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Evaluation of Haematological and Haemorrheological Changes in Street Cleaners in Benin City

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Abstract

Aim/Objective: Occupational exposure to environmental pollutants poses significant health risks, particularly for street cleaners who are routinely exposed to dust, vehicle emissions, and other contaminants. This aim of this study was to evaluate the haematological and haemorrheological changes among street cleaners in selected environs of Benin City, Edo State, Nigeria. **Methodology:** A total of 100 participants, comprising 50 street cleaners and 50 age- and gender-matched controls, were recruited using a simple random sampling technique. Sociodemographic and occupational data were obtained via structured questionnaires. Venous blood samples were collected under aseptic conditions for analysis of complete blood count, erythrocyte sedimentation rate (ESR), and plasma fibrinogen concentration using automation, Westergren method and Clauss method respectively. **Results:** Findings indicated that street cleaners in Benin City were slightly older (35.84 ± 8.09 years) than controls (33.84 ± 4.21 years), with a predominance of males in both groups (88.0% vs. 80.0%). Most street cleaners had 1 - 5 years of work experience and worked 4 - 8 hours per day, 3 - 5 days per week. Use of personal protective equipment (PPE) varied, with only 36.0% always using PPE, although all participants had access to water and soap for hand hygiene. Haematological analysis revealed no significant difference between WBC counts in street cleaners ($5.25 \pm 0.18 \times 10^3/\mu L$) and control ($5.37 \pm 0.19 \times 10^3/\mu L$) ($p < 0.05$). Red blood cell (RBC) counts were significantly lower in street cleaners ($3.92 \pm 0.07 \times 10^{12}/L$) relative to controls ($5.26 \pm 0.08 \times 10^{12}/L$, $p < 0.001$). Haemoglobin (HGB) levels were also reduced in street cleaners (11.45 ± 0.17 g/dL) than control (13.80 ± 0.26 g/dL) ($p < 0.001$). Red cell indices, including MCV, MCH, MCHC, and RDW, were significantly higher in street cleaners, whereas platelet counts and mean platelet volume (MPV) were lower. ESR levels were significantly higher among street cleaners (17.92 ± 1.50 mm/hr) com-

pared to controls (5.78 ± 0.51 mm/hr) ($p < 0.001$), and fibrinogen concentrations were also elevated in street cleaners (460.68 ± 14.88 mg/dL) relative to controls (286.88 ± 6.83 mg/dL) ($p < 0.001$). Correlation analysis showed that fibrinogen and ESR had strong negative correlation with RBC, HGB, and HCT ($p < 0.05$). However, ESR and fibrinogen were strongly positively correlated with each other. **Conclusion:** Street cleaning in Benin City is associated with significant hematological and haemorrheological alterations in street cleaners likely driven by chronic exposure to environmental pollutants, systemic inflammation, and oxidative stress.

Keywords

Street Cleaners, Haematology, Haemorheology, Erythrocyte Sedimentation Rate, Fibrinogen, Occupational Exposure

1. Introduction

Solid waste management includes the collection, transport, deposition, treatment and recycling of waste produced by individual households, public institutions and workplaces [1]. Street cleaning is an integral part of the solid waste management system and an important duty to ensure a clean environment. Specific challenges significantly differ around the world. The increasing population, especially in Africa, Asia and South America, has resulted in severe pressure on urban land, urban utilities and services. In those areas, a major goal is the prevention of transmission of infectious diseases, and this is why street sweepers play an important role in maintaining health in the communities [2]. For waste collectors and compost workers, the activities and their influence on occupational health have been described in some European studies [3]. Waste collectors usually pick up waste from its point of production, empty refuse containers onto trucks, and deliver the waste to disposal and processing facilities [4]. Benin City, the largest urban center in Edo State, in southern Nigeria houses much of the challenges of waste disposal issue and indiscriminate dumping, thus far, described. Many of its suburbs (*i.e.*, including residential areas and public places) are littered with domestic and sewage waste, garbage, and chemical waste [5]. Industrial operation is characterized by the generation of large volume of waste in the form of solid, liquid and gas. As a result, the Edo State Waste Management Board (EWMB), established by the local authorities, put in place a monitoring program to regulate environmental quality and implement steps towards a waste-free society. Despite its efforts, Benin City still falls short of achieving Board benchmark levels and ongoing waste management practices are needed. Street cleaners play a major role in cleaning the environment [6].

Less is known about the hazards and health effects of street cleaning, and there are no general regulations in this field. Like waste and compost workers, street cleaners are physically stressed and exposed to bioaerosols, which can cause mus-

culoskeletal and respiratory symptoms. When cleaning public facilities or emptying garbage cans, they may suffer from cut injuries, skin irritations and infections. Because they mostly work outdoors, they are exposed to cold, wind or heat [7]. Environmental/traffic pollution (dust, particulate matter, ozone, carbon monoxide, nitrogen oxides) and natural UV exposure have to be taken into account as well. In most countries, regardless of whether these are developing, emerging or industrialized countries, street cleaning is predominantly done by hand sweeping by an individual worker or a group. Sweeping can be done with push brooms, as is often the case in developing countries, or mechanically, e.g., by using leaf blowers. However, street cleaners also work with sweepers, machines and mowers or gritting vehicles. In general, activities of street cleaners and the associated health hazards seem to be very complex. According to a study by [8], street sweeping is one of the most popular occupations of less privileged people in India. Also in a Nigerian study, about 30% of street sweepers never had any formal education [2]. Most of the street cleaners have little knowledge on occupational health hazards and safety, e.g., regarding the transmission of infections [9]. While developed countries take measures to prevent occupational health hazards, this is not the case in developing countries [8]. In Nigeria, street sweepers often use only short-handled brooms and take no precautionary measures, such as wearing face masks or sprinkling water on the street before sweeping, to minimize dust exposure [2].

Haematology is a branch of medical science concerned with the study of the blood, its cellular components, and the blood-forming organs. It focuses on analyzing the quantity and structural characteristics (morphology) of the different blood cells, which include red blood cells (also known as erythrocytes), white blood cells (leucocytes), and platelets (thrombocytes). Haematological investigations are necessary for identifying a wide range of disorders, including infections, anaemia, blood cancers, and clotting abnormalities. They also serve to evaluate the extent of physiological or pathological damage to the blood system [10]. They are reliable indicators of an individual's overall health and physiological status.

Haemorrheology is the study of how blood flows through the vessels, focusing on the physical and mechanical properties of blood and its components, especially red blood cells and plasma. Two key haemorrheological parameters are fibrinogen and erythrocyte sedimentation rate (ESR) [11]. Fibrinogen is a plasma protein that plays an important role in blood clotting and significantly affects blood viscosity. High levels of fibrinogen are often linked to inflammation and an increased risk of cardiovascular disease [12]. ESR measures how quickly red blood cells settle at the bottom of a test tube in one hour, serving as a general marker of inflammation in the body [13]. For street cleaners, who are regularly exposed to dust, pollutants, and harmful environmental agents, these parameters can be particularly relevant. Prolonged exposure to such conditions can trigger inflammatory responses in the body, which may be reflected in elevated fibrinogen levels and ESR. Regular monitoring of these indicators in street cleaners can help assess their health status and

identify any early signs of inflammation or other health risks [1].

In Benin City, Edo State, street cleaners often work long hours under challenging conditions, with limited access to personal protective equipment (PPE) or health monitoring services [14]. Given their constant exposure to various environmental pollutants, it is imperative to investigate the potential impact on their haematological and haemorheological profiles. Such an investigation can provide crucial insights into the health risks faced by this vulnerable occupational group and inform public health interventions.

2. Materials and Methods

2.1. Study Area

The study was conducted in Benin City, Edo State, Nigeria, focusing on street cleaners operating in selected environs, including Uselu, Ugbowo, Oluku, Ekenwan, and their surrounding areas. Benin City comprises three Local Government Areas; Egor, Oredo and Ikpoba-Okha Local Government Areas respectively, with a population of 1,086,882 people. Benin City is bounded to the west by Ovia North East Local Government Area and the North-East by Uhunmwuode Local Government Area and South by Ethiope-West Local Government Area of Delta State. Benin City is known for its dense urban population engaged in various economic activities, including waste management and maintaining a serine environs.

2.2. Study Population

The study population comprised of street cleaners working in the selected environs of Benin City and the surrounding areas with the responsibility of maintaining clean streets, roads and environment in general. A control group matched for age and gender but without occupational exposure to street cleaning was recruited for comparative analysis.

2.3. Study Subjects

In this study, a total of one hundred (100) adult street cleaners working in Uselu, Ugbowo, Oluku, Ekenwan, and the surrounding environs of Benin City were recruited. Only individuals who had been actively engaged in street cleaning for at least six months and who voluntarily consented to participate were included in the study. Both male and female street cleaners aged 18 years and above were considered eligible.

2.4. Questionnaire/Informed Consent

A structured questionnaire was administered to all participants. This study utilized a pre-tested 26 items questionnaire to obtain information about the refuse, its disposal and effects on environment The questionnaire pretested in a sample (N = 10 participants took part in the pretest), and necessary adjustment was made to suit the study aim and objectives. A thorough review of entire questionnaire was done by senior research colleagues to ascertain its validity. The questionnaire

was segmented into three sections (A-B) with sub questions. Section A (social demographic) consisted of questions designed to elicit details about their personal data, sex, age, marital status, educational qualification, alcohol consumption and cigarette smoking. Section B (effect of refuse on environment) comprises of questions on what is the effect of refuse on the environment? Mode of refuse disposal? Effect of refuse on human health?

2.5. Selection Criteria

2.5.1. Inclusion Criteria

1) Street cleaners aged 18 years and above working in Uselu, Ugbowo, Oluku, Ekenwan, and the surrounding environs of Benin City.

2) Individuals who have been actively engaged in street cleaning for at least six months.

3) Street cleaners who voluntarily provide informed consent to participate in the study.

4) Workers who are apparently healthy and without a history of chronic hematological or cardiovascular disorders.

2.5.2. Exclusion Criteria

1) Individuals below 18 years of age.

2) Street cleaners who have been employed for less than six months.

3) Workers with known chronic illnesses such as anemia, hypertension, diabetes, or bleeding disorders that may affect hematological or haemorheological parameters.

4) Those who decline to provide consent or are unwilling to participate.

5) Individuals currently on medications that could influence blood parameters, such as anticoagulants or hematopoietic drugs.

6) Pregnant or lactating women.

2.6. Sample Size Determination

Sample size was determined using single population proportion estimate considering the level of significances at 5% and the prevalence of occupational hazard from street cleaning from a previous study conducted which was 94% [15].

The sample size for this study was obtained using Formula as described in a study by Nyirarukundo *et al.* (2025) [16].

$$\text{Sample size} = \frac{Z^2 P(1-P)}{d^2}$$

N = required sample size

Z = confidence level at 95% (standard value of 1.96)

P = Prevalence of occupational hazard from street cleaning (94% = 0.940)

D = margin of error at 5% (standard value = 0.05)

$$N = \frac{1.96^2 \times 0.940(1-0.940)}{0.05^2} = 87$$

2.7. Ethical Approval

Ethical approval was sought and obtained from the Research and Ethics Committee of the Ministry of health, Edo State.

2.8. Sample Collection

Under aseptic conditions, approximately 5 milliliters of venous blood were collected from the antecubital vein of each study participant using a sterile needle and syringe. Three milliliters (3 ml) of the blood were dispensed into an ethylene diamine tetra-acetic acid (EDTA) container for full blood count (FBC) and erythrocyte sedimentation rate (ESR) analysis. The remaining 2 ml was dispensed into sodium citrate container and then centrifuged at 4000 rpm for 5 minutes to separate the plasma. The plasma obtained was used for fibrinogen determination. All samples were handled carefully to maintain integrity and prevent hemolysis prior to laboratory analysis.

3. Laboratory Analysis

3.1. Full Blood Count

The Complete blood parameters were analysed immediately after sample collection using the automated three parts ERMA Haematology Auto analyser PCE-210N (Diamond Diagnostic; Holliston, USA). Calibration and standardization of the equipment, processing and analysis of the samples were done strictly according to the manufacturer's instructions.

3.2. Erythrocyte Sedimentation Rate (ESR)

The erythrocyte sedimentation rate (ESR) was measured using Westergren methods.

3.3. Fibrinogen Concentration-Clauss Method

The Clauss method measures plasma fibrinogen concentration based on the time it takes for a clot to form when a high concentration of thrombin is added to diluted plasma. The clotting time is inversely proportional to the fibrinogen concentration: shorter clotting times indicate higher fibrinogen levels, while longer times indicate lower levels.

4. Results

The mean age of the control group was 33.84 ± 4.21 years, while street cleaners were slightly older with a mean age of 35.84 ± 8.09 years. In terms of age distribution, almost half of the controls (48.0%) were between 21 - 30 years, whereas the largest proportion of street cleaners (36.0%) were in the 31 - 40 years' group. Males predominated in both groups, representing 80.0% of controls and 88.0% of street cleaners, with females accounting for 20.0% and 12.0%, respectively. Regarding marital status, half of the controls were single (50.0%) compared to 30.0% of street

cleaners, while marriage was more common among street cleaners (66.0%) than controls (44.0%); small proportions in both groups were divorced, and only the control group recorded widows (2.0%). Educational attainment varied across groups, with more controls (56.0%) attaining tertiary education compared to street cleaners (26.0%), while secondary education was most common among street cleaners (58.0%) and controls (36.0%). Religion was dominated by Christianity in both groups, accounting for 80.0% of controls and 92.0% of street cleaners; Islam was reported by 14.0% of controls and 8.0% of street cleaners, while traditional religion was observed only among controls (6.0%) (Table 1).

Table 1. Sociodemographic parameters of control participants and street cleaners.

Parameters	Control (%) (n = 50)	Street Cleaners (%) (n = 50)
Mean Age	Mean age = 33.84 ± 4.21	Mean age = 35.84 ± 8.09
Age (Years)		
21 - 30	24 (48.0)	16 (32.0)
31 - 40	15 (30.0)	18 (36.0)
41 - 50	7 (14.0)	14 (28.0)
51 - 60	4 (8.0)	2 (4.0)
Gender		
Male	40 (80.0)	44 (88.0)
Female	10 (20.0)	6 (12.0)
Marital Status		
Single	25 (50.0)	15 (30.0)
Married	22 (44.0)	33 (66.0)
Divorced	2 (4.0)	2 (4.0)
Widowed	1 (2.0)	0 (0)
Education		
None	0 (0)	0 (0)
Primary	4 (8.0)	8 (16.0)
Secondary	18 (36.0)	29 (58.0)
Tertiary	28 (56.0)	13 (26.0)
Religion		
Christianity	40 (80.0)	46 (92.0)
Islam	7 (14.0)	4 (8.0)
Traditional	3 (6.0)	0 (0)

Gloves (64%) and boots (70%) were the most frequently worn items, while goggles (20%) were the least utilised. Face/nose masks were worn by 56% of street

cleaners, with only 12% reporting no PPE use at all (Figure 1). Household waste (90%) and dust/sand (80%) were the most frequently encountered waste categories, followed by animal waste (36%) and medical waste (30%). Industrial/chemical waste (20%) and glass/sharps (16%) were less commonly reported, while human waste (24%) was also noted (Figure 2).

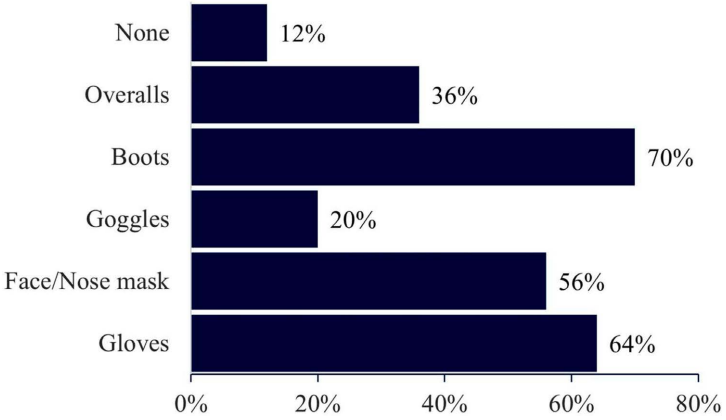


Figure 1. Use of personal protective equipment by street cleaners.

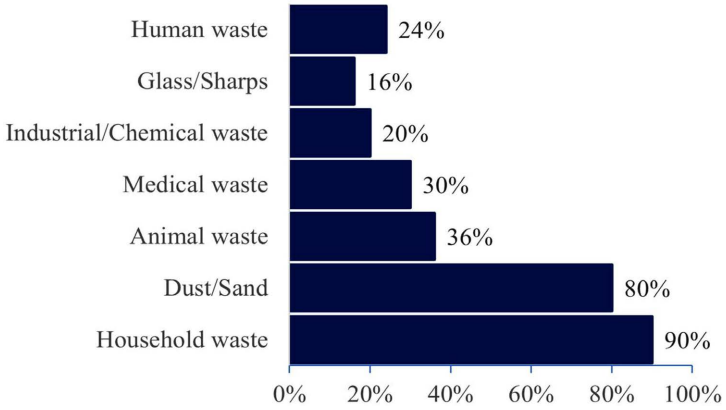


Figure 2. Type of wastes handled by street cleaners.

Among the street cleaners, 20.0% had worked for less than 1 year, 40.0% for 1 - 5 years, 28.0% for 6 - 10 years, and 12.0% for more than 10 years, indicating that the majority had between 1 and 5 years of work experience. In terms of daily working hours, most respondents (68.0%) reported working 4 - 8 hours per day, while 24.0% worked less than 4 hours, and only 8.0% worked more than 8 hours daily. With respect to the number of working days per week, 60.0% of the street cleaners worked 3 - 5 days, 36.0% worked 6 - 7 days, and only 4.0% worked fewer than 3 days. The use of personal protective equipment (PPE) varied, with 36.0% reporting that they always used PPE, 24.0% using it most times, 20.0% sometimes, and smaller proportions using it rarely (10.0%) or never (10.0%). Notably, all respondents (100.0%) reported having access to water and soap for handwashing (Table 2).

Table 2. Occupational information of street cleaners (n = 50).

Questions	Number	Percentage
How long on the job?		
<1 year	10	20.0
1 - 5 years	20	40.0
6 - 10 years	14	28.0
>10 years	6	12.0
How many hours per day?		
<4 hours	12	24.0
4 - 8 hours	34	68.0
>8 hours	4	8.0
How many days per week?		
<3 days	2	4.0
3 - 5 days	30	60.0
6 - 7 days	18	36.0
How often PPE used?		
Always	18	36.0
Most times	12	24.0
Sometimes	10	20.0
Rarely	5	10.0
Never	5	10.0
Access to water/soap for handwashing?		
Yes	50	100.0
No	0	0

The mean white blood cell (WBC) count was not significantly different street cleaners ($5.25 \pm 0.18 \times 10^3/\mu L$) compared to controls ($5.37 \pm 0.19 \times 10^3/\mu L$, $p = 0.110$). Lymphocyte (LYM) percentages were slightly lower in street cleaners (45.10% ± 1.01%) than in controls (47.11% ± 1.09%), but this difference was not statistically significant ($p = 0.180$). MID (%) and granulocyte (GRAN) percentages showed no significant differences between the two groups ($p = 0.186$ and $p = 0.358$, respectively). Red blood cell (RBC) counts were significantly reduced in street cleaners ($3.92 \pm 0.07 \times 10^{12}/L$) compared with controls ($5.26 \pm 0.08 \times 10^{12}/L$, $p < 0.001$). Haemoglobin (HGB) levels were significantly lower in street cleaners (11.45 ± 0.17 g/dL) than in controls (13.80 ± 0.26 g/dL, $p < 0.001$). Haematocrit (HCT) did not differ significantly between groups ($p = 0.462$). Red cell indices showed marked differences. Street cleaners had significantly higher mean corpuscular volume (MCV) (92.38 ± 0.91 fL vs. 69.89 ± 0.67 fL, $p < 0.001$), mean corpuscular haemoglobin (MCH) (35.23 ± 0.36 pg vs. 21.75 ± 0.21 pg, $p < 0.001$), and mean corpuscular haemoglobin concentration (MCHC) (38.14 ± 0.17 g/dL vs.

31.21 ± 0.14 g/dL, $p < 0.001$). Red cell distribution width (RDW) was also significantly elevated among street cleaners for both RDW-SD (52.91 ± 0.63 fL vs. 38.09 ± 0.36 fL, $p < 0.001$) and RDW-CV (17.71% ± 0.10% vs. 14.35% ± 0.12%, $p < 0.001$). Platelet counts were markedly lower in street cleaners (151.64 ± 8.25 × 10^3/μL) compared with controls (328.58 ± 17.47 × 10^3/μL, $p < 0.001$). Finally, mean platelet volume (MPV) was significantly reduced in street cleaners (10.07 ± 0.11 fL) relative to controls (10.76 ± 0.15 fL, $p < 0.001$) (Table 3). The effect sizes for all significant haematological parameters, along with their corresponding 95% confidence intervals, are presented in Table 4.

Table 3. Haematological parameters of control and street cleaners.

Parameters	Control (n = 50)	Street Cleaners (n = 50)	t	*p* value
WBC (×10^3/μL)	5.37 ± 0.19	5.25 ± 0.18	−3.346	0.110
LYM (%)	47.11 ± 1.09	45.10 ± 1.01	1.351	0.180
MID (%)	8.90 ± 0.32	9.45 ± 0.26	−1.332	0.186
GRAN (%)	43.98 ± 1.18	45.44 ± 1.06	−0.923	0.358
RBC (10^{12}/L)	5.26 ± 0.08	3.92 ± 0.07	13.082	<0.001
HGB (g/dL)	13.80 ± 0.26	11.45 ± 0.17	−8.119	<0.001
HCT (%)	36.60 ± 0.48	36.05 ± 0.57	0.738	0.462
MCV (fL)	69.89 ± 0.67	92.38 ± 0.91	−19.902	<0.001
MCH (pg)	21.75 ± 0.21	35.23 ± 0.36	−32.293	<0.001
MCHC (g/dL)	31.21 ± 0.14	38.14 ± 0.17	−30.739	<0.001
RDW-SD (fL)	38.09 ± 0.36	52.91 ± 0.63	−20.527	<0.001
RDW-CV (%)	14.35 ± 0.12	17.71 ± 0.10	−21.608	<0.001
PLT (×10^3/μL)	328.58 ± 17.47	151.64 ± 8.25	9.157	<0.001
MPV (fL)	10.76 ± 0.15	10.07 ± 0.11	3.690	<0.001

Values shown are Mean ± SEM, $p < 0.05$ was considered statistically significant.

Table 4. Effect sizes of differences in significantly different haematological parameters.

Parameters	Cohen's d (Effect Size)	95% Confidence Interval
RBC (10^{12}/L)	2.62	2.076, 3.149
HGB (g/dL)	1.62	2.074, 1.168
MCV (fL)	−3.98	−4.657, −3.296
MCH (pg)	−6.46	−7.440, −5.471
MCHC (g/dL)	−6.15	−7.089, −5.200
RDW-SD (fL)	−4.11	−4.797, −3.407
RDW-CV (%)	−4.32	−5.038, −3.598
PLT (×10^3/μL)	1.83	1.360, 2.296
MPV (fL)	0.74	0.331, 1.142

Note. Cohen's *d* values are interpreted as follows: 0.20 - 0.49 = small effect, 0.50 - 0.79 = moderate effect, and ≥0.80 = large effect. Positive values indicate higher mean values in the control group relative to street cleaners, while negative values indicate higher mean values in street cleaners relative to controls.

The erythrocyte sedimentation rate (ESR) was significantly higher among street cleaners (17.92 ± 1.50 mm/hr) compared with controls (5.78 ± 0.51 mm/hr, $p < 0.001$). Similarly, fibrinogen concentration was markedly elevated in street cleaners (460.68 ± 14.88 mg/dL) relative to controls (286.88 ± 6.83 mg/dL, $p < 0.001$) (Table 5).

Table 5. Fibrinogen concentration and erythrocyte sedimentation rate of control and street cleaners.

Parameters	Control (n = 50)	Street Cleaners (n = 50)	t	*p* value
ESR (mm/hr)	5.78 ± 0.51	17.92 ± 1.50	−7.645	<0.001
Fibrinogen (mg/dL)	286.88 ± 6.83	460.68 ± 14.88	−10.619	<0.001

Values shown are Mean ± SEM, $p < 0.05$ was considered statistically significant.

RBC showed strong positive correlations with HGB (r = 0.79) and HCT (r = 0.77). HGB was also strongly and positively correlated with HCT (r = 0.97). ESR had strong negative correlations with RBC (r = –0.74), HGB (r = –0.83), and HCT (r = –0.83), while fibrinogen was also negatively correlated with these same red cell parameters: RBC (r = –0.54), HGB (r = –0.72), and HCT (r = –0.69). ESR and fibrinogen, however, were strongly and positively correlated with each other (r = 0.91). Platelet count showed weak correlations with most parameters. WBC did not show notable correlations with other parameters (Figure 3). The p values of the correlations are shown in Table 6.

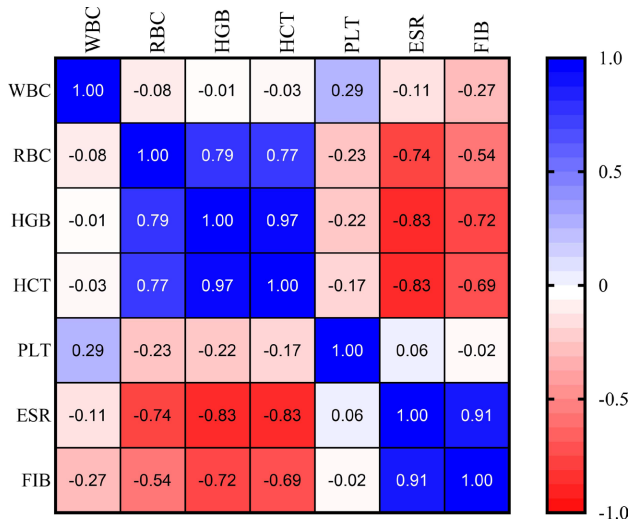


Figure 3. Correlation heatmap of some haematological parameters, erythrocyte sedimentation rate and fibrinogen concentration. **Note.** Values shown are Pearson's correlation coefficients (*r*). Correlation coefficients (r) range from –1 to +1, where values closer to +1 indicate a stronger positive relationship, values closer to –1 indicate a stronger negative relationship, and values near 0 indicate little or no linear relationship. **Key:** WBC = White Blood Cells, RBC = Red Blood Cells, HGB = Hemoglobin, HCT = Hematocrit, PLT = Platelets, ESR = Erythrocyte Sedimentation Rate, FIB = Fibrinogen.

Table 6. Correlations of some haematological parameters, erythrocyte sedimentation rate and fibrinogen concentration.

Parameters	WBC	RBC	HGB	HCT	PLT	ESR	Fibrinogen
WBC	–	0.574	0.934	0.816	0.041	0.427	0.054
RBC	0.574	–	<0.001	<0.001	0.105	<0.001	<0.001
HGB	0.934	<0.001	–	<0.001	0.126	<0.001	<0.001
HCT	0.816	<0.001	<0.001	–	0.236	<0.001	<0.001
PLT	0.041	0.105	0.126	0.236	–	0.668	0.869
ESR	0.427	<0.001	<0.001	<0.001	0.668	–	<0.001
Fibrinogen	0.054	<0.001	<0.001	<0.001	0.869	<0.001	–

Note. Two-tailed significance (p) values from Pearson's correlations are reported.

5. Discussion

This study evaluated haematological and haemorheological changes among street cleaners in Benin City, with the aim of identifying potential occupational health risks associated with exposure to environmental pollutants, physical exertion, and work-related stress. Street cleaning is a physically demanding occupation that often involves exposure to dust, vehicular emissions, biological wastes, and extreme weather conditions which are factors that have been documented to have side effect in the body [1].

In this study, the mean age of street cleaners (35.84 ± 8.09 years) shows that this occupation is mainly taken up by individuals in their productive years, with most workers between 31 - 50 years. Similar studies have also reported that middle-aged adults dominate sanitation jobs due to limited alternative employment opportunities in Nigeria [17]. Males were more represented than females, reflecting the physically demanding nature of the job. This agrees with findings from other studies on waste handlers and street sweepers [18]. Most street cleaners were married, suggesting family responsibilities as a driving factor for taking up the work, similar to previous reports [19]. Educationally, a majority had only secondary education, consistent with studies showing that low educational attainment often leads to engagement in informal, high-risk occupations [20].

The occupational profile of street cleaners indicates substantial exposure to multiple health risks. Prolonged years on the job and long daily working hours increase cumulative exposure to dust, fumes, and hazardous wastes, which have been associated with respiratory problems and infections in previous studies [21]. Although access to water and soap was universal, irregular use of PPE suggests gaps in occupational health compliance, likely due to discomfort, inadequate supply, or lack of enforcement. Similar studies among sanitation workers in Nigeria and other developing countries have consistently reported poor PPE adherence despite high exposure risks [22]. The limited use of essential gear such as goggles and overalls also increase vulnerability to injuries, chemical irritants, and infections [23].

In this study, white blood cell counts were not different in street cleaners compared to controls. However, in comparison to other studies, elevations in WBC have been reported among sanitation and waste handlers in both Nigeria and other countries [24] [25], with authors attributing such increases to persistent antigenic stimulation and chronic inflammation. Street cleaners had significantly lower RBC counts, yet their haemoglobin concentrations were higher than those of the control group. This can be explained by the observed changes in red cell indices. The significantly elevated MCV, MCH, and MCHC indicate that the surviving erythrocytes are larger and contain more haemoglobin per cell, consistent with macrocytosis and hyperchromia [26]. This suggests that, in response to environmental stressors such as exhaust fumes and chemical pollutants, the bone marrow may produce fewer but haemoglobin-rich red cells as a compensatory mechanism to preserve oxygen transport [27]. Inhalation of carbon monoxide from moving cars, in particular, leads to the formation of carboxyhaemoglobin, which reduces oxygen delivery to tissues and stimulates erythropoietin release, thereby enhancing haemoglobin synthesis [28]. At the same time, oxidative stress and toxic exposures may accelerate red cell destruction or impair normal erythropoiesis, contributing to the overall reduction in RBC numbers [29]. The higher MCV, MCH, and MCHC values in street cleaners, coupled with the elevated RDW can be explained by oxidative damage to red cell membranes, micronutrient deficiencies such as folate or vitamin B12 deficiency, or impaired bone marrow function [30], which are all conditions that are more common in low-income populations who often undertake street cleaning [31]. Increased RDW has been linked not only to anaemia but also to systemic inflammation and even higher cardiovascular risk [32]. Platelet parameters also showed significant alterations, with street cleaners exhibiting both reduced platelet counts and reduced mean platelet volume (MPV). This shows impaired platelet production, as smaller platelet size reflects reduced bone marrow activity or toxic suppression of megakaryopoiesis. Chronic exposure to environmental pollutants such as hydrocarbons and other toxicants may directly inhibit platelet formation or damage progenitor cells in the bone marrow, leading to a simultaneous decline in platelet number and size [27].

Street cleaners demonstrated markedly elevated ESR and fibrinogen levels compared to controls, both of which were statistically significant. Elevated ESR is a nonspecific marker of inflammation and reflects the tendency of red blood cells to aggregate in the presence of increased plasma proteins such as fibrinogen and globulins [33]. The significantly higher fibrinogen concentration observed among street cleaners provides a direct explanation for the rise in ESR, since fibrinogen promotes rouleaux formation and accelerates erythrocyte sedimentation [34]. Similar findings have been reported in occupational groups with high exposure to dust and exhaust fumes, where persistent environmental stressors triggered systemic inflammation and elevated acute-phase reactants [35] [36]. Chronic exposure to pollutants in the street cleaning environment is therefore likely to induce a persistent low-grade inflammatory state, stimulating hepatic synthesis of fibrin-

ogen and other acute-phase proteins [37]. Elevated fibrinogen not only drives higher ESR but also contributes to increased blood viscosity and hypercoagulability [38]. These findings are consistent with earlier reports linking stress to elevated fibrinogen and increased cardiovascular risk [39] [40]. The strong positive correlations between RBC, HGB, and HCT reflect their close physiological relationship in determining oxygen-carrying capacity [41]. The negative correlations of ESR and fibrinogen with these red cell parameters suggest that systemic inflammation and increased plasma protein levels may suppress erythropoiesis or promote red cell destruction [42]. The strong positive correlation between ESR and fibrinogen confirms fibrinogen's role as a major driver of red cell aggregation and sedimentation during inflammation [43].

A limitation of this study is that although the minimum sample size calculation indicated that 87 street cleaners were required, only 50 participants were ultimately recruited and included in the analysis due to participant dropout and challenges encountered during data collection. This reduction in sample size may have introduced selection bias, as the characteristics of those who participated may differ from those who did not complete the study. In addition, the smaller sample size may have reduced the statistical power to detect some associations or differences, particularly for parameters with small effect sizes. Therefore, the findings should be interpreted with caution. Nevertheless, several haematological and haemorheological parameters demonstrated statistically significant differences with large effect sizes, suggesting that the observed alterations are likely to be of biological and clinical relevance. Future studies involving larger sample sizes and multiple study locations are recommended to validate and extend these findings.

6. Conclusion

This study indicates that street cleaners in Benin City experience some changes in their blood parameters compared to controls. Although white blood cell counts showed no major differences, street cleaners had lower red blood cell and platelet counts. Their red cell indices, erythrocyte sedimentation rate, and fibrinogen levels were higher, suggesting changes in red blood cells and increased inflammation. Overall, the results suggest that street cleaning may affect blood health, highlighting the importance of regular health checks for street cleaners.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Appendix. Questionnaire for Street Cleaners and Control Group in Benin City

Research Topic: Evaluation of the Haematological and Haemorheological changes in street cleaners in Benin City, Edo state.

Section A (Sociodemographics)

1) Age (in years): _____

2) Gender: ☐ Male ☐ Female

3) Marital Status: ☐ Single ☐ Married ☐ Divorced/Separated ☐ Widowed

4) Highest Educational Qualification: ☐ No formal education ☐ Primary ☐ Secondary ☐ Tertiary

5) Religion: ☐ Christianity ☐ Islam ☐ Traditional

Section B: Occupational Information (For Street Cleaners Only)

1) If you are in the Control Group, please skip

2) Are you a street cleaner? ☐ Yes ☐ No (If no, end interview)

3) How long on the job? ☐ <1 year ☐ 1 - 5 years ☐ 6 - 10 years ☐ >10 years

4) How many hours per day? ☐ <4 hrs ☐ 4 - 8 hrs ☐ >8 hrs

5) How many days per week? ☐ <3 days ☐ 3 - 5 days ☐ 6 - 7 days

6) PPE used? (Tick all that apply) ☐ Gloves ☐ Face/Nose mask ☐ Goggles ☐ Boots ☐ Overalls ☐ None ☐ Other: _____

7) How often PPE used? ☐ Always ☐ Most times ☐ Sometimes ☐ Rarely ☐ Never

8) Types of waste handled? (Tick all that apply) ☐ Household ☐ Dust/Sand ☐ Industrial/Chemical ☐ Medical ☐ Animal ☐ Glass/Sharps ☐ Human waste ☐ Other: _____

9) Access to water/soap for handwashing? ☐ Yes ☐ No ☐ Sometimes