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The ERS Spirometry Tent: a unique form of screening for airway obstruction

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ABSTRACT

Introduction: to raise public awareness of the importance of early detection of airway obstruction (AO) and to enable many people who had not been tested previously to have their lung function measured, the European Lung Foundation (ELF) and the European Respiratory Society (ERS) organized the Spirometry Tent during the annual ERS Congresses 2004-2009.

Methods: 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 hospital/universities gave their service for free. Lower limit of normal (LLN) and GOLD criteria for diagnosing and grading AO were used.

Results: of 12448 participants in six congress cities, 10395 (83.5%) performed acceptable spirometry (mean age 51.0±18.4 years; 25.5% smokers; 5.5% asthmatic). AO was present in 12.4% of investigated subjects according to LLN criterion and 20.3% according to GOLD criterion. Through multinomial logistic regression analysis, age, smoking habits and asthma were significant risk factors for AO. 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, 2.8 (2.2-3.6) for reported asthma diagnosis.

Conclusions: the Spirometry Tent, in addition to being a useful advocacy tool, represents an unusual occasion for early detection of AO in large numbers of city residents with an important public health perspective.

Key words: airway obstruction, general population, LLN criterion, GOLD criterion, screening.

Introduction

Chronic Obstructive Pulmonary Disease (COPD) has been described by the ATS (American Thoracic Society)/ERS (European Respiratory Society) 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 WHO, COPD will become the 3rd commonest cause of mortality [3] and the 7th commonest cause of disability-adjusted life-years (DALYs) 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 clinic, medication and hospital admissions. The socio-economic burden from COPD is also expected to increase. In Europe, direct/indirect costs of COPD were estimated at about 38.7 billion Euros in 2000 [5].

The growing burden of COPD is mainly due to the aging 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 GOLD-defined COPD stage II or higher (forced expiratory volume in one second (FEV_1)/forced vital capacity (FVC) <0.70 and FEV_1 <80% predicted) were 10.1% overall, 11.8% for men and 8.5% for women [6].

Within 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 years) to 12.3% (60–69 years) in men and from 1.4% (40–49 years) to 4.5% (60–69 years) in women [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 years or more [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 over-estimate of COPD using the GOLD criterion compared with the LLN criterion. Celli et al, using the Third National Health and Nutrition Examination Survey (NHANES) data, showed a

COPD prevalence of 18.4% according to the GOLD criterion and of 15.6% according to the LLN criterion [10]. In the Korean NHANES survey these results were confirmed: 10.9% with LLN criterion vs 15.5%, with GOLD criterion [11].

Other studies also suggest an important association between COPD and asthma. Silva et al. in a prospective observational study showed that subjects with active asthma, compared to non asthmatics, 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 under-diagnosed 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 under-diagnosis and to prevent the development of severe stage of COPD, some screening programs have been performed in the population at risk, showing prevalence values of COPD ranging from about 20% to about 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 Spirometry Tent during the annual ERS Congresses in 2004–2009 organized by the ELF and ERS, in order to increase the public awareness of AO 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 to detect early cases of AO in the general population and to detect them potentially in early stage of AO.

Materials and methods

Every year, between 2004-2009, during the Annual Congress of the ERS, the ELF and the ERS have organised a public spirometry event. This was usually done in a public space like 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 attract a large number of people.

During the ERS Congresses of Glasgow, Copenhagen, Munich, Stockholm, Berlin and Vienna, 12448 volunteers, who 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. 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, Zurich, Switzerland), 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 doesn't 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 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 maneuver 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 freely decide to take this letter to their general practitioner.

As per the data collectors, no change was performed in the software and outputs of the ndd Easy One Spirometer. Available data were sent to the ELF Secretariat in Sheffield which forwarded them to the Pisa team for the statistical analyses.

The lower limit of normality (LLN) [23] was derived from population-specific prediction equations [24, 25]. AO was reported if FEV_1/FVC was <LLN [10, 11]. The stage was defined by the level of FEV_1 in % of predicted (adjusted for age) [24]: stage I if FEV_1 was $\geq$70% predicted; stage II if 60% $\leq FEV_1$ <70% predicted; stage III if 50% $\leq FEV_1$ <60% predicted; stage IV if 35% $\leq FEV_1$ <50% predicted; stage V if FEV_1 <35% predicted [23]. Subjects with $FEV_1/FVC \geq$LLN were considered as non obstructed.

To make comparisons with international studies possible, we also reported the prevalence of AO as defined by the fixed GOLD criterion (FEV_1/FVC <0.7) [26]. The stage was defined by level of FEV_1 in % of predicted (adjusted for age) [24]: stage I if FEV_1 was $\geq$80% predicted; stage II if 50% $\leq FEV_1$ <80% predicted; stage III if 30% $\leq FEV_1$ <50% predicted; stage IV if FEV_1<30% predicted [26]. Subjects with $FEV_1/FVC \geq 0.7$ were considered as non obstructed.

Spirometries of F quality grade were not considered in the analyses (n=2053, 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 (StataCorp 2005. Stata Statistical Software: Release 9.0. College Station, TX: StataCorp).

Chi-square test was used to compare categorical variables and analysis of variance 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, no smokers), gender, asthma (reported asthma symptoms, reported asthma diagnosis, non asthma) as independent variables and LLN severity categories (stage I, stage II, stage III, stage IV+) or GOLD severity categories (stage I, stage II, stage III+) as dependent variable. The choice to use LLN IV+ category and GOLD III+ category is due to the small number of subjects in these severity levels.

Results

12448 volunteers were investigated during the ERS Congresses. Of these, 2053 (16.5%) performed spirometry with a quality grade equal F: these subjects had a mean age of 44.7±21.5 years, 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 3 spirometric manoeuvres, 32.3% more than 3.

10395 (83.5%) performed spirometry with a quality grade above F: 826 resided in Glasgow, 1039 in Copenhagen, 1787 in Munich, 2417 in Stockholm, 2798 in Berlin and 1528 in Wien. The descriptive statistics showed a slightly higher frequency of females (52.0%) and a mean age of 51.0±18.4 years, with the lowest mean age in Berlin (table 1). Stratifying the sample in decades of age, the most numerous age-classes were the 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 Wien (30.4%) (table 1).

Overall, 12.4% of participating subjects had a prevalence of AO 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%); stages II in Glasgow (3.3%); stages III in Glasgow and Copenhagen (1.3%); stages IV in Copenhagen and Stockholm (1.5%); stages V in Copenhagen (1.4%) (table 2).

The overall prevalence of AO 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%); stages II, III and IV in Copenhagen (11.1%, 1.9% and 1.1%, respectively) (table 2).

The use of the GOLD criterion instead of the LLN yielded an over-estimate of AO of about 64% in the overall sample. Considering the severity levels, the GOLD criterion over-estimated mild-moderate stages whilst it yielded similar values to LLN criterion in severe-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 (table 1 Supplementary material).

As regard 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 ≥80yrs), except for LLN Stage I which was higher in subjects with age ≤19yrs (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).

As regard the GOLD categories, higher values of prevalence rates of all the analyzed variables were found, except for GOLD Stage III+ (table 1 Supplementary material).

Figure 1 describes the association between AO, age and smoking habits. Among smokers, the prevalence of AO increased from 40-49 yrs of age upwards, reaching a value of 29% at 70-79 yrs using the LLN criterion and a value of 68% at age ≥80 yrs using the GOLD criterion. Among ex smokers, the prevalence of AO increased from 60-69 yrs of age upwards, reaching a value of 27% at age ≥80 yrs, using the LLN criterion, and increased from 40-49 yrs of age upwards, reaching a value of 51% at age ≥80 yrs using the GOLD criterion. Non-smokers showed an increase in the prevalence of AO at age ≥70 yrs, reaching a value of 11%, using the LLN criterion, and an increase

from 60-69 years of age upwards, reaching a value of 40.0% at age ≥80 years, using the GOLD criterion. Overall, figure 1 showed that, using the GOLD criterion instead of the LLN, AO was under-estimated until the decade 30-39 yrs and over-estimated starting with the decade 40-49 yrs.

Multinomial logistic regression analysis was used to determine significant risk factors for the degree of AO as measured by each LLN stage (table 4) and GOLD stage (table 2 Supplementary material), included as the dependent variable; decades of age, gender, smoking habits and asthma were the independent variables. The spirometry quality grades were not included in the analysis because they didn't show a significant association with the dependent variable.

Considering the LLN criterion, males had a significantly lower relative risk ratio (RRR) to develop stage I (RRR 0.7, 95% confidence interval (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 AO: 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 relative risk ratio 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 relative risk ratio 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 criterion, a different trend for age with Stage I was found: lower values of RRR for ≤19 years, much higher RRR for older decades with the highest values for 70-79 years (RRR 10.9, 95% CI 7.6-15.8) and ≥80years (RRR 16.6, 95% CI 10.8-25.5); by contrast, a similar trend for smoking and asthma was found. With respect to Stage II and III+, analogous figures were shown with higher RRR, especially for age (table 2 Supplementary material).

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 AO, 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, which can only be made by clinicians upon integration of medical history, physical examination and objective tests. This is not possible from simple questionnaires and pre-bronchodilator spirometry as was done in the Spirometry Tent event. Although this was an observational account of a public health promotion effort rather than a standard scientific study, it was, the prevalence rates of AO detected with the

spirometry tent using the LLN criterion (12.4%) and the GOLD criterion (20.3%) were very close to the median values, reported in figure 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 all over the world; the value of GOLD stage I+ was 19.3% (computed from table 3 of reference 6) [6]. Celli et al. in the NHANES survey measured a prevalence rate of 18.4% (GOLD criterion Stage I+) and of 15.6% (LLN criterion Stage I+) in a general adult population sample [10]. In the Korean NHANES survey prevalence rates of 15.5% (GOLD criterion Stage I+) and of 10.9% (LLN criterion Stage I+) were measured [11].

In Poland, spirometric screening to early detect COPD in high-risk populations (n= 11,027) was performed. AO 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$\pm$11.5 yrs), of which 64% were current smokers, 25.1% former smokers and 10.9% lifelong nonsmokers. In total, 20.3% had AO [20], i.e. the same value we found in 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% of the smokers (aged 40–55 yrs; n=512) showed AO [27]. In a primary care setting in the Netherlands, 29.9% of the smokers (aged 40–65 yrs; n=805) had AO [16]. Similar findings were found in Israel where 1058 adults aged 45-75 yrs with a history of at least 20 pack-years cigarette smoking were screened for AO, and showed a prevalence of 22.2% [17]. In a primary care setting in Belgium, screening by spirometry showed a 46.6% prevalence of AO 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 in pharmacy customers (aged >40 years; n=100) with respiratory symptoms and/or a history of smoking; they were invited to perform spirometry and 24% showed AO [28].

To compare our data with those of previously described screening studies we have assessed the presence of AO 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 AO, computed using either the LLN or the GOLD criterion, and previously reported risk factors such as gender, age, smoking and asthma.
Concerning gender, there were different results using the LLN or GOLD criterion: the GOLD criterion showed a higher risk of having AO among males compared to females (RRR 1.3 for stage II), confirming findings by recent studies. A study performed in subjects aged $\geq$55 yrs living in Rotterdam found in males a hazard ratio of 1.6 (95% CI, 1.4-2.2) 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]. Our data using the LLN criterion, 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 gender, as reported by other authors [30]. Indeed, females in stage I had a significantly higher prevalence of smoking habit with respect to males, which didn't 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 men, a well known risk factor for developing AO. In addition, at the same level of smoking history, women may be more likely to develop obstruction than men [30].

Our findings also suggest an increased risk of developing AO in older age with the highest value at age >= 80 years, 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) (figure 1).

Interestingly, our data showed a not-negligible prevalence of LLN stage I (12.7%) in subjects of age ≤19 years and of GOLD stage I (8.3%) in subjects of age 40-49 years, indicating the need to start screening for AO at a younger age than previously thought. Recently, De Marco et al, using the European Community Respiratory Health Survey database, showed that, in subjects with AO, respiratory symptoms (chronic cough or phlegm and/or dyspnea) were associated with accelerated lung function decline only among smokers, suggesting that young symptomatic smokers with mild/moderate AO represent a high-risk subgroup [31].

Our results confirmed an increased risk of having AO 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 reported prevalence rates of COPD of 24.6% in smokers and 14.5% in ex-smokers and 7.8% in non-smokers, reaching values of 50%, 33% and 21%, respectively, in elderly subjects (76-77 yrs) [8].

Our data also demonstrated a strong relationship between AO 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. who in a prospective observational study showed that subjects with active asthma, had a 12.5-times-higher risk of acquiring COPD, compared to non asthmatics [12]. This is in line also 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 AO has been shown from the estimation of overlapping prevalence in the general population (proportional Venn diagram). Viegi et al 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, in relationship to AO determined by spirometry. Around 18% of the Italian general population either reported the presence of OLD or showed spirometric signs of AO. Furthermore, asthma, chronic bronchitis and emphysema largely coexisted [13].

Comparison between LLN and GOLD criterion

Our data confirmed that the use of a fixed ratio (FEV_1/FVC <0.7) can lead to an over-estimation of AO: overall, using the GOLD criterion compared to the LLN , there was an over-estimate of AO of about 64% (20.3% vs 12.4%). In particular, considering the severity levels, the GOLD criterion over-estimated the mild-moderate stages, whilst it was comparable to LLN criterion in severe-very severe stages. Viegi et al had already shown, in the year 2000, that the fixed ratio criterion, with respect to the ERS criteria for AO, over-estimates the prevalence of AO (18% vs 11.3%). They also indicated that the GOLD criterion had higher sensitivity but lower specificity for reported symptoms/disease than the ERS criterion [34].

Moreover, our findings indicate that the GOLD criterion over-estimates AO in the oldest subjects and underestimates AO in the youngest subjects with respect to the ERS-ATS recommended criterion, as reported by other authors [10, 20, 35]. In particular, using the GOLD criterion compared with the LLN , AO was under-estimated until the decade 30-39 yrs and over-estimated starting with the decade 40-49 yrs (figure 1).

Weaknesses of the study

A possible weakness of this study was the use of different teams, that didn't perform a common spirometry training; this aspect might have caused a wide variability of the results in the different countries. In reality, the variability between countries seemed 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]. On the other hand, these prediction equations are so far 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 over-estimation of AO. Johannessen et al estimated in a random population sample of Norway 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, prevalence of LLN AO would be 9.1% and of GOLD AO would be 14.8%, yet 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 AO obtained with the Spirometry Tents was very close to the median value obtained by ad hoc organized scientific studies; thus, these results highlighted the usefulness of detecting AO 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 AO. An early detection would permit to prevent the severe forms of the disease, by implementing early smoking cessation and appropriate treatment.

As added value, our data provide further evidence for the recent debate about the use of LLN or GOLD criterion [38, 39].

The ELF-ERS Spirometry Tent is illustrative of the worldwide effort to increase the awareness of AO among the public, the media and policy makers carried out by the WHO and partners (respiratory, allergological and general practitioner societies, patients and governmental organizations) within the Global Alliance against chronic Respiratory Diseases (GARD) [4, 40] which followed 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

The Spirometry Tent, besides being an useful advocacy tool for ELF and ERS, represented an unique opportunity to detecting AO in large numbers of city residents, yielding prevalence rates and associations with risk factors for AO consistent with standard scientific surveys.

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

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Table 1. Descriptive characteristics of participating subjects by countries

	Glasgow	**Copenhagen**	**Munich**	**Stockholm**	**Berlin**	**Vienna**	**Total**	**p-value**
n	826	1039	1787	2417	2798	1528	**10395**	
Gender (%):								
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	50.9	53.0	58.6	53.2	40.8	56.0	**51.0**	
(mean±SD):	±15.7	±17.6	±16.2	±17.3	±18.0	±17.4	**±18.4**	<0.001
Decades of age (%):								
≤19 yrs	2.1	2.3	1.4	2.3	12.7	2.8	**5.0**	
20-29 yrs	9.3	10.3	6.5	10.7	20.9	7.5	**12.1**	
30-39 yrs	13.4	13.0	7.3	10.2	14.0	8.1	**11.0**	<0.001
40-49 yrs	20.7	13.1	10.8	13.9	19.5	14.9	**15.4**	
50-59 yrs	23.1	19.3	17.0	20.7	13.6	17.4	**17.7**	
60-69 yrs	19.1	23.7	32.2	25.2	13.5	27.0	**22.9**	
70-79 yrs	10.7	14.3	19.1	12.8	5.5	15.6	**12.3**	
>=80yrs	1.6	4.0	5.7	4.2	0.3	6.7	**3.6**	
Smoking habits (%):								
Non smokers	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 (%):								
Non asthma	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**	
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**	

* chi-square test was performed to compare F and (A-B-C-D) quality grades by country; the results showed a p-value < 0.001.

Table 2. Prevalence of AO categories by countries

	Glasgow	**Copenhagen**	**Munich**	**Stockholm**	**Berlin**	**Vienna**	**Total**	**p-value**
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***	

* some subjects with some missing information about lung function

[#] ATS-ERS criterion: $FEV_1/FVC < LLN$
stage I: $FEV_1 \geq 70\%$ predicted; stage II: $60\% \leq FEV_1 < 70\%$ predicted; stage III: $50\% \leq FEV_1 < 60\%$ predicted; stage IV: $35\% \leq FEV_1 < 50\%$ predicted; stage V: $FEV_1 < 35\%$ predicted.

[#] GOLD criterion: $FEV_1/FVC < 70\%$
stage I: $FEV_1 \geq 80\%$ predicted; stage II: $50\% \leq FEV_1 < 80\%$ predicted; stage III: $30\% \leq FEV_1 < 50\%$ predicted; stage IV: $FEV_1 < 30\%$ predicted.

Table 3. LLN percentages in the overall sample by gender, age, smoking habit and asthma

	n	Non obstructed	Stage I	Stage II	Stage III	Stage IV+	p-value
Gender (%):							
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 (mean±SD):	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 (%):							
≤19 yrs	518	82.3	12.7	2.9	0.6	1.5	
20-29 yrs	1257	91.8	6.1	0.9	0.3	0.9	
30-39 yrs	1139	91.0	7.4	0.9	0.4	0.3	
40-49 yrs	1604	89.5	7.7	1.3	0.6	0.9	<0.001
50-59 yrs	1842	88.0	7.4	2.1	1.1	1.4	
60-69 yrs	2380	86.2	7.5	2.3	1.6	2.5	
70-79 yrs	1282	84.2	6.3	3.8	1.8	3.9	
≥80yrs	359	82.2	8.3	2.8	4.2	2.5	
Smoking habits (%):							
Non smokers	4916	90.9	5.7	1.6	0.6	1.2	
Ex smokers	2811	85.8	7.6	2.6	1.8	2.2	<0.001
Smokers	2654	83.6	10.6	2.2	1.4	2.2	
Asthma (%):							
Non asthma	9234	89.0	7.0	1.7	0.9	1.4	
Symptoms	575	81.8	7.8	3.8	3.3	3.3	<0.001
Diagnosis	572	71.8	14.9	5.6	3.2	4.5	

ATS-ERS criterion: FEV_1/FVC <LLN
stage I: $FEV_1 \geq 70\%$ predicted; stage II: $60\% \leq FEV_1 < 70\%$ predicted; stage III: $50\% \leq FEV_1 < 60\%$ predicted; stage IV+: $FEV_1 < 50\%$ predicted.

Table 4. Results of multinomial logistic regression (relative risk ratio and 95% confidence interval) (stage LLN)

	Stage I	**Stage II**	**Stage III**	**Stage IV+**
Gender (%):				
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 (%):				
20-29 yrs	1.0	1.0	1.0	1.0
<=19yrs	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 yrs	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 yrs	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 yrs	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 yrs	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 yrs	1.4 (1.0-1.9)	5.6 (2.9-11.0)	7.9 (2.7-23.3)	6.5 (3.3-12.7)
>=80yrs	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 (%):				
Non smokers	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 (%):				
Non asthma	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)

ATS-ERS criterion: FEV_1/FVC <LLN
stage I: $FEV_1 \geq 70\%$ predicted; stage II: $60\% \leq FEV_1 < 70\%$ predicted; stage III: $50\% \leq FEV_1 < 60\%$ predicted; stage IV+: $FEV_1 < 50\%$ predicted.

Figure 1. Airway obstruction prevalence by smoking habits by decades of age

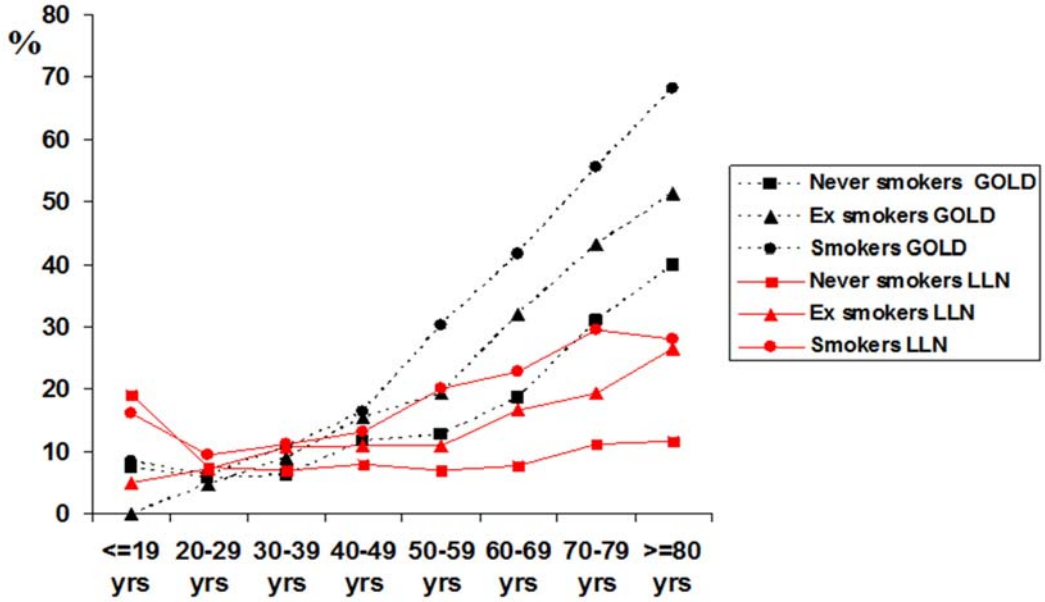
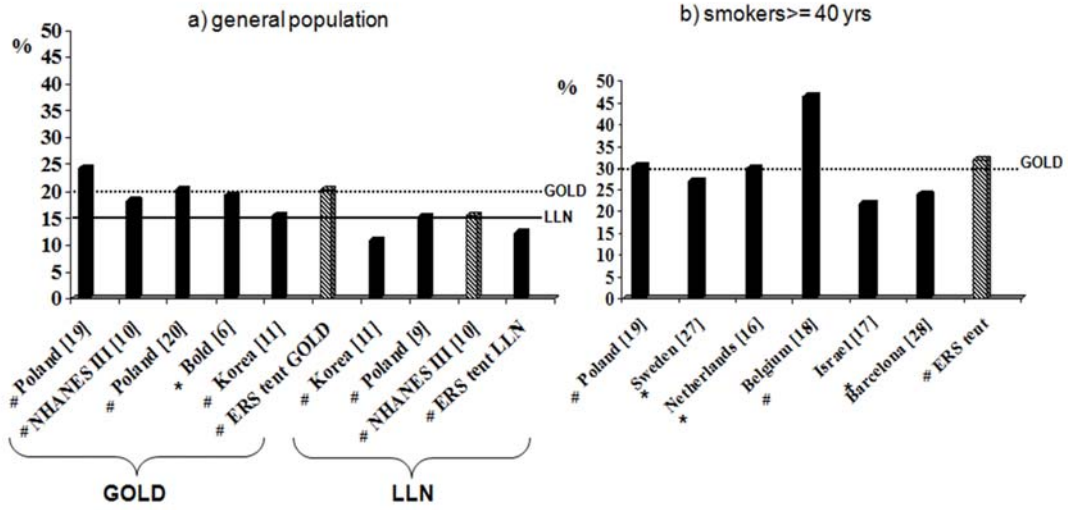


Figure 2. Prevalence of airway obstruction: comparison with other studies



In general population, the prevalence values range from 15.5% to 24.3%, with a median value of *19.8% (GOLD criterion).*

In general population, the prevalence values range from 10.9% to 15.6%, with a median value of *15.3% (LLN criterion).*

In smokers, the prevalence values range from 22% to 46.6%, with a median value of *29.9% (GOLD criterion).*

**** spirometric test with bronchodilator # spirometric test without bronchodilator***