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Hematological, cholesterolemic and clinical profile in exposed to outdoor air pollution linked to the incineration of biomedical waste in Benin

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Abstract

Introduction: Incineration is one of the treatment methods for biomedical waste (BMW). It is a source of toxic air pollutant emission. The study aimed to compare the haematological, cholesterolemic and clinical profile of subjects exposed to this pollution to controls.

Methods: This was a comparative cross-sectional study on 154 exposed subjects selected within 500 meters of the incineration sites of solid biomedical waste and controls, among new blood donors, matched on age, sex, level of education, cooking mode. The hematological parameters and cholesterolemia were obtained by standardized procedure on automata. The proportions of subjects were compared with a chi-square test. The dispersion analysis of the biological parameters was made by the non-parametric Wilcoxon test at the 5% threshold.

Results: The two groups were comparable for matching. The frequency of respiratory symptoms ranged from 20.1 - 79.2% in exposed versus 4.5 - 54.5% in controls. The frequency of neurological symptoms ranged from 26.6 - 76.6% in exposed versus 1.9 - 51.9% in controls. Hemoglobin (p=0.001), hematocrit (p=0.051) were low in the exposed and white blood cells (p=0.003) and platelets (p<0.001) high. Total cholesterol (p<0.001) was twice as high and HDL six times lower in the exposed (p<0.001).

Conclusion: The exposed presented a more altered hematological and cholesterolemic profile with more frequent symptoms. It is essential to improve the management practice of BMW in our hospitals through the use of innovative, less polluting technologies

Keywords: Incineration, biomedical waste; Outdoor air pollution; Hematological and cholesterol profile; Clinical symptoms

1. Introduction

The ambient air pollution is a main public health issue. According to the World Health Organization (WHO), almost nine persons over ten living in urban areas are concerned by air pollution [1] . Exposure to the outdoor air pollution is the nineth mortality risk factor and responsible of at least seven millions deaths in the world every year [2,3]. Current

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projections indicate that without efficient interventions, the contribution to the outdoor air pollution related to the premature mortality may double to 2050 [4]. Pollutant emission related to incinerated biomedical waste (BMW) constitute a particular source of outdoor air pollution [5].

Incineration is one of the oldest methods and the most frequent is the disposal of BMW. It is preferred because of the rapid decrease , till 90% waste, as well as the production of heat for the boilers and energy. [6]. But their use came up against many objections because of the harmful gas emission such as carbon dioxide and monoxide (CO_2 et CO) as well as carcinogenic gas such as dioxins and furans that are generated as a result of an incomplete combustion of BMW components like plastics materials, polyvinyl chloride (PVC) or usual biomedical materials [7,8]. These toxic air pollutants and toxic ash residue are transported by the air and gas coming from the fireplace of the incinerator such as flying ashes reaching surrounding populations [9].

The current analytic data support a link between the exposure to airbone particles during these incinerations and a huge risk of cardiovascular, respiratory diseases and cancers. [10–12]. An exposure of low intensity and sustainable to dioxins and furans in human is responsible of a damage of the immune system and defects in the development of the nervous system, endocrine system and reproductive functions [13–15]. On the other side, these particles may disrupt the hormonal balance and therefore, lead to many health troubles, mainly development defects [16].

In the sub-region and precisely in Benin, many studies have shown that the disposal of BMW is often made in old incinerators or handcrafted ovens, with significant smoke emission or residue in the form of ash in the public landfill. [17,18]. If data are available on the health risks induced by the management of BMW among health care personnel, less is known about the negative externalities linked to the exposure of populations to BMW incineration discharges [19]. This is more of concern whereas by nature hospital are often located in densely populated areas. This proximity increases the exposure potential and, per unit volume of incinerated waste, the exposure level of surrounding populations are comparable or higher than heavy metal emission , dioxins and furans in industrial zones [20].

In order to contribute to a better knowledge of sanitary risks related to the exposure to incineration discharge of BMW for factual actions, we have undertaken this research which aims to study the hematological, cholesterol and clinical signs of exposed subjects to outdoor air pollution related to the BMW incineration in Benin.

2. Material and methods

2.1. Frame

The study was carried out in southern Benin in the communes of Cotonou, Abomey Calavi and Ouidah. Data collection took place from February to December 2021

2.2. Study type and population

This was a comparative cross-sectional study between the surrounding population of health structures with functional incinerators considered as exposed and a control population chosen from among new blood donors in the Zinvié area, without an incinerator considered as an unpolluted area.

2.3. Sampling

A probabilistic sampling by simple random choice made it possible to select three health facilities at the peripheral level with functional incinerators in the Atlantique and Littoral departments. The health facilities were selected by excluding those close to major road traffic and high urban exposure near the incineration sites of central and departmental structures and some at the peripheral level. Thus, the Ouidah-Kpomassè-Tori-Bossito District Hospital (HZ OKT), the Zinvié Cross Hospital (Zinvié HLZ) and the Cotonou 1-4 Health Center were selected.

Exposed were chosen for convenience around these health facilities. After identifying the prevailing wind direction, the first household on that direction was included. Then, the households were visited step by step up to the calculated size. Among the controls, new blood donors who met the matching criteria were systematically included according to their order of arrival at the collection sites in the identified areas.

The number of subjects to include per group was calculated from the formula

$$T= [(P1Q1+P2Q2) \times (Z\,\alpha/2+Z1\text{-}ß)^{2}] / (P2\text{-}P1)2 \ [21].$$

With Q1= 1- P1; P1 the frequency of haematological defects in exposed subjects, Q2= 1- P2; P2 is the frequency of haematological defects in controls, Z $\alpha/2$ =1.96 (confidence level) and Z1-ß = 0.80 (Margin of error accepted).

In the absence of data on the proportion of hematological or cholesterolemic defects in the context of the study, a maximum proportion of 50% was chosen in exposed subjects and 34% in control subjects for an expected difference in frequency of 16%. The calculated size is 141 per group. To compensate for possible refusals to participate and to improve power, the size has been increased by 10%. The expected total size was 310 subjects including 155 exposed and 155 controls.

2.4. Eligibility criteria

2.4.1. Inclusion of exposed

All subjects aged 18 to 60 years were included (i); who has resided for at least three (3) years (ii), less than approximately 500 meters around one of the three selected health facilities (iii) and whose house is on the most frequent direction of the wind (iv).

2.4.2. Inclusion of controls

Were included any subject aged 18 to 60 years (i), who has resided for at least three (3) years in the unpolluted target area (ii), who gives blood for the first time in Zinvié (iii). They were chosen by pairing with the presentations on the basis of the criteria of age (± 5 years), sex, level of education and cooking method.

2.4.3. Exclusion criteria for exposed and controls

Excluded from both study groups were subjects who had other exposure to smoke or dust such as road traffic, active or passive smoking, occupational exposure to fish smoking, extraction cement industry, exposure to dust through the work of "street sweeper".

2.5. Tools and data collected

A questionnaire was used to collect data from the structured individual interview with the exposed and control subjects, as well as a results's sheet of the hematological and biochemical examinations. The questionnaire was structured in four parts including:

- Socio-demographic characteristics concerned age, monthly income, level of education, marital status, type of fuel used for cooking, type of housing.
- Anthropometric and blood pressure characteristics included weight, height, systolic blood pressure and diastolic blood pressure.
- Respiratory signs, namely coughing, sneezing, chronic bronchitis (defined according to who criteria as chronic cough and sputum occurring 3 months a year for at least 2 years) and diseases or symptoms of the nervous system namely insomnia, vertigo, asthenia and headaches which are assessed over the last six months preceding the interview.
- The values of biochemical parameters (total cholesterol, HDL cholesterol) and hematological (hemoglobin (g/dl), red blood cell count (t/l), hematocrit (%), mcv (fl), tcmh (pg), mchc (%), leukocytes, neutrophils (g/l), lymphocytes (g/l), monocytes (g/l), eosinophils (g/l), basophils (g/l), platelets (g/l)).

Anthropometric parameters such as weight (kg) and height (m) were measured according to standard World Health Organization protocols [22]. The body mass index (BMI) was obtained by the ratio: weight (kg) / height (m2). A BMI <18.5 was considered underweight, between 18.5 and 24.9: normal, between 25 and 29.9 overweight and ≥ 30: obese.

The collection team was made up of four male and female investigators (nurse, biologist) and two supervisors (a public health doctor and an environmentalist) per study site. Interviewers are trained on data collection tools. A translation of the questionnaire was provided in the local language for unschooled participants. A pre-survey carried out in the area of the Center Hospitalier Universitaire de la Mère et de l'Enfant Lagune (CHU-MEL) in Cotonou (structure not sampled) enabled us to improve the collection tools.

2.6. Criteria for judgement

The hematological or cholesterol profile between exposed subjects and controls was assessed by comparing the proportion of subjects with abnormally high or low values for the different parameters.

The following threshold values used in clinical practice in Benin were considered:

2.6.1. Bio-chemical parameters

- Total cholesterol (g/L): 1.50-2.25 (man and woman)
- HDL cholesterol (g/L): 0.50-0.75 (man and woman)

2.6.2. Hematologic parameters

- Hemoglobin, male 12 to 16 g/dL
- Hemoglobin, female 11.5 to 14 g/ dL
- Hematocrit, male 36 to 49
- Hematocrit, female 30 to 40
- Number of red blood cells, male 4 to 6 T/L
- Number of red blood cells, female 3,5 to 5 T/L
- M.C.V: 80 to 93 fL (male and female)
- M.C.H.: 25 to 32 pg (male and female)
- M.C.H.C.: 30 to 36 % (male and female)
- Platelets: 150 to 400 G/L (male and female)
- Leukocytes: 3 to 8 G/L (male and female)

Leukocyte count: (male and female), Normal absolute values in Giga per liter (G/L)

- Neutrophils: 1.5 to 6
- Eosinophilic Polynuclei: 0.15 to 0.5
- Basophilic Polynuclei: 0.05 to 0.15
- Monocytes: 0.2 to 1.0
- Lymphocytes: 1.5 to 4

2.7. Sample collection and laboratory analysis

To assess hematological and cholesterol parameters in the subjects, a venous blood sample was collected from all participants using an EDTA (ethylene diamine tetra-acetic acid) Vacutainer tube and a dry tube. The samples were taken under fasting conditions between 8:00 and 10:00 a.m. by level A laboratory technicians and kept in a cooler with accumulators and thermometer until the laboratory. The manipulations were carried out the same day in compliance with the rules of good practice on the Selectra ProM biochemistry automaton and the Sysmex XN 350 hematology automaton.

The XN-350 is an analyzer based on the hydrodynamic focusing system and flow fluorocytometry. Different methods are used for the different parameters of the blood count, such as spectrophotometry with cyanide-free SLS method for hemoglobin determination, impedancemetry for red blood cell and platelet count, flow cytometry for white blood cell count and flow fluorocytometry for white blood cell differential and reticulocyte count

Cholesterol determination is performed by the enzymatic method using specific ELITechGroup (Sées, France) reagent kits on the Selectra ProM closed analyzer.

2.8. Statistical analysis

Data were entered with Statistical Package for the Social Sciences (SPSS) version 23 and analyzed with R 4.1.1 software. Statistical analysis of continuous variables used the median, interquartile range, and extremes when the distribution of the variable tested by the Kolmogorov test was skewed. Categorical variables were presented by their absolute and relative frequency. We checked the comparability of the two groups according to subject characteristics and judgment criteria by using the nonparametric Wilcoxon test for continuous data and the McNemar test for categorical data. The significance level was set at 0.05.

3. Results

3.1. Sociodemographic ad anthropometric characteristics of exposed subjects to biomedical waste incineration discharge and case control

A total of 154 subjects were surveyed in each group. The mean age of the exposed subjects was 34.2 ±10.8 and of the controls 33.9 ±10.5 years. The two groups were comparable with respect to age (p=0.361), sex (p=1.000), education level (p=0.997), and marital status (p=0.389). The mean BMI (kg/m2) was 24.8±5.4 in the exposed and 24.5±4.5 in the unexposed (p=0.480). The proportion of subjects with high blood pressure was 30.5% in the exposed versus 20.1% in the unexposed. The two groups were not comparable with respect to hypertensive profile (p=0.049) (Table I).

Table 1 Respondents' socio-demographic and anthropometric characteristics

	exposed (N=154)		**controls (N=154)**		**p-value**
	Size	**(%)**	**Size**	**(%)**	
Gender					1.000
Male	72	(46.8)	72	(46.8)	
Female	82	(53.2)	82	(53.2)	
Age (year)					0.361
18-29	61	(39.6)	63	(40.9)	
30-39	46	(29.9)	44	(28.6)	
40-49	28	(18.2)	36	(23.4)	
≥50	19	(12.3)	11	(7.1)	
Educational level					0.997
Unschooled	34	(22.1)	33	(21.4)	
Primary	43	(27.9)	43	(27.9)	
Secondary	62	(40.3)	62	(40.3)	
University	15	(9.7)	16	(10.4)	
Matrimonial status					0.389
Married	57	(37.0)	72	(46.8)	
Single	34	(22.1)	28	(18.2)	
Cohabiting	61	(39.6)	52	(33.8)	
Widowed	2	(1.3)	2	(1.3)	
Monthly income (CFA francs)					<0.001
<40 000	80	(51.9)	49	(31.8)	
≥ 40 000	74	(48.1)	105	(68.2)	
Owner of the dwelling in which you live					0.061
Yes	110	(71.4)	124	(80.5)	
No	44	(28.6)	30	(19.5)	
Type of housing					0.008
Low standard, single family house	58	(37.7)	76	(49.4)	
Low standard, common yard	73	(47.4)	70	(45.5)	

	exposed (N=154)		controls (N=154)		p-value
	Size	(%)	Size	(%)	
Other	23	(14.9)	8	(5.2)	
Energy source for cooking					
Wood	53	(34.4)	40	(26.0)	0.122
Coal	120	(77.9)	107	(69.5)	0.197
Gas	43	(27.9)	31	(20.1)	0.115
Electricity	20	(13.0)	31	(20.1)	0.125
BMI (kg/m^2)					
Obese	23	(14.9)	16	(10.4)	
Overweight	40	(26.0)	44	(28.6)	0.480
Normal	84	(54.5)	90	(58.4)	
Lean	7	(4.5)	4	(2.6)	
Blood pressure					0.049
High	47	(30.5)	31	(20.1)	
Normal	107	(69.5)	123	(79.9)	

3.2. Respiratory and neurological symptoms

Respiratory diseases or symptoms were more frequent in exposed subjects. Among the exposed subjects, 20% had bronchitis compared to 4.5% among the controls ($p < 0.001$). The occurrence of a cough in the last 6 months prior to the survey was 87% in the exposed group versus 53.2% in the unexposed group ($p < 0.001$). Similarly, 79.2% of exposed individuals had experienced sneezing compared with 54.5% of unexposed individuals ($p < 0.001$).

Table 2 Respiratory and neurological symptoms in exposed and controls

	Exposed (N=154)		Controls (N=154)		p-value
	Size	(%)	Size	(%)	
Diseases of the respiratory system					
Bronchitis	31	(20.1)	7	(4.5)	<0.001
Cough*	134	(87.0)	82	(53.2)	<0.001
Sneezing*	122	(79.2)	84	(54.5)	<0.001
Diseases of the nervous system*					<0.001
Insomnia	41	(26.6)	3	(1.9)	<0.001
Vertigo	118	(76.6)	80	(51.9)	<0.001
Asthenia	44	(28.6)	9	(5.8)	<0.001
Headaches	50	(32.5)	25	(16.2)	0.001
Consultation for respiratory and neurological symptoms (Yes)	51	(33.1)	2	(1.3)	<0.001
Hospitalizations for respiratory and neurological symptoms (Yes)	6	(3.9)	1	(0.6)	0.2131

* affections in the last 6 months

Neurological symptoms were also more common in exposed subjects. The proportions of exposed subjects with insomnia, vertigo or headache were 26.6%, 76.6%, 32.5% respectively in the exposed subjects versus 1.9%, 51.9%, 1.3% in the unexposed. These respiratory or neurological symptoms required more visits to a health facility in the exposed (33.1%) compared to the controls (1.3%) (Table 2).

3.3. Hematological profile of exposed subjects and controls to BMW incineration discharge

Red blood cell counts were decreased in 2% of the exposed group versus less than 1% of the control group. Red blood cell counts were not significantly different between the two groups (p=0.781). Hemoglobin levels were significantly different between the groups (p=0.001). Indeed, 25.3% of the exposed group had a low hemoglobin level compared to 17.5% of the control group. The hematocrit level was lower in the exposed (8.4%) than in the controls (3.2%). The hematocrit level was borderline significant between groups (p=0.051). In the exposed subjects, 30% had a decreased mean corpuscular volume (MCV) compared to 22.1% in the control subjects (p=0.294). The frequency of abnormalities in mean corpuscular hemoglobin content (MCH) (p=0.249) or mean corpuscular hemoglobin concentration (MCHC) (p=0.989) were not significantly different. Exposed subjects had the lowest and highest MCHC values. Platelet counts were frequently lower in control subjects (22.1%) compared to exposed subjects (9.1%). However, exposed subjects had high blood platelet counts (p<0.001). As for white blood cells, there was a significant difference between the two groups (p=0.003). Exposed patients (3.2%) more frequently had higher values of leukocytes (hyperleukocytosis) than control patients (1.3%). The same was true for absolute values of neutrophils (neutrophilic polynucleosis) (p=0.002), lymphocytes (lymphocytosis) (p=0.604), monocytes (monocytosis) (p=0.009), eosinophils (eosinophilia) (p=0, 582) and basophils (basophilia) (p=0.074) which were more frequently elevated in the exposed subjects even though the two groups were not significantly different in all these parameters (Table 3).

The quantitative statistical analysis of the dispersion of the different hematological parameters showed a significant difference between the two groups as found by the qualitative analysis. However, the quantitative analysis showed that high absolute lymphocyte values were significantly (p<0.001) observed in the exposed subjects (Table 4).

3.4. Cholesterol profile of exposed subjects and controls to BMW incineration discharge

Total cholesterol was abnormally higher in the exposed (31.8%) than in the controls (16.2%). The two groups did not have the same total cholesterol profile (p=<0.001). In contrast, analysis of HDL cholesterol levels showed a higher frequency of low values in the exposed (50.6%) compared with the unexposed (8.4%) although high values were more noted in the control (11.7%) compared with the exposed (6.5%).

Quantitative statistical analysis of the dispersion of total or HDL cholesterol levels revealed a significant difference between the two groups (Table 4).

Table 3 Comparison of cholesterolemic and hematological parameters of subjects exposed and controls to incineration discharges of biomedical waste

	Exposed (N=154)		**Controls (N=154)**		**p-value**
	Size	**(%)**	**Size**	**(%)**	
Biochemical profile					
Total cholesterol (g/L)					**<0.001**
Diminished	8	(5.2)	24	(15.6)	
Normal	97	(63.0)	105	(68.2)	
High	49	(31.8)	25	(16.2)	
HDL cholesterol (g/L)					**<0.001**
Diminished	78	(50.6)	13	(8.4)	
Normal	66	(42.9)	123	(79.9)	
High	10	(6.5)	18	(11.7)	
Hematological profile					
Hemoglobin level					0.001

	Exposed (N=154)		Controls (N=154)		p-value
	Size	(%)	Size	(%)	
Diminished	39	(25.3)	27	(17.5)	
Normal	106	(68.8)	115	(74.7)	
High	9	(5.8)	12	(7.8)	
Number of red blood cells					0.781
Diminished	3	(1.9)	1	(0.5)	
Normal	138	(89.6)	139	(69.8)	
High	13	(8.4)	14	(7.0)	
Hematocrit					0.051
Diminished	13	(8.4)	5	(3.2)	
Normal	123	(79.9)	121	(78.6)	
High	18	(11.7)	28	(18.2)	
MCV value					0.294
Diminished	46	(29.9)	34	(22.1)	
Normal	88	(57.1)	97	(63.0)	
High	20	(13.0)	23	(14.9)	
MCH value					0.249
Diminished	33	(21.4)	23	(14.9)	
Normal	115	(74.7)	127	(82.5)	
High	6	(3.9)	4	(2.6)	
MCHC value					0.989
Diminished	9	(5.8)	10	(6.5)	
Normal	144	(93.5)	143	(92.9)	
High	1	(0.6)	1	(0.6)	
Number of leukocytes					0.003
Diminished	1	(0.6)	11	(7.1)	
Normal	147	(95.5)	141	(91.6)	
High	6	(3.9)	2	(1.3)	
Neutrophils					0.002
Diminished	20	(13.0)	35	(22.7)	
Normal	129	(83.8)	118	(76.6)	
High	5	(3.2)	1	(0.6)	
Lymphocytes					0.604
Diminished	9	(4.5)	20	(10.1)	
Normal	143	(71.9)	177	(88.9)	
High	2	(1.0)	2	(1.0)	
monocytes					0.009
Diminished	25	(12.6)	44	(22.1)	
Normal	124	(62.3)	109	(54.8)	

	Exposed (N=154)		Controls (N=154)		p-value
	Size	(%)	Size	(%)	
High	5	(2.5)	1	(0.5)	
Polymorphonuclear Eosinophils					0.582
Diminished	84	(42.2)	93	(46.7)	
Normal	64	(32.2)	56	(28.1)	
High	6	(3.0)	5	(2.5)	
Polymorphonuclear basophils					0.011
Diminished	123	(61.8)	139	(69.8)	
Normal	27	(13.6)	15	(7.5)	
High	4	(2.0)	0	(0.0)	
Number of pads					<0.001
Diminished	14	(9.1)	34	(22.1)	
Normal	136	(88.3)	120	(77.9)	
High	4	(2.6)	0	(0.0)	

Mean Corpuscular Haemoglobin (MCH), Mean Corpuscular Haemoglobin Concentration (MCHC), Mean Cell Volume (MCV).

Table 4 Comparison of the distribution of the values of the cholesterolemic and hematological parameters of the exposed and the controls

	Exposed (N=154)			Controls (N=154)			p-value
	M	IIQ	Extremes	M	IIQ	Extremes	
Biochemical profile							
Total cholesterol (g/L)	2.07	1.83-2.34	0.99-3.44	1.89	1.58-2.16	0.92-3.07	<0.001
HDL cholesterol (g/L)	0.49	0.39-0.60	0.20-1.05	0.56	0.51-0.62	0.17-1.28	<0.001
Hematological profile							
Hemoglobin (g/dL)	12.70	11.60-14.00	8.0-17.20	13.25	12.0-14.0	7.50-17.50	0.026
Red globule (T/L)	4.72	4.28-5.21	3.45-7.29	4.86	4.46-5.17	2.48-8.58	0.189
Hematocrit (%)	39.55	35,90-43,70	28.33-53	41.00	36.7-44.5	24.0-85.20	0.046
MCV (fL)	83.80	79,10-89,30	63.10-107.3	84.45	80.5-88.90	29.30-109.0	0.377
CMH (pg)	27.00	25.30-28,80	13.70-33.40	27.70	25.90-29.10	15.60-35.10	0.069
MCHC (%)	32.00	31.10-33.20	27.10-39.90	32.30	31.30-33.20	22.80-36.70	0.231
Leukocytes	5.40	4.50-6.50	2.80-16.30	4.90	3.90-5.90	1.30-9.30	<0.001
Neutrophils	46.00	38.00-52.00	18.00-77.00	44.50	36.00-52.00	13.00-77.00	0.009
Lymphocytes (G/L)	46.00	38.00-52.00	17.00-70.00	45.00	39.00-51.00	20.00-84.00	<0.001
Monocytes	6.00	4.00-8.00	0.00-22.00	7.00	3.00-9.00	0.00-17.00	0.048
Polymorphonuclear Eosinophils	2.50	2.00-4.00	0.00-16.00	3.00	2.00-4.00	0.00-24.00	0.367
Polynuclear basophils	0.00	0.00-0.00	0.00-5.00	0.00	00.00	0.00-4.00	0.029
Platelets (G/L)	227.0	190-276	75.00-538.00	193.00	152-253	14.00-399.00	**<0.001**

M: Median; IR: Interquantile Range; MCH: Mean Corpuscular Haemoglobin; MCHC: Mean Corpuscular Haemoglobin Concentration; MCV: Mean Cell Volume

3.5. Comparison of the proportion of subjects with abnormalities according to hematological parameters in exposed and controls

Considering the low or high values, it appears that the subjects exposed to the incineration rejection of BMW more frequently had an anomaly in the hemoglobin, red blood cell, MCV, MCH levels (figure 1).

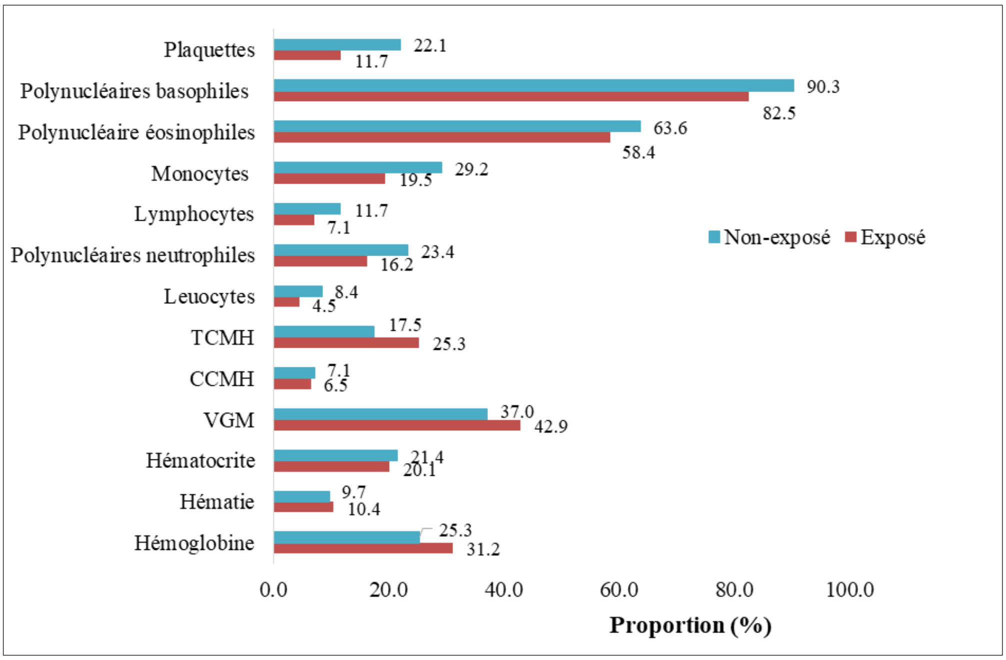

Figure 1 Comparison of the proportion of subjects with defects according to hematological parameters in exposed and controls

4. Discussion

The study found that respiratory or neurological diseases were significantly more frequent in subjects exposed to the discharge from incineration of MBR. The same finding has been made in several studies but in different contexts. In Algeria, respiratory diseases are very frequent among steel workers, especially in the most polluted units, as well as among the inhabitants of the housing estate surrounding the plant [23]. Similarly, in a meta-analysis, the diagnosis of upper respiratory disorders appeared to increase as the exposure of the subjects to waste combustion pits increased [15]. Other authors found that short-term air pollution from traffic or organic carbon led to an increase in respiratory infection symptoms and emergency room visits by children [24,25]. It is known that particles contained in air pollutants or incinerator discharges are harmful to health because they can obstruct and inflame the nasal and bronchial passages [26-29]. In addition, the finest particles pass through the lung alveolus wall and into the bloodstream, affecting other internal organs such as the heart, liver, kidneys and brain [27].

Data on the impact of BMW incineration releases on hematological or cholesterol parameters are scarce in the available literature. This limits the comparison of results with available data. However, airborne particles emitted during BMW incineration have also been found in other studies among air pollutants [15,30-32].

Our study found that the exposed had significantly lower hemoglobin or hematocrit values. The same finding was made in a study in Serbia among children exposed to air pollution with a 3.76-fold higher frequency of anemia in the exposed group compared to the control group [33]. On the other hand, according to Eloge and al. in Cameroon, hemoglobin or hematocrit levels were not altered in motorcycle cab drivers, urban outdoor workers or gas station salesmen exposed to air pollution [34]. Red blood cells play a fundamental role in respiration by transporting respiratory gases (oxygen and carbon dioxide) between the lungs and tissues, thanks to the hemoglobin they contain. However, the present study did not show a difference between the two groups with respect to the hematite count or eosinophilic polynuclei, in contrast to the results of the study by Avogbe and al. in Benin, which showed that the exposed motorcycle drivers had a lower absolute number of eosinophils than the controls, following an exposure of more than five hours per day of the subjects [35]. It should be noted that eosinophils are considered today as a multifunctional cellular actor capable of participating in the early processes involved in innate immunity, as they represent the first barrier of the organism towards many microbial aggressors [36].

The study showed a high incidence of hyperleukocytosis in the exposed subjects. In a study of municipal waste incinerators, although hematological tests were within normal limits for several parameters, the authors noted a significant increase in leukocytes in the exposed group [37]. Similarly, the study by Steenhof and al. showed that exposure to particulate matter could lead to changes in total leukocytes between 2 and 18 h after exposure to air pollution [38]. This noted hyperleukocytosis could reveal the existence of an infection, since these are the elements that are related to the immune system defenses against foreign bodies. The higher the leukocytosis, the more one could suspect a great contamination of the incineration discharges on the surrounding population.

We observed that the exposed population had slightly higher monocyte values than the controls, but also generally lower monocyte values (monocytopenia). An experimental study on rats exposed to fly ash from incinerators also showed a significant increase in monocyte counts in these rats [39]. In addition, a community-based study in China on outdoor air pollution and white blood cells revealed that the value of monocytes might be a function of the chemical nature of the particles [40]. According to this study, the number of monocytes in the exposed population could be increased under short-term (within one week) exposure of carbon monoxide (CO), but would be decreased when subjects are more exposed to sulfur dioxide (SO2). This may suggest that BMW incineration releases are composed of CO and SO2.

In the study, there was more hypereosinophilia than hypoeosinophilia in the exposed group compared to the control group. Hinson and al. in Benin noted that hypereosinophilia is more frequent in exposed urban dwellers than in rural dwellers compared to the reference population [41]. The two groups studied were not significantly different according to the level of lymphocytes. This finding is contrary to that of Eloge and al. in Cameroon who found that lymphocytes are increased in groups exposed to air pollution [34].

In the study we noted thrombocytosis only in the exposed population group. In a systematic review, adults living in areas with high PM 2.5 particles for 2 years were more likely to develop thrombocytosis with an increased risk of venous thromboembolism in the population of elderly subjects exposed to these particles for 7 to 8 years [42]. In contrast to our study, Hinson and al. reported in Benin that the decrease in platelet counts was more marked in motorcycle cab drivers exposed to benzene than in the other groups and 16.12% had thrombocytosis [41]. The subjects in the previous study were more exposed to benzene, which could account for the difference observed.

The study showed that total cholesterol was twice as high in subjects exposed to incineration discharges compared to controls and cholesterol (HDL) was greatly reduced in exposed subjects. Several studies have shown the role played by air pollutants in the alteration of lipid functions. Kim and al. in the Meta-AIR study in China found that a one standard deviation change in long-term exposure to nitrogen dioxide (NO2) was associated with an 11.3 mg/dL increase in total cholesterol. The authors point out that the risk of lipid disorders is 4 to 5 times greater, especially in obese subjects [43]. In addition, the AIRCHD study in Beijing, which evaluated the influence of air pollution and cardiovascular dysfunction in adults, showed a significant decrease in cholesterol levels when the levels of exposure to air pollutants are high [44]. Furthermore, for Yang and al. in China in 2018, the increase of 10 µg/m3 in the level of air pollutants (PM1) is accompanied by a 1.6% increase in total cholesterol but 3.2% increase in LDL cholesterol and a 1.4% decrease in HDL cholesterol [45]. In a multicenter cross-sectional study, frequent exposure to acetylene black or lamp smoke averaged over a one-year period was significantly associated with a decrease in HDL cholesterol [46]. These data clearly show the power of air pollution on cholesterol.

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To our knowledge, this study is the first in Africa to analyze the hematological and cholesterol profile and clinical manifestations in the specific context of exposure to incineration discharges from MBW. It was relatively large in size, providing a solid knowledge base for public health interventions. The population of new blood donors used as a reference may not be representative of the non-exposed population. Furthermore, the observed alteration of biochemical and hematological markers cannot be systematically attributed to exposure to particles emitted by BMW incinerators because of the dynamics and multitude of air pollutants. In addition, the clinical manifestations or markers could be associated with other apparent or silent pathologies such as viral infections and helminths that may be responsible for symptoms such as headaches, fatigue and respiratory disorders.

5. Conclusion

The study revealed that the hematological and cholesterol profiles of the population surrounding the BMW incineration sites are more altered than in the control group. The exposed population had lower hemoglobin and hematocrit, higher thrombocytosis, higher white blood cell count and lower HDL cholesterol. Regarding the clinical aspects, this pollution would participate in the occurrence of several respiratory and neurological symptoms that were more frequent in the exposed subjects. It is necessary to improve the policy of treatment of BMW in our hospitals by using modern technologies that minimize the release of air pollutants. In view of the limitations of the present study, prospective cohort studies of sufficient statistical power with measurement of pollutants emitted by the BMW incinerators at the incineration area and in the study, subjects should be carried out,

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare no conflict of interest.

Statement of ethical approval

The current study is part of the Chaire Pol project. The research protocol obtained the opinion of the ethics committee under the number N°0321/ CLERB-UP/P/SP/R/SA of October 09, 2020, and the research approval of the Ministry of Health through the letter N° 1342/MS/DC/SGM/DRFMT/SA of March 10, 2020, before the beginning of the investigation.

Statement of informed consent

The study participants had each signed a consent form. Explanation of the purpose of the survey, anonymity, and guarantee of confidentiality were observed.

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