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Effect of firewood smoking on the respiratory parameters of fish smokers

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Abstract
Position of the Problem: The lack of industry and the precariousness of electricity and gas in underdeveloped countries such as Benin means that women, in their daily activities, resort to the use of firewood. They are therefore frequently exposed to fumes and gases from wood combustion during smoking. The aim of the research was to study the prevalence of obstructive ventilatory disorder in women exercising the fish smoking activity in Porto-Novo.
Methods: Explore the respiratory function of women fish smokers working at artisanal smoking sites in Porto-Novo. Following an investigation of the history and pathological respiratory manifestations that occurred over the past 12 months, subjects underwent functional respiratory exploration.
Results: The main results obtained reveal that the subjects are moderately young and not obese. Obstructive syndromes are also found in the upper and lower airways of the subjects. Rhinitis is the most common respiratory disease in these subjects, followed by chronic bronchitis and asthma. The diagnosis of dyspnea revealed only stage I and II dyspnea.
Conclusion: Women's exposure to smoke and gases from burning firewood during fish smoking practices has a negative impact on their respiratory parameters. Extending this study to more women, other parts of the country and long-term follow-up would lead to more relevant conclusions.

Keywords: Fish smoking, respiratory parameters, women, firewood

1. Introduction
Health is a broad concept that can be influenced by many factors, including environmental ones [1]. These factors include air pollution, which is manifested by the presence of gases or aerosols in the atmosphere that cause a change that could have harmful consequences one's health or the environment. Through its activities, man emits into the air many pollutants that have significant effects on health, particularly in terms of cardiorespiratory mortality and morbidity [2].
Much scientific work has demonstrated the health effects of air pollution in terms of morbidity (i.e. pathologies) and mortality, both in the short term and in the longer term [3]. Mortality due to exposure to indoor air pollution could be responsible for nearly 2 million excess deaths in developing countries and about 4% of the global burden of disease [1]. Similarly, both indoor and outdoor pollution contribute to the deaths of 7 million people per year [2].
In underdeveloped countries where electricity and gas are scarce and expensive commodities, many families, both rural and urban, use wood (biomass) as their main source of energy for cooking food. In Porto-Novo and surrounding areas, some women are exposed daily to the fumes and gases resulting from the combustion of biomass due to their professional activity of smoking fish. Smoking is a processing operation that has been practised for generations in many parts of the world, for the preservation of products (meat, fish or cheese) and food diversification. The flavouring and colouring preservative functions are well correlated with the addition of smoke. The absence of industries means that they still use traditional methods, including the use of wood as fuel [4]. These means of transformation used have an impact on the natural environment and on human life. The smoke produced by the combustion of wood contains about a hundred toxic substances diffused in fine particles, some of which are known to be carcinogenic [5].
In Cotonou, a study carried out on women working on a traditional fish smoking site revealed a rather expressive respiratory symptomatology. 83.33% of the respondents had at least one respiratory symptom and 19% had to stop their activity due to lung diseases [4].

This work is therefore part of this perspective and focuses on women fish smokers in the city of Poro-Novo.
What is the influence of smoke from the combustion of firewood on the ventilation parameters of the latter? Considering the vital principle of respiration for living being and the threat of air pollution, particularly that caused by wood smoke, this study aims to evaluate the impact of smoke from fish smoking on the respiratory function of women engaged in this activity.

2. Material and methods

2.1 Type and scope of the study

The study is experimental and comparative. It was carried out from July to September 2015 with women working on artisanal fish smoking sites in Porto-Novo. The information collected was processed in the Laboratory of Effort Physiology (LaEfP) located at INJEPS. The study does not involve the integrity of the subjects and does not pose any particular risk.

2.2 Experimental protocol

The study was carried out in three phases: the preparatory phase, the investigation phase and the experimental phase.

2.3 The preparatory phase

The preparatory phase was devoted to obtaining authorization from the Scientific Sectoral Committee (SSC) and then to meeting with the subjects to obtain their free, informed and written consent.

2.4 The investigation phase

The survey included a questionnaire exploring the pathological history and pathological respiratory manifestations in the subjects over the past 12 months. A room was set up on site and served as a setting for the interrogation and spirometric examination.

2.5 The experimentation phase

After reading the study, subjects gave their free, written and informed consent. Then, the values of the anthropometric parameters of each subject were recorded. Explanations were given to them so that they could learn about the objectives and conduct of the test. Single-use mouthpieces were used to avoid the risk of cross-contamination in subjects. The spirometry test was performed according to the method described by Fischberg *et al*. [6] before and after the smoking activity. It was carried out using the portable SPIROBANK II S/N 001267 MIR spirometer regularly calibrated.

2.6 Variables studied

The variables studied were:

2.6.1 Dependent variables

- the FVC (Forced Vital Capacity),
- the FEV1 (Maximum Expiratory Volume at the first Second),
- Tiffenau's report (FEV1/FVC)
- the PEF (Peak Expiratory Flow Rate)
- DEM25; 50; 75 (Maximum Expiratory Flow at 25; 50 and 75% of the FVC)
- The percentage decrease in FEV1 which is calculated according to the following formula:

Calculation of the percentage decrease in FEV1 [7]. Let Δ be this value,

$$\Delta = \frac{\text{FEV1 before} - \text{FEV1 after}}{\text{FEV1 before}} \times 100$$

2.6.2 Independent variables

- The age of the practitioner
- The size
- Body mass
- Seniority in the practice of fish smoking activity
- Exposure time per day and per week

2.7 Study population and sampling

The population of study was composed of women from Porto-Novo practicing the fish smoking activity who have met the selection criteria. A total of fifty (50) women participated in the study. The sample was selected by a non-random method using the reasoned choice technique.

2.8 The selection criteria

2.8.1 Inclusion criteria

Included in this study are:

- women who have given their consent in writing, free and informed consent;
- women with no respiratory pathology (apparently healthy);
- women with at least two years' seniority in the practice of fish smoking;
- women aged 18 and over and residing in Porto-Novo.

2.8.2 Criteria for non-inclusion

Not included in the study:

- women who have not given their consent;
- women not residing in Porto-Novo;
- women with a history of active and/or passive smoking (spousal smoking);
- women who were sick a week before the day of the experiment.

2.9 Statistical analysis

The results were processed with Abacus Concepts Inc.'s Stat View 5 software. (Berkely, CA, USA). The verification of normality and variance homogeneity was performed with Chi 2 and Kolmogorov SMINOV tests.
Comparisons of mean values were made using parametric tests, including matched t-series tests. The level of significance is considered at $p < 0.05$.

3. Results

3.1 Anthropometric characteristics of the subjects studied

The data in Table I show that the average body mass index value is 23.47 ± 3.25 (Kg/m^2). According to the obesity classification table, this value is between 18.5 and 25 (Kg/m^2).

Table 1: Anthropometric characteristics of the subjects

Anthropometric parameters	Number of subjects N=50
Age (years)	38.85 ± 09.21
Size (Cm)	160.4 ± 0.7
Weight (kg)	60.10 ± 7.78
BMI (kg/m^2)	23.47 ± 3.25

BMI = Body Mass Index

3.2 Respiratory symptoms listed according to seniority

Table II shows that as seniority increases, the number of subjects with respiratory symptoms increases. It can then be concluded that respiratory symptoms increase in women with the duration (year) of exposure to pollutants.

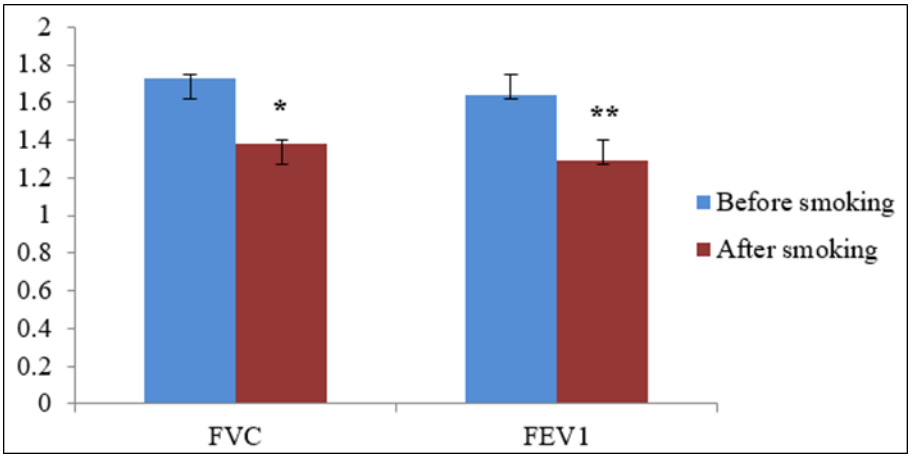
Table 2: Distribution of respiratory disorders listed by seniority

Seniority/ Symptoms	[2; 10] (N=8)		[10; 20] (N=28)		[20; +∞] (N=14)	
	(%)		(%)		(%)	
Rhinitis	4	50	21	75	12	85.71
Chronic Bronchitis	5	62.5	19	67.85	8	57.14
Asthma	2	25	11	39.28	6	42.85
Dyspnea stage I	3	37.5	15	53.57	10	64.28
Dyspnea stage II	1	12.5	6	21.42	4	28.57

3.3 Subject Respiratory Parameters

The percentage decrease in FEV1 shows an average value of 14.91%.

2.3.1 Proximal respiratory variables



*: p< 0,05 ; **: p< 0,001

Fig 1: Vital capacity strength and FEV1 of subjects before and after smoking

Figure 1 shows a decrease in proximal respiratory parameters before and after exposure to smoke. The values of the respiratory parameters after exposure are significantly different from those before exposure with p = 0.017 for FVC; and p = 0.007 for FEV1.

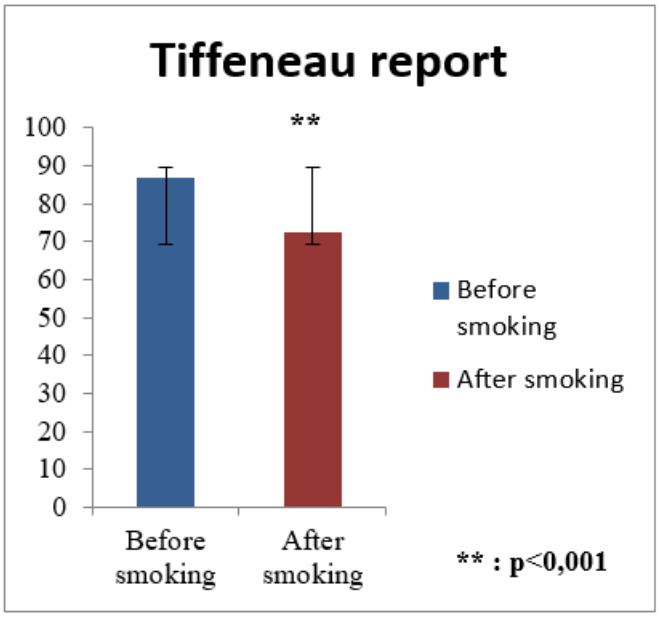


Fig 2a: Tiffeneau report before and after smoking

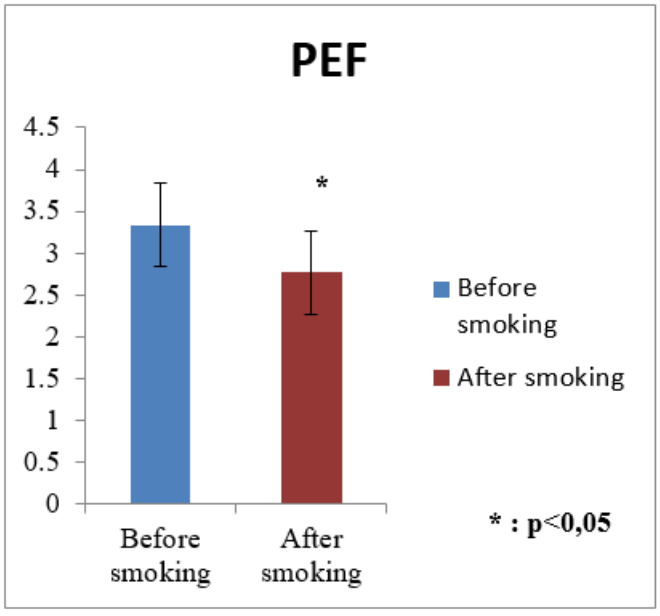


Fig 2b: Peak Expiratory Flow before and after smoking

Fig 2: Tiffeneau report and PEF of subjects before and after smoking

From the observation of Figure 2, there is a very significant difference between the value of the Tiffeneau ratio before exposure (Figure 2a) and that after exposure with p= $8.9*10^{-5}$. On the other hand, the value after exposure of the peak expiratory flow (Figure 2b) differs significantly from that before exposure with a p value of = 0.001.

2.3.2 Distal respiratory variables

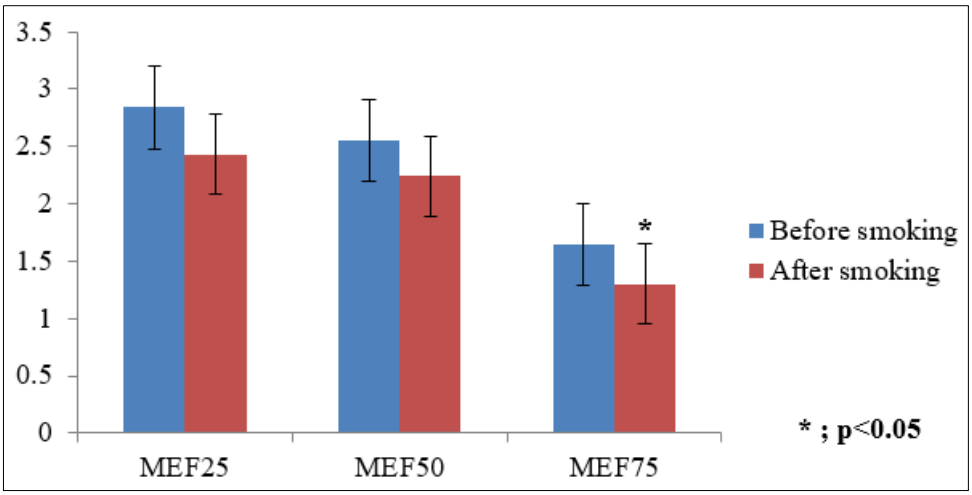


Fig 3: Distal respiratory variables of subjects before and after smoking

It appears that after the fish smoking activity, the values of the minimum expiratory flow rates decreased from their pre-exposure value in the study subjects. The decrease is highly significant for DEM_{75} with p = 0.002.

4. Discussion

The objective of this study is to highlight possible respiratory problems related to the practice of fish smoking among women practising this activity on artisanal fish smoking sites in Porto-Novo. To do this, we measured the respiratory parameters of these women before and after the fish smoking activity in order to evaluate the state of their airways.

The study took into account women practising the activity of smoking fish on artisanal sites in Porto-Novo. These women have a seniority of at least 2 years. However, subjects who had worked in this occupation for less than 10 years and even more than 15 years were taken into account, which does not necessarily guarantee an objective comparison of the subjects' respiratory variables, especially since the exposure times to environmental and climatic conditions are different. Nevertheless, they have an average exposure time of 12 hours per week. However, studies have shown that the extent of the risk incurred as a result of exposure to air pollutants depends on the duration of the exposure. To achieve our objectives, a clinical questionnaire was administered to the respondents to identify various respiratory symptoms. This questionnaire allowed us to calculate body mass index (BMI) and to list the respiratory diseases from which these subjects suffer. But the questionnaire as the only means of investigation is not reliable for assessing respiratory disorders. To compensate for this deficiency, a spirometry was performed for all subjects. Thus, the respiratory parameters, namely: forced vital capacity (FVC) in litres, maximum expiratory volume at the first second (FEV1) in L, peak expiratory flow (PEF) in L/s, Tiffeneau ratio (Q = FEV1), maximum expiratory flows at 25, 50 and 75% of vital capacity in L/s (DEM_{25}, DEM_{50} and DEM_{75}) were also recorded. It should be noted that these respiratory parameters were collected from these subjects using spirometric tests that they underwent very early in the morning upon arrival at the sites and then just at the end of smoking before even conditioning the fish for marketing. We therefore respected the measurement tools (questionnaire and spirometry) that were tested in the literature for screening for bronchial obstruction diseases [8]. We were unable to collect the pollutants emitted by these biomass fumes, but we can nevertheless report a significant presence of these gases and particles in large quantities due to the deposition of suspended smoke on the clothes and bodies of the smokers, the embarrassment to the vision caused by this smoke and the few coughing fits it caused. Combining this with the fact that most subjects (80%) had ten years or more of seniority, we can say that this population is doubly at risk. First in relation to their professional activity and then in relation to other exposure in households that is not without risks to their health. Indeed, studies [8-10] have shown that women who use wood as their main source of energy for cooking are exposed to respiratory diseases. As a result, we were unable to perform blood sampling and bronchoalveolar lavage due to limited financial resources. We must therefore analyse the different results obtained.

The literature tells us that mobilizable lung volumes decrease with age [11]. These authors, in a cross-sectional and longitudinal study, showed that the loss of mobilizable volume per year is almost identical for men and women and that this speed increases with age. In addition, size is considered to be the major predictor of lung function at any age. In the same vein, the same authors showed that the age-related decline in FEV1 could be explained by height loss due to aging, since an elderly person can lose 0.5 cm of height per year. Some studies have shown that obesity causes respiratory failure and reduces respiratory compliance by causing a loss of elasticity of the respiratory muscles [12, 13]. It should also be noted that the data in the literature, despite methodological diversity, has shown that an increase in body weight is at the origin a restrictive syndrome, and is associated with a so-called "harmonious" decrease in forced vital capacity (FVC) and maximum expiratory volume per second (FEV1). This association varies according to age and gender [12]. It is therefore accepted that anthropometric parameters as well as age influence respiratory variables.

However, the subjects in our study have an average age of 38.85 ± 09.21; they are therefore moderately young women. In addition, their average BMI is 23.47 ± 3.25, which allows us to affirm with the World Health Organization (WHO)

classification that they are not obese. In view of all this data, we can therefore assume that the likely influences of obesity and age on ventilatory parameters can therefore be excluded. We therefore believe it is necessary to analyse the listed respiratory diseases.

The respiratory system is a preferred route of exposure for air contaminants, whether gases or particles that can have harmful effects in the short or long term [14]. Thus, the lung, due to its interaction with the ambient air, is therefore a target organ for fine particles. The results of our study clearly show that every woman has at least one respiratory condition. This causality has been demonstrated by several authors. Indeed, several studies have shown the decrease in airways (proximal and distal) following long-term exposure to air pollutants. After inhalation, a large number of fine particles ($PM_{2.5}$) reach the most distal regions of the lungs [15]. In addition, exposure to inhalable particles could induce oxidative damage, which could lead to the abnormal secretion of inflammatory mediators closely involved in the development of lung diseases [16]. This confirms the conditions in each of the women. These listed conditions (Table II) show that women engaged in fish smoking activity are exposed to high concentrations of air pollutants because, according to data from WHO and other studies conducted in this field, there is a correlation between pollution and cardiorespiratory morbidity. Indeed, in a study conducted by this International Organization (WHO), women exposed to high concentrations of domestic smoke are twice as likely to suffer from COPD as those who use cleaner fuels [17].

Our results therefore confirm those of a study conducted among women working on artisanal fish smoking sites in Cotonou, which showed that rhinitis was also the most common respiratory disease among subjects with 77.38%, followed here by chronic cough with 70.23% and stage I dyspnea with 59.52% [4]. The same study revealed a quite expressive respiratory symptomatology of 83.33% of the respondents with 19% having to stop their activity due to lung disease. Similar results have been found in several studies. This is the example of a Brazilian cohort that has shown a link between chronic exposures to biomass combustion particles and the degradation of respiratory function, the development of respiratory discomfort and COPD [18]. Other studies have also justified that exposure to biomass combustion is strongly associated with the occurrence of chronic bronchitis in rural women (7.01% vs. 2.92%). More recently, a Tunisian study showed a strong association between biomass exposure and the development of obstructive ventilatory disorder in non-smoking women [8].

These conditions listed in our subjects are undoubtedly the consequences of airway inflammation following exposure to this smoke since there is also a certain degree of systemic inflammation when exposed to air pollutants. Indeed, associations between many markers of inflammation and exposure to pollution in the short and long term have been identified [19]. Exposure to biomass combustion causes inflammation of the airways and the effect is greater at high concentrations of particulate matter [20]. Particles after long exposure to high concentrations can aggravate chronic bronchitis by maintaining inflammation of the airways. This different data therefore confirm the existence of a causal relationship between the atmospheric concentration of certain pollutants and respiratory symptomatology (dyspnea, chronic bronchitis, etc.). This is why these conditions appear in some subjects in the study. In addition, the analysis in Table II shows that as seniority increases, respiratory symptomatology increases in the population of these women. Our results therefore confirm those of a study [21] carried out in Porto-Novo which showed that the appearance of respiratory pathologies following exposure depends on the duration of the said exposure and the concentration of pollutants. It is therefore obvious that the risk incurred as a result of exposure to air pollution depends on the duration of the exposure. The extent of exposure depends on the type of fuel, ventilation often absent in primitive habitats without chimneys and the duration of exposure.

These respiratory symptoms are inevitably the disadvantages of decreasing respiratory parameters. So what is the link between the decrease in respiratory volumes and exposure to pollutants from biomass combustion?

The ventilatory parameters of subjects taken after smoking activity decreased significantly compared to those taken before smoking. A thorough analysis of these observed decreases indicates the presence of pollutants that would be deposited in each part of the respiratory tree. Indeed, the results obtained, in particular the significant difference observed in the proximal respiratory variables after exposure, reveal obstructive syndromes in the subjects' upper airways. This is expressed by decreases in FEV1, FVC and PEF because a drop in the end values from the baseline values of these parameters is a sign of obstruction of the subjects' airways [22,23]. The data is currently consistent and highlight the association between long-term exposure to different pollutants, respiratory symptoms, and the decrease in FEV1 and FVC in children and adolescents [24]. Exposure to particulate matter from biomass smoke is associated with a significant decrease in FEV1 and FVC. These authors demonstrated that there is an epidemiological concordance in the urban adult population between long-term pollution (PM_{10}, NO_2) and respiratory symptomatology (chronic bronchitis, dyspnea), and long-term pollution (PM_{10}, NO_2) and the decrease in FEV1 and FVC. As for the distal airways, the significant decrease observed after exposure of the maximum expiratory flow rates is a sign of obstruction in these airways. This decrease is much more significant at the level of the mean maximum expiratory flow ($p=0.002$) which is most often used as an indicator of distal bronchial obstruction.

These observed results are the result of the fact that these women use drums that do not allow smoke to escape. However, studies have shown that smoke from biomass is composed of volatile organic compounds (VOCs), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), carbon monoxide (CO), etc., which have harmful effects on health and in particular the respiratory system. According to a Japanese study [25], these gases are the cause of respiratory diseases, such as asthma, respiratory infections, etc. They increase the risk of blindness and heart disease. The effects of VOCs are most often manifested by eye irritation [26]. Eye irritation and the presence of coughs prove the presence of VOCs and sulphur dioxide (SO_2) in this smoke. SO_2 is an irritant gas, particularly in the eyes, skin and lungs. In addition, by binding to the smooth muscle receptors surrounding the bronchial tubes, it induces a contraction mechanism of this muscle, which causes a decrease in the size of the bronchial tubes [26].

These results confirm, subject to the measurement of pollutants at smoking sites, those of a Chinese study conducted on asthmatic children exposed to particles that justified the drop in PEF due to the presence of these particles [27]. In addition, the presence of obstructive syndromes in the subjects' lower airways would justify the presence of particles, particularly fine particles in the smoke produced by wood combustion. This assertion is supported by a study that

showed that an increase in particulate matter levels is associated, in the short term (a few days), with an excess risk of mortality, including cardiorespiratory, hospitalization for respiratory illness, worsening asthma, respiratory symptoms and impaired lung function [14]. Many studies [8, 20] have also linked the presence of particles to cases of serious respiratory diseases, such as asthma, bronchitis and emphysema, as well as various forms of cardiovascular disease.

In this study, we found that the activity of fish smoking exposes women to the same risk of obstructive ventilatory disorder and respiratory symptoms.

5. Conclusion

In view of the health threat posed by air pollution, we were interested in this study to assess respiratory disorders related to the exposure of women who smoke fish in Porto-Novo. We observed in the study population that each subject had at least one respiratory symptom. In addition, the decrease in respiratory variables after exposure reveals obstructive syndromes in the subjects' airways.

It therefore appears that women's exposure to smoke and gases from wood combustion during fish smoking is a major threat to their health in general and to the respiratory system in particular; which is vital for humans.

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