



# Prevalence and Characteristics of Chronic Obstructive Pulmonary Disease in Dairy Farmers

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## Abstract

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**BACKGROUND:** Respiratory hazards are one of the most common occupational hazards in farming and can cause various respiratory disorders in exposed workers. Dairy farmers are exposed to various agents related to the breeding and care of livestock which are associated with development of chronic obstructive pulmonary disease (COPD).

**AIM:** The objective of the study was to assess the prevalence and characteristics of COPD in dairy farmers and to evaluate the role of job exposure and smoking as predictors for respiratory health impairment.

**METHODS:** A cross-sectional study was performed, including 83 dairy farmers (mean age: 52.6 ± 8.7 years; mean exposure duration: 23.7 ± 7.6 years) and 80 office workers as a control group (mean age: 52.7 ± 8.2 years) matched for age, smoking habits, and socioeconomic status. Methods for the evaluation of study participants included a questionnaire on respiratory symptoms in the past 12 months, baseline spirometry and bronchodilator reversibility testing, and diagnostic criteria for COPD.

**RESULTS:** The mean post-bronchodilator values of spirometry parameters are significantly lower in subjects among dairy farmers with negative bronchodilator test compared to those in controls, while the mean post-bronchodilator values of spirometry parameters are lower in dairy farmers with negative BD tests exposed more than 20 years compared to those with exposure <20 years, being statistically significant for forced expiratory volume in 1 s/forced vital capacity%,  $MEF_{25}$ ,  $MEF_{50}$ , and  $MEF_{75}$ . The COPD prevalence is non-significantly higher in dairy farmers compared to controls and is significantly associated with age over 40 years in dairy farmers ( $p = 0.035$ ). The odds for COPD development in dairy farmers is about 36 times higher in subjects exposed for more than 20 years ( $OR = 36.00 (1.21-37.77) CI 95%$ ) compared to those with exposure duration <20 years and is about 6 times higher in dairy farmers who are current smokers. COPD is significantly associated with smoking duration among smokers in both groups, while combined effect of smoking, smoking duration, and cigarettes smoked daily has a significant impact on COPD development in dairy farmers. According to the global initiative for chronic obstructive lung disease classification, depending on the degree of airflow limitation, mild and moderate types of COPD are detected in dairy farmers, and only mild type in controls, showing no significant difference between the two groups.

**CONCLUSION:** The study findings recognized the role of farming exposure, and smoking as well, as predictors for respiratory health impairment, and furthermore confirmed their potential to be a predictive factor for development of COPD. These facts should be helpful in detection of critical points for action, indicate the need for adverse occupational exposures reduction through adequate preventive measures and regular health examinations, implementation of relevant engineering controls, smoking cessation programs, and complete and efficient respiratory health assessment.

## Introduction

According to the results of studies conducted in United Kingdom and United States of America in the past few decades, the incidence of chronic obstructive pulmonary disease (COPD) is about 10% of the general adult population. In the USA, this disease has been the fourth leading cause of death among the population over the age of 45, and it is estimated that 24 million Americans suffer from it [1]. Cigarette smoking is the most important exogenous risk factor for the development of COPD, but there is also considerable evidence from epidemiological and experimental studies that occupational exposure is the second key exogenous factor for the development of the disease. According

to the current guidelines of the American Thoracic Society (ATS), in the occurrence of COPD in 15–20% of cases, that is, in one out of five cases, occupational exposure to irritating gases, fumes, vapors, and dust plays a significant role. Of particular importance for the occurrence of COPD is the interaction of occupational exposure with tobacco smoke, that is, active and passive smoking. The combined effect of tobacco smoke and occupational agents is usually multiplicative, that is, it is much greater than their additive effect [2].

Recent studies on the occurrence of COPD in non-smokers show that 25–45% of patients with COPD are non-smokers, and the main risk factors are fossil fuel smoke, occupational exposure to dust and fumes, indoor air pollution, etc. This emphasizes the importance of occupational exposure, suggesting that the population

attributable fraction ranges from 19% (among smokers) to 31% (among non-smokers) [3], [4]. The significance of the role of occupational agents in the occurrence of the disease is based on the excessive occurrence of COPD in workers from certain occupations exposed to dust, fumes, organic solvents, exhaust gases, etc., as well as the results of experimental animal studies [5].

There is increasing evidence that farming exposure is associated with the occurrence of COPD. The most frequently mentioned occupational hazards in farmers related to the occurrence of COPD are following agents: Grain dust, animal feed, gases, and smoke from various sources (ammonia, artificial fertilizers, disinfectants, etc.) [6]. Studies of agricultural workers have reported rates of chronic bronchitis ranging from 7.5% among Finnish farmers to 23% among farmers from Manitoba, Canada. A higher frequency of chronic bronchitis has been registered in research among livestock farmers in the countries of the former Yugoslavia [7], while the results of studies among milk producers from Vermont, USA indicate a frequency of 30% among smokers and 16% among non-smokers [8]. The results of several studies performed with indoor animal breeders indicate a higher frequency of chronic bronchitis in these workers compared to other agricultural workers [9]. The breeding of different types of animals (large and small livestock, poultry, etc.) and the accompanied activities involve different work tasks, working conditions and occupational hazards. Regardless of the animals being raised, common activities include feeding and watering, cleaning the stables, cleaning and caring for the animals, activities associated with birth and care of the young, as well as waste disposal.

Respiratory hazards are one of the most common occupational hazards in farming and can cause various respiratory disorders in exposed workers [6]. Livestock farmers are exposed to various agents that can be inhaled: Organic dust that contains microorganisms, mycotoxins, allergens, decomposition gases, pesticides, etc., and are related to the breeding and care of livestock [10].

Apart from workplace exposure to respiratory hazards, smoking is a significant factor that contributes to the occurrence of chronic respiratory diseases among agricultural workers. Many epidemiological studies dedicated to respiratory diseases monitor smoking, but also the joint effect of smoking and occupational exposure of agricultural workers [11]. The frequency of active smokers among farmers raising pigs and producing milk in France is 28% and 27%, respectively [12]. According to the results of a study at the Institute of Occupational Health of R. Macedonia, the frequency of active smokers among agricultural workers is 40.2% [13].

### **Objective of the study**

The study objective was to assess the prevalence and characteristics of COPD in dairy

farmers, and evaluate the role of job exposure and smoking as predictors for respiratory health impairment.

## **Subjects and Methods**

### **Study design and setting**

A cross-sectional study was carried out at the Center for Respiratory Functional Diagnostics in the Institute for Occupational Health, Skopje, within the period March 2019–January 2020, as a continuum of our investigation related to the work activities, exposure to respiratory hazards, and lung function impairment among dairy farmers.

The Institute's ethics committee has approved the content of our study protocol, whereas each examined subject was informed and gave written consent before any involvement in the study.

### **Study sample**

We have used the software program PEPI 4.04 to calculate the representative study sample (95% confidence level and confidence interval  $\pm 5$ ), taking an exposed group of 83 dairy farmers and 80 matched office controls in a large-scale agricultural enterprise (having in mind possible selection and response bias). These groups were analyzed by certain different findings in our previous study as well [14].

### **Subjects**

The survey examined 83 subjects (mean age =  $52.6 \pm 8.7$ ) employed as dairy farmers (mean duration of exposure  $23.7 \pm 7.6$ ). Their main activities included preparation of fodder feeding and animal meals, milking, working in the barn, preparation of straw, and hay making, cattle rising, as well as taking care about milk hygiene and animal health. They were exposed to various respiratory agents: dust, inappropriate microclimate conditions, chemical hazards, vapors, gases, as well as to heavy manual work, animal contact, unfavorable body positions, and repetitive hand movements. Inclusion criteria for examined group (EG): employed subjects with age range 18–64 years involved in dairy farming and exposed to at least one occupational respiratory hazard (dust, gases, fumes, and vapors).

To avoid selection bias and results' deviations, the study did not include subjects with exposure to respiratory hazards other than dairy farming. Depending on the exposure duration the examined subjects were divided in two subgroups: Exposed less or more than 20 years.

Furthermore, similar group of 80 office workers (mean age =  $52.7 \pm 8.2$ ) matched for age, duration of employment, daily smoking, and socioeconomic status was studied as a control group (CG), without occupational exposure to respiratory hazards.

The subjects in both groups diagnosed by physician to have some chronic respiratory disorder (asthma, COPD, bronchiectasis, sarcoidosis, etc.), or treated with bronchodilators and/or corticosteroids were not included in the study. Furthermore, we did not include any subjects in whom either spirometry or bronchodilator reversibility testing was contraindicated. All study subjects, before any involvement in the study, were informed about the study and gave their written consent accordingly, while the study protocol was approved by the Institute's ethics committee.

### Questionnaire

All participants in the study were interviewed by physician and completed the standardized questionnaire, including questions on work history, respiratory symptoms in the past 12 months, and smoking habit. Chronic respiratory symptoms in the past 12 months (cough, phlegm, dyspnea, wheezing, and chest tightness) were obtained using the European Community for Coal and Steel questionnaire (ECCS-87), and the European Community Respiratory Health Survey questionnaire [15], [16].

Smoking status was classified according to the World Health Organization (WHO) guidelines on definitions [17]. Namely, daily smoker was defined as a subject who smoked at the time of the survey at least once a day, except on days of religious fasting. Among daily smokers, lifetime cigarette smoking and daily mean of cigarettes smoked were also assessed. Pack-years smoked were calculated according to the actual recommendations [18]. Ex-smoker was defined as a formerly daily smoker, who no longer smokes. Passive smoking or exposure to environmental tobacco smoke was defined as the exposure of a person to tobacco combustion products from smoking by others [19].

### Baseline spirometry and bronchodilator reversibility testing

Spirometry testing was performed in all study subjects by spirometer Ganshorn SanoScope LF8 (Ganshorn Medizin Electronic GmbH, Germany), measuring forced vital capacity (FVC), forced expiratory volume in 1 s (FEV1), FEV1/FVC ratio, and maximal expiratory flow at 50%, 75%, and 25–75% of FVC (MEF50, MEF75, and MEF 25–75, respectively), by recording the best result from three measurements of the values of FEV1 within 5% of each other. The results were expressed as percentages of the predicted values according to the ECCS norms. The spirometry results were given as rate of proportion of their predicted values

due to the current European Respiratory Society and ATS recommendations including reproducibility and acceptability [20]. Bronchodilator reversibility testing was performed following the actual global initiative for chronic obstructive lung disease (GOLD) spirometry guide [21] with spirometric measurements before and 20 min after administration of 400  $\mu\text{g}$  salbutamol by metered dose inhaler, to assess airflow limitation.

### Diagnostic criteria for COPD

COPD was defined by post-bronchodilator FEV1/FVC ratio lower than 0.70 in subjects with dyspnea, chronic cough and/or cough with phlegm, according to the current recommendations by GOLD [21].

### Statistical analysis

Data were analyzed by Statistica for Windows version 7. Continuous variables were expressed as mean values with standard deviation and categorical variables as numbers and percentages. Study variables were checked for normality by Kolmogorov–Smirnov and Shapiro–Wilk's W test. The Chi-square test (or Fisher's exact test) was used for testing differences in the prevalence of certain variables, while the comparison of spirometric measurements was performed by independent-samples and paired samples t-test.  $p < 0.05$  was considered statistically significant. Multiple regression analysis was used to assess the associations between COPD and smoking habit characteristics in dairy farmers.

## Results

Table 1 gives an overview of overall and demographic characteristics of the study subjects.

**Table 1: Demographics of the study subjects [14]**

Variable	Dairy farmers (n = 83)	Office workers (n = 80)
Gender/M/F ratio	2.6	2.7
Age range (years)	20–63	21–64
Age (years)	$52.6 \pm 8.7$	$52.7 \pm 8.2$
BMI (kg/m <sup>2</sup> )	$25.4 \pm 3.6$	$26.2 \pm 3.7$
Duration of employment (years)	$26.3 \pm 10.1$	$25.3 \pm 9.8$
Duration of exposure	$23.7 \pm 7.6$	/
Daily smokers	39 (46.9%)	39 (48.7%)
Life-time smoking (years)	$18.9 \pm 7.6$	$19.2 \pm 7.8$
Cigarettes/day	$14.6 \pm 6.8$	$14.8 \pm 7.2$
Pack-years smoked	$12.5 \pm 4.8$	$12.9 \pm 4.9$
Ex-smokers	9 (10.8%)	12 (15%)
Passive smokers	7 (14%)	8 (16%)

Numerical data are expressed as mean value with standard deviation; frequencies as number and percentage of study subjects with certain variables. BMI: Body mass index, kg: Kilogram, m: Meter.

The subjects of examined and CG reported neither diagnose of any chronic respiratory non-occupational disease (sarcoidosis and tuberculosis) established before the study, nor treatment with oral corticosteroids, bronchodilators, antihistamines or any other medications that could potentially influence the functional and clinical findings.

The mean post-bronchodilator values of spirometric parameters are significantly lower in subjects among EG with negative bronchodilator test compared to those in CG (Table 2).

**Table 2: Mean post-bronchodilator values of spirometric parameters among subjects of EG and CG with negative bronchodilator tests**

Spirometric parameters	EG (n = 9)	CG (n = 5)	p-value*
FVC (% pred.)	76.4 ± 4.9	83.2 ± 5.1	0.030
FEV <sub>1</sub> (% pred.)	68.1 ± 6.7	77.8 ± 6.9	0.025
FEV <sub>1</sub> /FVC%	62.6 ± 6.4	71.9 ± 6.3	0.021
MEF <sub>25</sub> (% pred.)	42.8 ± 7.1	52.4 ± 7.6	0.034
MEF <sub>50</sub> (% pred.)	43.1 ± 6.3	51.8 ± 6.8	0.033
MEF <sub>75</sub> (% pred.)	44.2 ± 6.3	53.2 ± 7.1	0.030
MEF <sub>25-75</sub> (% pred.)	49.1 ± 7.3	59.5 ± 7.4	0.025

Data are expressed as mean value with standard deviation. FVC: Forced vital capacity, FEV<sub>1</sub>: Forced expiratory volume in 1 s; MEF<sub>25</sub>, MEF<sub>50</sub>, MEF<sub>75</sub>: Maximal expiratory flow at 50%, 75%, and 25–75% of FVC, respectively; % pred.: % of predicted value. \*Tested by paired-sample t-test.

Table 3 gives an overview of mean post-bronchodilator values of spirometric parameters in dairy farmers with negative BD tests having exposure duration ≤20 years and above 20 years.

**Table 3: Mean post-bronchodilator values of spirometric parameters among examined subjects due to exposure duration**

Spirometric parameters	Exposed >20 years (n = 7)	Exposed ≤20 years (n = 2)	p-value*
FVC (% pred.)	74.1 ± 3.7	78.5 ± 4.6	0.457
FEV <sub>1</sub> (% pred.)	65.3 ± 4.2	69.7 ± 2.5	0.212
FEV <sub>1</sub> /FVC%	60.1 ± 4.3	68.1 ± 2.1	0.043
MEF <sub>25</sub> (% pred.)	38.2 ± 4.3	46.3 ± 2.4	0.042
MEF <sub>50</sub> (% pred.)	40.1 ± 3.7	47.4 ± 2.9	0.039
MEF <sub>75</sub> (% pred.)	41.3 ± 2.9	48.1 ± 3.1	0.011
MEF <sub>25-75</sub> (% pred.)	47.2 ± 4.1	51.2 ± 2.7	0.244

Data are expressed as mean value with standard deviation. FVC: Forced vital capacity, FEV<sub>1</sub>: Forced expiratory volume in 1 s; MEF<sub>25</sub>, MEF<sub>50</sub>, MEF<sub>75</sub>: Maximal expiratory flow at 50%, 75%, and 25–75% of FVC, respectively; % pred.: % of predicted value. \*Tested by independent-sample t-test.

The mean post-bronchodilator values of spirometric parameters are lower in dairy farmers with negative BD tests exposed more than 20 years compared to those with exposure <20 years, being statistically significant for FEV<sub>1</sub>/FVC%, MEF<sub>25</sub>, MEF<sub>50</sub>, and MEF<sub>75</sub>.

The frequencies of COPD symptoms (dyspnea, chronic cough, and phlegm), negative BD tests, and values of post-bronchodilator FEV<sub>1</sub>/FVC lower than 0.70, as well as COPD prevalence in dairy farmers and controls, are shown in Table 4.

**Table 4: Frequencies of COPD symptoms, negative BD tests, values of post-bronchodilator FEV<sub>1</sub>/FVC lower than 0.70, and COPD prevalence in examined subjects and controls**

Variables	EG (n = 83) (%)	CG (n = 80) (%)
Respiratory symptoms in the last 12 months	24 (28.9)	15 (18.8)
Negative BD tests	9 (10.8)	5 (6.3)
Post-bronchodilator FEV <sub>1</sub> /FVC <0.70	8 (9.6)	4 (5)
COPD	7 (8.4)	3 (3.8)

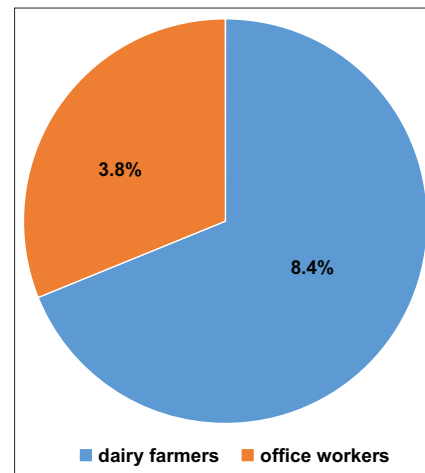
Data are expressed as number and percentage of study subjects with certain variables, COPD: Chronic obstructive pulmonary disease.

The COPD prevalence is non-significantly higher in dairy farmers compared to controls (Figure 1).

The odds for COPD development is non-significantly higher in dairy farmers (OR = 2.36 [0.52–12.04] CI 95%), compared to controls.

The COPD prevalence in EG is non-significantly higher in males, while in CG it is registered only in males (Figure 2).

COPD is significantly associated with age over 40 years in dairy farmers ( $p = 0.035$ ), while this

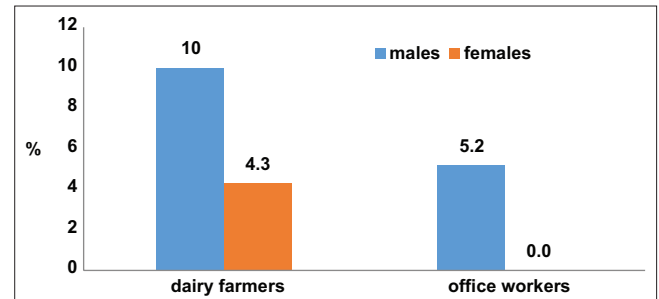


**Figure 1: Prevalence of chronic obstructive pulmonary disease in dairy farmers and controls**

association in controls is non-significant.

The association of COPD and exposure duration and smoking is shown on Table 5.

The odds for COPD development in dairy farmers is about 36 times higher in subjects exposed more than 20 years (OR = 36.00 [1.21–37.77] CI 95%) compared to those with exposure duration <20 years. The COPD odds in CG is non-significantly higher in smokers (OR = 2.10 [0.33–11.97] CI 95%), while that in EG is about 6 times higher in smokers (OR = 6.12 [0.95–37.77] CI 95%), compared to non-smokers.



**Figure 2: Gender distribution of chronic obstructive pulmonary disease in EG and CG**

The associations between COPD in dairy farmers who are smokers and smoking duration, number of cigarettes smoked daily, and with combined effect of smoking, smoking duration, and number of cigarettes smoked daily are shown in Table 6.

COPD is significantly associated with smoking duration among smokers in both groups, while

**Table 5: Association between COPD and exposure duration and active smoking**

Variables	EG (n = 7) (%)	p**	CG (n = 3) (%)	p**
COPD and exposure duration ≤20 years	1/7 (14.3)	p = 0.014	/	/
COPD and exposure duration >20 years	6/7 (85.7)		/	
COPD and active smokers	6/7 (10.3)	p = 0.014	2/3 (66.7)	NS
COPD and non-smokers	1/7 (4.5)		1/3 (33.3)	0.500

Data are expressed as number and percentage of study subjects with certain variable, \*\*Tested by Fisher's exact test.



**Table 6: Associations between COPD and smoking duration, number of cigarettes smoked daily, and with effect of smoking, smoking duration, and number of cigarettes smoked daily**

Variables	EG (p)	CG (p)
Smoking duration	p < 0.01* Beta = 0.312	p < 0.05* Beta = 0.183
Cigarettes/daily	NS*	NS*
Smoking/smoking duration/cigarettes daily	p < 0.05** Beta = 0.157	NS**

\*Tested by Mann Whitney U-test, \*\*Tested by multiple regression.

association with number of cigarettes smoked daily is non-significant in both groups.

The combined effect of smoking, smoking duration, and number of cigarettes smoked daily has a significant impact on COPD development in dairy farmers, while the impact in controls is non-significant. The association of COPD and passive smoking and ex-smoking, as well as drug, food and insect allergy is non-significant in both groups.

COPD is significantly associated with the obstructive pattern of ventilatory insufficiency in dairy farmers ( $p < 0.05$ ), while in controls this association is non-significant. The association with obstructive pattern in small airways is non-significant among the subjects in both groups.

According to the GOLD classification of COPD, depending on the degree of airflow limitation, mild and moderate types of COPD were detected in dairy farmers, and only mild type in controls (Table 7), showing no significant difference between two groups.

**Table 7: Prevalence of COPD types in dairy farmers and controls**

COPD types	EG (n = 83)	CG (n = 80)	p*
Mild FEV <sub>1</sub> ≥80% of predicted	4 (4.8%)	3 (3.8%)	p = 0.960
Moderate 50% < FEV <sub>1</sub> < 80% of predicted	3 (3.6%)	/	/
Severe 30% < FEV <sub>1</sub> < 50% of predicted	/	/	/
Very severe FEV <sub>1</sub> < 30% of predicted	/	/	/

\*Tested by Fisher's exact test.

All subjects from EG diagnosed with COPD indicate a worsening of the symptoms during or immediately after work and their improvement or withdrawal during absences from work (weekends, sick leave, and vacations), while subjects from CG with diagnosed COPD do not indicate such connection.

## Discussion

The current research assessed the effects of occupational exposure to respiratory hazards on the occurrence of COPD in dairy farmers employed in a large scale agricultural and farming enterprise. The CG consists of an adequate number of office workers, complementary to the exposed persons according to gender and age, while about 70% of the dairy farmers have exposure duration equal to or >20 years. A relatively high prevalence of active smokers was registered in both groups (around 50%), higher than in previous studies by Stoleski *et al.* among agricultural

workers [22], [23], [24]. The largest number of active smokers in both groups has smoking experience of 11–20 years and smoke 11–20 cigarettes daily, while both groups have a similar prevalence of ex-smokers and passive smokers.

Results from a Danish study examining the relationship between exposure and respiratory response in pig farmers show an annual decrease in FEV<sub>1</sub> of about 12 mL in exposed workers [25], while another Canadian study by Zejda *et al.* investigating the effect of occupational exposure on lung function in livestock farmers indicated a significant association between the level of VC reduction and the number of working hours [26]. A study of farmers in Serbia showed an annual decrease in FEV<sub>1</sub> value of up to 44 mL, as well as significantly reduced values of FVC and FEV<sub>1</sub> compared to control workers, without determining the influence of smoking habit [27]. The Turkish study by Kuchuk *et al.* examining the impact of specific occupational exposure on functional lung parameters in cow breeders, reported a significant correlation between the level of reduction in FVC and FEV<sub>1</sub> values and the length of occupational exposure [28]. The longitudinal study by Dalphin *et al.* among farmers in France revealed a significant correlation between the reduction of Tiffeneau index values (FEV<sub>1</sub>/FVC%), with the intensity and duration of occupational exposure to organic dust [29]. The synergy between specific occupational exposure and smoking has been confirmed in many other studies dealing with the respiratory health of agricultural workers. According to the longitudinal study of Tashkin *et al.* [30], the annual decrease in FEV<sub>1</sub> value is between 7 and 33 mL, depending on the length and intensity of occupational exposure to air pollutants and tobacco smoke.

A review of the existing literature in this domain confirms the fact that the COPD rate associated with occupational exposure has increased significantly in the last few decades and is slowly becoming a major cause of morbidity in many occupations, and thus a relevant public health problem [31]. A large number of epidemiological studies demonstrate the fact that tobacco smoke is undoubtedly the main cause of COPD, although some studies point out that the population attributable fraction for COPD related to occupational exposure to dust, gases, vapors and fumes may be 15–20% in the general population, but can reach up to 30% in non-smokers [32], [33]. However, recent research in this area indicates that it is not the only one and offers consistent evidence from epidemiological studies that chronic airflow limitation can also be registered in non-smokers occupationally exposed to dust, gases, vapors, and fumes [34], [35]. The previous research by Stoleski *et al.* among cow breeders investigates the frequency of COPD in non-smokers, but also the influence of specific occupational exposure on the development of COPD and its

characteristics [36] and establishes a relatively high rate of passive smokers in exposed and CGs, which argues in addition that the activities aimed at smoking cessation at the national level are still insufficient [13].

Husman *et al.* [37] put occupation in relation to COPD in their longitudinal study of farmers and other occupations in Finland, showing that its prevalence was 2.7% among farmers compared with 0.7% among workers of other occupations, which proves the harmful effect of occupational exposure in agriculture as independent of smoking, emphasizing the fact that chronic bronchitis is a disease related to work in farming. Dalphin *et al.* examining the prevalence of chronic bronchitis among French cattle breeders who raise cows show that they have a higher risk of developing chronic bronchitis, but at the same time of the occurrence of obstructive pattern in the airways [38]. Furthermore, Greskevitch *et al.* [39] reported that livestock farmers have a significantly increased risk of mortality related to respiratory diseases, and in relation to smoking habits, ex-smokers have a higher prevalence of asthma compared to non-smokers.

In the current research, the mean post-bronchodilator values of the spirometric parameters are significantly lower in dairy farmers compared to controls, having negative BD tests. Mean post-bronchodilator values of spirometric parameters are lower in examined subjects with negative BD tests exposed for longer than 20 years compared to those with shorter exposure than 20 years, with statistical significance for FEV<sub>1</sub>/FVC%, MEF<sub>25</sub>, MEF<sub>50</sub>, and MEF<sub>75</sub>. The frequency of COPD is non-significantly higher in dairy farmers (8.4%) compared to controls (3.8%). The prevalence of COPD in a previous study by Stoleski *et al.* is significantly higher among cattle breeders (10.7%) compared to office workers (2.7%), confirming the increased risk of developing COPD in farming [36]. The prevalence of chronic bronchitis and development of COPD was also studied by Eduard *et al.* who compared cereal farmers and livestock farmers [40]. They conclude that livestock farmers suffer from both conditions and have a risk ratio of 1.9 for chronic bronchitis and 1.4 for COPD. The previous research shows that exposure to farm dust is associated with the development of COPD [37]. COPD in non-smoking livestock farmers working indoors was studied by Monsó *et al.* [41], who detected COPD in 18 out of a total of 105 examined herders (17.1%), eight respondents (7.6%) had a moderate degree of the disease, while three cases (2.9%) had a severe form of COPD. Considering data from longitudinal studies, Hnizdo *et al.* [42] in regard to the occurrence of airways obstruction related to occupation, report that in Latin Americans the largest percentage of the attributive fraction (32%) is due to farming. Non-smoking farmers compared to non-smokers from other professions have a 1.6 times higher risk of developing irreversible bronchial obstruction. Similar to these results, the frequency of COPD with GOLD category I or higher category in non-smoking farmers was 24.5% compared

to 15.9% in non-smoking respondents from other occupations ( $p < 0.017$ ).

In the actual study, COPD is significantly associated with age over 40 years among dairy farmers, while in controls this association is non-significant. In terms of exposure duration, the risk of COPD development among dairy farmers is about 36 times higher among subjects with exposure duration >20 years compared to those with exposure duration <20 years. The combined joint effect of smoking, length of smoking experience and the number of cigarettes smoked daily, significantly influence the occurrence of COPD in dairy farmers, while their influence in controls is non-significant. According to the GOLD classification of COPD, mild and moderate COPD was detected in dairy farmers, while all controls were diagnosed with a mild degree of COPD. Regarding age, in the previous research by Stoleski *et al.* [36], COPD was associated with age over 45 years, as a result of the cumulative effect of various occupational and non-occupational exposures during life in predisposed individuals. Furthermore, a significant association was observed between COPD and the length of exposure experience in livestock farmers, and in addition, COPD was associated with work-related chronic respiratory symptoms. Lamprecht *et al.*, in a study of 1258 subjects from the general population over 40 years of age [34] found that 7.7% of the risk of COPD developing was related to agriculture, and mild COPD was present in about 30% of the subjects. Regarding the age groups of the respondents, Iversen *et al.* [43] investigating chronic bronchitis among Danish farmers, found a prevalence of 23.6%, of which 17.9% was registered among farmers aged 31–50 years, and 33% among farmers aged 51–70 years. The rates are highest among pig farmers (32%), but also among those who raise cows and pigs at the same time (28.4%). The lowest rates were registered for those who raise only cows (17.5%), as well as among respondents who have no contact with animals (18.6%). Analyzing chronic bronchitis in randomly selected Swiss cattle breeders, Danuser *et al.* [44], reported a prevalence rate of 16% and showed its significant increase with the increasing age of the subjects, while additional risk factors were smoking and exposure duration in closed facilities longer than 4 h daily. The prevalence of chronic bronchitis among non-smoking farmers in Switzerland, according to the same study, was 12% and is significantly higher compared to the same in the general population (6.8%).

There are many studies dealing with work-related COPD [45], where the population attributable fraction for COPD related to occupational exposure has been estimated between 9% and 31% [46]. In any case, the true attributable population risk for COPD according to occupational exposure is still unknown [47], [48] because work-related COPD is rarely clinically diagnosed. Balmes and Nowak [49] emphasize that the contribution of occupational exposure must not be

ignored because “the association between inadequate working conditions and COPD is significant as a general finding, in addition to the substantial contribution of the smoking habit to the disease prevalence”. This is a strong evidence that occupational exposure should be taken into account when evaluation the risk factors for COPD development.

Finally, the actual study has its own limitations. A considerably low number of study subjects could have certain impact on the data obtained and their analyze in both groups, whereas the absence of workplace monitoring may jeopardize clear understanding the impact of exposure type and degree on COPD development. Furthermore, similar to any cross-sectional survey, the results could be biased by the influence of healthy workers' effect.

Nevertheless, this study has also its strength, translated into the research about the farming job exposure and its respiratory effects among dairy farmers.

## Conclusion

The findings of the current survey are within the results range of similar studies about the cause-effect association between job exposure to respiratory hazards among dairy farmers and development of persistent airway obstruction. The results recognized the role of exposure, and smoking as well, as predictors for respiratory health impairment, and furthermore confirmed their potential to be a predictive factor in the COPD development. These facts should be helpful in detection of critical points for action, should indicate the need of adverse occupational exposures reduction through adequate preventive measures and regular health examinations, implementation of relevant engineering controls, smoking cessation programs, and complete and efficient respiratory health assessment.

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