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Occupational diesel exhaust exposure as a risk factor for COPD

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Abstract

Purpose of Review—Chronic obstructive pulmonary disease (COPD) is a major source of morbidity and mortality worldwide. Although cigarette smoking is the major cause of COPD, occupational exposures have emerged as an important risk factor, especially in nonsmokers. In this review we assess the state of the literature on the association of COPD with a specific occupational exposure, diesel exhaust.

Recent Findings—A large body of literature links general occupational exposures to dust and fumes with an increased risk of COPD, particularly in nonsmokers. Few studies, however, have explicitly examined the role of occupational diesel exhaust exposures to COPD risk. Suggestive recent findings link occupational diesel exposures to an increased risk of COPD,

Summary—The available literature directly examining the effects of occupational diesel exhaust on risk of COPD is quite small, but does suggest that increasing exposures are associated with increasing risk. Additional research, with more advanced exposure metrics is needed to fully elucidate this association.

Keywords

chronic obstructive pulmonary disease (COPD); occupation; diesel exhaust; fumes

Introduction

Chronic obstructive pulmonary disease (COPD) is a common disease that results in considerable morbidity and mortality in the United States and worldwide. Its clinical course is characterized by acute exacerbations resulting in large numbers of physician and hospital outpatient visits (~8 million), emergency department visits (~1.5 million), and hospitalizations (~726,000) in the US (1). COPD was the underlying cause in approximately 1 in 20 deaths in the US in 2006 and was the fourth leading cause of death worldwide in 2008 (1–3).

Occupational exposures, especially to dust and fumes, have been identified as potentially significant risk factors for COPD (4). Since 1989 a number of review articles have

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synthesized the association of occupation on risk of COPD and determined that it is an important risk factor (5–15). Numerous studies have attempted to determine the population attributable risk percent to account for the percentage of COPD due specifically to work-related factors. Estimates of this percentage for the general population range from 0–37%, with a median value of 15% (4). Higher percentages were reported for non-smokers (12–53%)(16–20). In a recent analysis, an 8.8% reduction in occupational exposures to dust/gases/fumes would result in an estimated 20% reduction in the prevalence of COPD worldwide (21). All of these reviews have highlighted the importance of exploring occupational risk factors for COPD.

Recent attention has focused specifically on diesel exhaust exposure as an important occupational risk factor. Diesel exhaust is a complex mixture of particulate matter (PM) and gases, and includes particles <1.0 µm diameter with mutagenic and polycyclic aromatic hydrocarbon (PAH) carcinogenic compounds adsorbed to a carbon core and ultrafine particles made up of condensed organics (22). Individuals in a variety of occupations, including transportation (railroads, trucks, buses), construction, mining and maintenance, are routinely exposed to diesel exhaust. There is no one accepted measure specific to diesel exhaust. However, work in an exposed job, as determined by industrial hygiene assessment or expert review; or self-reported exposure to occupational dust and fumes or specifically to diesel exhaust, have been used in the epidemiologic literature to assess associations with COPD.

The goal of this review is to assess the body of literature on the association of occupational diesel exhaust exposure and risk of COPD incidence and mortality. Results from observational epidemiology studies are presented, with emphasis on more recent publications. They are organized by specificity of exposure assessment for diesel exhaust.

Occupations with Likely Diesel Exhaust Exposure and COPD Risk

One of the most comprehensive studies of occupations with exposure to diesel exhaust and COPD was based on data from the US Third National Health and Nutrition Examination Study (NHANES III). Using data on occupation and industry collected as part of the standardized interview, the association between 25 *a priori* selected occupational categories and COPD defined based on lung function testing was examined (18). After adjustment for age, sex, race/ethnicity, body mass index, smoking (status and pack-years), educational level and socioeconomic status, elevated odds ratios (OR) were observed for industries with likely diesel exhaust exposure, such as, construction (OR 1.3, 95% confidence interval (95%CI) 0.8–2.3) and transportation and trucking (OR 1.2, 95%CI: 0.8–2.0), Figure 1. The odds ratios were higher in never smokers (construction OR 3.5; 95%CI 0.9–14.0, transportation and trucking OR 2.0; 95%CI 0.3–15.0). Odds ratios were also elevated when the analysis was performed by occupation, with ORs for occupations such as vehicle mechanics, transportation, construction workers, and motor vehicle operators ranging from 1.2 to 2.0 in the total sample and 2.1 to 3.4 in never smokers.

In a cohort study (23) of workers in the US railroad industry, worker job histories were classified into years of work in different job categories with varying levels of exposure to diesel exhaust from locomotives. After adjusting for age, calendar year and time since leaving work, each additional year of work in a job with locomotive exposure was associated with a 2.5% (95%CI 0.9%–4.2%) increased risk of COPD mortality. These associations were robust to indirect control for cigarette smoking. These were similar to findings from an earlier case-control study in the same industry, where increasing years of work were associated with an OR1.02 (95%CI 1.01–1.04) (24).

Diesel Exhaust Exposure and COPD Risk

Few studies have had the ability to examine the effects of diesel exhaust specifically on the risk of COPD (25). However, in a recent case-control study of participants in the Kaiser Permanente Northwest health maintenance organization, COPD cases and controls completed a questionnaire with information on demographics, family history, and a detailed work history (26). As part of the job history, individuals reported routine (weekly) exposures to diesel exhaust. In addition, industrial hygienists assessed the potential for diesel exhaust exposure based on a review of the jobs and industries each individual reported. In logistic regression models adjusted for age and sex, individuals with any diesel exhaust had an OR of 1.9 (95%CI 1.3–3.0) compared to those with no exposure. The risk was higher among never-smokers (OR 6.4, 95%CI 1.3–31.6) and among those rated by the industrial hygienists to have moderate exposure.

Occupational Dust/Fume Exposure and COPD Risk

There are hundreds of studies looking at occupational dust and/or fume exposure. Excellent summaries of the literature were conducted by the American Thoracic Society in 2003 (27) and again in 2010 (28*). In both cases they concluded that occupational exposures were important risk factors for COPD. Diesel exhaust may be one of the fumes being referred to; however, this specificity is often not available.

Five recent studies have examined the effects of general occupational gas, dust, or fume exposure. In a US population based case-control study, two methods were used to assess exposure to vapors, gases, dust, and fumes: a question asking specifically if each job involved exposure to any of these four entities, and a job exposure matrix (JEM) based on an occupational history and expert review (29). The OR for COPD with self-reported exposure was 2.1 (95%CI 1.4–3.0) and with high likelihood of exposure from the JEM was 1.2 (95%CI 0.6–2.3), after adjustment for age, sex, race/ethnicity and smoking status.

In a South-African hospital based case-control study, exposure to dust, gas, and fume exposure was determined from both self-reports and a JEM derived from occupational histories taken from each participant (30*). After adjustment for age, sex, smoking status, and history of tuberculosis, self reported chemical, gas, and fume exposure years were associated with an OR of 2.9 (95%CI 1.3–6.3) for low exposure and 3.6 (95%CI 1.6–7.9) for high exposure. The equivalent measures from the JEM were associated with an OR of 2.2 (95%CI 1.1–4.7) for low exposure and 1.8 (95%CI 0.8–3.9) for high exposure.

Risk factors for COPD were examined among 4,291 never smokers participating in Burden of Obstructive Lung Disease (BOLD) from 14 different countries (31*). As part of the standardized questionnaire, participants were asked if they had worked for longer than 3 months in a list of occupations previously associated with risk of COPD (for gases/fumes/vapors: welding, fire fighting, chemical or plastic manufacturing, public transportation, or dry cleaning). In multivariable models, 10 or more years of work in a job with gas/fume/vapor exposure was associated with an OR of 1.54 (95%CI 0.71–3.34) in males, and no association in females.

In a population-based study in the north of England, questionnaires were sent to a randomly selected subsample of the population (32*). The questionnaire specifically asked if each individual had prior occupational exposure to a variety of substances, including asbestos, welding, and dust/fumes. Among respondents who also underwent lung function testing, any occupational exposure was associated with an OR of 3.0 (95%CI 1.3–6.9), adjusted for age, gender, hay fever, cigarette smoking, and the interaction between gender and occupational exposures.

Among a series of 185 male patients with COPD at a large hospital in Spain, information was obtained on employment status and lifetime occupational history (33). A JEM was constructed to determine the levels (none, low, high) of three exposures, biological dust, mineral dust, and gases and/or fumes. Among those with any work ever in a job with a high level of gas and/or fume exposure, the relative risk (RR) of having an FEV1 less than 30% predicted (compared to >70% predicted) was 11.4 (95%CI 1.4–95.0) and each additional 10 years of work in such a job was associated with a RR of 1.9 (95%CI 1.0–3.7).

Conclusion

The available literature directly examining the effects of occupational diesel exhaust on risk of COPD is quite small. However, these investigations, along with a large body of literature exploring general occupational exposures to dust and fumes suggest a role of occupational diesel exhaust exposure on risk of COPD. Additional research, with more advanced exposure metrics is needed to fully elucidate this association.

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Summary

- A large body of literature links general occupational exposures to dust and fumes with an increased risk of COPD, particularly in nonsmokers.
- The available literature directly examining the effects of occupational diesel exhaust on risk of COPD is quite small, but does suggest that increasing exposures are associated with increasing risk.
- Additional research, with more advanced exposure metrics is needed to fully elucidate the impact of occupational diesel exposure on COPD risk.

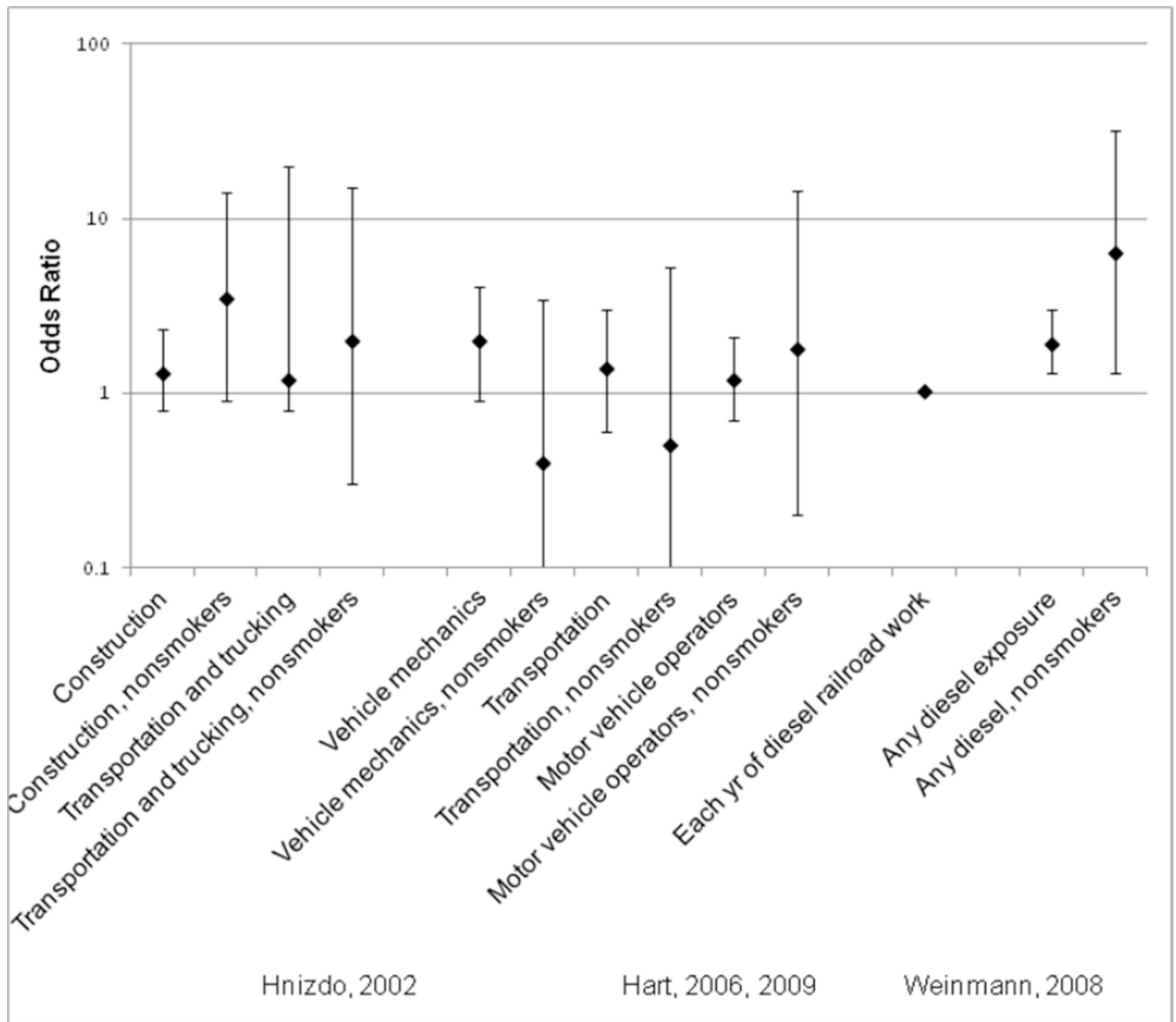


Figure 1. COPD odds ratios and 95% confidence intervals for various occupational diesel exhaust exposures