

# Spirometry parameters in smokers and non-smokers with and without respiratory symptoms in the PURE Poland Study population

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## ABSTRACT

**Aim of the study:** To assess lung function and its relationship with smoking status and respiratory symptoms in the Prospective Urban and Rural Epidemiology (PURE) Poland Study population.

**Material and methods:** Analysis was carried in a cohort consisting of 2036 adults enrolled in the PURE Poland Study. This paper presents the results of 1217 (773 female) subjects in whom spirometry was performed and who were assessed for smoking status. We estimated the odds ratio for spirometry parameters values (forced respiratory volume in 1 second [FEV<sub>1</sub>], forced vital capacity [FVC], and FEV<sub>1</sub>/FVC) using logistic regression, adjusted for sex, age, smoking status, and respiratory symptoms in the last six months.

**Results:** Forty eight percent of participants were never smokers, 34% were former smokers, and 17% were current smokers. Chronic obstructive pulmonary disease (COPD) was diagnosed in 1.52%, 1.45%, and 2.39% of this population, respectively, and asthma in 4.88%, 1.69%, and 2.87%, respectively. Respiratory symptoms in the last six months were more common in current smokers than never smokers and former smokers. Conversely, spirometry parameters values (FEV<sub>1</sub>, FVC, and FEV<sub>1</sub>/FVC) did not differ significantly between the groups. In the logistic regression analyses, the strongest decrease of risk factors for FEV<sub>1</sub>/FVC, FEV<sub>1</sub>, and FVC were increasing age, and for Tiffeneau index former smoking status. Among women the decrease in FVC was more pronounced than in men (OR 3.82; 95% CI 2.18-6.68). The presence of respiratory symptoms did not increase the risk of decline of spirometry parameters.

**Conclusions:** Lung function based on spirometry parameters in the surveyed PURE Poland Study population was more dependent on increasing age and female sex than on smoking status and respiratory symptoms.

**KEY WORDS:** spirometry, lung function, PURE, tobacco, respiratory symptoms, respiratory diseases.

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## INTRODUCTION

According to the European Commission, smoking is the largest avoidable health risk factor in Europe. It causes more health problems than alcohol, high blood pressure, excessive weight or high cholesterol, and drugs combined [1]. Tobacco smoking is also a major avoidable cause of premature mortality in Poland. Almost one in three Polish men

do not live to the age of 65 years, and almost half of this premature mortality can be accounted for by the much higher prevalence of smoking in Poland than in Western Europe [2]. Chronic obstructive pulmonary disease (COPD), one of the cardiorespiratory outcomes of tobacco smoking, is globally increasing in prevalence and is expected to be the third largest cause of death by 2020 [3].

Over the years, we have observed that smoking prevalence in Poland declined between the 1976 and 2014 from 73% to 28% among men and from 30% to 19% among women [4]. This meaningful decrease was possible, among other factors, thanks to intervention programs originating from the Polish Anti-tobacco Law of 1995 [5]. This positive trend led to the curbing smoking and, later, a fall in the rates of tobacco-related diseases. According to the GBD study [6] the annualised rates of smoking prevalence decrease between 1990 and 2015 was 1.7% among Polish men and 0.9% among Polish women, placing them among the fastest declines in the world. In Europe, only Sweden, Denmark, and the Netherlands witnessed more rapid smoking declines in males [4].

Spirometry is a basic method of monitoring many lower respiratory tract diseases. British scientists found that spirometric values predicted mortality more precisely than systolic blood pressure or body mass index, emphasising the importance of conducting spirometry in primary prevention in the general population, even among lifelong non-smokers [7]. Smoking can influence lung function measured by spirometry values, but the presence of respiratory symptoms with preserved pulmonary function among smokers is also possible [8-10].

In this paper, we investigate the prevalence of cigarette smoking and its impact on respiratory symptoms and lung function measured by spirometry parameters among adults of all ages in the population of the Prospective Urban and Rural Epidemiology (PURE) Poland cohort.

## MATERIAL AND METHODS

Analysis of lung function and its relationship with smoking status and respiratory symptoms was carried out between 2007 and 2010 in a cohort enrolled in the PURE Poland Study. The PURE Poland Study baseline covered, in total, a group of 2036 adults (754 men and 1282 women), including both urban (59%) and rural (41%) inhabitants of Lower Silesia, a geographical region in south-west Poland. All participants were examined in accordance with the PURE project protocol, which has been described in detail elsewhere [11]. The PURE study protocol included questionnaires (family, household, individual health questionnaire, and food frequency questionnaire), anthropometric measurements, blood pressure measurements, blood draw, and spirometry. This paper presents the results of 1217 (773 female) subjects on whom spirometry was performed and who were assessed for smoking status. Spirometry was performed with a spirometer (*Micro Medical Micro Gp*). Prebronchodilatory forced respiratory volume in 1 second (FEV1) and forced vital capacity (FVC) were typically measured with at least three sets of values and had two measurements differing by less than 5% as a criterion for reproducibility. The highest measurements of FEV1 and FVC were used in the analyses. FEV1, FVC, and FEV1/

FVC as a percentage of predicted value were calculated using internally derived reference values based on a subsample of healthy, asymptomatic (without wheezing, dyspnoea, chest pain or tightness, sputum, cough, and asthma) never-smokers with age and height used as covariates separately for men and women. Individuals without bronchoconstriction were defined as having a FEV1/FVC ratio equal to or greater than 70%. Severity of airflow was evaluated using FEV1 as a percentage of predicted value. FEV1 equal to or greater than 70 was assumed to be correct. Diagnoses of asthma and COPD were self-reported by participants. Participants were considered ever smokers if they reported smoking at least one cigarette per day for at least one year. Ever smokers were divided into current smokers (survey question: “do you currently smoke cigarettes?”) and former smokers (survey question: “did you formerly smoke cigarettes?”) implicating that the participant used to smoke cigarettes but had stopped smoking before the survey).

We estimated the odds ratio for spirometry parameter values (FEV1, FVC, and FEV1/FVC) using logistic regression, adjusted for sex, age, smoking status, and respiratory symptoms in the last six months. Statistical analysis was performed using Statistica 13.1 software. Statistical significance was established at  $p < 0.05$ .

Written and informed consent was obtained from all individual participants included in the study. The study was reviewed and accepted by the Bioethics Committee of Wrocław Medical University (positive opinion no. KB-443/2006) and was therefore performed in accordance with the ethical standards laid down in an appropriate version of the 1964 Declaration of Helsinki.

## RESULTS

A total of 1217 participants (968 urban and 231 rural) completed the survey questionnaire and conducted a spirometry test according to the American Thoracic Society (ATS) criteria. Sixty three percent (63.52%) of the participants were female.

The characteristics of the population stratified by smoking status are shown in Table 1. Forty nine percent (48.81%) of the participants indicated they were never smokers, 34% were former smokers, and 17.2% were current smokers. Mean age did not differ among these three cohorts.

There were significant differences by sex in smoking status distribution. Most female participants declared themselves as non-smokers (56.27%), 28.33% as former-smokers, and only 15.40% as current smokers. Among men 35.91% identified as never-smokers, 43.92% as former-smokers, and 20.27% as current smokers.

COPD was diagnosed among 1.52% of never smokers, 1.45% of former smokers, and 2.39% of current smokers, and asthma in 4.88%, 1.69%, and 2.87%, respectively. All reported respiratory symptoms in the last six months (wheezing in the chest, cough for at least

**TABLE 1.** Characteristics of the population stratified by smoking status

Characteristic	Non-smokers	Former smokers	Current smokers	p-value
Percent (n) of overall population	48.81 (594)	34.02 (414)	17.17 (209)	
Mean age, years	53.46 ±10.12	52.23 ±8.60	52.22 ±8.13	
Males, % (n)	35.81 (159)	43.92 (195)	20.27 (90)	0.0000
Females, % (n)	56.27 (435)	28.33 (219)	15.40 (119)	
Asthma diagnosis and/or COPD diagnosis, % (n)	6.40 (38)	3.14 (13)	5.30 (11)	
FEV1% predictive value	99.53 ±21.99	100.34 ±21.06	109.58 ±35.78	0.0000
FVC% predictive value	102.98 ±26.53	105.79 ±24.57	114.50 ±40.41	0.0000
FEV1/FVC	0.88 ±0.08	0.88 ±0.09	0.88 ±0.09	
Respiratory symptoms in the last 6 months, % (n)				
Wheezing in the chest	7.58 (45)	7.97 (33)	12.44 (26)	0.0843
Cough for at least 2 weeks	22.05 (131)	14.98 (62)	23.02 (50)	0.0063
Early morning cough with chest tightness	4.55 (27)	3.86 (16)	7.18 (15)	0.1754

COPD – chronic obstructive pulmonary disease, FEV1 – forced respiratory volume in 1 second, FVC – forced vital capacity

**TABLE 2.** Percentage of normal and declined FEV1/FVC value by sex, age, smoking status, and respiratory symptoms in the last six months and odds ratios of the decline (logistic regression models – adjusted OR [95% CI])

Characteristics of population	FEV1/FVC normal, % (n)	FEV1/FVC declined, % (n)	Adj. OR (95% CI)	p-value
Females	97.54 (754)	2.45 (19)	0.91 (0.44-1.89)	0.794
Year of birth				
After 1960	98.73 (312)	1.27 (4)	1.0 (ref.)	
Between 1940 and 1960	97.53 (828)	2.47 (21)	1.98(0.67-5.81)	0.215
Before 1939	88.24 (45)	11.76 (6)	5.26 (2.02-13.67)	0.001
Smoking status				
Nonsmokers	99.0 (588)	1.0 (6)	1.00 (ref.)	
Former smokers	95.41 (395)	4.60 (19)	4.71 (1.87-11.9)	0.001
Current smokers	97.13 (203)	2.87 (6)	2.90 (0.92-9.08)	0.068
Respiratory symptoms in the last six months				
Wheezing in the chest	95.19 (99)	4.81 (5)	2.11 (0.79-5.62)	0.135
Cough for at least 2 weeks	97.53 (237)	2.47 (6)	0.96 (0.39-2.37)	0.931
Early morning cough with chest tightness	94.93 (55)	2.17 (3)	2.20 (0.65-7.47)	0.205

FEV1 – forced respiratory volume in 1 second, FVC – forced vital capacity

two weeks, and early morning cough with chest tightness) were more common among current smokers than non-smokers and former smokers. Conversely, spirometry parameters values (FEV1, FVC, and FEV1/FVC) did not differ significantly between the groups (Table 1).

In the logistic regression analyses sex was not a risk factor for the decrease of the Tiffeneau index (Table 2). The strongest risk factors for such a decrease were older age and former smoking status. Reported respiratory symptoms in the last six months were not a risk factor for FEV1/FVC decrease. For FEV1% of predicted value and FVC% of predicted value decrease the strongest risk factor was increasing age (Table 3). Among women

the decrease in FVC% of predicted value was more pronounced than in men (OR 3.82 95%CI 2.18-6.68). The presence of respiratory symptoms did not increase the risk of decline of spirometry parameters.

## DISCUSSION

Our study is one of the few papers focusing on the association between smoking status, respiratory symptoms, and lung function in the general population. We found that current respiratory symptoms reported by participants were more frequent among current smokers than former and never-smokers, but the lung function was not affected by smoking status (except for FEV1/FVC

**TABLE 3.** Percentage of normal and declined FEV1% of predicted value and FVC% of predicted value by sex, age, smoking status, and respiratory symptoms in the last six months and odds ratios of its decline (logistic regression models – adjusted OR [95% CI])

Characteristics of population	FEV1% predicted normal, % (n)	Adj. OR (95% CI)	p-value	FVC% predicted normal, % (n)	Adj. OR (95% CI)	p-value
Females	90.69 (501)	1.65 (1.04-2.63)	0.034	88.23 (682)	3.82 (2.18-6.68)	< 0.001
Year of birth						
After 1960	96.84 (306)	1.00 (ref.)		95.57 (302)	1.00 (ref.)	
Between 1940 and 1960	90.69 (770)	3.14 (1.60-6.14)	0.06	89.87 (763)	2.43 (1.36-4.34)	0.003
Before 1939	82.35 (42)	2.09 (0.98-4.45)	0.001	88.24 (45)	1.19 (0.50-2.85)	0.71
Smoking status						
Nonsmoking	90.91 (540)	1.00 (ref.)		90.40 (537)	1.00 (ref.)	
Former smoking	91.30 (378)	0.95 (0.61-1.48)	0.829	90.82 (376)	0.95 (0.62-1.47)	0.824
Current	96.17 (201)	0.40 (0.19-0.85)	0.017	94.74 (198)	0.52 (0.27-1.02)	0.056
Respiratory symptoms in the last 6 months						
Wheezing in the chest	93.27 (97)	0.81 (0.37-1.80)	0.605	91.35 (95)	0.99 (0.49-2.03)	0.983
Cough for at least 2 weeks	93.00 (226)	0.83 (0.48-1.43)	0.499	92.18 (224)	0.86 (0.52-1.45)	0.582
Early morning cough with chest tightness	91.38 (53)	1.08 (0.42-2.77)	0.871	84.48 (49)	2.01 (0.96-4.22)	0.064

FEV1 – forced respiratory volume in 1 second, FVC – forced vital capacity

among former smokers) or the presence of respiratory symptoms. Not surprisingly, the strongest parameters decreasing spirometry values were increasing age and female sex for FVC%.

Some limitations of our study should be considered. Both tobacco smoking status and respiratory symptoms were self-reported by the participants, which could have caused some underestimations. The diagnosis of COPD and asthma were based on the questionnaire responses about the doctor's diagnosis of these diseases. On the other hand, the study examined a relatively large sample forming part of the well-respected international PURE study [11].

Smoking prevalence in our cohort was lower than in previous studies in Poland, which is in line with the trend of decline of smoking in the previous years. In our findings sex was a statistically significant differentiating factor of smoking status. According to our findings, the percentage of current smokers was higher among men than women. The same tendency can be observed in other studies, both in Poland and internationally [1, 12-14]. Sex disparities in smoking prevalence, although they still exist, seem to be narrowing, especially in high-income countries, including Poland. Poland is among the countries with a particularly high rate of smoking women. In urban areas, the smoking prevalence among women has become equal to that among men, especially in younger populations [15].

According to Gupta *et al.*, lung function (measured as FEV1 and FVC) was strongly associated with all-cause mortality, including respiratory and non-respiratory causes of death even among never smokers [7]. According to data obtained within the Atherosclerosis Risk in Communities (ARIC) Study, FVC, but not airway obstruction, predicted survival in asymptomatic adults regardless of age, smoking status, occupation, or blood pressure [16]. In our study FVC values did not differ depending on smoking status but were clearly lower in elderly people and lower among women than men. In our study COPD was more prevalent among smokers, which is consistent with findings in literature, i.e. the Rotterdam Study [17]. However, the number of COPD diagnoses in our population was small, so the observation should be treated with caution. Some COPD diagnoses in never smokers can be the result of the presence of other environmental risk factors, besides tobacco smoking [17]. It is estimated that 25-45% of patients with COPD have never smoked [18]. According to Hancox *et al.* [19], both tobacco smoking and childhood-persistent asthma were associated with lower FEV1/FVC ratios, but there was no evidence that tobacco smoking had a greater effect on lung function than asthma.

In our study, FEV1/FVC decline was most prevalent among former smokers, contrary to the results obtained in other studies [20, 21], in which quitting smoking was

associated with improved lung function. On the other hand, smoking cessation can be associated with weight gain, and increased body mass index (BMI) was associated with lower lung function [22], but we can only speculate that this phenomenon partially explains our observation. The other underlying mechanism may be the “healthy smoker effect” – the situation in which smokers, who experience adverse symptoms like cough, wheezing in the chest, or chest tightness while smoking, are more likely to give up smoking than smokers, who do not experience any symptoms related to lung function [23]. According to Kohansal *et al.*, participants who quit smoking after the age of 40 years were characterised by declined FEV1 in comparison to never smokers and participants who quit earlier, but not significantly different from current smokers [21]. In our study we did not precisely determine when smoking cessation occurred. In our study, respiratory symptoms like wheezing in the chest, cough for at least two weeks, and early morning cough with chest tightness were more frequent among current smokers than former and non-smokers, but the lung function was not affected by smoking status or the presence of respiratory symptoms. The evidence for the presence of respiratory symptoms with normal FEV1 in smokers was recently discussed by Rodrigues-Roisin *et al.* [9], who concluded that as the decline in lung function is not always present among smokers, a better understanding of the biological mechanisms underlying symptoms in smokers with intact FEV1/FVC is needed to improve the ability to treat respiratory symptoms that occur before the development of COPD. For example, in an urban population-based study, two groups of current smokers with normal spirometry were randomly selected and followed over four years. In the group with normal diffusing capacity of the lung for carbon monoxide (DLCO), only 3% of subjects developed significant reductions in FEV1/FVC and DLCO. In the subset with low DLCO at baseline, 22% developed COPD. There were no respiratory clinical or radiographic differences between these two groups [24]. In our study we did not conduct additional tests of lung function, thus we were not able to identify the potential risk group of future COPD incidents in our population. In another recently published survey from the Subpopulations and Intermediate Outcome Measures in COPD Study cohort [10], ever- or former smokers and never smokers with normal FEV1 were studied. Chronic respiratory symptoms were observed in 50% of smokers. In this study the use of the COPD Assessment Test (CAT), a questionnaire designed for COPD, provided a broader assessment of symptomatic burden than just respiratory symptoms. Compared with asymptomatic current or former smokers and never smokers, symptomatic smokers were younger and more likely to be current smokers. There were no differences in the spectrum of symptoms between symptomatic smokers with normal FEV1 and patients in early stages

of COPD. There are also some limitations of our study to consider. The device used in the survey did not allow us to achieve the whole range of spirometry parameters (e.g. time to PEF, BEV, and EOFE).

## CONCLUSIONS

Lung function based on spirometry parameters in the surveyed PURE Poland study cohort had a stronger correlation with increased age and female sex, rather than with smoking status or respiratory symptoms. Respiratory symptoms were more frequent in current smokers. Such symptoms may come before airflow limitation; thus, the study suggests that the strategy of early diagnosis and management should give special attention and priority to symptoms, not spirometry values.

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## DISCLOSURE

The authors report no conflict of interest.

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#### AUTHORS' CONTRIBUTIONS

KPZ, BS and ABR analyzed and interpreted data, wrote the manuscript and revised it. DGD wrote and revised the manuscript. MW collected and analyzed data. AS and WZ contributed to concept and design and revised the manuscript. KZ contributed to concept and design, wrote and revised the manuscript. All authors have given final approval of the version to be published.