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Chronic bronchitis and emphysema among workers exposed to dust, vapors, or fumes by industry and occupation

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Abstract

Exposures to dust, vapors, or fumes (DVF) are associated with chronic bronchitis (CB) and emphysema. The 2007–2012 National Health and Nutrition Examination Survey data were used to estimate age-standardized prevalence of CB and emphysema among ever-employed adults by exposure status and industry and occupation groups. Age-standardized CB and emphysema prevalence were 2.3% and 1.9%, respectively. Of the estimated 111 million U.S. workers exposed to DVF, 2.7% reported CB and 2.8% reported emphysema. Workers in the “accommodation, food services” industry and “food preparation, serving related” occupations were more likely to report CB and emphysema. Current findings indicate that workplace exposures may be associated with high prevalence of CB and emphysema in certain industry and occupational groups. Early diagnosis and identifying associated workplace exposures are important steps in CB and emphysema prevention efforts.

Keywords

Chronic bronchitis; emphysema; industry; occupation; occupational exposure; NHANES

Introduction

Workplace exposures to mineral dust, organic dust, exhaust fumes, and other gases, vapors, and fumes are associated with chronic obstructive pulmonary disease (COPD).[1] Smoking is the leading cause of COPD, however previous findings indicate high COPD prevalence among never-smokers in certain industries and occupations, indicating other risk factors (eg workplace exposures) may be associated with COPD.[2] While characterizing workplace exposure among workers is difficult in the absence of air sampling, we used self-reported workplace information collected in the National Health and Nutrition Examination Survey (NHANES) to estimate chronic bronchitis (CB) and emphysema prevalence among ever-employed adults by workplace exposure (dust, vapors, or fumes, DVF) status and by industry and occupation.

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Materials and methods

The NHANES data for 2007–2008, 2009–2010, and 2011–2012 were combined (sample n=17,713 persons aged 20–79 years) to improve precision and reliability of the estimates.[3,4] Excluded from the study sample were 785 persons who were never-employed or did not report a longest held job, resulting in a sample size of 16,928. Data were weighted to produce nationally representative estimates.[4,5] Study protocols were approved by the National Center for Health Statistics' (NCHS) Research Ethics Review Board and informed consent was obtained from all participants.

Longest held industry and occupation for ever-employed participants were determined from the question, "Thinking of all the paid jobs or businesses you ever had, what kind of work were you doing the longest?" NIOSH's Division of Surveillance, Hazard Evaluations, and Field Studies generated four-digit industry and occupation codes for longest held job based on 2002 Census Bureau Occupation Codes (https://wwwn.cdc.gov/Nchs/Nhanes/2011-2012/OCQ_G.htm). Industry was coded based on the type of business or establishment where the participant worked and occupation based on the type of work performed. NCHS collapsed the four-digit codes into the 22 industry groups and 23 occupation groups.

Participants reporting "yes" to any of the work questions: exposure to mineral dust (eg "dust from rock, sand, concrete, coal, asbestos, silica or soil"), organic dust (eg "dust from flours, grains, wood, cotton, plants or animals"), exposure to exhaust fumes (eg "exhaust fumes from trucks, buses, heavy machinery or diesel engines"), and/or other fumes (eg "vapors from paints, cleaning products, glues, solvents, and acids; or welding/soldering fumes") were considered to have DVF exposure (https://wwwn.cdc.gov/Nchs/Nhanes/2007-2008/OCQ_E.htm).

Participants were determined to have CB if they reported a doctor or other health professional ever told them they had chronic bronchitis and they still have chronic bronchitis. Participants were determined to have emphysema if they reported a doctor or other health professional ever told them they had emphysema. Participants were classified as never-smokers if they reported smoking less than 100 cigarettes during their lifetime and ever-smokers if they smoked at least 100 cigarettes during their lifetime.

Statistical analyses were performed using SAS® 9.4 (SAS Institute Inc., Cary, North Carolina, USA) complex survey procedures to adjust for differential probabilities of selection and the complex sampling design.[5] Age-standardized prevalence with corresponding 95% confidence intervals (CIs) were calculated using the standard age distribution of the 2000 U.S. Census Population.[5] Two-sided t-tests determined statistically significant ($p < .05$) differences between point estimates. NHANES sampling weights were used to calculate CB and emphysema estimates, representative of the civilian, non-institutionalized U.S. population. Reliability of prevalence estimates was determined by calculating relative standard errors.[5]

MultiLog procedure in SAS callable SUDAAN was used to calculate adjusted CB and emphysema prevalence ratios (PRs) for each industry and occupation group. PRs were adjusted for age, gender, race/Hispanic origin, and smoking status as previous publications

have shown COPD prevalence varies based on these factors.[1,2,6] The reference groups included those with no CB or emphysema. Additional analyses stratified by smoking status were not possible due to small sample sizes.

Results

Of the estimated 213 million ever-employed adults, the CB prevalence was 4.6% (crude prevalence) and 2.3% (age-standardized prevalence), and the emphysema prevalence was 2.7% (crude prevalence) and 1.9% (age-standardized prevalence). Age-standardized CB and emphysema prevalence were high among ever-employed U.S. adults 60–79 years of age, those with less than high school education, and ever-smokers, and the prevalence generally increased with increasing cigarette-pack-years. CB prevalence was highest among females and non-Hispanic blacks and emphysema prevalence was highest among males and non-Hispanic whites (Table 1).

Age-standardized CB prevalence among ever-employed adults in “food preparation, serving” occupations was significantly higher than the total 2.3%. By industry group, the highest CB prevalence was among workers in “armed forces” (P=4.2%, 95% CI: 1.5–7.0%) followed by the “accommodation, food services” industry (P=3.4%, 95% CI: 2.2–4.6%) (Table 2).

An estimated 52% (111 million) of ever-employed adults reported DVF exposures. Among workers reporting any DVF exposures, workers in “food preparation, serving related occupations” had the highest CB prevalence (P=4.6%, 95% CI: 2.7–6.4%). “Accommodation, food services” industry workers (PR = 1.8, 95% CI: 1.2–2.6) and workers in “production” occupations (PR = 1.5, 95% CI: 1.1–2.2) were more likely to have CB. Workers in the “accommodation, food services” industry and “food preparation, serving related” occupations had significantly higher CB prevalence compared to the total 2.7%.

Age-standardized emphysema prevalence among ever-employed adults in “mining” and “accommodation, food services” industries and “food preparation, serving related”, “construction, extraction”, and “transportation, material moving” occupations were significantly higher than the total 1.9%. The highest emphysema prevalence was among workers in the “mining” industry (P=5.1%, 95% CI: 1.4–8.8%) followed by “accommodation, food services” industry (P=3.8%, 95% CI: 2.3–5.3%) (Table 2). “Accommodation, food services” industry workers reporting any DVF exposure had a higher likelihood of reporting emphysema (PR = 1.9, 95% CI: 1.1 −3.0). Among workers reporting any DVF exposures, workers in the “management, administrative, waste services”, “accommodation, food services” industries and “food preparation, serving related” occupations had significantly higher emphysema prevalence compared to the total 2.8%.

Discussion

During 2007–2012, an estimated 111 million ever-employed adults reported workplace exposures and of those, 5.1 million had CB and 2.9 million had emphysema. Prevalence of CB and emphysema varied by selected sociodemographic characteristics, industry, and occupation. Reported DVF exposure varied by industry and occupation group with workers

in the “construction” industry and “construction, extraction” occupations reporting the highest percent of DVF exposure.

Workers in the “accommodation, food services” industry and “food preparation, serving related” occupations reporting DVF exposures were more likely to report CB or emphysema. Previous findings indicate cooking processes to heat food produce vapors and particulates associated with higher COPD prevalence.[7] In addition, workers in the “accommodation, food services” industry are exposed to cleaning chemicals, which can impair respiratory function.[6] Workers in “production” occupations reporting DVF exposures were more likely to report CB. DVF exposures among these workers are associated with a variety of materials including metals, plastics, food, textiles, and wood. During the production of automobiles, DVF exposure can occur from processes such as heating ferrous and non-ferrous metals in furnaces, injection molding of plastic and metals, machining of parts, and grinding metal.[8] Respirable silica exposure from abrasive blasting and green sand in molds may also occur.[8]

Current findings of higher CB or emphysema prevalence in “construction, extraction”, “food preparation, serving”, “production”, and “healthcare support” occupations was consistent with the higher prevalence of spirometry defined airflow obstruction among these workers.[9,10] In addition, occupational exposure to vapors, gases, dusts, and fumes was associated with increased COPD mortality in construction workers.[11] The higher prevalence of airflow obstruction and doctor-diagnosed self-reported CB and/or emphysema in these occupations highlight the importance of prioritizing prevention efforts in “construction, extraction”, “food preparation, serving”, “production”, and “healthcare support” occupations.

A strength of this study is that NHANES data are population-based and include information on longest held industry and occupation, occupational exposure, and health outcomes. Additionally, these data provide national estimates of CB and emphysema among ever-employed adults and help identify occupational exposures that may partially contribute to CB or emphysema development. However, there are some limitations. Survey participants were asked about exposures in any job, and the longest held job may not be the job where occupational exposures associated with CB or emphysema occurred. Moreover, validation of self-reported information on occupational exposures, industry, occupation, CB, or emphysema was not possible due to lack of information on air monitoring, occupational history, or medical records, which may have introduced bias. Despite combining three NHANES survey cycles, the prevalence of CB or emphysema and exposure for some industry and occupational groups were unreliable as were results when stratifying by smoking status. Finally, NHANES is a cross-sectional study and the times of CB or emphysema diagnosis were not available, thus temporal associations between exposure and diagnosis were unavailable.

These findings indicate workplace exposures are associated with CB or emphysema in certain industry and occupational groups. Identifying workplace exposures within industry and occupational groups is an important step to improve CB and emphysema prevention efforts. Workplace interventions can improve workers’ health behaviors and health status, reduce health risks for disease, and have the potential to impact areas such as health care

costs and workplace absenteeism, productivity, recruitment and/or retention, culture, and employee morale.[12]

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Table 1.

Age-standardized[a] prevalence (P) of chronic bronchitis and emphysema among ever-employed U.S. adults aged 20–79 years[b] for selected characteristics, NHANES 2007–2008 to 2011–2012.

	Estimated workers in thousands (weighted data)	**Chronic bronchitis[b] *n* = 463**	**Emphysema[b] *n* = 389**
Characteristics	*n*	P (%) 95% (CI)[c]	P (%) 95% (CI)
Total	219,336	2.30 (1.9–2.7)	1.9 (1.6–2.1)
Age (years)			
20–39	80,573	1.1 (0.7–1.4)	0.3 (0.1–0.4)*
40–59	84,422	2.4 (1.7–3.1)	1.6 (1.3–2.0)
60–79	54,342	4.3 (3.4–5.2)	5.1 (4.3–5.9)
Gender			
Male	107,608	1.5 (1.1–1.9)	2.3 (1.9–2.7)
Female	111,729	3.0 (2.4–3.7)	1.5 (1.2–1.8)
Race/Hispanic origin			
Non-Hispanic White	150,486	2.5 (1.9–3.1)	2.1 (1.8–2.5)
Non-Hispanic Black	24,852	2.7 (2.0–3.4)	1.3 (0.9–1.6)
Mexican American	17,349	1.0 (0.5–1.5)	0.5 (0.3–0.8)
Other Hispanic	11,738	1.5 (0.8–2.1)	1.1 (0.6–1.5)
Other	14,911	1.3 (0.5–2.1)	1.9 (0.9–2.8)
Education			
Less than high school	39,129	3.8 (2.9–4.7)	3.9 (3.0–4.7)
High school graduate/GED	50,449	2.5 (1.8–3.2)	2.0 (1.3–2.7)
At least some college	129,571	1.8 (1.4–2.1)	1.2 (0.9–1.5)
Smoking status			
Never-smoker	119,262	1.4 (1.0–1.7)	0.2 (0.1–3.7)
Ever-smoker	99,948	3.4 (2.7–4.1)	3.6 (3.1–4.1)
Cigarette-pack-years[d]			
<3 years	30,787	2.1 (1.2–2.9)	2.1 (1.2–3.0)
3–10.9	23,981	2.9 (1.5–4.3)	1.3 (0.7–2.0)
11 – 26.9	21,813	3.7 (2.5–4.9)	2.6 (1.8–3.4)

	Estimated workers in thousands (weighted data)	Chronic bronchitis[b] *n* = 463	Emphysema[b] *n* = 389
≥27	23,367	6.2 (3.7–8.6)	8.6 (6.0–11.3)

[a] Age-standardized prevalence estimates were based on the age distribution of the 2000 U.S. Census Population 20–79 age structures. Age-specific estimates are reported for age categories.

[b] Sample respondents aged 20–79 years with valid longest held job data were evaluated for chronic bronchitis and emphysema. Thirty-two (32) participants were missing self-reported chronic bronchitis data, 22 participants were missing self-reported emphysema data, 20 participants were missing education data, and 13 were missing smoking status data.

[c] CI, confidence interval.

[d] Pack-years were estimated for ever-smokers aged 20–79 years.

[*] These estimates have a relative standard error (RSE) >30% and <50% and should be used with caution as they do not meet standards of reliability/precision.

Table 2.

Age-standardized prevalence (P) and prevalence ratios (PR) of CB and emphysema among ever-employed U.S. adults aged 20–79 years by industry and occupation, NHANES 2007–2008 to 2011–2012.

	Estimated workers in thousands (weighted data), *n*		Chronic bronchitis			Emphysema		
				Workers with any DVF exposures			Workers with any DVF exposures	
	n	Workers with any DVF exposures *n* (%)	P% (95% CI) all workers	P% (95% CI)	PR[a] (95% CI)	P% (95% CI) all Worker	P% (95% CI)	PR[a] (95% CI)
Total	212,780	110,808 (52.1)	2.3 (1.9–2.7)	2.7 (2.1–3.4)	1.2 (1.1–1.3)	1.9 (1.6–2.1)	2.8 (2.3–3.3)	1.3 (1.2–1.4)
Industry group								
Agriculture, forestry, fishing	4,717	3,783 (80.2)	0.9 (0.3–1.5)[b] *	**	–	2.1 (0.2–4.0)*	**	–
Mining	1,775	1,593 (89.7)	**	**	–	5.1 (1.4–8.8)[b] *	**	–
Utilities	2,118	1,339 (63.2)	**	**	–	**	**	–
Construction	16,124	14,477 (89.8)	1.7 (0.8–2.6)	2.0 (0.9–3.1)*	0.9 (0.6–1.4)	3.0 (1.6–4.3)	3.3 (1.6–4.9)	1.0 (0.7–1.6)
Manufacturing: durable goods	18,667	12,594 (67.5)	2.4 (1.4–3.4)	2.6 (1.5–3.7)	0.9 (0.6–1.5)	2.8 (1.8–3.9)	4.1 (2.6–5.7)	1.3 (0.9–2.0)
Manufacturing: non-durable goods	11,887	6,990 (58.8)	2.9 (0.8–5.1)*	4.2 (0.9–7.6)*	1.5 (0.9–2.6)	1.6 (0.9–2.2)	2.2 (1.0–3.4)	0.7 (0.4–1.4)
Wholesale trade	5,523	2,991 (54.2)	2.8 (0.3–5.4)*	3.0 (0.6–5.5)*	1.3 (0.5–3.3)	**	**	–
Retail trade	20,572	9,154 (44.5)	2.0 (1.0–3.0)	2.6 (0.7–4.5)*	0.8 (0.4–1.5)	1.5 (1.0–2.0)	1.6 (0.3–2.8)*	0.5 (0.2–0.9)[b]
Transportation, warehousing	8,602	5,917 (68.8)	3.0 (1.4–4.6)	3.5 (1.4–5.5)	1.3 (0.8–2.4)	2.8 (1.3–4.3)	3.8 (1.7–5.9)	1.3 (0.7–2.3)
Information, finance, real estate group	17,644	5,681 (32.2)	1.9 (1.0–2.7)	2.6 (0.6–4.6)*	0.8 (0.4–1.6)	1.2 (0.5–1.9)*	**	–
Professional, scientific, technical services	11,706	4,332 (37.0)	1.4 (0.2–2.5)*	2.9 (0.2–5.5)*	1.2 (0.5–3.2)	**	**	–
Management, administrative, waste services	6,906	4,503 (65.2)	2.6 (1.1–4.1)	4.4 (1.2–7.5)	1.3 (0.7–2.5)	3.2 (0.8–5.5)*	6.7 (2.1–11.2)[b] *	2.1 (1.0–4.3)
Educational services	17,629	6,439 (36.5)	2.0 (0.9–3.1)	1.9 (0.7–3.1)*	0.7 (0.4–1.4)	1.2 (0.5–1.9)	2.5 (0.6–4.5)*	1.3 (0.7–2.7)
Health care, social assistance	25,854	8,737 (33.8)	2.9 (2.0–3.8)	3.3 (1.4–5.2)	0.9 (0.6–1.4)	1.2 (0.8–1.7)	1.9 (1.0–2.8)	0.7 (0.4–1.3)
Arts, entertainment, recreation	3,907	1,890 (48.4)	**	**	–	**	**	–
Accommodation, food services	16,305	8,303 (50.9)	3.4 (2.2–4.6)	5.2 (2.6–7.8)[b]	1.8 (1.2–2.6)	3.8 (2.3–5.3)[b]	5.4 (2.4–8.4)[b]	1.9 (1.1–3.0)
Other services	8,433	4,886 (57.9)	1.1 (0.6–1.7)[b]	1.0 (0.3–1.7)[b] *	0.3 (0.1–0.7)	1.1 (0.5–1.7)	2.0 (0.9–3.2)*	0.7 (0.3–1.5)
Private household	1,829	784 (42.9)	**	**	–	**	**	–

	Estimated workers in thousands (weighted data), *n*		Chronic bronchitis			Emphysema		
				Workers with any DVF exposures			Workers with any DVF exposures	
	n	Workers with any DVF exposures *n* (%)	P% (95% CI) all workers	P% (95% CI)	PR[a] (95% CI)	P% (95% CI) all Worker	P% (95% CI)	PR[a] (95% CI)
Public administration	9,437	4,361 (46.2)	1.4 (0.4–2.3) *	**	–	1.2 (0.6–1.8)	1.3 (0.2–2.3)[b] *	0.5 (0.2–1.2)
Armed forces	2,398	1,799 (75.0)	4.2 (1.5–7.0) *	4.0 (0.9–7.1) *	1.8 (0.8–4.2)	*	**	–
Occupation group			P (95% CI)	P (95% CI)	PR[a] (95% CI)	P (95% CI)	P% (95% CI)	PR[a] (95% CI)
Management occupations	21,752	11,490 (52.8)	0.9 (0.4–1.5)[b] *	**	–	0.9 (0.3–1.4) *	1.2 (0.3–2.0)[b] *	0.4 (0.2–0.9)
Business, computer, architecture, life science, community, legal occupations	24,096	9,266 (38.5)	1.3 (0.6–2.0)[b]	**	–	0.4 (0.1–0.6) *	0.4 (0.1–0.7)[b] *	0.1 (0.1–0.3)
Education, training, library occupations	12,346	3,965 (32.1)	2.4 (0.9–3.9)	2.0 (0.4–3.6) *	0.8 (0.3–1.8)	0.8 (0.4–1.3)[b]	**	–
Arts, design, entertainment, sports, media occupations	4,262	1,709 (40.1)	**	**	–	**	**	–
Healthcare practitioners, technical occupations	9,521	2,881 (30.3)	2.3 (0.8–3.9) *	3.1 (0.3–5.8) *	0.9 (0.3–2.4)	0.8 (0.1–1.4)[b] *	1.1 (0.0–2.2)[b] *	0.5 (0.2–1.3)
Healthcare support occupations	5,569	1,931 (34.7)	3.0 (1.1–4.8) *	5.0 (0.6–9.5) *	1.1 (0.5–2.7)	2.2 (0.5–3.8) *	**	0.2 (0.1–1.0)[b]
Protective service occupations	4,147	2,901 (70.0)	**	**	–	3.1 (0.5–5.7) *	3.5 (0.4–6.6) *	1.5 (0.5–4.2)
Food preparation, serving related occupations	12,990	6,502 (50.1)	4.6 (2.7–6.4)[b]	7.4 (3.7–11.1)[b]	2.5 (1.7–3.6)[b]	4.1 (2.6–5.7)[b]	5.4 (2.1–8.7)[b] *	1.7 (0.9–3.2)
Building & grounds cleaning, maintenance occupations	8,366	5,623 (67.2)	2.1 (1.0–3.2)	1.9 (0.7–3.1) *	0.6 (0.3–1.2)	2.6 (1.3–3.9)	4.3 (1.8–6.8)	1.6 (1.0–2.7)
Personal care, service occupations	6,477	2,793 (43.1)	2.5 (1.5–3.6)	2.8 (0.6–5.1) *	0.6 (0.2–1.4)	**	**	–
Sales & related occupations	20,570	8,437 (41.0)	2.2 (1.2–3.1)	2.7 (1.0–4.4) *	0.8 (0.4–1.5)	1.7 (1.0–2.4)	2.6 (1.1–4.1) *	0.9 (0.4–2.0)
Office, administrative support occupations	27,281	9,276 (34.0)	2.4 (1.5–3.4)	3.0 (1.5–4.4)	0.8 (0.5–1.3)	1.7 (0.9–2.4)	2.9 (1.3–4.6) *	1.1 (0.6–1.8)
Farming, fishing, forestry occupations	2,224	1,785 (80.3)	**	**	–	**	**	–
Construction, extraction occupations	14,212	13,316 (93.7)	2.5 (1.4–3.7)	2.8 (1.5–4.1)	1.3 (0.9–2.0)	3.9 (2.2–5.6)[b]	4.2 (2.2–6.1)	1.3 (0.9–1.9)
Installation, maintenance, repair occupations	6,776	5,735 (84.6)	1.5 (0.7–2.3)	1.9 (0.8–2.9)	0.8 (0.4–1.6)	2.7 (1.5–3.9)	3.6 (1.9–5.3)	1.1 (0.6–2.0)
Production occupations	18,767	13,246 (70.6)	3.6 (2.0–5.2)	4.4 (2.3–6.4)	1.5 (1.1–2.2)	2.9 (1.8–3.9)	3.8 (2.2–5.3)	1.2 (0.8–1.8)

	Estimated workers in thousands (weighted data), *n*		Chronic bronchitis			Emphysema		
				Workers with any DVF exposures			Workers with any DVF exposures	
	n	Workers with any DVF exposures *n* (%)	P% (95% CI) all workers	P% (95% CI)	PR[a] (95% CI)	P% (95% CI) all Worker	P% (95% CI)	PR[a] (95% CI)
Transportation, material moving occupations	11,498	8,702 (75.7)	2.7 (1.6–3.8)	2.9 (1.5–4.2)	1.3 (0.8–2.1)	3.8 (1.7–5.8)[b]	4.2 (1.5–6.8) *	1.4 (0.9–2.3)
Armed forces	1,373	1,033 (75.2)	**	**	–	2.5 (0.7–4.3) *	**	–

DVF, dust, vapors, or fumes.

–, RSE for prevalence estimate ≥50%, so PR was not reported.

“Information, Finance, Real Estate Group” includes the industry groups Information Services; Finance, Insurance; and Real Estate, Rental, Leasing.

“Business, Computer, Architecture, Life Science, Community, Legal” includes the occupation groups Business and Financial Operations Occupations; Computer, Mathematical Science Occupations; Architecture, Engineering Occupations; Life, Physical, Social Science Occupations; Community, Social Services; Legal Occupations.

[a]Prevalence ratios are adjusted for age, sex, race/Hispanic origin, and smoking status.

[b]Statistically significant ($p < .05$) difference compared to national average (total).

*These estimates have a relative standard error (RSE) >30% and <50% and should be used with caution as they do not meet standards of reliability/precision.

**RSE ≥50% and not reported.

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