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Environmental Air Pollution and its Impact on Respiratory Health in Bayelsa State, Nigeria

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Abstract*: Background: Air pollution is a major environmental and public health challenge, particularly in oil-producing regions such as Bayelsa State, Nigeria. The presence of pollutants like sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), ammonia (NH_3), and particulate matter (PM2.5, PM10) poses a significant risk for respiratory conditions. This study investigates the relationship between ambient air pollution and respiratory health in Bayelsa State. Methods: A community-based cross-sectional study was conducted among 428 adult residents across five local government areas (LGAs). Air quality measurements were obtained using standardized sensors, and respiratory health was assessed using Peak Expiratory Flow Rate (PEFR) tests and structured questionnaires. Data analysis involved t-tests, ANOVA, and logistic regression to determine associations between pollutant exposure and respiratory conditions. Results: The mean concentrations of SO_2, NO_2, CO, PM2.5, and PM10 exceeded WHO and Federal Ministry of Environment (FMOEnv) permissible limits. Southern Ijaw and Yenagoa recorded the highest pollution levels. Respiratory conditions such as wheezing (25.7%), pneumonia (18.1%), asthma (11.6%), and COPD (11.0%) were prevalent. Poor lung function (low PEFR) was significantly associated with pollutant exposure ($p < 0.0001$). Conclusion: The study confirms a strong link between air pollution and respiratory diseases in Bayelsa State. Urgent policy interventions are needed, including stricter emission controls, public health education, and improved healthcare access to mitigate pollution-related health risks.

***Keywords*: Air pollution, respiratory health, Bayelsa State, Nigeria, particulate matter, environmental policy.**

1. Introduction

Air pollution is a major public health concern worldwide, contributing significantly to respiratory diseases and other health complications. The World Health Organization (WHO) estimates that ambient (outdoor) air pollution is responsible for millions of premature deaths annually, with low- and middle-income countries experiencing the highest burden (WHO, 2022c). In Nigeria's Niger Delta region, where Bayelsa State is located, environmental pollution has become a critical issue due to extensive industrial activities, including oil exploration, gas flaring, and illegal crude oil refining. These activities have led to the release of harmful pollutants such as sulfur dioxide (SO_2), nitrogen oxides (NO_2), carbon monoxide (CO), ammonia (NH_3), and particulate matter (PM2.5 and PM10), all of which have been linked to respiratory conditions (Manisalidis et al., 2020).

Bayelsa State, a key oil-producing region in the Nigeria's Niger Delta, faces severe environmental challenges due to widespread pollution from both legal and illegal oil-related activities. Gas flaring, a common practice in the region, releases toxic substances into the air, leading to poor air quality and increased risks of respiratory diseases among residents (Watts & Zalik, 2020). Additionally, unregulated artisanal refining—popularly known as "kpofire"—has further exacerbated air pollution, resulting in long-term exposure to hazardous chemicals (Amanze, 2022). The combination of industrial pollution and domestic sources, such as biomass burning for cooking, creates an environment where respiratory health is continuously at risk (WHO, 2022a).

Research has consistently shown that exposure to high levels of air pollutants increases the incidence of respiratory conditions such as asthma, chronic obstructive pulmonary disease (COPD), pneumonia, and lung infections (Allen et al., 2017). In Bayelsa State, many residents report symptoms like persistent cough, wheezing, shortness of breath, and chest tightness, all of which are commonly associated with air pollution exposure. Despite the alarming health implications, there has been limited research on the direct relationship between air pollution and respiratory health in the region (Godson & Sridhar, 2009).

This article explores the impact of environmental air pollution on respiratory health in Bayelsa State. It examines the levels of key air pollutants in the region, assesses their compliance with WHO and national air quality standards, and analyzes the prevalence of respiratory diseases among residents. Furthermore, it highlights the socio-economic factors contributing to air pollution vulnerability and discusses potential policy interventions to mitigate its health impacts. Addressing air pollution in Bayelsa State is crucial for improving public health and ensuring environmental sustainability.

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2. Materials and Methods

A. Study Design

This study employed a community-based cross-sectional design to assess the relationship between environmental air pollution and respiratory conditions among residents of Bayelsa State, Nigeria. Both quantitative and analytical methods were utilized to measure air pollutant levels and evaluate their health impacts. Data collection involved air quality monitoring, lung function assessments, and structured questionnaires administered to study participants.

B. Study Area

Bayelsa State, located in the Niger Delta region of Nigeria, experiences significant environmental pollution due to its extensive oil exploration activities. The study was conducted in five local government areas (LGAs) across two senatorial zones—Bayelsa West and Bayelsa Central. These regions were purposively selected to represent both fresh and saltwater ecosystems, which influence human settlement patterns and pollution exposure levels.

C. Study Population and Sampling

The study targeted adults aged 18 years and above residing in Bayelsa State and employed a multi-stage sampling technique to ensure representative data collection. Bayelsa West and Bayelsa Central zones were purposively selected due to their high industrial activity and pollution exposure. A proportional allocation method was used to distribute households across 69 communities, followed by the random selection of 214 households to ensure equal representation across Local Government Areas (LGAs). Within each household, systematic random sampling was applied to select study participants.

A sample size of 428 participants was determined using the Leslie Kish formula, with an additional 10% adjustment for potential non-response (Kish, 2003). This approach ensured a diverse and representative sample, allowing for a comprehensive assessment of air pollution exposure and respiratory health outcomes in Bayelsa State.

D. Air Quality Assessment

Ambient air quality was assessed using standardized air sampling equipment strategically placed across designated locations in each Local Government Area (LGA). The targeted pollutants and their respective measurement techniques included Sulfur Dioxide (SO_2) using a passive sampler, Carbon Monoxide (CO) measured with a Non-Dispersive Infrared (NDIR) sensor, and Nitrogen Dioxide (NO_2) assessed via a gas filter correlation analyzer. Particulate Matter (PM2.5 and PM10) levels were monitored using a high-volume air sampler, while Ammonia (NH_3) was detected using an electrochemical sensor. Sampling occurred twice daily (morning and evening) over three consecutive days, with results compared to WHO and FMOEnv air quality standards.

E. Lung Function Measurement

Peak Expiratory Flow Rate (PEFR) was assessed using a handheld peak flow meter. Participants performed three forced expiratory maneuvers, and the highest value was recorded. PEFR readings were categorized as normal or poor respiratory function based on standardized reference values for age, sex, and height.

F. Data Collection Instrument

A structured, interviewer-administered questionnaire was used to collect data on demographic characteristics (age, sex, occupation, education), knowledge and awareness of respiratory diseases, self-reported respiratory symptoms, and household exposure factors such as cooking fuel type and proximity to industrial sites. To ensure validity and reliability, the questionnaire was pre-tested in two non-study communities, achieving a Cronbach's alpha reliability score of ≥ 0.70, indicating strong internal consistency. The structured format allowed for accurate interpretation by interviewers, ensuring inclusion of participants with varying literacy levels and enhancing the quality and reliability of responses gathered during the study.

G. Data Analysis

Quantitative data were analyzed using IBM SPSS Statistics version 27, applying various statistical tests to examine relationships between air pollution exposure and respiratory health outcomes. Descriptive statistics were used to summarize demographic characteristics, while t-tests and ANOVA compared mean pollutant levels across different Local Government Areas (LGAs). Logistic regression analysis was conducted to assess the association between air pollution exposure and respiratory conditions, with odds ratios (ORs) and 95% confidence intervals (CIs) used to determine the effect sizes of exposure risks. A p-value of <0.05 was considered statistically significant, ensuring robust and reliable conclusions regarding the impact of environmental pollutants on respiratory health.

H. Ethical Considerations

Ethical approval was granted by the Health Research Ethics Committee of the Bayelsa State Ministry of Health, ensuring compliance with research guidelines. Written informed consent was obtained from all participants after a detailed explanation of the study. Confidentiality, voluntary participation, and anonymity were strictly maintained to protect respondents' privacy and rights throughout the study.

3. Results

A. Demographic Profile of Study Participants

Table 1 presents the demographic distribution of the study participants, highlighting factors that may influence exposure to air pollution and respiratory health outcomes.

The age distribution indicates that the majority fall within the 30–44 years age bracket (33.9%), followed by those aged 45–54 years (27.1%), suggesting a predominantly middle-aged population. This group is often actively engaged in occupational and outdoor activities, increasing their exposure to environmental pollutants. Long-term exposure may also

Table 1
Demographic information of the study participants

Demographic Information	Bayelsa West (n=180)		Bayelsa Central (n=248)		Overall	
	Freq	%	Freq	%	Freq	%
Age years (Mean: 46.8 ± 6.7)						
18 -29	19	10.6	31	12.5	50	11.7
30-44	64	35.6	81	32.7	145	33.9
45-54	48	26.7	68	27.4	116	27.1
55 – 64	41	22.8	55	22.2	96	22.4
65+	8	4.4	13	5.2	21	4.9
Total	180	100.0	248	100.0	428	100.0
Gender						
Male	116	64.4	164	66.1	280	65.4
Female	64	35.6	84	33.9	148	34.6
Total	180	100.0	248	100.0	428	100.0
Duration since resident in the community						
Less than 5 years	23	12.8	37	14.9	60	14.0
5 – 9 years	35	19.4	55	22.2	90	21.0
10 -15	68	37.8	83	33.5	151	35.3
Above 15	54	30.0	73	29.4	127	29.7
Total	180	100.0	248	100.0	428	100.0
Occupation						
Fishing	27	15.0	31	12.5	58	13.6
Farming	39	21.7	36	14.5	75	17.5
White collar	27	15.0	61	24.6	88	20.6
Trading	51	28.3	64	25.8	115	26.9
Mining	14	7.8	13	5.2	27	6.3
Unemployed	12	6.7	21	8.5	33	7.7
Other (eg student)	10	5.6	22	8.9	32	7.5
Total	180	100.0	248	100.0	428	100.0
Educational Level						
Primary	34	18.9	43	17.3	77	18.0
Secondary	84	46.7	97	39.1	181	42.3
Tertiary	38	21.1	87	35.1	125	29.2
Non-formal	24	13.3	21	8.5	45	10.5
Total	180	100.0	248	100.0	428	100.0
Monthly Income Level (in Naira)						
Below 30,000	37	20.6	41	16.5	78	18.2
30,000- 59000	55	30.6	56	22.6	111	25.9
59,000 - 99,0000	43	23.9	67	27.0	110	25.7
100,000- 149000	28	15.6	61	24.6	89	20.8
150,000 and above	17	9.4	23	9.3	40	9.3
Total	180	100.0	248	100.0	428	100.0

contribute to respiratory health issues. The younger (18–29 years: 11.7%) and older (65+ years: 4.9%) age groups were less represented, possibly due to differences in mobility, work engagement, or study participation rates.

The study was male-dominated (65.4%), with women making up 34.6% of participants. The higher male representation could be linked to men's greater involvement in outdoor jobs such as fishing, farming, and trading, which increase exposure to air pollution. Socio-cultural factors may have also contributed to lower female participation, as women may have been engaged in domestic responsibilities or had limited mobility in decision-making regarding research participation.

A significant proportion of participants (65%) had lived in their communities for over 10 years, with 29.7% residing for more than 15 years. This suggests long-term exposure to environmental pollutants from oil exploration, gas flaring, and crude oil refining. These individuals may have developed chronic health conditions related to pollution exposure, making them valuable for assessing the impact of environmental degradation on respiratory health.

The occupational distribution shows that trading (26.9%) and farming (17.5%) were the most common occupations, followed by white-collar jobs (20.6%). Farmers are particularly vulnerable to airborne contaminants from industrial waste and pesticide exposure, while traders, especially those working in open markets, may experience prolonged exposure to vehicle emissions and dust particles. Even white-collar workers, though largely working indoors, may not be entirely shielded from air pollution due to poor indoor air quality and exposure to biomass fuels.

Education plays a key role in health awareness, with 42.3% of participants completing secondary education, while 29.2% attained tertiary education. However, 10.5% of respondents had no formal education, indicating a gap in health literacy and awareness of pollution-related risks. Targeted health education programs are necessary, particularly for individuals with lower literacy levels.

Income distribution reveals that 51.6% earned between ₦30,000–₦99,000, while only 9.3% earned above ₦150,000. Limited financial access to healthcare services, preventive screenings, and treatment may lead to delayed diagnoses and poor respiratory disease management. Also, lower-income households may rely more on polluting energy sources such as firewood and kerosene, further increasing their exposure to indoor air pollution.

B. Ambient Air Quality Levels in Bayelsa State

Figure 1 presents the distribution of key air pollutants across different Local Government Areas (LGAs) in Bayelsa State, highlighting significant variations in pollutant concentrations. The study measured Sulfur Dioxide (SO_2), Nitrogen Dioxide (NO_2), Carbon Monoxide (CO), Ammonia (NH_3), and Particulate Matter (PM2.5 and PM10), revealing consistently high pollution levels, particularly in industrial and oil-producing regions.

Southern Ijaw LGA recorded the highest levels of SO_2 (201.2 µg/m³), PM2.5 (113.4 µg/m³), and PM10 (275.4 µg/m³), confirming its status as a pollution hotspot due to industrial emissions, oil exploration, and gas flaring. Similarly, Yenagoa LGA exhibited the highest NO_2 concentration (152.1 µg/m³), likely due to vehicular and industrial emissions, while Ekeremor LGA had the highest CO levels (23.4 µg/m³), possibly linked to biomass combustion and traffic-related sources. Ammonia (NH_3) concentrations peaked in Southern Ijaw (0.94 µg/m³) and Yenagoa (0.834 µg/m³), suggesting industrial and agricultural contributions.

The data reveal that PM10 levels were elevated across all LGAs, raising serious concerns about respiratory health risks. The findings indicate that air pollution in Bayelsa State exceeds WHO and national safety standards, posing significant public health and environmental challenges. Given the severity of pollution, immediate policy interventions are needed to strengthen emission regulations, enhance air quality monitoring, and improve public awareness of pollution-related health risks.

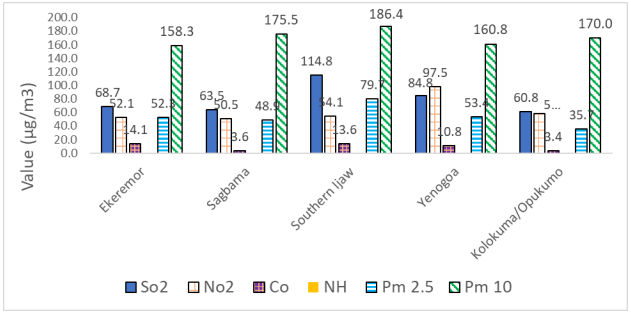

Fig. 1. Compound bar chart for distribution of ambient level of common air pollutants (SO_2, CO_2, CO, NH, PM2.5, and PM 10) in the study LGAs of Bayelsa

C. Total Ambient Air Pollution Levels in Bayelsa State

Figure 2 presents an exploratory analysis of the total ambient levels of key air pollutants in Bayelsa State, comparing them against permissible limits set by the World Health Organization (WHO) and the Federal Ministry of Environment (FMOEnv), Nigeria. The results confirm that air quality in Bayelsa State is significantly polluted and unhealthy, with most pollutants exceeding recommended safety thresholds.

The figure highlights that Ammonia (NH_3), Particulate Matter (PM2.5 and PM10) exceeded both WHO and FMOEnv limits, indicating that the air quality in the study area is hazardous. PM2.5 and PM10 levels are particularly concerning, as prolonged exposure to these fine and coarse particles is associated with respiratory diseases, cardiovascular complications, and reduced lung function. The persistence of elevated NH_3 levels suggests contamination from industrial emissions, agricultural activities, and waste disposal.

However, Sulfur Dioxide (SO_2) and Nitrogen Dioxide (NO_2) remained within both WHO and FMOEnv permissible limits, making them the only pollutants that did not exceed regulatory thresholds. Despite this, the presence of these gases at any level remains a concern, as long-term exposure to NO_2 and SO_2 can still contribute to airway inflammation and lung irritation.

A statistical comparison of air pollutant concentrations with WHO and FMOEnv standards reveals significant differences in pollution levels. Carbon Monoxide (CO), PM2.5, and PM10 were found to significantly exceed FMOEnv permissible limits ($P < 0.05$), with CO ($P = 0.007$, 95% CI = 1.24–6.98), PM2.5 ($P = 0.007$, 95% CI = 4.13–23.30), and PM10 ($P = 0.032$, 95% CI = 1.85–38.52) showing particularly high exceedance levels. The positive 95% confidence interval (CI) values for most pollutants, except NH_3, further reinforce that Bayelsa State's air quality is significantly poor and hazardous to public health.

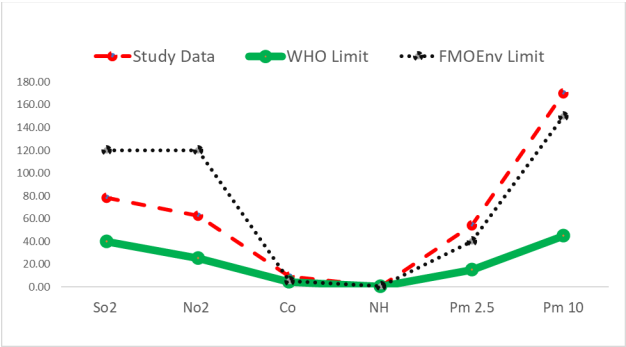

Fig. 2. Side by side ambient air quality level (AAQL) using assessing air pollution (SO2, NO2, CO, NH, PM2.5 and PM10) in Bayelsa state, Nigeria

D. Prevalence of Respiratory Symptoms Among Residents

Table 2 presents data on the prevalence of common respiratory symptoms among residents of Bayelsa State, shedding light on the possible impact of air quality on public health. The findings reveal that 75.5% of respondents reported no respiratory symptoms, while 24.5% experienced at least one symptom within six months of the study. Although the majority did not report any symptoms, the presence of respiratory

Table 2
Reported common symptoms of respiratory symptoms/check-up among residents of Bayelsa state

Reported Common respiratory symptoms	Bayelsa West	Bayelsa Central	Total
No respiratory disease symptom	129 (71.7%)	194 (78.2%)	323 (75.5%)
Have cough for more than 4 weeks duration	23 (12.8%)	23 (9.3%)	46 (10.7%)
Sputum production	22 (12.2%)	25 (10.1%)	47 (11.0%)
Chest pain	31 (17.2%)	36 (14.5%)	67 (15.6%)
Fast breeding	16 (8.9%)	26 (10.5%)	42 (9.8%)
Had respiratory checkup within 6 months	7 (3.9%)	8 (3.2%)	15(3.5%)
History of Asthma/COPD	3 (1.7%)	3 (1.3%)	6 (1.4%)

Table 3
Association between air pollution exposure and the development of respiratory conditions among the residence of Bayelsa state

Exposure Status	Poor		Normal		Total	P	OR	95% CI	
	PEFR < 400 L/Min)		PEFR (400 - 700 L/Min)						
	Freq	%	Freq	%				Lower	Upper
SO_2									
Exposed	65	22.2	228	77.8	293 (68.5)	0.0031	2.5	1.31	4.99
Unexposed	14	10.4	121	89.6	135 (31.5)				
NO_2									
Exposed	68	22.2	238	77.8	306 (71.5)	0.0015	2.9	1.44	6.28
Unexposed	11	9.0	111	91.0	122 (28.5)				
CO									
Exposed	66	21.0	248	79.0	314 (73.4)	0.0234	2.1	1.07	4.27
Unexposed	13	11.4	101	88.6	114 (26.6)				
NH									
Exposed	60	21.3	222	78.7	282 (65.9)	0.0367	1.81	1.01	3.35
Unexposed	19	13.0	127	87.0	146 (34.1)				
$PM_{2.5}$									
Exposed	69	21.6	250	78.4	319 (74.5)	0.0042	2.7	1.31	6.12
Unexposed	10	9.3	98	90.7	108 (25.2)				
PM_{10}									
Exposed	68	21.5	249	78.5	317 (74.1)	0.0029	2.7	1.35	5.89
Unexposed	11	9.2	109	90.8	120 (28.0)				

complaints among nearly a quarter of the population raises significant concerns, particularly in an environment with high levels of air pollutants such as PM2.5, PM10, SO_2, and NO_2.

Among those with symptoms, cough lasting more than four weeks (10.7%), sputum production (11.0%), and chest pain (15.6%) were the most commonly reported issues. A persistent cough lasting over four weeks is often an early sign of chronic respiratory diseases such as chronic obstructive pulmonary disease (COPD), bronchitis, or asthma. Similarly, sputum production can indicate lung irritation due to prolonged exposure to airborne pollutants, while chest pain could be linked to airway inflammation and reduced lung function. The presence of these symptoms suggests that long-term exposure to air pollution in Bayelsa State may be affecting respiratory health, particularly among vulnerable populations such as the elderly, children, and individuals with pre-existing conditions.

Despite the significant proportion of individuals experiencing respiratory symptoms, only 3.5% of respondents had undergone respiratory check-ups, highlighting low healthcare utilization for respiratory conditions. This finding suggests that many residents may lack access to healthcare services, awareness of respiratory health risks, or financial resources for medical consultations. The low rate of medical check-ups is particularly concerning, as early diagnosis and management of respiratory conditions are critical in preventing disease progression. Delayed medical attention could lead to chronic health issues, reduced quality of life, and increased mortality risks.

E. Association Between Air Pollution and Respiratory Health

Table 3 presents the association between air pollution exposure and the development of respiratory conditions among residents of Bayelsa State. The findings indicate that exposure to Sulfur Dioxide (SO_2), Nitrogen Dioxide (NO_2), Carbon Monoxide (CO), Ammonia (NH_3), and Particulate Matter (PM2.5 and PM10) is significantly linked to poor respiratory health.

A total of 293 participants (68.5%) were exposed to SO_2, with 22.2% of them developing poor respiratory conditions, compared to 10.4% in the unexposed group. Statistical analysis revealed that individuals exposed to SO_2 were 2.5 times more likely to develop respiratory conditions ($p = 0.0031$, OR = 2.5, 95% CI = 1.31–4.99). Similarly, exposure to NO_2 significantly increased the risk of respiratory issues, with affected individuals having 2.9 times higher odds of developing respiratory conditions than the unexposed group ($p = 0.0015$, OR = 2.9, 95% CI = 1.44–6.28).

Regarding CO exposure, 31% of those exposed developed respiratory conditions, compared to 14.4% in the unexposed group. This association was statistically significant ($p = 0.0234$, OR = 2.1, 95% CI = 1.07–4.27), indicating that exposure to CO nearly doubles the likelihood of respiratory issues. Additionally, 21.3% of NH_3-exposed individuals reported poor respiratory conditions, compared to 13% in the unexposed group. The findings confirm that exposure to NH_3 increases the risk of respiratory conditions by 1.8 times ($p = 0.0367$, OR = 1.8, 95% CI = 1.01–3.35).

Exposure to particulate matter (PM2.5 and PM10) was also strongly associated with poor respiratory health. Among those exposed to PM2.5 (n = 329, 74.5%), 21.6% developed respiratory conditions, compared to 9.3% of the unexposed group. Likewise, among individuals exposed to PM10 (n = 317, 74.1%), 21.5% experienced respiratory issues, compared to 9.2% in the unexposed group. Statistical analysis confirmed that exposure to both PM2.5 and PM10 increases the likelihood of respiratory conditions by 2.7 times (PM2.5: $p = 0.0042$, OR = 2.7, 95% CI = 1.31–6.12; PM10: $p = 0.0029$, OR = 2.7, 95% CI = 1.35–5.89).

4. Discussion

The findings of this study provide compelling evidence of the adverse effects of air pollution on respiratory health in Bayelsa State, Nigeria. The demographic profile of the study population indicates that the majority of participants were middle-aged, engaged in outdoor occupations such as farming and trading. This demographic group is particularly vulnerable to chronic exposure to airborne pollutants, increasing the risk of developing long-term respiratory complications. The study also

highlights a male-dominated sample, suggesting that men, due to their occupational roles, may be more frequently exposed to environmental hazards. Also, a large proportion of participants who had resided in their communities for over a decade underscores long-term exposure to industrial emissions, gas flaring, and crude oil refining, further exacerbating respiratory health risks.

The analysis of ambient air quality levels in the study location reveals alarming pollution levels, particularly in industrialized and oil-producing areas such as Southern Ijaw, Yenagoa, and Ekeremor LGAs. The elevated concentrations of SO_2, NO_2, CO, NH_3, PM2.5, and PM10 indicate severe environmental degradation beyond permissible limits set by the World Health Organization (WHO) and the Federal Ministry of Environment (FMOEnv). Of particular concern are PM2.5 and PM10, which were consistently higher than national and international safety standards across multiple LGAs. Fine particulate matter (PM2.5) is known to penetrate deep into the lungs, increasing susceptibility to asthma, COPD, and cardiovascular diseases, while PM10 exposure has been linked to chronic lung infections and reduced pulmonary function (Manisalidis et al., 2020). Comparing measured pollution levels with regulatory thresholds revealed a stark disparity, further emphasizing the unhealthy air quality in Bayelsa State. While SO_2 and NO_2 remained within permissible limits, they still contribute to lung irritation and inflammatory responses, particularly in individuals with pre-existing respiratory conditions. Carbon Monoxide (CO) levels exceeded FMOEnv limits in Southern Ijaw and Ekeremor LGAs, likely due to vehicular emissions and biomass burning. The high levels of NH_3 recorded in industrial areas such as Southern Ijaw and Yenagoa suggest waste mismanagement, industrial discharge, and agricultural pollution, which may contribute to long-term respiratory toxicity.

The study found that close to twenty-five percent of participants reported at least one respiratory symptom within six months, with chronic cough, sputum production, and chest pain being the most prevalent. These symptoms align with established health effects of long-term exposure to air pollutants, particularly PM2.5, PM10, and gaseous pollutants like NO_2 and SO_2, which have been linked to airway inflammation, bronchial hyperreactivity, and increased respiratory morbidity (Lelieveld et al., 2019). The low healthcare utilization for respiratory check-ups further highlights a gap in access to medical care and early disease detection, suggesting that many cases of pollution-related respiratory conditions remain undiagnosed and unmanaged.

The Peak Expiratory Flow Rate (PEFR) analysis provides further insight into the impact of pollution on lung function. The average PEFR across the study group was 451.6 ± 77.6 L/min, with Bayelsa West recording lower values (429.8 ± 73.4 L/min) compared to Bayelsa Central (473.3 ± 87.5 L/min). This suggests regional variations in air pollution exposure, with Bayelsa West experiencing poorer air quality and greater respiratory health risks. A good portion of participants had PEFR values below the normal range, indicating compromised lung function. Furthermore, the mean PEFR for participants with normal respiratory function was significantly higher compared to those with respiratory impairment, demonstrating a strong association between air pollution exposure and lung function deterioration.

The study's statistical analysis establishes a clear link between air pollution exposure and increased risk of respiratory conditions. Individuals exposed to SO_2 had a 2.5-fold higher likelihood of developing respiratory conditions compared to unexposed individuals. Similarly, NO_2 exposure increased respiratory disease risk by 2.9 times. These findings align with existing studies demonstrating the inflammatory and oxidative stress effects of NO_2 and SO_2 on lung tissues, which contribute to chronic bronchitis, airway hyperresponsiveness, and exacerbation of asthma symptoms (Fuller et al., 2022). Also, exposure to CO was associated with a 2.1-fold higher risk of respiratory impairment. CO inhalation interferes with oxygen transport in the blood, leading to hypoxia, fatigue, and increased cardiovascular strain. Furthermore, NH_3 exposure increased the odds of respiratory conditions by 1.8 times, supporting previous research on the irritant effects of ammonia on the respiratory tract. The strongest associations were observed with particulate matter exposure. Individuals exposed to PM2.5 and PM10 were 2.7 times more likely to develop respiratory conditions compared to unexposed individuals. These results are consistent with global evidence linking PM pollution to reduced lung function, airway obstruction, and increased mortality from respiratory diseases (Ghosh et al., 2021).

The findings underscore an urgent need for environmental interventions and policy reforms in Bayelsa State. Immediate measures should include stricter air quality regulations, enforcement of industrial emissions control, and improved urban planning to reduce exposure to vehicular and industrial pollutants. Additionally, public health campaigns must raise awareness of pollution-related health risks, particularly in vulnerable communities. Expanding respiratory health screening programs and access to medical care is also critical in addressing undiagnosed respiratory conditions and reducing disease burden.

5. Conclusion

This study provides robust evidence of widespread air pollution exposure and its significant impact on respiratory health in Bayelsa State. Elevated levels of PM2.5, PM10, CO, NH_3, and NO_2 pose serious health risks, with exposure strongly linked to reduced lung function, increased respiratory symptoms, and a higher prevalence of respiratory diseases. The high statistical significance of pollution-health associations highlights the critical need for regulatory intervention, improved healthcare access, and targeted public health strategies. Without urgent action, the long-term health burden of pollution in Bayelsa State will continue to escalate, leading to increased morbidity and mortality from respiratory conditions.

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