Impact of air pollution from the Libreville landfill on children aged 3 to 11 years. Comparative study of children living in the vicinity versus children living far

Abstract :

Introduction: According to the WHO, environmental health is estimated to cause 12.6 million yearly deaths. The main objective was to determine the impact of airborne pollutants from this landfill on the health of children aged 3 to 11 years living in the area.

Methods: This was a prospective, cross-sectional, descriptive, and analytical study: case-controls. Air pollutants were measured at the landfill site and the control sites. We compared the clinical status and health history of the children living near the river with that of the control children.

Results: A total of 160 subjects were included: 80 cases and 80 controls, 70 girls and 90 boys, with a median age of 7 years. The Mindoubé landfill produces the annual dose of particulate matter (PM) PM10 more than 4000 times daily: PM2.5 and PM1. It also produces CO and hydrogen sulfide above the thresholds set by the WHO. Children living on or near the site were more likely to develop ENT pathology (OR=40.1; p<0.001), dermatosis (OR =9.8; p<0.001), and pneumonitis (OR=5.8; p<0.001). Multivariate analysis found that living at the landfill site was a determining factor of OR = 4.7 95% CI [3, 6.1]; *p<0.001*.

Conclusion: The air pollution highlights the danger of this landfill for residents and other neighborhoods in Libreville. Without the need to carry out a prospective study, this type of site needs to be taken care of urgently, at the risk of constituting time bombs.

Keywords: air pollution – respiratory tract diseases – landfill – children - Libreville.

Introduction :

In March 2016, the World Health Organization (WHO) declared that unhealthy environmental conditions would cause 12.6 million deaths yearly. Environmental risk factors such as air, water, and soil pollution, chemical exposure, climate change, or ultraviolet radiation contributed to more than 100 diseases or injuries. Stroke, heart disease, cancer, and chronic respiratory disease now account for nearly two-thirds of deaths from environmental causes.

According to this report, children and the elderly were the most exposed to environmental risks, with the most significant impact on children under 5 years of age and subjects aged 50 to 75 years [**1].**

The effects of landfills on the health of populations, especially children, have been taken into account for several decades and have been highlighted in the Millennium Development Goals (2000-2015) in the fourth, sixth and seventh goals: to reduce child mortality; to combat disease; and to ensure a sustainable human environment. Then, the Sustainable Development Goals took over in 2016 and emphasized the same concerns in the eleventh, twelfth and fifteenth goals **[2].**

In response to the various expressions of the impact of a landfill on the environment and the health of its residents, UNEP conducted a study in 2007 on the effects of the Dandora landfill (Kenya) on children's health. This survey examined 328 young people between the ages of 2 and 18 living near this landfill and its health implications. A pioneer in environmental impact assessment, the survey was intended as a model for Africa and urban centers in developing countries **[3].**

In Gabon, we have not found any study determining the impact of waste or a landfill on the health of residents, especially children. A giant garbage dump in Mindoubé, the only official garbage treatment site in Libreville, formerly outside Libreville but gradually encompassed by unplanned urbanisation, led us to question its health role. We hypothesised that the gases produced by this landfill were similar to those found in other studies but also that these fumes impacted the nearby children's health.

The main objective of our study was to determine the impact of airborne pollutants from this landfill on the health of children aged 3 to 11 years living in the vicinity, more specifically, to measure the concentrations of airborne pollutants emitted by the landfill.

METHOD

It was a prospective, cross-sectional and analytical study. It took place in Libreville from 1st of October 2019 to 31 March 2020. It concerned children living around the Mindoubé landfill (south of Libreville) within a two-kilometer radius. We compared their medical history and health status to controls who were children living beyond 5 kilometers from the landfill. We matched children by age and gender.

We included children aged 3 to 11 years living in Libreville and divided them into two subgroups. The first group was children living on the site of the Mindoubé landfill for at least 1 year and up to 2 km radius in the surrounding area, whom we have named "residents" (G1). The second group (G2) consisted of children matched by sex and age and living beyond a 5-kilometer radius of the landfill, whom we referred to as controls. We recruited all the children voluntarily from the families. They had to have a health record. We did not include children under 3 years of age, over 11 years of age, those whose parents had refused to participate in the study, those who were transient, and those who had lived there for less than a year. According to Schwartz's formula, the sample size gave us 80 subjects, with Za: deviation reduced, corresponding to the value that considers the error of 5% with a 95% confidence interval. (Za=1.96), p: prevalence of chronic malnutrition in Gabon at 4% among children under 15 years of age, i: desired precision for prevalence; i=5%. D= attenuation factor 1.3. A total of 76.7 rounded to 80 subjects.

We carried out data collection in two phases. On 1 October 2021, 15 November 2021 and 30 December 2021, we collected environmental air data at the Mindoubé site at the entrance to the landfill (point 1) and at the centre of the dump (point 2). These measurements were also carried out on the same dates at three control sites near the control's homes. The measurements of hydrogen sulfide (H_2S), carbon monoxide (CO) and particulate matter (PM) in the air were carried out by SOBRAGA's QHSE laboratory using ALTAIR 4X© gas detectors and Dustmate©. The ALTAIR 4X© detector is a portable multi-gas analyser. It is of military technology, equipped with new generation sensors (MSA XCell®) with fast response, allowing the capture of CO and H2S according to the programming, with a specificity of resistance to H2 interference. The Dustmate© is a portable analyser that, in "environment" mode (i.e. in the open air), allows the dissociation and obtention of particle concentrations PM10 (particles > size to about 10 µm), PM2.5 (particles size > to about 2.5 µm), PM1 (particles size > to about 1 µm).

The second phase consisted of collecting data concerning the children: the socio-demographic situation of the child's family, the search for a medical history over the last twelve months (health record), and a physical examination. Cases and controls were recruited from the same schools, The variables collected were for the child's family: age in years, level of education, mother's occupation, and the marital status of each family. For the child: age in years, sex, weight, height, episodes of upper or lower respiratory infection, and episodes of dermatological conditions reported in the diary.

The survey was approved by the Gabonese Ministry of Health, the Ministry of the Environment and the Presidency of the Republic. The associations of the residents of this landfill andAverda,the company in charge of the management of this landfill, also gave their approval and help. Parents gave their written consent by signing the informed consent form on the day of inclusion. The survey went on in a fully respected Data confidentiality.

Quantitative variables were expressed as mean or median. Qualitative variables were expressed in terms of frequency. The prevalence of asymptomatic carriage was described with a 95% confidence interval. The univariate analysis assessed the association between a clinical event and living on the landfill site or socio-demographic characteristics by calculating the odds ratio with a 95% confidence interval according to the Miettinen method. This analysis allowed us to extract the variables of interest for the multivariate analysis performed in logistic regression. The *p-value* selected as significant was <0.05 for a two-sided Chi-square test.

RESULTS

We included a total of 160 children, 80 cases and 80 controls. The children were divided by sex into 70 girls (35 in each group) and 90 boys (45 in each group). The median age of the children in general was 7 years, and the median age of the G1 and G2 controls was 7 years. The children had a median rank of 3rd among their siblings. They came from families raising a median of 4 children at home in general, with G1 = 4 and G2 = 3.

Families lived at the landfill site with a median presence of 8 years, with extremes ranging from 1 to 27 years. The mean age of the mothers of the children in the study was 33.9 ± 7 years, the G1 mothers = 34.3 ± 9 years, and the G2 mothers = 33.4 ± 6 years. The other characteristics of the families are summarised in Table 1.

The determination of air pollutants showed that the averages of H_2S, CO, PM1, PM2.5 and PM 10 were above the values of the measurements made in the control sites and above the WHO maxima (Table 2).

Living at the site was the factor found to be associated with pulmonary, dermatological and ENT conditions (Table 3). Multivariate analysis found that living at the landfill site was a determining factor of OR = 4.7 95% CI [3, 6.1]; $p<0.001$.

DISCUSSION

The presence of a public landfill, initially external, then gradually integrated into the urban perimeter, aroused our curiosity, particularly about its medium- and long-term impact on the health of residents. Despite all the difficulties and limitations, we managed to include 160 children, which allowed us to establish the health impact of this landfill on the young children living nearby. We decided to conduct an exposed-unexposed, cross-sectional, analytical study rather than a cohort study. The cohort study would have required more material and financial resources and, above all, more time. Its scale would have required a local or national entity to carry it out. The managementof our project neededless means than a cohort. Although less potent than a cohort, this methodology allowed us to urgently respond to the risk factor represented by the proximity of the Mindoubé discharge in the appearance of several diseases. The socio-demographic parameters of children and their families in general can be superimposed on the results of the 2023 Demographic and Health Survey **[4].** A comparison of the socio-demographic characteristics of the two groups shows that living around or on the landfill site is, first and foremost, a phenomenon of poverty. The subjects residing on the site live in dwellings more often precarious than the controls.

A high level of particulate matter was found, with PM2.5 levels four times higher than normal at the inlet of the landfill. PM10 was 1.5 times higher than normal at the same entrance, with levels ten times higher than normal at the centre of the landfill. Gases (carbon monoxide, hydrogen sulfide) also exceeded the WHO-permitted values for carbon monoxide and hydrogen sulfide. We remind that these measurements were made instantaneously. Exposure to high levels of gases and particles emitted from the landfill increased the risk of developing ENT pathology by 50 times and the risk of developing pleuropulmonary pathology by 6.4 times. The cumulative effects would, therefore, be dangerous for the health of children living near this landfill. The study by Carrillo et al. had similar results. Indeed, they stipulated that exposure to air pollution increased the prevalence of respiratory diseases, such as asthma, in Hidalgo County, Texas. This prevalence was 9.4% **[5].** Bai et al. found an increase in acute bronchitis related to exposure to air pollution. Indeed, an increase in the concentration of PM2.5 and CO increased paediatric consultations. The cumulative effect of relative risk was estimated at 1.03%, particularly during the winter. Children between 6 and 14 years were the most vulnerable **[6].**UNEP found respiratory illnesses the most common in Dandora at 46.9% **[3].** Bates et al. in Bhaktapur, Nepal, highlighted the role of kerosene cooking fuels and biomass as risk factors for lower airway infections (LAI) inside homes. However, PM2.5 from kerosene was the most potent. Indeed, increasing PM2.5 quartiles were associated with an increase in ORs at 1.51, 2.22, and 2.48 for the three highest exposure quartiles **[7].**Malley et al. demonstrated that exposure to PM2.5 was a possible risk factor for preterm birth. The number of deliveries associated with PM2.5 was estimated at 2.5 million worldwide, with an estimated low concentration threshold of 10µg/m3. In this meta-analysis, South and East Asia, North Africa, the Middle East and West Africa had the highest associated percentages of PM2-associated preterm births; 5.18% of total preterm births were associated with PM2.5 **[8].**

Tonsillar hypertrophywas the most common ENT sign found in those exposed. 56.3% (n=45) of the children living in Mindoubé had this anomaly at a rate of 56.3% (n=45) compared to 2.5%(n=2) among the unexposed. The primary sources of pollution were air pollution due to the high presence of PM2.5 and PM10. This phenomenon could explain that air pollution exposes children to a high risk of developing an ENT or pulmonary pathology.

They, therefore, have a significant impact on the LA and upper airway (UA).Children in our study were 50 times more likely to have ENT pathology than controls. The survey by Zmirou et al. stipulated that particles could enter the respiratory system as far as the terminal alveoli. Compared to adults, The proportion of particles that reach the alveoli is three times higher in children and up to 8 times in newborns **[9].**

The fact that UA is the main gateway for infectious and allergenic agents could explain the high prevalence of ENT diseases found in children. In addition, UA play a role in the body's defences, which are immature in young children. The fact that children are constantly exposed to pneumatic allergens emitted by landfills would explain the high proportion of tonsillar hypertrophy**.**

Our study found the majority of dermatoses in exposed subjects compared to non-exposed issues with a rate of 78.7% compared to 7.4%. The social and economic level and the limited access to drinking water in some households would explain the high frequency of these dermatological pathologies. The Hassen et al. study found results similar to ours. It has been shown that skin pathology is one of the first reasons for medical recourse for people in precarious situations **[10].** A meta-analysis on dermatological pathologies due to particulate matter conducted by Ngoc et al. found that particulate matter (PM10 and PM2.5) was associated with an increased risk of dermatological pathologies, especially atopic dermatitis. This risk of AD was higher in infants and school-aged children. With its size and higher concentration of metals, PM2.5 was more related to the risk of AD in younger subjects than PM10. Indeed, an increase of 10μg/m3 in PM 2.5 increases the risk to 1.60% compared to 1.01% for PM10 [**11].**

Our survey also found living on the landfill as the most significant risk factor for pulmonary diseases; the children of Mindoubé were nearly 6 times more likely to develop lung disease than the controls. Several studies found results similar to ours, such as that of Amnesi-Maesano et al., which demonstrated the causal role of PM2.5 in the development of atopy, bronchial hyperresponsiveness and asthma in children in the group most exposed to PM2.5 in the vicinity of their homes **[12].** The WHO states that particulate matter has more health effects than other pollutants. Even at low concentrations, small particulate matter pollution has a health impact. Indeed, no threshold has been identified below that does not affect health. In developing countries, exposure to indoor pollutants released during domestic use of solid fuels in open fireplaces or traditional stoves increases the risk of acute lower respiratory tract infection and related mortality in young children **[13].** The study by Lu et al. showed that exposure to indoor air pollutants was associated with respiratory diseases. Compared to U.S. households, Romanian households had a higher percentage of smoke, limited use of indoor air conditioning, and environmental tobacco smoke that was associated with asthma and allergy symptoms. Additional risk factors identified for allergy symptoms included living in apartments, near pesticide spraying areas, and the use of incense sticks. The significantly higher risk of flu-like symptoms was associated with mould and moisture, using an air conditioner and iron stove heating in the children's room. They observed that increased respiratory symptoms in school-age Romanian children were partly related to environmental exposure at home **[14].** Lavigne et al. demonstrated that perinatal exposure to ambient air pollution was associated with the incidence of childhood asthma. Exposure to PM 2.5 in the second trimester of pregnancy increased the risk of developing childhood asthma to 1.07%. Increased impacts have been observed in children born to mothers with asthma, smoking during pregnancy, and male and preterm or low birth weight **[15].** However, Crockroft's found results contrary to ours. It revealed that only allergens cause asthma and that air pollution has an inconsistent and minor effect on the onset of asthma **[16].**

CONCLUSION

This survey showed that children living on or near the site were 40 times more likely to develop an ENT pathology and 9.8 times the risk of developing dermatosis. The Mindoubé landfill produces more than 4000 times a day the annual dose of PM10, PM2.5 and PM1. It also produces CO and hydrogen sulfide above the thresholds set by the WHO.

Exposure to the discharge also increased the risk of developing lung disease by 6 times. They also revealed that most of the people of Mindoubé live close by.

The air pollution highlights the danger of this landfill for residents and other districts of Libreville. Without the need to carry out a prospective study, health and political decisions for residents and the site are urgent, at the risk of constituting a time bomb.

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Consent:

Parents gave their written consent by signing the informed consent form on the day of inclusion. The survey went on in a fully respected Data confidentiality.

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Table 1: Socoi-demographic characteristics of families

	General		G1 (case)		G2 (controls)	
	n	%	n	%	n	%
Mother'slevel of education						
Primary	33	20.6	28	35	5	6.3
Secondary	94	58.8	48	60	46	57.5
University	33	20.6	4	5	29	36.2
Mother'semployment						
Frame	8	5	2	2.5	6	7.5
Free	28	17.5	14	17.5	14	17.5
Unoccupied	92	57.5	58	72.5	34	42.5
NC	32	20	6	21.2	26	32.5
Professional activity of the head of household						
Frame	14	8.8	2	2.5	12	15
Free	18	11.2	10	12.5	8	10
Unoccupied	77	48.2	51	63.8	26	32.5
NC	51	31.8	17	21.2	34	42.5
Home Building Materials						
Woodenplanks	59	36.9	50	62.5	9	11.2
Solid	101	63.1	30	37.5	71	88.8

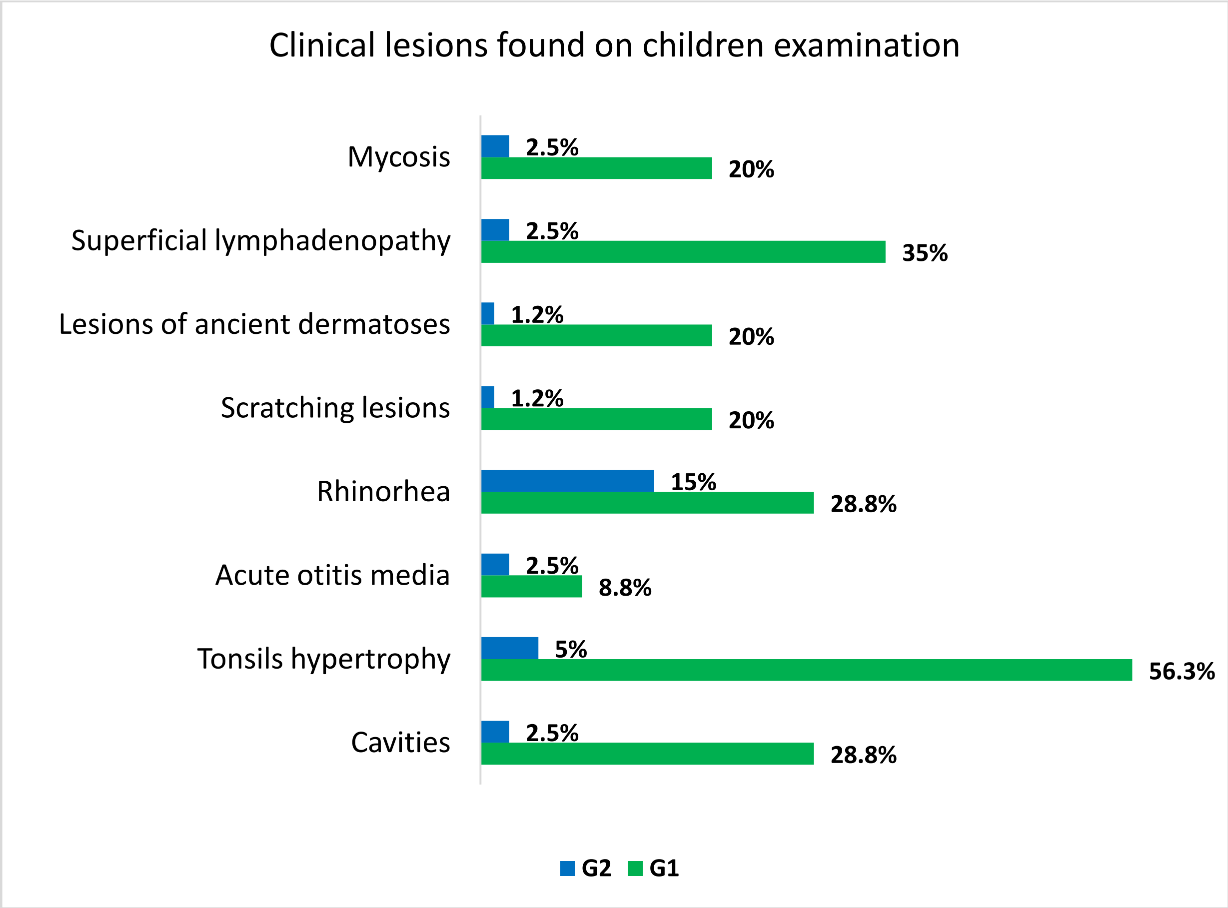

Figure 1: Clinical lesions found on examination of the included children

Table 2: Values of the means of measurement at the three points

Particulate matter (WHO threshold values)	**Point n°1 (µg/m^3)**	**Point n°2 (µg/m^3)**	**Witness point (µg/m^3)**
PM1.0 (< 70µg/m^3/year)	52	4320	8
PM 2.5 (< 25µg/m^3/24h)	105	365	12
PM 10 (< 50 µg/m^3/24h)	85	5960	10
CO(104µg/m^3/8h)	28625	11450	30
H2S (7µg/m^3)	114	171	Undetectable

Table 3: Risk factors for dermatological, ENT and pulmonary pathology

	OR	95% CI	*p*
Dermatological pathologies			
Living on the landfill site	9.8	[7.4 ; 12.1]	< 0.001
Unemployedmother	2.1	[1.8 ; 2.4]	0.0039
Number of children> 4	2.4	[1.7; 4.2]	0.004
Pulmonary pathologies			
Living on the Landfill	5.8	[5.1 ; 6.2]	<0.001
Unemployedmother	5.4	[5.0 ; 5.7]	<0.001
ENT pathologies			
Living on the Landfill	40.1	[29.8 ; 50.5]	<0.001
Unemployedmother	2	[1.6 ; 3.7]	0.001