



The European Respiratory Society spirometry tent: a unique form of screening for airway obstruction

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ABSTRACT: In order to raise public awareness of the importance of early detection of airway obstruction and to enable many people who had not been tested previously to have their lung function measured, the European Lung Foundation and the European Respiratory Society (ERS) organised a spirometry testing tent during the annual ERS Congresses in 2004–2009.

Spirometry was performed during the ERS Congresses in volunteers; all participants answered a simple, brief questionnaire on their descriptive characteristics, smoking and asthma. Portable spirometers were freely provided by the manufacturer. Nurses and doctors from pulmonary departments of local hospitals/universities gave their service for free. Lower limit of normal (LLN) and Global Initiative for Chronic Obstructive Lung Disease (GOLD) criteria for diagnosing and grading airway obstruction were used.

Of 12,448 participants in six congress cities, 10,395 (83.5%) performed acceptable spirometry (mean age 51.0 ± 18.4 yrs; 25.5% smokers; 5.5% asthmatic). Airway obstruction was present in 12.4% of investigated subjects according to LLN criteria and 20.3% according to GOLD criteria. Through multinomial logistic regression analysis, age, smoking habits and asthma were significant risk factors for airway obstruction. Relative risk ratio and 95% confidence interval for LLN stage I, for example, was 2.9 (2.0–4.1) for the youngest age (≤ 19 yrs), 1.9 (1.2–3.0) for the oldest age (≥ 80 yrs), 2.4 (2.0–2.9) for current smokers and 2.8 (2.2–3.6) for reported asthma diagnosis.

In addition to being a useful advocacy tool, the spirometry tent represents an unusual occasion for early detection of airway obstruction in large numbers of city residents with an important public health perspective.

KEYWORDS: Airway obstruction, general population, Global Initiative for Chronic Obstructive Lung Disease criteria, lower limit of normal criteria, screening

Chronic obstructive pulmonary disease (COPD) has been described by the American Thoracic Society (ATS)/European Respiratory Society (ERS) guidelines on COPD [1] as a disease “characterised by airflow limitation that is not fully reversible”.

COPD is one of the most important causes of mortality and morbidity worldwide; it represents the commonest cause of death from respiratory diseases, which are the third most common cause

of death (8%) in the 25 member states of the European Union (EU) [2]. However, these figures may be underestimated. According to the World Health Organization (WHO), COPD will become the third commonest cause of mortality [3] and the seventh commonest cause of disability-adjusted life years worldwide by 2030 [4].

COPD represents a huge burden for healthcare systems and causes increasing costs for society due to absence from work, visits to the doctor’s

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clinic, medication and hospital admissions. The socioeconomic burden from COPD is also expected to increase. In Europe, direct/indirect costs of COPD were estimated at ~38.7 billion Euros in 2000 [5].

The growing burden of COPD is mainly due to the ageing of the world's population and to the continued use of tobacco [4]. Recently, the Burden of Obstructive Lung Disease (BOLD) Initiative measured the prevalence of COPD and its risk factors in 12 cities all over the world. Prevalence rates of Global Initiative for Chronic Obstructive Lung Disease (GOLD)-defined COPD stage II or higher (forced expiratory volume in 1 s (FEV₁)/forced vital capacity (FVC) <0.70 and FEV₁ <80% predicted) were 10.1% overall, 11.8% for males and 8.5% for females [6].

Within the Northern Ireland, Cost and Epidemiology of Chronic Obstructive Pulmonary Disease (NICECOPD) study on a general population sample in the Greater Belfast area, the prevalence of COPD varied from 4.9% (40–49 yrs) to 12.3% (60–69 yrs) in males and from 1.4% (40–49 yrs) to 4.5% (60–69 yrs) in females [7]. A Swedish study showed a prevalence of GOLD COPD of 14.3% [8]. A recent Polish study showed a prevalence of COPD, according to the lower limit of normality (LLN), of 15.3% in subjects aged ≥40 yrs [9].

In recent years, some studies have evaluated the impact of different definitions of airway obstruction on the estimated prevalence of obstruction in general population samples, showing an overestimate of COPD using the GOLD criteria compared with the LLN criteria. Using the Third National Health and Nutrition Examination Survey (NHANES) data, *CELLI et al.* [10] showed a COPD prevalence of 18.4% according to the GOLD criteria and of 15.6% according to the LLN criteria. In the Korean NHANES survey, these results were confirmed: 10.9% with LLN criteria *versus* 15.5% with GOLD criteria [11].

Other studies also suggest an important association between COPD and asthma. In a prospective observational study, *SILVA et al.* [12] showed that subjects with active asthma, compared with nonasthmatics, had a 12.5 times higher risk of acquiring COPD [12]. Overlapping asthma and COPD prevalence rates in an Italian general population (proportional Venn diagram) were reported by *VIEGI et al.* [13].

Despite the high social and economic burden, COPD is an often underdiagnosed or misclassified disease. Many studies showed that spirometry is not commonly used for the diagnosis of COPD in primary care. In Sweden, only 30% of subjects with a diagnosis of COPD in their medical records had undergone spirometry [14]. In the USA, analysis of medical records of patients admitted to academic tertiary care hospitals showed that only 31% of those with a COPD diagnosis had spirometry, by contrast 78% of subjects with congestive heart failure had echocardiography [15].

To overcome underdiagnosis and to prevent the development of severe stage of COPD, some screening programmes have been performed in the population at risk, showing prevalence values of COPD ranging from ~20% to ~47% [16–20].

Thus, the European Lung Foundation (ELF) Council and the ERS Executive Committee considered it worthwhile to ask us

to analyse the data collected at the ELF/ERS spirometry tent during the annual ERS Congresses in 2004–2009, in order to increase the public awareness of airway obstruction and lung health. Moreover, the spirometry tent event had the aim of enabling many people, who had not been tested previously, to have their lung function measured so as to detect early cases of airway obstruction in the general population and to detect them potentially in early stage of airway obstruction.

MATERIALS AND METHODS

Every year, between 2004 and 2009, during the Annual Congress of the ERS, the ELF and the ERS organised a public spirometry event. This was usually performed in a public space, such as a railway station or a tent in a city square, to give local citizens the opportunity to have their lung function tested for free. Extensive media coverage leading up to the event helped to attract a large number of people.

During the six ERS Congresses in Glasgow (UK in 2004); Copenhagen (Denmark in 2005); Munich and Berlin (Germany in 2006 and 2008, respectively); Stockholm (Sweden in 2007) and Vienna (Austria in 2009), 12,448 volunteers decided freely to perform the spirometry and answered a simple brief questionnaire about their descriptive characteristics, smoking habits and asthma. The answers were manually entered into the spirometer's computer prior to performing the test.

Portable spirometers were freely provided by the manufacturer (NDD Medical Technologies, Zurich, Switzerland). Nurses and doctors from pulmonary departments of local hospitals/universities gave their service for free.

During all the events, lung function data were obtained using the NDD EasyOne Spirometer (NDD Medical Technologies), which is a hand-held, battery-operated device that uses an ultrasonic sensor to measure air flow. It was chosen for its level of accuracy and portability that meets published recommendations of the ERS and ATS, and because it does not require regular calibration [21]: indeed, the spirometer was not calibrated during the event. The potential stability of the calibration was one reason why this spirometer was selected for use in the BOLD and PLATINO (Proyecto Latinoamericano de Investigación en Obstrucción Pulmonar) studies [6, 22]. The humidity and the temperature were measured at the beginning of each event and the values inserted in the spirometer. Subjects performed the manoeuvre in a sitting position wearing a nose clip. The post-bronchodilation spirometric test was not performed.

Subjects with abnormal spirometry (abnormal curves or values) or people who had symptoms and were worried were given a letter addressed to their general practitioner suggesting further tests for possible confirmation of the findings and follow-up. Subjects could decide freely to take this letter to their general practitioner.

As confirmed by the data collectors, no change was performed in the software and outputs of the NDD EasyOne Spirometer. Available data were sent to the ELF Secretariat in Sheffield, UK, which forwarded them to the Pisa team (Pulmonary Environmental Epidemiology Unit, CNR Institute of Clinical Physiology, Pisa, Italy) for the statistical analyses.

The LLN [23] was derived from population-specific prediction equations [24, 25]. Airway obstruction was reported if FEV₁/FVC was <LLN [10, 11]. The stage was defined by the level of FEV₁ in % pred (adjusted for age) [24]: stage I if FEV₁ was ≥70% pred; stage II if 60% ≤FEV₁ <70% pred; stage III if 50% ≤FEV₁ <60% pred; stage IV if 35% ≤FEV₁ <50% pred; and stage V if FEV₁ <35% pred [23]. Subjects with FEV₁/FVC ≥LLN were considered as nonobstructed.

To make comparisons with international studies possible, we also reported the prevalence of airway obstruction as defined by the fixed GOLD criteria (FEV₁/FVC <0.7) [26]. The stage was defined by level of FEV₁ in % pred (adjusted for age) [24]: stage I if FEV₁ was ≥80% pred; stage II if 50% ≤FEV₁ <80% pred; stage III if 30% ≤FEV₁ <50% pred; and stage IV if FEV₁ <30% pred [26]. Subjects with FEV₁/FVC ≥0.7 were considered as nonobstructed.

Spirometries of F-quality grade were not considered in the analyses (n=2,053, *i.e.* 16.5% of total participants).

Ethical approval was not sought since it was not a clinical trial and, after having been briefly instructed about the procedure and the meaning of the test, subjects freely decided to participate in the spirometry tent event. The protocol was approved by the ELF Council.

Statistical analyses

Analyses were performed using the Statistical Package STATA (Stata Statistical Software Release 9.0; StataCorp 2005, College Station, TX, USA).

The Chi-squared test was used to compare categorical variables and ANOVA to compare the mean values of continuous variables between groups.

In order to take into account the role of different risk factors, a multinomial regression analysis was performed by using the decades of age, smoking habits (smokers, ex-smokers or non-smokers), sex and asthma (reported asthma symptoms, reported asthma diagnosis or nonasthma) as independent variables, and LLN severity categories (stage I, II, III or IV+) or GOLD severity categories (stage I, II or III+) as dependent variable. The choice to use the LLN IV+ category and GOLD III+ category is due to the small number of subjects in these severity levels.

RESULTS

12,448 volunteers were investigated during the ERS Congresses. Of these, 2,053 (16.5%) performed spirometry with a quality grade equal F: these subjects had a mean age of 44.7 ± 21.5 yrs, 51.2% were males, 29.4% current smokers, 19.4% ex-smokers, 3.6% had asthma diagnosis and 3% had asthma symptoms; 67.7% performed at least three spirometric manoeuvres and 32.3% more than three manoeuvres.

10,395 (83.5%) performed spirometry with a quality grade above F: 826 resided in Glasgow, 1,039 in Copenhagen, 1,787 in Munich, 2,417 in Stockholm, 2,798 in Berlin and 1,528 in Vienna. The descriptive statistics showed a slightly higher frequency of females (52.0%) and a mean age of 51.0 ± 18.4 yrs, with the lowest mean age in Berlin (table 1). Stratifying the sample in decades of age, the most numerous age classes were 40–49 yrs, 50–59 yrs and 60–69 yrs (table 1). The prevalence of smokers was 25.5% (maximum in Copenhagen, 51.4%) and of

ex-smokers was 27.1% (maximum in Glasgow, 31.5%) (table 1). There was a prevalence of 5.5% both for reported asthma symptoms (maximum in Stockholm, 7.7%) and asthma diagnosis (maximum in Glasgow, 7.4%) (table 1). As regards the spirometry quality grade, the highest values of quality A were in Glasgow (41.2%), Copenhagen (36.1%) and Vienna (30.4%) (table 1).

Overall, 12.4% of participating subjects had a prevalence of airway obstruction as defined by LLN stage I+, ranging from 10.2% in Vienna to 15.6% in Copenhagen. Considering the individual LLN categories, the highest prevalence rates were: stage I in Berlin (8.8%); stage II in Glasgow (3.3%); stage III in Glasgow and Copenhagen (1.3%); stage IV in Copenhagen and Stockholm (1.5%); and stage V in Copenhagen (1.4%) (table 2).

The overall prevalence of airway obstruction as defined by GOLD stage I+ was 20.3% with a range from 16.4% in Berlin to 25.4% in Copenhagen. Considering the individual GOLD categories, the highest prevalence rates were: stage I in Munich (12.6%) and stages II, III and IV in Copenhagen (11.1%, 1.9% and 1.1%, respectively) (table 2).

The use of the GOLD criteria instead of the LLN yielded an overestimate of airway obstruction of ~64% in the overall sample. Considering the severity levels, the GOLD criteria overestimated mild-to-moderate stages whilst it yielded similar values to LLN criteria in severe-to-very severe stages.

Further analyses were performed to compare the descriptive characteristics and the presence of asthma in the whole sample through the LLN categories (table 3) and the GOLD categories (online supplementary table S1).

Regarding the LLN categories, females had a significantly higher prevalence of LLN I (8.6%) and LLN III (1.3%), whilst males had a higher prevalence of LLN II (2.1%) and LLN IV+ (1.8%). Subjects with LLN I had the lowest mean age and those with LLN III had the highest mean age. Stratifying by decades of age, the oldest age groups showed a higher prevalence of all the LLN categories (stage II and IV+ in the decade 70–79 yrs and stage III in subjects with age ≥80 yrs), except for LLN stage I, which was higher in subjects aged ≤19 yrs (table 3). These youngest subjects had a mean age of 14.7 ± 3.9 yrs, 23.0% were current smokers, 3.9% ex-smokers, 6.6% had asthma diagnosis and 3.7% had asthma symptoms (data not shown).

Smokers, ex-smokers and subjects with reported asthma symptoms or diagnosis had higher prevalence rates in all the LLN categories: in particular, LLN stage I for smokers and ex-smokers (10.6% and 7.6%, respectively) and for subjects with reported asthma symptoms and asthma diagnosis (7.8% and 14.9%, respectively) (table 3).

Regarding the GOLD categories, higher values of prevalence rates of all the analysed variables were found except for GOLD stage III+ (online supplementary table S1).

Figure 1 describes the association between airway obstruction, age and smoking habits. Among smokers, the prevalence of airway obstruction increased from 40–49 yrs of age upwards, reaching a value of 29% at 70–79 yrs using the LLN criteria and a value of 68% at age ≥80 yrs using the GOLD criteria. Among ex-smokers, the prevalence of airway obstruction increased

TABLE 1 Descriptive characteristics of participating subjects by countries

	Glasgow	Copenhagen	Munich	Stockholm	Berlin	Vienna	Total	p-value
Subjects n	826	1039	1787	2417	2798	1528	10395	
Sex								
Females	49.0	50.8	55.6	54.2	49.1	52.4	52.0	<0.001
Males	51.0	49.2	44.4	45.8	50.9	47.6	48.0	
Age yrs	50.9±15.7	53.0±17.6	58.6±16.2	53.2±17.3	40.8±18.0	56.0±17.4	51.0±18.4	<0.001
Decades of age yrs								
≤19	2.1	2.3	1.4	2.3	12.7	2.8	5.0	
20–29	9.3	10.3	6.5	10.7	20.9	7.5	12.1	
30–39	13.4	13.0	7.3	10.2	14.0	8.1	11.0	<0.001
40–49	20.7	13.1	10.8	13.9	19.5	14.9	15.4	
50–59	23.1	19.3	17.0	20.7	13.6	17.4	17.7	
60–69	19.1	23.7	32.2	25.2	13.5	27.0	22.9	
70–79	10.7	14.3	19.1	12.8	5.5	15.6	12.3	
≥80	1.6	4.0	5.7	4.2	0.3	6.7	3.6	
Smoking habits								
Nonsmokers	41.4	28.0	54.0	49.6	50.1	47.6	47.4	<0.001
Ex-smokers	31.5	20.6	28.3	30.4	22.7	30.5	27.1	
Smokers	27.1	51.4	17.7	20.0	27.2	21.9	25.5	
Asthma								
Nonasthmatic	87.8	91.0	86.7	85.3	91.0	92.8	89.0	<0.001
Symptoms	4.8	5.7	7.1	7.7	3.8	3.7	5.5	
Diagnosis	7.4	3.3	6.2	7.0	5.2	3.5	5.5	
Subjects [#] n	888	1187	1978	2820	3918	1657	12448	
Quality grades[†]								
F	7.0	12.5	9.6	14.3	28.6	7.8	16.5	
D	21.1	27.8	32.5	33.1	39.0	30.1	33.0	<0.001
C	20.5	16.9	23.6	21.6	17.8	18.3	19.7	
B	10.2	6.7	5.3	8.7	4.5	13.4	7.4	
A	41.2	36.1	29.0	22.3	10.1	30.4	23.4	

Data are presented as % or mean ±SD, unless otherwise stated. [#]: with quality grades; [†]: Chi-squared test was performed to compare F and (A-B-C-D) quality grades by country; the results showed a p-value <0.001.

from 60–69 yrs of age upwards, reaching a value of 27% at age ≥80 yrs using the LLN criteria, and increased from 40–49 yrs of age upwards, reaching a value of 51% at age ≥80 yrs using the GOLD criteria. Nonsmokers showed an increase in the prevalence of airway obstruction at age ≥70 yrs, reaching a value of 11%, using the LLN criteria, and an increase from 60–69 yrs of age upwards, reaching a value of 40.0% at age ≥80 yrs using the GOLD criteria. Overall, figure 1 showed that, using the GOLD criteria instead of the LLN criteria, airway obstruction was underestimated until the decade 30–39 yrs and overestimated starting with the decade 40–49 yrs.

Multinomial logistic regression analysis was used to determine significant risk factors for the degree of airway obstruction as measured by each LLN stage (table 4), and GOLD stage (online supplementary table S2), included as the dependent variable; decades of age, sex, smoking habits and asthma were the independent variables. The spirometry quality grades were not included in the analysis because they did not show a significant association with the dependent variable.

Considering the LLN criteria, males had a significantly lower RRR to develop stage I (RRR 0.7, 95% CI 0.6–0.8) with respect

to females. The youngest age group had a significantly higher RRR for LLN stage I (RRR 2.9, 95% CI 2.0–4.1). The oldest age groups had a significant RRR of having higher severity levels of airway obstruction: RRR 5.6 (95% CI 2.9–11.0) for stage II and RRR 6.5 (95% CI 3.3–12.7) for stage IV+ in the decade 70–79 yrs and RRR 20.3 (95% CI 6.5–63.0) for stage III in subjects with age ≥80 yrs. Ex- and current smokers showed significantly increased risks in all LLN categories, with the highest RRR in the LLN stage III (RRR 3.0, 95% CI 1.9–4.7, and RRR 4.0, 95% CI 2.4–6.6, respectively). Analogous figures were shown for reported asthma symptoms and asthma diagnosis with the highest RRR in LLN stage III (RRR 4.3, 95% CI 2.6–7.2, and RRR 5.3, 95% CI 3.1–9.0, respectively) (table 4).

Considering the GOLD criteria, a different trend for age with stage I was found: lower values of RRR for subjects ≤19 yrs of age, much higher RRR values for older decades and the highest values for 70–79 yrs (RRR 10.9, 95% CI 7.6–15.8) and ≥80 yrs (RRR 16.6, 95% CI 10.8–25.5); by contrast, a similar trend for smoking and asthma was found. With respect to stages II and III+, analogous figures were shown with higher RRR, especially for age (online supplementary table S2).

TABLE 2 Prevalence of airway obstruction categories by countries

	Glasgow	Copenhagen	Munich	Stockholm	Berlin	Vienna	Total	p-value
Subjects n	825 [#]	1037 [#]	1781 [#]	2417	2795 [#]	1526 [#]	10381 [#]	
LLN[†]								
Stage I	8.7	8.7	6.1	7.0	8.8	5.8	7.5	<0.001
Stage II	3.3	2.7	1.7	1.6	1.9	2.0	2.0	
Stage III	1.3	1.3	1.2	1.1	1.0	1.2	1.1	
Stage IV	0.9	1.5	1.2	1.5	1.1	0.9	1.2	
Stage V	1.3	1.4	0.3	0.3	0.5	0.3	0.6	
Stage I+	15.5	15.6	10.5	11.5	13.3	10.2	12.4	
GOLD[‡]								
Stage I	11.4	11.3	12.6	10.0	8.4	11.0	10.4	<0.001
Stage II	10.6	11.1	7.3	8.2	6.4	8.0	8.0	
Stage III	1.5	1.9	1.3	1.7	1.4	1.1	1.5	
Stage IV	0.7	1.1	0.3	0.2	0.2	0.3	0.4	
Stage I+	24.2	25.4	21.5	20.1	16.4	20.4	20.3	

Data are presented as %, unless otherwise stated. LLN: lower limit of normal; GOLD: Global Initiative for Chronic Obstructive Lung Disease. [#]: some subjects had some missing information about lung function. [†]: American Thoracic Society/European Respiratory Society criteria: forced expiratory volume in 1 s (FEV₁)/forced vital capacity (FVC) <LLN. Stage I: FEV₁ ≥70% predicted; stage II: 60% ≤FEV₁ <70% pred; stage III: 50% ≤FEV₁ <60% pred; stage IV: 35% ≤FEV₁ <50% pred; and stage V: FEV₁ <35% pred. [‡]: GOLD criteria: FEV₁/FVC <70%. Stage I: FEV₁ ≥80% pred; stage II: 50% ≤FEV₁ <80% pred; stage III: 30% ≤FEV₁ <50% pred; and stage IV: FEV₁ <30% pred.

DISCUSSION

The ELF/ERS spirometry tent, as well as being an important advocacy tool, turned out to be a unique way of screening for early detection of airway obstruction, permitting many people,

who had not been tested previously, to have their lung function measured. It should be pointed out that it was not an aim of this event to provide information on COPD or asthma diagnoses, as this can only be made by clinicians upon

TABLE 3 Lower limit of normal (LLN) percentages in the overall sample by sex, age, smoking habit and asthma

	Subjects n	Nonobstructed	Stage I	Stage II	Stage III	Stage IV+	p-value
Sex							
Females	5401	86.5	8.6	1.9	1.3	1.7	<0.001
Males	4980	88.9	6.2	2.1	1.0	1.8	
Age	10381	50±18.2	49.8±19.5	56.9±19.5	62.6±16.1	60.1±17.4	<0.001
Decades of age yrs							
≤19	518	82.3	12.7	2.9	0.6	1.5	<0.001
20–29	1257	91.8	6.1	0.9	0.3	0.9	
30–39	1139	91.0	7.4	0.9	0.4	0.3	
40–49	1604	89.5	7.7	1.3	0.6	0.9	
50–59	1842	88.0	7.4	2.1	1.1	1.4	
60–69	2380	86.2	7.5	2.3	1.6	2.5	
70–79	1282	84.2	6.3	3.8	1.8	3.9	
≥80	359	82.2	8.3	2.8	4.2	2.5	
Smoking habits							
Nonsmokers	4916	90.9	5.7	1.6	0.6	1.2	<0.001
Ex-smokers	2811	85.8	7.6	2.6	1.8	2.2	
Smokers	2654	83.6	10.6	2.2	1.4	2.2	
Asthma							
Nonasthmatic	9234	89.0	7.0	1.7	0.9	1.4	<0.001
Symptoms	575	81.8	7.8	3.8	3.3	3.3	
Diagnosis	572	71.8	14.9	5.6	3.2	4.5	

Data are presented as % or mean ±SD, unless otherwise stated. American Thoracic Society/European Respiratory Society criteria: forced expiratory volume in 1 s (FEV₁)/forced vital capacity <LLN. Stage I: FEV₁ ≥70% predicted; stage II: 60% ≤FEV₁ <70% pred; stage III: 50% ≤FEV₁ <60% pred; and stage IV+: FEV₁ <50% pred.

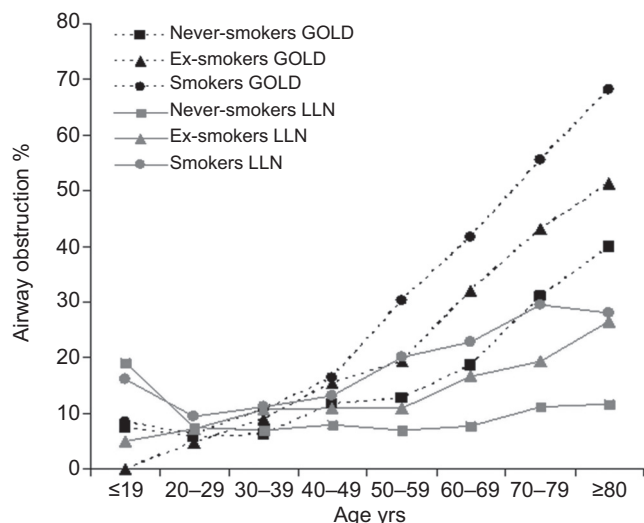


FIGURE 1. Airway obstruction prevalence by smoking habits by decades of age. GOLD: Global Initiative for Chronic Obstructive Lung Disease; LLN: lower limit of normal.

integration of medical history, physical examination and objective tests. This is not possible from simple questionnaires and pre-bronchodilator spirometry, as was performed in the spirometry tent event. Although this was an observational account of a public health promotion effort rather than a standard scientific study, the prevalence rates of airway obstruction detected with the spirometry tent using the LLN criteria (12.4%) and the GOLD criteria (20.3%) were very close to the median values (fig. 2) of the results of other scientific studies performed in several countries.

The BOLD Initiative reported a prevalence rate of GOLD-defined COPD stage II+ of 10.1% considering 12 cities around the world; the value of GOLD stage I+ was 19.3% (computed from table 3 in [6]). In the NHANES survey, CELLI *et al.* [10] measured a prevalence rate of 18.4% (GOLD criteria stage I+) and of 15.6% (LLN criteria stage I+) in a general adult population sample. In the Korean National Health and Nutrition Examination Survey (NHANES) survey, prevalence rates of 15.5% (GOLD criteria stage I+) and of 10.9% (LLN criteria stage I+) were measured [11].

In Poland, spirometric screening to early detect COPD in high-risk populations ($n=11,027$) was performed. Airway obstruction was found in 24.3% of the subjects reaching a value of 30.6% in smokers aged ≥ 40 yrs with a smoking history of >10 pack-yrs [19]. The study then continued with a total of 110,355 subjects (aged 53.5 ± 11.5 yrs), of whom 64% were current smokers, 25.1% former smokers and 10.9% lifelong nonsmokers. In total, 20.3% had airway obstruction [20], *i.e.* the same value we found from the ERS spirometry tent data.

Other screening studies have been performed primarily in populations at risk, such as smokers. In a primary care setting in Sweden, 27% ($n=512$) of the smokers (aged 40–55 yrs) demonstrated airway obstruction [27]. In a primary care setting in the Netherlands, 29.9% ($n=805$) of the smokers (aged 40–65 yrs) had airway obstruction [16]. Similar findings were found in Israel, where 1,058 adults aged 45–75 yrs with a

TABLE 4 Results of multinomial logistic regression

	LLN stage			
	I	II	III	IV+
Sex				
Females	1.0	1.0	1.0	1.0
Males	0.7 (0.6–0.8)	1.1 (0.9–1.5)	0.7 (0.5–1.1)	1.1 (0.8–1.5)
Decades of age yrs				
20–29	1.0	1.0	1.0	1.0
≤ 19	2.9 (2.0–4.1)	4.6 (2.1–10.2)	3.1 (0.7–14.0)	2.6 (1.0–6.7)
30–39	1.3 (0.9–1.8)	1.0 (0.4–2.4)	1.2 (0.3–4.7)	0.4 (0.1–1.3)
40–49	1.3 (1.0–1.8)	1.5 (0.7–3.2)	2.0 (0.6–6.6)	1.1 (0.5–2.3)
50–59	1.3 (1.0–1.7)	2.5 (1.3–4.9)	3.5 (1.2–10.4)	1.7 (0.8–3.5)
60–69	1.4 (1.1–1.9)	3.0 (1.5–5.7)	5.8 (2.0–16.5)	3.5 (1.8–6.7)
70–79	1.4 (1.0–1.9)	5.6 (2.9–11.0)	7.9 (2.7–23.3)	6.5 (3.3–12.7)
≥ 80	1.9 (1.2–3.0)	4.3 (1.8–10.5)	20.3 (6.5–63.0)	4.5 (1.8–11.2)
Smoking habits				
Nonsmokers	1.00	1.00	1.00	1.00
Ex-smokers	1.6 (1.3–1.9)	1.8 (1.3–2.5)	3.0 (1.9–4.7)	1.9 (1.3–2.7)
Smokers	2.4 (2.0–2.9)	2.3 (1.6–3.2)	4.0 (2.4–6.6)	3.2 (2.1–4.6)
Asthma				
Nonasthmatic	1.00	1.00	1.00	1.00
Symptoms	1.3 (0.9–1.7)	2.6 (1.6–4.1)	4.3 (2.6–7.2)	2.7 (1.6–4.4)
Diagnosis	2.8 (2.2–3.6)	4.7 (3.2–7.1)	5.3 (3.1–9.0)	4.8 (3.1–7.4)

Data are presented as % or relative risk ratio (95% confidence interval), unless otherwise stated. American Thoracic Society/European Respiratory Society criteria: forced expiratory volume in 1 s (FEV₁)/forced vital capacity $<$ lower limit of normal. Stage I: FEV₁ $\geq 70\%$ predicted; stage II: $60\% \leq$ FEV₁ $<70\%$ pred; stage III: $50\% \leq$ FEV₁ $<60\%$ pred; and stage IV+: FEV₁ $<50\%$ pred.

history of at least 20 pack-yrs cigarette smoking were screened for airway obstruction, and a prevalence of 22.2% was reported [17]. In a primary care setting in Belgium, screening by spirometry showed a 46.6% prevalence of airway obstruction in current smokers (aged 40–70 yrs; $n=146$), of which 29.5% were newly detected [18]. A quite different screening programme was performed in Barcelona (Spain) in 100 pharmacy customers (aged >40 yrs) with respiratory symptoms and/or a history of smoking; they were invited to perform spirometry and 24% demonstrated airway obstruction [28].

To compare our data with those of previously described screening studies we have assessed the presence of airway obstruction in smokers aged ≥ 40 yrs: the ELF/ERS spirometry tent data (31.9%) showed a result very close to the median value reported in figure 2 (29.9%). Our data also confirmed the association of airway obstruction, computed using either the LLN or the GOLD criteria, with previously reported risk factors such as sex, age, smoking and asthma.

Concerning sex, there were different results using the LLN or GOLD criteria: the GOLD criteria showed a higher risk of having airway obstruction among males compared with females (RRR 1.3 for stage II), confirming findings of recent studies. A study performed in subjects aged ≥ 55 yrs living in

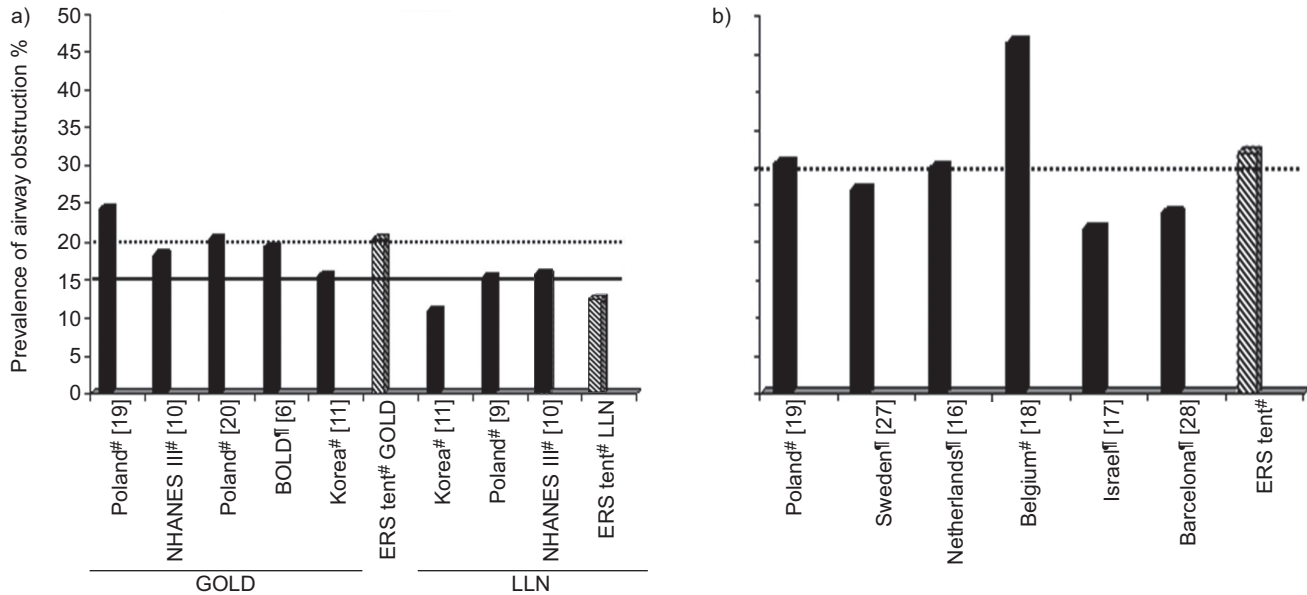


FIGURE 2. Prevalence of airway obstruction in a) the general population and b) smokers aged ≥ 40 yrs. In the general population, the prevalence values ranged from 15.5% to 24.3%, with a median value of 19.8% (Global Initiative for Chronic Obstructive Lung Disease (GOLD);), and from 10.9% to 15.6%, with a median value of 15.3% (lower limit of normal (LLN); —). In smokers, the prevalence values range from 22% to 46.6%, with a median value of 29.9% (GOLD criteria). NHANES: National Health and Nutrition Examination Survey; ERS: European Respiratory Society. #: spirometric test without bronchodilator; †: spirometric test with bronchodilator.

Rotterdam, the Netherlands, found a hazard ratio of 1.6 (95% CI, 1.4–2.2) in males for the development of COPD, adjusted for age and smoking habits, in comparison to females [29]. Other studies have also shown a higher prevalence of COPD in males with respect to females [7, 22], although there are reports which contradict these data [30]. Using the LLN criteria, our data also showed a protective effect in males for stage I. This might be due to a different susceptibility to the deleterious effects of tobacco smoking by sex, as reported by other authors [30]. Indeed, females in stage I had a significantly higher prevalence of smoking habit with respect to males, which did not occur in the other severity levels (data not shown). A possible explanation could be that female smokers have a higher prevalence of bronchial hyperresponsiveness than males, a well known risk factor for developing airway obstruction. In addition, at the same level of smoking history, females may be more likely to develop obstruction than males [30].

Our findings also suggest an increased risk of developing airway obstruction in older age with the highest value at ≥ 80 yrs of age, reaching a prevalence of 27% and 51% in ex-smokers (LLN and GOLD, respectively) and of 28% and 68% in smokers (LLN and GOLD, respectively) (fig. 1).

Interestingly, our data showed a non-negligible prevalence of LLN stage I (12.7%) in subjects aged ≤ 19 yrs and of GOLD stage I (8.3%) in subjects aged 40–49 yrs, indicating the need to start screening for airway obstruction at a younger age than previously thought. Recently, using the European Community Respiratory Health Survey database, De MARCO *et al.* [31] showed that, in subjects with airway obstruction, respiratory symptoms (chronic cough or phlegm and/or dyspnoea) were associated with accelerated lung function decline only among smokers, suggesting that young symptomatic smokers with mild-to-moderate airway obstruction represent a high-risk subgroup [31].

Our results confirmed an increased risk of having airway obstruction among smokers and ex-smokers. In the 1970s, it was estimated that 15–20% of smokers develop COPD [32]. More recently, in a longitudinal Swedish study, LINDBERG *et al.* [8] reported prevalence rates of COPD of 24.6% in smokers, 14.5% in ex-smokers and 7.8% in nonsmokers, reaching values of 50, 33 and 21%, respectively, in elderly subjects (76–77 yrs).

Our data also demonstrated a strong relationship between airway obstruction and patient-reported asthma diagnosis (RRR 5.3 for LLN stage III and RRR 5.5 for GOLD stage III+); these results are consistent with those of SILVA *et al.* [12] who, in a prospective observational study, showed that subjects with active asthma had a 12.5-times-higher risk of acquiring COPD compared with nonasthmatics. This is also in line with the recently reported finding that childhood asthma in males gave an odds ratio for COPD in adult age of 10.48 *versus* 3.74 in females, both values higher than for smokers [33].

A comorbid relationship between asthma and airway obstruction has been shown from the estimation of overlapping prevalence in the general population (proportional Venn diagram). VIEGI *et al.* [13] quantified the proportion of the general population with obstructive lung disease (OLD) and the intersections of physician-diagnosed asthma, chronic bronchitis and emphysema in two Italian general population samples compared with airway obstruction determined by spirometry. Approximately 18% of the Italian general population reported either the presence of OLD or showed spirometric signs of airway obstruction. Furthermore, asthma, chronic bronchitis and emphysema largely coexisted [13].

Comparison between LLN and GOLD criteria

Our data confirmed that the use of a fixed ratio (FEV₁/FVC <0.7) can lead to an overestimation of airway obstruction:

overall, using the GOLD criteria compared with the LLN, there was an overestimation of airway obstruction of ~64% (20.3% *versus* 12.4%). In particular, the GOLD criteria overestimated the mild-to-moderate stages when considering the severity levels; however, it was comparable to LLN criteria in severe-to-very severe stages. VIEGI *et al.* [34] had already shown, in 2000, that the fixed ratio criteria with respect to the ERS criteria for airway obstruction overestimates the prevalence of airway obstruction (18% *versus* 11.3%). They also indicated that the GOLD criteria had higher sensitivity but lower specificity for reported symptoms/disease than the ERS criteria [34].

Moreover, our findings indicate that using the GOLD criteria overestimates airway obstruction in the oldest subjects and underestimates airway obstruction in the youngest subjects with respect to the ATS/ERS recommended criteria, as reported by other authors [10, 20, 35]. In particular, using the GOLD criteria compared with the LLN, airway obstruction was underestimated until the decade 30–39 yrs and overestimated starting with the decade 40–49 yrs (fig. 1).

Weaknesses of the study

A possible weakness of this study was the use of different teams that did not perform a common spirometry training event; this aspect might have caused a wide variability of the results in the different countries. In reality, the variability between countries seemed to be due to different anthropometric features.

The use of the prediction equations from the European Community for Coal and Steel (ECCS) [24] to derive the LLN might have underestimated FEV₁ and FVC predicted values, as reported by other authors [36]. However, it should be pointed out that ECCS equations were derived from old data collected from a number of different studies, using different methods and from different populations [36]. Conversely, these prediction equations, at present, are the most widely used in Europe, facilitating international comparisons of our results.

It should be taken into account that in the ELF/ERS spirometry tent the post-bronchodilation spirometric test was not performed, which could also give an overestimation of airway obstruction. In a random population sample in Norway, JOHANNESSEN *et al.* [37] estimated that the prevalence of GOLD-defined COPD (with bronchodilation) was 27% lower than COPD defined without bronchodilatation (7.0% and 9.6%, respectively) [37]. Applying this reduction factor to our results meant that prevalence of LLN airway obstruction would be 9.1% and of GOLD airway obstruction would be 14.8%; extremely relevant values from a public health perspective.

Strengths of the study

The main strength of this study was the large sample size (n=10,395); indeed no other European study reached this number of investigated subjects, with the exception of the Polish spirometric screening study (n=110,355) [20]. Moreover, the same spirometer was used during all the events, an instrument already selected for use in the BOLD and PLATINO studies.

Although this was not a standard scientific study, the prevalence of airway obstruction obtained with the spirometry tents was very close to the median value obtained by *ad hoc*

organised scientific studies; thus, these results have highlighted the usefulness of detecting airway obstruction in large numbers of city residents during large awareness initiatives. These initiatives enabled many people who had not been tested previously to have their lung function measured and to eventually identify early cases of airway obstruction. An early detection would permit prevention of the severe forms of the disease by implementing, for example, early smoking cessation and appropriate treatment.

Additionally, our data contribute further evidence towards the recent debate over the use of LLN or GOLD criteria [38, 39].

The ELF/ERS spirometry tent is illustrative of the worldwide effort to increase the awareness of airway obstruction among the public, the media and policy makers, carried out by the WHO and partners (respiratory, allergological and general practitioner societies, patients and governmental organisations) within the Global Alliance against Chronic Respiratory Diseases (GARD) [4, 40], which followed on from the publication by the ELF and ERS of the *European Lung White Book* in 2003 [5]. The ERS is now preparing the second edition of the *European Lung White Book*, which can foster new opportunities offered by the EU for research on chronic respiratory diseases [41]. The Forum of International Respiratory Society (FIRS) launched an awareness campaign called "2010: the Year of the Lung" (www.yearofthelung.org). October 14, 2010, designated as World Spirometry Day, has been a further occasion to test the screening properties of such a large awareness initiative.

Conclusions

Besides being an useful advocacy tool for ELF and ERS, the spirometry tent represented an unique opportunity to detecting airway obstruction in large numbers of city residents, yielding prevalence rates and associations with risk factors for airway obstruction consistent with standard scientific surveys.

Moreover, the results of this study confirm the importance of spirometry screening for young smokers with respiratory symptoms. The identification of early cases of airway obstruction might help target early smoking cessation, the most important action proven to reduce risk of developing severe disease.

STATEMENT OF INTEREST

Statements of interest for W. MacNee and P. Lange, and for the study itself can be found at www.erj.ersjournals.com/site/misc/statements.xhtml

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