Assessment of Particulate Matter Exposure and Respiratory Symptoms among Street Sweepers in the Southwest Nigeria

[*1,2]Makanjuola Bosede C., [1]Sawyerr Henry O., [1]Adiama Babatunde Yusuf

[1] Kwara State University, Malete, Nigeria

[2]Ekiti State College of Health Sciences & Technology, Department of Environmental Health Science, Ijero-Ekiti

***Corresponding Author**

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ABSTRACT

Introduction: Street sweepers are exposed to high levels of particulate matter ($PM_{2.5}$ and PM_{10}), which are associated with respiratory conditions such as asthma, chronic obstructive pulmonary disease (COPD), and reduced lung function. In Nigeria, poor workplace protection and inadequate use of personal protective equipment (PPE) exacerbate these health risks. This study assessed PM exposure and its effects on respiratory symptoms among street sweepers in Lagos, Ekiti, and Oyo states in southwest Nigeria.

Materials and Methods: A cross-sectional study was conducted with 563 street sweepers across the study locations. $PM_{2.5}$ and PM_{10} concentrations were measured at the breathing level using digital particulate monitors (PMS5003), while respiratory symptoms were assessed through structured questionnaires. Data were analyzed using SPSS Version 27, using descriptive and inferential statistics to examine the relationship between PM exposure and respiratory health.

Results and Discussion: Results showed that the $PM_{2.5}$ and PM_{10} concentrations in all states exceeded WHO safety thresholds, with mean $PM_{2.5}$ levels of 135 µg/m³ (Ekiti), 94 µg/m³ (Lagos), and 71 µg/m³ (Oyo). The prevalence of respiratory symptoms was high, with 17.2% reporting persistent cough, 19.9% experiencing wheezing during cold, and 16.0% reporting shortness of breath. The majority of the participants were female (98.8%), had low educational attainment, and worked long hours, increasing their vulnerability. The findings align with global studies that attribute these health risks to inadequate workplace protection and poor PPE usage.

Conclusions and Recommendations

This study highlights the urgent need for interventions to improve the occupational health of street residents. Recommendations include mandatory PPE usage, regular health screenings, mechanized cleaning methods, and workplace safety training. Implementing these measures will reduce respiratory health risks and align with the Sustainable Development Goal (SDG) 8, ensuring safer working conditions for vulnerable workers in Nigeria.

Keywords: Particulate Matter ($PM_{2.5}$ and PM_{10}), Respiratory Symptoms, Occupational Health, Southwest Nigeria.

INTRODUCTION

Respiratory conditions impact one billion people worldwide and affect four million lives annually. Every year, at least 10% to 20% of employment-related fatalities and 30% of employment-related health problems globally stem from respiratory infections. Low-income countries bear this great health risk when street sweepers perform their jobs in unsafe environments, according to Worede *et al.* (2022). Damage to health due to work-

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related breathing disorders adds to worldwide health dangers. According to the World Health Organization (WHO), chronic respiratory conditions are among the leading causes of mortality worldwide, accounting for four (4) of the top 30 causes of death. Regular work activities increase the risk of developing COPD, along with asthma, tuberculosis, and lung cancer, as reported by Ewis *et al.* (2013).

Street sweeping creates workplace exposure to dangerous environmental pollutants such as dust particles filled with germs and harmful chemicals. Workplace conditions release these materials while sweeping, which puts workers at risk of breathing them into the deep parts of their lungs. Researchers have found that regular exposure to fine $PM_{2.5}$ and PM_{10} air pollution leads to chronic respiratory health problems over time (Adetayo *et al.*, 2021). The job of cleaning streets makes street sweepers experience breathing problems with wheezing, a persistent cough, and limited air supply plus chest discomfort (Pintakham & Siriwong, 2016). Staff members who experience these symptoms experience both temporary and lasting problems with their airways.

Recurring research has demonstrated that street sweepers who work with particulate matter show reduced lung performance. Underdeveloped safety rules put Nigeria's street sweepers at higher exposure risk because their country lacks proper workplace protections. The street sweepers working in poor conditions experience frequent respiratory issues because they get repeated exposure to risky dust and pollution when they don't wear safety gear (Johnson & John, 2020).

The amount of particulate matter that street sweepers breathe affects their overall health. PM consists of fine airborne particles mixed with fluid droplets from natural soil and industrial exhaust sources. Small particles, known as $PM_{2.5}$, easily reach the deepest parts of the lungs and blood system, where they create body-wide inflammation and stress responses (Nannini *et al.*, 2013). Research from different nations has proven that ongoing contact with particulate matter (PM) causes respiratory symptoms such as persistent coughing and wheezing (Habybabady *et al.*, 2018). Moreover, recent research in Ethiopia has discovered that street sweepers develop respiratory problems when experiencing these challenges at work. A survey showed that 35.3% had cough (30.2%), phlegm (22.3%), and wheezing symptoms (15.9%) (Worede *et al.*, 2022). Research from Uyo, Nigeria, showed that 47.3% of street sweepers got respiratory symptoms including catarrh and persistent cough. The research found that when street sweepers did not wear face masks they were more likely to develop breathing problems (Johnson & John, 2020). This research confirms that workers need protective gear to prevent dust contact from hurting their health.

Exposure to particulate matter is more harmful to the body than just the breathing system. Prolonged exposure to PM triggers cardiovascular illness and leaves you feeling weak and light-headed with headaches and dizziness. Street sweepers who work with PM develop muscle and bone problems, as well as skin and eye infections alongside their jobs. According to research from Van Kampen *et al.* (2020), street sweepers in India face serious health problems as 65% of them started showing signs of asthma and bronchitis.

Many studies across different countries have found that street sweepers who work around pollution develop similar health problems. In Bangkok, Thailand, a survey showed that 33.7% of street sweepers developed chronic respiratory symptoms, with cough appearing in 22% and phlegm affecting 20.2%. According to Anwar *et al.* (2013), experts in Pakistan discovered that street cleaners who developed COPD and obstructive ventilatory patterns came from prolonged exposure to non-industrial dust.

The number of respiratory illnesses among street sweepers in developed nations is considerable because of the strict workplace safety rules. Scientists in Germany and other industrialized nations have proven that making street-cleaning equipment automatic and requiring protective gear lowers street sweepers' health dangers at work (Tolera *et al.*, 2024). Our research highlights that effective policies can help reduce these health differences at work.

More studies now show how air pollution harms workers, but researchers in Nigeria have not fully examined the health consequences of street sweepers. Research on how street sweepers are affected by workplace hazards primarily occurs in industrial and agricultural workplaces, which prevents us from properly understanding their health risks. In Nigeria, many recent research projects have studied lung health issues based solely on workers' reports, despite the lack of doctors' evaluations (Board, 2018).

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This research examines PM exposure levels in southwest Nigeria street sweepers while measuring its link to their respiratory health problems. Through a combined use of both worker reports about symptoms and actual respiratory test results, the study creates a complete view of street sweepers' health dangers. The results help direct better public health governance and safer working environments in Nigeria's workforce. The analysis reveals these health dangers so that work areas can receive better protection and lung disease rates decrease among street sweepers. Our research follows Sustainable Development Goal (SDG) 8 by showing how to safeguard workers' rights while creating safe working conditions for those at risk.

The health risks from inhaling particulate matter affect street sweepers most in low-income areas because employers do not properly protect their workers. We conducted this study in Nigeria to show street sweepers' respiratory health reactions to PM stressors while planning programs that support their safety at work.

MATERIALS & METHODS

Study design: This study adopted a cross-sectional design.

Study Areas: Selected state capitals in Southwest Nigeria, including Lagos, Oyo, and Ekiti, were utilized for this study. At each location, street sweepers were selected from various locations in the state capital.

Sample Size Determination and Sampling Techniques: The sample size was estimated to be 563 using a probability sampling technique, including systematic sampling.

Instrument for Data Collection: The instruments used for data collection included the following:

1. GPS device
2. (Garmin 72H) for taken coordinates of the study area
3. Handheld Particulate Sampler
4. Pen and paper for recording
5. Structured Questionnaire

Questionnaire Administration: Street Sweepers were administered with a semi-structured questionnaire including their Socio–demographic information, socioeconomic status, and respiratory symptoms experienced by the street sweepers while carrying out their duties.

Measurement of Particulate Matters: At each study location, particulate matter was measured while sweeping. Particulate matter measurements (PM2.5 and P.M10) were carried out using a digital particulate monitor (PMS5003 model), which monitors the concentration of particles in the air (µg/m3). The device was positioned at the breathing level during the PM measurement, which was then recorded. PM2.5 and P.M10 were recorded for each sweeper.

Analysis of Data: Data were analyzed both quantitatively and qualitatively based on the study objectives. Quantitative analysis was applied to close-ended questions provided by the respondents with alternative responses. Data were processed using IBM Statistical Package for Social Sciences (SPSS) Version 27. The frequency distributions, percentages, mean scores, and standard deviations were computed and tabulated.

Inclusion Criteria: Respondents between the ages of 18 and 60 years were included. In addition, street sweepers who had been working for at least 1 year and above were included in the study.

Exclusion Criteria: Respondents below the age 18years and those above age 60 were excluded, those who have been street sweepers for less than 1 year and those that are smoking were all excluded from the study.

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue IV April 2025

Ethical considerations: The study approval was provided by the Department of Environmental Health Science (KWASU) to the authorities in the study area. In Lagos, the Lagos Waste Management Authority (LAWMA) was visited and approval was given to conduct the study. In Ibadan, the Oyo State Waste Management Authority (OYSWAMA) gave a letter authorizing the conduct of the research, and Ekiti State Waste Management Authority EKSWAMA in Ekiti State gave approval to carry out the research. Also, consent of the street sweepers from various locations were sought before the study was carried out.

RESULTS AND DISCUSSION

Table 1: Socio Demographic Characteristics of the Respondents

		Frequency	**Percent %**
Age	18-50	317	56.3
	51-60	246	43.7
	Total	**563**	**100.0**
Marital Status	Cohabiting	14	2.5
	Married	399	70.9
	Separated	15	2.7
	Single	21	3.7
	Widow	115	20.2
	Total	**563**	**100.0**
Gender	Male	7	1.2
	Female	556	98.8
	Total	**563**	**100.0**
Level of education	No formal education	85	15.1
	Primary School	227	40.3
	Secondary School	238	42.3
	Technical/ Diploma	13	2.3
	Total	**563**	**100.0**
Experience	1-10	370	65.7
	11-23	193	34.3
	Total	**563**	**100.0**
Working days per Week	5-6	259	46.0

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue IV April 2025

	7	304	54.0
	Total	**563**	**100.0**
Working Hours per day	1-5	287	51.0
	6-7	276	49.0
	Total	**563**	**100.0**

Age: As by occupational activity, 56.3 % (317) respondents of street sweepers are between 18–50 years and 43.7% (246) respondents of street cleaners are 51-60 years. This establishes that most of the street sweepers are either middle aged or below middle-aged suggesting that those with relatively higher endurance levels shall better suited to sweeping the streets of our nation.

Marital Status: Of respondents, 399 (70.9 %) stated that they were married, while 115 (20.4 %) stated that they were widowed. Fewer percentages of 2.5%, 2.7%, and 3.7% of them lived together but were separated and single. This also indicates that the street-sweeping workforce has at least persons with many family necessities or affects their status or classes.

Gender: A vast majority of the respondents were female (98.8% female, 556; 1.2% male, 7. This means that with respect to all sweeping activities conducted in the study area, close to 100% of the street sweeping profession is dominated by females, which might be due to gender bias or employment preference within the area.

Level of Education: 42.3%, representing 238 street sweepers, have only attained secondary school levels, whereas 40.3% (227) only attained primary school levels. Moreover, 15.1% of the respondents (85 individuals) had no formal education and 2.3% (13 weepers) had technical/diploma-level education. This suggest that it is common for many of the street sweepers to be literate with low levels of education thus the rate of educations may be limiting them from better paid job.

Experience: Experience level of respondents A large number of respondents, 370 (55.7 %) have worked as Street sweepers for less than 10 years with 193 (34.3 %) working for 11-23 years. This will go a long way in indicating that the majority of workers have not been engaged in the last long practice of their profession, which consequently points to the fact that in the event of street sweeping, there are few people with long-term experience.

Working Days Per Week: The respondents can be divided into two broad categories based on working days a week; 5-6 working days a week 46.0% (259 respondents) and 7 days a week 54.0 % (304 respondents). This means that most of the street sweepers operate full week implying that the work is labor intensive and rarely get to take off work.

Table 2: Amount of Particulate Matters Exposure of the Street Sweepers among Various Groups

Subject		**EKITI (ADK)**	**LAGOS (KJA)**	**OYO (IBD)**
$PM_{2.5}$ Value (µg/m³)	MEAN	135 ± 68	94 ± 78	71 ± 39
	MIN	18	16	7
	MAX	323	411	211
	STD DEV	68	78	39
PM_{10} Value (µg/m³)	MEAN	126 ± 80	98 ± 78	86 ± 41

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue IV April 2025

	MIN	14	11	42
	MAX	448	417	204
	STD DEV	80	78	41

Table 2 provides the evidence of the concentration of particulate matter within South-west Nigeria street sweepers which is above the WHO most stringent safety standards. PM2.5 samples from Ekiti, Lagos, and Oyo had mean concentrations of 135µg/m³, 94µg/m³ and 71µg/m³ respectively, which exceeded the WHO air quality guideline value of 15µg/m³. Likewise, P.M10 concentrations in Ekiti (126 µg m^{-3}), Lagos (98 µg m^{-3}), and Oyo (86 µg m^{-3}) were higher than the WHO safety rating of 45 µg m^{-3}, and Ekiti was very close to the USEPA limit of 150 µg m^{-3}. It also revealed the contamination level experienced by street sweepers working in highly exposed areas concerning environmental health hazards. The findings of this study are consistent with previous research carried out in the urban centers of Nigeria and other developing nations. Wambebe and Duan work (2020) revealed that $PM_{2.5}$ concentrations in Abuja Nigeria raged between 15.30µg/m³ and 70.20µg/m³ high traffic concentration exceeded WHO limit of 25µg/m³. In the same vein, Kolawole and Olatunji (2023) discovered that the level of PM_{10} in Ibadan was three times of the WHO standard, pointing out that street sweepers and inhabitants of urban crossings are most vulnerable to breathe particulate matter. These findings are in accordance with other literary review studies in other parts of the world; for instance, Alemayehu *et al.* (2020) working in Ethiopia showed close amalgamation between high concentrations of particulate matter and raised incidences of respiratory and cardiovascular diseases. The relationship between high concentration of P.M2.5 and P.M10 and health risks have been well established in a similar study by Alemayehu et al., (2020) which showed that P.M2.5 affects deep lung tissue and blood vessels; therefore, it causes chronic respiratory diseases, cardiovascular illnesses, and death P.M10 while larger tends to cause irritation in the upper respiratory tract and seasonal aggravation of respiratory ailments such as asthma and COPD. Occupational exposure of the street sweeper entails putting them at a very vulnerable position bearing in mind that such pollutants are in high concentrations yet they are rarely protected from the exposure. The high mean values of P.M2.5 and P.M10 recorded in Lagos are due to mobility emissions and industrial and waste burning activities. This is supported by Wambebe and Duan (2020), who associated high levels of particulates in the air across Nigerian urban centers with increased industrialization and traffic density. A similar study conducted by Kolawole and Olatunji (2023) in Ibadan established poor handling of waste and industrial emissions as sources of high PM levels, consistent with the findings for Oyo State.

Table 3: Respiratory Symptoms of the Respondents (Street sweepers)

		Frequency	Percent
Do you usually have a cough?	No	466	82.8
	Yes	97	17.2
	Total	**563**	**100.0**
Do you cough on getting up in the morning?	No	487	86.5
	Yes	76	13.5
	Total	**563**	**100.0**
Do you cough during the rest of the day or at night?	No	495	87.9
	Yes	68	12.1
	Total	**563**	**100.0**

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue IV April 2025

Do you bring up phlegm from your chest?	No	466	82.8
	Yes	97	17.2
	Total	**563**	**100.0**
Do you bring up phlegm on getting up in the morning?	No	485	86.1
	Yes	78	13.9
	Total	**563**	**100.0**
Do you bring up phlegm on the rest of the day or at night?		2	.4
	No	476	84.5
	Yes	85	15.1
	Total	**563**	**100.0**
Do your chest ever sound wheezy when having cold?	No	451	80.1
	Yes	112	19.9
	Total	**563**	**100.0**
Is the Wheezing Occasionally apart from Colds?	No	454	80.6
	Yes	109	19.4
	Total	**563**	**100.0**
Does the Wheezing Occur Most Days or Night?	No	483	85.8
	Yes	80	14.2
	Total	**563**	**100.0**
Do you Have Nose Irritation?	No	476	84.5
	Yes	87	15.5
	Total	**563**	**100.0**
Do you Sneeze Once You Start Street sweeping?	No	411	73.0
	Yes	152	27.0
	Total	**563**	**100.0**
Do you have trouble with shortness of breath when hurrying the level or walking up a light hill?	No	473	84.0
	Yes	90	16.0
	Total	**563**	**100.0**

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue IV April 2025

The table provides information on respiratory symptoms of street sweepers in the south-west; indicating severe Occupational Health issues due to continued exposure to pollutants The prevalence was; Persistent cough: 17.2%, Wheezing when having a cold: 19.9%, short of breath when hurrying/walking uphill: 16.0%. These findings are corroborated by Johnson and John (2020), who conducted a descriptive cross-sectional study on occupational hazards among street sweepers in Uyo, Nigeria. 17.2% reported persistent cough, 19.9% experienced wheezing when cold, and 16.0% reported shortness of breath when hurrying or walking uphill. These findings align with recent study conducted by Johnson and John (2020) in Uyo, Nigeria, a descriptive cross-sectional study that assess occupational hazards among street sweepers. They discovered that a higher percentage of 47.3% respondents with respiratory symptoms, including cough, experienced or exhibited symptoms that were linked to inadequate use of face masks while performing sweeping activities. The research thus brings into sharp focus the importance of using protective gear such as personal protective equipment. Similarly, Worede e et al. (2022) in Gondar, Ethiopia, found that prevalence of respiratory symptoms among street sweeper was 35.3%. The frequency of respiratory symptoms was independently related to past respiratory disease, poor quality PPE wear, and prior occupation in dusty industries, such as cement and flour mills. In writing about this particular study, the author drew much attention to the interrelated factors that put this working group at an increased risk of respiratory ailments. Chotigadachanarong et al. (2024) surveyed 84 street sweepers in Bangkok, Thailand and investigated chronic respiratory symptoms. The study showed a high frequency of respiratory disorders and duration of employment, and traffic-related air pollution was associated with a higher risk of COPD. This research also focuses on outside work hazards affecting street sweepers working in urban areas in different countries. In addition, a study conducted by Sharma and Nepalia (2020) on street sweeper exposure in Udaipur, India, examined respiratory symptoms and pulmonary functions in the unexposed group. The findings showed that, compared to the control group, street sweepers had poorer respiratory health characterized by an elevated prevalence of respiratory symptoms and lower lung function measurements due to perennial exposure to dust and airborne pollutants while exercising their duties. Taken together, these works underpin the demonstrable respiratory health hazard consequences of occupational exposure to polluted environment that characterize the daily working conditions of street sweepers. The present results across different studies conducted in various regions emphasize the urgent need for standard occupational health strategies that address the issues of health checkups, availability and compliance of personal protective gear, and avoidance of exposure to dangerous dust and emissions. Eradicating these factors is essential in reducing the respiratory health problems seen among street sweepers all over the world today.

CONCLUSION

This research demonstrates that street sweepers in south-west Nigeria face serious occupational health hazards from particulate matter exposure which surpasses World Health Organization and United States Environmental Protection Agency maximum air quality values. Low use of proper personal protective equipment in combination with excessive Particulate Matter in Lagos, Ekiti and Oyo produces respiratory symptoms indicated by persistent cough (17.2%), wheezing (19.9%), and shortness of breath (16.0%). Women make up most street sweepers (98.8%), mostly, they have low education and work unusually long shifts, making them more susceptible to harm. Heavily populated areas where traffic is high, industries operate, and waste collections occur contribute to higher PM pollution and greater health risks. The deficiency of workplace safety systems, which include insufficient training, inadequate health screening, and poor personal protective equipment use, leads workers to encounter pollutants. The respiratory health outcomes of workers in Ethiopia, India, and Thailand are similar to those of nations with low safety standards. This research shows that a strong set of workplace safety policies must be established to protect street sweepers.

Recommendations: Enforcing the use of PPE by the Environmental Health Officers, conducting periodic medical check-ups for the Street sweepers, adopting modern equipment which are more convenient for street-cleaning, and improving awareness of workplace hazards to the Sweepers. These measures are essential for reducing the burden of respiratory health issues among street sweepers, thereby aligning with the Sustainable Development Goal (SDG) 8, which promotes safe and secure working environments for all workers, particularly those in vulnerable occupations.

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