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Effects of biomass combustion and occupational exposures on lung function in random population sample of Malopolska inhabitants

Wpływ spalania biomasy i narażeń zawodowych na czynność płuc w losowej próbie populacyjnej mieszkańców Małopolski

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Abstract

Introduction: Risk factors other than tobacco smoking contribute to about 20% of chronic obstructive pulmonary disease cases. Exposure to these risk factors and their influence on lung function has not been adequately studied in the population of Malopolska.

Material and methods: In random population sample of adults at least forty years old, residents of 2 districts of Malopolska, data on exposure to known and probable respiratory risk factors were collected using questionnaire. All subjects without contraindications performed pre- and post-bronchodilatator spirometry.

Results: We analyzed data from 618 subjects; 94.8% subjects lived for longer than 6 months in a dwelling where stove using coal or wood has been used for cooking and/or heating. At the time of study as many as 32.5% subjects were still using coal or wood for cooking or heating. Coal or wood were used as fuel on average for more than 30 years; 67% of subjects have ever worked in professions carrying a risk of exposure to potential respiratory risk factors. We have identified an independent relationship of farming with lower FEV_1/FVC values as well as increased chronic obstructive pulmonary disease risk.

Conclusions: Significant proportion of Malopolska inhabitants has been exposed to risks associated with cooking or heating with coal or wood. In the studied population farming was related to increased risk of chronic obstructive respiratory disease.

Key words: COPD, occupational risk factors, combustion of coal and wood

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Introduction

Chronic obstructive pulmonary disease (COPD) is a major healthcare challenge in people over 40 years of age, both in Poland and in many other European countries [1]. Studies carried out in the urban population [2, 3] and in the general population [4] inhabiting different regions of Poland concluded that clinically significant COPD occurs in approximately 10% persons of more than 40 years of age. When considering demographical data [5], the estimated population of persons with moderate or severe COPD in Poland amounts 1.8 million. Tobacco smoking remains the most common risk factor for COPD development in European countries, including Poland [6, 7]. Current estimates claim that 30% of persons in the general population still smoke cigarettes in Poland; however, this figure used to be much higher [4, 8]. Tobacco smoke is not the only cause of COPD development, since at least 20% patients affected by the disease are never smokers [4, 9, 10].

Other risk factors for COPD development also have an influence on individual maximal lung capacity, and include genetic factors, past diseases of the respiratory tract from childhood, and socioeconomic issues as well as alpha-1-antitrypsin deficiency and environmental factors other than tobacco smoking [11]. Lifetime exposures that may convey the risk for COPD development include exposure to products of biomass combustions, professional contact with noxious agents, and air pollution [7, 9, 10]. Exposure to products of biomass combustion has a significant impact on potential COPD development in countries where manure is used as fuel in open-hearth fireplaces [10]. Such facilities are currently uncommon in Poland; however, many elderly people used to burn coal and wood in fireplaces or stoves in the past. The prevalence of this environmental exposure and its health impact has not been investigated in detailed population-based studies in Poland.

Professional exposure to noxious vapours and emissions may have a significant impact on lung function [10, 11]. This kind of exposure varies in different regions of Poland; however, almost 30% of citizens are currently industry workers, and thus can potentially be exposed to noxious vapours and emissions. It should be emphasized that the lung function of an individual is also influenced by exposures that occurred several derodes earlier, when environmental and industrial standards were much less restrictive than today's.

Available data concerning exposure to products of coal and wood combustion and professional exposures are scarce. Therefore, analysis of confirmed and potential risk factors for COPD development in inhabitants of the Malopolska region was performed based on data collected for the Burden of Obstructive Lung Disease (BOLD) study [12–14].

The aim of the study was: 1) to evaluate the frequency of household usage of coal and wood as energy sources in the kitchen, 2) to investigate the frequency of professional activities that can potentially have a negative impact in lung function, and 3) to analyse the impact of the above-mentioned potentially noxious factors on lung function in the studied population.

Material and methods

Detailed specification of the BOLD study methodology was published before [4, 12, 13]. Based on the current demographic data (obtained from census), the patient sample was randomly selected for the purpose of the study. This group included subjects of > 40 years of age, inhabitants of districts of Proszowice and Chrzanow in the region of Malopolska. The sample was sex and age stratified. Qualified interviewers contacted study participants who gave their consent. Participants answered questions in a detailed questionnaire concerning symptoms of the respiratory tract and exposure to noxious agents including products of biomass combustion as well as professional exposures. Spirometry was also performed in all study participants, using a portable spirometer (EasyOneTM; NDD Medical Technologies, Chelmsford, USA and Zurich, Switzerland), before and after admission of a broncholytic (200 μg inhaled salbutamol).

Percentage values were compared between the groups using the chi-square test, with Yates correction for small groups. Quantitative data were compared with Student's t-test for independent variables and Mann Whitney U-test. Potential correlations between exposure to risk factors of COPD and lung function were investigated in multiparameter analysis, using models including patient sex, age, and exposure to cigarette smoke (active and passive smoking). Statistical analyses were performed using Statistica 9.0 software (StatSoft, Inc. 2009, STATISTICA version 9.0, www.statsoft.com).

Results

Analysis included data from 618 patients, with spirometry results from 526 of them (85.1%) in whom quality of spirometric testing was sufficient.

Of all the analysed subjects, 94.8% persons lived for more than 6 months in a house where coal or wood was used as fuel for heating and/or cooking (Tab. 1). Coal as a main source of energy was used for more than 6 months by 93.7%, and wood by 75.4% of patients. In all cases where indoor fireplaces or stoves were used for heating and/or cooking, exhaust fumes were emitted outdoors (fireplaces with closed hearths). Mean duration of exposure to coal combustion in the household was 32.4 years (SD [standard deviation] ± 18.0 years), and 35.4 years (± 19.1 years) in the case of wood combustion. Mean duration time spent in the kitchen was 2.2 ± 2.3 hours a day, and was significantly longer for women compared to men (2.9 ± 2.5 and 1.5 ± 1.9 hours, respectively; $p < 0.001$). A similar difference between the genders was observed in cases where wood was used as fuel for cooking (3.7 ± 3.1 vs. 1.5 ± 1.8 hours; $p < 0.001$). Persons who at the time of the study still used fireplaces burning coal for cooking were significantly older (60.5 ± 12.8 vs. 55.5 ± 11.5 years, respectively; $p < 0.001$) and less educated (8.3 ± 2.8 vs. 10.9 ± 3.4 years of education; $p < 0.001$). Similar differences were observed for persons using wood as a source of energy for cooking.

Coal was used as fuel for house heating by the responders for on average 36.0 ± 18.9 years and wood for 32.6 ± 21.9 years. Persons who still used coal burning as a source for home heating were insignificantly older but significantly less educated (9.6 ± 3.2 vs. 11.1 ± 3.6 years of education; $p < 0.0001$). A similar trend was observed for the level of education in persons still using wood for house heating, although no statistical significance was observed.

Sixty-seven per cent of interrogated subjects reported exposure to noxious agents in the workplace at some time during their lifetime (Tables 2 and 3).

Table 1. Proportion of subjects potentially exposed to coal and wood combustion

Exposure	Proportion of exposed subjects % (n)	
	Ever*	Current**
Cooking with coal	89.0 (550)	20.1 (124)
Heating with coal	88.7 (548)	47.6 (294)
Cooking with wood	20.9 (129)	5.2 (32)
Heating with wood	15.0 (93)	7.5 (46)

*longer than 6 months
**at the time of questionnaire application

Table 2. Proportion of subjects reporting expose to occupational risk factors and occupation potentially influencing the lung function

Exposure	Proportion of exposed subjects % (n)			p
	Total (n = 618)	Women (n = 308)	Men (n = 310)	
Dusty job	49.8 (308)	26.6 (82)	70.3 (226)	< 0.001
Hard-rock mining	5.2 (32)	1.6 (5)	8.7 (27)	0.0001*
Coal mining	19.4 (120)	2.6 (8)	36.1 (112)	< 0.001*
Sandblasting	1.3 (8)	0.64 (2)	1.9 (6)	0.290*
Working with asbestos	2.4 (15)	1.3 (4)	3.5 (11)	0.120*
Chemical or plastics manufacturing	7.0 (43)	7.8 (24)	6.1 (19)	0.416
Flour, feed or grain milling	3.4 (21)	2.3 (7)	4.5 (14)	0.188*
Steel milling	3.9 (24)	0.64 (2)	7.1 (22)	0.0001*
Welding	7.7 (48)	0.64 (2)	14.8 (46)	< 0.001*
Fire fighting	3.2 (20)	0.32 (1)	6.1 (19)	0.001*
Farming	31.1 (192)	30.2 (93)	31.9 (99)	0.640

p for difference between sexes, χ^2 test, with Yates' correction when marked with asterisk*

Table 3. Time of exposure to potentially harmful occupational factors

Exposure	Exposure time (years)			
	Mean	Standard deviation	Minimum	Maximum
Dusty job†	20.5	12.9	1.0	55.0
Hard-rock mining	13.9	8.9	1.0	30.0
Coal mining	18.3	11.2	1.0	45.0
Sandblasting	8.4	6.0	2.0	20.0
Working with asbestos	10.0	8.1	1.0	28.0
Chemical or plastics manufacturing	18.0	10.8	1.0	38.0
Flour, feed or grain milling	13.9	14.2	1.0	52.0
Steel milling	12.9	9.7	2.0	31.0
Welding	14.3	10.5	1.0	52.0
Fire fighting	18.0	10.6	2.0	40.0
Farming	31.8	16.3	1.0	60.0

†Regardless from exposure type

Table 4. Influence of exposure to chosen risk factors on lung functions

	Cooking with coal		
	Yes	No	p
FEV_1/FVC (± SD)	74.6 (9.3)	79.1 (6.7)	0.0004
FEV_1 (% predicted) (± SD)	94.5 (18.3)	98.0 (13.2)	0.16
	Farming		
	Yes	**No**	**p**
FEV_1/FVC (± SD)	72.9 (10.7)	76.1 (8.3)	< 0.0001
FEV_1 (% predicted) (± SD)	94.0 (19.4)	95.2 (17.4)	0.47

p for difference between the groups, Mann-Whitney's U test

Thirty-one per cent of persons were involved in farming for more than three months. Mean duration of agricultural work was 31.8 years (± 16.2) and was similar for men and women.

Tables 1 and 2 present the frequencies of respective exposures. Among those, cooking on coal burning hearths and farming correlated with decreased forced expiratory volume in 1 second/forced vital capacity (FEV_1/FVC) (Tab. 4).

Multiparameter analysis did not identify independent risk factors for decreased FEV_1/FVC other than coal combustion. Correlation with p-value close to statistical significance ($p = 0.047$) was observed only when age, sex, and coal combustion were analysed as continuous variables (number of years of exposure multiplied by mean daily exposure). No statistically significant correlations were found when exposure to wood combustion was analysed as a categorical variable or when tobacco smoking was additionally considered as a continuous or categorical variable.

Multiparameter analysis involving sex, age, tobacco smoking, and farming as continuous variables (years of exposure) revealed that the latter is an independent risk factor for decreased FEV_1/FVC ($p < 0.0001$). Statistical significance was also found when farming was analysed as a categorical variable ($p = 0.002$). Including exposure to tobacco smoke into the analysis did not significantly change its results. Duration of farming activity correlated with FEV_1/FVC value ($r = –0.37$, $p < 0.0001$) (Fig. 1). The effect of farming upon FEV_1/FVC values was similar in both sexes and did not differ between smokers and non-smokers. Chronic obstructive pulmonary disease (defined as FEV_1/FVC < 0.7) was detected in 26.6% of persons who had a history of farming activity (48 subjects) and 18.7% of patients (68 persons) who never experienced this kind of exposure ($p = 0.005$). Stage II

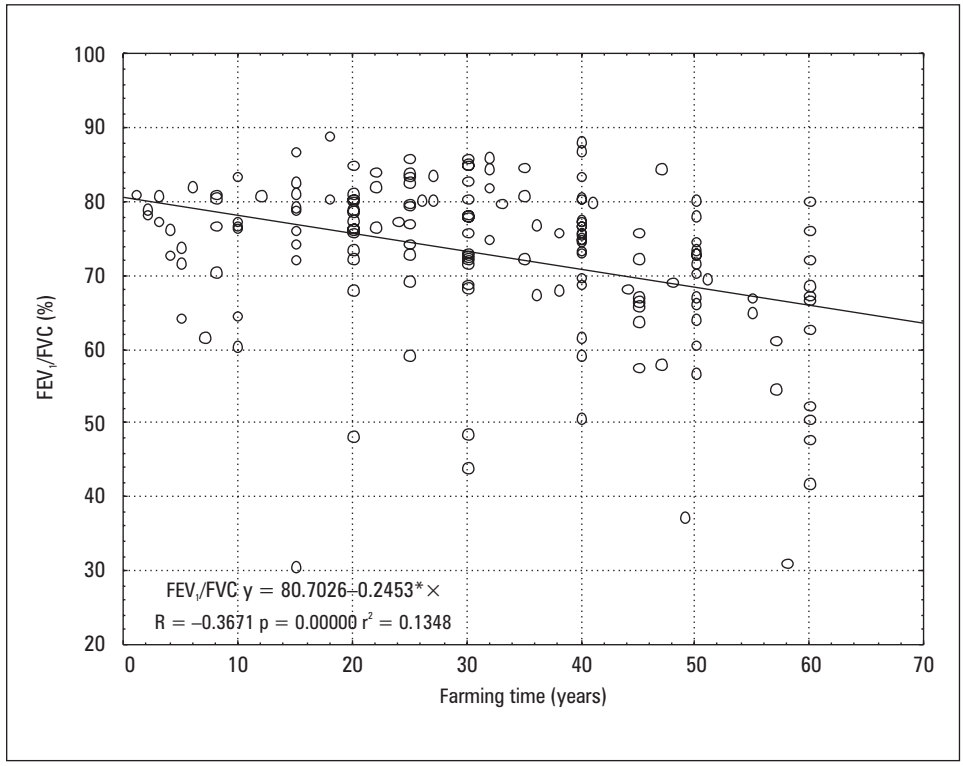

Figure 1. Relationship of FEV_1/FVC to the length of work on farm

COPD or higher, according to the Global Initiative For Chronic Obstructive Lung Disease (GOLD) spirometric classification ($FEV_1/FVC < 0.7$ and $FEV_1 < 80\%$ expected value), was identified in 13.6% of persons with a history of agricultural work (22 subjects) and 9.4% of patients who had no farming history (34 persons; $p = 0.145$).

Discussion

Most studied patients, who were inhabitants of two districts in the Malopolska region, experienced in their lifetime household exposure to coal or wood combustion, used for heating or cooking. In most cases, this type of exposure was of long duration, and lasted on average for over 30 years. Construction of questions included in the survey ("Has a wood/coal burning fireplace or stove been used as the main source of energy for cooking and/or heating for more than 6 months in your household?") did not permit analysis of the differences in exposure between the sexes, but the duration of exposure to coal/wood burning for cooking purposes was much longer in women, as could be expected.

Exposure to coal or wood combustion was much more pronounced in the past, but at the time of the study one fifth of its participants were still using coal burning fireplaces or stoves. This is important information for the public health perspective, as coal combustion in the household may increase the risk of respiratory tract infections in children and lung cancer in women [15]. Most available publications describing the influence of combustion of coal, wood, or biomass on the risk of COPD concern subjects in households with open-hearth fireplaces or stoves. These data cannot be extrapolated for Poland, where only closed hearts were used both in the past and currently, with exhaust fumes being transported and emitted outdoors. Significantly lower FEV_1/FVC values were found in subjects exposed to coal combustion in the household. However, multiparameter analysis showed that cooking on coal burning stoves was not an independent risk factor for worsened lung function. Given the small number of persons in the control group (almost 90% of studied patients used coal burning stoves for cooking), it cannot be excluded that analysis of a bigger population would yield different results. Exposure to biomass combustion occurred in the past for most of the subjects; therefore, analysis can be affected by recall bias, due to potentially imprecise recapitulation of long gone situations and exposures by the study subjects. At the time of the study, coal and wood burning fireplaces and stoves were more often used for heating or cooking by older and less educated

patients. The presented data concerned inhabitants of two districts of the Malopolska region, and cannot be extrapolated to other regions of the country. The obtained results warrant further studies of air pollution indoors and its influence on health status in the Polish population.

More than half the patients were exposed to various noxious agents in their workplace. This finding emphasises important and long-lasting contact with potentially harmful substances in industry workers in the two analysed districts of the Malopolska region.

Of all the analysed professional exposures, only a history of farming was significantly correlated with decreased lung function and higher risk of COPD. Multiparameter analysis confirmed that this risk factor is independent from patient sex, age, and passive or active exposure to tobacco smoke. Moreover, duration of agricultural activity correlated with worse lung function. Austrian authors presenting results of the BOLD study from their country also found that farming was a risk factor for COPD development. The percentage of patients having $FEV_1/FVC < 0.7$ among all persons with a history of agricultural work was similar in the Austrian study and in the presented paper [16]. Agricultural labour is characterised by exposure to many agents potentially harmful to the respiratory tract. These include organic and inorganic dusts as well as various chemical compounds used as fertilizers and pesticides/fungicides [17]. This kind of exposure is to some extent region-specific; therefore, confirmation of the relationship between farming and risk of COPD in Poland is of practical importance.

Apart from farming, no other professional exposures were identified as significant risk factors of worsened lung function in the presented study. Of all investigated professional exposures, working in the mining industry is a well-known risk factor for COPD [18, 19]. The fact that a history of mining-related exposures had no significant impact on lung function in the presented study may be explained by the lack of specification of the kind of professional activity in the survey; therefore, it was not possible to separate miners from surface mine personnel. Of note, almost 3% of female respondents reported working in the mining industry.

The presented study is one of the few population-based publications in Poland to investigate exposure to agents potentially harmful to the respiratory tract. The most important conclusion was the finding that a significant percentage of inhabitants of the Malopolska region were exposed to coal or wood combustion at home or had professional exposure to potentially harmful substances. Moreover, farming turned out to be correlated with reduced FEV_1/FVC values in the studied population.

Conflict of interest

The authors declares no conflict of interest.

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