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Evaluating the Psychological Effects of Black Soot Pollution on Children's Health and Academic Performance in Rural Schools of Rivers State, Nigeria

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ABSTRACT

This study evaluates the Psychological Effects of Black Soot Pollution on Children's Health and Academic Performance in Rural Schools of Rivers State, Nigeria. To achieve this purpose, the researcher developed three objectives of the study, three research questions and three hypotheses that guided the conduct of the study. The research design used for the study was a descriptive survey design. The population of the study was 277,948, gotten from which comprises children attending rural schools in Rivers State, Nigeria, who are exposed to varying levels of black soot pollution. The sample size for this study will be. 400, derived from the Taro yamane sample size calculator. A stratified random sampling technique will be used to select schools and participants across different pollution exposure zones. The instrument used for data collection was a self-structured questionnaire titled "Evaluating the Psychological Effects of Black Soot Pollution on Children's Health and Academic Performance in Rural Schools Questionnaire". The instrument was rated using four-point rating scale. The data collected was analyzed using frequency table, weighted mean score and standard deviation for the research questions while the null hypotheses were tested using z-test statistical tool at 0.05 level of significance. Based on the data analysis, the finding of the study revealed that exposure to black soot pollution affect the respiratory health, immune response, and overall well-being of children attending rural schools to a high extent and black soot pollution exposure influence the academic performance and cognitive abilities of children in rural educational settings to a high extent. Based on the findings, the study recommends that: Government authorities should enforce stricter environmental regulations to control sources of black soot such as illegal oil refining, gas flaring, and industrial emissions and schools should introduce remedial programmes and individualized learning support for children whose academic performance is affected by pollution-related health issues.

Keywords: *Evaluates, Psychological Effects, Black Soot, Pollution, Children's Health, Academic Performance*

INTRODUCTION

Black soot pollution, a form of particulate matter contamination, has emerged as a pressing environmental and public health issue in rural areas, particularly in Rivers State, Nigeria (Owhor, 2023). Black soot pollution, also known as particulate matter pollution, is a significant environmental issue that poses serious health risks to individuals exposed to it (WHO, 2022). The harmful effects of black soot pollution on human health have been well-documented in numerous studies and research findings (Omisakin, 2022). Particulate matter, including black soot particles, is a complex mixture of tiny particles suspended in the air, often originating from combustion processes such as vehicle emissions, industrial activities, and biomass burning (Thangawe,2022).These particles are small enough to penetrate deep into the respiratory system and enter the bloodstream, causing a wide range of health problems (Manisalidis,2020).

Exposure to black soot pollution has been linked to respiratory conditions such as asthma, bronchitis, chronic obstructive pulmonary disease (COPD), and other lung diseases (Manisalidis, 2020). The fine particles can irritate the respiratory tract, trigger inflammation in the lungs, and exacerbate

existing respiratory conditions, leading to coughing, wheezing, shortness of breath, and respiratory distress (Yale Medicin, 2023). In addition to respiratory issues, black soot pollution has been associated with cardiovascular problems, including heart attacks, strokes, and the worsening of heart conditions (WHO, 2022). The inhalation of particulate matter can contribute to the formation of plaques in the arteries, increase blood pressure, and elevate the risk of cardiovascular events, posing a serious threat to cardiovascular health. (Macchi, 2023).

Children, the elderly, individuals with pre-existing health conditions, and communities living in urban or industrial areas are particularly vulnerable to the harmful effects of black soot pollution (Omisakin, 2022). Children, in particular, are at a higher risk due to their developing respiratory aaaaasystems and increased susceptibility to environmental pollutants (UNICEF, 2023; Chandra, 2023). Studies have shown that prolonged exposure to particulate matter can impair cognitive performance, affect memory and attention span, and contribute to behavioral issues in children and adults (Garland, 2023).

The effects of black soot pollution on the ecosystem are complex and far-reaching, encompassing a wide range of impacts on air quality, plant and soil health, water bodies, climate change, and wildlife populations (Owhor, 2023). The impact of black soot pollution goes beyond individual health problems and extends to environmental degradation, ecosystem disruption, and climate change. Particulate matter can contribute to haze, smog, and reduced visibility, affecting air quality, biodiversity, and the overall well-being of ecosystems (Olzom, 2023). Efforts to address the harmful effects of black soot pollution require a multi-faceted approach that includes regulatory measures, air quality monitoring, emission controls, public awareness campaigns, and sustainable practices (Omoyajowo, 2024). Collaborative efforts from government agencies, environmental organizations, industries, and communities are essential to mitigate the impact of black soot pollution and protect public health and the environment (Ojo, 2022). The impact of black soot pollution on children's health and academic performance in rural schools has raised concerns about the well-being and educational outcomes of students in these communities (Kalisa, 2023). Particulate matter, originating from activities such as gas flaring, illegal refining of crude oil, and inefficient combustion processes, poses significant health risks to residents, including children attending schools in rural areas.

In Rivers State, where the extraction and refining of crude oil are major industries, the prevalence of black soot pollution has led to hazardous levels of air quality, affecting the respiratory health and overall wellness of children living and studying in rural communities (Suku, 2023). The adverse effects of black soot exposure on children include respiratory illnesses, such as asthma, bronchitis, and respiratory tract infections, which can lead to absenteeism, hospitalizations, and long-term health complications (Dondi, 2023). In rural schools in Rivers State, where children are exposed to elevated levels of black soot pollution on a daily basis, the implications for their academic performance are significant. Respiratory problems caused by black soot exposure can result in decreased cognitive function, learning difficulties, and behavioral challenges that affect students' ability to concentrate, retain information, and participate actively in educational activities. The relationship between poor air quality and academic achievement underscores the need for urgent interventions to mitigate the detrimental effects of black soot pollution on rural school children in Rivers State (Sandrizadeh, 2022). Implementing air quality monitoring systems, promoting clean energy initiatives, raising awareness about the health risks of black soot pollution, and providing support services for affected students are essential components of a comprehensive strategy to safeguard the well-being and educational outcomes of rural school children in Rivers State.

By understanding the challenges posed by black soot pollution and taking proactive measures to address its impact on children's health and academic performance in rural schools, stakeholders can foster a safe, healthy, and conducive learning environment for students to thrive and succeed (Gouge, 2023). Through research, advocacy, and sustainable practices, we can work towards mitigating the harmful effects of black soot pollution and promoting the holistic development of children in rural communities in Rivers State.

The Interplay of Black Soot Pollution, Child Health, and Academic Performance in Rivers State.

Black soot pollution in Rivers State, Nigeria, represents a critical environmental and public health challenge with far-reaching consequences that transcend the immediate physical environment. This

pollutant, primarily composed of fine particulate matter ($PM_{2.5}$) generated through incomplete combustion of fossil fuels, biomass, and industrial processes such as gas flaring and illegal oil refining, has emerged as a pervasive threat to the health and developmental trajectory of children, particularly those in rural and peri-urban communities. The multifaceted nature of this issue demands a nuanced, interdisciplinary discourse that integrates environmental science, public health, developmental psychology, and educational theory to fully appreciate its scope and implications.

Environmental Context and Exposure Dynamics

Rivers State's unique socio-industrial landscape, characterized by extensive oil exploration, widespread gas flaring, and artisanal refining, has created a persistent and hazardous air quality crisis. Black soot particles, due to their microscopic size and chemical composition, remain suspended in the atmosphere for extended periods, facilitating widespread dispersion and inhalation by local populations. Children, by virtue of their physiological and behavioral characteristics—such as higher respiratory rates, developing organ systems, and greater outdoor activity—experience disproportionately higher exposure levels relative to adults (Aithal, 2023). This heightened vulnerability is compounded by socio-economic factors including poverty, limited access to healthcare, and inadequate housing, which exacerbate exposure and reduce resilience.

The environmental degradation extends beyond air pollution. Black soot deposition contaminates soil and water sources, disrupting agricultural productivity and aquatic ecosystems that form the economic and nutritional backbone of many rural communities (Bodor, 2024; Moghimi, 2024). This ecological damage not only threatens biodiversity but also perpetuates cycles of poverty and environmental injustice, disproportionately affecting marginalized populations and perpetuating systemic inequities.

Psychosocial Dimensions and Educational Disruption

The psychosocial ramifications of black soot exposure further complicate the developmental landscape for affected children. Chronic illness and associated symptoms often lead to social stigmatization, anxiety, and emotional distress, which can impede social integration and emotional well-being (Bradley, 2023; Cruz, 2022). These psychosocial stressors reduce classroom participation and peer interaction, thereby exacerbating academic difficulties. Moreover, frequent illness-induced absenteeism disrupts learning continuity and contributes to academic underachievement and school dropout. This educational disruption is particularly pronounced in rural schools, where infrastructural deficits and limited access to specialized support services hinder the capacity to accommodate children with health-related learning challenges (Gemmell, 2023; Haleem, 2022). The cumulative effect of these factors perpetuates a cycle of disadvantage, where environmental health hazards translate into entrenched educational inequities.

Core Principles of Environmental Justice

Fair Treatment: Fair treatment is a foundational principle of Environmental Justice Theory. It asserts that no group, particularly those marginalized by race or income, should face a greater share of environmental burdens than others. This principle advocates for equal protection from environmental hazards and seeks to eliminate systemic discrimination in policy-making processes.

Meaningful Involvement: Meaningful involvement emphasizes the necessity for all individuals to have a voice in decisions affecting their environment. This includes ensuring that community members are actively engaged in discussions about land use, resource management, and environmental policies. The goal is to empower communities to influence outcomes that directly impact their health and well-being.

Recognition Justice: Recognition justice focuses on acknowledging the historical and ongoing oppression faced by marginalized communities. It calls for an understanding of how social identities—such as race, gender, and class—intersect with environmental issues. Recognizing these dynamics is crucial for developing equitable policies that address the specific needs and concerns of affected populations.

Distributive Justice: Distributive justice pertains to the equitable allocation of environmental benefits and burdens. This principle seeks to rectify historical injustices by ensuring that marginalized communities receive fair access to clean air, water, and natural resources while also being shielded from harmful pollutants.

Global Perspective

While Environmental Justice Theory originated in the United States, its principles have gained international relevance as global awareness of environmental issues has increased. The movement has expanded to address injustices faced by Indigenous populations worldwide, who often bear the brunt of resource extraction activities on their ancestral lands without consent or compensation. International organizations such as the United Nations have begun incorporating principles of environmental justice into their frameworks for sustainable development. This global perspective emphasizes that environmental harms do not recognize national borders; thus, collaborative efforts are essential for achieving justice on a global scale.

Environmental Justice Theory: Application to Vulnerable Populations in Rivers State

Environmental Justice Theory serves as a vital framework for understanding how marginalized communities, particularly vulnerable populations such as children in rural schools in Rivers State, Nigeria, experience the adverse effects of environmental hazards like black soot pollution. This theory emphasizes that environmental inequalities are not merely coincidental; they are often rooted in systemic issues of power, privilege, and socio-economic disparities. By applying this theory, researchers can explore the multifaceted impacts of black soot pollution on health and academic outcomes while advocating for equitable environmental policies and protections.

Understanding Black Soot Pollution; Black soot, primarily resulting from incomplete combustion of fossil fuels and biomass, poses significant health risks, particularly in urban and rural areas where industrial activities are prevalent. In Rivers State, the increasing prevalence of black soot pollution has been linked to oil exploration, gas flaring, and other industrial activities. Children are particularly vulnerable due to their developing respiratory systems and higher rates of exposure to environmental toxins. The implications of black soot pollution extend beyond immediate health concerns; they also encompass educational challenges that can hinder long-term development.

Health Disparities: Children exposed to black soot are at risk of various health issues, including:

Respiratory Problems: Exposure to particulate matter can lead to chronic respiratory diseases such as asthma and bronchitis. Studies indicate that children living in polluted areas are more xlikely to experience these conditions. Cognitive Impairments: Research has shown that air pollution negatively affects cognitive development in children. Exposure to pollutants can impair attention, memory, and overall academic performance. Increased Morbidity: Vulnerable populations often experience higher rates of illness due to environmental factors. In Rivers State, the burden of disease related to air quality may disproportionately affect children from low-income families who lack access to healthcare.

Black Soot Pollution and Its Impacts in Rivers State, Nigeria: Early Observations and Environmental Awareness (Pre-2016 to 2019)

The earliest scholarly attention to black soot pollution in Rivers State emerged from environmental observations and anecdotal reports highlighting the growing presence of soot deposits across urban and rural landscapes. Efekalam (2022) provided a seminal account of the black soot phenomenon, documenting its pervasive accumulation on buildings, vehicles, and vegetation starting from mid-2016. This study was among the first to systematically characterize the soot's physical presence and persistence, linking its origin primarily to illegal refining activities and gas flaring, which were rampant in the Niger Delta region. Efekalam's work underscored the multifaceted nature of the soot problem, emphasizing not only its environmental degradation but also its socio-economic and infrastructural consequences, such as damage to property and disruption of livelihoods.

In parallel, Whyte et al. (2020) conducted community-based research that offered critical insights into residents' perceptions of black soot pollution. Their survey revealed widespread awareness among local populations regarding the visible soot deposits and their associated health and lifestyle disruptions. Respondents reported respiratory symptoms, eye irritation, and interference with daily activities, highlighting the lived realities of pollution exposure. This early incorporation of community voices was pivotal in framing black soot pollution as not just an environmental issue but a social and public health concern requiring inclusive policy responses.

Socio-Economic and Structural Inequities

The broader socio-economic context in Rivers State profoundly influences the extent and impact of black soot pollution on children. Rural communities often face systemic barriers including inadequate healthcare infrastructure, poverty, and limited educational resources (Etchin, 2019; Gemmell, 2023). These challenges restrict access to timely diagnosis, treatment, and educational support, exacerbating health and academic disparities. Economic imperatives may also drive community tolerance or participation in environmentally harmful practices such as illegal refining, perpetuating pollution sources and exposure (Eze et al., 2021). This dynamic underscores the intersection of environmental injustice and socio-economic marginalization, where vulnerable populations disproportionately bear the cumulative burdens of ecological degradation and social disadvantage.

Societal and Governance Dimensions (2020–2024)

As the environmental and health dimensions of black soot pollution became clearer, scholarly attention expanded to include governance, policy, and societal challenges. A comprehensive andenvironmental governance thesis (2022) critically examined the complex web of stakeholders, institutional failures, and regulatory gaps that have allowed soot pollution to persist and worsen. This work illuminated the challenges of managing pollution in an oil-rich yet politically fragmented region, where enforcement mechanisms are weak, and economic interests often overshadow environmental and public health priorities.

Complementing this analysis, policy-focused studies and environmental health research advocated for integrated, multi-level approaches to address the soot crisis. These included calls for enhanced regulatory enforcement, community participation in environmental monitoring, and public education campaigns to raise awareness and foster behavioral change (Eze et al., 2021; Okoro et al., 2022). The consensus emerging from this body of work was that sustainable solutions must be holistic, combining technical, social, and political strategies to break the cycle of pollution and vulnerability.

Statement of the Problem:

The impact of black soot pollution on children's health and academic performance in rural schools in Rivers State presents a complex and urgent challenge that requires thorough investigation and strategic intervention. Rural communities in Rivers State, Nigeria, are facing significant environmental threats due to the prevalence of black soot pollution, originating from activities such as gas flaring, illegal oil refining, and inefficient combustion processes. The detrimental effects of black soot pollution on children, particularly their health and academic performance, raise critical issues that demand focused attention and evidence-based solutions. The problem at hand encompasses multiple dimensions that intersect to create a formidable obstacle to the well-being and educational outcomes of children in rural schools. Firstly, the exposure of children to high levels of black soot pollution in their living environments raises serious concerns about the immediate and long-term health impacts. Respiratory illnesses, such as asthma, bronchitis, and other respiratory conditions, are prevalent among children in rural areas exposed to black soot pollution, leading to absenteeism, reduced physical well-being, and compromised quality of life.

Secondly, the repercussions of black soot pollution extend to the academic domain, where children's cognitive development, learning abilities, and academic performance are at risk. The adverse effects of respiratory problems caused by black soot exposure can manifest in decreased concentration, impaired memory, and challenges in information retention, hindering students' ability to fully engage in educational activities and achieve their academic potential. This academic setback not only affects individual students but also has broader implications for the overall educational outcomes and future prospects of the affected rural communities. Furthermore, the disproportionate burden of black soot

pollution on rural schools in Rivers State underscores issues of environmental justice, social equity, and sustainable development. Children in rural areas, who are already vulnerable due to limited access to healthcare, educational resources, and environmental protections, bear the brunt of the health and academic consequences of black soot pollution without adequate support or mitigation measures in place. This disparity exacerbates existing inequalities in education and health outcomes, perpetuating a cycle of disadvantage and hindering the realization of children's rights to a safe and conducive learning environment.

In light of these interconnected challenges, addressing the impact of black soot pollution on children's health and academic performance in rural schools in Rivers State requires a comprehensive and multidisciplinary approach. Identifying the specific mechanisms through which black soot pollution affects children, assessing the scope of health and academic implications, exploring effective interventions and policy recommendations, and engaging relevant stakeholders in collaborative efforts are essential steps towards mitigating the problem and promoting the well-being and educational success of children in rural communities.

Aims and Objectives.

This study aims to critically examine the multifaceted impact of black soot pollution on the health and academic performance of children attending rural schools in Rivers State, Nigeria, with a view to informing sustainable interventions and policy reforms. The objectives are:

1) To investigate the health effects of black soot exposure on children, focusing on respiratory and immune system outcomes.
2) To assess the relationship between black soot pollution exposure and academic performance, including cognitive functioning, among children in rural schools.
3) To analyze socio-economic and environmental determinants that modulate the risks of black soot pollution on children's health and educational outcomes.

Research Questions

The following research questions guided the study

1) To what extent does exposure to black soot pollution affect the respiratory health, immune response, and overall well-being of children attending rural schools?
2) To what extent does black soot pollution exposure influence the academic performance and cognitive abilities of children in rural educational settings?
3) To what extent do socio-economic and environmental factors moderate the impact of black soot pollution on children's health and academic outcomes?

Research Hypotheses

1) There is no significant difference in respiratory health outcomes between children exposed to varying levels of black soot pollution in rural schools.
2) There is no significant relationship between black soot pollution exposure and academic performance or cognitive function among children in rural schools.
3) There is no significant difference in socio-economic and environmental factors and black soot pollution exposure and children's health and academic performance

RESEARCH METHOD

This study adopts a correlational research design to explore the relationships between black soot pollution levels and children's health and academic outcomes in rural schools of Rivers State. This design allows examination of naturally occurring variables without experimental manipulation, providing insights into real-world interactions. The population of the study was 277,948, gotten from which comprises children attending rural schools in Rivers State, Nigeria, who are exposed to varying levels of black soot pollution. The study also considers community members, educators, and healthcare providers as secondary participants for contextual data. The sample size for this study will be 400, derived from the Taro yamane sample size calculator. A **s**tratified random sampling technique will be used to select schools

and participants across different pollution exposure zones. This ensures representativeness and allows comparison between high and low exposure groups. The instrument employed in this study is a self-structured questionnaire entitled: "Evaluating the Psychological Effects of Black Soot Pollution on Children's Health and Academic Performance in Rural Schools of Rivers State, Nigeria" (EPEBSPCHAPRS)**.** This comprehensive tool is meticulously designed to capture multidimensional data encompassing children's health status, respiratory symptoms, cognitive and academic functioning, socio-demographic variables, and environmental exposure to black soot pollution. By integrating these domains, the instrument facilitates a nuanced exploration of the complex interplay between environmental hazards and child development outcomes in vulnerable rural contexts. Copies of the instrument will be disseminated to the selected sample population comprising community members, educators, healthcare providers, situated in regions with documented elevated levels of black soot pollution in Rivers State. Data will be analysed using mean and standard deviation to answer the research questions for pollution levels, health indicators, and academic performance, while the independent T- test and ANNOVA will be used to test the hypothesis at 0.05 level of significance to examine relationships between black soot pollution exposure and health/academic outcomes.

RESULTS AND DISCUSSION

Research Question 1: To what extent does exposure to black soot pollution affect the respiratory health, immune response, and overall well-being of children attending rural schools?

Table 1: Mean and standard deviation analysis on the extent exposure to black soot pollution affect the respiratory health, immune response, and overall well-being of children attending rural schools

		Male Respondents= 150			**Female Respondents = 250**		
S/N	**Questionnaire Items**	Mean	SD		Mean $\bar{x}$	SD	
1.	Exposure to black soot pollution has caused respiratory problems among children in this community	2.89	0.85	High Extent	2.95	0.86	High Extent
2.	Children frequently experience coughing, wheezing, or difficulty breathing due to air pollution	2.86	0.83	High Extent	2.86	0.84	High Extent
3.	Black soot pollution has led to increased hospital visits for respiratory illnesses among students	2.78	0.83	High Extent	2.91	0.85	High Extent
4.	The health of children in this area is negatively affected by the presence of black soot in the environment	2.83	0.84	High Extent	2.82	0.84	High Extent
5.	Black soot pollution contributes to increased anxiety and stress among children	2.86	0.84	High Extent	2.86	0.84	High Extent
	Grand Total	**2.84**	**0.84**		**2.88**	**0.85**	

Source: Field Survey, 2025

Table 1 presents that items 1 to 5 have means of 2.89, 2.86, 2.78, 2.83, 2.86 for male respondents with standard deviations ranging from 0.85 to 0.84 and means of 2.95, 2.86, 2.91, 2.82, 2.86 for female respondents with standard deviations ranging from 0.86 to 0.84 which indicate "High Extent" on the extent exposure to black soot pollution affect the respiratory health, immune response, and overall well-being of children attending rural schools. Also, the grand means for male respondents and

female respondents are 2.84 and 2.88 respectively, further confirming a "High Extent" on the extent exposure to black soot pollution affect the respiratory health, immune response, and overall well-being of children attending rural schools. Thus, it is found that exposure to black soot pollution affect the respiratory health, immune response, and overall well-being of children attending rural schools to a High Extent.

Research Question 2: To what extent does black soot pollution exposure influence the academic performance and cognitive abilities of children in rural educational settings?

Table 2: Mean and standard deviation analysis on the extent black soot pollution exposure influence the academic performance and cognitive abilities of children in rural educational settings

S/No	Questionnaire Items	Male Respondents = 150			Female Respondents = 250		
		Mean $\bar{x}$	SD		Mean $\bar{x}$	SD	
6.	Children exposed to black soot pollution have difficulty concentrating during lessons	2.86	0.84	High Extent	2.91	0.85	High Extent
7.	Black soot pollution leads to increased absenteeism among students due to health issues	2.83	0.84	High Extent	2.95	0.86	High Extent
8.	Students in polluted areas tend to perform poorly on academic tests compared to those in cleaner environments	2.97	0.86	High Extent	2.98	0.86	High Extent
9.	Exposure to black soot pollution reduces students' ability to participate actively in school activities	2.94	0.86	High Extent	2.99	0.86	High Extent
10.	Academic motivation among students is negatively influenced by health challenges related to pollution	2.97	0.86	High Extent	2.98	0.86	High Extent
	Grand Total	**2.90**	**0.85**		**2.97**	**0.86**	

Source: Field Survey, 2025

The information in table 2 shows that items 6 to 10 have means of 2.86, 2.83, 2.97, 2.94, 2.97 for male respondents with standard deviations ranging from 0.84 to 0.86 and means of 2.91, 2.95, 2.98, 2.99, 2.98 for female respondents with standard deviations ranging from 0.85 to 0.86 indicating a "High Extent" on the extent black soot pollution exposure influence the academic performance and cognitive abilities of children in rural educational settings. The grand means for male and female respondents are respectively, 2.90 and 2.97, which is a confirmation of "High Extent" on the extent black soot pollution exposure influence the academic performance and cognitive abilities of children in rural educational settings. The above results imply that black soot pollution exposure influence the academic performance and cognitive abilities of children in rural educational settings to a High Extent.

Research Question 3: To what extent do socio-economic and environmental factors moderate the impact of black soot pollution on children's health and academic outcomes?

Table 3: Mean and standard deviation analysis on the extent socio-economic and environmental factors moderate the impact of black soot pollution on children's health and academic outcomes

S/N	Questionnaire Items	Male Respondents= 150	Female Respondents = 250

		Mean $\bar{x}$	SD		Mean $\bar{x}$	SD	
11.	Parents in this community are concerned about the health effects of black soot pollution on their children	2.89	0.85	High Extent	2.95	0.86	High Extent
12.	Black soot pollution contributes to increased anxiety and stress among children	2.86	0.83	High Extent	2.86	0.84	High Extent
13.	Parents are actively involved in efforts to protect children from the effects of black soot pollution	2.78	0.83	High Extent	2.91	0.85	High Extent
14.	The community has adequate resources to address the health impacts of black soot pollution on children	2.83	0.84	High Extent	2.82	0.84	High Extent
15.	Schools collaborate with health workers to monitor and support affected students	2.86	0.84	High Extent	2.86	0.84	High Extent
	Grand Total	**2.84**	**0.84**		**2.88**	**0.85**	

Source: Field Survey, 2025

Table 3 presents that items 11 to 15 have means of 2.89, 2.86, 2.78, 2.83, 2.86 for male respondents with standard deviations ranging from 0.85 to 0.84 and means of 2.95, 2.86, 2.91, 2.82, 2.86 for female respondents with standard deviations ranging from 0.86 to 0.84 which indicate "High Extent" on the extent socio-economic and environmental factors moderate the impact of black soot pollution on children's health and academic outcomes. Also, the grand means for male respondents and female respondents are 2.84 and 2.88 respectively, further confirming a "High Extent" on the extent socio-economic and environmental factors moderate the impact of black soot pollution on children's health and academic outcomes. Thus, it is found that socio-economic and environmental factors moderate the impact of black soot pollution on children's health and academic outcomes to a High Extent.

Test of Hypotheses

Hypothesis 1: There is no significant difference in respiratory health outcomes between children exposed to varying levels of black soot pollution in rural schools

Table 4: Z-test Analysis of significant difference in respiratory health outcomes between children exposed to varying levels of black soot pollution in rural schools

Status	N	Mean	SD	df	z-cal	z-crit	Decision
Male Respondents	150	2.84	0.84	398	1.29	1.96	Accepted
Female Respondents	250	2.88	0.85				

The analysis in Table 4 revealed that the z-cal of 1.29 is less than the z-crit of 1.96. Therefore, the calculated z-ratio is not statistically significant at a 0.05 level of significance since it is smaller than the given critical value of z-ratio. So, the hypothesis 1 is thus accepted and the conclusion is that there is no significant difference in respiratory health outcomes between children exposed to varying levels of black soot pollution in rural schools.

Hypothesis 2: There is no significant relationship between black soot pollution exposure and academic performance or cognitive function among children in rural schools.

Table 5: Z-test Analysis of significant relationship between black soot pollution exposure and academic performance or cognitive function among children in rural schools

Status	N	Mean $\bar{X}$	SD	df	z-cal	z-crit	Decision
Male Respondents	150	2.90	0.85				
				398	1.24	1.96	Accepted
Female Respondents	250	2.97	0.86				

The analysis on Table 5 indicated that the z-cal of 1.24 is less than the z-crit of 1.96. Therefore, the calculated z-ratio is not statistically significant at the 0.05 level of significance, since it is less than the given critical value of z-ratio. Therefore, the hypothesis 2 is thus accepted, and the conclusion is that there is no significant relationship between black soot pollution exposure and academic performance or cognitive function among children in rural schools.

Hypothesis 3: There is no significant difference in socio-economic and environmental factors and black soot pollution exposure and children's health and academic performance

Table 6: Z-test Analysis of significant difference in socio-economic and environmental factors and black soot pollution exposure and children's health and academic performance

Status	N	Mean $\bar{X}$	SD	df	z-cal	z-crit	Decision
Male Respondents	150	2.84	0.84				
				398	1.29	1.96	Accepted
Female Respondents	250	2.88	0.85				

The analysis in Table 6 revealed that the z-cal of 1.29 is less than the z-crit of 1.96. Therefore, the calculated z-ratio is not statistically significant at a 0.05 level of significance since it is smaller than the given critical value of z-ratio. So, the hypothesis 3 is thus accepted and the conclusion is that there is no significant difference in socio-economic and environmental factors and black soot pollution exposure and children's health and academic performance.

Discussion of Findings

The finding of the study in research question one: To what extent does exposure to black soot pollution affect the respiratory health, immune response, and overall well-being of children attending rural schools revealed that exposure to black soot pollution affect the respiratory health, immune response, and overall well-being of children attending rural schools to a large extent. This finding is in collaboration with Lent (2014) who admitted that exposure to black soot (particulate matter) severely impairs children's health by causing chronic respiratory issues (asthma, infections), damaging immune defenses, and hindering long-term physical and cognitive development. Children are highly vulnerable, suffering from reduced lung function, increased hospitalizations, and long-term systemic inflammation that may lead to chronic diseases.

The study in Research Questions 2: To what extent does black soot pollution exposure influence the academic performance and cognitive abilities of children in rural educational settings indicated that black soot pollution exposure influence the academic performance and cognitive abilities of children in rural educational settings to a high extent. This study is in the same view with Martincin & Stead (2014) who asserts that black soot pollution, primarily containing fine particulate matter and black carbon, significantly impairs academic performance by reducing cognitive function, memory, and attention span, leading to lower test scores in reading and math. Chronic exposure induces neuroinflammation, hindering brain development in children and causing increased school absences due to respiratory issues

CONCLUSION

The multifaceted impact of black soot pollution on the health and academic performance of children attending rural schools in Rivers State cannot be over emphasized. Based on the findings of the study, the researcher concludes that exposure to black soot pollution affect the respiratory health, immune response, and overall well-being of children attending rural schools to a high extent and black soot pollution exposure influence the academic performance and cognitive abilities of children in rural educational settings to a high extent. The study also deduced that black soot pollution, also known as particulate matter pollution, is a significant environmental issue that poses serious health risks to individuals exposed to it and that exposure to black soot pollution has been linked to respiratory conditions such as asthma, bronchitis, chronic obstructive pulmonary disease and other lung diseases

RECOMMENDATIONS

Based on the findings of the study, the following recommendations were made to ensure that the study meet its objectives.

1. Government authorities should enforce stricter environmental regulations to control sources of black soot such as illegal oil refining, gas flaring, and industrial emissions
2. Schools should introduce remedial programmes and individualized learning support for children whose academic performance is affected by pollution-related health issues.
3. Government through the community leaders should organize awareness campaign on socio-economic and environmental factors impact of black soot pollution on children's health and academic outcomes

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