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# Respiratory symptoms and pulmonary function in the population of Parona (PV) according to tobacco smoke exposure

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## Abstract

**Background**
The health status of a population sample living in Parona (Pavia) was surveyed to evaluate the association between exposure to active and passive smoke and chronic respiratory symptoms.
**Methods**
483 subjects were studied. The protocol included a questionnaire administrated by a physician, pulmonary function test and blood analysis.
**Results**
124 subjects were current smokers, 104 subjects were past smokers and 252 were non-smokers. Sixty two (12.9%) of the subjects had pathological PFT: 48 (10%) had airflow obstruction and 14 (2.9%) had restriction of lung volumes. The prevalence of pathological tests was significantly higher in males than in females ($p < 0.05$). Most of pathological tests have been found in smokers: the prevalence was 16.9% in current smokers, 14.4% in quitters, 11.8% in ETS-exposed people and 9.4% in ETS-non-exposed. The frequency of pathological PFTs was significantly higher in subjects exposed ($p < 0.05$). The mean value of FVC% predicted tended to be lower in smokers, intermediate in ETS exposed subjects.
**Conclusions**
Chronic respiratory symptoms were reported significantly more often by smokers. The prevalence of pathological pulmonary function tests was significantly higher and FVC tended to be lower in subjects exposed to active and/or passive smoking than in non-exposed. Our results demonstrate the health impact of smoke on the general population of a low polluted area. Besides smoking cessation, lowering ETS exposure could represent one of the most important tool to improve respiratory health, and may contribute to prevent and reduce progression to COPD .

*Key words: lung function abnormalities, tobacco smoking, Environmental Tobacco Smoke, surveillance, general population*

**Acronyms**
COPD (Chronic Obstructive Pulmonary Diseases)
FEV1 (Forced Expiratory Volume in one second)
ETS (Environmental Tobacco Smoke)
OR (Odds Ratio)
FVC (Forced Vital Capacity)
CHD (Coronary Heart Diseases)
PV (Pavia)
PFTs (Pulmonary Function Tests)
RBC (Red Blood Cells)
WBC (White Blood Cells)
PLT (Platelets)
Ht (Hematocrit)
Hb (Haemoglobin)

## Introduction
The prevalence of COPD is constantly growing throughout the world and a further increase is expected both in developed and in developing countries, as these diseases will be the fifth cause of death and disability by 2020, surpassing cardiovascular diseases [1]. In fact "untreated COPDs" are a cause of early death, due to decreased pulmonary or cardiovascular function. Although the prevalence of COPD is increasing more and

more, cases are frequently unidentified with negative consequences: early interventions can improve the quality of life, both in smokers and in non smokers, reducing relapses and sometimes restoring respiratory functions. COPD shortens FEV1 (forced expiratory volume in one second), increases the prevalence of dyspnoea and other respiratory symptoms, causing progressive deterioration of health status [2]. COPD is linked to several risk factors, among these cigarette smoke [2,3,4] (both main and sidestream smoke) seems to be the most important [5].

Although chronic bronchitis is much more prevalent in smokers, it is also diagnosed in non-smokers [6]. Several authors have tried to highlight the link between ETS and pulmonary diseases (7-21]. Manning showed that increased bronchitis symptoms occur in teenagers exposed to active or passive smoking and that these symptoms were more frequently reported in passive smokers compared to those not exposed to smoking (OR=1.82) [7]. Rizzi reported that in healthy male adolescents current exposure to ETS is associated with lung function impairment independently of the effects of maternal smoking during pregnancy [8]. Xu found a significant association between exposure to ETS and reduced levels of FEV1 and FVC (Forced Vital Capacity); such an association was dose-dependent [9]. Furthermore, Radon indicated that a daily exposure to ETS in workplaces increases the risk of respiratory symptoms indipendently of exposure to other airborne contaminants [10] and Chen showed an impairment of pulmonary function among non-smokers that were exposed to ETS in workplaces [11]. There is also a lot of evidence proving the link between ETS, lung cancer and coronary heart diseases outside of the workplace [12,13,14]: therefore tobacco smoking is the most important cause of avoidable disability and early death [5]. Although smoking is recognized as one of the most relevant risk factors for human health, the effects of environmental smoke for pulmonary disease have mainly been studied in workplaces [11,14] and further investigations are needed in the general population.

The aim of this study was to evaluate the association between exposure to active and passive smoke and chronic respiratory symptoms in a free living population sample from a rural area of northern Italy.

## Population and methods

Parona (PV) is a municipality situated in a low polluted area of the Po valley with about 1600 inhabitants. The local economy , originally based on agriculture, has experienced the spread of small industrial enterprises in the last few years. During the year 2000 all males and females of Parona aged 15 to 74 years were invited to participate to a survey on their health status by a personalized letter. The study protocol included a questionnaire administered by a physician, pulmonary function test and blood analysis.

The questionnaire was directed at collecting data about their health status (respiratory symptoms), smoking habits, as well as information on exposure to passive smoking. The questions concerning the respiratory symptoms were drawn from the standardized questionnaire by Italian C N R (Consiglio_Nazionale delle Ricerche) [22].

The whole population tested was grouped, according to smoking habits and ETS exposure, in current smokers, past smokers (88.3% quitted at least one year before the screening), non-smokers ETS exposed and non-smokers non ETS exposed; the first three groups have been classified as "smoke-exposed", the last group as "non smoke-exposed".

Pulmonary function tests consisted of spirometry with forced vital capacity manoeuvres. FEV1 and FVC were determined by a portable computerized spirometer (Pony Graphic COSMED) according to the ATS criteria (ATS Standardization of spirometry –1994 update. AJRCCM 1995). The predicted values were calculated according to the Barcelona Multicentric Study [23]. Airflow obstruction was defined as FEV1/FVC ratio <70% and restriction of lung volume was defined as FVC value <80% of predicted in the absence of airflow obstruction .

Results from atopic subjects were not considered in the analysis, because their findings could represent a confounder.

RBC (Red Blood Cells), WBC (White Blood Cells), Platelets (PLT) count, Hematocrit (Ht) and Haemoglobin (Hb) were determined by Automatic Analyzer Contraves 801.

No sample size calculation was performed for this study, as the aim was to survey the whole population of the rural town of Parona.

All data were analyzed using SPSS. Mean values and frequencies were calculated. A general linear model was used to assess the association of FEV1 and FVC with smoking habits, adjusting for the following confounders: sex, age, height and weight. An univariate analysis was done according to smoking exposure, considering FEV1 and FVC as dependent variables. In univariate analyses, chi square tests were used for categorical variables, and Student t test was used for continuous variables. Pearson's linear correlation was also performed to explain the eventual association between the number of cigarettes pack/years and

PFT data. Statistical significance was inferred when 2- tailed p values were<0.05.

### Results

We collected data on 483 participants, (210 males and 273 females), 36.1% of the whole population aged 15 to 74 years; 43.5% were male and 56.5% were female.(Table 1).The mean age of the participating subjects was 50.4±15.6 years: most of the subjects were 65 to 74 years old, while few people aged 15 to 34 participated.The distribution of respondents according to sex and age is reported in table I. Educational level of respondents was the following: 0-5 education years (223 subjects - 46.6%), 6-8 education years (136 subjects – 28.4%), 9 years and more (120 – 25%). Four subjects did not report their own education. As far as marital status is concerned: 332 subjects were married (69.1%), 94 subjects were unmarried (19.5%), 44 were widowed (9.1%), 11 were divorced or legally separated (2.3%) and 2 subjects did not report their marital status.

### Questionnaire

The analysis of the questionnaires showed that 83 subjects were reported to suffer from chronic cough, 85 from chronic phlegm and 120 reported to suffer from breathlessness.

One hundred twenty-four (124) subjects were current smokers (25.9%), 64 males (30.5%) and 61 females (22.3%), 104 subjects were past smokers (21.7%) and 252 were non-smokers.

Among non-smokers 93 (19.4%) were ETS exposed and 159 (33.1%) were non ETS exposed. Thus, 322 subjects (66.9%) were classified as "smoke-exposed" and 159 as "non smoke-exposed". The mean age of quitters and non-exposed was significantly higher ($p < 0.001$) than the other groups (non-exposed 54.6±15.3 years, quitters 54.0±13.7 years, smokers 46.6±15.0 and exposed to ETS 44.1±15.4). Cough and phlegm were reported significantly more often by smokers than by the other groups ($p=0.001$ for both); heart attacks and angina were reported significantly more often by past-smokers ($p < 0.05$) (Table 2).

### Pulmonary function tests

All but 2 subjects underwent PFTs and in one subject it was not possible to obtain an acceptable-quality manoeuvre after repeated attempts. Sixty-two (12.9%) of the subjects had pathological PFT: 48 (10%) had airflow obstruction and 14 (2.9%) had lung volume restriction. The prevalence of pathological tests was significantly higher in males than in females ($p < 0.05$), and in subjects older than 65 years (14.3%) than in the others: only one subject had pathological test among those younger than 24 years (3.3%).

### Effects of smoking on lung function

Most of the pathological tests were found in smokers. In fact, the prevalence of pathological respiratory tests was 16.9% in current smokers, 14.4% in quitters, 11.8% in ETS-exposed people, and, finally, 9.4% in ETS-non-exposed. Data were substantially unchanged after age-standardization: the largest number of pathological tests was evident in smokers (18.2%) followed by past-smokers (14.1%), ETS exposed (12.8%), and non-exposed (6.3%). The frequency of pathological PFTs was significantly higher in subjects exposed

**Table 1. Numbers of respondents distributed according to age and sex and percentage of participation in each age class of the whole Parona population**

| Age | Men | Respondents (%) | Women | Respondents (%) | All | Respondents (%) |
|---|---|---|---|---|---|---|
| 15-24 | 15 | 15.96 | 15 | 17.44 | 30 | 16.67 |
| 25-34 | 24 | 17.39 | 36 | 28.80 | 60 | 22.81 |
| 35-44 | 45 | 31.25 | 42 | 40.38 | 87 | 35.08 |
| 45-54 | 35 | 25.0 | 55 | 42.97 | 90 | 33.58 |
| 55-64 | 40 | 44.94 | 67 | 62.67 | 107 | 54.31 |
| 65-74 | 51 | 65.38 | 58 | 56.31 | 109 | 60.22 |
| All | 210 | 30.70 | 273 | 41.81 | 483 | 36.13 |

**Table 2. Symptoms (Cough, phlegm, breathless) according to smoking habit and ETS exposure**

| Symptoms | Groups | | | | Total |
|---|---|---|---|---|---|
| | Current Smokers | Quitters | ETS exposed | Non exposed | |
| Cough | 40 (48.19%) *** | 17 (20.48%) | 12 (14.46%) | 14 (16.87%) | 83 (100%) |
| Phlegm | 35 (41.18%) *** | 25 (29.41%) | 12 (14.12%) | 13 (15.29%) | 85 (100%) |
| Breathless | 32 (26.66%) | 28 (23.34%) | 19 (15.83%) | 41 (34.17%) | 120 (100%) |

*** = $p < 0.001$

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to smoke than in non-exposed ($p < 0.05$). In smokers no correlation was found between PFTs and the number of cigarette pack/years.

The mean value of FEV1 % predicted (96±18) and FVC % predicted (100±17) were the lowest in smokers, while they were the highest in non-exposed subjects (respectively FEV1 %= 101 ±19 and FVC %= 105±17). FEV1/FVC varied from 79.8 (smokers) to 82.2 (ETS exposed). The mean value of FVC% predicted tended to be lower in smoke-exposed subjects than in non exposed ($p = 0.07$); it was intermediate in ETS exposed subjects. The result of the multivariate analysis (adjusted for sex, age, height and weight) showed the same trend and a significant difference for FEV1 between smokers and non smokers non ETS exposed ($p = 0.049$). The same trend was found in the four groups divided in quartiles (figure 1, table 3, 4, 5).

## Blood tests

Considering blood tests (RBC, WBC, PTLs, Haemoglobin and Hematocrit), low values of leucocytes were present in non-exposed subjects ($p < 0.001$) and mean values of WBC (6.553 cells/mcl vs 6.054 cells/mcl), haemoglobin (13.96 gr/dl vs 13.42) , hematocrit (41.18% vs 39.78%) were significantly higher in exposed ($p < 0.001$). The mean values of platelets were significantly lower (231.78/l vs 248.47/l; p<0,05) in subjects with abnormal respiratory tests and the number of subjects with low platelets count was higher among subjects with abnormal tests($p<0.05$).

## Discussion

The major findings of this study in the general population of a low-polluted area are as follows: 1) chronic respiratory symptoms were reported significantly more often by smokers than by the

**Table 3. Adjusted effects of the smoking habit and the putative prognostic factors, estimated by multiple linear model for FEV1**

| Effect | Estimate | Standard Error | p. | 95% Confidence Interval | |
|---|---|---|---|---|---|
| | | | | Lower Bound | Upper Bound |
| Intercept | 3.642 | 0.135 | 0.000 | 3.376 | 3.908 |
| Weight | 0.007 | 0.002 | 0.000 | 0.004 | 0.010 |
| Height | -0.008 | 0.003 | 0.19 | -0.014 | -0.001 |
| Age | -0.034 | 0.002 | 0.000 | -0.037 | -0.031 |
| Men* | 0.797 | 0.052 | 0.000 | 0.694 | 0.900 |
| Smokers** | -0.126 | 0.064 | 0.049 | -0.0251 | -0.001 |
| Quitters** | -0.025 | 0.067 | 0.713 | -0.157 | 0.108 |
| ETS exposed** | -0.049 | 0.069 | 0.0477 | -0.185 | 0.087 |

* Women as reference group

**Not ETS exposed as reference group

**Table 4. Adjusted effects of the smoking habit and the putative prognostic factors, estimated by multiple linear model for FVC**

| Effect | Estimate | Standard Error | p. | 95% Confidence Interval | |
|---|---|---|---|---|---|
| | | | | Lower Bound | Upper Bound |
| Intercept | 4.149 | 0.160 | 0.000 | 3.835 | 4.463 |
| Weight | 0.009 | 0.002 | 0.000 | 0.005 | 0.012 |
| Height | -0.009 | 0.004 | 0.022 | -0.017 | -0.001 |
| Age | -0.035 | 0.002 | 0.000 | -0.039 | -0.032 |
| Men* | 1.052 | 0.062 | 0.000 | 0.930 | 1.173 |
| Smokers** | -0.124 | 0.075 | 0.102 | -0.272 | 0.024 |
| Quitters** | -0.099 | 0.080 | 0.213 | -0.256 | 0.057 |
| ETS exposed** | -0.075 | 0.082 | 0.360 | -0.235 | 0.086 |

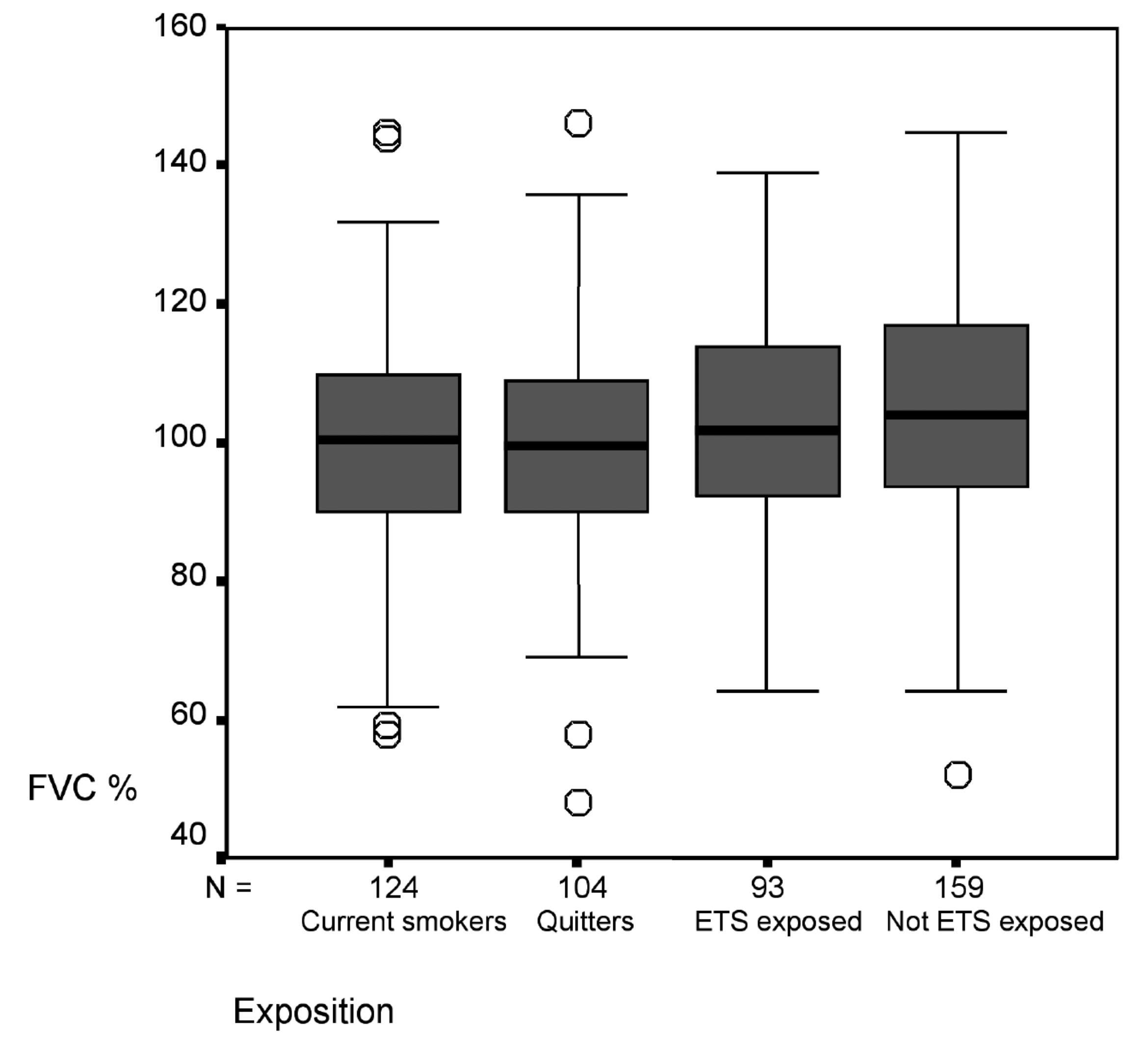
* Women as reference group

**Not ETS exposed as reference group

**Table 5. Distribution of FVC % and FEV1 % of predicted by quartiles according to smoking habit and ETS exposure**

| Quartiles | Groups | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Current Smokers | | Quitters | | ETS exposed | | Non exposed | |
| | FVC % | FEV1% | FVC % | FEV1% | FVC % | FEV1% | FVC % | FEV1% |
| 25 | 90 | 84 | 90 | 89 | 92 | 88 | 94 | 90 |
| 50 | 101 | 98 | 100 | 99 | 102 | 101 | 104 | 99 |
| 75 | 110 | 110 | 109 | 109 | 115 | 111 | 117 | 113 |
| 100 | 145 | 134 | 146 | 129 | 139 | 129 | 145 | 145 |

**Figure 1. Percentile distribution of predicted FVC values in the four groups according to exposure**




Legend: Black horizontal bar= median values
Upper and lower line of each box = interquartiles range
Thin vertical lines are the expected range of all the values

other groups; 2) the prevalence of pathological pulmonary function tests was significantly higher and FVC tended to be lower in subjects exposed to active and/or passive smoking than in those who were non-exposed; 3) leucocytes values were significantly lower in non-exposed subjects, while RBC, WBC, haemoglobin, and hematocrit were significantly higher in exposed subjects.

Parona is a municipality located in a rural, low-polluted area of the Po Valley. In our population sample, the prevalence of smokers is similar to the Italian average for males, but higher for females. As expected, chronic cough and phlegm were significantly more frequent in current smokers but a considerable proportion of symptomatic subjects were non-smokers. This finding support those of Cerveri and coll. [24] who, although detected a major role of smoking in inducing respiratory symptoms, found that about 30% of young adults with chronic cough and phlegm, particularly among females, were non-smokers. In these subjects they suggested a different pathogenesis such as asthma, chronic rhinosinusitis or gastroesophageal reflux.

The prevalence of pathological pulmonary function tests was significantly higher in males and in subjects exposed to active and/or passive smoking. In a previous survey Viegi found the same results in a similar geographical area [25]. We found the highest prevalence of pathological pulmonary function tests in current smokers; the mean values of FVC and FEV1 were lowest in current smokers but only FVC tended to be significantly lower in smoke-exposed subjects than in no- exposed. There is a reason for these results: the reduction of FVC may be an early marker of the morphological changes first occurring in the small airways of subjects exposed to smoke. In fact, it has recently been suggested that a decrease in FVC reflects small airway narrowing, with gas trapping, determined by loss of elastic load or airway thickening whereas the decrease in FEV1 reflects smooth muscle contraction in the large airways [26].

Hematocrit, haemoglobin, RBC and WBC mean values were higher in current smokers, quitters and ETS exposed. This finding, already reported in previous studies [27,28,29,30], could be due to a chronic carbon monoxide induced hypoxia and might have contributed to the excess of heart attacks and angina observed in past-smokers.

The limitation of this study are the limited number of respondents and the lack of objective measurements for passive smoking such a salivary, serum or urine cotinine concentrations. This constraint was mainly due to the high costs that a population study would have brought for the determination of these variables.

In conclusion, our results demonstrate the health impact of active and passive smoking on the general population of a low polluted area. In particular, we demonstrated that the negative impact of passive smoke appears evident in the general population and not only in at risk subjects [28] as previously showed.

The final message is that, besides smoking cessation, lowering ETS exposure could represent one of the most important tools to improve respiratory health, acting in the community, especially in workplaces [31] as well as in public indoor spaces and this may contribute to the prevention and reduction of COPD [2].

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