Impact of chronic airflow obstruction in a working population

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ABSTRACT: Data on the individual and collective impact of chronic airflow obstruction at a population level are scarce. In a nationwide survey, dyspnoea, quality of life and missed working days were compared between subjects with and without spirometrically diagnosed chronic airflow obstruction.

Subjects aged ≥45 yrs were recruited in French health prevention centres (n=5,008). Results of pre-bronchodilator spirometry and questionnaires (European Community Respiratory Health Survey-derived questionnaire and European quality of life five-dimension questionnaire) were collected. Adequate datasets were available for 4,764 subjects aged 60±10 yrs (only 2% were aged ≥80 yrs).

The prevalence of airflow obstruction (forced expiratory volume in one second/forced vital capacity of <0.70) was 7.5%. The vast majority (93.9%) of cases had not been diagnosed previously. Health status was significantly influenced by dyspnoea. Both were associated with the number of missed working days. Despite mild-to-moderate severity, subjects with chronic airflow obstruction exhibited more dyspnoea, poorer quality of life and higher numbers of missed working days (mean 6.71 *versus* 1.45 days·patient^{-1}·yr^{-1} in patients without airflow obstruction, for the population with no known heart or lung disease).

In conclusion, even mild-to-moderate airflow obstruction is associated with an impaired health status, which represents an additional argument in favour of early detection in chronic obstructive pulmonary disease.

Chronic obstructive pulmonary disease (COPD) is one of the leading causes of mortality, handicap and healthcare costs worldwide [1, 2]. Its prevalence is high, ranging 4–10% [3], but the disease remains largely under-diagnosed [4–6]. This may relate to the relatively late occurrence and underestimation of symptoms [7], which correlate poorly with lung function [8].

COPD alters quality of life, mainly through dyspnoea and exacerbations, and is associated with several extrarespiratory manifestations [9, 10]. Ultimately, it leads to respiratory failure and premature death. Based on these assumptions, guidelines advocate the need for early detection of the disease in order to: 1) motivate patients towards smoking cessation [11]; and 2) permit the use of treatments that can reduce the impact of COPD on symptoms, activities, quality of life and healthcare costs [1, 2, 12, 13]. However, this impact has seldom been evaluated at the general population level; in most cases, subjects recruited into quality-of-life studies have been patients with known COPD, which excludes the most prevalent fraction of the diseased population, *i.e.* the less severe and undiagnosed cases. Thus it is difficult to estimate the global consequences of the disease on health status in the population, and the possible effect of early detection at this level.

The present analysis was designed to assess the impact of chronic airflow obstruction on dyspnoea, quality of life (measured with a generic questionnaire) and missed working days in a population sample that was constituted with the primary objective of determining the prevalence of chronic airflow obstruction [14].

MATERIALS AND METHODS
Study design
Subjects were recruited in 31 health prevention centres that are accessible to all workers. The sample was constructed according to national statistics on age and sex distribution in the

general population of the considered age range (subjects aged ⩾40 yrs). Subjects filled in a standardised auto-questionnaire, and a technician who was not aware of the answers to the questionnaire measured forced expiratory volume in one second ($FEV1$) and forced vital capacity (FVC). All subjects received an information note before their participation.

Questionnaire and spirometry

The data obtained from each individual included the usual demographic and anthropometric description, information on risk factors, clinical symptoms, associated chronic diseases and presumptive diagnosis, and previous assessment of lung function.

The questionnaire was derived from the European Community Respiratory Health Survey questionnaire [15]. Details of its content have already been published. Dyspnoea was measured using the modified UK Medical Research Council 0–4 scale, and quality of life was assessed using a generic five-dimension questionnaire, the European quality of life five-dimension (EuroQol-5D/EQ-5D) questionnaire [16]. Declared missed working days during the previous year were recorded.

Pre-bronchodilator spirometry was performed by trained technicians using spirometers that were calibrated daily. Three measures were performed, with the best technically adequate measurement being chosen for analysis. Subjects were excluded from the analyses when only one spirometric measurement was adequate or when the variation between the two highest $FEV1$ was >200 mL. Predicted values were calculated using European Respiratory Society equations [17, 18]. Airflow obstruction was defined by an $FEV1$/FVC ratio of <0.70.

Statistical analysis

The present study was powered to assess the prevalence of chronic airflow obstruction in the chosen population. Considering the expected prevalence of airflow obstruction of ~5%, an allowed risk of error of 0.5% of this percentage and possible analysis in two strata, 4,500 individuals had to be recruited for the present survey. Results are expressed as percentages or mean±SD.

Based on questionnaire data, analyses were performed in three populations: the whole population, nonasthmatics, and subjects with no declared respiratory or cardiac disease.

In each of these populations, percentages were compared by two-way and multi-way frequency analysis, and means by ANOVA and unpaired t-tests. Relationships between continuous variables were assessed using linear regression. A difference was considered significant at a p-value of <0.05. Bonferroni corrections were performed for multiple comparisons.

Finally, multivariate logistic regression analyses were performed in order to identify independent predictors of quality of life and work loss. For these analyses, the dependent variables were: 1) the scores of each EQ-5D domain, and 2) the presence or absence of ⩾1 missed working day, respectively. This last analysis was restricted to the active fraction of the population, *i.e.* subjects aged <65 yrs.

RESULTS

Characteristics of the studied population

A total of 5,008 subjects were included in the present survey during an 8-month recruitment period; this corresponded to a 93.5% response rate among subjects initially asked to participate. Adequate questionnaire and spirometry data were available for 4,764 (95.1%) subjects (table 1). Their mean age was 60 yrs; 81% of subjects were aged <70 yrs and only 2% were aged >80 yrs. Known chronic respiratory disease was reported by 9.1% of subjects for asthma, 2.6% for COPD and 5.8% for chronic bronchitis. Questions regarding symptoms revealed that chronic bronchitis was genuinely present in 3.9% of subjects. The prevalence of chronic airflow obstruction in nonasthmatics was 7.5%. In the majority (59%) of these patients, the severity of airflow obstruction was mild ($FEV1$ of ⩾80% of the predicted value) and chronic bronchitis was absent. The severity of airflow obstruction was moderate ($FEV1$ of 50–80% pred) in 36.1%, and severe or very severe ($FEV1$ of <50% pred) in 4.8%. Among nonasthmatic subjects in whom airflow obstruction was found, only 6.1% had been previously diagnosed as having a chronic respiratory disease.

Impact of chronic airflow obstruction: dyspnoea and quality of life

In the whole population and in subjects with no known heart or lung disease, dyspnoea grade correlated significantly (p<0.0001) but weakly (r=0.28) with the EQ-5D visual analogue scale score. There were also significant relationships between dyspnoea grade and EQ-5D subscores (mobility, activity, anxiety, autonomy and pain; all p<0.001; data from the whole population are shown in table 2).

Altogether, 7.2% of subjects with grade 0 dyspnoea showed airflow obstruction *versus* 10.7% of those with dyspnoea of grade ⩾1, 14.8% of those with dyspnoea of grade ⩾2 and 21.8% of those with grade 4 dyspnoea.

In subjects without known chronic respiratory or heart disease, but who were diagnosed as having airflow obstruction during the examination, the severity of dyspnoea increased with that of airflow obstruction (fig. 1).

In the whole population, patients who declared having asthma, COPD or chronic heart failure exhibited lower aggregated EQ-5D scores than controls, with all domains of the questionnaire being affected (data not shown). In patients with no chronic respiratory or cardiac disease, EQ-5D visual analogue scale scores decreased with $FEV1$ (% pred; mean score 70.5±14.8 *versus* 72.8±14.8 in subjects with and without airflow obstruction; p=0.004), whereas, in all EQ-5D domains, airflow obstruction was associated with lower proportions of patients declaring no limitation than among subjects with no airflow obstruction (87 *versus* 93% for mobility, 97 *versus* 99% for autonomy, 90 *versus* 93% for activity, 38 *versus* 46% for pain and 49 *versus* 55% for anxiety; all p<0.05). Multivariate analysis showed that age and $FEV1$ were independent predictors of all EQ-5D domains except anxiety, which was mainly influenced by sex (table 3).

Missed working days

The number of missed working days was significantly associated with: 1) health status, as measured by EQ-5D visual

TABLE 1	Description of studied population		
	Total	**Females**	**Males**
Sex ratio male/female		0.92 (2290/2474)	
Age yrs	59.9 $\pm$ 10.1	60.4 $\pm$ 10.3	59.3 $\pm$ 9.9
Socioeconomic status			
Manual workers	3208 (67.3)	1718 (69.4)	1490 (65.1)
Managers	1493 (31.3)	700 (28.3)	793 (34.6)
Nonworking population[#]	63 (1.3)	56 (2.3)	7 (0.3)
Habitat			
Rural	1327 (28.0)	661 (26.9)	666 (29.2)
Town <50,000 inhabitants	1451 (30.6)	738 (30.0)	713 (31.3)
Town >50,000 inhabitants	1960 (41.4)	1059 (43.1)	901 (39.5)
Known diagnosis			
COPD	123 (2.6)	63 (2.6)	60 (2.6)
Chronic bronchitis	275 (5.8)	145 (5.9)	130 (5.7)
Comorbid illness			
Asthma	429 (9.1)	236 (9.5)	193 (8.4)
Bronchiectasis	54 (1.1)	30 (1.2)	24 (1.1)
Heart failure	119 (2.5)	52 (2.1)	67 (3.0)
Smoking status			
Never-smoker	2297 (49.6)	1561 (64.2)	736 (33.4)
Ex-smoker	1473 (31.8)	544 (22.4)	929 (42.2)
Current smoker	862 (18.6)	326 (13.4)	536 (24.4)
Cumulative smoking[¶]			
1–14 pack-yrs	816 (40.9)	339 (48.5)	477 (36.8)
15–24 pack-yrs	510 (25.6)	169 (24.2)	341 (26.3)
$\geqslant$25 pack-yrs	669 (33.5)	191 (27.3)	478 (36.9)
Daily cigarette consumption			
$\leqslant$1	50 (2.4)	30 (4.0)	20 (1.5)
2–20	1722 (81.9)	628 (83.8)	1094 (80.8)
$\geqslant$21	331 (15.7)	91 (12.1)	240 (17.7)
Occupational exposure to dusts, gas, fumes	1423 (30.3)	480 (19.8)	943 (41.5)
MRC dyspnoea grade			
0	3700 (79.5)	1836 (76.4)	1864 (82.7)
1	706 (15.2)	412 (17.1)	294 (13.0)
2	128 (2.7)	70 (2.9)	58 (2.6)
3	89 (1.9)	63 (2.6)	26 (1.2)
4	33 (0.7)	22 (0.9)	11 (0.5)
Chronic cough and sputum production			
No cough/expectoration	4142 (86.9)	2197 (88.8)	1945 (84.9)
Chronic cough alone	310 (6.5)	152 (6.1)	158 (6.9)
Chronic expectoration alone	127 (2.7)	47 (1.9)	80 (3.5)
Chronic cough/expectoration	185 (3.9)	78 (3.2)	107 (4.7)

Data are presented as mean $\pm$ SD or n (%), unless otherwise indicated (percentages given for cumulative smoking are based on total current and ex-smoking population). COPD: chronic obstructive pulmonary disease; MRC: Medical Research Council. [#]: retired and others; [¶]: current and ex-smokers.

analogue scale and all EQ-5D domains except autonomy; and 2) dyspnoea grade (data not shown; p<0.01 for all analyses).

Most subjects reported no missed working days during the year preceding the examination (fig. 2). However, in all groups (whole population, nonasthmatics and subjects with no declared respiratory or cardiac disease), a decreased FEV1/FVC ratio was associated with an increase in the number of missed working days (6.71 $\pm$ 39.09 *versus* 1.45 $\pm$ 14.33 days in subjects with no respiratory or heart disease; p=0.0015). In the

whole population and in nonasthmatics, the number of missed working days was higher in subjects reporting symptoms of chronic bronchitis than in other subjects (5.56 $\pm$ 15.45 *versus* 1.75 $\pm$ 16.54 days; p=0.05), and patients with an FEV1 of 50–80% pred missed more working days than those with an FEV1 of $\geqslant$100% pred (4.62 $\pm$ 32.80 *versus* 1.54 $\pm$ 13.90 days; p=0.04). These differences were nonsignificant in nonasthmatics declaring no comorbid respiratory or cardiac disease. Other differences between FEV1 categories were also nonsignificant. On multivariate analysis, chronic bronchitis was the only

TABLE 2	Relationship between dyspnoea grade and generic questionnaire# domains in the whole population/nonasthmatic patients with airflow obstruction				
Dyspnoea grade	**Domain**				
	Mobility	**Autonomy**	**Activity**	**Anxiety**	**Pain**
0	95.6/91.5	99.3/98.0	95.7/93.1	54.7/57.4	50.3/45.6
1	86.1/82.1	98.3/100.0	87.5/89.5	36.9/29.9	29.6/35.8
2	74.2/61.1	95.3/88.9	79.7/77.8	33.9/38.9	14.8/16.7
3	55.1/53.3	90.9/86.7	67.1/66.7	22.5/26.7	17.2/26.7
4	54.6/40.0	81.8/80.0	63.6/40.0	30.3/20.0	3.0/0.0

Data are presented as the percentage of the whole population/nonasthmatic patients with airflow obstruction in each dyspnoea grade who report no limitation/impairment in the domain under consideration. #: European quality of life five-dimension questionnaire.

independent predictor of missed working days (odds ratio 6.0; 95% confidence interval 2.8–12.7; p<0.0001; table 3), but interacted strongly with airflow obstruction (p<0.001 in test for interaction).

DISCUSSION

In the present sample of 4,764 subjects visiting health prevention centres, airflow obstruction was present in 7.5% of nonasthmatics and was of mild-to-moderate severity in the vast majority of cases. In these subjects, exertional dyspnoea was more frequent, quality of life assessed by the EQ-5D generic questionnaire was poorer and the number of missed working days was greater than in other subjects. The vast majority (93.9%) of subjects with airflow obstruction were not previously known to be suffering from any kind of chronic respiratory disease.

Limitations and strengths of the study

To the best of the present authors' knowledge, the present study is one of the largest spirometrically based population studies assessing the impact of chronic airflow obstruction using a validated quality-of-life questionnaire.

Airflow obstruction was defined according to pre-bronchodilator spirometry results, which is not in accordance with current guidelines. However, this was inevitable since French health prevention centres are not permitted to deliver any kind of medication. In addition, the use of pre-bronchodilator results is in line with several recent epidemiological studies, such as those of DE MARCO and co-workers [15, 19]. In their most recent article, these authors conclude that the use of pre-bronchodilator values results in exposure to a risk of overestimation of the prevalence of COPD. They also show that this risk is minimised by exclusion of asthmatic subjects. For this reason, all analyses were performed in the whole population, in nonasthmatics alone and in subjects with no known heart or respiratory disease. Regarding FEV1/FVC ratio, the use of the fixed 0.70 cut-off rather than the lower limit of normal for the diagnosis of airflow obstruction may result in overestimation of the prevalence of the disease in the elderly
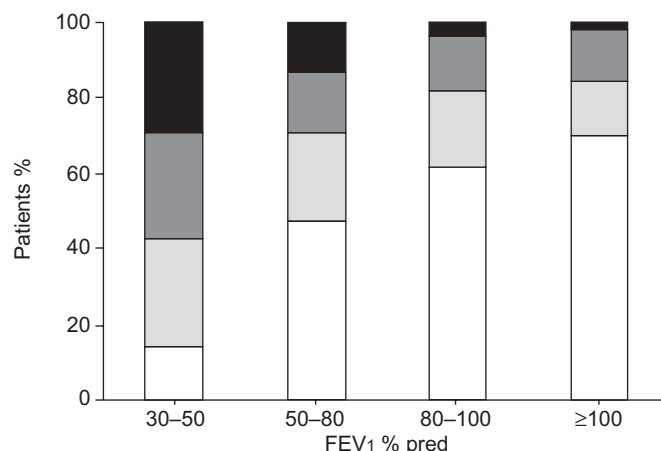

FIGURE 1. UK Medical Research Council dyspnoea grades (□: 0; ▣: 1; ▨: 2; ■: 3) by forced expiratory volume in one second (FEV1) in subjects with no known heart or lung disease but in whom chronic airflow obstruction (FEV1/forced vital capacity of <0.70) was demonstrated. No subjects reported grade 4 dyspnoea. % pred: % predicted.

(and underestimation in younger adults, although the latter did not form part of the present study population). However, for practical reasons, the fixed cut-off is the recommended means of diagnosing chronic airflow obstruction in current guidelines. In addition, elderly subjects and those aged <40 yrs represented a small part of the present population, limiting the overall risk of error.

The mode of recruitment was certainly a source of bias since: 1) the main purpose of health examination centres is prevention; and 2) visits to these centres are offered mainly to the working population. Thus subjects of the studied population are less likely to exhibit symptoms or be known to have any disease than the general population (healthy worker effect). Accordingly, the proportion (6.1%) of patients with a known diagnosis of COPD was lower than in other studies [4, 5, 20]. Thus the prevalence and impact of chronic airflow obstruction may be underestimated, which may help to explain the low number of subjects with an FEV1 of <50% pred and the low proportion of subjects with airflow obstruction who reported symptoms of chronic bronchitis, severe dyspnoea or a previously known diagnosis of respiratory disease. In addition, the results presented herein cannot be extrapolated to the nonworking population. Despite these considerations, the overall prevalence data were very similar to those from other studies in developed countries regarding asthma, chronic bronchitis and airflow obstruction [4, 5, 21–23].

Another limitation is the declarative nature of the data on work loss. There is no means of assessing how this may have affected the present results. It can only be assumed that, since missed working days are important events in the life of workers, they are likely to be remembered accurately enough and not significantly overestimated.

Impact of airflow obstruction

Despite its mild severity, patients with chronic airflow obstruction exhibited poorer quality of life and increased dyspnoea and number of missed working days.

TABLE 3	Predictors of quality of life and missed working days on multivariate logistic regression analysis in subjects without a known diagnosis[#]			
EQ-5D domain[¶]	**Reference**	**OR (95% CI)**	**p-value**
Mobility 2	1		
FEV$_1$ 30–<50% pred	≥80% pred	13.8 (2.6–73.9)	0.0022
FEV$_1$ 50–<80% pred	≥80% pred	1.8 (1.1–3.0)	0.0208
Age ≥75 yrs	45–54 yrs	3.1 (1.0–9.4)	0.0428
Activity 2	1		
FEV$_1$ 50–<80% pred	≥80% pred	2.0 (1.2–3.4)	0.0062
Age ≥75 yrs	45–54 yrs	5.0 (1.5–16.6)	0.0089
Daily cigarettes ≥21	2–20	2.1 (1.1–3.9)	0.0198
Anxiety 2	1		
Female sex	Male	2.1 (1.7–2.7)	<0.0001
Anxiety 3	1		
Female sex	Male	3.7 (2.3–6.0)	<0.0001
Pain 2	1		
FEV$_1$ 50–<80% pred	≥80% pred	1.4 (1.1–1.9)	0.0190
Age ≥75 yrs	45–54 yrs	1.9 (1.1–3.4)	0.0325
Pain 3	1		
Age 55–64 yrs	45–54 yrs	3.0 (1.4–6.4)	0.0048
Age 65–74 yrs	45–54 yrs	3.6 (1.0–12.2)	0.0432
Age ≥75 yrs	45–54 yrs	4.4 (1.1–18.4)	0.0414
FEV$_1$ 50–<80% pred	≥80% pred	2.1 (1.1–4.0)	0.0212
Missed working day ≥1[+]			
Chronic bronchitis	None	6.0 (2.8–12.7)	<0.0001

EQ-5D: European quality of life five-dimension questionnaire; OR: odds ratio; CI: confidence interval; FEV$_1$: forced expiratory volume in one second; % pred: % predicted. [#]: of chronic obstructive pulmonary disease, asthma or any other predefined comorbid illness (bronchiectasis or chronic heart failure); [¶]: no independent predictor was found for mobility class 3 or activity class 3; [+]: analysis restricted to those aged <65 yrs (n=1,310).

FIGURE 2. Distribution of number of missed working days reported during the previous year in the population with no known lung or heart disease, by presence (■) or absence (□) of a) chronic bronchitis and b) airflow obstruction.

This observation remained true even in patients with no known heart or lung illness.

Dyspnoea

In the present patients, impairment of quality of life was influenced by dyspnoea, although this symptom was much less severe than in patients with possible COPD identified in the Confronting COPD survey [6]. For instance, among persistent smokers with a Global Initiative for Chronic Obstructive Lung Disease airflow obstruction stage of >1 (in whom dyspnoea was the most prevalent), only 8.3% reported a dyspnoea grade of ≥3, whereas the corresponding figure in the Confronting COPD survey was 42.6%. Thus even mild dyspnoea can be associated with impaired quality of life.

Quality of life

Among subjects with chronic airflow obstruction identified in the general population, a diagnosis of COPD is more likely when quality of life is more impaired [24]. In addition, lung function is an independent predictor of all EQ-5D domains except anxiety. However, despite the under-representation of severe cases and marked underdiagnosis of COPD in the present study, quality of life was impaired by airflow
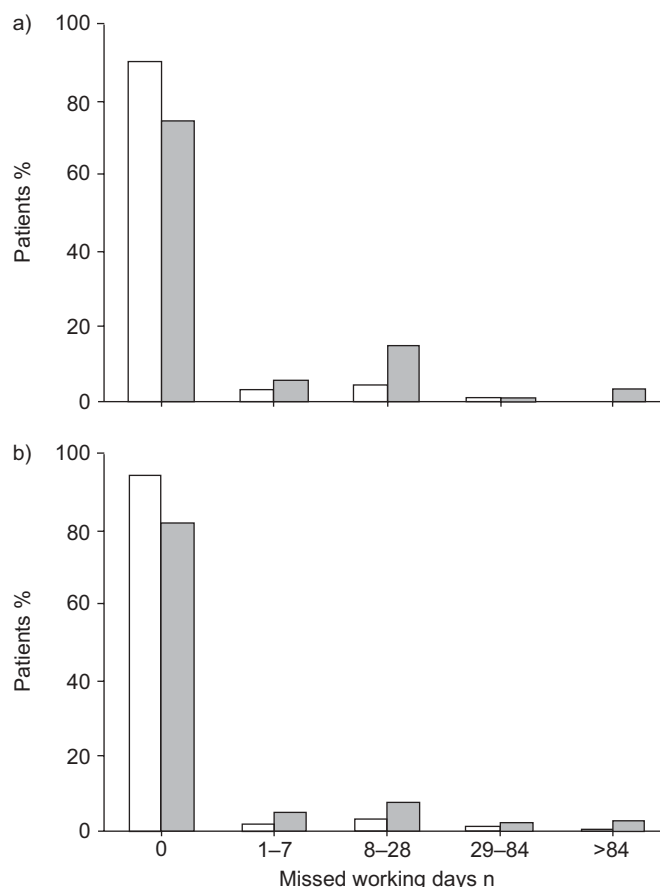
obstruction. In the USA, the National Health and Nutrition Examination Survey (NHANES) also showed that undiagnosed airflow obstruction in the general population is associated with impaired health and functional status. In that study, health status was not assessed using a dedicated questionnaire but rather with questions about general health status, walking 402 m, lifting or carrying something as heavy as 4.54 kg and needing help with personal care [25]. In the Confronting COPD survey [6], patients with airflow obstruction also reported activity restrictions related to their respiratory condition. Depending upon the item under consideration, 30–70% of subjects with or at risk of COPD reported limitations in sport and recreation, physical exertion, social life, sleep, household chores and sex life. In line with these findings, data from the Spanish EPIDEPOC study found significant impairment of quality of life measured with the 12-item short-form health survey questionnaire in stable COPD subjects followed in primary care, even in mild disease stages [26].

Impact on work

COPD is not only a disease of the elderly; its prevalence in subjects aged ≤65 yrs is not negligible and has a noticeable impact on resource utilisation and healthcare costs [27]. In these subjects, ability to work is an important determinant of life satisfaction [28]. In the Confronting COPD survey [6],

35.7% of patients reported that ''their condition prevented them from working, limited their ability to work or had caused them working time loss in the past year''. This percentage increased to 45.3 in subjects aged <65 yrs, who were less likely to form part of the 54.8% of the population who were retired [7]. The proportion of retired subjects was much lower (1.3%) in the present population; this is related to the mode of recruitment since health examination centres target only working subjects. The much lower proportion of subjects reporting work loss in the present population is probably related to several factors: slightly younger age (60 *versus* 63 yrs in the Confronting COPD survey [6]), different mode of recruitment (systematic prevention visits by subjects who presume they are healthy *versus* general population) and variable studied; the present study used only the number of missed working days to assess disease consequences on work, whereas RENNARD *et al.* [7] also included reported ''limitations in the ability to work'' in their assessment, introducing a possibly more subjective component, the contribution of which it is difficult to assess. Finally, there was no means of determining whether or not airflow obstruction was less severe in the present population than in the Confronting COPD survey [6], since lung function was not assessed in that study.

In NHANES III, even patients with spirometrically mild COPD were less likely to be in the labour force than controls. More precisely, mild, moderate and severe COPD were associated with a 3.4, 3.9 and 14.4% reduction in the labour force participation rate relative to those without COPD [29].

Finally, multivariate analysis did not identify lung function as an independent predictor of missed working days, whereas chronic bronchitis was so identified. Thus, when the COPD fraction of a population has mostly mild or mild-to-moderate disease, work loss seems to relate more to chronic bronchitis than to airflow obstruction. However, this result should be interpreted with caution since the power of the analysis was relatively low, due to the small number of subjects reporting any missed working day (n=69) among the population restricted to those aged <65 yrs with no cardiac or respiratory comorbid illness (n=1,310). This also prevented reliable multivariate analysis with the number of missed working days divided into subcategories.

In conclusion, the present study on a large sample from health prevention centres found a significant impact of mild-to-moderate airflow obstruction on dyspnoea, quality of life and missed working days despite a very low proportion of subjects spontaneously reporting symptoms or a known respiratory disease. Such findings suggest that systematic screening for chronic obstructive pulmonary disease may be justified in the general population since identified cases suffer from a significant although underestimated impact of the disease, which might be limited by early implementation of preventive and therapeutic measures.

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