

## Inhalation of smoke from cooking activities in Katanga, a health burden among women users of charcoal and firewood

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### Abstract

This study focused on the Inhalation of smoke from culinary activities in Katanga. It was carried out over a period of approximately 4 years. The study population consisted of women whose average age was 37.8 (16) years. On the one hand, 119 rural women (permanent users of coal in the Futuka village and 121 urban women (FU) in the Vallée urban district of the city of Lubumbashi were approached and selected.

The fundamental question was whether prolonged or sporadic exposure to smoke from cooking activities could be an exposure factor to the risk of respiratory infections. Following the investigations made and the multiple functional explorations, we arrived at the confirmation of this hypothesis. In view of the results obtained, we found that the frequency of use of these biomasses oscillated respectively between 63.6% in town and 75% in rural areas.

In the two female categories considered, the rates of cough and morning and usual sputum were, in almost all cases, higher among women from Futuka than among those from the Vallée district. Concerning the crisis of breathlessness and difficulty breathing, we noticed that for the three parameters observed (morning awakening with difficulty breathing, shortness of breath at rest during the day and shortness of breath after intense effort), the women users of the Vallée district were the more affected. For the values, apart from the Tiffnaud ratio (FEV1/FVC%), the functional exploration using the spirometer showed overall that almost all the spirometric parameters led to statistically significant differences between urban women (FU) of the Vallée district and rural (FR) of the Futuka village. These are the forced vital capacity (FVC% pred with a p=0.034), the peak expiratory flow (PEF with a p value of 0.000) and the expiratory volume at the first second (FEV1% pred with a p value of 0.000).

**Keywords:** Respiratory Effects; Charcoal; Firewood; Producers; Users

### 1. Introduction

The release of toxic substances from culinary activities into the environment has a negative impact on the quality of inhalable air and on the health of living beings, particularly among the most vulnerable people (women, children, the elderly). The persistence of pathologies affecting the respiratory tract of people exposed to the risk of inhaling fine

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particles and gases resulting from the use of charcoal is observed above all in developing countries, such as the DRC, where electricity and gases are scarce commodities.

Nearly a third of the world's population uses solid fuels from plant materials (biomass) or coal for cooking, heating, or lighting (Linares, B., et al. 2010). It has been established that any combustion of wood can result in severe indoor air pollution and lead to cancer when the smoke is poorly ventilated (Gordon et al. 2014; Maurice, 2010). As a result, millions of people regularly die around the world as a result of activities related to the use of charcoal. Yet using improved stoves is easy, affordable, clean and efficient (Keita, 2012).

It has also been shown in the literature that women who use biomass have a higher prevalence of respiratory tract symptoms than women who do not use it (Mukherjee, 2014). The main known health effects range from bronchospasm and chronic cough to lung cancer and an increased risk of heart attack and other cardiovascular diseases. All these pathologies are caused by the inhalation of fine particles and wood smoke. The latter is composed of gaseous products resulting from combustion such as harmful gases such as carbon monoxide (CO) and sulfur dioxide, SO<sub>2</sub> (Ademe, 2011; Linares, 2010).

While the impact of wood smoke, including particulate matter from it, on respiratory health is known, however, the links of association between exposure to these substances, housing characteristics and respiratory health remain. still almost undocumented in our province in general and in the city of Lubumbashi and its surroundings in particular. This is why in this article, we present the results relating to two types of women users of charcoal, those of the Vallée district of the city of Lubumbashi and the Futuka village located 31 km from the city of Lubumbashi.

### *Objective*

To evaluate the factors of exposure to air pollutants derived from cooking activities and to compare the state of respiratory health (sub-clinical, clinical, and functional) of women belonging to two different groups and potentially exposed to the risk of air pollutants derived from charcoal. wood and firewood was the objective pursued.

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## **2. Methodology**

### **2.1. Study type and subject categories**

This is a descriptive study with an analytical aim carried out in the province of Haut-Katanga and particularly in the city of Lubumbashi and its surroundings. In its first phase, the study described the socio-demographic and anthropological profile, the vital parameters and other specific characteristics of the permanent users of charcoal from the aforementioned environments. Thereafter she approached the realization of the functional tests of association with the exposure to the fumes of the charcoal through the manipulation or their direct use. The investigations were carried out over a period of approximately 4 years and the population studied consisted of women whose average age was 37.8 years. In addition, the number of women permanent users of charcoal amounted to 121 subjects for the urban district of the Valley of the city of Lubumbashi and 119 for the village of Futuka.

### **2.2. Age categories of subjects**

Within each group, three categories of women of different ages were considered: Young women (15 - 30 years old); Adult women (31 - 50 years old) and post-menopausal housewives (51 years old and over).

#### *2.2.1. Parameters considered*

For each household, a detailed questionnaire containing the following parameters was administered:

Identify;

- Anthropometric parameters;
- Vital parameters;
- Culinary habits;
- Spirometric data;
- Metric CO data (carbon monoxide concentration);
- Observed respiratory health issues.

### 2.3. Data entry and analysis

Data entry and analysis were performed using Excel, SPSS 20.0 software (for all variables). A univariate analysis was carried out on each of the variables under study, in order to determine the basic characteristics of the descriptive statistics (characteristic of central tendency, that is to say the mean, the median, the mode, the quantiles).

## 3. Results

### 3.1. Description of population

The first results of this study concerned the description of the population subjected to our investigations, through the age, the anthropometric parameters, the vital signs, the socio-economic data, the culinary habits and the consumption of alcohol and tobacco. .

**Table 1** Anthropometric data, numbers, means and standard deviations (SD) by exposure category and age

No.	Women's categories	Effective	Age, in years (SD)	Weight, in kg (DS)	Height, in cm (DS)	BMI (DS)
1	F. Urban (FU)	NOT				
	Youth	40	21 (3)	55 (6)	160 (6)	21.3 (2.2)
	Breeders	52	33 (6)	64 (13)	160 (7)	24.8 (4.1)
	Post menopausal	29	59 (10)	59 (12)	156 (6)	24.1 (4.4)
	S/Total 1.	121				
2	F.Rurales (FR)	NOT				
	Youth	34	21 (2)	52 (8)	155 (8)	21.8 (2.2)
	Breeders	55	34 (6)	56 (13)	156 (8)	23.0 (4.4)
	Post menopausal	30	57 (9)	54 (13)	156 (5)	22.1 (4.3)
	S/Total 2,119					
	Grand total.	240	-	-	-	-

**Legend :** U Charcoal users, N = number; SD = standard deviation; BMI = body mass index; FU= Urban Women ; FR = Rural Women.

This table shows that the most numerous subjects in the two groups belonged to the category of reproductive women. In the Vallée urban district, they represented 43% of the total workforce and in the Futuka village 46.2%. Their average age was 33 in the first case and 34% in the second. With regard to weight and body mass index, they were higher in adult women qualified as reproductive than in young and post-menopausal women. Comparatively, the average data of urban women were all higher than those of rural women.

**Table 2** Vital parameters of the subjects (Blood pressure, Heart rate) during the household survey among women charcoal users

Women's categories	Effective	Psyst (in mm Hg)	Pdiast (in mm Hg)	Fcard Ox (Batt/min)	Fcard.Man (Batt/min)
		Avg (SD)	Avg (DS)	Avg (SD)	Avg (SD)
<i>F. Urban (FU)</i>	NOT				
Youth	(40)	120.0 (12.8)	76.4 (12.5)	81.9 (10.3)	81.2 (9.9)
Breeders	(52)	119.5 (16.4)	76.7 (13.6)	77.2 (11.3)	77.9 (12.7)
Post menopausal	(29)	139.6 (22.0)	86.1 (11.9)	80.6 (11.4)	79.2 (11.5)
<i>F.Rurales (FR)</i>					

Youth	(34)	112.8 (10.0)	73.4 (8.7)	81.4 (12.2)	81.0 (12.9)
Breeders	(55)	121.7 (17.9)	80.4 (14.2)	84.9 (15.1)	99.8 (114.3)
Post – menopausal	(30)	139.8 (20.3)	86.5 (12.5)	80.4 (13.3)	79.1 (12.5)

**Legend:** **Psyst** = systolic pressure ; **Pdiast** = diastolic pressure ; **Fcard Ox** = Heart rate taken with the oximeter ; **Fcard.Man** = Heart rate taken manually .

Although the mean values of systolic and diastolic blood pressure were within the normal range, there were nevertheless, in each group, a few individuals with elevated blood pressure. The situation, thus evoked, also concerned the heart rates, taken with the oximeter and those obtained manually.

### 3.2. Fuels used and cooking habits

Tables 3 and 4 bring together the results relating to the fuels used for cooking food and the location of the place where this activity is carried out.

**Table 3** Distribution of female charcoal users (urban, rural) according to cooking habits and fuels used.

Fuels used	F. Urban (FU)	F. _ Rurales (FR)
Charcoal	116 (95.9%)	104 (87.4%)
Firewood	0(0%)	15 (12.6%)
Electricity	5 (4.1%)	0(0%
Gas	0(0%)	0(0%)
Total 121 119		

Reading Table 3 shows that coal is the fuel most used by all the subjects included in this work. Its use varies between 87% and 95.9% respectively in rural and urban sites. We also noted both a low use of electricity in the targeted urban site (4.1% ), and of wood in rural areas (12.6%). The table further indicated that gas was not used anywhere.

**Table 4** Distribution of female charcoal users by daily frequency of fuel use

Frequency	F. Urban	F. Rural
Once	16 (13.2%)	23 (19.3%)
Twice	77 (63.6%)	75 (63%)
Thrice	26 (21.1%)	19 (15.9%)
more than three times	2 (1.6%)	2 (1.6%)
Totals	121	119
240		

The highest daily frequency of charcoal use was twice at both permanent charcoal user sites (63%). On the other hand, on the whole, use beyond three times was observed very little.

### 3.3. Tobacco and alcohol consumption

With regard to alcohol consumption, the table below indicates that beer occupied the first position in urban areas with 35.5% among users in the Vallée district (FU). In addition, among rural users in the Futuka village (FR), this consumption was slightly low, 29.4%. While that of the local drink called "Lutuku" amounted respectively to 4.9% in the Vallée district and 10.% in the Futuka village. As for tobacco consumption, the data collected show low consumption of this substance in the two targeted areas, respectively with 2.5% in urban areas and 7.5% in rural areas.

**Table 5** Distribution of female charcoal users according to tobacco and alcohol consumption

Settings	FU (N=121 )	F.R (N=119 )
Tobacco		
No – smokers	113 (93.4%)	102 (85.7%)
Smokers	3 (2.5%)	9 (7.6%)
Ex – smokers	5 (4.1%)	8(6.7%)
Totals	121	119
Alcohol		
Beer	43 (35.5%)	35 (29.4%)
lutuku	6 (4.95%)	12 (10%)
Whiskey	5 (4.13%)	4 (3.36%)
Other drinks	67 (55.37%)	51 (42.8%)

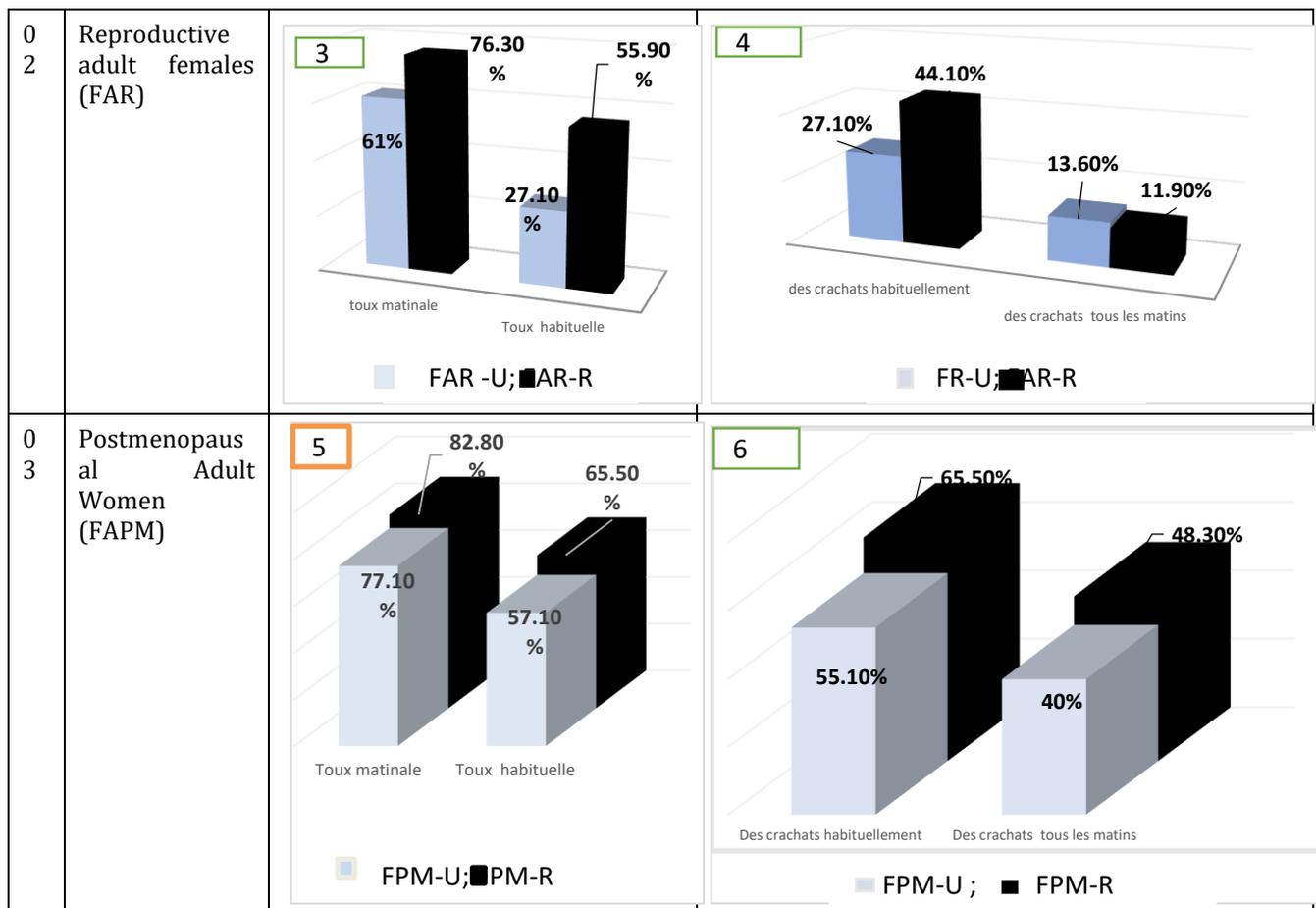
### 3.4. Respiratory symptomatology

In this section, in relation to respiratory symptomatology , we have considered cough and sputum, shortness of breath as well as the description of breathing.

#### 3.4.1. Cough and expectoration

The three categories of women who use coal have been maintained: young women, adult women who are still giving birth (of childbearing age) and post-menopausal women. The recorded results are collated in Figure 1.

N o.	Categories of women	Cough	Spitting																		
		morning and usual	morning and usual																		
0 1	Young women (F)	<div style="border: 1px solid black; padding: 5px;"> <p><b>1</b></p> <table border="1"> <caption>Cough Symptoms Data</caption> <thead> <tr> <th>Symptom</th> <th>FJ-U (%)</th> <th>FJ-R (%)</th> </tr> </thead> <tbody> <tr> <td>toux matinale</td> <td>64%</td> <td>86.10%</td> </tr> <tr> <td>Toux habituelle</td> <td>48%</td> <td>63.90%</td> </tr> </tbody> </table> </div>	Symptom	FJ-U (%)	FJ-R (%)	toux matinale	64%	86.10%	Toux habituelle	48%	63.90%	<div style="border: 1px solid black; padding: 5px;"> <p><b>2</b></p> <table border="1"> <caption>Spitting Symptoms Data</caption> <thead> <tr> <th>Symptom</th> <th>FJ-U (%)</th> <th>FJ-R (%)</th> </tr> </thead> <tbody> <tr> <td>des crachats habituels</td> <td>48%</td> <td>55.60%</td> </tr> <tr> <td>des crachats tous les matins</td> <td>12%</td> <td>16.70%</td> </tr> </tbody> </table> </div>	Symptom	FJ-U (%)	FJ-R (%)	des crachats habituels	48%	55.60%	des crachats tous les matins	12%	16.70%
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des crachats tous les matins	12%	16.70%																			



**Figure 1** Graphs of morning and usual cough and sputum observed in subjects FJ, FAR and FPM users of charcoal in the two study sites, urban (La Vallée district) and rural (Village Futuka); U=urban and R=rural.

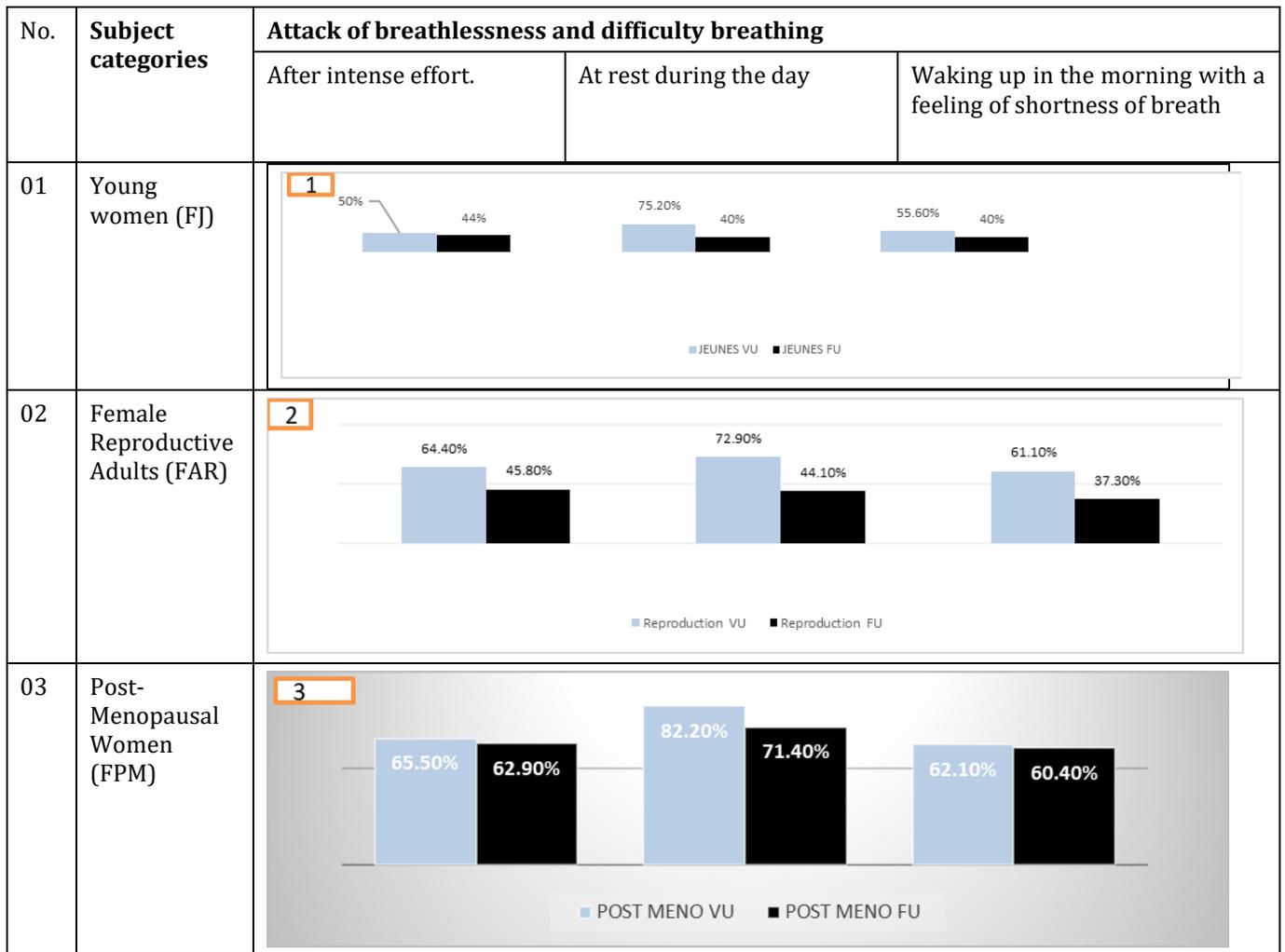
In the three female categories considered, apart from the case of morning sputum of reproductive women everywhere else, the rates of morning and usual sputum were higher among rural women in Futuka than among urban women in the Vallée district of the city of Lubumbashi. Moreover, it also appears clearly that the frequencies of cough remained higher than those of sputum in all categories of subjects subjected to our investigations. However, if the rates of morning cough were higher than those of usual cough, on the other hand, for sputum, the opposite situation was found: the frequency of morning sputum was lower than that of usual sputum. The ranking in descending order of cough and sputum frequencies was respectively as follows:

For cough: young women > post - menopausal women > reproductive women ;

For sputum: post-menopausal women > young women > reproductive women.

### 3.4.2. Attack of breathlessness and difficulty breathing

Figure 2 below contains the graphs relating to three manifestations of shortness of breath recorded in the three categories of housewives considered in the present study: morning awakening with difficulty breathing, the attack of shortness of breath at rest during the day and the crisis of breathlessness after intense effort.



**Figure 2** Graph of manifestations of shortness of breath in FJ, FR and FPM women charcoal users at the two study sites, VU and FU.

From the graphs relating to shortness of breath, we found that the rates of respiratory discomfort and of the attack of shortness of breath at rest during the day were all significantly higher in young women and in reproductive women in the urban district of the “Vallée” ( FJ-U and FAR-U) than among their colleagues in Futuka village (FJ-R and FAR-R).

*Functional exploration with spirometry.*

In the spirometric study, we performed a double comparison. The spirometry values observed were compared in urban (FU) and rural (FR) women using charcoal (Table 6). Here, we applied the t-sample test, for the control of three categories of women under study (FJ, FAR, FPM).

**Table 6** Comparison of the distributions of spirometric values (FVC, FEV1, FVC/FEV1, DEP) observed in women users of charcoal, in the urban (FU) sites of the Vallée district and the rural (FR) sites of the Futuka village

PARAMETRE	FU	FR	P value F
Tests exécutés	n= 121	n= 119	
Score 0 et autres	n=28	n= 41	
Tests retenus	n=93 (76,9%)	n=78 (65,5%)	
FVC% préd			
Score 3	N= 24	N= 19	

[min - max]	[55.47 - 114.34]	[61.50 - 112.32]	P value =0.034 F=3.122
Moy ± DS	84,59 (12.55)	89.68 (11.38)	
Score 3+2b+1b	N=79 (24+25+30)	N=59 (19+25+15)	
[min - max]	[43.26 - 114.33]	[57.69 - 115.64]	P value=0.079 F=4.723
Moyenne (DS)	81.95 (15.57)	93.94 (13.64)	
FEV1 % préd			
Score 3	N= 24	N= 19	
[min - max]	[48.74 - 113.44]	[58.81 - 116.60]	P value=0.54 F=6.75
Moy ± DS	83,94 (17.55)	87.23 (14.60)	
Score 3+2a+1c	N= 35 (24+9+2)	N= 34 (19+11+4)	
[min - max]	[48.74 - 113.44]	[58.33 - 116.60]	P value = 0.000 F=5.14
Moy ±DS	85.35 (17.34)	86.02 (13.95)	
FEV1/FVC%			
Score 3	N= 24	N= 19	
[min - max]	[53.33 - 92.64]	[49.66 - 99.51]	P value=0.418 F= 6.12
Moy ± DS	80.46 (11.12)	82.00 (13.01)	
DEP			
Score 3	N= 24	N= 19	
[min - max]	[41.97 - 110.20]	[50.35 - 109.97]	P value=0.723 F=0.432
Moy ± DS	82.60 (15.74)	89.02 (16.58)	
Score 3+2a+1a	n=35 (24+9+2)	n= 32 (19+10+3)	
[min - max]	[41.97 - 110.67]	[50.34 - 109.97]	P value=0.000 F=3.122
Moy ± DS	76.55 (16.20)	83.05 (16.91)	

Légende : FVC : capacité vitale forcée ; FEV1: volume expiratoire à la première seconde; DEP: Débit Expiratoire de pointe.

Apart from the Tiffnaud ratio (FEV1/FVC%), the functional exploration using the spirometer globally showed that almost all of the spirometric parameters led to statistically significant differences between urban women (FU) in the neighborhood Valley and rural (FR) village Futuka. These are the forced vital capacity (FVC% pred with a p=0.034), the peak expiratory flow (PEF with a p value of 0.000) and the expiratory volume at the first second (FEV1% pred with a p value of 0.000).

## 4. Discussion

### 4.1. Socio-demographic characteristics of the subjects

#### 4.1.1. Age of the population and consumption of alcohol and tobacco

Our survey was carried out over a period of approximately 4 years, from January 2014 to July 2019. The population studied consisted of women whose average age was 37.8 years. With regard to tobacco consumption, the rate of non-smokers was higher than that of female smokers: 93.4% among urban women and 85.7% in rural areas (Table 5). Even if certain results of the literature, evoked in this work, are close to ours, we can all the same point out that the quantities of the tobacco consumed daily by the subjects subjected to our investigations remain lower than the threshold limit recommended by the WHO ( WHO, 2014). This consideration is consistent with the results of the Demographic and Health Survey II (EDS) according to which 96% of women aged 15 to 49 did not smoke in the DRC, and that in 71% of cases people did not smoke at home ( DHS II, 2014). Regarding alcohol consumption, it is reported in the literature that

it was higher among women aged 25-59 than among younger women and among those who are married than among single people (Patricia P. and al, 2013). In this study, we observed that the consumption of beer was more observed in urban areas (35.5%). On the other hand, in rural areas (Futuka village), the locally produced drink (Lutuku) was more consumed (10%).

#### 4.1.2. Culinary habits and use of fuels

##### Main fuel

With regard to the data related to the use of fuels in the culinary context, we noted that both groups used massively coal (87.4 and 95.9%), than other sources of heating. (Table 3). To better understand the great demand for coal as fuel used by the rural women of the village of Futuka and their colleagues in the urban district called "La Vallée", it is above all necessary to consider also the partial rural character of this young district located in the suburbs of the city of Lubumbashi.

##### Frequency and location of cooking activities

As for the daily frequency of cooking activities, it was mostly twice among all charcoal users (63.6 to 74%). The preponderance of the frequency of twice is certainly attributable to the fact that in our culinary habits, the woman generally prepares food twice a day: in the morning, for the midday meal and in the afternoon, for the dinner.

In this regard, the results of DHS II, 2014, showed that almost all households (96%) used solid fuels, in this case charcoal (71%), and that in rural, 99% of households used these fuels for cooking. In another publication made by the Association for the Prevention of Atmospheric Pollution of Nord-Pas de Calais in 2010, France, the authors reported that approximately 80% of the subjects spent their time in the accommodations where the culinary activities. This aspect also converges with the results we obtained according to which cooking activities inside houses varied between 78% and 83% in rural areas and between 66.1% and 80% in urban areas. This situation obviously entails the risks of exposure to several pathologies linked to indoor air pollution, which is generally less known to the public than that linked to outdoor urban air pollution. Indeed, domestic smoke contains a large number of substances that are hazardous to health, these are in particular fine particles (diameter < 10 µm), Nanoparticles (ultrafine) with a diameter <0.1 µm, Polycyclic Aromatic Hydrocarbons, Volatile Organic Compounds (VOC) and Dioxins (APPA, 1998). The particles emitted by the wood fire have the particularity of not being retained by the nostrils, nor by the throat, and of penetrating directly into the lungs and the blood.

Other previous work has found that exposure to indoor air pollution may be responsible for an estimated 2-3 million deaths per year, and developing countries are said to be at the center of the debate. (Kirk, 2013; Global Burden of Disease Study (GBDS), 2014; Daniel et al, 2013).

##### Respiratory symptomatology

In the two female categories considered, the rates of cough and morning and usual sputum were, in almost all cases, higher among rural women in Futuka than among women in the Vallée district of the city of Lubumbashi. It is not impossible that this state of affairs may result from the possible presence of an endemic pathology, such as Chronic Obstructive Pulmonary Disease "COPD", justifying the symptoms thus observed in the women of the Futuka village, cough and excessive production spitting.

In any case, during our investigations, we had realized that most of the women users of charcoal, who produced sputum, also developed an acute or chronic respiratory disease manifested by coughing. This would be justified by the deterioration of the lower part of the respiratory tree generally affecting the upper part and vice versa (Taytard A., 2014; Reginakl., 2017).

The fact that we found that young girls and post-menopausal women were more affected by coughing and sputum than reproductive women could in particular be attributed, to a certain extent, to the possibility offered by the Pre-Consultation sessions. Natales (CPN) to the latter, in terms of the early detection of certain pathologies. This allows reproductive women to seek treatment in time.

Given that the latter are regularly subjected to the inhalation of pollutants of domestic origin, one can think of a permanent and chronic irritation of the respiratory tract which would favor this state of affairs. On this subject, our results agree with those of Paul reported in 2015, and according to which the fact of spitting and coughing regularly

was probably linked to the inhalation of polluting substances including fine particles of domestic origin and pollution urban ( Paul , 2015).

#### Functional exploration with spirometry

For all of the spirometric observations analyzed in charcoal users of the two targeted environments (FU, FR), the Student test applied led to statistically significant differences, in particular for FVC% pred, score 3, ( $p = 0.034$ ), the FV1% pred, score  $3+2a+1c$  (0.000) and the DEP, scores 3 and  $3+2a+1$  with a  $p$  value, 0.000.

In fact, we observed in the field that, unlike the users of the Futuka village, those of the Vallée district were permanently subjected to the continuous inhalation of fine particles from car traffic and smoke from culinary activities. This double exposure would result in a dysfunction of the respiratory tree leading to the various respiratory manifestations observed.

With regard to Forced Vital Capacity and Peak Expiratory Flow (FVC, PEF), our results corroborate those reported in the literature according to which the progressive decrease in ventilatory parameters is observed as one goes deeper. in the lung, the spirometric values tend to decrease progressively according to the different stages.

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## 5. Conclusion

Two categories of women users of charcoal and firewood were considered in this research. On the one hand, the rural women of the Futuka village and the urban women of the Vallée district of the city of Lubumbashi. Demonstration of the respiratory effects required the use of sociodemographic data, respiratory symptomatology, vital and anthropometric parameters as well as spirometric data. We noted that both groups relied heavily on coal (87.4 to 95.9%) than on other sources of heating. Cooking activities were done inside homes and varied from 78% to 83% in rural areas and between 66.1% and 80% in urban areas. Respiratory tree dysfunction affected both groups in varying proportions. We retain that the spirometric data indicated statistically significant differences.

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## Compliance with ethical standards

### *Disclosure of conflict of interest*

No conflict of interest to be disclosed.

### *Statement of informed consent*

Informed consent was obtained from all individual participants included in the study.

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