Obstructive Lung Disease and Low Lung Function in Adults in the United States

Data From the National Health and Nutrition Examination Survey, 1988-1994

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Background: Obstructive lung disease (OLD) is an important cause of morbidity and mortality in the US adult population. Potentially treatable mild cases of OLD often go undetected. This analysis determines the national estimates of reported OLD and low lung function in the US adult population.

Methods: We examined data from the Third National Health and Nutrition Examination Survey (NHANES III), a multistage probability representative sample of the US population. A total of 20050 US adults participated in NHANES III from 1988 to 1994. Our main outcome measures were low lung function (a condition determined to be present if the forced expiratory volume in 1 second-forced vital capacity ratio was less than 0.7 and the forced expiratory volume in 1 second was less than 80% of the predicted value), a physician diagnosis of OLD (chronic bronchitis, asthma, or emphysema), and respiratory symptoms.

Results: Overall a mean (SE) of 6.8% (0.3%) of the population had low lung function, and 8.5% (0.3%) of the population reported OLD. Obstructive lung disease (age-adjusted to study population) was currently reported among 12.5% (0.7%) of current smokers, 9.4% (0.6%) of former smokers, 3.1% (1.1%) of pipe or cigar smokers, and 5.8% (0.4%) of never smokers. Surprisingly, 63.3% (0.2%) of the subjects with documented low lung function had no prior or current reported diagnosis of any OLD.

Conclusions: This study demonstrates that OLD is present in a substantive number of US adults. In addition, many US adults have low lung function but no reported OLD diagnosis, which may indicate the presence of undiagnosed lung disease.

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SUBJECTS AND METHODS

STUDY POPULATION

The NHANES III was conducted from 1988 to 1994 by the National Center for Health Statistics of the Centers for Disease Control and Prevention, Atlanta, Ga.6 In this study a stratified multistage clustered probability design was used to select a representative sample of the US population, yielding results that can be extrapolated to the entire US population. Study participants completed extensive questionnaires in the household and a comprehensive physical examination, including pulmonary function testing, either in the household or at a specially equipped mobile examination center. A total of 81 sites were included in the final sample. The study was approved by the National Center for Health Statistics Institutional Review Board.

SUBJECTS

Our study sample was limited to adults aged 17 years and older who classified themselves as whites or blacks, had pulmonary function testing performed in either the home or the mobile examination center, and had complete data on their race, smoking status, height, and presence of respiratory symptoms. Of the 20050 adult study participants, 543 were not of white or black race, 3355 did not have pulmonary function testing done, 8 were missing data on smoking status, race, or height, and 56 were missing data on 1 or more respiratory symptom. In addition, we excluded 4 women from the analysis who were current cigar or pipe smokers. After the exclusions, we had data from 16084 subjects available for our main analysis.

VARIABLE DEFINITIONS

The race of the participants was classified as either white or black and was determined by self-report on the questionnaire. We defined subjects as being current smokers, former smokers, or never smokers based on their responses to series of questions. One had to have smoked more than 100 cigarettes to qualify as a former or current smoker and could not be currently smoking cigarettes to qualify as a pipe or cigar smoker. Former smokers were asked how old they were when they last smoked cigarettes. Subjects were asked "Has a doctor ever told you that you have asthma?" and similar questions about chronic bronchitis and emphysema. Subjects with a positive response to the question about asthma or chronic bronchitis were also asked "Do you still have asthma?" and "Do you still have chronic bronchitis?" We considered subjects who responded that they currently had asthma or bronchitis, or that they had ever had a diagnosis of emphysema, to have a current diagnosis of OLD. We considered subjects with a positive response to a previous diagnosis of either chronic bronchitis or asthma, but a negative response to current disease, to have a past diagnosis of OLD. We classified subjects as having a symptom if they gave a positive response to the following questions involving specific symptoms (cough, phlegm, wheezing, and dyspnea): "Do you usually cough on level ground or walking up a slight hill?" If a subject had a positive response to any of these 4 symptoms, we considered that subject to have a respiratory symptom.

For most analyses, we stratified subjects into 6 age strata: 17 to 24 years, 25 to 44 years, 45 to 64 years, 65 to 74 years, 75 to 84 years, and 85 years and older. For use in logistic regressions we classified subjects as having or not having cardiovascular disease (positive response to physician-diagnosed stroke, myocardial infarction, or congestive heart failure); obesity (body mass index \(\text{BMI}\) > 28, calculated as the weight in kilograms divided by the square of the height in meters); inactivity (based on self report as being less active than peers); and low socioeconomic status (based on family income below poverty level).

PULMONARY FUNCTION DATA

Using either a dry rolling seal spirometer in the mobile examination center or a portable spirometer in the home examination, spirometry was conducted on the examinees. Procedures for testing were based on the 1987 American Thoracic Society recommendations. To obtain acceptable protocol curves, examinees performed 5 to 8 forced expirations. We used published prediction equations for forced expiratory volume in 1 second (FEV1) to calculate the predicted FEV1 for whites and blacks, stratified by sex.10

We then determined the value of the FEV1 (as a percentage of the predicted value) for each subject. We defined subjects with an FEV1-forced vital capacity (FVC) ratio of less than 0.70 and an FEV1 less than 88% of their predicted value as having low lung function, and further divided this group into subjects with an FEV1 of 58% or more and those with less than 58% of their predicted value, corresponding to people with stage 1 vs stage 2 or 3 OLD."
RESULTS

Our final data set contained 16084 subjects representing an estimated 1693 million adults in the United States. Relative SEs for the data presented are less than 10%, except for data on pipe and cigar smokers, where the SEs are less than 35%. Among the population, an estimated 14.3 million (8.5%) had current OLD, and another 7.3 million (4.3%) had OLD in the past, but not currently (Table 1). The proportion of the population with past or current OLD varied by sex, race, and smoking status, with women reporting more disease than men, whites reporting more disease than blacks, and current or former smokers reporting more disease than never smokers (Table 1). Obstructive lung disease was present among 12.5% of current smokers, 9.4% of former smokers, 3.1% of pipe or cigar smokers, and 5.8% of never smokers (all age-adjusted to study population). Former smokers were, on average, older than never and current smokers (Table 1). Mean level of lung function, either as the FEV1/FVC ratio or FEV1 percent predicted, was always lower among current smokers, former smokers, and pipe or cigar smokers, compared with never smokers (Table 1). Among whites, the reported COPD component of OLD generally increased with age, while among blacks this trend was less apparent (Figure 1).

Subjects frequently reported more than 1 OLD. For example, 25.0% of subjects with current bronchitis reported that they had current asthma, and 34.3% of subjects with current asthma reported that they had current chronic bronchitis. Similarly, 19.4% of the subjects with emphysema reported that they had current asthma, and 25.0% of the subjects with emphysema reported that they had current chronic bronchitis. Among subjects who reported having at some point been diagnosed with asthma, 63.7% reported current asthma, and 58.3% of subjects who reported having been at some point diagnosed with chronic bronchitis also reported a current diagnosis.

Pulmonary function testing was not obtained on 3355 of the original 20050 subjects. The significant predictors of not having testing done were the presence of cardiovascular disease (odds ratio [OR], 1.4; 95% confidence interval [CI], 1.2-1.7) and age (OR, 1.9; 95% CI, 1.4-2.5) for those aged 65-74 years; OR, 2.9; 95% CI, 2.3-3.8 for those aged 75-84 years; and OR, 5.3; 95% CI, 3.8-7.3 for those aged 85 years and older, compared with those aged 17-24 years). Overall, 6.8% of the population, or an estimated 11.5 million people had low lung function (Table 2). An additional 7.2% of the population had an FEV1/FVC ratio of less than 0.7 but an FEV1 greater than 80% of the predicted value. Significant predictors of low lung function included current smoking (OR, 4.3; 95% CI, 3.2-5.7), former smoking (OR, 2.0; 95% CI, 1.5-2.5), pipe or cigar smoking (OR, 2.7; 95% CI, 1.4-5.0), current OLD (OR, 5.4; 95% CI, 4.1-7.0), prior OLD (OR, 1.8; 95% CI, 1.0-3.0), and age (ORs increased from 2.1 for those aged 25 to 44 years to 21.0 for those aged 85 years and older, compared with those aged 17-24 years). Moderate to severe lung obstruction (FEV1 less than 50% of the predicted value and an FEV1/FVC ratio of less than 0.7) was more common among current and former smokers and among people aged 45 years and older (Figure 2 and Figure 3). Overall, 1.5% of the population, or an estimated 2.6 million people, had an FEV1 of less than 50% of the predicted value, including an estimated 900000 people with an FEV1 of less than 35% of the predicted value. Lower levels of lung function were associated with higher levels of reported symptoms (Table 3). Current and former smokers reported respiratory symptoms more frequently than never smokers (Table 3).
These studies used different approaches, with current asthma and smoking. From these studies, we suggest that pipe and cigar smokers are getting enough doses of smoke to cause lung damage, but our findings may also reflect, in part, former cigarette smoking (in our study, 69.3% of pipe and cigar smokers were former cigarette smokers). In addition, our finding of decreased lung function in pipe and cigar smokers demands intervening in this group.

The results of our analysis also confirmed previously known associations between aging and increased airway obstruction. The prevalence of low lung function increased with increasing age (Figure 2) except in the oldest group, which may be related to either differential mortality or inability to do pulmonary function testing. While it is certainly known that the individuals with low lung function die young, our data also suggest that people over age 45 years may have significantly decreased lung function that remains undiagnosed (Figure 2 and Figure 5). The patterns we found of reported OLD also were consistent with reports of COPD increasing with age (Figure 1). The racial differences we observed, of generally lower levels of reported OLD in blacks compared with whites, is consistent with other observations.

There have been numerous, but much smaller regional prevalence studies done in the United States, most notably in Berlin, NH; Tecumseh, Mich.; and Glenwood Springs, Colo. These studies used different degrees of airflow obstruction and had different definitions of the diseases characterized by airflow obstruction. In Berlin, NH, the prevalence of all chronic nonspecific respiratory diseases ranged from 15.4% to 39.1% among men and from 15.2% to 19.8% among women, and low levels of lung function were found among 3.1% to 21.7% of men and 6.7% to 13.9% of women. In Tecumseh, Mich, about 14% of adult men and 8% of adult women had chronic bronchitis, obstructive airway disease, or both. In Glenwood Springs, Colo, about 13% of adult men and 10% of adult women had chronic bronchitis and 13% and 4%, respectively, had low lung function. The above-noted findings can be contrasted with our own findings of 8.5% of adults reporting current OLD and 6.8% having low lung function.

Our data also showed a large degree of overlap between asthma and COPD. Subjects with both diseases had lower lung function and more respiratory symptoms than subjects with just one or the other disease (Table 3). Asthma is a potentially reversible disease when diagnosed and treated early in its course with bronchoactive and anti-inflammatory medications. By contrast, COPD...
tends to be a progressive disease, with relentless decline in lung function and resultant morbidity and mortality beginning in the fifth or sixth decade of life. Preventing or forestalling this burden of disease may be possible through aggressive smoking cessation and, perhaps, medications that may improve baseline lung function. The search for other drugs to modulate the inflammatory processes incident to the pathogenesis of COPD is also ongoing.

This survey is subject to several limitations that affect the interpretation of these results. The entire medical history, including the previous and current diagnoses, the respiratory symptoms, and the smoking histories, were entirely self-reported. It is possible that subjects may have underreported or overreported in any of these categories. For instance, we found that only 33.9% and 25.6% of subjects with COPD reported cough and phlegm, respectively. While the criteria for a positive response to these questions were stringent, this may indicate that either symptom or disease reporting was inaccurate. Another limitation was that current smokers who either smoked irregularly or had just stopped smoking could be misclassified as former smokers. In our analyses, however, many of our findings were consistent with known relationships between respiratory disease, respiratory symptoms, and lung function, suggesting that any
Table 3. Characteristics of Participants With Low Lung Function, Stratified by Reported Lung Disease and Level of Lung Function*

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>No. of Participants</th>
<th>Lung Function</th>
<th>Any Symptom</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimated Population</td>
<td>Low Lung Function</td>
<td>Cough, %</td>
</tr>
<tr>
<td></td>
<td>Reported Lung Disease Category</td>
<td>FEV1 &lt; 80% of predicted value</td>
<td>20.5</td>
</tr>
<tr>
<td>COPD only &amp; asthma</td>
<td>2,322,000</td>
<td>938,000</td>
<td>29.9</td>
</tr>
<tr>
<td>Asthma only</td>
<td>5,950,000</td>
<td>1,751,000</td>
<td>17.4</td>
</tr>
<tr>
<td>Chronic bronchitis or asthma in the past</td>
<td>1,002,000</td>
<td>1,002,000</td>
<td>18.2</td>
</tr>
<tr>
<td>No COPD or asthma</td>
<td>7,200,000</td>
<td>514,000</td>
<td>9.5</td>
</tr>
<tr>
<td>FEV1/FVC &lt; 0.70</td>
<td>2,456,000</td>
<td>2,456,000</td>
<td>100.0</td>
</tr>
<tr>
<td>FEV1/FVC &lt; 0.70 or FEV1/FVC, 50% to 85% of predicted value</td>
<td>9,066,000</td>
<td>9,066,000</td>
<td>100.0</td>
</tr>
<tr>
<td>FEV1/FVC &lt; 0.70 or FEV1/FVC, 35% to 49% of predicted value</td>
<td>12,170,000</td>
<td>12,170,000</td>
<td>100.0</td>
</tr>
<tr>
<td>FEV1/FVC &lt; 0.70</td>
<td>145,600,000</td>
<td>145,600,000</td>
<td>100.0</td>
</tr>
<tr>
<td>Total</td>
<td>169,352,000</td>
<td>169,352,000</td>
<td>100.0</td>
</tr>
</tbody>
</table>

*Low lung function is a forced expiratory volume in 1 second (FEV1) of less than 70% and an FEV1/FVC ratio of less than 0.70.

Figure 4. The age-adjusted percentage of people with a forced expiratory volume in 1 second (FEV1) of less than 70% and an FEV1/FVC ratio of less than 0.70 who also had a past diagnosis of obstructive lung disease, stratified by sex and smoking status. All patients with respiratory symptoms were included in the analysis. From the Third National Health and Nutrition Examination Survey, 1988-94.

Figure 5. The age-adjusted percentage of people with a forced expiratory volume in 1 second (FEV1) of less than 70% and an FEV1/FVC ratio of less than 0.70 who also had a past diagnosis of obstructive lung disease, stratified by sex and smoking status. All patients with respiratory symptoms were included in the analysis. From the Third National Health and Nutrition Examination Survey, 1988-94.

misreporting bias potentially present did not have a large effect on the results.

Another potential bias of this study design is that not everyone completed pulmonary function testing. It is possible that subjects unable to do pulmonary function testing were also more likely to have low levels of lung function, thus resulting in an underestimate in the burden of the prevalence of low lung function in the United States. Selection was limited to a noninstitutionalized, nonmilitary population, so it was not truly ran- domized to a general population. Only patients who were ambulatory and able to participate were studied, which might have created a selection bias.

Pulmonary function testing may provide an interventational opportunity in the United States. Since early intervention may alter the course and prognosis of OLD, it is important that all clinicians who encounter smokers and any patient with respiratory symptoms, particularly those over age 45 years, be able to make an accurate diagnosis. Previous studies have shown, though, that
The National Lung Health Education Program is a new health care initiative aimed at involving primary care physicians in the early identification and treatment of obstructive lung disease. The National Lung Health Education Program is promoting the widespread use of simple office spirometry to measure the FEV₁, FVC, and FEV₁/FVC ratio. The present study demonstrates that a significant proportion of the US population older than 45 years has low lung function, which may represent unrecognized and potentially treatable OLD. Spirometry remains the most efficient means of identifying and treating this population.

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REFERENCES


symptoms alone are not adequate to diagnose COPD, and that spirometry may need to be more widely used to detect early disease.

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