HHS Public Access
Author manuscript
Am J Ind Med. Author manuscript; available in PMC 2020 May 01.

Published in final edited form as:
Am J Ind Med. 2019 May ; 62(5): 393–403. doi:10.1002/ajim.22958.

Occupational exposure and airflow obstruction and self-reported COPD among ever-employed US adults using a COPD-job exposure matrix

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Abstract

Introduction: This study examined the association of spirometry-defined airflow obstruction and self-reported COPD defined as self-reported doctor diagnosed chronic bronchitis or emphysema, with occupational exposure among ever-employed US adults.

Methods: Data were obtained from the National Health and Nutrition Examination Survey (NHANES) 2007–2008 to 2011–2012, a nationally representative study of the non-institutionalized civilian US population. Reported current and/or longest held job were used to create prevalence estimates and prevalence odds ratios (PORs) (adjusted for age, gender, race, and smoking status) for airflow obstruction and self-reported COPD by occupational exposure,

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AUTHORS' CONTRIBUTIONS
BD, LK, SF participated in the conception or design of the work; BD, LK, JH, and SF participated in the acquisition, analysis, and interpretation of data; BD and LK 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.

Institution at which the work was performed: National Institute for Occupational Safety and Health (NIOSH), Centers for Disease Control and Prevention, Morgantown, WV; National Center for Health Statistics (NCHS) Research Data Center, Hyattsville, MD.

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.

DISCLOSURE (AUTHORS)

The authors report no conflicts of interest.

DISCLOSURE BY AJIM EDITOR OF RECORD
Rodney Ehrlich declares that he has no conflict of interest in the review and publication decision regarding this article.

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.

determined using both NHANES participants' selfreported exposures and eight categories of COPD job exposure matrix (JEM) assigned exposures.

Results: Significant PORs for airflow obstruction and self-reported COPD respectively were observed with self-reported exposure for ≥20 years to mineral dust (POR = 1.44; 95% confidence interval (CI) 1.13–1.85; POR = 1.69; 95% CI 1.17–2.43) and exhaust fumes (POR = 1.65; 95% CI 1.27–2.15; POR = 2.22; 95% CI 1.37–3.58). Airflow obstruction or self-reported` COPD were also associated with COPD-JEM assigned high exposure to mineral dust, combined dust, diesel exhaust, vapor-gas, sensitizers, and overall exposure.

Conclusion: Airflow obstruction and self-reported COPD are associated with both self-reported and JEM-assigned exposures.

Keywords

airflow obstruction; CDC; COPD; job exposure matrix; NHANES; occupational exposure; prevalence

1 | INTRODUCTION

Occupational exposure to vapors, gases, dusts, and fumes is causally associated with increased levels of obstructive lung function impairment and increased prevalence of chronic bronchitis.[1–3] Although tobacco smoking is the primary risk factor for chronic obstructive pulmonary disease (COPD), a recent American Thoracic Society (ATS) statement, based on a review of the literature, concluded that occupational exposures are causally related to development of COPD and that the occupational attribution to COPD is over 15%.[4]

An understanding of workers' occupational exposures can be captured through several different methods. One method is to obtain self-reported exposures through an interview or questionnaire administered to study participants.[5] Self-reported exposures can be linked to respiratory health outcomes in epidemiologic studies. However, self-reports of occupational exposure may be subject to various biases (eg, recall bias or interviewer bias). Using a job exposure matrix (JEM) can reduce or eliminate the individual's recall bias through assigning exposure levels based on occupation.

Blanc et al[6] developed a JEM for COPD and found associations between COPD and the overall exposure category including vapor-gas, dust, and fumes.[7] Some more recent studies on COPD and occupational exposure using another instrument, the ALOHA JEM, found that occupational exposure to pesticides was associated with airflow obstruction[8] while the European Community Respiratory Health Survey found occupational exposures to biological dusts, gases and fumes, and pesticides were associated with the 20 year incidence of COPD.[9] In addition, one United Kingdom study assessed COPD and found associations between both self-reported and JEM-associated exposures to vapors, gas, dust, and fumes.[10] Another United Kingdom study reported that occupational exposure in coal mining, factory work, work with solvents, and welding and shipyard work were predictors of respiratory symptoms.[11]

The National Institute for Occupational Safety and Health (NIOSH) developed a JEM for COPD that has separate exposure categories for vapor-gas, dust, and fumes in addition to an independently assigned overall vapor-gas, dust, and fumes exposure category. This COPD-JEM has been applied to occupational data collected from population-specific studies and found to be a useful tool for measuring the attribution of spirometry-defined COPD with occupational exposure.[12,13] NIOSH recently expanded the COPD-JEM to include diesel exhaust fumes and sensitizers.

The purpose of the present study was to examine, in a nationally representative sample, the association of spirometry-defined airflow obstruction and self-reported COPD with multiple measures of occupational exposures. This study is novel because detailed four-digit occupation codes for each NHANES study participant were matched with detailed occupation codes using the NIOSH COPD-JEM. Occupational exposures were determined by: (i) NHANES self-reported occupational exposure data and (ii) application of the NIOSH COPD-JEM to NHANES data on self-reported, longest-held occupation.

2 | METHODS

2.1 | Study design and population

The NHANES is a continuous, cross-sectional survey conducted by the National Center for Health Statistics. A complex, multistage probability sampling design is used to generate a representative sample of the civilian, non-institutionalized US population.[14,15] Participants receive a detailed in-home interview followed by a physical examination at a mobile examination center. 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.[16] These cycles contain the most current NHANES data on respondent’s longest held job, occupational exposures, and spirometry.

The sample for the analysis of airflow obstruction included ever-employed NHANES respondents aged 18–79 years with valid pre-bronchodilator spirometry and height data (n = 13 044). The sample for the analysis of self-reported COPD included ever-employed NHANES respondents aged 20–79 years (n = 15 777). There is overlap between the samples because both included those aged 20–79 years that were interviewed and who received a physical examination. The analytic sample for self-reported COPD includes more participants because it is not limited to people with valid spirometry.

2.2 | Variable definitions

Respondents 18–19 years of age were asked different smoking questions than respondents 20–79 years of age. A history of tobacco or nicotine products use was used to identify “never smokers” including those 18–19 years of age who did not use tobacco or nicotine products (including cigarettes) in the last 5 days; and those 20–79 years who smoked <100 cigarettes during their entire life. “Ever smokers” included those 18–19 years of age who used tobacco or nicotine products (including cigarettes) in the last five days and those 20–79 years who smoked at least 100 cigarettes during their entire life.

Respiratory health outcomes were established by questionnaire responses for participants 20–79 years and spirometry data. Participants were determined to have self-reported COPD if they reported that a doctor or other health professional had ever told them that they had chronic bronchitis and they still had chronic bronchitis, or a doctor or other health professional had ever told them that they had emphysema. For more details on the NHANES variables analyzed, see documentation of NHANES.[14]

Spirometry details for the 2007–2008 to 2011–2012 NHANES are discussed elsewhere.[5,17] Airflow obstruction was defined per the ATS/European Respiratory Society (ERS) criterion as the ratio of forced expiratory volume in the first second to forced vital capacity (FEV_1/FVC) <lower limit of normal (LLN) (ie, the lower 5th percentile).[18] Normative reference equations developed from NHANES III data were used to determine the predicted and LLN pulmonary function values.[19] Post-bronchodilator spirometry was performed as a part of the NHANES study. However only a limited number of NHANES participants selected for post-bronchodilator spirometry actually performed it.

For this study, self-reported longest held occupation for ever-employed participants (both currently working and no longer working) was used. Longest held occupation was determined from the NHANES question, “Thinking of all the paid jobs or businesses you ever had, what kind of work were you doing the longest?” If the participant reported the kind of work they were doing the longest was the same as their current, then current occupation was used as the longest held.[14] Workers reporting their longest held occupation was “Armed forces” were included. We excluded from our analysis participants not reporting a longest held occupation, such as participants who had never worked. NIOSH’s Division of Surveillance, Hazard Evaluations, and Field Studies generated four-digit occupation codes for respondents’ current and/or longest held job using the US Census Bureau’s 2002 version of its Occupation and Industry coding system.[20] The coding procedures remained the same across all three cycles. These restricted data were accessed via the National Center for Heath Statistics’ Research Data Center (https://www.cdc.gov/rdc/b1datatype/dt100.htm).

2.3 | Occupational exposure

2.3.1 | Self-reported—NHANES participants were asked about exposures to specific substances in the workplace. Those responding “yes” for questions about work exposure to mineral dust (“dust from rock, sand, concrete, coal, asbestos, silica or soil”), organic dust (“dust from flours, grains, wood, cotton, plants or animals”), exhaust fumes (“exhaust fumes from trucks, buses, heavy machinery or diesel engines”), or other gases, vapors or fumes (“vapors from paints, cleaning products, glues, solvents, and acids; or welding/soldering fumes”) in any of their jobs were considered to have self-reported exposure to the respective substances. They were then asked to report the number of years they had been exposed to the respective substance. We grouped self-reported years of exposure into categories (no exposure, >0–9 years, 10–19 years, ≥20 years of exposure) for each substance. Participants reporting “yes” to any of the above occupational exposure questions were also considered to have “ever dust and/or fume” exposure.

2.4 | COPD-JEM assigned

A NIOSH COPD-JEM was previously constructed by three NIOSH industrial hygienists and was based on the principles of the Blanc et al COPD-JEM.[7] The Blanc COPD-JEM contained one overall vapor-gas, dust, and fumes exposure category. The NIOSH COPD-JEM[12,13] was developed to be a generalizable tool to assess COPD risk by assigning exposure levels (low exposure, medium exposure, or high exposure) to all the US Census Bureau's 2002 occupations.[20] The low exposure level included no exposure and low exposure to vapor-gas, dust, and fumes. For each self-reported, longest held NHANES occupation, NIOSH COPD-JEM exposure levels (representing the likelihood of the presence and severity of occupational exposure) were assigned for eight COPD-related occupational exposure categories. The occupational exposure categories applied in this study included mineral dust, organic dust, combined dust, diesel exhaust fumes, vapor-gas, sensitizers, and fumes, in addition to an overall COPD-related occupational exposure category. The combined dust category takes into consideration both organic dust and mineral dust (plus metal dust) and uses the highest exposure level of either the organic dust or the mineral dust exposure level. Sensitizers included respiratory hazards associated with COPD such as welding operations, glues, isocyanates, and animal dander.[21] The overall NIOSH COPD-JEM occupational exposure level considers the above exposure categories and environmental tobacco smoke and assigns one exposure level for each self-reported, longest held NHANES occupation.

2.5 | 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-standardized prevalence of airflow obstruction and self-reported COPD with corresponding 95% confidence intervals (CIs) were calculated using PROC SURVEYREG for occupational exposure. For standardization we used the standard age distribution of the 2000 US Census Population age structure for age groups 18–39, 40–59, and 60–79 years for airflow obstruction and 20–39,40–59, and 60–79 years for self-reported COPD.[22] NHANES examination sampling weights were used to obtain estimates representative of the civilian, non-institutionalized US population for airflow obstruction outcomes and interview sampling weights were used to obtain representative estimates for self-reported COPD.

Variance estimates were computed using the Taylor series linearization approximation method. We calculated relative standard errors (RSE), and identified estimates with an RSE greater than 30%, which are potentially unreliable and should be interpreted with caution. Estimates with an RSE >36% are not presented.

We used multivariable logistic regression models to calculate prevalence, prevalence odds ratios (POR), and 95% CIs for airflow obstruction and self-reported COPD by occupational exposure. PORs by occupational exposure were adjusted for age, gender, race/Hispanic origin (non-Hispanic white, non-Hispanic black, Mexican American, other Hispanic, and other), and cigarette use (ever, never). The reference group for each of the self-reported exposures were those that did not report exposure to that substance. The reference group for each JEM-assigned exposure was the low exposure level for that substance. Significant exposures were those where the 95% CI did not include 1.0. Adjusted PORs by occupational exposure were also calculated for never smokers.

3 | RESULTS

3.1 | Prevalence

The prevalences of airflow obstruction among ever-employed US adults overall, and for never smokers and ever smokers by self-reported and COPD-JEM assigned exposures are presented in Table 1. The age-standardized prevalence of airflow obstruction was 12.40%. The prevalence of airflow obstruction among never smokers was, in general, significantly lower than the prevalence among ever smokers.

The prevalences of self-reported COPD among ever-employed US adults overall, and for never smokers and ever smokers by self-reported and COPD-JEM assigned exposures are presented in Table 2. The age-standardized prevalence of self-reported COPD was 3.47%.

3.2 | Prevalence odds ratios (PORs)

The PORs for airflow obstruction and self-reported COPD, adjusted for age, gender, race, and smoking status, by self-reported and COPD-JEM assigned exposures are presented in Table 3.

3.3 | Airflow obstruction—self-reported exposure

The PORs for airflow obstruction among those self-reporting ≥20 years of mineral dust exposure, organic dust exposure, or exhaust fumes exposure were significantly higher compared to each non-exposed reference group (Table 3).

3.4 | Airflow obstruction—COPD-JEM assigned exposure

When compared to the low exposure level in each COPD-JEM occupational exposure category, the odds of airflow obstruction among those with high exposure level were elevated for mineral dust, combined dust, diesel exhaust, vapor-gas, sensitizers, and overall exposure (Table 3). There were no associations with fumes.

A supplement provides age-standardized prevalence and PORs for moderate and more severe airflow obstruction by self-reported and JEM-assigned exposures. The results are provided in Supplement Table S1.

3.5 | Self-reported COPD—self-reported exposure

The odds of self-reported COPD were elevated for those with self-reported exposure compared to those with no exposure in each category of exposure for mineral dust, organic dust, exhaust fumes, and other gases/vapors or fumes. Additionally, the years of exposure also resulted in elevated odds of self-reported COPD for most categories of exposure (Table 3). There were also elevated odds of self-reported COPD among never smokers exposed to mineral dust (POR = 2.14; 95% CI 1.57–2.91), exhaust fumes (POR = 2.33; 95% CI 1.43–3.79), and ever dust and/or fumes (POR = 1.35; 95% CI 1.02–1.80) (data not shown).

3.6 | Self-reported COPD—COPD-JEM assigned exposure

When compared to the low COPD-JEM exposure level in each occupational exposure category, the odds of self-reported COPD among those with high exposure level was elevated for combined dust, diesel exhaust, vapor-gas, sensitizers, and overall exposure (Table 3). Among never smokers the numbers were generally either too small to analyze or estimates were unreliable. There were no associations with fumes.

4 | DISCUSSION

This is the first study to examine the association between airflow obstruction, self-reported COPD, and occupational exposure using NHANES 2007–2008 to 2011–2012 detailed, four-digit occupation data and a COPD-JEM. The detailed NHANES occupation data were necessary to match with the detailed US Census Bureau's 2002 occupation codes in the NIOSH COPD-JEM. The NIOSH COPD-JEM provided exposure levels representing the likelihood of exposures related to COPD for each detailed occupation. Application of this COPD-JEM to recent, nationally representative NHANES data allowed us to estimate the prevalence (airflow obstruction or self-reported COPD) for the low, medium, and high exposure levels for each work exposure. Therefore, we were able to determine that airflow obstruction is associated with both self-reported exposures (mineral dust, organic dust, and exhaust fumes) and JEM-assigned exposures (mineral dust, organic dust, combined dust, diesel exhaust, vapor-gas, sensitizers, and overall exposure). Self-reported COPD is also associated with both self-reported exposures (mineral dust, organic dust, exhaust fumes, other gases/vapors/fumes, and ever dust and/or fumes) and JEM-assigned exposures (mineral dust, organic dust, combined dust, diesel exhaust, vapor-gas, sensitizers, and overall exposure).

Halldin et al[5] investigated self-reported occupational exposure among ever-employed NHANES 2007–2010 participants aged 40–79 years and found significant associations between chronic bronchitis and, separately, between emphysema and dust and/or fume exposure, dust exposure, and exhaust fume exposure. Although Halldin et al[5] did not find occupational exposure to be significantly associated with airflow obstruction, we found the odds of airflow obstruction were significantly elevated in those reporting organic dust exposure and specifically in those with 10–19 years of organic dust exposure compared to those not exposed. In our analysis, we included NHANES ever-employed US adults aged 18–79 years and an additional survey cycle of data (2011–2012) which may explain some of the differences in the results of the two studies.

We also found that ≥20 years of exposure to mineral dust, organic dust, or exhaust fumes was associated with 44–73% higher odds of airflow obstruction than no exposure. This is consistent with Minov et al[23] who reported the prevalence of COPD (defined as post-bronchodilator FEV1/FVC < 0.70) in dusty occupation groups was related to exposure ≥20 years. Lytras et al[9] found 20 years of occupational exposures to biological dusts, gases and fumes, and pesticides were associated with increased incidence of COPD (defined as FEV_1/FVC < LLN post-bronchodilator spirometry). Biological dust is similar to the category of organic dust.

As only a limited number of NHANES participants selected for post-bronchodilator spirometry actually performed it, we used pre-bronchodilator spirometry. Alif et al,[24] in their systematic review and meta-analysis of occupational exposure and COPD (defined as $FEV_1/FVC < 0.70$ and/or $FEV_1/FVC <$ LLN), reported that four of five studies had used pre-bronchodilator spirometry and had found exposure to mineral dust and gases/fumes to be associated with increased risk of COPD.

Tables 1–3 present self-reported and JEM-assigned exposures. The exposures captured in this study may involve different types of work. For example, combined dust includes mineral dust (including silica dust), organic dust, and metal dust from work in construction and extraction (including mining dust).[25,26] Metal furnace work may involve exposure to silica dust where green sand is used toline molds. Metal dust and fume exposure can result from welding, grinding, and smelting. Organic dust exposure can result from sawing and sanding wood.

Exhaust fumes or diesel exhaust are produced from diesel engines; exposures occur in a variety of extraction occupations including drillers and mining workers[27] and construction occupations including highway maintenance repair and equipment operators.[28,29] Vapor-gas exposure may occur in roofing, metal plating, metal furnace operations, and welding.

4.1 | Limitations and strengths

The NIOSH COPD-JEM, based on the principles of the Blanc et al[7] COPD-JEM, was expanded to include additional exposure categories and was not limited to an overall exposure level. Although in NHANES occupation was determined by interview, applying the NIOSH COPD-JEM may be a less costly and time consuming method of assigning occupational exposures than evaluating the full occupational history to derive specific exposures. The JEM method is also useful in evaluating occupational exposures when self-reported data beyond occupation (or longest occupation) are not available.[24] The application of the JEM method is more resistant to recall bias since exposures are assigned.[30,31] Sadhra et al[32] conducted a systematic review of occupational COPD and JEMs and concluded that self-reported occupational exposures may result in overestimates of occupational COPD. However, there are also limitations with JEM-assigned exposures which may not capture the individual's unique exposure, resulting in misclassification.

Even a large study such as NHANES has limits. For example, clinical data were not available to validate self-reported COPD. Additionally, estimates were not presented for some categories of never smokers (Tables 2 and 3) because of RSEs >36%. Potentially unreliable RSEs may be due to less airflow obstruction and self-reported COPD among never smokers. Furthermore, those that never smoke and are working may be healthier. Participants with any airflow obstruction defined by spirometry or self-reported COPD were included in the analysis. We did not exclude those with asthma because the type of airflow obstruction (eg, asthma, chronic bronchitis, emphysema) among those with spirometry-defined airflow obstruction was not determined in this study. It is unknown if asthma would change the estimates. Main confounders adjusted for included age, gender, race, and cigarette use, although potential confounding by other factors cannot be ruled out. However, when Halldin etal analyzed NHANES 2007–2010data, there was no trend in airflow obstruction by level of education (an indicator of socioeconomic status).[5]

A strength is the high quality spirometry data in this recent, nationally representative data set with detailed, four-digit Census occupation codes. We were able to apply the NIOSH COPD-JEM to detailed occupations. The COPD-JEM was created for use in the US population and was used in MESA[12] and Kaiser Permanente studies.[33]

5 | CONCLUSION

Airflow obstruction and self-reported COPD are associated with both self-reported and JEM-assigned exposures in a nationally representative study. The detailed occupations added to this NHANES data allowed the use of a COPD-JEM for exposure assessment. Results from this study use a nationally representative dataset of ever-employed US adults to identify occupational exposures with the greatest airflow obstruction burden. The NIOSH COPD-JEM may be applicable in other studies.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

ACKNOWLEDGMENTS

The authors would like to acknowledge Kathleen B. Fedan, NIOSH and Dr. Chia-Yih Wang, NCHS for providing helpful comments and critique of the manuscript.

FUNDING

The authors report that there was no funding source for the work that resulted in the article or the preparation of the article. All authors are employees of the Federal Government and work was performed as part of their official duties.

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TABLE 1

Age-standardized[a] prevalence (P) of airflow obstruction among ever-employed US adults aged 18–79[b] years by occupational exposures and smoking status, NHANES 2007–2008 to 2011–2012

	Unweighted sample size[d]	Airflow obstruction[c]					
		Overall		Never smokers		Ever smokers	
		P (%)	95% CI	*P* (%)	95% CI	*P* (%)	95% CI
Total	**13 044**	**12.40**	**11.63–13.18**	**7.15**	**6.31–8.00**	**18.47**	**17.29–19.65**
Self-reported exposure (NHANES)							
Mineral dust	4134	14.33	12.92–15.74	7.28	5.93–8.63	19.60	17.36–21.84
No exposure	8879	11.59	10.52–12.65	7.12	5.94–8.29	17.86	16.22–19.50
Organic dust	2911	15.41	13.97–16.86	8.31	6.62–10.01	20.90	18.91–22.89
No exposure	10 125	11.54	10.63–12.45	6.86	5.93–7.79	17.59	16.12–19.06
Exhaust fumes	3230	15.23	13.59–16.87	7.81	6.02–9.59	20.08	17.49–22.66
No exposure	9812	11.48	10.59–12.37	6.99	5.96–8.02	17.77	16.33–19.21
Other gases/vapors/fumes	4151	13.91	12.35–15.47	6.91	5.63–8.19	19.40	17.17–21.63
No exposure	8890	11.69	10.65–12.73	7.23	6.21–8.25	17.86	16.11–19.61
Ever dust and/or fumes	6990	13.65	12.68–14.62	7.30	6.22–8.37	18.94	17.37–20.51
Never dust and/or fumes	6054	11.07	9.78–12.36	7.03	5.85–8.21	17.80	15.45–20.16
COPD-JEM occupational exposures							
Mineral dust							
Low	11 558	12.10	11.34–12.87	7.12	6.16–8.08	18.25	17.13–19.37
Medium	822	12.12	8.72–15.51	5.98	2.85–9.10	16.56	11.61–21.51
High	635	19.49	14.46–24.52	10.64	5.29–16.00	24.02	18.23–29.81
Organic dust							
Low	11 320	12.01	11.19–12.82	7.01	6.08–7.93	17.79	16.58–19.01
Medium	1046	14.58	11.36–17.79	8.07	5.29–10.85	21.84	16.11–27.56
High	649	17.15	11.86–22.44	9.32	4.57–14.06	24.58	16.56–32.61
Combined dust							
Low	9962	11.62	10.81–12.43	6.97	5.94–8.00	17.40	16.21–18.58

	Unweighted sample size[d]	Airflow obstruction[c]					
		Overall		Never smokers		Ever smokers	
		P (%)	95% CI	*P* (%)	95% CI	*P* (%)	95% CI
Total	**13 044**	**12.40**	**11.63–13.18**	**7.15**	**6.31–8.00**	**18.47**	**17.29–19.65**
Medium	1867	13.40	10.98–15.81	6.89	4.84–8.93	19.49	15.63–23.35
High	1186	18.63	14.93–22.33	10.04	6.02–14.07	24.49	19.08–29.90
Diesel exhaust							
Low	11 087	11.98	11.14–12.81	7.06	6.05–8.06	18.13	16.82–19.44
Medium	986	11.78	9.22–14.34	6.51	3.68–9.35	15.98	12.40–19.57
High	942	19.16	15.11–23.22	10.11	4.97–15.24	24.07	18.61–29.53
Vapor-gas							
Low	9,218	11.59	10.65–12.52	7.08	5.99–8.16	17.37	16.03–18.72
Medium	2240	14.01	11.54–16.47	6.43	5.04–7.81	21.00	16.89–25.11
High	1557	16.01	13.23–18.78	8.83	5.97–11.68	20.96	16.53–25.39
Sensitizers							
Low	8522	11.34	10.34–12.33	7.13	6.04–8.22	16.79	15.34–18.24
Medium	2326	14.66	12.41–16.91	6.39	4.60–8.18	22.11	18.74–25.49
High	2167	15.26	12.22–18.30	8.39	6.54–10.23	21.12	16.64–25.61
Fumes							
Low	12 162	12.31	11.47–13.15	7.20	6.29–8.12	18.37	17.11–19.62
Medium	462	12.10	7.98–16.22	**	**	18.65	11.29–26.01
High	391	16.57	10.83–22.32	10.28*	3.30–17.26	20.44	13.71–27.18
Overall exposure							
Low	8039	10.86	9.85–11.87	7.11	5.98–8.25	16.09	14.59–17.59
Medium	2947	14.72	12.66–16.79	6.28	4.51–8.06	21.57	18.72–24.41
High	2029	16.84	13.86–19.82	8.77	6.35–11.20	22.80	18.52–27.09

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

**RSE for the estimated prevalence with airflow obstruction >36% and not reported because it is potentially unreliable.

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

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

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

[d] For airflow obstruction, 31 participants were missing mineral dust exposure data, 8 missing organic dust exposure data, 2 missing exhaust fumes data, 3 missing other gases/vapors/fumes data, and 29 missing in each JEM category.

TABLE 2

Age-standardized[a] prevalence (P) of self-reported COPD among ever-employed US adults aged 20–79[b] years by occupational exposures and smoking status, NHANES 2007–2008 to 2011–2012

		Self-reported COPD					
		Overall		Never Smokers		Ever Smokers	
	Unweighted sample size[c]	P^d (%)	95% CI	P^d (%)	95% CI	P^d (%)	95% CI
Total	**15 777**	**3.47**	**2.91–4.03**	**1.48**	**1.12–1.84**	**5.61**	**4.77–6.44**
Self-reported exposure (NHANES)							
Mineral dust	4971	4.47	3.59–5.35	1.66	0.87–2.45	6.33	5.15–7.51
No exposure	10 764	3.05	2.50–3.60	1.42	1.05–1.79	5.22	4.28–6.16
Organic dust	3454	4.98	3.80–6.16	1.22	0.51–1.93	7.62	5.67–9.57
No exposure	12 309	3.06	2.60–3.52	1.51	1.13–1.89	4.93	4.23–5.63
Exhaust Fumes	3875	5.24	3.96–6.52	2.02	1.26–2.78	7.18	5.31–9.05
No exposure	11 896	2.89	2.45–3.32	1.35	0.97–1.73	4.89	4.16–5.62
Other gases/vapors/fumes	4991	4.43	3.76–5.09	1.55	1.11–1.99	6.40	5.34–7.46
No exposure	10 780	3.05	2.48–3.62	1.44	1.01–1.87	5.17	4.17–6.17
Ever dust and/or fumes	8413	4.50	3.72–5.28	1.54	1.06–2.02	6.75	5.61–7.89
Never dust and/or fumes	7364	2.43	1.94–2.92	1.45	1.06–1.83	3.86	3.08–4.63
COPD-JEM occupational exposures							
Mineral dust							
Low	13 948	3.35	2.84–3.85	1.45	1.09–1.81	5.53	4.71–6.35
Medium	1005	4.62	2.94–6.29	**	**	5.90	3.74–8.06
High	778	4.41	1.95–6.86	**	**	6.23	2.69–9.76
Organic dust							
Low	13 638	3.39	2.88–3.91	1.51	1.14–1.87	5.43	4.67–6.18
Medium	1302	5.32	3.51–7.14	1.46	0.64–2.29	9.50	5.83–13.16
High	791	2.44	1.10–3.78			3.57	1.67–5.46
Combined dust							
Low	11 973	3.15	2.67–3.62	1.49	1.11–1.86	5.07	4.36–5.77

		Self-reported COPD					
		Overall		Never Smokers		Ever Smokers	
	Unweighted sample size[c]	P^d (%)	95% CI	P^d (%)	95% CI	P^d (%)	95% CI
Total	**15 777**	**3.47**	**2.91–4.03**	**1.48**	**1.12–1.84**	**5.61**	**4.77–6.44**
Medium	2316	5.19	3.77–6.62	1.66	0.83–2.49	8.19	5.77–10.61
High	1442	4.09	2.41–5.76	**	**	5.92	3.41–8.43
Diesel exhaust							
Low	13 404	3.35	2.83–3.87	1.44	1.09–1.79	5.59	4.74–6.45
Medium	1184	3.16	1.89–4.43	**	**	4.30	2.68–5.92
High	1143	5.36	3.35–7.37	**	**	6.88	4.52–9.23
Vapor-gas							
Low	11 045	3.23	2.73–3.74	1.49	1.10–1.87	5.34	4.52–6.17
Medium	2794	4.30	2.95–5.65	1.53	0.64–2.42	6.66	4.79–8.53
High	1892	4.11	2.73–5.49	**	**	5.63	3.88–7.38
Sensitizers							
Low	10154	3.13	2.67–3.59	1.57	1.18–1.97	4.99	4.25–5.74
Medium	2844	4.31	3.04–5.59	**	**	6.90	4.94–8.86
High	2733	4.26	3.04–5.48	1.33*	0.46–2.20	6.68	4.86–8.51
Fumes							
Low	14 689	3.43	2.91–3.94	1.48	1.12–1.84	5.56	4.76–6.36
Medium	567	3.68	1.62–5.74			6.47	3.27–9.68
High	475	4.99	2.49–7.50			5.66	2.94–8.38
Overall exposure							
Low	9592	2.71	2.29–3.12	1.42	1.07–1.77	4.37	3.71–5.03
Medium	3642	5.37	4.17–6.56	1.95	0.84–3.05	7.94	6.15–9.74
High	2497	4.51	3.07–5.94	**	**	6.80	4.92–8.69

[*] RSE for the estimated prevalence with self-reported COPD >30% and ≤36%.

[**] RSE for the estimated prevalence with self-reported COPD >36% and not reported because it is potentially unreliable.

[a] Age-standardized prevalence estimates based on the age distribution of the 2000 US Census Population age structure for 20–79 year-old adult samples. NHANES interview sampling weights were used for self-reported COPD outcome.

[b] Sample 20–79 years of age with valid longest held occupation data were evaluated for self-reported COPD. Self-reported COPD was defined as self-reported, doctor or health professional diagnosis of chronic bronchitis (and still have chronic bronchitis) or emphysema.

[c] For self-reported COPD, 42 participants were missing mineral dust exposure data, 14 missing organic dust exposure data, 6 missing exhaust fumes data, 6 missing other gases/vapors/fumes data, and 46 missing in each JEM category.

[d] Prevalence blank due to small numbers.

TABLE 3

Prevalence odds ratios[a] (POR) of airflow obstruction and self-reported COPD among ever-employed US adults by occupational exposures, NHANES 2007–2008 to 2011–2012

	Airflow obstruction[b]		Self-reported COPD[c]	
	POR	**95% CI**	**POR**	**95% CI**
Self-reported exposure NHANES				
Mineral dust	1.07	0.91–1.26	**1.62**	1.19–2.21
No exposure	Ref.		Ref.	
>0–9 years exposure	0.92	0.75–1.12	**1.48**	1.02–2.15
10–19 years exposure	1.08	0.79–1.48	**1.90**	1.25–2.89
≥20 years exposure	**1.44**	1.13–1.85	**1.69**	1.17–2.43
Organic dust	**1.23**	1.05–1.44	**1.64**	1.29–2.08
No exposure	Ref.		Ref.	
>0–9 years exposure	0.95	0.78–1.15	**1.50**	1.01–2.22
10–19 years exposure	**1.61**	1.13–2.29	**2.18**	1.41–3.37
≥20 years exposure	**1.73**	1.35–2.21	1.52	0.99–2.33
Exhaust Fumes	1.13	0.97–1.31	**2.01**	1.48–2.74
No exposure	Ref.		Ref.	
>0–9 years exposure	0.89	0.73–1.09	**1.83**	1.30–2.59
10–19 years exposure	1.22	0.91–1.63	**2.15**	1.32–3.49
≥20 years exposure	**1.65**	1.27–2.15	**2.22**	1.37–3.58
Other gases/vapors/fumes	1.03	0.89–1.19	**1.47**	1.20–1.79
No exposure	Ref.		Ref.	
>0–9 years exposure	0.96	0.81–1.14	1.19	0.93–1.54
10–19 years exposure	0.99	0.74–1.32	**1.97**	1.35–2.87
≥20 years exposure	1.23	0.93–1.63	**1.61**	1.16–2.23
Ever dust and/or fumes	1.05	0.90–1.23	**2.04**	1.64–2.53
Never dust and/or fumes	Ref.		Ref.	
COPD-JEM occupational exposures				
Mineral dust				

	Airflow obstruction[b]		Self-reported COPD[c]	
	POR	**95% CI**	**POR**	**95% CI**
Low	Ref.		Ref.	
Medium	0.85	0.62–1.16	**1.47**	1.02–2.10
High	**1.44**	1.09–1.90	1.40	0.79–2.47
Organic dust				
Low	Ref.		Ref.	
Medium	**1.34**	1.02–1.76	**1.71**	1.25–2.34
High	1.45	0.98–2.12	0.84	0.51–1.39
Combined dust				
Low	Ref.		Ref.	
Medium	1.15	0.92–1.44	**1.81**	1.36–2.43
High	**1.57**	1.21–2.04	**1.52**	1.03–2.24
Diesel exhaust				
Low	Ref.		Ref.	
Medium	0.85	0.66–1.09	1.02	0.69–1.51
High	**1.44**	1.12–1.85	**1.82**	1.18–2.81
Vapor-gas				
Low	Ref.		Ref.	
Medium	1.15	0.91–1.45	**1.46**	1.05–2.02
High	**1.31**	1.05–1.64	**1.39**	1.04–1.85
Sensitizers				
Low	Ref.		Ref.	
Medium	**1.27**	1.03–1.56	**1.43**	1.05–1.96
High	**1.33**	1.01–1.76	**1.50**	1.13–1.99
Fumes				
Low	Ref.		Ref.	
Medium	0.88	0.60–1.28	1.20	0.69–2.09
High	1.19	0.80–1.77	1.43	0.89–2.30
Overall exposure				
Low	Ref.		Ref.	
Medium	**1.32**	1.08–1.61	**2.20**	1.70–2.86

	Airflow obstruction[b]		Self-reported COPD[c]	
	POR	**95% CI**	**POR**	**95% CI**
High	**1.54**	1.21–1.96	**2.02**	1.46–2.80

Ref., Reference group.

[a]POR adjusted for age, gender, race, and smoking status. Bold font indicates significant (95% CI does not include 1.00).

[b]Sample 18–79 years of age with valid spirometry, height, and longest held occupation data were evaluated for airflow obstruction (defined as FEV1/FVC < LLN).

[c]Sample 20–79 years of age with valid longest held occupation data were evaluated for self-reported COPD (defined as self-reported, doctor or health professional diagnosis of chronic bronchitis [and still have chronic bronchitis] or emphysema).