ECRONICON OPEN ACCESS

EC PULMONOLOGY AND RESPIRATORY MEDICINE

Research Article

Prevalence and Factors Associated with Self-Reported Chronic Obstructive Pulmonary Disease among Adults Aged 40 - 79: The National Health and Nutrition Examination Survey (NHANES) 2007-2012

Timothy Tilert[1]*, Ryne Paulose-Ram[1], Donna Howard[2], James Butler[2], Sunmin Lee[3] and Min Qi Wang[2]

[1]Division of Health and Nutrition Examination Surveys, National Center for Health Statistics, Centers for Disease Control and Prevention, Hyattsville, Maryland, USA

[2]Department of Behavioral and Community Health, University of Maryland School of Public Health, Maryland, USA

[3]Department of Epidemiology and Biostatistics, University of Maryland School of Public Health, Maryland, USA

***Corresponding Author:** Timothy Tilert, Division of Health and Nutrition Examination Surveys, National Center for Health Statistics, Centers for Disease Control and Prevention, Hyattsville, Maryland, USA.

Received: July 13, 2018; **Published:** August 28, 2018

Abstract

Introduction: Chronic obstructive pulmonary disease (COPD) is a respiratory disease that often goes undiagnosed, particularly in its early stages.

Objective: To examine sociodemographic, general health, and COPD specific factors, including severity of lung obstruction, that are associated with healthcare provider-diagnosed COPD among U.S. adults.

Methods: NHANES cross-sectional data collected from 2007 - 2012 on adults aged 40 - 79 years (n = 10,219) were analyzed. The primary outcome was self-reported COPD diagnosis with predictive factors analyzed via chi-square and logistic regression analyses.

Results: During 2007 - 2012, 5.2% of US adults aged 40-79 reported being diagnosed with COPD. Among those diagnosed, 50.8% reported fair or poor health, 47.1% were currently smoking cigarettes, 49.1% were taking prescription respiratory medication, 36.4% had moderate or worse lung obstruction, and nearly 90% had one or more respiratory symptoms. Logistic regression revealed positive associations between receiving a COPD diagnosis and the following: being white (AOR: 3.08, 95% CI: 1.82 - 5.20); being aged 60 - 79 years (AOR: 1.65, 95% CI: 1.07 - 2.53); reporting fair/poor health (AOR: 2.91, CI: 1.55 - 5.46); having 4 - 9 (AOR: 3.5, CI: 1.3 - 9.4) or 10 or more healthcare visits in prior year (AOR: 5.06, CI: 1.62 - 15.77); being a former (AOR: 1.75, CI: 1.2 - 2.5) or current smoker (AOR: 1.70, CI: 1.17 - 2.48); having more severe lung obstruction (AOR: 4.90, CI: 3.28 - 7.32); having 3 or more respiratory symptoms (AOR: 22.07, CI: 12.03 - 40.49).

Conclusions: Multiple factors are associated with self-reported COPD diagnosis with number of reported respiratory symptoms having the strongest association. After controlling for other factors, having mild lung obstruction was not associated with being diagnosed.

Keywords: *COPD; Diagnosis; Prevalence; Spirometry; NHANES; Smoking*

Introduction

Chronic obstructive pulmonary disease (COPD) is a lung disease characterized by persistent respiratory symptoms and chronic airflow obstruction that is usually progressive and often interferes with normal breathing. The airflow obstruction is caused by a mixture of small airway disease (obstructive bronchiolitis) and parenchymal destruction (emphysema) with the relative contributions, and impact, of each

varying from person to person [1]. While the more familiar terms 'chronic bronchitis' and 'emphysema' are no longer used in the formal definition of COPD, they are still included within the COPD diagnosis [2].

COPD develops gradually and is usually diagnosed in persons 40 years and older [1]. The most common respiratory symptoms include breathlessness (dyspnea), chronic cough, chronic sputum production and wheezing though the presence of the characteristic symptoms of COPD may precede the development of airflow limitation by many years [1]. Conversely, significant airflow limitation may develop without overt symptoms. As a result, COPD is difficult to detect in its early stages and mild COPD often goes undiagnosed. COPD diagnosis is further complicated by the presence of other disorders, such as asthma and bronchiectasis, which may also present with similar symptoms and signs. Consequently, it is estimated that between 50 and 80% of all COPD cases go undiagnosed [2-5].

The main objective of this study was to examine sociodemographic, general health, and COPD specific factors, including severity of lung obstruction, that are associated with healthcare provider-diagnosed COPD among U.S. adults.

Material and Methods

Study and data

This study was based on analyses of the 2007-2012 National Health and Nutrition Examination Survey (NHANES) data, which were the years that spirometry testing was conducted on the survey. NHANES is a cross-sectional survey of the civilian, non-institutionalized U.S. population conducted by the National Center for Health Statistics [6]. Data were collected via household interviews and standardized physical examinations in specially equipped mobile examination centers (MEC). The NHANES samples are selected through a complex, multistage, probability design. The 2007-2012 NHANES cycles oversampled major U.S. demographic subgroups including Hispanic and Black persons, low income white persons, and persons aged 80 years and older. Additionally, Asian persons were oversampled in 2011-2012. The procedures to select the sample and conduct the interview and examination have been specified elsewhere [7]. Informed consent was obtained from all participants and the NCHS Research Ethics Review Board approved the protocol [8].

Analyses were conducted on data collected from adults aged 40 to 79 years old. The lower boundary of the analyzed age cohort (40 years) was based on guidelines for diagnosis which recommend considering spirometry in symptomatic patients over the age of 40 years [1]. The upper boundary of the analyzed age cohort (79 years) was selected as this was the maximum eligible age for the NHANES spirometry examination.

During 2007 - 2012, 14,825 persons aged 40-79 years were eligible for the survey, 10,531 (71%) were interviewed and 10,219 (69%) were examined in the NHANES MEC.

Self-reported, healthcare-provider diagnosed COPD

During the in-home interview participants were asked detailed questions on specific medical conditions. A participant was classified as having healthcare provider-diagnosed COPD if they responded affirmatively to either of the following questions on emphysema or chronic bronchitis: "Has a doctor ever told you that you have emphysema?" or "Do you still have chronic bronchitis?" [9,10].

Demographic and other covariates

Demographic data were collected during the household interview. Age was categorized as 40 - 59 and 60 - 79 years. Self-reported race and Hispanic origin were categorized as non-Hispanic white, non-Hispanic black, and Hispanic. Due to small sample size and heterogeneity of group, participants who reported other race or Hispanic groups (including multiple races) were not reported separately but were included in total estimates. Self-reported education was categorized as less than 12th grade, high school graduate or equivalent, and some college to include anyone who had attended college for any length of time.

General health status was categorized as very good or excellent, good, and fair or poor. The number of times in the past year a person reported seeing a doctor or healthcare professional was categorized as collected: none, 1, 2 or 3, 4 to 9 and 10 or more with the exception of the two highest categories (10 - 12 and 13 or more) which were combined for a more balanced data distribution. Presence of co-morbid conditions (coronary heart disease, stroke, cancer/malignancy, diabetes and hypertension) were identified based on affirmative responses to being told by a doctor or other health professional that he/she had the particular condition. Number of co-morbid medical conditions was derived based on the presence of these five conditions.

Cigarette smoking

A current smoker was a respondent who reported smoking at least 100 cigarettes in their lifetime and at the time of the interview reported smoking every day or some days OR by a serum cotinine value greater than 10 ng/mL [11]. A former smoker was a respondent who reported smoking at least 100 cigarettes during their lifetime but currently did not smoke. A never smoker was a participant who reported smoking fewer than 100 cigarettes during their lifetime.

Respiratory symptoms and medication use

Presence of chronic cough was defined as affirmative responses to "Do you usually cough on most days for 3 consecutive months or more during the year?" and the follow-up question that the coughing had been for at least 2 years. Presence of chronic phlegm was defined as affirmative responses to "Do you bring up phlegm on most days for 3 consecutive months or more during the year?" and the follow-up question that bringing up of phlegm had been for at least 2 years. Presence of wheezing was defined by the question, "In the past 12 months, how many attacks of wheezing or whistling have you had?" Number of attacks was categorized as 0, 1 - 3 and 4 or more. Presence of dyspnea was based on an affirmative response to "Have you had shortness of breath either when hurrying on the level or walking up a slight hill?" Number of respiratory symptoms was derived based on the presence of these four symptoms.

Participants were defined as using a respiratory medication if they reported past 30-day use of any of the following drug classes based on the Global Initiative for Chronic Obstructive Lung Disease (GOLD) treatment guidelines: long-acting bronchodilator, short-acting bronchodilator, inhaled corticosteroid, systemic corticosteroid, methylxanthine, and leukotriene modifier.

Spirometric assessment of COPD and lung obstruction severity

NHANES spirometry data were used to identify persons with lung obstruction and assess severity levels. Spirometry testing was performed on NHANES participants aged 6 - 79 years during 2007 - 2012. It was conducted in accordance with recommendations of the American Thoracic Society [12] using Ohio 822/827 dry-rolling seal volume spirometers. The full exam protocol is detailed elsewhere [13]. Using pre-bronchodilator spirometry values, participants were defined as having evidence of COPD when the ratio of the forced expiratory volume in one second (FEV1) to the forced vital capacity (FVC) is less than the lower limit of normal (LLN) representing the lower 5^{th} percentile based on person's age, sex, height, and race/ethnicity [14]. LLN values were determined using normative reference equations developed from NHANES III data by Hankinson., *et al* [15].

Adults showing no spirometric evidence of COPD were categorized as having no measured lung obstruction. Those showing spirometric evidence of COPD were further categorized as having mild (FEV1 > 70% predicted) or moderate or worse (FEV1 ≤ 70% predicted) lung obstruction [14]. Percent of predicted FEV1 was defined as the observed FEV1 value divided by the predicted FEV1 value estimated for a person of the same age, gender, race/ethnicity, and height using race-specific reference equations [15]. Reference values are available for non-Hispanic white, non-Hispanic black, and Mexican Americans. For the Hispanic group, the reference values provided for Mexican Americans were used.

Prior to the spirometry examination, participants were asked if they currently had a breathing problem that required the use of supplemental oxygen during the daytime. Persons who reported a healthcare provider diagnosis of COPD and were excluded from the spirometry exam due to daily supplemental oxygen use, which is suggestive of advanced disease, were assigned a lung obstruction severity of moderate or worse (n = 84).

Statistical methods

Statistical analyses were performed using STATA™ version 13.1 (StataCorp, College Station, TX). Examination sample weights were used to account for differential probabilities of selection, nonresponse, and non-coverage. Taylor series linearization was used to calculate standard errors to account for the complex sampling design. Differences in the prevalence of diagnosed COPD between subgroups was evaluated using T-tests for categorical variables and linear trend tests using linear regression and orthogonal contrasts for continuous variables. Chi-square tests were performed to examine the association between covariates and the presence of a COPD diagnosis. Multivariable logistic regression was used to assess predictors of diagnosis along with their associated odds ratios and statistical significance. All reported estimates have a relative standard error ≤30% [16].

Missing data

The percentage of missing data at the individual variable level ranged from 0% (multiple variables) to approximately 20% for the spirometry measures with the overall fraction of missing information for the aggregated NHANES data being roughly 4%. To assess the impact of the missing data, sensitivity analyses were conducted on the proportions with diagnosed COPD and the characteristics of those with and without diagnosed COPD using 40 multiply imputed datasets. As estimates were similar between those based on the unmodified (complete case) data and those based on the multiply imputed data, all estimates presented here are based on the unmodified data for ease of reproducibility.

Results

Prevalence of diagnosed COPD among US adults 40 - 79 years

During 2007 - 2012, 5.2% of adults aged 40 - 79 years reported being diagnosed with COPD, which includes ever emphysema and current chronic bronchitis. Prevalence was similar by sex, higher among non-Hispanic white (5.9%) and non-Hispanic black (4.6%) adults than Hispanic (2.0%) adults, and higher among adults aged 60 - 79 (8.3%) than 40 - 59 (3.6%) years (Table 1). Prevalence of diagnosed COPD significantly decreased with increasing education going from 9.2% among adults with less than a high school education to 3.7% among those with any college education. Prevalence was 14.3% among adults who reported fair or poor health status compared to 5.0% who reported good health and 1.7% who reported very good/excellent health. Prevalence of diagnosed COPD increased as the number of health care visits in the past year increased going from 1.8% among those with 1 visit to 12.6% among those with 10 or more visits.

Table 1: *Prevalence of self-reported diagnosed COPD among US adults aged 40-79 years: NHANES, 2007-2012.*

[a]*: Categories may not sum to the total (10,219) due to missing data.*

[b]*: Self-reported, health professional-diagnosed COPD was assessed by an affirmative response to either ever having emphysema (MCQ160G) or still having chronic bronchitis (MCQ170K).*

[c]*: Values are based on two-sided t-tests on the difference in prevalence between the designated subgroup and the reference subgroup.*

[d]*: Values are based on linear trend test using linear regression and orthogonal contrasts.*

Characteristics (n = 10,219 persons)	n[a]	Weighted percent with diagnosed COPD[b] (SE)	p-value[c]
Total	10,219	5.2% (0.4)	-
Gender			
Male	5,016	4.8% (0.5)	Ref
Female	5,203	5.6% (0.5)	0.216
Race and ethnic origin			
Non-Hispanic white	4,435	5.9% (0.5)	Ref
Non-Hispanic black	2,353	4.6% (0.6)	0.074
Hispanic	2,632	2.0% (0.3)	< 0.001
Age in years			
40 - 59	5,593	3.6% (0.4)	Ref
60-79	4,626	8.3% (0.7)	< 0.001
Education			<0.001[d]
Less than 12th grade	3,104	9.2% (1.1)	
HS Grad/GED/Equivalent	2,329	5.6% (0.7)	
Any College	4,774	3.7% (0.3)	
General health condition			< 0.001[d]
Very good or excellent	3,027	1.7% (0.3)	Ref
Good	3,641	5.0% (0.7)	< 0.001
Fair or poor	2,598	14.3% (1.2)	< 0.001

Other medical conditions			
Coronary heart disease	507	15.6% (2.4)	-
Stroke	493	16.2% (2.1)	-
Cancer	1,171	9.2% (1.4)	-
Diabetes	2,024	10.0% (1.1)	-
Hypertension	4,710	7.3% (0.6)	-
Number of other medical conditions			< 0.001[d]
0	4,403	2.7% (0.4)	
1	3,420	6.0% (0.5)	
2	1,810	8.4% (1.1)	
3 or more	586	17.3% (2.4)	
Number of healthcare visits in past year			< 0.001[d]
0	1,367	1.9% (0.5)	
1	1,570	1.8% (0.4)	
2 or 3	2,774	3.1% (0.4)	
4 to 9	2,910	7.1% (0.8)	
10 or more	1,593	12.6% (1.5)	
Smoking status			
Never smoker	4,990	2.1% (0.2)	Ref
Former smoker	2,712	6.6% (0.6)	< 0.001
Current smoker	2,513	10.2% (0.9)	< 0.001
Measured lung obstruction			
No measured lung obstruction	7,247	3.1% (0.4)	Ref
Mild	722	4.1% (0.7)	0.147
Moderate or worse	466	33.7% (2.5)	< 0.001
Respiratory symptoms			
Chronic cough	893	23.5% (1.9)	-
Chronic phlegm	755	22.5% (2.1)	-
Wheezing episodes past year			< 0.001[d]
0	8,696	2.4% (0.2)	
1 - 3	798	17.2% (1.8)	
4 or more	662	28.5% (2.6)	
Dyspnea	3,318	13.2% (1.0)	-
Number of respiratory symptoms			< 0.001[d]
0	6,110	0.9% (0.2)	
1	2,575	5.8% (0.7)	
2	973	14.9% (1.5)	
3 or more	561	36.7% (2.9)	

Prevalence of COPD diagnosis was greater among adults who were current smokers (10.2%) than past (6.6%) or never (2.1%) smokers. A third (33.7%) of adults with moderate or worse lung obstruction had been diagnosed with COPD compared to 4.1% of those with mild lung obstruction and 3.1% with no lung obstruction. As the number of respiratory symptoms increased the prevalence of diagnosed COPD also increased. Specifically, prevalence was less than 1% (0.9%) when no respiratory symptoms were reported, 5.8% with 1 symptom, 14.9% with 2, and 36.7% with 3 or more symptoms.

Characteristics of US adults aged 40 - 79 with and without diagnosed COPD

Table 2 provides the characteristics of those with diagnosed COPD and those without diagnosed COPD, which includes those with undiagnosed COPD as well as those without the condition. Adults aged 40 - 79 years with diagnosed COPD were significantly different from those without diagnosed COPD in all sociodemographic and health characteristics examined, except gender (Table 2). Specifically, among those with diagnosed COPD, a higher proportion were non-Hispanic white (81.2% vs 71.4%), aged 60 - 79 (54.5% vs. 33.4%), and had less higher education (40.9% vs 58.4%).

Table 2: *Characteristics of US adults aged 40-79 years with and without self-reported diagnosed COPD by socio-demographic factors, health status and chronic conditions: NHANES, 2007-2012.*

[a]: Self-reported, health professional-diagnosed COPD was assessed by an affirmative response to either ever having emphysema (MCQ160G) or still having chronic bronchitis (MCQ170K).

[b] Chi-square values are based on the difference in the percentage of those self-reporting/not self-reporting a COPD diagnosis between categories. For the condition and symptom variables, it is the difference in the percentage of those self-reporting/not self-reporting a COPD diagnosis between those reporting/not reporting the condition or symptom.

Characteristics (n = 10,219 persons)	With diagnosed COPD[a] (n = 566)	Without diagnosed COPD[a] (n = 9,653)	p-value[b]
Gender			0.219
Male	44.0% (3.3)	48.2% (0.6)	
Female	56.0% (3.3)	51.8% (0.6)	
Race and ethnic origin			< 0.001
Non-Hispanic white	81.2% (2.7)	71.4% (2.0)	
Non-Hispanic black	9.6% (1.6)	11.0% (1.1)	
Hispanic	4.2% (0.8)	11.1% (1.3)	
Age in years			< 0.001
40 - 59	45.5% (2.6)	66.6% (0.6)	
60 - 79	54.5% (2.6)	33.4% (0.6)	
Education			< 0.001
Less than 12th grade	33.8% (2.6)	18.3% (0.9)	
HS Grad/GED/Equivalent	25.3% (2.5)	23.3% (0.9)	
Any College	40.9% (3.2)	58.4% (1.4)	
General health condition			< 0.001
Very good or excellent	13.8% (2.2)	44.2% (1.0)	
Good	35.4% (3.2)	38.4% (0.9)	
Fair or poor	50.8% (3.3)	17.3% (0.7)	

Other medical conditions			
Coronary heart disease	12.7% (1.6)	3.8% (0.3)	< 0.001
Stroke	10.9% (1.4)	3.1% (0.2)	< 0.001
Cancer	21.9% (2.2)	11.9% (0.5)	< 0.001
Diabetes	28.5% (2.7)	14.2% (0.5)	< 0.001
Hypertension	57.2% (2.8)	40.0% (0.7)	< 0.001
Number of other medical conditions			< 0.001
0	24.6% (2.5)	49.7% (0.7)	
1	37.6% (2.2)	32.5% (0.6)	
2	23.2% (2.5)	14.0% (0.5)	
3 or more	14.6% (1.9)	3.8% (0.2)	
Number of healthcare visits in past year			< 0.001
0	4.6% (1.2)	13.1% (0.5)	
1	5.7% (1.3)	16.7% (0.4)	
2 or 3	17.1% (2.3)	29.6% (0.8)	
4 to 9	38.9% (2.8)	27.8% (0.5)	
10 or more	33.7% (2.9)	12.9% (0.6)	
Smoking status			< 0.001
Current smoker	47.1% (3.1)	22.7% (0.8)	
Former smoker	33.4% (2.8)	26.0% (0.8)	
Never smoker	19.6% (1.6)	51.3% (0.8)	
Disease reported			
None	-	100.0% (0.0)	-
Emphysema	39.5% (2.7)	N/A	
Chronic bronchitis	45.3% (2.6)	N/A	
Both	15.2% (1.9)	N/A	
Taking prescription respiratory medication	49.1% (3.0)	5.6% (0.4)	< 0.001
Measured lung obstruction severity			< 0.001
No measured lung obstruction	55.7% (3.0)	87.0% (0.6)	
Mild	7.9% (1.1)	9.3% (0.5)	
Moderate or worse	36.4% (2.9)	3.6% (0.3)	
Respiratory symptoms			
Chronic cough	41.4% (2.5)	7.3% (0.5)	< 0.001
Chronic phlegm	30.9% (2.4)	5.7% (0.3)	< 0.001
Wheezing episodes past year			< 0.001
0	40.7% (3.2)	88.8% (0.4)	
1-3	25.4% (2.5)	6.6% (0.4)	
4 or more	33.9% (3.0)	4.6% (0.3)	
Dyspnea	76.5% (2.7)	27.7% (0.8)	< 0.001
Number of respiratory symptoms			< 0.001
0	10.7% (1.9)	64.1% (0.9)	
1	27.2% (2.7)	24.3% (0.6)	
2	26.2% (2.4)	8.2% (0.4)	
3 or more	36.0% (2.2)	3.4% (0.3)	

Over one half (50.8%) of adults with diagnosed COPD reported fair or poor health while only 13.8% reported very good or excellent health compared to 17.3% reporting fair/poor health and 44.2% reporting very good or excellent health among those without diagnosed COPD. Slightly more than three-quarters of adults (75.4%) with diagnosed COPD reported one or more of the following co-morbid conditions: hypertension, diabetes, cancer, heart disease, or stroke compared to 50.3% reporting one or more of these conditions for those without diagnosed COPD. 72.6% of adults with COPD reported having 4 or more healthcare visits in the prior year compared to only 40.7% of adults without COPD.

Nearly half (47.1%) of adults with diagnosed COPD currently smoked cigarettes and 33.4% were former smokers. These proportions were significantly different from adults without diagnosed COPD where more than one-half (51.3%) were never cigarette smokers and 22.7% currently smoked.

Among adults with diagnosed COPD, 39.5% reported having been diagnosed with emphysema alone, 45.3% reported current chronic bronchitis alone and 15.2% reported both diseases. Nearly half (49.1%) reported using a prescribed respiratory drug. Of those with diagnosed COPD, 55.7% showed no spirometric evidence of lung obstruction while 7.9% presented with mild lung obstruction and 36.4% had moderate or worse lung obstruction. Among adults without diagnosed COPD, 87% had no measured lung obstruction. However, 9.3% had mild lung obstruction and 3.6% had moderate or worse lung obstruction.

Respiratory symptoms were prevalent among adults with diagnosed COPD with 76.5% reporting dyspnea or shortness of breath, 41.4% having chronic cough, 30.9% chronic phlegm, and 59.3% at least one wheezing episode in the past year. Nearly 90% (89.4%) reported having at least one of these four respiratory symptoms compared to 35.9% among those without diagnosed COPD.

Predictors of being diagnosed with COPD by a healthcare professional

Table 3 details the adjusted odds ratios, confidence intervals, and associated *p*-values from multivariable logistic regression modeling used to examine the association of various covariates with a COPD diagnosis outcome. After controlling for all the other variables in the model, non-Hispanic blacks were 49% less likely (AOR = 0.51, 95% CI = 0.35 to 0.74) and Hispanics were 68% less likely (AOR = 0.32, 95% CI = 0.19 to 0.55) than non-Hispanic whites to be diagnosed with COPD. Persons aged 60-79 years were 65% more likely (AOR = 1.65, 95% CI = 1.07 to 2.53) than persons aged 40-59 years to be diagnosed with COPD. Those reporting fair or poor health were nearly three times as likely to be diagnosed with COPD (AOR = 2.91, 95% CI = 1.55 to 5.46) than those reporting being in very good or excellent health. Persons reporting 4 to 9 healthcare visits in the past year were 3.49 times as likely (AOR = 3.49, 95% CI = 1.30 to 9.39) to be diagnosed with COPD than those with no healthcare visits in the prior year and those with 10 or more healthcare visits in the past year were over 5 times as likely (AOR = 5.06, 95% CI = 1.62 to 15.77) to be diagnosed than those with no healthcare visits in the previous year.

Table 3: *Adjusted logistic regression analysis [a] of factors associated with self-reported diagnosed COPD [b] among US adults aged 40-79 years: NHANES, 2007-2012.*

[a]: Multivariable logistic regression model included all variables shown in table above.

[b]: Self-reported, health professional-diagnosed COPD was assessed by an affirmative response to either ever having emphysema (MCQ160G) or still having chronic bronchitis (MCQ170K).

[c]: Medical conditions include self-reported healthcare provider diagnosed coronary heart disease, stroke, cancer, diabetes, or hypertension.

[d]: Respiratory symptoms include self-reported chronic cough (3 consecutive months or more during year AND for at least 2 years), chronic phlegm (3 consecutive months or more during year AND for at least 2 years), wheezing episode (past 12 months), or dyspnea.

Characteristics (n = 7,839 persons in model)	Adjusted Odds Ratio (95% CI)	p-value
Gender		
Male	Ref	-
Female	0.76 (0.52, 1.12)	0.166
Race and ethnic origin		
Non-Hispanic white	Ref	-
Non-Hispanic black	0.51 (0.35, 0.74)	0.001
Hispanic	0.32 (0.19, 0.55)	< 0.001
Age in years		
40 - 59	Ref	-
60 - 79	1.65 (1.07, 2.53)	0.023
Education		
Less than 12th grade	Ref	-
HS Grad/GED/Equivalent	0.68 (0.39, 1.17)	0.159
Any College	0.71 (0.44, 1.16)	0.170
General health condition		
Very good or excellent	Ref	-
Good	1.54 (0.94, 2.53)	0.085
Fair or poor	2.91 (1.55, 5.46)	0.001
Number of other medical conditions[c]		
0	Ref	-
1	1.10 (0.68, 1.78)	0.695
2	1.12 (0.61, 2.05)	0.712
3 or more	1.32 (0.68, 2.54)	0.402
Number of healthcare visits in past year		
0	Ref	-
1	2.05 (0.62, 6.77)	0.233
2 or 3	1.88 (0.70, 5.08)	0.207
4 to 9	3.49 (1.30, 9.39)	0.014
10 or more	5.06 (1.62, 15.77)	0.006
Smoking status		-
Never smoker	Ref	
Former smoker	1.75 (1.23, 2.48)	0.002
Current smoker	1.70 (1.17, 2.48)	0.007
Measured lung obstruction severity		
No measured lung obstruction	Ref	-
Mild	0.81 (0.55, 1.20)	0.293
Moderate or worse	4.90 (3.28, 7.32)	< 0.001
Number of respiratory symptoms[d]		
0	Ref	-
1	3.91 (2.11, 7.24)	< 0.001
2	9.57 (5.43, 16.88)	< 0.001
3 or more	22.07 (12.03, 40.49)	< 0.001

Former smokers and current smokers were 75% and 70% more likely (AOR = 1.75, 95% CI = 1.23 to 2.48 and AOR = 1.70, 95% CI = 1.17 to 2.48, respectively) than never smokers to be diagnosed with COPD.

In terms of lung obstruction severity, adults with moderate or worse lung obstruction were nearly five times as likely (AOR = 4.90, 95% CI = 3.28 to 7.32) than those with no measured lung obstruction to be diagnosed with COPD. Having mild disease was not significantly associated with being diagnosed with COPD.

Finally, the likelihood of being diagnosed with COPD significantly increased as the number of reported respiratory symptoms increased. Specifically, adults reporting 1 respiratory symptom were nearly 4 times as likely (AOR = 3.91, 95% CI = 2.11 to 7.24), those reporting 2 respiratory symptoms were nearly 10 times as likely (AOR = 9.57, 95% CI = 5.43 to 16.88) and those reporting 3 or more respiratory symptoms were about 22 times as likely (AOR = 22.07, 95% CI = 12.03 to 40.49) than those with no respiratory symptoms to be diagnosed with COPD.

Discussion

Approximately 5.2% of US adults aged 40 - 79 years were estimated to have been diagnosed with COPD based on NHANES 2007 - 2012. This estimate is based on persons reporting ever having emphysema or currently having chronic bronchitis, which is similar to previous studies using NHANES [9,10]. Case-definitions using other surveys (e.g. BRFSS, BOLD, NHIS), however, have included different combinations of the variables on ever emphysema, ever chronic bronchitis, current chronic bronchitis, and COPD. Based on NHIS 2012-2014, Ward., *et al.* found that the prevalence of self-reported diagnosed COPD increased when an explicit question on COPD was included with the ever emphysema and ever chronic bronchitis questions [17]. Such a question, however, was unavailable on NHANES during 2007 - 2012 when the lung function testing was conducted on the survey. In terms of bronchitis, our prevalence estimate would have been higher at 8.6% (SE 0.6) if we had used ever chronic bronchitis rather than current chronic bronchitis. However, the confirmation of current bronchitis after affirmation of ever bronchitis allows the exclusion of respondents who may have once had acute bronchitis but currently do not.

Univariate analyses showed significant differences between those with and without diagnosed COPD across a number of sociodemographic factors with disproportionate percentages of those with a COPD diagnosis being older, less educated, with more co-morbid chronic conditions and presenting more respiratory symptoms. While the recent BRFSS analyses by Kosacz., *et al.* showed a higher prevalence of self-reported COPD in men than women [18], our results showed no appreciable difference in COPD diagnosis status by gender. A possible narrowing of the gender gap is alluded to in the most recent GOLD report which noted that while most studies in the past showed COPD prevalence to be greater among men than women, data from developed countries show that the prevalence of the disease is now almost equal in men and women [1]. It was further suggested in the GOLD report that this narrowing of the COPD prevalence gap between genders is likely due to changing patterns of tobacco smoking. Similar to our univariate results, the previously mentioned BRFSS analyses reported higher proportions of self-reported COPD among older persons and those who did not graduate from high-school [18]. After controlling for other covariates, however, we found education level to no longer be associated with a COPD diagnosis.

Cigarette smoking is widely recognized as the most significant environmental risk factor for COPD. Accordingly, we found over 80% of adults with diagnosed COPD were ever-smokers versus less than 49% who ever smoked among those without diagnosed COPD. A number of studies have suggested that the receipt of a COPD diagnosis could contribute to reduced levels of smoking among those with disease [19,20]. Yet, in spite of their COPD diagnosis, we found nearly 50% (47.1%) of those diagnosed with COPD were still currently smoking. This figure is higher than the 36.7% prevalence of current smoking among those reporting a COPD diagnosis in the 2011 BRFSS data [21] but virtually mirrors the 47.3% of adults with self-reported COPD who were current smokers in the optional smoking cessation module of the 2011 BRFSS [22].

Although COPD is defined based on airflow limitation, the impact of symptoms usually determines the decision to seek medical help [1]. Consistent with this, we found nearly 90% of adults with diagnosed COPD reporting one or more respiratory symptoms. Further, adults with 3 or more respiratory symptoms were 22 times as likely to be diagnosed with COPD than those with no respiratory symptoms. Chronic dyspnea is the most characteristic symptom of COPD [1] and our results showed that three-fourths of adults with a COPD diagnosis reported having dyspnea. The relationship between COPD and respiratory symptoms is not always predictable, however, given that symptoms may precede the development of airflow limitations and, conversely, not all persons with lung obstruction exhibit symptoms [1]. We found that over half (55.7%) of adults with diagnosed COPD had no measured lung obstruction though almost all presented with one or more respiratory symptoms (results not shown). Lamprecht., *et al.* found that only 36.4% of their aged 40+ study participants who reported having COPD had airway obstruction, the remaining 63.6% had a COPD diagnosis with no airway obstruction [3]. These cases where there is a reported COPD diagnosis but no measured lung obstruction may be due to a number of factors including, but not limited to, improved lung function resulting from treatment, diurnal variation in lung function measures, participants' erroneous reporting of a diagnosis or physician misdiagnosis. We also found that nearly 13% of adults 40 - 79 years who did not report a COPD diagnosis had spirometric evidence of lung obstruction. However, nearly three-quarters of them (9.3%) had mild lung obstruction. Based on the adjusted regression analysis, having mild lung obstruction was not significantly associated with diagnosis while adults with moderate or worse lung obstruction were four times as likely to be diagnosed than those with no lung obstruction. These findings relating symptoms, airflow limitation and diagnosis add support to the GOLD committee premise that while COPD is defined based on airflow limitation, diagnosis in the clinical setting may be driven by the presentation of respiratory symptoms.

Limitations to the Study

Limitations to this study include those normally associated with cross-sectional studies, most notably it is impossible to determine cause-effect or temporal relationships. A number of items used in these analyses were also collected using questionnaires and are subject to recall bias and other limitations of self-reported data. Additionally, as NHANES does not include persons from institutionalized settings (e.g., nursing facilities and assisted-care facilities) and because COPD is associated with older age, our results may reflect an underestimation of the true prevalence of diagnosed COPD. Finally, in order to include spirometry data, these analyses were limited to using data last collected in 2012. This is a limitation as there are newer data available for the estimation of self-reported COPD prevalence. The greatest strength of this study is its use of NHANES nationally representative data which included both self-reported diagnosis information as well as objective lung function measures to afford comparisons between self-reported COPD and measured lung obstruction.

Conclusions

Approximately 5.2% of US adults aged 40 - 79 years were estimated to have self-reported COPD during 2007 - 2012. Among those with diagnosed COPD, over one third had moderate or worse lung function, just under half were still currently smoking, and nearly 90% had at least one respiratory symptom. Multiple factors were found to be associated with the receipt of a COPD diagnosis with number of reported respiratory symptoms having the strongest association. After controlling for other factors, having mild lung obstruction was not associated with a COPD diagnosed.

Declarations of Interest

None.

Authors' Contributions

TT conceived of the analyses, analyzed and interpreted the data, and drafted the manuscript. RP provided significant conceptual input, assisted with analysis of the data, and helped to draft the manuscript. MW, DH, JB and SL each provided conceptual input and interpretation of the data along with critical manuscript revisions of important intellectual content. All authors read and approved the final manu-

Disclaimer

The findings and conclusions in this publication are those of the authors and do not necessarily represent the official position of the National Center for Health Statistics of the Centers for Disease Control and Prevention.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Bibliography

1. GOLD 2017 Global Strategy for the Diagnosis, Management and Prevention of COPD (2018).
2. "WHO | COPD: Definition". WHO (2018).
3. Lamprecht Bernd., *et al*. "Determinants of Underdiagnosis of COPD in National and International Surveys". *Chest* 148.4 (2015): 971-985.
4. Lindberg Anne., *et al*. "Prevalence and Underdiagnosis of COPD by Disease Severity and the Attributable Fraction of Smoking". *Respiratory Medicine* 100.2 (2006): 264-272.
5. Mannino David M., *et al*. "Chronic Obstructive Pulmonary Disease Surveillance-United States, 1971-2000". *Respiratory Care* 47.10 (2002): 1184-1199.
6. NHANES - National Health and Nutrition Examination Survey Homepage (2018).
7. Zipf George., *et al*. "National Health and Nutrition Examination Survey: Plan and Operations, 1999-2010". *Vital Health Statistics 1* 56 (2013): 1-37.
8. NHANES - NCHS Research Ethics Review Board Approval (2017).
9. Mannino David M., *et al*. "Asthma and Chronic Obstructive Pulmonary Disease Overlap: The Effect of Definitions on Measures of Burden". *Chronic Obstructive Pulmonary Diseases* 4.2 (2017): 87-96.
10. Halldin Cara N., *et al*. "Changes in Prevalence of Chronic Obstructive Pulmonary Disease and Asthma in the US Population and Associated Risk Factors". *Chronic Respiratory Disease* 12.1 (2015): 47-60.
11. Hukkanen Janne., *et al*. "Metabolism and Disposition Kinetics of Nicotine". *Pharmacological Reviews* 57.1 (2005): 79-115.
12. Miller Martin Raymond., *et al*. "Standardisation of Spirometry". *European Respiratory Journal* 26.2 (2005): 319-338.
13. NHANES - Respiratory Health - Bronchodilator Procedures Manual (2011).
14. Pellegrino Riccardo., *et al*. "Interpretative Strategies for Lung Function Tests". *European Respiratory Journal* 26.5 (2005): 948-968.
15. Hankinson John L., *et al*. "Performance of American Thoracic Society-Recommended Spirometry Reference Values in a Multiethnic Sample of Adults: The Multi-Ethnic Study of Atherosclerosis (MESA) Lung Study". *Chest* 137.1 (2010): 138-145.
16. NHANES - Analytic Guidelines, 1999-2010 (2013).
17. Ward Brian W., *et al*. "Measuring the Prevalence of Diagnosed Chronic Obstructive Pulmonary Disease in the United States Using Data From the 2012-2014 National Health Interview Survey". *Public Health Reports* 132.2 (2017): 149-156.

18. Kosacz NM., *et al*. "Chronic Obstructive Pulmonary Disease among Adults-United States, 2011". *MMWR. Morbidity and Mortality Weekly Report* 61.46 (2012): 938-943.

19. Danielsen Signe Elise., *et al*. "A New Diagnosis of Asthma or COPD Is Linked to Smoking Cessation - the Tromsø Study". *International Journal of Chronic Obstructive Pulmonary Disease* 11 (2016): 1453-1458.

20. Stratelis Georgios., *et al*. "The Impact of Repeated Spirometry and Smoking Cessation Advice on Smokers with Mild COPD". *Scandinavian Journal of Primary Health Care* 24.3 (2006): 133-139.

21. Cunningham Timothy J., *et al*. "Associations of Self-Reported Cigarette Smoking with Chronic Obstructive Pulmonary Disease and Co-Morbid Chronic Conditions in the United States". *COPD: Journal of Chronic Obstructive Pulmonary Disease* 12.3 (2015): 281-291.

22. Schauer Gillian L., *et al*. "Smoking Prevalence and Cessation Characteristics among U.S. Adults With and Without COPD: Findings from the 2011 Behavioral Risk Factor Surveillance System". *COPD: Journal of Chronic Obstructive Pulmonary Disease* 11.6 (2014): 697-704.

Volume 7 Issue 9 September 2018