Int J Med. Public Health. 2022; 12(3):103-106
A Multifaceted Peer Reviewed Journal in the field of Medicine and Public Health
www.ijmedph.org

Original Article

Effects of Wood Smoke Exposure and Associated Factors on Respiratory Parameters of Pygmies Involved in the Smoking of Game Meat in the Congo/Brazzaville

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ABSTRACT

Introduction: This study assesses the effects of pollutants generated by the burning of firewood by pygmies practicing the smoked meat trade. **Materials and Methods:** A total of 56 rural pygmies aged 36.92 ± 4.69 years old were divided into two groups, whose 29 exposed pygmies (practicing meat smoking) and 27 less exposed pygmies (not practicing this trade). Levels of PM2.5 pollutants and respiratory parameters were measured. A questionnaire including demographic data and another to identify symptoms of respiratory diseases were used. Epi info 7 software was used to perform the analyses. **Results:** This study indicates high concentrations of pollutants in the environment where this occupation is practiced. All spirometric parameters decreased in the exposed pygmies. The symptomatology was chronic cough, shortness of breath, wheezing and dyspnea that were higher in the exposed pygmy group. There was a strong association between the age of the subjects, the duration of exposure and the level of pollutants with certain symptoms. **Conclusion:** These results suggest that pygmies involved in smoking game meat inhale significant quantities of toxic particles. This pollution has health and environmental implications. Screening programmer are needed for this population.

Keywords: Pollution, Wooden smoke, Respiratory parameters, Pygmies, Congo.

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History
- Submission Date: 18-04-2022;
- Revised Date: 14-05-2022;
- Accepted Date: 24-05-2022.

DOI : 10.5530/ijmedph.2022.3.21

Article Available online
http://www.ijmedph.org/v12/i3

INTRODUCTION

Exposure to smoke or environmental pollutants can lead to increased airway inflammation and poorer clinical outcomes.[1] Fuel pollution is responsible for 3.7-4.8 million deaths, according to Wold Health Organisation (WHO) estimates, while the Global Burden of Disease study estimates 2.3-3.6 million deaths worldwide.[2] The products generated by fuelwood burning contribute to air pollution, particularly in indoor environments. In sub-Saharan Africa, nearly 646 million people use solid fuels to meet primary energy demand for heating and cooking,[3] and the absolute number of users is expected to continue to increasing until 2030.[4]

In Congo's forest departments, pygmies have always practiced customary self-subsistence hunting. This is an important part of their economical and cultural organization.[5] The continued demand for game meat from urban centers keeps higher the prices of these products, encouraging pygmies to engage in more commercial hunting activities.[6] The trade in game meat, as in all meat marketing chains, is not without risks. Indeed, during the various transactions linked to the changes between actors in the marketing chains of the "game meat" sector, the product, which is generally not packaged, sometimes undergoes degradation that alters its nutritional qualities. To preserve the meat, the pygmies practicing this activity use solid fuels in their homes. The use of this meat smoking technique exposes them to very high concentrations of harmful pollutants with potential health effects such as respiratory problems, cardiovascular problems, infant mortality and eye troubles.

Several studies have suggested that air pollutants from solid fuel combustion, specially fine particulate matter (PM2.5), Carbon monoxide (CO) and polycyclic aromatic hydrocarbons,[7-9] can cause serious health problems. Pun *et al.*[10] have shown that household exposure to wood smoke is associated with an increased risk of asthma and respiratory symptoms.

The existing literature has little information on respiratory infections in pygmies who are exposed to biomass smoke during meat smoking practice. The objective of this study was to evaluate the effects of pollutants generated by the combustion of firewood in pygmies practicing meat smoking.

Cite this article : Moussouami SI, Alongo YRG, Nsompi F, Mack MA, Issiako BN, Mbemba F. Effects of Wood Smoke Exposure and Associated Factors on Respiratory Parameters of Pygmies Involved in the Smoking of Game Meat in the Congo/Brazzaville. Int J Med Public Health. 2022;12(3):103-6.

MATERIALS AND METHODS

Study Design and Sample

This cross-sectional study was conducted between April and June 2021. The research revolved around pygmies involved in smoked game meat located in Sibiti, Lekoumou department. These pygmies were selected from different traditional meat smoking sites. Seven hunting meat smoking sites (out of 16) belonging to local pygmies were randomly selected.

Only non-smoking male pygmies over the age of 18 years who volunteered to participate in the study were eligible. No subjects with a history of respiratory disease were included in the study.

The total number of pygmies sampled in this study was 56. These subjects were divided into two groups according to their exposure: the most exposed group ($n = 29$; 51.7%) and the least exposed group ($n = 27$; 45.7%). The more exposed group was made up of pygmies engaged in meat smoking, while the unexposed group was made up of pygmies not engaged in this activity. In each group, subjects were selected randomly from the sites and from the local volunteers.

Data Collection

Demographic data, relevant medical history, diagnosis of respiratory disorders (cough, asthma, rhinitis, chest tightness) were recorded using a questionnaire based on Weiler and Ryan's model.[11]

Anthropometric measurements were carried out on pygmies in a standing position, immobile without support, with bare and jointed feet and lightly clothed. The height (T) was measured with a graduated scale allowing to appreciate the millimeter, a digital impedance meter scale of the brand Beurer (BG-22, Germany), sensitive to 100 g and with a maximum range of 150 kg were used to measure the body mass (BMI) then the percentage of fat. The body mass index (BMI) was calculated as the ratio of body mass in kg to height (in meters squared).

A Spirobank G portable spirometer (CE, MIR: Medical International Research), was used by trained personnel in accordance with ATS spirometry criteria and standardization procedures; vital capacity (VC), forced vital capacity (FVC), forced expiratory volume in seconds (FEV1) and the FVC/FEV1 ratio were assessed. The technician calibrated the spirometer twice a day according to the manufacturer's instructions. The mean percentage of the predicted value for each spirometer was calculated according to the sex, height of each subject. All subjects were briefed on the spirometry maneuvers.

At the outbreak sites and over a period of 24 hr, pollutant levels were measured at the different sites using a photometric device.

Statistical Analysis

The data for this study were entered using Epi info 7 software and analyzed using the software. The values were presented as means, standard deviations and frequencies. Regression models were constructed to assess the effect of subjects' age, smoking status and duration of exposure to pollutants on respiratory factors.

Compliance with Ethical Standards

The study was approved by the ethics and research committee of the Marien Ngouabi University. All participants signed an informed consent in accordance with the Declaration of Helsinki.

RESULTS

The exposed group had a lower prevalence of non-educated subjects (41.3%) *versus* 59.2% and a higher frequency of current smokers (65.5% versus 11.1%) than the unexposed group.

The average age of the subjects in the exposed and unexposed groups was of 36.46 ± 5.05 years *versus* 37.46 ± 4.48 years; height was 158.83 ± 3.67 cm and 159.81 ± 4.87 cm and BMI 25.20 ± 2.36 kg/m^2 and 25.25 ± 2.22 kg/m^2 respectively. No significant differences were observed between the above-mentioned values. Equivalence is accepted because the comparison of the anthropometric values of the two groups showed no significant difference. The subjects engaged in meat smoking had a lower respiratory profile than the least exposed pygmies (Table 1).

Respiratory symptoms and allergy were more frequent in pygmies in the exposed group than in the unexposed group (58.6% *versus* 29.6%). The exposed group also had higher prevalence asthma (68.9% *versus* 22.2%), breathlessness (62.0% *versus* 22.2%), wheezing (66.9% *versus* 29.6%), chronic cough (68.9% *versus* 25.9%) and dyspnea (62.1% *versus* 29.6%) (Table 2).

Regression analysis showed that the increasing risk of asthma and wheezing (OR = 2.6; 97.5% CI 0.3, 55.7) was greater in exposed pygmies aged over 40 years.

Table 1: Sociodemographic and spirometric characteristics of the pygmies studied.

Sociodemographic and spirometric characteristics	Exposure ($n = 29$) x ± SD	No exposure ($n = 27$) x ± SD	*p*-value
Age (years)	36.46 ± 5.05	37.46 ± 4.48	0.39
Heigh (cm)	158.83 ± 3.67	159.81 ± 4.87	0.86
Weigh (kg)	63.60 ± 6.32	63.84 ± 4.49	0.08
BMI (kg/m^2)	25.20 ± 2.36	25.05 ± 2.22	0.79
FVC (L)	2,48 ± 0,21	2,98 ± 0,17	< 0.001
FEV1(L)	1.79 ± 0.90	2.77 ± 0.26	< 0.001
FEF (L/s)	3.21 ± 0.19	5.21 ± 0.75	< 0.001
FEF 25-75 (L/s)	2,66 ± 0.72	3,25 ± 0.75	< 0.001
General caracteristics	Exposure %(CI 95)	No Exposure %(CI 95)	
Educational level			
- None	41.3(23.4-59.3)	59.2(40.7-77.7)	
- Primary	31.0(14.1-47.8)	/	0.006
- 2nd grade	27.6(11.3-43.8)	40.7(22.2-59.2)	
Exposure time			
- Under 5 years	31.0(14.1-47.8)		
- Between 5 and 10 years	27.6(11.3-43.8)	/	/
- Over 10 years	41.4(23.4-59.3)		

Table 2: Frequency of respiratory symptoms in exposed and less exposed pygmies.

Respiratory symptoms	Exposure ($n = 29$) 95%IC	No Exposure ($n = 29$) 95%IC	*p*-value
Allergy	58.6(40.6-76.5)	29.6(12.4-46.8)	0.05
Asthma	68.9(52.1-85.8)	22.2(6.5-37.9)	0.001
Shortness of breath	62.0(44.4-79.7)	14.8(1.4-28.2)	0.000
Wheezing	66.9(52.1-85.8)	29.6(12.4-48.8)	0.007
Chronic cough	68.9(52.1-85.8)	25.9(9.4-42.4)	0.003
Dyspnea	62.1(44.4-79.7)	29.6(12.4-46.8)	0.03

Table 3: Association between respiratory symptoms and determinants in exposed pygmies.

	Allergy	Chronic cough	Asthma	Wheezing	Shortness of breath	Dyspnea
	OR adjusted 95%IC	OR adjusted 95%IC	OR adjusted 95%IC	OR adjusted 95%IC	OR OR adjusted 95%IC	OR adjusted 95%IC
Age						
- < 40 years	1	1	1	1	1	1
- > 40 years	0.2(0.0-1.6)	0.8(0.1-7.4)	2.6(0.3-55.7)	2.6(0.3-55.7)	0.5(0.1-3.4)	0.5(0.0-3.4)
Exposition time						
- 5 and 10 years	1	1	1	1	1	1
- < 5 years	0.7(0.1-5.2)	0.04(0.0-0.4)	0.4(0.0-3.1)	1.1(0.1-12.3)	0.4(0.0-3.1)	3.3(0.5-28.1)
- > 10 years	0.8(0.1-12.3)	1.5(0.0-44.3)	1.0(0.1-7.9)	0.4(0.0-3.1)	0.5(0.0-3.1)	5.0(0.7-40.5)
Nevel PM25						
- < 100 m	1	1	1	1	1	1
- 100 and 200 m	1.8(0.3-10.9)	0.8(0.1-6.1)	3.3(0.3-76.2)	5.1(0.5-11.3)	1.5(0.2-13.8)	0.8(0.1-8.8)
- > 200 m	3.6(0.5-33.0)	0.6(0.0-4.5)	0.2(0.0-1.4)	0.5(0.1-3.6)	0.1(0.0-0.8)	0.03(0.0-0.6)

Regression analysis also showed that there was an increasing risk of chronic cough and duration of exposure (OR = 1.5; 97.5% CI 0.0, 44.3). The magnitude of the risk estimate for respiratory symptoms was small when the level of the pollutants (PM2.5) was measured more than 200 m from the homes (Table 3).

DISCUSSION

This study was carried out to identify the respiratory symptoms and lung profile of pygmies exposed to wood smoke and smoked hunting meat. The results showed that the risk of developing dyspnea and wheezing was significantly higher in pygmies who smoked meat (the most exposed group). These respiratory symptoms were positively associated with quantitative measurements of particulate matter (PM2.5). Subjects with respiratory symptoms were more likely to have poorer lung function.

Many studies suggest that airway damage in exposed subjects is strongly correlated with pollutants. The data from the present study are consistent with those from the study of children in south Nigeria exposed to wood smoke in a fishing port showing altered lung function parameters.[12] Indeed, the population in this study uses traditional means of meat preservation which are low efficiency stoves with no smoke exhaust. The particles emitted during wood burning provoke inflammatory responses and fibrosis of the airways which would certainly be the cause of the observed decrease in respiratory values. Wood smoke induces an increase in the oxidative load and causes irreversible changes in the protective antioxidant systems in the airways. This oxidative stress associated with wood smoke will cause significant inflammation and respiratory system decline in the lungs.[13]

Measurement of PM2.5 particles at sites and away from homes for 24 hr in this study reported higher concentrations around homes. Similar results have been found in several subsequent studies.[14-15] Them, the higher than permissible limits are multi-causal risk factors for developing respiratory health disorders in an exposed population. A recent study has shown that PM2.5 particles cause inflammation of the lungs and airways.[16]

Time of exposure to air pollutants has a strong influence on the decline in lung function and the increasing rate of respiratory diseases. These results corroborate those of studies of Turkish women. These studies indicated a strong relationship between exposure time during cooking or bread preparation and the development of lung diseases.[17] Another study on respiratory symptoms and obstructive ventilatory disorders in Tunisian women exposed to biomass noted that exposure is only counted from a minimum exposure time of 2 hr per day for at least 10 years, which corresponds to an exposure time of more than 20 hr-years.[18] However, it is difficult to accurately quantify the actual time in hours per day, days per week and month.

The prevalence of respiratory symptoms was higher in exposed pygmies than in the less exposed ones. These results are similar to those reported by Kwas *et al.*[19] These authors noted that exposure to smoke increases the risk of contracting respiratory diseases such as: Allergy, Asthma, Chronic Bronchitis, Rhinitis and Stage II Dyspnea. Similarly, others have found monotonic and positive exposure-response relationships of exposure to coal smoke with modelled odds ratios (OR) of phlegm, cough with phlegm, and bronchitis.[20-21]

Indeed, exposure to particulate matter is associated with a higher incidence of upper airway symptoms, such as nasal obstruction and airway irritation from particulate matter entering the respiratory system.[22]

The duration of exposure of more than ten years and respiratory disorders was found to be strictly related to the pathologies identified in this study. Currently, several studies are evaluating the relationship between duration of exposure to wood smoke and the development or exacerbation of respiratory and allergic diseases. A recent study also suggests that the duration of exposure is correlated with the severity of lung damage assessed by lung function measurements.[23] This relationship can be explained by the fact that wood smoke exposes the lung to extreme levels of oxidative stress. In the gas phase, wood smoke contains a significant amount of reactive oxidative molecules per puff. Wood smoke induces an increase in oxidative load and causes irreversible changes in the protective antioxidant systems in the airways. This oxidative stress associated with wood smoke will cause significant inflammation and respiratory system decline in the lungs.[23]

Innovation and Applications

This study showed that the occupation of smoked hunting meat increases the risk of respiratory disease common among pygmies in the Republic of Congo. It is therefore necessary to promote good hygiene rules in order to limit the risks associated with exposure to wood smoke. The use of smokehouses with smoke evacuation should be considered in order to reduce the level of exposure to respiratory diseases. This work will serve

as a basis for promoting good practice in this occupation and developing more effective techniques to preserve the health of this at-population in danger.

CONCLUSION

The results of this study suggest a strong relationship between exposure to wood smoke and impaired lung function in pygmies practicing meat smoking in Lekoumou, a rural milieu in the Congo. To reduce these risks, alternative smoking and meat preservation techniques are needed in this community of pygmies. To establish causal links of respiratory symptoms, further longitudinal studies are needed, too.

ACKNOWLEDGEMENT

Authors would like to express a thein, gratitude to all the pygmies of the rural Lekoumou area for their enable the completion of their also than call administration and health officials whose multiple supports have been with strong in impact to fulfill this research. We are also grateful to all colleagues in the laboratory and their contribution with indelible advice have helped us successfully conduct this study.

Funding

This research was supported by the Research Program of Marien Ngouabi University through the Laboratory of Physiology of Effort and Biomechanics (LPB), the Higher Institute of Physical Education and Sport, which provided the funding.

CONFLICT OF INTEREST

The authors declare that there is no conflicts of interest.

ABBREVIATIONS

PM: Fine Particulate Matter; **WHO:** Wold Health Organisation; **CO:** Carbon Monoxide; **VC:** Vital Capacity; **FVC:** Forced Vital Capacity; **FEV1:** Forced expiratory volume in seconds: **BMI:** Body mass index.

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Cite this article : Moussouami SI, Alongo YRG, Nsompi F, Mack MA, Issiako BN, Mbemba F. Effects of Wood Smoke Exposure and Associated Factors on Respiratory Parameters of Pygmies Involved in the Smoking of Game Meat in the Congo/Brazzaville. Int J Med Public Health. 2022;12(3):103-6.