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Airflow obstruction among ever-employed U.S. adults aged 18-79 years by industry and occupation: NHANES 2007-2008 to 2011-2012

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Abstract

Introduction—This study estimated the prevalence of spirometry-defined airflow obstruction by industry and occupation and chronic obstructive pulmonary disease (COPD) among ever-employed U.S. adults.

Methods—Data came from the National Health and Nutrition Examination Survey (NHANES) 2007–2008 to 2011–2012, a nationally representative study of the non-institutionalized civilian U.S. population. Data on respondent's current and/or longest held job were used to create prevalence estimates and adjusted prevalence odds ratios (PORs) for airflow obstruction and COPD.

Results—Among ever-employed U.S. adults, airflow obstruction prevalence was 12.40% and COPD was 3.47%. High airflow obstruction prevalence and significant PORs were reported in

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AUTHORS' CONTRIBUTIONS

LK, BD, and SF participated in the conception or design of the work; LK, BD, JH, and SF participated in the acquisition, analysis, and interpretation of data; LK and BD drafted the work; CH, JH, and SF revised the work critically for important intellectual content; and all authors provided final approval of this article to be published and agreement to be accountable for all aspects of the work.

DISCLOSURE (AUTHORS)

The authors declare no conflicts of interest.

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Steven B. Markowitz declares that he has no conflict of interest in the review and publication decision regarding this article.

INSTITUTION AND ETHICS APPROVAL AND INFORMED CONSENT

The study protocol for the National Health and Nutrition Examination Survey was approved by the NCHS Research Ethics Review Board (ERB). All participants provided written informed consent.

DISCLAIMER

The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the National Institute for Occupational Safety and Health, the National Health Center for Health Statistics' Research Data Center, the National Center for Health Statistics, or the Centers for Disease Control and Prevention. Mention of product names does not imply endorsement by NIOSH/CDC.

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

mining; manufacturing; construction; and services to buildings industries as well as extraction; bookbinders, prepress, and printing; installers and repairers; and construction occupations.

Conclusion—Prevalence of airflow obstruction varies by industry and occupation. Industries and occupations with increased risk were identified using the most current NHANES data including detailed occupations and spirometry.

Keywords

airflow obstruction; CDC; COPD; industry; occupation; occupational exposure; NHANES; prevalence

1 | INTRODUCTION

Spirometry-defined airflow obstruction is a key feature of obstructive lung diseases including chronic obstructive pulmonary disease (COPD).[1] Spirometry-based definitions are one method of characterizing airflow obstruction presence and severity while self-reported COPD is also used in epidemiological studies.[2] National Health and Nutrition Examination Survey (NHANES) 2007–2010 data indicated among U.S. adults aged 40–79 years, the prevalence of American Thoracic Society/European Respiratory Society (ATS/ERS) spirometry-defined airflow obstruction was 14.5% and the prevalence of self-reported COPD was 3.2%.[3,4]

COPD is primarily attributed to smoking, but exposure to occupational vapors, gases, dusts, and fumes is causally associated with increased levels of obstructive lung function impairment and increased prevalence of chronic bronchitis, as demonstrated by industry-specific epidemiological studies.[5–7] After adjusting for smoking status, an analysis of NHANES 1988–1994 data indicated workers in specific industry and occupation groups are more likely to have spirometry-defined obstructive lung disease (ratio of forced expiratory volume in the first second to forced vital capacity (FEV_1/FVC) < 0.70 and FEV_1 < 80% of the predicted value) including workers in rubber, plastics, and leather manufacturing industries; textile mill products manufacturing industries; Armed Forces industries; and food products manufacturing industries and freight, stock, and material handler occupations and Armed Forces occupations.[8] Among NHANES 2007–2008 ever-employed U.S. adults, the prevalence of spirometry-defined airflow obstruction was highest in the installation, maintenance and repair (22.1%) and construction and extraction (20.7%) 2002 U.S. Census Bureau major occupation groups.[9] However, airflow obstruction estimates for some occupation groups were unreliable and industry-specific estimates were not presented.[9] We calculated the current burden of spirometry-defined airflow obstruction and COPD for industry groups and for more specific occupation groups than were previously reported.[9]

2 | METHODS

2.1 | Study design and population

The NHANES is a continuous, cross-sectional survey conducted by the National Center for Health Statistics (NCHS). A complex, multistage probability sampling design is used to generate a representative sample of the civilian, non-institutionalized U.S. population.[10,11]

Participants receive a detailed in-home interview followed by a physical examination at a mobile examination center (MEC). Data are collected continuously, but released in 2-year cycles. Data from three 2-year cycles were included in the analysis: 2007–2008, 2009–2010, and 2011–2012. The examination response rate for each cycle was 75.4%, 77.3%, and 69.5% respectively.[12] These cycles contain the most current data on each respondent's longest held job and spirometry results.

In the 2007–2008 to 2011–2012 NHANES, 17392 persons aged 18–79 years provided interview data and attended the examinations in the MEC. Of the 17 392 that were eligible for spirometry (eligibility criteria for spirometry are available at http://www.cdc.gov/nchs/data/nhanes/nhanes_07_08/manual_mecinterview.pdf), 2511 were excluded for safety reasons or did not perform spirometry, 691 had poor quality spirometry data with grades D or F, and 533 were missing. Of the 13 657 with a complete spirometry exam and valid spirometry tests (quality grades A, B, or C), we excluded two participants without height measurements and 611 who have never been employed. Spirometry exclusion and quality details are discussed elsewhere.[13,14] The sample for the analysis of airflow obstruction included 13 044 ever-employed survey respondents aged 18–79 years.

Of 16 486 participants aged 20–79 years that were interviewed and attended the examination in the MEC, we excluded 709 who have never been employed resulting in 15 777 ever-employed respondents in the sample for the analysis of COPD. Respiratory health questions to determine COPD outcome were not asked of participants aged 18–19 years.

Study protocols were approved by NCHS' Research Ethics Review Board and informed consent was obtained from all participants.

2.2 | NHANES variableand outcomes

Body mass index (BMI) (kg/m^2) was generated from height and weight measurements obtained during the physical examination. Based on BMI, respondents' weight status was categorized as underweight ($<18.5\ kg/m^2$), normal weight ($18.5–24.9\ kg/m^2$), overweight ($25.0–29.9\ kg/m^2$), or obese ($\geq 30\ kg/m^2$).[15]

History of cigarette use was used to determine both smoking status (respondents aged 18–79 years) and cigarette pack-years (respondents aged 20–79 years). The definition of smoking status varied by age because respondents aged 18–19 years answered different smoking status questions than respondents aged 20–79 years. For respondents aged 18–19 years, never smokers were those who reported no use of tobacco or nicotine products in the past 5 days or use of tobacco or nicotine products in the past 5 days excluding cigarettes and ever smokers were those who reported using cigarettes in the past 5 days. For respondents aged 20–79 years, never smokers were those who reported smoking fewer than 100 cigarettes during their entire lifetime and ever smokers were those who reported smoking at least 100 cigarettes during their lifetime. For ever smokers, cigarette pack-years were calculated using the reported number of years smoked and the reported number of cigarettes smoked per day or the number of cigarettes they smoked per day when they last smoked cigarettes.

Respiratory health outcomes were identified using responses to questions asked in the household interview. Survey participants (aged 20–79 years) were considered to have self-reported chronic bronchitis or self-reported emphysema if they reported that a doctor or other health professional ever told them that they had chronic bronchitis and they still had chronic bronchitis or a doctor or other health professional ever told them that they had emphysema. For brevity, we refer to self-reported chronic bronchitis or self-reported emphysema as “COPD.”

Spirometry was performed following ATS/ERS recommendations using Ohio 822/827 dry-rolling seal volume spirometers.[16,17] Airflow obstruction was defined per ATS/ERS spirometry criterion (using pre-bronchodilator values) as $FEV_1/FVC <$ lower limit of normal (LLN) (ie, the lower 5th percentile).[2] Those with airflow obstruction were further evaluated to identify moderate and more severe airflow obstruction when $FEV_1/FVC <$ LLN and $FEV_1 < 70\%$ of the predicted value.[2] Normative reference equations developed from NHANES III data determined the predicted and LLN pulmonary function values.[18] To estimate reference values for the “other” race/Hispanic origin group, we applied a correction factor of 0.88 to the non-Hispanic white reference values which has been previously published.[14,19] For the “other Hispanic” group, we applied the reference values for Mexican Americans.[14]

We examined the longest held job of ever-employed participants (both currently working and those not working). Respondents aged 16 years and older were asked, “Which of the following were you doing last week?” Respondents who reported that they were, “working at a job or business” or “with a job or business but not at work” were asked to provide the name of their employer, the industry/business of their employer, what their job title/occupation was, and their main work activities at their job. Those respondents, as well as respondents who reported that they were, “looking for work” or “not working at a job or business” were then asked, “Thinking of all the paid jobs or businesses you ever had, what kind of work were you doing the longest?”

Respondents who were currently employed could state that their current job was also their longest held job or they could state that another job was their longest held job. Respondents who were not employed could state what their longest held job was from all the jobs they had previously held. Respondents then reported information about their longest held job (if different from their current job): the industry/business of their employer, their job title/occupation, and their main work activities at their job. Data collection procedures were the same across all three cycles. Workers who were not currently in the U.S. Armed Forces, but who stated that their longest held job was in the “Armed Forces,” were included in our analysis.

Using these data, the Centers for Disease Control and Prevention’s National Institute for Occupation Safety and Health (NIOSH) generated four-digit industry and occupation codes for each respondent’s current and/or longest held job using the U.S. Census Bureau’s 2002 version of its Occupation and Industry coding system.[20] The coding procedures remained the same across all three cycles. Four-digit industry and occupational coded NHANES data are not publicly available and were accessed via the NCHS’ Research Data Center.[21]

For this analysis, we combined 264 detailed, four-digit industry codes into 44 industry groups and 501 four-digit occupations into 57 occupation groups. An epidemiologist (LK) and Certified Industrial Hygienist (BD) first combined industry codes and occupation codes (a priori and blinded to the subject's airflow obstruction and COPD status) having a similar potential for respiratory hazards associated with COPD based on consensus and in consultation with the literature.[22] After applying theses initial industry and occupation groups to the data, industry and occupation groups were further combined with additional input from sociologist (SF) to have enough observations in each group for statistical analysis (Supplement Tables S1 and S2).

2.3 | Statistical analysis

Statistical analyses were performed using SAS® 9.4 (SAS Institute Inc., Cary, NC) complex survey procedures to adjust for differential probabilities of selection and the complex sampling design. Age-specific and age-standardized prevalence of airflow obstruction and COPD with corresponding 95% confidence intervals (CIs) were calculated for the ever-employed civilian, non-institutionalized U.S. population using PROC SURVEYREG for demographic and health characteristics. We used the standard age distribution of the 2000 U.S. Census Population (age groups 18–39, 40–59, and 60–79 or 20–39, 40–59, and 60–79) for standardization.[23] NHANES examination sampling weights were used to obtain prevalence estimates representative of the civilian, non-institutionalized U.S. population for airflow obstruction outcomes. Interview sampling weights were used to obtain prevalence estimates for COPD except when COPD prevalence was analyzed by BMI status and examination sampling weights were used. Variance estimates were computed using the Taylor series linearization approximation method. We calculated relative standard errors (RSE) ([the standard error of the estimate/estimate]*100), and identified estimates with an RSE > 30% which are potentially unreliable and should be interpreted with caution. Estimates with a RSE > 36% are not presented.

We used multivariable logistic regression models to calculate prevalence odds ratios (PORs) and 95% CIs for airflow obstruction by industry and occupation. PORs were adjusted for age, gender, race/Hispanic origin, and smoking status (never/ever). The reference industry group was all other ever-employed U.S. adults who were not in the industry group of interest. The reference occupation group was all other ever-employed U.S. adults who were not in the occupation group of interest. We did not present prevalence estimates and PORs for moderate and more severe airflow obstruction and COPD by industry and occupation because many of these estimates had potentially unreliable RSEs.

3 | RESULTS

Characteristics of ever-employed U.S. adults are summarized in Table 1. The age-standardized prevalence of airflow obstruction among ever-employed U.S. adults aged 18–79 years was 12.40% and those with airflow obstruction were further evaluated for moderate and more severe airflow obstruction (3.05%) (Table 1). The prevalence of airflow obstruction and moderate and more severe airflow obstruction increased with age and was highest in adults aged 60–79 years. Prevalence of airflow obstruction and moderate to more

severe airflow obstruction was highest in non-Hispanic whites (13.56%, 3.49%), those with less than high school education (15.35%, 4.90%), and adults with a BMI categorized as underweight (24.07%, 9.61%). The prevalence of airflow obstruction was 7.15% among never smokers compared with 18.47% among ever smokers (Table 1).

The age-standardized prevalence of COPD among ever-employed U.S. adults aged 20–79 years was 3.47% (Table 1). The prevalence of COPD was highest in adults aged 60–79 years (8.08%), females (3.89%), non-Hispanic whites (3.85%), those with less than high school education (6.30%), and adults with a BMI categorized as underweight (8.61%). The prevalence of COPD was 1.48% among never smokers and 5.61% among ever smokers. COPD prevalence increased as cigarette pack-years category increased, from 1.93% among ever smoking adults with less than three pack-years to 12.44% among adults with at least 27 pack-years.

Workers in the mining industry group had the highest prevalence of airflow obstruction (22.66%) followed by workers in the manufacturing fiber, fabric, textile, carpet mills, knitting, apparel, footwear, leather tanning industry group (20.29%) (Table 2).

Workers in the mining (POR = 2.04; 95% CI 1.05–3.97), manufacturing motor vehicles and motor vehicle equipment (POR = 1.66; 95% CI 1.20–2.30), construction (POR = 1.64; 95% CI 1.26–2.13), and services to buildings, landscaping and waste management services (POR =1.57; 95% CI 1.08–2.27) industry groups had significantly higher odds of airflow obstruction as compared with all other workers not in their respective industry groups (Table 2). When compared with all other workers, workers in the above industry groups had 57–104% higher likelihood of airflow obstruction.

Workers in the extraction occupation group had the highest prevalence of airflow obstruction (34.49%) followed by workers in the bookbinders, prepress, and printing (31.64%), and installation, maintenance, and repair (power-line, telecommunications line, vending machine, locksmiths, manufactured building, signal and track switch, commercial divers, riggers) (29.15%) occupation groups (Table 3).

Adjusted PORs and 95% CIs for airflow obstruction by occupation groups indicate workers in extraction (POR = 3.82; 95% CI 1.55–9.43), bookbinders, prepress, and printing (POR = 3.14; 95% CI 1.56–6.30), installation, maintenance, and repair (power-line, telecommunications line, vending machine, locksmiths, manufactured building, signal and track switch, commercial divers, riggers) (POR = 3.11; 95% CI 1.48–6.55), construction laborers and construction trades helpers (POR = 1.94; 95% CI 1.28–2.94), and construction equipment operators, electricians, pipelayers, roofers, construction inspectors, fence erectors, highway maintenance, rail-track laying, and miscellaneous construction (POR = 1.58; 95% CI 1.02–2.46) had significantly higher odds of airflow obstruction as compared with all other workers. When compared with all other workers, workers in the above occupation groups had 58–282% higher likelihood of airflow obstruction.

4 | DISCUSSION

This study found the prevalence of spirometry-defined airflow obstruction was 12.40%, moderate and more severe airflow obstruction was 3.05%, and COPD was 3.47% among ever-employed U.S. adults. Prior analyses of 2007–2010 NHANES data used the general U.S. population (not limited to ever-working adults) of a older age range (40–79 years) than analyzed in this study and reported prevalence estimates of 14.5% for airflow obstruction and 4.4% for moderate and more severe airflow obstruction.[13] The prevalence of both airflow obstruction and COPD was higher in those aged 60–79 years, non-Hispanic whites, those with less than high school education, those with an underweight BMI, and in those that ever smoked.

We also generated the prevalence and association of airflow obstruction by industry and occupation groups. Workers in many industry and occupation groups associated with elevated prevalence of airflow obstruction and/or significant PORs may be exposed to significant respiratory health hazards. For example, workers in the mining industry group and workers in extraction occupations may be exposed to diesel engine exhaust from machinery and equipment, volatile organic compounds (VOCs), other polycyclic aromatic hydrocarbons, fumes and dusts (eg, silica, coal mine dust, and metallic compounds) associated with lung inflammation, and other chemicals.[22,24] Workers in the construction industry group and workers in the occupation group construction laborers and construction trades helpers as well as construction equipment operators, electricians, pipelayers, roofers, construction inspectors, fence erectors, highway maintenance, rail-track laying, and miscellaneous construction were associated with elevated prevalence of airflow obstruction and significantly higher odds of airflow obstruction. Other construction and extraction occupation groups including first-line supervisors/managers of construction trades and extraction workers (19.95%) and carpenters (19.04%) had high prevalence of airflow obstruction. Construction laborers may be exposed to diesel exhaust, other byproducts of machinery combustion, dusts (eg, wood dust and silica), vapors, and fumes. First-line supervisors/managers of construction trades and extraction workers often have similar exposures as construction laborers.[22]

Workers in the occupation group installation, maintenance, and repair (power-line, telecommunications line, vending machine, locksmiths, manufactured building, signal and track switch, commercial divers, riggers) also had a high airflow obstruction prevalence. These workers may be exposed to fumes from soldering or wire insulation. Work in the services to buildings, landscaping and waste management services industry group was associated with elevated prevalence of airflow obstruction and significantly higher odds of airflow obstruction. These workers may have pesticide, herbicide, wood dust, fungi, and cleaning agent exposures.[22]

Hnizdo et al. reported working in manufacturing industries (rubber, plastics, and leather; textile mill products; food products) was associated with spirometry-defined obstructive lung disease in an earlier study of the 1988–1994 NHANES population.[8] Our results also showed a high prevalence of airflow obstruction in the manufacturing fiber, fabric, textile, carpet mills, knitting, apparel, footwear, leather tanning industry (20.29%) where solvents, dusts,

and formaldehyde may be present.[22] The prevalence of airflow obstruction in the manufacturing motor vehicles and motor vehicle equipment industry group was 19.60% and workers in this industry had significantly higher odds of airflow obstruction potentially due to exposures during the production process, such as metal fumes, respirable silica, carbon monoxide, and coolant mist.[22] The prevalence of airflow obstruction in the manufacturing pulp and paper products, printing activities industry (16.61%) may be driven by the high prevalence of disease among bookbinders, prepress, and printing workers (31.64%). Organic solvents and toner used in the printing industry, adhesives involved in bookbinding or other finishing tasks, ozone and VOCs from duplicating and reproduction machines, and paper dust, are all potential sources of harmful exposures in these workers.[22]

A thorough depiction of airflow obstruction prevalence was lacking for workers in agriculture and forestry industries due to unreliable estimates in the agriculture, forestry, fishing, and hunting (except crop production) industry group and the farm, ranch and other agricultural managers; farmers and ranchers occupation group. However, workers in the crop production industry had a high prevalence of airflow obstruction (16.77%). Exposures in the crop production industry associated with obstructive lung disease include gas and vapors from pesticides and herbicides, mineral dusts, and organic dusts from agricultural work.[24]

The prevalence of airflow obstruction was also elevated in food preparation and serving related occupations (except chefs, cooks, waiters and waitresses) (17.68%) and waiters and waitresses (15.56%). Food service workers may be exposed to cleaning and disinfectant products and gas, fumes, and particulate matter emissions from both the cooking process and combustion of fuel used for cooking.[22,25,26]

4.1 | Limitations and strengths

Self-reported doctor-diagnosed chronic bronchitis and self-reported emphysema were used to define COPD and clinical data were not available to validate COPD. The NHANES is a cross-sectional survey, so it is not possible to determine causality of airflow obstruction and COPD. Similarly, we cannot determine the occupational or non-occupational causes of airflow obstruction since occupational exposure was not included in this analysis. However, analysis of NHANES 1988–1994 data indicate tobacco smoking, occupational exposure, and socioeconomic status contribute to the increased risk of spirometry-defined obstructive lung disease among some workers.[8,27] Because airflow obstruction generally results from long-term exposure, we used longest held industry and occupation data to include the job which potentially contributed to disease. However, relevant occupational exposures associated with the development of airflow obstruction may have occurred in an occupation other than the longest held. We did not determine the type of airflow obstruction (eg, asthma, chronic bronchitis, emphysema) among those with spirometry-defined airflow obstruction and some occupational exposures are attributed to different types of obstructive disease. Another limitation is that those with COPD may or may not have spirometry-defined airflow obstruction.

Despite combining data from three NHANES survey cycles, confidence intervals for some prevalence estimates and PORs provided a wide range of possible values for the parameter and should be examined when interpreting data. Due to small cell sizes, we were not able to

report gender-specific or smoking-specific prevalence estimates and we had to group together some industries and occupations that we had interest in analyzing at the detailed, four-digit level. For example, we were interested in the prevalence of airflow obstruction among workers in specific service industries, such as barber shops, beauty salons, and nail salons, as these workers may be exposed to products and chemicals that can cause lung irritation and respiratory diseases. However, due to small cell sizes, these industries were grouped with other service industries in the barber shops, beauty and nail salons, dry-cleaning and laundry services, funeral homes, other personal services, and labor unions industry group so we could not calculate the airflow obstruction prevalence in these specific service industries.

The strengths of this study were that its data come from a recent, nationally representative data set. NHANES ensures rigorous quality standards are followed for data collection, which is especially important for tests like spirometry, where data quality can impact interpretation of disease classifications. In addition, we were able to examine 44 industry groups and 57 occupation groups, which had not been done in prior research on this topic using NHANES data.

This study provides the distribution of ever workers with airflow obstruction by detailed industry and occupation group. This study observed elevated PORs for specific industries including mining, manufacturing motor vehicles and motor vehicle equipment, construction, and services to buildings, landscaping and waste management services, industries that had previously been shown to be at risk for airflow obstruction. However, we identified workers in the occupation group including installation, maintenance, and repair (power-line, telecommunications line, vending machine, locksmiths, manufactured building, signal and track switch, commercial divers, riggers) to have an elevated prevalence of airflow obstruction. To our knowledge, this occupation group has not been previously studied or identified as having increased risk for airflow obstruction. Additional research is needed to understand the association between these groups and an increased risk for airflow obstruction and also what exposures may be causing the increased risk.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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TABLE 1

Age-specific and age-standardized[a] prevalence (P) of airflow obstruction, moderate and more severe airflow obstruction, and COPD among ever-employed U.S. adults for selected characteristics, NHANES 2007–2008 to 2011–2012

	Ever-employed U.S. adults aged 18–79 years[b]					Ever-employed U.S. adults aged 20–79 years[c]		
		Airflow obstruction[d]		Moderate and more severe airflow obstruction[e]			COPD[f]	
Characteristics	**Unweighted sample size**	***P* (%)**	**95% CI**	***P* (%)**	**95% CI**	**Unweighted sample size**	***P* (%)**	**95% CI**
Total	13 044[g]	12.40	11.63–13.18	3.05	2.67–3.43	15 777[h]	3.47	2.93–4.01
Age (years)								
18–39 or 20–39	5263	9.87	8.76–10.98	0.81	0.51–1.12	5651	1.21	0.90–1.53
40–59	4513	13.56	11.81–15.32	3.80	2.82–4.78	5582	3.59	2.81–4.37
60–79	3268	16.06	14.56–17.55	6.83	5.80–7.86	4544	8.08	6.75–9.41
Gender								
Male	6684	13.57	12.14–15.00	3.34	2.69–3.99	7959	3.06	2.43–3.69
Female	6360	11.25	10.07–12.43	2.77	2.26–3.28	7818	3.89	3.15–4.62
Race/Hispanic origin								
Non-Hispanic White	5672	13.56	12.59–14.53	3.49	3.02–3.96	6741	3.85	3.13–4.57
Non-Hispanic Black	2859	11.24	9.89–12.58	2.95	2.17–3.74	3545	3.52	2.76–4.28
Mexican American	2042	8.18	7.17–9.20	0.75	0.43–1.07	2438	1.11	0.75–1.48
Other Hispanic	1363	8.54	6.98–10.11	1.51	1.00–2.01	1681	2.04	1.31–2.77
Education								
Less than high school	3145	15.35	13.64–17.05	4.90	3.62–6.18	4100	6.30	4.87–7.73
High school graduate/GED	3055	14.02	12.26–15.79	3.90	3.06–4.74	3643	3.81	2.92–4.69
Some college/associate's degree	3881	12.01	10.72–13.30	3.00	2.21–3.79	4504	3.49	2.93–4.05
4-year degree or more	2940	10.15	8.36–11.94	1.51	1.02–2.01	3516	1.44	0.96–1.92
BMI category (kg/m^2)								
Underweight (<18.5)	199	24.07	14.26–33.89	9.61*	3.09–16.14	242	8.61	4.89–12.32
Normal (18.5–24.9)	3722	15.99	14.13–17.85	3.77	2.52–5.01	4151	2.76	1.74–3.78
Overweight (25.0–29.9)	4328	12.53	11.47–13.58	2.77	2.22–3.31	5024	2.66	2.02–3.29
Obese (≥30.0)	4720	9.45	8.46–10.44	2.68	2.17–3.20	5703	4.72	3.92–5.52
Smoking status								

	Ever-employed U.S. adults aged 18–79 years[b]					Ever-employed U.S. adults aged 20–79 years[c]		
		Airflow obstruction[d]		Moderate and more severe airflow obstruction[e]			COPD[f]	
Characteristics	**Unweighted sample size**	***P* (%)**	**95% CI**	***P* (%)**	**95% CI**	**Unweighted sample size**	***P* (%)**	**95% CI**
Never smoker	7151	7.15	6.31–8.00	0.81	0.54–1.08	8474	1.48	1.12–1.84
Ever smoker	5849	18.47	17.29–19.65	5.45	4.70–6.20	7291	5.61	4.77–6.44
Cigarette pack (years)[i]								
<3						1808	1.93	1.05–2.81
3–10.9						1798	3.87	2.36–5.38
11–26.9						1619	5.02	3.78–6.26
≥27						1669	12.44	8.96–15.91

CI, confidence interval.

[*] RSE for the estimated prevalence with airflow obstruction >30% and ≤36%.

[a] Age-standardized prevalence estimates were based on the age distribution of the 2000 U.S. Census Population 18–79 and 20–79 age structures. Age-specific estimates are reported for age categories. NHANES examination sampling weights were used for airflow obstruction outcomes and interview sampling weights were used for COPD outcome with the exception of examination sampling weights for BMI.

[b] Sample respondents aged 18–79 years with valid spirometry, height, and longest held occupation data were evaluated for airflow obstruction.

[c] Sample respondents aged 20–79 years with longest held occupation data were evaluated for COPD.

[d] Airflow obstruction was defined as FEV1/FVC<LLN.

[e] Moderate and more severe airflow obstruction was defined as FEV1/FVC<LLN and FEV1<70% of the predicted value.

[f] COPD was self-reported, doctor or health professional diagnosis of chronic bronchitis (and still have chronic bronchitis) or self-reported emphysema.

[g] For airflow obstruction, 23 participants were missing education data, 75 missing BMI data, 44 missing smoking status data.

[h] For COPD, 14 participants were missing education data, 657 missing BMI data, 12 missing smoking status data.

[i] Pack-years were estimated for ever smokers aged 20–79 years. Pack-years were missing for 397 ever smokers.

TABLE 2

Age-standardized prevalence[a] and prevalence odds ratios (POR) of airflow obstruction among ever-employed U.S. adults aged 18–79 years by industry, NHANES 2007–2008 to 2011–2012

	Ever-employed U.S. adults				
Industry[b]	**Unweighted sample size[c]**	***P* (%)**	**95% CI**	**POR[d]**	**95% CI**
Total	13 004				
Mining	104	22.66	10.78–34.54	2.04	1.05–3.97
Manufacturing fiber, fabric, textile, carpet mills, knitting, apparel, footwear, leather tanning	218	20.29	9.35–31.23	1.98	0.93–4.21
Manufacturing motor vehicles and motor vehicle equipment	194	19.60	14.73–24.46	1.66	1.20–2.30
Construction	1045	17.91	14.19–21.63	1.64	1.26–2.13
Services to buildings, landscaping, and waste management services	345	17.63	11.53–23.74	1.57	1.08–2.27
Air, rail, water, pipeline, and scenic transportation; warehousing and storage	144	17.04	10.07–24.01	1.44	0.86–2.42
Crop production	170	16.77	7.28–26.26	1.38	0.68–2.81
Manufacturing pulp and paper products, printing activities	102	16.61*	6.32–26.91	1.47	0.74–2.90
Other retail stores (except retail industries specified)	368	14.96	10.53–19.38	1.24	0.86–1.77
Utilities	119	14.70	9.52–19.87	1.54	0.93–2.54
Manufacturing metal production, processing, and products; machinery manufacturing	303	14.34	8.84–19.84	1.30	0.87–1.95
Restaurants and other food services, drinking places	1042	14.34	10.53–18.14	1.09	0.80–1.48
Manufacturing computer, communications, navigational equipment, electronic components, appliances, electrical equipment, and supplies	161	14.18	7.00–21.36	1.09	0.62–1.92
Barber shops, beauty and nail salons, dry-cleaning and laundry services, funeral homes, other personal services, and labor unions	216	13.66	7.80–19.53	1.04	0.64–1.71
Manufacturing sawmills and wood preservation, wood products, prefabricated wood buildings, furniture	123	13.56*	4.90–22.21	1.04	0.50–2.20
Retail trade - automobile and other motor vehicle dealers, auto parts, gas stations, fuel dealers	158	13.52	7.74–19.30	1.10	0.67–1.82
Manufacturing petroleum, resin, chemicals, plastics, rubber, pottery, clay, glass, cement, and nonmetallic mineral products	282	13.07	7.56–18.58	0.99	0.62–1.58
Truck transportation	176	13.00	7.73–18.28	1.31	0.74–2.32
Nursing care and residential care facilities	268	12.60	8.90–16.30	1.13	0.79–1.60
Information services	218	12.30	6.47–18.13	0.99	0.58–1.68
Manufacturing food, beverage, and tobacco products	231	12.25	7.31–17.19	1.03	0.65–1.63
Educational services - elementary and secondary schools	648	11.79	8.60–14.98	0.90	0.67–1.21
Administration of environmental quality and economic programs, national security	136	11.19*	3.70–18.68	0.96	0.46–2.01

	Ever-employed U.S. adults				
Industry[b]	**Unweighted sample size**[c]	***P* (%)**	**95% CI**	**POR**[d]	**95% CI**
Educational services - colleges, universities, technical and trade schools, other educational services	299	11.15	6.15–16.16	0.88	0.54–1.45
Arts, entertainment, recreation, and accommodation	406	11.07	6.86–15.28	0.84	0.56–1.26
Professional and business services - including architectural, engineering, design, management, scientific, veterinary, investigation and security, and other professional services	297	10.82	6.30–15.34	0.86	0.55–1.34
Banking and related activities, savings institutions	275	10.56	6.12–15.00	0.91	0.58–1.44
Justice, public order, and safety activities; administration of human resource programs	249	10.50	5.18–15.83	0.76	0.42–1.35
Wholesale trade groceries, retail trade grocery and specialty food stores	371	10.39	5.47–15.32	0.83	0.52–1.33
Bus and urban transit, taxi service, transportation services, postal service, couriers	279	10.25	5.29–15.21	0.88	0.50–1.52
Automotive repair, car washes, other repair, and maintenance services	203	10.20	5.85–14.54	0.80	0.48–1.34
Healthcare - offices of health practitioners, outpatient care centers, home health, and other health care services	466	10.02	6.32–13.72	0.74	0.48–1.16
Individual, community, vocational rehabilitation, and child day care services	293	9.94	4.72–15.16	0.73	0.40–1.33
Legal, accounting, computer systems, advertising, management, employment, business support, travel, and other administrative and business support services	422	9.67	6.04–13.29	0.75	0.51–1.11
Retail trade - furniture and home furnishings, hardware, lawn and garden, pharmacies, clothing, shoe, jewelry, and department stores	459	9.50	6.33–12.67	0.78	0.55–1.11
Religious, civic, business, professional, political organizations, and private household services	306	9.23	5.04–13.41	0.68	0.41–1.15
U.S. military	139	9.23	4.35–14.11	0.73	0.43–1.26
Non-depository credit, financial investments, and insurance carriers; real estate and rental	469	9.21	5.91–12.52	0.74	0.52–1.06
Hospitals	485	9.07	5.37–12.77	0.69	0.45–1.08
Manufacturing medical equipment and supplies, toys, and miscellaneous products	156	8.96*	3.31–14.61	0.85	0.40–1.83
Wholesale trade (except grocery)	263	8.38	4.81–11.95	0.62	0.40–0.98
Agriculture, forestry, fishing, and hunting (except crop production)	107	**			
Manufacturing aircraft and aerospace products, railroad rolling stock, ships, boats, and other transportation equipment	122	**			
Public administration - executive offices and legislative bodies, public finance, and other general government and support	167	**			

CI, confidence interval.

*RSE for the estimated prevalence with airflow obstruction >30% and ≤36%.

**RSE for the estimated prevalence with airflow obstruction >36% and results are not presented.

[a]Age-standardized prevalence estimates were based on the age distribution of the 2000 U.S. Census Population 18–79 age structure. NHANES examination sampling weights were used for airflow obstruction.

[b]The industry groups were created by combining four-digit industry codes from the U.S. Census Bureau's 2002 version of its Occupation and Industry coding system.

[c] 40 participants were missing industry data or were uncodable.

[d] POR adjusted for age, gender, race/Hispanic origin, and smoking status.

TABLE 3

Age-standardized prevalence[a] and prevalence odds ratios (POR) of airflow obstruction among ever-employed U.S. adults aged 18–79 years by occupation, NHANES 2007–2008 to 2011–2012

	Ever-employed U.S. adults				
Occupation[b]	**Unweighted sample size**[c]	***P* (%)**	**95% CI**	**POR**[d]	**95% CI**
Total	13 011				
Extraction	32	34.49	15.55–53.44	3.82	1.55–9.43
Bookbinders, prepress, and printing	45	31.64	15.02–48.26	3.14	1.56–6.30
Installation, maintenance, and repair (power-line, telecommunications line, vending machine, locksmiths, manufactured building, signal and track switch, commercial divers, riggers)	52	29.15	13.28–45.01	3.11	1.48–6.55
Construction laborers and construction trades helpers	278	20.42	13.62–27.22	1.94	1.28–2.94
Production inspectors, testers, and packaging/filling machine operators and tenders	126	20.08*	7.77–32.40	1.56	0.74–3.31
First-line supervisors/managers of construction trades and extraction workers	80	19.95	9.16–30.74	1.87	0.96–3.64
Metal furnace operators, model makers, molders, machine tool setters, tool makers, heat treating equipment setters, lay-out workers, plating workers, welding workers, tool grinders, all other metal and plastic workers	198	19.33	8.42–30.24	1.68	0.82–3.44
Carpenters	165	19.04	10.24–27.84	1.74	0.97–3.11
Construction equipment operators, electricians, pipelayers, roofers, construction inspectors, fence erectors, highway maintenance, rail-track laying, and miscellaneous construction	206	17.74	11.82–23.65	1.58	1.02–2.46
Food preparation and serving related occupations (except chefs, cooks, waiters and waitresses)	389	17.68	12.41–22.95	1.31	0.91–1.88
Automotive service technicians and mechanics	99	17.57	9.05–26.09	1.45	0.80–2.62
Laundry and dry-cleaning, pressers, sewing machine operators, shoemakers, tailors, and textile and upholstery workers	199	16.63*	5.33–27.93	1.63	0.71–3.77
Construction - carpet, floor, tile, and drywall installers; glaziers; insulation workers; painters; paperhangers; plasterers	151	16.55	9.11–24.00	1.41	0.82–2.44
Waiters and waitresses	246	15.56*	4.53–26.59	1.07	0.53–2.16
Nursing, psychiatric, and home health aides	291	15.50	10.31–20.70	1.32	0.89–1.97
Driver/sales workers and truck drivers	308	15.27	10.10–20.44	1.36	0.93–2.00
Bus, truck, heavy vehicle, small engine, and miscellaneous vehicle mechanics; control and valve, heating, home appliance, and other installers, repairers, and maintenance workers; millwrights	138	15.15	9.37–20.93	1.25	0.75–2.06
Building and grounds cleaning and maintenance occupations	696	15.06	11.12–19.00	1.29	0.94–1.76
Artists and related workers, jewelers, painters, production workers, and helpers	201	14.21	9.34–19.08	1.35	0.87–2.08
Farming, fishing, and forestry occupations	166	14.02*	5.56–22.49	1.10	0.52–2.33
Assemblers, structural metal fabricators, and fitters	167	13.52*	4.77–22.27	1.11	0.57–2.18
Cooks, chefs, and head cooks	319	13.38	7.84–18.91	1.08	0.68–1.70

	Ever-employed U.S. adults				
Occupation[b]	**Unweighted sample size**[c]	***P* (%)**	**95% CI**	**POR**[d]	**95% CI**
Transportation occupations	173	13.32*	5.03–21.61	1.00	0.50–1.98
Boilermakers, brickmasons, cement masons, sheet metal, reinforcing and structural iron, and steel workers	64	13.29*	4.45–22.12	1.08	0.52–2.25
Computer scientists, programmers, software engineers, support specialists; database and network administrators and analysts	220	12.96	7.90–18.02	1.07	0.69–1.67
Retail salespersons	319	12.76	8.45–17.07	0.93	0.64–1.36
Personal care and service occupations, funeral directors, veterinarians, gaming cage workers	186	12.27	6.60–17.94	1.04	0.59–1.83
First-line supervisors/managers of retail and non-retail sales workers	284	12.14	7.31–16.98	0.99	0.64–1.54
Material moving occupations	212	12.13	6.10–18.16	0.93	0.52–1.68
Sales and related occupations (except cashiers and retail salespersons)	319	11.92	8.58–15.27	0.94	0.70–1.26
Supervisors of office and administrative support workers; switchboard, telephone, and communications operators; billing and bookkeeping workers	320	11.81	6.77–16.86	1.01	0.59–1.72
Cashiers	337	11.78	5.01–18.55	1.04	0.60–1.80
Business and financial operations (agents and business managers, purchasing agents, buyers, claims adjusters, compliance officers, cost estimators, and human resources specialists)	111	11.77*	4.06–19.48	0.85	0.47–1.53
Mathematicians, architects, surveyors and technicians, engineers and technicians, drafters	245	11.59	6.24–16.94	0.89	0.55–1.44
Construction managers; food service managers	168	11.52	5.40–17.64	0.80	0.44–1.46
Installation, maintenance, repair (motor, electronics)	124	11.51	5.60–17.41	1.02	0.59–1.75
Computer control operators, metal and plastic machine operators, machinists	100	11.26	7.02–15.51	1.06	0.62–1.82
Design, entertainment, sports, and media occupations	222	11.18	6.23–16.13	0.82	0.51–1.32
Business and financial operations (logisticians, accountants, tax workers)	273	10.77	6.24–15.30	0.89	0.56–1.41
Management occupations (gaming lodging, medical, natural sciences, postmasters, real estate, social and community service)	298	10.47	6.01–14.92	0.74	0.45–1.21
Education, training, and library occupations	619	10.22	7.43–13.01	0.74	0.54–1.01
Child care workers, personal and home care aides, recreation workers, residential advisors	274	10.02	5.10–14.95	0.82	0.47–1.44
Healthcare practitioners and technical occupations, healthcare support occupations	569	10.00	7.05–12.95	0.78	0.55–1.10
Management occupations (chief executives, general managers, legislators, business, financial, industrial production, transportation, education)	438	9.92	5.51–14.34	0.79	0.49–1.27
Laborers and freight, stock, and material movers	201	9.68	5.21–14.15	0.78	0.46–1.31
Protective service occupations	249	9.23*	3.61–14.84	0.61	0.30–1.25
Office and administrative support (Cargo agents, couriers, postal service mail carriers, shipping and stock clerks, secretaries, and administrative assistants)	457	9.21	5.31–13.12	0.71	0.44–1.15
Interviewers; clerks (file, hotel, new accounts, order, reservation, postal service, production); library, human resources assistants; receptionists; meter readers; weighers; dispatchers; postal service mail sorters	267	9.07	4.53–13.62	0.70	0.41–1.18

	Ever-employed U.S. adults				
Occupation[b]	**Unweighted sample size**[c]	***P* (%)**	**95% CI**	**POR**[d]	**95% CI**
Clerks (payroll, procurement, brokerage, correspondence, court, credit), tellers, customer service representatives	220	8.34	3.32–13.36	0.60	0.33–1.10
Life, physical, and social science; community and social service; legal occupations	412	8.25	4.70–11.80	0.62	0.40–0.97
Computer operators, typists, office and administrative support workers	300	8.13	4.98–11.27	0.64	0.42–0.98
First-line supervisors/managers of production and operating workers	97	**			
Bakers, butchers, food roasting, food batchmakers, food cooking machine operators	89	**			
Farm, ranch and other agricultural managers; farmers and ranchers	97	**			
Woodworkers (cabinetmakers, furniture finishers, model makers, sawing and woodworking machine operators)	38	**			
Operators (power plant, boiler, water and liquid waste treatment plant, chemical processing machine, extruding machine, furnace), crushing workers, cutting worker	78	**			
Armed forces	79	**			

CI, confidence interval.

*RSE for the estimated prevalence with airflow obstruction >30% and ≤36%.

**RSE for the estimated prevalence with airflow obstruction >36% and results are not presented.

[a]Age-standardized prevalence estimates were based on the age distribution of the 2000 U.S. Census Population 18–79 age structure. NHANES examination sampling weights were used for airflow obstruction.

[b]The occupation groups were created by combining four-digit occupation codes from the U.S. Census Bureau's 2002 version of its Occupation and Industry coding system.

[c]33 participants were missing occupation data or were uncodable.

[d]POR adjusted for age, gender, race/Hispanic origin, and smoking status.