Respiratory symptoms in charcoal production workers in the cities of Lindolfo Collor, Ivoti and Presidente Lucena, Brazil*

Sintomas respiratórios em trabalhadores de carvoarias nos municípios de Lindolfo Collor, Ivoti e Presidente Lucena, RS

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Abstract

Objective: To determine the prevalence of respiratory symptoms and smoking, as well as pulmonary function parameters among charcoal production workers in three cities in southern Brazil. **Methods:** This was an observational study including 67 individuals. Data were obtained by means of interviews and spirometry. **Results:** Of the 67 workers, 50 (75.0%) were male; mean age, 46.52 ± 13.25 years; mean BMI, 25.7 ± 3.85 kg/m^2; FEV_1, 3.24 ± 0.82 L (93.2 ± 16.0% of predicted); FVC, 4.02 ± 0.92 L (95.5 ± 14.3% of predicted); and FEV_1/FVC, 80.31 ± 9.82. The most common upper airway symptoms were sneezing and nasal secretion—in 24 workers (35.82%)—whereas the most common lower airway symptom was cough—in 15 (22.38%). Of the 67 workers, 21 (31.34%) were smokers. In comparison with the nonsmokers, the smokers more often presented with cough (OR = 5.00; p = 0.01), nasal obstruction (OR = 3.50; p = 0.03), nasal itching (OR = 8.80; p = 0.01) and wheezing (OR = 10.0; p = 0.03), as well as presenting with lower FEV_1 values (2.93 ± 0.80 vs. 3.38 ± 0.80 L; p = 0.04). We detected occupational rhinitis in 14 workers (20.85%), asthma in 4 (5.97%) and COPD in 4 (5.97%). **Conclusions:** Respiratory symptoms and airflow reduction were more common in the smoking workers. Controlling the progression of the pyrolysis did not increase the prevalence of respiratory symptoms in the charcoal production workers studied.

Keywords: Air pollution; Spirometry; Charcoal.

Resumo

Objetivo: Determinar a ocorrência de sintomas respiratórios e tabagismo, assim como parâmetros de função pulmonar, em trabalhadores da produção de carvão vegetal em três municípios do sul do Brasil. **Métodos:** Estudo do tipo observacional com 67 indivíduos, no qual os dados foram obtidos através de entrevistas e espirometria. **Resultados:** Do total de 67 trabalhadores, 50 (75,0%) eram homens; média de idade = 46,52 ± 13,25 anos; média de IMC = 25,7 ± 3,85 kg/m^2; VEF_1 = 3,24 ± 0,82 L (93,2 ± 16,0% do previsto); CVF = 4,02 ± 0,92 L (95,5 ± 14,3% do previsto); e VEF_1/CVF = 80,31 ± 9,82. Os sintomas de vias aéreas superiores mais frequentes foram espirros e secreção nasal, em 24 trabalhadores (35,82%), enquanto o das vias aéreas inferiores foi tosse, em 15 (22,38%). Dos 67 trabalhadores, 21 (31,34%) eram tabagistas. Os tabagistas apresentaram mais tosse (OR = 5,00; p = 0,01), obstrução nasal (OR = 3,50; p = 0,03), prurido nasal (OR = 8,80; p = 0,01) e sibilância (OR = 10,0; p = 0,03), assim como menor VEF_1 (2,93 ± 0,80 L vs. 3,38 ± 0,80 L; p = 0,04) que os não tabagistas. Rinite ocupacional foi detectada em 14 trabalhadores (20,85%), asma brônquica em 4 (5,97%) e DPOC em 4 (5,97%). **Conclusões:** A ocorrência dos sintomas respiratórios e a redução do fluxo aéreo foram maiores nos trabalhadores tabagistas. O controle da pirólise não aumentou a ocorrência de sintomas respiratórios nos trabalhadores de carvoarias.

Descritores: Poluição do ar; Espirometria; Carvão vegetal.

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Introduction

In Brazil, the production of charcoal on a commercial scale began in the state of Minas Gerais in the mid-19th century.[1] Brazil is considered one of the largest charcoal producers in the world, producing approximately 12 million tons in 2002.[2] In the regions where charcoal is produced, smoke is released into the air almost daily, as a result of the carbonization of wood obtained through the felling of acacia trees. This rudimentary process, which depends on human labor, puts charcoal workers in continuous contact with the smoke from the kilns. In addition to the activities of felling, transporting and storing acacia, there is a dangerous activity, which is performed by the senior or most experienced charcoal worker: controlling the wood carbonization process. The worker responsible for this activity is designated the "pyrolysis monitor". This activity exposes the worker to direct contact with smoke, which might be inhaled in large quantities for a period of three to five days. However, this entire work process occurs outdoors, and charcoal workers are therefore not exposed to smoke in an enclosed space.

A study involving pyrolysis monitors in Greece demonstrated that cough, expectoration, wheezing and dyspnea were significantly more prevalent among those individuals than among individuals who were not exposed to smoke.[3] Another study, conducted at the Del Mar Hospital in Barcelona, Spain, demonstrated that 55 (92%) of 60 females hospitalized for COPD had been exposed to smoke from the burning of wood or charcoal.[4]

Taking into consideration the extent of production in the charcoal producing region of Brazil and the almost complete lack of information regarding the respiratory health of charcoal producers, the objective of the present study was to determine the prevalence of respiratory manifestations and smoking among charcoal workers in the cities of Lindolfo Collor, Presidente Lucena and Ivoti, as well as to evaluate the pulmonary function of those workers.

Methods

The cities of Lindolfo Collor, Presidente Lucena and Ivoti are located in the state of Rio Grande do Sul, in the Vale dos Sinos and Caí River region. The charcoal industry is a source of extra income for a large number of farm workers and rural workers who reside in these cities, and, for some individuals, it is the principal or only source of income they can count on to support their families. According to a survey conducted by the *Empresa de Assistência Técnica e Extensão Rural do Rio Grande do Sul* (EMATER-RS, Technical Assistance and Rural Extension Corporation of Rio Grande do Sul), there were, in the city of Lindolfo Collor, 39 charcoal plants, 20 of which were active. In the city of Ivoti, there were 26 charcoal plants, of which 16 were active. In the city of Presidente Lucena, there were 5 charcoal plants, all of which were active. Therefore, 41 charcoal plants were actively producing charcoal in 2007. We evaluated all individuals who worked directly in the production of charcoal and who were registered as charcoal workers in public institutions and listed as such in the EMATER-RS registry itself. The study design was approved by the Human Research Ethics Committee of the Feevale University Center.

For the clinical analysis, we used a questionnaire that was based on two previously published questionnaires designed to investigate respiratory diseases.[5,6] For the functional analysis, we used a portable MicroLab spirometer (Micro Medical, Ltd., Kent, UK), which yielded flow-volume curves. The following variables were measured by spirometry: FVC; FEV_1; and the FEV_1/FVC ratio. All variables were measured before and after bronchodilator use.

The participants were classified as presenting or not presenting respiratory manifestations in the upper or lower airways. Individuals who reported nasal itching, nasal secretion, sneezing, nasal obstruction or any combination of the four were classified as presenting upper airway-specific signs and symptoms. Individuals reporting wheezing, cough, expectoration, dyspnea, chronic expectoration, dyspnea at work, wheezing at work or chronic cough (for three weeks or more), as well as those having been clinically and functionally diagnosed with asthma or COPD, were classified as presenting lower airway-specific signs and symptoms. A second approach to the outcome measure referred to the presence of specific respiratory signs and symptoms investigated as isolated events. These included cough, expectoration and dyspnea. A third outcome measure referred

to the clinical diagnosis of chronic bronchitis. Individuals who presented cough with expectoration on the majority of the days, for at least three months a year and for at least the past two years, were classified as having chronic bronchitis. Cases of allergic rhinitis were defined as the presence of nasal itching, nasal obstruction and nasal secretion when in contact with dust and temperature changes, even outside the work environment. Individuals who presented these symptoms in the workplace (the symptoms improving when the individual was not working) were classified as having occupational rhinitis. Asthma was defined as the presence of dyspnea, cough, wheezing or recurrent retrosternal oppression in the last years, after having had influenza or not, especially when the individual was off work or on a trip. The clinical diagnosis of occupational asthma was established based on the presence of these symptoms during the period in which the individual was employed as a coal worker.

The prevalence of symptoms and diseases (expressed as frequency) was compared between groups using the chi-square test. Continuous variables are expressed as mean and standard deviation and were compared between groups using the Student's t-test. In order to identify possible risk factors, chi-square tests and logistic regressions were performed, and risk is expressed as the OR value. Statistical analysis of the results was performed using the program Statistical Package for the Social Sciences, version 10.0 (SPSS Inc., Chicago, IL, USA). Values of $p < 0.05$ were considered statistically significant.

Results

We analyzed 45 charcoal plants, which included the production of charcoal in 126 kilns, exposing a total of 67 workers to charcoal smoke. Of the 67 workers, 50 (75%) were male and 17 (25%) were female. The mean age was 46.52 ± 13.25 years; the mean BMI was 25.7 ± 3.85 kg/m^2; the mean number of hours worked per day was 5.46 ± 3.12; and the mean number of years of work in this field was 19.14 ± 12.21. Table 1 shows the characteristics of workers in the three cities under study. The means of the spirometric variables indicated that pulmonary function was within the normal range in all 67 workers.

Table 1 - Characteristics of charcoal production workers.

Variable	Workers (n = 67)
Male gender[a]	50 (75.00)
Age,[b] years	46.5 ± 13.3
BMI,[b] kg/m^2	25.7 ± 3.9
Smokers[a]	21 (31.34)
Occupational data	
Hours worked/day[b]	5.5 ± 3.1
Years of work[b]	19.1 ± 12.2
Distance between kilns and residence[a]	
≤ 200 m	27 (40.29)
> 200 m	40 (59.71)
Use of PPE[a]	5 (7.46)
Type of activity[a]	
Wood bearer	59 (88.05)
Bagger	64 (95.52)
Pyrolysis monitor	48 (71.64)
Pulmonary function[b]	
FVC, L	4.02 ± 0.92
FVC, % of predicted	95.50 ± 14.30
FEV_1, L	3.24 ± 0.82
FEV_1, % of predicted	93.20 ± 16.00
FVC, L, after BD use	4.18 ± 0.90
FVC, % of predicted, after BD use	97.91 ± 14.14
FEV_1, L, after BD use	3.46 ± 0.84
FEV_1, % of predicted, after BD use	97.79 ± 15.01
FEV_1/FVC	80.31 ± 9.82
FEV_1/FVC, after BD use	82.82 ± 9.40

PPE: personal protective equipment; and BD: bronchodilator. [a]Results expressed as n (%). [b]Results expressed as mean ± SD.

Table 2 shows the prevalence of respiratory symptoms in charcoal workers according to upper and lower airway involvement, as well as the prevalence of possible diseases diagnosed. Of the 67 individuals under study, 35.82% presented with sneezing and nasal secretion, which were the most common upper airway symptoms. When asked about the presence of lower airway symptoms, workers reported cough, expectoration and dyspnea as being the most common symptoms (22.38%, 26.86% and 11.94%, respectively). The diagnosis of respiratory disease, based on the clinical history and on pulmonary function (evaluated by spirometry), demonstrated that the most common diseases among charcoal production workers were occupational rhinitis (20.85% of the sample), allergic

Table 2 - Respiratory manifestations in the upper and lower airways and diagnosis of respiratory disease.

Respiratory manifestation	n (%)
Upper airways	
Nasal itching	11 (16.41)
Nasal obstruction	22 (32.83)
Sneezing	24 (35.82)
Nasal secretion	24 (35.82)
Lower airways	
Cough	15 (22.38)
Chronic cough	5 (7.46)
Wheezing	5 (7.46)
Expectoration	18 (26.86)
Chronic expectoration	7 (10.44)
Dyspnea	8 (11.94)
Diagnosis	
Allergic rhinitis	6 (8.95)
Occupational rhinitis	14 (20.85)
Asthma	4 (5.97)
COPD	4 (5.97)
Recent respiratory infection	2 (2.98)
Chronic bronchitis	3 (4.47)
Occupational asthma	1 (1.49)

rhinitis (8.95% of the sample), asthma (5.97% of the sample) and COPD (5.97% of the sample). The only individual with occupational asthma was a smoker, as were the 4 individuals with COPD and the 3 workers with a clinical diagnosis of chronic bronchitis.

The analysis of the respiratory symptoms reported by the smoking workers (Table 3) showed that those workers were 8.80 times more likely to present nasal itching when the kiln was operating than were the nonsmoking workers (p = 0.01). The smoking workers were also more likely to present nasal obstruction (OR = 3.50; p = 0.03). In addition, they were 5.00 times more likely to present cough (p = 0.01) and 10.58 times more likely to present wheezing (p = 0.03). Smoking had no significant influence on the other symptoms.

Table 4 shows the comparison between workers in terms of pulmonary function parameters, by smoking status. These data showed that smoking was associated with worsening of pulmonary function in the charcoal production workers, since the values of FVC and FEV_1 were significantly lower in smokers.

When we investigated the effect that job position (pyrolysis monitor or not) had on the prevalence of respiratory symptoms and on pulmonary function parameters, we found no statistically significant differences between the two job position categories.

The influence that the distance between the kilns and the residences of the workers had on respiratory symptoms was also evaluated. We observed that nasal obstruction was significantly more common among workers who lived less than 200 m from the kilns (p = 0.036). There were no other significant differences related to the distance between the residences and the kilns in terms of respiratory symptoms or pulmonary function.

Table 3 - Development of respiratory manifestations in charcoal producers according to the smoking habit.

Respiratory manifestation	Smokers[a] (n = 21)	Nonsmokers[a] (n = 46)	OR (95% CI)	p
Upper airways	n (%)	n (%)		
Nasal itching	5 (23.8)	6 (13.0)	2.08 (0.55-7.80)	0.30
Nasal itching when kiln is operating	8 (38.1)	3 (6.5)	8.80 (2.03-38.14)	0.01
Nasal obstruction	11 (52.4)	11 (23.9)	3.50 (1.17-10.43)	0.03
Sneezing	10 (47.6)	14 (30.4)	2.07 (0.71-6.01)	0.27
Nasal secretion	11 (52.4)	13 (28.2)	2.79 (0.95-8.14)	0.09
Lower airways				
Cough	9 (42.9)	6 (13.0)	5.00 (1.47-16.90)	0.01
Chronic cough	3 (14.2)	1 (2.2)	7.49 (0.73-76.83)	0.08
Wheezing	4 (19.0)	1 (2.2)	10.58 (1.10-101.44)	0.03
Expectoration	8 (38.0)	10 (21.7)	2.21 (0.71-6.82)	0.23
Chronic expectoration	4 (19.0)	6 (13.0)	1.56 (0.39-6.27)	0.71
Dyspnea	5 (23.8)	3 (6.5)	4.47 (0.95-20.92)	0.09

[a]Results expressed as n (%).

Table 4 - Comparison between smoking workers and nonsmoking workers in terms of pulmonary function variables.

Pulmonary function	Smokers (n= 21)	Nonsmokers (n= 46)	p
FEV_1, L	2.93 ± 0.80	3.38 ± 0.80	0.04
FEV_1, % of predicted	86.48 ± 20.56	96.24 ± 12.52	0.05
FVC, L	3.78 ± 0.71	4.13 ± 0.98	0.15
FVC, % of predicted	89.71 ± 14.01	98.20 ± 13.81	0.02
FEV_1/FVC	76.86 ± 12.94	81.89 ± 7.67	0.11

Results expressed as mean ± SD.

The reductions in FEV_1 (% of predicted) and in the FEV_1/FVC ratio were lower in charcoal workers who wore protective masks than in those who did not (p = 0.03 and p = 0.01, respectively; Table 5).

Discussion

The influence of the work environment on human health has generated great interest and has been the subject of numerous studies in the literature. However, few studies have investigated the effects of charcoal production on the health of workers. In the present study, charcoal workers and producers spent, on average, 5.46 h/day working in charcoal production. Another relevant aspect was that most activities were performed outdoors, which allowed greater dispersion of the particles from charcoal production and prevented workers from being exposed to smoke in enclosed spaces.

A major limitation of the present study is that the concentrations of particulate matter and other gases in the charcoal plants were not measured. Had these concentrations been measured, further information would have been gathered, and it would have been possible to correlate respiratory symptoms with the concentration of air pollutants. However, we considered the present study to be relevant because individuals working in charcoal production are unequivocally exposed to smoke. In addition, there is a lack of studies focusing on the production of charcoal as it is produced in the region.

A study conducted in Greece and involving 22 charcoal production workers reported cough in 50%; however, the mean number of hours worked per day in the charcoal plants in Greece was 14.1 ± 6.4.[3] This greater prevalence of cough might be due to the number of hours of exposure, since in the present study the mean number of hours worked per day was 5.46 ± 3.12. Another study investigating a sample of workers exposed to smoke at work (wildland firefighters in Canada) reported that cough occurred in 24.4% of the sample.[7] In the present study, cough was observed in 22.38% of the charcoal production workers, a prevalence lower than the 30.50% found among fertilizer production workers in the city of Rio Grande, also located in the state of Rio Grande do Sul,[8] and far lower than the 73% found among pig farmers in the city of Braço do Norte, which is in the state of Santa Catarina, Brazil.[6]

Chronic cough, defined as cough that persists for three weeks or more, was observed in only 5 (7.46%) of the charcoal production workers evaluated in our study. This symptom, defined in the same way, was found in 14.7% of the fertilizer production workers in the city of Rio Grande,[8] and in 23.6% of the pig farmers in the city of Braço do Norte.[6] A study conducted in Canada and involving grain workers reported chronic cough in 28.8% of the individuals analyzed.[9] The fact that charcoal is produced outdoors (which facilitates the dispersion of smoke) might explain why the prevalence of this symptom was lower among charcoal production workers than among those in other fields of work, such as fertilizer production, pig farming in enclosed or semi-enclosed pigsties and grain storage in silos, all of which favor a greater concentration of pollutants.

Among the 67 workers evaluated in the present study, expectoration was observed in 18 (26.86%), and the expectoration was chronic

Table 5 - Comparison between workers who wore personal protective equipment (masks) and those who did not in terms of pulmonary function variables.

Pulmonary function	Wears a mask (n= 5)	Does not wear a mask (n= 62)	p
FEV_1, L	3.65 ± 0.49	3.20 ± 0.83	0.11
FEV_1, % of predicted	108.80 ± 12.28	91.92 ± 15.66	0.03
FVC, L	4.27 ± 0.54	3.99 ± 0.94	0.34
FVC, % of predicted	101.80 ± 7.92	9.03 ± 14.65	0.13
FEV_1/FVC	85.60 ± 3.29	79.89 ± 10.06	0.01

Results expressed as mean ± SD.

in 7 (10.44%). The overall prevalence of expectoration in the present study was lower than that found by another group of authors,[3] who reported expectoration in 36% of charcoal production workers, as well as being lower than the 28.9% found in the study involving wildland firefighters and the 27.1% .[7] In another study,[9] chronic expectoration was reported in 27.1% of the individuals exposed to the dust in silos, a prevalence that was also higher than that found in the present study.

In the present study, dyspnea was found in 8 of the 67 workers (11.94%), and wheezing was found in 5 (7.46%). Dyspnea was less common in the present study than in a study that analyzed farm workers in France (24.8% of the individuals).[10] In addition, dyspnea was far less common in the present study than in the study involving 22 charcoal production workers in Greece, in which 64% of the workers reported dyspnea and 32% reported wheezing.[3] A population-based study involving 3,454 Thais ranging in age from 20 to 44 years showed that wheezing occurred in 16.4% of the sample; the study did not specifically report a history of exposure to air pollutants or occupational pollutants.[11]

In the present study, charcoal workers who lived within 200 m of the kilns were more likely to present nasal obstruction, which was reported by 22 (32.83%) of the 67 workers interviewed. This prevalence is higher than the 20% found in the study involving wildland firefighters in Canada[7] but lower than the 42.7% found in the study involving pig farmers in the city of Braço do Norte.[6]

In the present study, allergic rhinitis was observed in 6 (9%) of the 67 workers investigated, and occupational rhinitis was observed in 14 (20.9%). This is lower than the prevalence found in the study involving fertilizer production workers in the city of Rio Grande, Brazil (43.3%),[8] and lower than that found in a study involving bakers in Europe (40.2%).[12]

In the present study, 3 of the 67 workers (4.47%) had been clinically diagnosed with chronic bronchitis, a rate that was lower than that found in the study involving fertilizer production workers in the city of Rio Grande, Brazil (8.5%),[8] and lower than that found in the study involving farm workers in France (12%).[10] In the present study, COPD was found in 5.97% of the sample, a prevalence that was lower than the 15.8% found in the Brazilian population over 40 years of age[5] but higher than the 3.5% found in individuals over 40 years of age residing in one of the three largest districts in the city of Novo Hamburgo, Brazil.[13] However, the prevalence of COPD was lower in the present study than in a large study conducted in Austria and involving individuals who worked in sites where the concentration of dust was high (26.1%).[14] Studies have demonstrated that the prevalence of COPD varies according to the site investigated: in China, the prevalence of COPD was estimated at 5.9% of the sample[15]; in Greece, it was estimated at 8.4% of the sample[16]; and in Spain, it was estimated at 9.1% of the sample.[17]

In the present study, asthma was found in 4 workers (5.97%), and a clinical diagnosis of occupational asthma was made in 1 worker (1.49%). The overall prevalence of asthma found in the present study was lower than that found in a study involving farm workers in the cities of Antonio Prado and Ipê, both of which are also in the state of Rio Grande do Sul, in which asthma symptoms were found in 25.1% of the sample.[18] However, the 5.97% prevalence of asthma found in the present study was closer to the 6.2% found among females who worked in tobacco production.[19] A probable explanation for the low prevalence of asthma in our sample is the fact that individuals who have asthma seek jobs in which there is no exposure to toxic substances, such as smoke.

Of the charcoal workers investigated in the present study, one third (31.34%) had been exposed to tobacco smoke at some point in their lives (smokers and former smokers). Nasal itching when the kilns were operating, cough, nasal obstruction and wheezing were more common in smokers than in those who had never smoked (Table 3). A study involving grain workers in certain cities in Canada reported that smokers were more likely to develop cough, expectoration, wheezing and dyspnea than were nonsmokers. According to the same study, former smokers were more likely to develop expectoration, dyspnea and wheezing than were nonsmokers.[9] In Croatia, the prevalence of wheezing and nasal secretion among workers exposed to tobacco dust in tobacco plantations was higher in smokers than in nonsmokers.[19] The same type of additive effect was detected in firefighters in the USA, cough and expectoration

being more common in firefighters who smoked than in those who did not.[20]

The means of FVC and FEV_1 were significantly lower in charcoal workers who smoked than in those who did not ($p < 0.05$). This result was similar to that of a study involving fertilizer production workers, in which it was demonstrated that the pulmonary function of smoking workers was significantly lower than was that of nonsmoking workers.[8]

Nasal obstruction was more common in charcoal workers who lived within 200 m of the kilns than in those who lived farther from the kilns ($p < 0.05$). Since the concentration of particles was not measured, this might be a random finding, which indicates the need for further research in this area.

Working in charcoal production was not a determinant of higher prevalence of respiratory symptoms. Smokers were significantly more likely to present with respiratory symptoms and impaired pulmonary function (as evaluated by spirometry). Being a pyrolysis monitor had no influence on the prevalence of symptoms among the individuals analyzed. However, further studies are needed in order to evaluate the real impact of this activity on the respiratory health of workers directly involved in the production of charcoal and on the respiratory health of the population residing near charcoal plants.

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