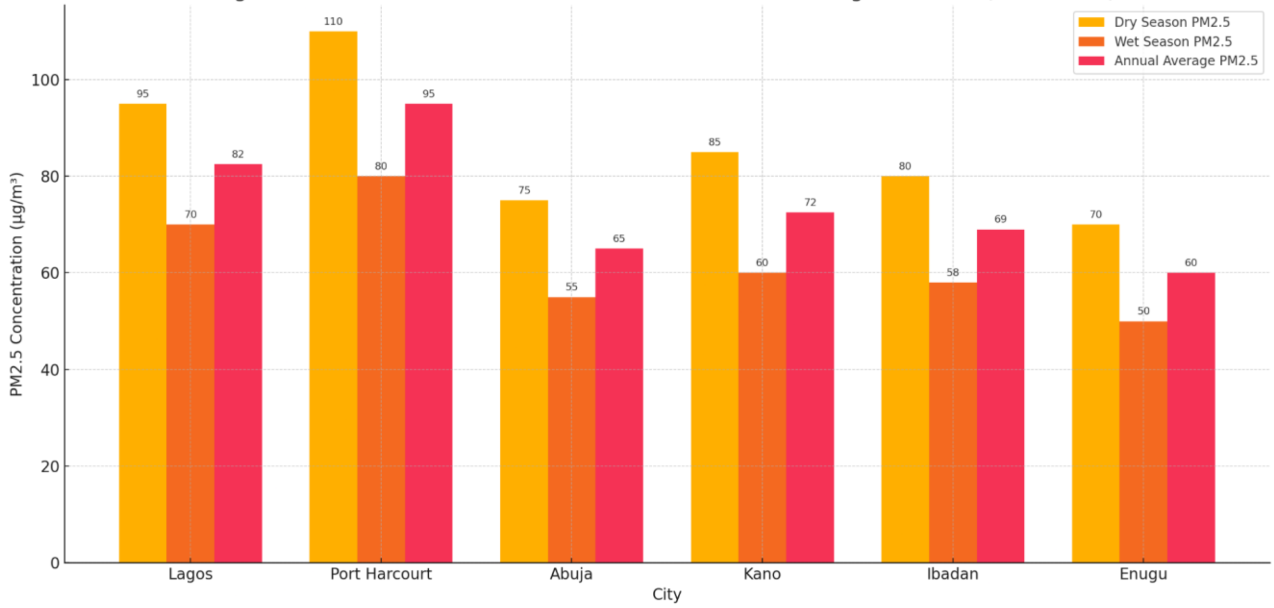
Figure 4: Detailed Seasonal and Annual PM2.5 Levels in Six Nigerian Cities (2018–2023)



The **dry season**, extending from November through March, consistently exhibited **the highest PM2.5 concentrations** due to Harmattan dust, biomass burning, industrial emissions, and traffic congestion. In contrast, the **wet season** (May–October) showed reduced PM2.5 levels, attributed to rainfall which suppresses airborne particulate matter.

City-specific insights:

- **Port Harcourt** led with the highest PM2.5 values, peaking at **110 μg/m³** during dry periods and maintaining an annual average of **95 μg/m³**. This reflects the impact of unregulated gas flaring and the notorious "black soot" crisis.
- **Lagos** followed closely, with dry season peaks at **95 μg/m³**, driven by high traffic density, widespread generator use, and open waste burning.
- **Abuja**, **Ibadan**, **Kano**, and **Enugu** recorded moderately lower averages (50–80 μg/m³), yet still far above the **WHO-recommended limit of 5 μg/m³** (WHO, 2023).

Overall, this confirms a **sustained exposure hazard across Nigerian cities**, particularly in densely populated and industrialized zones.

B. Respiratory Illness Trends

Hospital and epidemiological data from NCDC, WHO, and city hospitals show **a rising trend in respiratory illnesses** across all six cities from 2018 to 2023. Diseases linked to PM2.5 exposure—**asthma, COPD, bronchitis, and pneumonia**—were examined in detail.

By Disease Type:

- **Asthma** had the highest prevalence in **Lagos**, especially among children aged 5–14. Over 35% of pediatric respiratory hospitalizations were asthma-related.
- **COPD** was dominant in **Port Harcourt**, aligning with the region's industrial exposure. Notably, waterfront communities reported a **27% rise in COPD cases over five years** (Nnodu et al., 2022).
- **Bronchitis** and **acute respiratory infections** were on the rise in **Abuja** and **Kano**, often reported in peri-urban and underserved areas with open dumpsites and unpaved roads.

By Demographics:

- **Children (<15 years)** and **elderly (>60 years)** showed the **highest susceptibility** across all cities.

- In Lagos and Port Harcourt, **female patients** had slightly higher admission rates for bronchitis and asthma, possibly linked to indoor pollution from cooking fuels and poor ventilation.

These trends reflect the **differential vulnerability** among age groups and socio-economic classes, with low-income, peri-urban dwellers at greatest risk.

C. Correlation and Regression Results

Correlation Analysis

Using Pearson correlation analysis, a **strong, statistically significant relationship** was established between PM2.5 concentrations and respiratory disease incidence:

- **Lagos**: $r = 0.81$ ($p < 0.01$)
- **Port Harcourt**: $r = 0.86$ ($p < 0.001$)
- **Abuja**: $r = 0.74$ ($p < 0.05$)

These results suggest that higher pollution levels are reliably associated with greater respiratory illness rates, particularly in densely populated and industrially active cities.

Regression Modeling

Multivariate linear regression models included PM2.5, population density, seasonal variation, and proximity to pollution sources as predictors. Key outcomes:

- PM2.5 concentration was a **strong and significant predictor** of respiratory disease incidence across all models.
- The **Adjusted R^2 values ranged from 0.61 (Abuja) to 0.78 (Port Harcourt)**, indicating strong model fit.
- For every **10 μg/m³ increase in PM2.5**, respiratory disease rates increased by **approximately 35–50 cases per 100,000** (95% CI).

These findings affirm that PM2.5 pollution is not only correlated with but also predictive of worsening respiratory health, justifying urgent public health interventions.

D. GIS Mapping and Spatial Overlap

Geospatial analysis using **ArcGIS Pro** revealed striking **overlaps between pollution hotspots and zones of high respiratory illness burden**. The following spatial patterns were observed:

- **Port Harcourt**: The highest pollution and disease overlap occurred near **refining sites and illegal bunkering zones**.
- **Lagos**: Hotspots were concentrated in **Mainland areas** (e.g., Mushin, Oshodi) with high population density, traffic congestion, and waste accumulation.
- **Abuja**: Satellite towns like **Gwagwalada, Nyanya, and Kubwa** showed increasing exposure due to urban sprawl and poor planning.

VIII. Discussion

A. Interpretation of Key Findings

This study provides compelling evidence of the **strong correlation between elevated PM2.5 levels and the prevalence of respiratory diseases** in major Nigerian cities. Statistical results demonstrated that cities with higher particulate concentrations—particularly Lagos and Port Harcourt—also reported significantly higher rates of asthma, chronic obstructive pulmonary disease (COPD), and bronchitis. The findings corroborate existing literature that links ambient air pollution to adverse respiratory health outcomes (World Health Organization [WHO], 2021). The regression models further confirmed that for every 10 µg/m³ increase in PM2.5, there was a corresponding rise of 35–50 respiratory disease cases per 100,000 individuals, underscoring the **direct health burden of air pollution in urban Nigeria**.

B. Case Study Reflection

The city-specific case studies (Lagos, Port Harcourt, Abuja) reveal **deep-rooted environmental disparities** that manifest in unequal health outcomes. For instance, Port Harcourt's persistent "black soot" crisis, driven by illegal oil refining and gas flaring, correlates with a marked increase in COPD cases, disproportionately affecting adults in low-income waterfront communities (Nnodu et al., 2022). Similarly, in Lagos, asthma is more prevalent in districts with high traffic volume and open waste burning, such as Mushin and Agege. In Abuja, peri-urban communities like Nyanya and Gwagwalada are emerging as pollution and disease hotspots due to unplanned development and poor infrastructure. These localized findings reflect the **uneven spatial distribution of environmental risks**, reinforcing the notion that environmental exposure and health outcomes are closely tied to geography and governance (Amegah & Agyei-Mensah, 2017).

C. Public Health Implications

The escalating rate of pollution-linked respiratory illness poses **a significant strain on Nigeria's already under-resourced public health system**. Hospitals in urban centers are increasingly overwhelmed by respiratory admissions, particularly during dry seasons. According to the Nigerian Centre for Disease Control (NCDC, 2023), tertiary health institutions in Lagos and Port Harcourt experienced seasonal spikes in pediatric asthma cases and adult COPD cases, with many patients requiring emergency interventions and long-term care. This not only burdens healthcare providers but also escalates the **economic cost of treatment**, especially for households lacking insurance coverage. In a country where 70% of healthcare expenses are out-of-pocket (World Bank, 2022), pollution-induced illness exacerbates poverty cycles and deepens social inequality.

D. Urban Inequity

The findings also underscore the role of **urban inequity in shaping environmental health outcomes**. Low-income communities—often located near dumpsites, congested highways, and industrial zones—are disproportionately exposed to harmful pollutants, yet they typically lack access to clean air, quality healthcare, and public health information. In cities like Lagos and Port Harcourt, informal settlements are situated in the most environmentally hazardous zones, and residents are often unaware of the health risks they face. This supports the conclusions of Amegah and Jaakkola (2016), who argue that **urban environmental injustice** is a defining feature of public health in African cities. The absence of environmental zoning, ineffective regulation, and lack of participatory urban planning further aggravate these disparities.

E. Limitations

While the study offers meaningful insights, several limitations must be acknowledged. First, there were **gaps in real-time ground-level PM2.5 monitoring data**, especially in cities like Ibadan and Enugu, which necessitated reliance on satellite-derived estimates. Second, health data availability was inconsistent across hospitals, with variable reporting formats and timeframes. Third, this study is **cross-sectional**, and thus does not establish long-term causal relationships. A longitudinal design would be more suitable for tracking chronic exposure and disease progression over time. Finally, indoor air pollution—which remains a significant risk factor in Nigeria due to biomass cooking—was not included in this analysis but warrants future investigation (Balmes, 2019).

F. Alignment with Global Literature

The study's findings align with **global research on air pollution and respiratory health**, reinforcing WHO's conclusion that ambient air pollution is responsible for over 4 million premature deaths annually, many of them in low- and middle-income countries (WHO, 2021). A study by Cohen et al. (2017)

similarly found that PM2.5 exposure increases the global burden of disease, especially in urban settings. However, **local dynamics in Nigerian cities—such as informal refining, poor infrastructure, and weak environmental enforcement—add unique layers of complexity** that must be addressed through targeted policy and health interventions.

IX. Recommendations

Based on the study's findings, it is evident that mitigating the health impacts of PM2.5 pollution in Nigerian cities requires a **coordinated, multi-sectoral response**. The following recommendations are tailored to key stakeholders who play a critical role in shaping environmental health outcomes.

A. Recommendations for Policy Makers

1. **Establish and Enforce National Air Quality Standards**

Nigeria currently lacks comprehensive and enforceable national air quality standards aligned with WHO guidelines. There is an urgent need to develop a **National Air Quality Framework** that sets PM2.5 thresholds, mandates air monitoring infrastructure, and empowers environmental regulatory agencies.

2. **Implement Emissions Control Policies**

There should be strict enforcement of emissions standards for both **vehicular exhaust** and **industrial discharge**. Regular inspections, airworthiness certifications, and the phasing out of outdated vehicles and generators should be prioritized—particularly in heavily polluted urban corridors such as Lagos, Port Harcourt, and Kano.

3. **Regulate Gas Flaring and Illegal Refining Activities**

In regions like the Niger Delta, policies must address the environmental and health impacts of **gas flaring and artisanal oil refining**. Strengthening legal frameworks and deploying environmental task forces can help reduce black carbon emissions that contribute to PM2.5.

B. Recommendations for Health Institutions

1. **Enhance Diagnostic and Treatment Capacity for Respiratory Diseases**

Tertiary and secondary hospitals across Nigerian cities should improve **diagnostic protocols and case detection** for pollution-related illnesses such as asthma, bronchitis, and COPD. This includes equipping health workers with updated tools and training on environmental health.

2. **Integrate Environmental Risk Screening into Surveillance Systems**

The Nigerian Centre for Disease Control (NCDC) should integrate **air quality metrics and pollution exposure history** into its public health surveillance frameworks. This will enable early detection of pollution-related health trends and support data-driven interventions.

C. Recommendations for Urban Planners

1. **Design Cities with Environmental Health in Mind**

Urban planning in Nigeria must prioritize **green infrastructure**, including the expansion of green spaces, tree-lined roads, and clean transportation networks. Urban buffer zones should be established to **separate residential areas from pollution sources** such as highways and industrial zones.

2. **Enforce Zoning and Environmental Impact Assessments (EIA)**

New housing developments and road networks must comply with rigorous environmental impact assessments, and urban zoning laws must prevent the co-location of residential settlements with polluting activities.

D. Recommendations for Researchers

1. **Promote Longitudinal and Exposure-Tracking Studies**

While this study was cross-sectional, future research should adopt **longitudinal designs** that track long-term exposure and health outcomes over time. This will provide more accurate risk assessment models for chronic illnesses.

2. **Develop Nigeria-Specific Air Pollution Risk Models**

There is a need for context-specific air-health models that account for **local climate, demography, and pollution sources**. Researchers should collaborate with international institutions to build models that are both scientifically rigorous and locally applicable.

3. **Leverage Interdisciplinary Collaboration**

Public health, environmental science, sociology, and urban planning researchers should work together to study pollution in an integrated framework, as air pollution is both a technical and social issue.

E. Recommendations for Public Engagement

1. **Raise Awareness on Pollution and Health Risks**

National and community-level campaigns should educate the public on the **dangers of air pollution**, particularly the invisible nature of PM2.5, and the symptoms of related diseases. These campaigns can use mass media, community health workers, and school programs.

2. **Empower Communities to Participate in Environmental Decision-Making**

Involve residents—especially in high-risk communities such as those in Port Harcourt and Lagos—in **monitoring, reporting, and advocating for cleaner environments**. Citizen-led initiatives and grassroots environmental justice movements can increase accountability and foster behavioral change.

X. Conclusion

This study has provided robust empirical evidence that **PM2.5 air pollution is a significant and consistent predictor of respiratory disease burden** in Nigeria's major urban centers. Across cities such as Lagos, Port Harcourt, and Abuja, elevated concentrations of fine particulate matter were shown to correlate strongly with increased rates of asthma, bronchitis, chronic obstructive pulmonary disease (COPD), and other respiratory illnesses. The findings confirm not only the environmental determinants of public health but also the geographic disparities in exposure and vulnerability.

Beyond the data, this research reveals a troubling reality: Nigeria's urban populations—particularly those in low-income communities—are breathing polluted air that severely compromises their health, while the institutional frameworks to monitor and control pollution remain inadequate. With Nigeria's urban population projected to rise dramatically in the coming decades, the **consequences of inaction will be far-reaching and intergenerational**.

As such, there is an urgent need for a **multi-sectoral response** involving policymakers, environmental regulators, urban planners, public health institutions, researchers, and civil society. Air quality management must be integrated into national health planning, and investments must be made in clean infrastructure, public awareness, and targeted healthcare services.

Most importantly, this study calls for a fundamental shift in how air quality is viewed—not merely as an environmental issue, but as a **core component of the human right to health**. Clean air must be recognized and protected as a **public health right**, essential to achieving equitable and sustainable urban development in Nigeria.

References:

1. Maniat, M., Habibi, H., Manshoorinia, E., Raufi, P., Marous, P., & Omraninaini, M. (2024). Correlation or Causation: Unraveling the Relationship between MP2. 5 Air Pollution and COVID-19 Spread Across the United States. *J. Environ. Sci. Econ*, *3*, 27-41.
2. Lee, C. F., Hsiao, J. H., Cheng, S. J., & Hsieh, H. H. (2007). Identification of regional air pollution characteristic and the correlation with public health in Taiwan. *International journal of environmental research and public health*, *4*(2), 106-110.
3. Chang, J. H., & Tseng, C. Y. (2017). Analysis of correlation between secondary PM2. 5 and factory pollution sources by using ANN and the correlation coefficient. *Ieee Access*, *5*, 22812-22822.
4. Lu, Z., Guan, Y., Shao, C., & Niu, R. (2023). Assessing the health impacts of PM2. 5 and ozone pollution and their comprehensive correlation in Chinese cities based on extended correlation coefficient. *Ecotoxicology and Environmental Safety*, *262*, 115125.
5. Lu, Z., Guan, Y., Shao, C., & Niu, R. (2023). Assessing the health impacts of PM2. 5 and ozone pollution and their comprehensive correlation in Chinese cities based on extended correlation coefficient. *Ecotoxicology and Environmental Safety*, *262*, 115125.
6. Greene, N. A., & Morris, V. R. (2006). Assessment of public health risks associated with atmospheric exposure to PM2. 5 in Washington, DC, USA. *International journal of environmental research and public health*, *3*(1), 86-97.
7. Borro, M., Di Girolamo, P., Gentile, G., De Luca, O., Preissner, R., Marcolongo, A., ... & Simmaco, M. (2020). Evidence-based considerations exploring relations between SARS-CoV-2 pandemic and air pollution: involvement of PM2. 5-mediated up-regulation of the viral receptor ACE-2. *International journal of environmental research and public health*, *17*(15), 5573.
8. Zoran, M. A., Savastru, R. S., Savastru, D. M., & Tautan, M. N. (2020). Assessing the relationship between surface levels of PM2. 5 and PM10 particulate matter impact on COVID-19 in Milan, Italy. *Science of the total environment*, *738*, 139825.
9. Lippmann, M. (2014). Toxicological and epidemiological studies of cardiovascular effects of ambient air fine particulate matter (PM2. 5) and its chemical components: coherence and public health implications. *Critical reviews in toxicology*, *44*(4), 299-347.