HHS Public Access

Author manuscript

Am J Ind Med. Author manuscript; available in PMC 2022 January 01.

Published in final edited form as:

Am J Ind Med. 2021 January ; 64(1): 26–38. doi:10.1002/ajim.23196.

Incident chronic obstructive pulmonary disease associated with occupation, industry, and workplace exposures in the Health and Retirement Study

Sharon R. Silver, MS, **Walter A. Alarcon, MD, MSc**, **Jia Li, MS**

National Institute for Occupational Safety and Health, Division of Field Studies and Engineering, Work performed at National Institute for Occupational Safety and Health

Abstract

Background—Chronic health effects from accumulated occupational exposures manifest as the workforce ages. The Health and Retirement Study (HRS), a panel survey of U.S. adults nearing/in retirement, allows assessment of associations among industry and occupation (I/O), workplace exposures, and incident chronic obstructive pulmonary disease (COPD).

Methods—The study population comprised respondents from the 1992 HRS cohort employed in 1972 or later and not diagnosed with COPD as of initial interview. We examined associations with incident COPD through 2016 and 1) broad and selected detailed I/O, 2) workplace exposures, and 3) exposures within I/O. Given the cohort's baseline age (50–62), we calculated subhazard ratios (SHRs) for COPD accounting for competing risk of death.

Results—SHRs for COPD were significantly elevated for several industries: mining; blast furnaces, steelworks, rolling and finishing mills; groceries and related products; and automotive repair shops. Occupations with significantly elevated SHRs were maids and housemen; farm workers; vehicle/mobile equipment mechanics and repair workers; material moving equipment operators; and non-construction laborers. Significantly elevated COPD SHRs were observed for specific I/O-exposure pairs: blast furnace/steelworks/rolling/finishing mills and asbestos; automotive repair shops and aerosol paints; farm workers and pesticide exposures; and both material moving equipment operators and non-construction laborers exposed to dust and ash.

Conclusions—Certain jobs and occupational exposures are associated with increased risk for developing COPD in late pre-retirement and during retirement. Given the disability and economic costs of COPD, these findings support focusing exposure prevention and medical monitoring resources on groups of workers at increased risk.

Corresponding author: Sharon Silver, ssilver@cdc.gov, National Institute for Occupational Safety and Health, Division of Field Studies and Engineering, MS R-17, 1150 Tusculum Ave., Cincinnati, OH 45226, (513) 841-4313.

Authors' contributions: Ms. Silver designed the work and drafted and revised the manuscript. Ms. Li planned and conducted the statistical analyses, as well as providing comments key to revising the manuscript. Dr. Alarcon was responsible for acquisition of data for the work and provided extensive comments and revisions for the manuscript. All authors have approved this version of the manuscript for submission to AJIM and agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Disclosure (Authors): The authors declare no conflicts of interest.

Institution and Ethics approval and informed consent: The project was approved by the NIOSH Institutional Review Board (IRB).

Disclaimer: The findings and conclusions presented in this article are those of the authors and do not necessarily represent the views of the National Institute for Occupational Safety and Health/Centers for Disease Control and Prevention.

Background

As the workforce ages, health effects from accumulated occupational exposures may become apparent. Assessing the longitudinal health trajectories of workers in different industries and occupations (I&O) can be helpful both for projecting the future healthcare needs of current workers and for identifying groups that warrant targeted prevention and medical surveillance efforts. The Health and Retirement Study (HRS) presents an opportunity to examine the downstream effects of occupational exposures accrued during the working years. The HRS is a large, nationally representative longitudinal panel survey of U.S. residents older than 50 years that has been conducted since 1992.[1] Participants are surveyed at baseline, then re-interviewed at two-year intervals. At each interview, the survey collects information on respondents' current and longest-held jobs, as well as health outcomes. In addition, in 1992, 1994, and 1996, information on past occupational exposures was collected.

Chronic lung disease is one of the health outcomes in the HRS, ascertained by the question "Not including asthma, has a doctor ever told you that you have chronic lung disease such as chronic bronchitis or emphysema?" A positive answer to this HRS question has been considered by previous researchers to indicate that the respondent has chronic obstructive pulmonary disease (COPD). COPD is by far the most prevalent of the chronic non-malignant lower-respiratory diseases, and is the third leading cause of death in the U.S.;[2] the prevalence of diagnosed cases has been estimated as 12 to 16 million, with suggestions of up to an equal number of undiagnosed cases, in the U.S.[3,4]

Most examinations of associations between industry or occupation (I/O) and COPD risk have focused on a set of broad I/O groups. Studies of non-smoking workers have found highest prevalences of COPD for men in the protective services occupation and in several industries: agriculture, forestry, fishing, and hunting; administrative and support, waste management, and remediation services; and arts, entertainment, and recreation.[5] Among non-smoking women, the highest COPD prevalences were observed in the information industry and in the transportation and material moving occupational groups.[5] High prevalences have also been reported among machine operators, workers in the construction trades, financial record processors, cotton workers, farm machinery workers, and bus drivers.[6] An older study of broad industries found that after adjustment for smoking and other covariates, the mining, construction, and manufacturing industry sectors were at highest risk for COPD, followed by the agriculture, utilities, and transport industry sectors.[7] At a somewhat more detailed level, industries found to have statistically significant elevated prevalences of COPD were rubber, plastics, and leather manufacturing; textile mill products manufacturing; the Armed Forces; and food products manufacturing. High-risk occupations included freight, stock, and material handlers; and the Armed Forces.[8]

Occupational exposures associated with an increased risk of COPD include the general categories of dusts (including metal dust, organic dust, and mineral dust); smoke; diesel exhaust; gases; vapors sensitizers; chemicals (particularly pesticides and compressed gases); fibers; mists; fumes; and the combined vapors, gases, dust and/or fumes (VGDF) grouping.[9–12] More specific exposures such as silica, coal mine dust, welding fume, cadmium fume,

and endotoxins have also been identified as risk factors for COPD.[13] Non-occupational exposures associated with COPD risk include recreational exposure to some of these substances, as well as indoor and outdoor air pollution. Cigarette smoke is a strong risk factor for COPD and exposures can be personal or second-hand;[14] second-hand smoke includes workplace exposures, particularly before workplace smoking restrictions were common.[15] Results of assessments of whether smoking and occupational exposures to chemical and physical agents have additive risks for COPD have varied[16, 17].

Job groups at excess risk for COPD due to exposure to specific agents include workers exposed to mineral particulates (miners, workers handling or installing asbestos products, millers of wollastonite, and workers in the quarrying and carbon black manufacturing industries); metal fumes, irritant gases, and combustion products (mining and smelters, rubber manufacturing, welders, tunnel workers, and fire fighters); and organic dusts (grain workers, farmers, workers in poultry and swine confinement buildings).[17] Diesel exhaust has been associated with risk of COPD in industries including transportation and trucking and mining and construction and in occupations including vehicle mechanics, transportation, construction workers, and motor vehicle operators.[18] Construction workers are at high risk for COPD due to several other types of exposure as well. VGDF exposures have been linked to declines in lung function among older construction workers[16] and to increased COPD mortality risk, with the association strongest for fumes, even among non-smoking construction workers.[19]

Relations between COPD and I/O are suitable for assessment in the context of a longitudinal study, as COPD has been reported to be a disease of long latency following exposure to cigarettes and some occupational hazards.[13] The Health and Retirement Study (HRS) presents an opportunity to examine COPD risk by detailed I/O groups and to observe the effects of early self-reported exposures on downstream health, especially chronic diseases. The current analyses examined associations in the 1992 HRS cohort between longest-held industry or occupation reported at baseline and incident diagnoses of COPD reported in the 1994 through 2016 surveys and assessed the effects of occupational exposures. The analyses aimed to identify groups of workers with elevated risk for development of COPD.

Methods:

1. Data Sources

The HRS (Health and Retirement Study) is sponsored by the National Institute on Aging (grant number NIA U01AG009740) and is conducted by the University of Michigan. The survey follows adults as they transition to retirement.[20] New panels of participants are recruited periodically, and each panel is re-interviewed every two years, creating a longitudinal picture of health moving into and through retirement.

Self-reported incident chronic lung disease was ascertained at two-year follow-up interviews through 2016 by the question “Not including asthma, has a doctor ever told you that you have chronic lung disease such as chronic bronchitis or emphysema?” Those answering affirmatively in any interview between 1994 and 2016 were classified for these analyses as having incident COPD.

Data for the analyses come from several sources. The HRS data are available through an application process. In addition, the Research and Development Corporation (RAND), with technical and financial support from the Social Security Administration and the National Institute on Aging, produces a public use longitudinal data set, RAND HRS, based on the HRS data.[21] Occupation was elicited in HRS as a free-form answer and coded into three-digit 1980 U.S. Census Codes.[22] These groups were masked into 17 broader categories for the RAND public use data sets. The collection and coding of information about industry was similar, with masking from 3-digit 1980 U.S. Census codes into 13 broader categories for public use data. We used data from both HRS and RAND. in these analyses. Information on baseline (1992) occupational exposures and detailed longest-held I&O was derived from HRS data; information on baseline broad longest-held I&O and all other variables used in these analyses were from RAND HRS Longitudinal File 2016 (V1) data.[21] RAND determined a respondent's broad-category I/O with longest tenure based on a set of variables including current work status, current job, last job, previous job lasting 5+ years, start and end months and years for each job. NIOSH performed the same task using restricted (HRS) data to determine detailed-category I/O for each respondent's longest-held job. Information about the study design, sampling, and questions can be found at http://hrsonline.isr.umich.edu. The HRS/RAND public data that support the findings of this study are openly available in at https://hrs.isr.umich.edu/data-products/access-to-public-data. The HRS restricted data that support the findings of this study are available with restrictions from University of Michigan and were used under license for this study.

HRS ascertains vital status by submitting files to the National Death Index maintained by the National Center for Health Statistics for matching to determine fact, causes, and date of death. In almost all cases, exact dates of death were available and used; when exact dates were not available, the midpoint between the last wave during which the respondent was alive and the following wave was used. For onset of COPD, the midpoint between the first wave the respondent reported lung disease and the previous wave was used.

To assess occupational exposures, HRS respondents were asked the following question in the 1992 survey "Individuals are sometimes exposed to dangerous chemicals or other hazards at work. Have you ever had to breathe any kinds of dusts, fumes, or vapors, or been exposed to organic solvents or pesticides at work?" Respondents who replied affirmatively were asked whether they had been exposed for at least one year; those who said yes were asked "What kinds were they?" and answers were recorded in a free-response format, with no further prompts or examples given. Although respondents could list numerous exposures, the data-entry format only allowed for retention of two exposures. Respondents were also asked about their age when they were first and last exposed, as well as total years of exposure during their working lives, but these questions were about exposure in general and did not correspond to specific exposures. Answers were coded into more than 70 categories ranging from specific (asbestos) to nonspecific ("other") within 8 more general groups: solvents, cleaners, and coatings; petroleum derivatives; mineral fumes and dust (ranging from asbestos to mineral dust); wood, paper, and other plant products; biohazards; inorganic chemicals; agricultural and related chemicals; drugs and explosives; miscellaneous other hazards. A full exposure listing can be found in online (Table S-1).

2. Study population and statistical analyses

The current study population was drawn from members of the 1992 HRS cohort who were aged 50–62 at enrollment, were working as of 1972, and did not report having been diagnosed with COPD as of the initial 1992 interview. The longest-held industry, longest-held occupation, occupational exposures, and all covariate data were determined using information from the 1992 interview.

A number of covariates were relevant to assessment of the relations between COPD and industry or occupation. Sex, race (white, African American, and other), and ethnicity (Hispanic, non-Hispanic) were included in all models because of inter-group differences in COPD occurrence. Age group at baseline (50–55 vs. 56–62) was included to account for any residual cohort effects. Because the outcome of interest was COPD, adjustment for smoking was particularly important. Smoking history at the 1992 interview was used to classify each respondent as a non-smoker, former smoker, or current smoker. Smoking intensity for both former and current smokers was categorized using a peak intensity metric, the highest number of cigarettes smoked per day (1–10, 11–20, >20), rather than an average, and no details of changes in smoking intensity were collected. Thus, information needed to calculate pack years was not collected. Instead, for our analyses, we adjusted for smoking using the following categories from baseline smoking data: (never smoked; former smoker, 1–10 cigarettes/day; former smoker, 11–20 cigarettes/day; former smoker, n>20 cigarettes/day; current smoker, 1–10 cigarettes/day; current smoker, 11–20 cigarettes/day; and current smoker, >20 cigarettes/day. Education (less than high school, GED/high school graduate, some college, college and above) and household income (<$25,000, >=$25,000-<$50,000, >=$50,000-<$100,000, >=$100,000) at baseline were included for additional adjustment for residual confounding by smoking and for other lifestyle factors.

Associations between both broad and detailed I/O and incident COPD were examined. For each industry group, the subhazard ratio (SHR)[23] and 95% confidence intervals (CIs) were calculated by comparing the subhazard rate of incident COPD in workers in the I (or O) of interest to the sub-hazard rate of incident COPD in workers from all other industries (or occupations) combined, adjusting for cohort, sex, race, ethnicity, education, family income, and smoking. This approach was used for all broad I/O groups, as well as for detailed I/O groups with at least 45 respondents (cutoff selected to include the mining industry). SHRs for COPD for occupational exposures, independent of I&O classification, were calculated using the same methods.

Further analyses examined the contribution of occupational exposures and I/O for detailed I/O with elevated SHRs. SHRs were calculated for respondents a) from the I/O of interest (without the specific exposure); b) with the exposure alone (respondents not in the I/O of interest) accounting for demographic confounders and smoking, but without occupational exposures; and c) from the I/O of interest and reporting the exposure of interest. Each group was compared to the reference group of respondents who did not report the I/O as longest-held job and who did not report having the exposure of interest.

HRS data were collected using a stratified multistage probability design to ensure a nationally representative sample of the non-institutionalized U.S. civilian population. To

obtain results generalizable to the non-institutionalized U.S. civilian population, all estimates in this study were weighted to account for the unequal probabilities of selection, oversampling, and nonresponse. Although STATA's STCRREG procedure does not support the commonly used design-based variance estimation approach, it does account for sampling weights when sampling weights are specified and also handles clustering to allow for robust variance estimation. The model-based approach was used for this study, treating survey stratum and primary sampling unit (PSU) as fixed and random effects respectively in the regression models to allow for variance estimation that accounts for the stratified multistage sample design.

Because this was an older population (ages 50–62 at entry and 74–86 at end of follow-up), a significant number of respondents died before the end of the follow-up period (HRS ascertained date and cause of death by NDI linkage) without developing COPD. To address this issue, death was treated as a competing risk, with Fine and Gray's competing risk regression methods[23] implemented using STATA's STCRREG procedure (STATA version 13, StataCorp, College Station, TX). Age was used as the time scale, with respondents entering the analysis at their baseline age, given that they had lived to this age with no diagnosis of COPD, and exiting at their event/censoring age. The SHR of developing COPD during follow-up was estimated for respondents who reported a specific industry or occupation as their longest held versus all other industries or occupations combined after controlling for covariates of interest. Results were considered statistically significant when the 95% confidence intervals did not include 1.0.

Results:

A total of 9,000 respondents had worked in 1972 or later. Of these, 718 were excluded from the analyses because they reported at baseline that they had been told by a doctor that they had COPD. Another 375 were excluded because they did not have a follow-up survey. Of the remaining 7,907 eligible respondents who comprise the subject of these analyses, 1,250 reported being diagnosed with COPD during follow-up.

Demographic and smoking information for workers included in the analyses are shown in Table 1, along with the number of COPD cases and univariate SHRs. Most respondents (86%) were white, with another 10% African American. Hispanic ethnicity was reported by 6% of participants. SHRs for COPD were somewhat higher for female than for male respondents, for white than for African American respondents, and for non-Hispanic than for Hispanic respondents; while only the results for sex attained statistical significance, all three covariates were retained in the model. COPD SHRs were inversely related to household income and education; for both covariates, SHRs comparing each other level to the reference group were statistically significant.

Just over one-quarter of respondents (26%) were current smokers at the 1992 baseline interview, while another 38% were former smokers. Of current smokers, 27% were heavy smokers (more than one pack per day). Former smokers were more likely than current smokers to report heavy smoking (40%). Prevalence of ever-smoking at baseline interview differed by broad I&O (results not shown). Ever-smoking prevalences were highest for the

following broad occupations: members of the Armed Forces (86%), protective services (83%), and transport operators (78%). Prevalences were lowest for private household, cleaning, and building services (51%), professional specialty operations and technical support (54%), and health services (56%). Of the broad industries, ever-smoking prevalences were highest for entertainment and recreation (74%), durable manufacturing (73%), and public administration (72%) and were lowest for professional and related services (54%), agriculture, forestry, and fishing (55%), and finance, insurance, and real estate (55%).

SHRs comparing cigarettes smoked per day were significantly elevated for all categories except one (former smokers in the lowest cigarette consumption category) compared to non-smokers and increased with cigarettes smoked per day.

Table 2 presents the risk of developing COPD for broad and selected detailed I/O. Only one broad industry, mining and construction, had an elevated SHR (1.31, 95% CI 1.07–1.61) for COPD that was statistically significant after adjusting for demographic covariates and smoking. Within this group, the SHR for the detailed industry mining was 2.09 (95% CI 1.02–4.26), while that for the detailed construction industry was 1.23 (95% CI 0.98–1.54).

Of the broad occupations, only the mechanics and repair group had a significantly elevated SHR for COPD. Within this group, the detailed group comprising vehicle and mobile equipment mechanics and repairers had a significantly elevated SHR (1.53, 95% CI 1.04–2.26).

Several detailed I/O had significantly elevated SHRs, despite being components of broad I/O groups with non-elevated SHRs. For industries, significant elevations were observed in blast furnaces, steelworks, rolling and finishing mills (a subset of durable manufacturing); groceries and related products (a subset of wholesale); and automotive repair shops (within business and repair services). Detailed occupation groups with elevated SHRs were maids and housemen (within personal services); farm workers (farming, forestry, fishing); material moving equipment operators (among transport operators), and non-construction laborers (part of handlers and other operators).

Study participants reported a variety of occupational exposures (Table 3). Organic solvents comprised the most commonly reported exposure group (n=437), followed by asbestos, dust (not elsewhere classified), and pesticides (n= 298, 293, and 279, respectively).

The exposure associated with the highest SHR for COPD was other metals/metal byproducts (excluding lead/solder). Statistically significant elevations for COPD were also observed for workers exposed to asbestos or to dust (not elsewhere classified). The SHR for pesticides was somewhat elevated but did not attain statistical significance (1.31, 95% CI 0.97–1.76).

The individual and combined effects of 1) detailed I/O and 2) exposure to specific chemicals on incident COPD are reported in Table 4. SHRs are only shown for the few detailed I/O with elevated SHRs in univariable analyses that had at least five incident COPD cases reporting exposure to the chemical of interest.

Workers in blast furnaces, steelworks, rolling, and finishing mills industries who were exposed to asbestos had an elevated SHR (5.08, 95% CI 3.16–8.15, n=5). A smaller number of cases in this industry reported exposure to acids; this exposure was not associated with an increased risk of incident COPD (results not shown).

Workers in automotive repair shop industries reported exposures to multiple chemicals: aerosol paint, organic solvents, and exhaust from cars and trucks. Of these exposures, only aerosol paint was reported by more than five workers in this industry; the SHR for automotive shop workers exposed to paint was elevated (2.69, 95% CI 1.33–5.43, n=8). Among workers in automotive repair shops, exposure to exhaust from cars and trucks was associated with an elevated SHR, while exposure to organic solvents was not (n<5 for each exposure, results not shown).

Of the detailed occupations, material moving equipment operators reported exposures to asbestos and dust and ash. Five workers in the material moving equipment operator occupation reported exposure to dust and ash yielding as elevated SHR (2.17, 95% CI 1.14–4.13, n=5). The SHR for asbestos, a less commonly reported exposure (n<5, data not shown), exceeded 4.0 and was statistically significant.

Farm workers who were exposed to pesticides also had a significantly elevated SHR for COPD (3.40, 1.40–8.23, n=5). The group of farm workers was small, and not enough farm workers reported exposure to other agents to permit assessment of hazards other than pesticides. Finally, laborers (other than construction), who were exposed to dust (not elsewhere classified), had an elevated SHR (3.83, 1.89–7.75, n=5).

Discussion:

Results of this evaluation of the 1992 HRS cohort highlight differences in incident COPD morbidity risk by industry and occupation. A previous study using HRS data found that COPD had deleterious effects on employment and disability status,[24] a finding that highlights the importance of understanding and addressing risk factors for COPD, including occupational risk factors. Although reportable findings from this study were limited by small numbers of exposed participants, examination of I/O at a more detailed level provided increased clarity about the role of workplace exposures in COPD risk.

COPD incidence risk in the mining and construction industry exemplifies the advantage of the more detailed view. The elevated COPD morbidity risk observed in this study for the broad mining and construction industry is qualitatively consistent with previous findings of increased COPD prevalence in the construction trades.[6] Because miners comprise only approximately 10% of the mining and construction industry, this group often cannot be studied in isolation; in addition, results for the broader groups are sometimes assumed to be applicable to construction workers alone, given their large majority. However, many mining workers are exposed to industry-specific agents, such as coal dust, that are linked to both COPD and pneumoconioses. In the current study, which allowed separation of the mining and construction industries, mining had the highest point estimate for COPD of all detailed industries assessed, while the SHR for incident COPD among workers in the construction

industry (as well as the construction trades and extraction occupations) was more modest, although confidence intervals for the two estimates overlapped. Findings of a systematic review of COPD morbidity and mortality studies involving construction workers (but not miners) suggest that COPD risk within the construction industry varies by specific trade/exposure.[25] The more modest elevation seen in the construction workers in the current study may reflect the variability of exposures across the industry. The COPD risk associated with mining, however, is clear.

Current study findings of elevated SHR for COPD in the wholesale groceries and related products industry may be partially explained by the type of work and operations. For example, workers in this industry engage in wholesale operations involving a variety of foods including coffee, tea, and flavorings, and they may also be exposed to chemicals used in food storage. In the current study, not enough workers in this industry reported a single exposure to evaluate the relation with COPD, although dust exposure is likely common. It is possible that the COPD excess observed in this industry, which includes workers potentially exposed to flavorings or byproducts of coffee roasting and grinding, includes some misdiagnosed cases of bronchiolitis obliterans, a misclassification suggested previously,[26] particularly as during most of the study period, bronchiolitis obliterans did not exist as a diagnosis.

The elevated risk of incident COPD among maids and housemen observed in this study could not be evaluated relative to specific exposures due to the small number of cases reporting any single exposure category. A review of epidemiologic literature of occupational hazards to cleaning workers found associations between chronic bronchitis and 1) being in the cleaning occupation, 2) employment in non-domestic cleaning, 3) dish washing, 4) VGDF expsoure, and 5) use of cleaning solutions and high-pressure equipment or sprayers.[27]

The contribution of both I/O and exposure could be assessed for some groups of workers, although for each I/O, only a subset of exposures with potential to cause COPD could be evaluated due to small numbers of cases reporting each exposure. Despite this limitation, the findings generally support those of previous research. Even though most reports of lung disease in the mechanics/repair occupations are related to asbestos exposure in automobile mechanics,[28] substantial numbers of mechanics and repair workers have exposures to dusts, solvents, welding fumes, heavy metals, and other agents that may increase risk of COPD.[29,30] Dust and ash were associated with increased SHRs among exposed workers in two occupations: material moving equipment operators, and non-construction laborers. Among workers employed in the automotive repair shop industry, elevated SHRs were associated with exposure to aerosolized paint, but SHRs for other exposures among these workesr could not be reported due to small numbers. COPD incidence was also significantly elevated among farm workers who reported exposure to pesticides. Exposure to other substances, including dust and, for livestock farmers, ammonia and hydrogen sulfide, have been associated with increased risk of COPD or decreased lung function among farmers.[31–33] In the current study, only pesticide exposure was reported frequently enough by cases to be evaluated among farmers. Thus, a contribution from other exposures to the association observed between pesticide exposure and COPD in farm workers cannot be ruled out.

Finally, workers in the blast furnaces, steelworks, rolling and finishing mills industry group have a wide range of potential exposures (e.g. asbestos, metals, welding fume) that have been associated with multiple adverse lung effects among workers in this industry.[34–36] Of these exposures, only asbestos was reported by enough workers in this industry group to meet reporting criteria for this study; the SHR for COPD among asbestos-exposed workers in this group was highly elevated.

This study has several limitations, including some stemming from the use of survey data. One such limitation was the self-reported health outcome, the respondent's having been told by a doctor that he or she had a chronic lung disease excluding asthma, with chronic bronchitis and emphysema used as examples. Whether any respondents would have interpreted the HRS chronic lung disease question to include nonmalignant restrictive pulmonary diseases, including the pneumoconiosis, or other types of chronic pulmonary disease, is unknown. Exposures to asbestos, silica, and coal dust can lead to pneumoconiosis and can increase the risk for COPD either as a comorbidity with pneumoconiosis or as a sequella;[37] pertinent industries and occupations include manufacturing, shipyard, and insulation industries;[38] construction workers;[39–43] and specifically sheet metal workers;[44] automobile mechanics;[40] and workers in mining industries and occupations and those that process the products of mining.[45] All covariates, including smoking, were also self-reported. Because a detailed smoking history was not available from the baseline interview, residual confounding by smoking might persist, despite additional adjustment for income and education to address this issue.

Analyses of longest-held jobs exclude shorter, but potentially etiologically relevant, work in occupations with pertinent exposures. Pulmonary and non-pulmonary work-related conditions (i.e. wheezing, musculoskeletal injuries) that develop more quickly than COPD can lead workers to exit the I/O for one less likely to aggravate the condition before a lung disease manifests. This subsequent I/O may then become the new longest-held job and incident lung disease attributed to that job instead. Also, the early exit of symptomatic workers, together with the exclusion of prevalent COPD cases who also may have left jobs with relevant exposures, could result in a workforce comprised of less susceptible and healthier workers, further reducing opportunities to observe the effects of workplace exposures in these analyses.

The limited assessment of exposures in the survey is the primary limitation for the analyses of job-exposure relations in the current study. The occupational exposure history asked about ever exposure and was not linked to any specific job (current or longest held). Thus, the exposure may not have necessarily occurred in the job analyzed herein—the longest-held job. Moreover, exposures were elicited in free-form fashion, and only two of the exposures reported by each respondent were coded and available for analysis. The latter limitation is particularly problematic for groups such as steelworkers, who are likely to have exposures to multiple substances with adverse pulmonary effects. These limitations would generally cause misclassification of individuals with specific exposures to the unexposed category, reducing the power to detect statistically significant effects. Recall bias may also pertain. Occupational exposures were assessed at baseline and only ever/never exposure status was captured. The lack of information about exposure timing and duration, frequency, and

intensity precluded control for latency and development of quantitative exposure metrics. The information available for one of the most important covariates, smoking, did not allow calculation of pack years. Despite these limitations, results of the job-exposure relations that were analyzed are generally consistent with the literature.

Finally, many I/O groups were small and did not have enough workers with COPD reporting exposure to any individual substance to permit evaluation of exposure effects. While elevated risks have been seen elsewhere for railway workers exposed to diesel[18] and for textile workers, exposed to cotton dust and possibly silk,[46] the number of exposed COPD cases in these specific groups precluded assessment of these risks for these exposures in this study.

Strengths of the study include a sizable group of respondents followed for more than twenty years, from pre-retirement age well into retirement age for most of the group; this allowed for assessment of detailed I/O. The two-year follow-up interval allowed for reasonable estimation of the timing of incident diagnoses. The wide range of exposures assessed included some that were more specific than the VGDF group often employed with survey data.

In summary, these results suggest that working in some specific I/O confers an increased risk of developing COPD in late pre-retirement and in retirement, and that exposure to specific chemicals appears to exacerbate risk within some of those I/O. Therefore, workers currently or previously employed in I/O with increased risk for COPD, as well as those with specific occupational exposures conferring increased risk, may benefit from medical surveillance. In addition, exposure mitigation may be warranted for current workers in I/O observed to have increased risk of incident COPD. Longitudinal studies of larger populations, combined with detailed job and exposure information, are needed to fully assess the risk for COPD associated with the full range of exposures in these workforces. Obtaining a more comprehensive exposure history on all future HRS questionnaires could 1) allow examination of smaller I/O groups and more detailed exposures by combining adjacent waves of the study that have exposure information and 2) facilitate examination of secular trends.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgements

The authors wish to thank Marie Haring Sweeney and Girija Syamlal from NIOSH for their helpful comments on drafts 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. The article is based on previously collected data.

References:

1. Sonnega A, Faul JD, Ofstedal MB, Langa KM, Phillips JW, Weir DR. Cohort Profile: the Health and Retirement Study (HRS). Int J Epidemiol. 2014;43(2):576–585. [PubMed: 24671021]

2. Burden US of Disease Collaborators. The State of US Health, 1990–2016: Burden of Diseases, Injuries, and Risk Factors Among US States. JAMA. 2018;319(14):1444–1472. [PubMed: 29634829]

3. Doney B, Hnizdo E, Syamlal G, et al. Prevalence of chronic obstructive pulmonary disease among US working adults aged 40 to 70 years. National Health Interview Survey data 2004 to 2011. J Occup Environ Med. 2014;56(10):1088–1093. [PubMed: 25285832]

4. Sullivan J, Pravosud V, Mannino DM, Siegel K, Choate R, Sullivan T. National and state estimates of COPD morbidity and mortality - United States, 2014–2015. Chronic Obstr Pulm Dis. 2018;5(4):324–333. [PubMed: 30723788]

5. Syamlal G, Doney B, Mazurek JM. Chronic obstructive pulmonary disease prevalence among adults who have never smoked, by industry and occupation - United States, 2013–2017. MMWR Morb Mortal Wkly Rep. 2019;68(13):303–307. [PubMed: 30946736]

6. Bang KM. Chronic obstructive pulmonary disease in nonsmokers by occupation and exposure: a brief review. Curr Opin Pulm Med. 2015;21:149–154. [PubMed: 25590955]

7. Korn R, Dockery D, Speizer F, Ware J, Ferris B. Occupational exposures and chronic respiratory symptoms. A population-based study. Am Rev Respir Dis. 1987;136(2):298–304. [PubMed: 3497594]

8. Hnizdo E, Sullivan PA, Bang KM, Wagner G. Association between chronic obstructive pulmonary disease and employment by industry and occupation in the US population: a study of data from the Third National Health and Nutrition Examination Survey. Am J Epidemiol. 2002;156(8):738–746. [PubMed: 12370162]

9. Chong S, Lee KS, Chung MJ, Han J, Kwon OJ, Kim TS. Pneumoconiosis: comparison of imaging and pathologic findings. Radiographics. 2006;26(1):59–77. [PubMed: 16418244]

10. Kurth L, Doney B, Weinmann S. Occupational exposures and chronic obstructive pulmonary disease (COPD): comparison of a COPD-specific job exposure matrix and expert-evaluated occupational exposures. Occup Environ Med. 2017;74(4):290–293. [PubMed: 27777373]

11. Halldin CN, Doney BC, Hnizdo E. Changes in prevalence of chronic obstructive pulmonary disease and asthma in the US population and associated risk factors. Chron Respir Dis. 2015;12(1):47–60. [PubMed: 25540134]

12. Sadhra S, Kurmi OP, Sadhra SS, Lam KB, Ayres JG. Occupational COPD and job exposure matrices: a systematic review and meta-analysis. Int J Chron Obstruct Pulmon Dis. 2017;12:725–734. [PubMed: 28260879]

13. Cullinan P Occupation and chronic obstructive pulmonary disease (COPD). Br Med Bull. 2012;104:143–161. [PubMed: 23080418]

14. Jordan RE, Cheng KK, Miller MR, Adab P. Passive smoking and chronic obstructive pulmonary disease: cross-sectional analysis of data from the Health Survey for England. BMJ Open. 2011;1(2):e000153.

15. Hyland A, Barnoya J, Corral JE. Smoke-free air policies: past, present and future. Tob Control. 2012;21(2):154–161. [PubMed: 22345239]

16. Dement JM, Welch LS, Ringen K, Cranford K, Quinn P. Longitudinal decline in lung function among older construction workers. Occup Environ Med. 2017;74(10):701–708. [PubMed: 28515054]

17. Malo J, Chan_Yeung M, Kennedy S. Occupational Agents In: Barnes PJ, Drazen JM, Rennard S, Thomson NC, eds. Asthma and COPD: Basic Mechanisms and Clinical Mangement. London, UK: Academic Press; 2006.

18. Hart JE, Eisen EA, Laden F. Occupational diesel exhaust exposure as a risk factor for chronic obstructive pulmonary disease. Curr Opin Pulm Med. 2012;18(2):151–154. [PubMed: 22234274]

19. Toren K, Jarvholm B. Effect of occupational exposure to vapors, gases, dusts, and fumes on COPD mortality risk among Swedish construction workers: a longitudinal cohort study. Chest. 2014;145(5):992–997. [PubMed: 24264472]

20. Fisher GG, Ryan LH. Overview of the Health and Retirement Study and introduction to the special issue. Work Aging Retire. 2018;4(1):1–9. [PubMed: 29423243]

21. Health and Retirement Study, RAND HRS Longitudinal File 1992–2016 (v.1) public use dataset. Produced and distributed by the University of Michigan with funding from the National Institute on Aging (grant number NIA U01AG009740). Ann Arbor, MI
22. Nolte MA, Servais M, Turf M. Occupation and industry coding in HRS/AHEAD. Ann Arbor, MI: University of Michigan;2013.
23. Fine JP, Gray RJ. A proportional hazards model for the subdistribution of a competing risk. JASA. 1999;94:496–509.
24. Martinez CH, Richardson CR, Han MK, Cigolle CT. Chronic obstructive pulmonary disease, cognitive impairment, and development of disability: the health and retirement study. Ann Am Thorac Soc. 2014;11(9):1362–1370. [PubMed: 25285360]
25. Borup H, Kirkeskov L, Hanskov DJA, Brauer C. Systematic review: chronic obstructive pulmonary disease and construction workers. Occup Med (Lond). 2017;67(3):199–204. [PubMed: 28204712]
26. Kreiss K Occupational bronchiolitis obliterans masquerading as COPD. Am J Respir Crit Care Med. 2007;176(5):427–429. [PubMed: 17715381]
27. Charles LE, Loomis D, Demissie Z. Occupational hazards experienced by cleaning workers and janitors: A review of the epidemiologic literature. Work. 2009;34(1):105–116. [PubMed: 19923681]
28. Ameille J, Rosenberg N, Matrat M, et al. Asbestos-related diseases in automobile mechanics. Ann Occup Hyg. 2012;56(1):55–60. [PubMed: 21965465]
29. Niraimathi D, Kamakshi M, Nitin A, Vasudevan K. comparison of peak expiratory flow rate and forced vital capacity between petrol pump workers and automobile repair workers. Int J Biolog Med Res. 2014;5(2):4084–4088.
30. Egeghy PP, Nylander-French L, Gwin KK, Hertz-Picciotto I, Rappaport SM. Self-collected breath sampling for monitoring low-level benzene exposures among automobile mechanics. Ann Occup Hyg. 2002;46(5):489–500. [PubMed: 12176763]
31. Eduard W, Pearce N, Douwes J. Chronic bronchitis, COPD, and lung function in farmers: the role of biological agents. Chest. 2009;136(3):716–725. [PubMed: 19318669]
32. Kraim-Leleu M, Lesage FX, Drame M, Lebargy F, Deschamps F. Occupational Risk Factors for COPD: A Case-Control Study. PLoS One. 2016;11(8):e0158719. [PubMed: 27487078]
33. Szczyrek M, Krawczyk P, Milanowski J, Jastrzebska I, Zwolak A, Daniluk J. Chronic obstructive pulmonary disease in farmers and agricultural workers - an overview. Ann Agric Environ Med. 2011;18(2):310–313. [PubMed: 22216804]
34. Hamzah NA, Mohd Tamrin SB, Ismail NH. Metal dust exposure and lung function deterioration among steel workers: an exposure-response relationship. Int J Occup Environ Health. 2016;22(3):224–232. [PubMed: 27392157]
35. Koh DH, Lee SW, Ye BJ, Kim JI. Grouping schemes of welding fume exposure in shipyard welders. J Occup Environ Hyg. 2018;15(5):413–421. [PubMed: 29494296]
36. Walters GI, Robertson AS, Bhomra PS, Burge PS. Asbestosis is prevalent in a variety of construction industry trades. NPJ Prim Care Respir Med. 2018;28(1):11. [PubMed: 29615629]
37. Peng Y, Li X, Cai S, et al. Prevalence and characteristics of COPD among pneumoconiosis patients at an occupational disease prevention institute: a cross-sectional study. BMC Pulm Med. 2018;18(1):22. [PubMed: 29378587]
38. van Oyen SC, Peters S, Alfonso H, et al. Development of a Job-Exposure Matrix (AsbJEM) to Estimate Occupational Exposure to Asbestos in Australia. Ann Occup Hyg. 2015;59(6):737–748. [PubMed: 25841001]
39. Nynas P, Pukkala E, Vainio H, Oksa P. Cancer Incidence in Asbestos-Exposed Workers: An Update on Four Finnish Cohorts. Saf Health Work. 2017;8(2):169–174. [PubMed: 28593073]
40. Rice C, Heineman EF. An asbestos job exposure matrix to characterize fiber type, length, and relative exposure intensity. Appl Occup Environ Hyg. 2003;18(7):506–512. [PubMed: 12791547]
41. Tjoe Nij E, Heederik D. Risk assessment of silicosis and lung cancer among construction workers exposed to respirable quartz. Scand J Work Environ Health. 2005;31 Suppl 2:49–56. [PubMed: 16363447]
42. Linch KD. Respirable concrete dust--silicosis hazard in the construction industry. Appl Occup Environ Hyg. 2002;17(3):209–221. [PubMed: 11871757]

43. Dong XS, Wang X, Daw C, Ringen K. Chronic diseases and functional limitations among older construction workers in the United States: a 10-year follow-up study. J Occup Environ Med. 2011;53(4):372–380. [PubMed: 21407096]

44. West GH, Sokas RK, Welch LS. Change in prevalence of asbestos-related disease among sheet metal workers 1986 to 2016. Am J Ind Med. 2019;62(7):609–615. [PubMed: 31168870]

45. CDC. Silicosis mortality, prevention, and control -- United States, 1968–2002. MMWR Morb Mortal Wkly Rep 2005;54(16):401–405. [PubMed: 15858459]

46. Lai PS, Christiani DC. Long-term respiratory health effects in textile workers. Curr Opin Pulm Med. 2013;19(2):152–157. [PubMed: 23361196]

TABLE 1

Demographics - 1992 Health and Retirement Study (HRS) cohort working in 1972, employed in 1992, and not diagnosed with chronic obstructive pulmonary disease (COPD) as of baseline survey[1]

Characteristic	Frequency	Estimated Population Frequency (x 1,000)	Weighted % of all respondents (95% CI)	COPD cases	Subhazard Ratio (95% CI)
Total	7,907		100%		
Age					
50–55	4,102	10,298	51.8 (50.5 – 53.0)	652	1.00
56–62	3,805	9,602	48.2 (47.0 – 49.5)	598	1.11 (0.99, 1.25)
Sex					
Male	3,964	10,054	50.5 (49.6, 51.4)	589	1.00
Female	3,943	9,846	49.5 (48.6, 50.4)	661	*1.15 (1.01, 1.30)*
Race					
White	6,214	17,146	86.2 (84.7, 87.6)	1,024	1.00
African American	1,390	2,049	10.3 (9.1, 11.4)	183	0.81 (0.65, 1.01)
Other	303	705	3.5 (2.9, 4.2)	43	0.82 (0.59, 1.13)
Ethnicity (missing=1)					
Hispanic	686	1,203	6.0 (4.7, 7.4)	76	0.83 (0.63, 1.09)
Non-Hispanic	7,220	18,696	94.0 (92.6, 95.4)	1,174	1.00
Smoking status					
Never smoker	2,903	7,248	36.4 (35.0–37.8)	242	1.00
Current smoker					
1–10 cigarettes per day	681	1,525	7.7 (7.1, 8.3)	150	*3.22 (2.61, 3.97)*
11–20 cigarettes per day	847	2,169	10.9 (10.0, 11.8)	275	*4.81 (4.04, 5.72)*
>20 cigarettes per day	531	1,392	7.0 (6.2, 7.8)	194	*5.32 (4.22, 6.72)*
Former smoker					
1–10 cigarettes per day	904	2,156	10.8 (10.1, 11.6)	86	1.21 (0.92, 1.59)
11–20 cigarettes per day	931	2,412	12.1 (11.4, 12.8)	113	*1.55 (1.21, 1.97)*
>20 cigarettes per day	1,110	2,997	15.1 (14.0, 16.1)	190	*2.23 (1.82, 2.73)*
Household Income					
<$25k	1,198	2,578	13.0 (11.8, 14.1)	242	*2.01 (1.65, 2.45)*
$25k–$50k	1,579	3,766	18.9 (17.3, 20.5)	298	*1.85 (1.58, 2.16)*
$50k–$100k	2,600	6,627	33.3 (31.9, 34.7)	414	*1.46 (1.25, 1.70)*
>$100k	2,530	6,928	34.8 (32.7, 37.0)	296	1.00
Education					
Less than high school	1,883	4,051	20.4 (18.9, 21.8)	385	*2.22 (1.81, 2.71)*
GED/High-school graduate	2,993	7,678	38.6 (37.1, 40.0)	475	*1.56 (1.28, 1.92)*
Some college	1,570	4,110	20.7 (19.6, 21.8)	234	*1.44 (1.15, 1.79)*
College and above	1,461	4,060	20.4 (18.4, 22.4)	156	1.00

Italics indicate statistically significant results.

CI = confidence interval

[1] Participants were also required to have responded to at least one follow-up survey

Table 2

Number of workers, number of incident chronic obstructive pulmonary disease (COPD) cases, and sub-hazard ratio (SHR) for longest-held industry or occupation[1] - 1992 Health and Retirement Study (HRS) cohort[2]

Broad Industry or Occupation Group (3-digit 1980 U.S. Census code groups)	Detailed Industry or Occupation Group (3-digit 1980 U.S. Census code groups)	Number in industry or occupation	Estimated population size (x 1,000)	COPD cases	SHR[3] (95% CI)
Industry					
Agriculture, Forestry, Fishing (010–031)		226	500	32	0.97 (0.71–1.34)
Mining & Construction (040–060)		479	1,215	95	*1.31 (1.07–1.61)*
	Mining (040–050)	48	117	12	*2.09 (1.02–4.26)*
	Construction (060)	431	1,098	83	1.23 (0.98–1.54)
Manufacturing: Non-durable (100–222)		669	1,613	107	0.90 (0.73–1.16)
Manufacturing: Durable (230–392)		951	2,421	159	0.94 (0.77–1.14)
	Blast furnaces, steelworks, rolling & finishing mills (270)	51	142	13	*1.89 (1.18–3.61)*
Transportation (400–572)		578	1,502	80	0.93 (0.71–1.21)
Wholesale (500–571)		275	700	50	*1.14 (0.83–1.55)*
	Groceries & related products (550)	59	144	17	*2.04 (1.27–3.26)*
Retail (580–691)		920	2,328	170	1.01 (0.87–1.18)
Finance, Insurance, & Real Estate (700–712)		424	1,174	53	0.94 (0.69–1.27)
Business & Repair Services (721–760)		322	815	57	1.11 (0.84–1.47)
	Automotive repair shops (751)	59	145	18	*1.73 (1.02–2.96)*
Personal Services (761–791)		372	806	64	1.03 (0.82, 1.30)
Entertainment & Recreation (800–802)		81	222	16	1.23 (0.78–1.93)
Professional & Related Services (812–892)		1,796	4,509	239	0.96 (0.80–1.14)
Public Administration (900)		481	1,234	69	0.97 (0.75–1.27)
Occupation					
Managerial specialty operation (003–037)		1,081	2,973	135	0.88 (0.73–1.06)
Professional specialty operation & technical support (043–235)		1,124	3,031	141	1.15 (0.95–1.38)
Sales (243–285)		692	1,816	114	0.99 (0.79–1.24)
Clerical, administrative support (303–389)		1,185	3,195	170	0.86 (0.72–1.02)
Service: private household, cleaning & building services (403–407)		108	194	13	0.63 (0.32–1.25)
Service: protection (413–427)		109	279	22	1.22 (0.77–1.92)
Service: food preparation (433–444)		258	601	56	1.03 (0.77–1.39)
Health services (445–447)		189	377	28	0.87 (0.61–1.24)
Personal services (448–469)		424	920	72	0.93 (0.68–1.26)

Broad Industry or Occupation Group (3-digit 1980 U.S. Census code groups)	Detailed Industry or Occupation Group (3-digit 1980 U.S. Census code groups)	Number in industry or occupation	Estimated population size (x 1,000)	COPD cases	SHR[3] (95% CI)
	Maids & housemen (449)	67	137	*16*	*1.76 (1.03–3.00)*
Farming, forestry, fishing (473–499)		214	467	30	0.94 (0.68–1.28)
	Farm workers (479)	66	111	15	*1.88 (1.09–3.25)*
Mechanics & repair (503–549)		268	671	56	*1.44 (1.11–1.87)*
	Vehicle & mobile equipment mechanics & repairers (505–519)	133	323	30	*1.53 (1.04–2.26)*
Construction trade & extractors (553–617)		270	664	57	1.31 (0.96–1.78)
Precision production (633–699)		323	783	59	0.97 (0.72–1.31)
Operators: machine (703–799)		651	1,486	122	1.03 (0.84–1.27)
Operators: transport, etc. (803–859)		370	881	59	0.88 (0.64–1.21)
	Material moving equipment operators (843–859)	99	240	*22*	*1.58 (1.05–2.38)*
Operators: handlers, etc. (863–889)		220	498	43	1.28 (0.93–1.77)
	Laborers, except construction (889)	46	116	*13*	*2.09 (1.23–3.54)*
Member of Armed Forces (900)		124	306	20	1.16 (0.68–2.00)

Italics indicate statistically significant results.

CI = confidence interval

[1]Results for all broad industry and occupation groups are shown. Only SHRs that are statistically significant are shown for detailed I/O (3-digit 1980 U.S. Census codes)

[2]Members of 1992 HRs cohort who were employed by 1972 and still working in 1992, had not been diagnosed with chronic obstructive pulmonary disease at baseline survey, and responded to at least one follow-up survey

[3]Subhazard ratios for incident COPD reported as of 2016 interview adjusted for age group, sex, race, ethnicity, education, household income, and smoking status

Table 3

Occupational exposures[1] 1992 Health and Retirement Study (HRS) cohort[2]: Number of workers, incident chronic obstructive pulmonary disease (COPD) cases, and sub-hazard ratio (SHR)[3]

Exposure	Number reporting exposure	Estimated population with exposure (x 1,000)	Incident COPD cases	SHR ever vs. never exposed (95% CI)
Cleaning materials - other (includes bleach, ammonia, chemical cleaners, floor wax, "cleaners" NFS)	219	527	46	*1.44 (1.04–1.98)*
Glues and adhesives	52	121	11	1.21 (0.72–2.02)
Paint (aerosol paint)	180	459	31	0.89 (0.60–1.32)
Plastics, resins, and fiberglass	79	200	9	0.65 (0.33–1.31)
Solvents – organic[4]	437	1,169	79	1.04 (0.87–1.27)
Exhaust from cars, trucks, etc. (carbon monoxide, smog, car fumes)	88	246	15	1.26 (0.69–2.28)
Gasoline, aviation fuel, diesel fuel, propane gas	127	316	24	1.12 (0.73–1.70)
Oils (include grease from machinery)	47	113	9	0.98 (0.48–2.01)
Asbestos	298	800	71	*1.79 (1.38–2.31)*
Cement or sand	57	151	15	1.40 (0.78–2.52)
Dust (also ash) -- n.e.c. or NA source	293	706	64	*1.36 (1.03–1.80)*
Mineral dust, and other dust from mining; coal dust	70	196	15	1.15 (0.52–2.56)
Other metals or metal byproducts	76	193	20	*2.02 (1.23–3.30)*
Solder and lead	48	118	10	0.97 (0.50–1.56)
Welding fumes – specific mention	48	123	13	1.52 (0.81–2.85)
Paper, wood	64	175	11	0.86 (0.50–1.56)
Acids (battery acid, sulfuric, hydrochloride, or other specified acid)	158	399	31	1.07 (0.74–1.53)
Chlorine (gas)	54	140	8	1.03 (0.55–1.94)
Fertilizers and other agricultural chemicals[5]	76	188	6	0.38 (0.15–0.93)
Pesticides, rodenticides, and herbicides (Durslan, 24D, diazanon, malathion)	279	680	55	1.31 (0.97–1.76)
Chemicals not otherwise specified	154	370	28	0.84 (0.50–1.41)
Fume/vapors/pollution, not otherwise specified, also smoke other than rubber smoke or smoke from fire	104	260	16	0.79 (0.43–1.47)
Radiation, radioactivity	49	143	8	0.68 (0.32–1.45)

Italics indicate statistically significant results.

CI = confidence interval; NFS = not further specified; n.e.c = not elsewhere classified

[1] Occupational exposures with at least 45 workers reporting exposure.

[2] Members of 1992 HRs cohort who were employed by 1972, still working in 1992, had not been diagnosed with obstructive pulmonary disease at baseline survey, and responded to at least one follow-up survey

[3] Sub-hazard ratios reported as of 2016 interview adjusted for cohort, sex, race, ethnicity, education, household income, and smoking

[4] Includes paint thinner, turpentine, benzene, trichloroethylene, M.E.K. [methyl ethyl ketone], chloroform, acetone, carbon disulfide, tetrachloride, “cleaning solvents” or “solvents” NFS

[5] Excludes pesticides, rodenticides, and herbicides.

Table 4

Subhazard Ratios (SHRs)[1] for incident chronic lung disease for in workers, by reported industry/occupation and exposure to chemicals, 1992 HRS Cohort[2]

	Reported industry or occupation (I/O)	Reported exposure	Number in category	COPD cases in category	SHR compared to workers unexposed to agent and not in I/O (95% CI)
Industry(3-digit 1980 U.S. Census code)					
Blast furnaces, steelworks, rolling & finishing mills (270)[3]	yes	no	42	8	1.41 (0.75–2.67)
Asbestos	no	yes	277	63	*1.70 (1.30–2.21)*
Both	yes	yes	8	5	*5.08 (3.16–8.15)*
None	no	no	7,144	1,100	1.00
Automotive Repair Shops (751)[4]	yes	no	43	10	1.30 (0.66–2.58)
Aerosol paint	no	yes	154	21	0.70 (0.43–1.14)
Both	yes	Yes	15	8	*2.69 (1.33–5.43)*
None	no	no	7,259	1,137	1.00
Occupation					
Material moving equipment operators (843–859)[5]	yes	no	83	16	1.41 (0.86–2.32)
Dust and ash, n.e.c.	no	yes	268	56	1.28 (0.92–1.77)
Both	yes	yes	14	5	*2.17 (1.14–4.13)*
None	no	no	7,142	1,105	1.00
Farm Workers (479)	yes	no	46	10	1.42 (0.73–2.73)
Pesticides	no	yes	250	46	1.21 (0.88–1.67)
Both	yes	yes	20	5	*3.40 (1.40–8.23)*
None	no	no	7,191	1,121	1.00
Laborers, except construction (889)	yes	no	37	8	1.68 (0.86–3.28)
Dust and ash, n.e.c.	no	yes	273	56	1.23 (0.90–1.69)
Both	yes	yes	9	5	*3.83 (1.89–7.75)*
None	no	no	7,188	1,113	1.00

Italics indicate statistically significant results.

CI = confidence interval; n.e.c = not elsewhere classified

[1] Subhazard ratios reported as of 2016 interview adjusted for cohort, sex, race, ethnicity, education, household income, and smoking

[2] Members of 1992 HRs cohort who were employed by 1972, still working in 1992, had not been diagnosed with chronic obstructive pulmonary disease at baseline survey, and responded to at least one follow-up survey

[3] Exposures to acids were also reported by workers in the industry, but exposed n<5

[4] Exposures to organic solvents and exhaust from cars, trucks, etc. were reported by workers in the industry, but exposed n<5

[5] Exposures to asbestos were reported by workers in the occupation, but exposed n<5