Published in final edited form as:

Am J Ind Med. 2005 August ; 48(2): 110–117. doi:10.1002/ajim.20187.

Exposure to vapors gas dust or fumes: Assessment by a single survey item compared to a detailed exposure battery and a job exposure matrix

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Abstract

Background—Occupational exposure assessment often relies upon subject report. We examined the characteristics of self-reported exposure in respondents' longest held job to vapors, gas, dust, or fumes (VGDF) compared to other measures of exposure risk.

Methods—We analyzed data from 1,876 respondents from a national U.S. population-based telephone survey designed to estimate the association between occupational factors and chronic disease of the airways. We tested a single VGDF item against responses to a 16-item battery assessing specific inhalation exposures and against a job exposure matrix (JEM). We analyzed all of these measures for their association with adult-onset asthma after excluding subjects with COPD or asthma with onset before age 18.

Results—VGDF (single item) was reported by 744 (40%) of subjects; any of the 16 exposures by 899 (48%); and an intermediate or high exposure likelihood job by JEM was assigned to 682 (36%). The sensitivity of the VGDF item measured against the 16-item battery was 69%; the specificity was 88%; (classification agreement kappa=0.58); against the JEM classification the sensitivity was 64% and specificity 74% (kappa=0.37). The relative odds (OR) for adult-onset asthma associated with various measures of exposure were: VGDF, 1.7 (95% Confidence Interval [CI] 1.0 to 2.8; p=0.04); any of the 16 exposures, 1.6 (95% CI 1.0 to 2.7; p=0.06), and intermediate or high by JEM, 1.2 (0.7 to 2.1; p>0.50).

Conclusions—A single VGDF survey item appears to delineate exposure risk at least as well as a multiple-item battery assessing such exposures; it has modest agreement with a JEM-based exposure categorization.

Keywords

Occupation; job exposure matrix; asthma; population attributable risk

INTRODUCTION

The occupationally-associated, population attributable risk percent (PAR%) for asthma is recognized to be substantial [Blanc and Toren, 1999a]. Moreover, there is growing recognition that this association extends beyond asthma to COPD. [Balmes et al., 2003]. Despite the public health importance of the impact of work-related exposures in airway conditions, there is no single approach to the classification work-related exposure risks potentially related to lung disease. Three principal epidemiological methods have been used to analyze such work-relatedness: categorization by occupational groups broadly defined (e.g., blue collar and service trades compared to all others); job exposure matrix (JEM) assignment based on a likelihood of exposure within a grid of occupation-industry combinations; and exposures reported directly in structured questionnaire responses or in-depth open-ended interviews. We will review these approaches in greater detail when discussing the results of this study.

The most common item used in surveys to analyze work-related associations with lung disease ascertains self-assessed exposure to “vapors, gas, dust, or fumes” (VGDF). Although this item is easy to administer and has been strongly and consistently associated with adverse outcomes, its performance has not been well characterized across a variety of specific exposures that may be subsumed under the rubric of VGDF. We analyzed this question using a national U.S., population-based cohort of adults. Because we ascertained global exposure to VGDF as well as to a diverse list of individual exposure items, we could estimate the frequency of exposures measured by each of these approaches, as well by a JEM categorization.

METHODS

Data Source and Sample

The data for this analysis derive from a sample of adults aged 55–75 residing in the contiguous 48 states in the U.S. who were surveyed in 2001. Details of the sampling methodology have been reported previously [Trupin et al., 2003]. The study was approved by the UCSF institutional review board for research involving human subjects. This survey focused on the relationship between occupational exposures and COPD (including emphysema and chronic bronchitis). Carried out in 2001, it included 2,113 U.S. adults interviewed after being identified by random digit telephone dialing. Recruitment was derived from both a U.S. nationwide sample and a sample limited to geographic “hot spot” areas with increased COPD mortality [Kim, 1998]. This included recruitment of additional subjects reporting a physician’s diagnosis of asthma, COPD, emphysema, or chronic bronchitis, in order to enrich the cohort with lung disease cases.

The participation rate at baseline was 53% among households meeting an initial brief eligibility screening. By the nature of the survey, there are no demographic data for non-respondents. Of 2,113 respondents originally interviewed, we excluded 191 (9%) for this analysis because they had no prior history of any labor force participation. These subjects had been included in the previously published data [Trupin et al., 2003], but were not relevant to this analysis comparing occupational exposure measures. An additional 46 (2%) with missing responses to key variables were also excluded, leaving 1,876 subjects in all for this analysis.

Survey Instrument and Definition of Exposures and Outcomes

We ascertained exposure in the subjects’ longest-held job by asking, “Does/did this job expose you to vapors, gas, dust, or fumes?” (VGDF). Regardless of the response to that question, each participant was additionally asked about exposure to a list of 16 specific occupational inhalants that we developed for this study (due to an oversight, these had been enumerated as 15 in an earlier publication [Trupin et al., 2003]). The list inhalants queried included a range of dusts

and irritants; they are listed in Table I. Exposures to low molecular weight or high molecular weight sensitizing agents that could be important in occupational asthma (as opposed to COPD) were not specifically ascertained. Individuals who answered affirmatively to the VGDF question, yet denied all of the 16 specific exposures, were asked the type of exposure they had experienced (open-ended format). Their open-ended responses were subsequently evaluated to determine if they represented substantive work-related exposures, such as asbestos or solvent vapors, or non-occupational responses such as “house dust” or ambient air pollution. Secondhand tobacco smoke was assessed by a separate item.

Using an open-ended format, we ascertained the occupation and industry of subjects’ longest-held job and assigned these 2000 Census codes [U.S. Bureau of the Census]. The U.S. occupational codes were used to classify jobs according to their inherent exposure risk using a JEM approach. To create the JEM, we adapted a European job-code-based classification originally used to analyze data from the Swedish component of the European Community Respiratory Health Survey [Blanc et al., 1999b].

This JEM had two components: a classification of occupations for low, intermediate, or high probability of exposures related to COPD, and a second, similarly 3-tiered JEM for occupation classified by asthma risk. We had previously applied the COPD component of the JEM to this cohort in an analysis of the population attributable risk percent (PAR%) of occupation and COPD [Trupin et al, 2003]. In the present analysis, we used both the COPD and the asthma classifications. For comparison to the single questionnaire VGDF item, we combined the COPD and the asthma JEM rankings. In a three-level classification, whichever scheme yielded the highest rank was applied; we also dichotomized this such that if either scheme ranked an occupation as intermediate or high probability, the occupation was categorized as involving exposure. In sensitivity analyses, we also employed a modified version of the asthma JEM, expanded to include latex-related exposure in health care occupations as carrying increased asthma risk. For the purposes of categorizing lung conditions, subjects reporting a physician’s diagnosis of chronic bronchitis, emphysema, or COPD were considered to have COPD. Subjects reporting concomitant physician’s diagnoses of asthma and COPD were also defined as having COPD, while only subjects reporting a physician’s diagnosis of asthma alone were defined as having asthma in this analysis. This is the same classification that we used in previous analyses of this cohort [Trupin et al, 2003; Blanc et. al., 2004]. This is based on that rationale that in this age range, a COPD-related physician’s diagnoses would take precedence over a diagnosis of asthma. Self-report of COPD or asthma attributed without a physician’s diagnosis was not considered a valid health condition in this survey. Additional survey items assessed cigarette smoking and demographic characteristics.

Analyses

We tested classification agreement between the single VGDF item and two different benchmark measures of exposure: any exposure (intermediate or high likelihood) based on the combined COPD and asthma JEMs and, alternatively, self-reported exposure to any of the 16 specific exposure items queried. We assessed agreement calculating the kappa statistic stratified by key demographic characteristics and smoking status [Fleiss, 1981]. Treating the same two benchmark measures as “true” indicators of hazard, we calculated the sensitivity and specificity of the VGDF item in correctly detecting exposure. In a secondary analysis, we recalculated sensitivity and specificity limited to subjects currently employed in their longest held job. We analyzed the potential associations among the varying prevalence of the 16 specific exposures and underreporting with the single VGDF item, using the Spearman rank correlation.

Using a logistic regression analysis, we calculated the odds ratio and the PAR% for adult-onset asthma due to occupational exposure, including age, gender, race and smoking status in the

models [Greenland and Drescher, 1993]. For this analysis alone, we excluded all subjects who reported one of the COPD diagnoses as delineated previously (n=345) as well as subjects with childhood-onset asthma (reported onset prior to age 18; n=43) or with unknown age of onset (n=6). The purpose of this analysis was to contrast the risk estimates generated by the asthma-specific JEM classification, the single VGDF item, and exposure based on the 16 specific items. Analyses employed SAS release 8.02 (Cary, North Carolina) or STATA version 8.0 (College Station, TX).

RESULTS

The job mix and frequency of reported exposure to VGDF and to a series of specific exposures are shown in Table II. Of 1,876 subjects analyzed, 805 (43%) were in occupations grouped broadly as technicians, trades (including manufacturing and construction), service, or agricultural workers. Based on the combined asthma and COPD JEM, 682 (36%) were classified having intermediate or high likelihood of experiencing work-related exposures. Based on the single VGDF item, 744 (40%) reported exposure on their longest held job, whereas 899 (48%) reported exposure to at least one of the 16 exposures specifically surveyed.

We analyzed the agreement between the single VGDF item and both self-report of any of the 16 specific exposures and intermediate or high likelihood of exposure by the combined asthma-COPD JEM (Table III). The overall agreement yielded a kappa statistic = 0.58 for any of the 16 exposures and 0.37 for the JEM classification. In all cases, VGDF agreement was poorer for the JEM than for the 16 specific items. Against any of the 16 specific exposures, there was a statistically significant difference for agreement stratified by sex (for women, kappa = 0.51; for men, kappa = 0.60) and stratified by cigarette smoking status (kappa = 0.51 for never smokers and 0.64 for both former and current smokers). The pattern for significantly differing agreement between the VGDF item and the JEM classification was also present for women and men; for smoking there were substantive, but not statistically significant differences (p=0.06). In addition, there was better agreement with the JEM among White, non-Hispanics vs. all others and significantly poorer agreement by increasing educational level (p<0.05).

As a measure of the effect of health status on agreement, which could reflect recall bias, we also stratified by airway disease (Table III). The agreement between the single VGDF item and the 16 items was similar among those with COPD or asthma (kappa=0.58) and those without disease (kappa=0.57). Agreement with the JEM was also similar by disease status (0.40 vs. 0.36). Among the sub-strata with asthma alone (n=120; data not shown in Table), the agreement with the 16 item battery and the JEM was reduced, but also similar to non-disease group (0.53 and 0.32, respectively). In order to assess the effect of recall over time, we also analyzed agreement among those still working in their longest-held job at the time of interview compared to all others. Among those still employed, the agreement between the VGDF item and any of the 16 exposures (kappa=0.59) was similar to all others (kappa=0.57). The agreement of VGDF with exposure by JEM did not differ by current employment in the longest held job (kappa=0.37 in both groups).

Treating any of the 16 specific exposures as a “true” positive, 624 of 899 exposed were correctly identified by the VGDF item, yielding a sensitivity of 69%. Of 977 subjects reporting none of the 16 specific exposures, 857 gave a negative response to the VGDF item, equating to a specificity of 88%. Treating intermediate or high exposure by the combined asthma-COPD JEM as a “true” positive, 436 of 682 exposed were correctly identified, yielding a sensitivity of 64%; of 1194 subjects without exposure by the JEM, 886 were also negative for the VGDF item, yielding a specificity of 74%. To test the effect of an expanded JEM including latex risk, we recalculated the sensitivity and specificity using this modified JEM (789 exposed compared to 682 as noted above). In this analysis, the VGDF sensitivity was 60% and specificity 72%.

Exposure frequencies varied from 7% (animal feed) to 40–41% (diesel exhaust, indoor motors) (Figure 1). Exposures not accounted for by concomitant VGDF report ranged from 1–5%. There was no significant correlation between the frequency of each exposure and the proportion of the total for any given exposure that was not accounted for by the VGDF exposure item ($r = -0.19$; $p > 0.4$).

We analyzed open-ended responses for the 120 subjects (6% of all respondents) who denied any exposure yet reported VGDF. Among these, 19 identified household, office, or “regular” dust exposure; seven others did not specify the dust sufficiently to categorize it. Eight subjects named cigarette smoke and six others referred to perfume odor, ambient pollution, or outdoor exhaust in open-ended responses. These responses accounted for 40 (33%) of the 120. In addition, chalk dust was cited by nine, paper dust by six, and cooking fumes by three, totaling 18 (15%) of the subjects. Asbestos was named among five open-ended responses, solvents or other industrial chemicals were cited in 10, and other industrial dusts, chemical fumes, or gases accounted for the remaining open-ended responses. Thus, slightly more than half of the open-ended responses appeared to reflect substantive occupational exposures.

We examined the odds ratios (ORs) and PAR% estimates for the occupational contribution to adult-onset asthma prevalence. We did this among a subset of subjects after excluding those with COPD and childhood-onset asthma from the referent category (remaining $n=1482$, of whom 77 reported a physician’s diagnosis of asthma with adult-onset of disease). We compared the VGDF item to the 16-item exposure list including combinations of these measures) and to exposure classified by the asthma-specific JEM (Table IV). The point estimate for the Odds Ratio (OR) was highest for VGDF (1.7; 95% CI 1.03 to 2.8); its associated PAR% was 17%. The JEM approach yielded the lowest estimate of risk (OR 1.2; 95% CI 0.7 to 2.1). Re-calculating this association using an expanded asthma JEM to include potential latex-associated occupations did not yield a estimate of increased risk (OR=1.0; 95% CI = 0.6 to 1.7).

DISCUSSION

Ascertaining global occupational exposure to vapors, gas, dust, or fumes by self-report demonstrates modest agreement against an expanded battery of items eliciting 16 specific exposures and poorer agreement with a JEM-based classification. Only a small subset of subjects reported exposure to VGDF but not to any of the specific inhalants. Among these, approximately one-half provided open-ended responses consistent with substantive occupational exposures.

Subject-reported exposure has been the source of long-standing methodological debate in occupational health research, especially in work-related lung disease. Problems in defining exposure derive from misclassification effects and recall bias that might be amplified in the workplace milieu. When analysis is based on self-report, subjects may be unaware of the substances with which they may have come in contact (thus failing to report them accurately) or, conversely, they may systematically over-report exposures (especially in the presence of health conditions that they may believe are related to workplace factors). Our findings of similar agreement rates between the VGDF item and the JEM classification among those with and without airway disease argues against substantive disease-related over-reporting.

Relatively few studies have had an entirely independent source of information against which to cross-check respondents self-report of work activities in general or discrete exposures specifically. A study of work-related lung cancer comparing self-report to detailed industrial hygiene data found that although most respondents reported only a small percentage of their possible chemical exposures, 71% did accurately identify their main work assignment areas; these areas were characterized by exposure to agents such as vinyl chloride, chlorine, or styrene

[Bond et al., 1988]. An early validation study using work record data found that job duties were accurately described in 90% of those surveyed [Weiss and Dawis, 1960]. Another validation study of job histories in a cancer case-control study found that survey responses at the job level (specific exposures were not assessed) agreed with work records for more than 80% of the person-years studied [Baumgarten, et al., 1983].

Another approach to validating exposure is to compare self-reported exposures (global measures or check lists) with occupational data obtained from in-depth interviews. In a case-control study of cancer in Montreal, Canada, subjects were asked to report occupational exposure to any of 11 groups of exposures, followed by expert review of work histories to assess the likelihood of such exposures occurring on any job [Fritschi et al. 1996]. The overall kappa was 0.51; treating the expert review as the gold standard the sensitivity of self-report was 0.61 and sensitivity 0.90. In another study with similar methods, subjects in population-based investigation in Norway were asked generically, "Have you ever had a working place with much dust or fume in the air," and also asked about specific exposure to asbestos and to "quartz dust or stone dust with quartz" at work [Bakke et al. 2001]. In addition to these screening questions, subjects underwent detailed interviews by an occupational physician in order to assess potential exposures at any time in the work history. Testing against the physician interview as the "gold standard," the overall sensitivity of the global item was 65% and its specificity was 88%, very similar to our findings using the 16-item check list as the gold standard. The exposure items for asbestos (sensitivity 28%; specificity 98%) and quartz (sensitivity 45%; specificity 98%) performed in a manner indicating that true exposure was substantively under-reported.

Even though the data cited above do not suggest that systematic *over-reporting* is a major pitfall of questionnaires, we nonetheless recognize that the lack of an independent measure of exposure is a limitation in our analysis as in so many others. Moreover, the frequencies of some of the specific exposures, as shown in Figure 1, were relatively high. Because job record validation and industrial hygiene data are rarely available to confirm exposure in population-based surveys, JEM-based risk assignment has been supported as an approach that avoids the subjectivity of self-reported exposure. Formal JEM approaches go beyond broad classifications by assigning risk on a job-by-job basis using occupation or both occupation and industry of employment. Our occupation-based JEM is consistent with this methodology. There are, however, more sophisticated JEM approaches that use survey responses to modify the risk assignment, either on a probabilistic basis or based on structured or open-ended descriptions of job duties that may be even more targeted for lung disease [Milton et al., 1998, Le Moual et al., 2000, Kennedy et al., 2000, Zock et al., 2004]. In a variant of this approach, the responses from referents within a study can be used to establish the JEM applied to cases, avoiding potential reporting bias linked to disease [Flodin et al., 1996].

All JEM approaches assign risk recognizing that some misclassification results. Not all farmers are substantively exposed to dust, nor are all painters exposed to fumes, whereas some clerical employees may indeed be exposed to toxic inhalants. When there is a heterogeneous the labor force with widely varying working conditions, such over- and under-assignment of risk is more likely to occur. Thus, the JEM approach can be biased toward the null through misclassification error. It is possible that this counterbalances a theoretical bias in favor of a false positive association due to over-reporting among the symptomatic, if a self-reported exposure measure such as the single VGDF item is used. Data suggest that such recall bias is more relevant to "volunteered" information on exposures garnered in open-ended interviews, as opposed to prompted responses eliciting occupational exposures [Teschke et al., 2000].

We found that the single VGDF item yielded a strong and statistically significant measure of adult-onset asthma risk and a PAR% consistent with recent estimates based on the review of

multiple published studies [Blanc and Toren, 1999, Balmes et al, 2003]. Exposure based on the 16-item battery yielded a similar risk estimate, albeit with wider confidence intervals. If selective recall introduced reporting bias whereby those with asthma were more likely to respond affirmatively, this bias might have been stronger in response to the 16-item battery compared to the single VGDF item. Under this assumption, the OR associated with the 16-item battery would be higher than with the single VGDF item, a pattern opposite to the one that we observed. Both of these risk estimates may have been limited, in that we analyzed longest-held job only, not every job held throughout the subjects' working lives. Moreover, we did not have information specifying the precise job held at the time of asthma onset.

Although we treated the 16-item battery and the JEM-based exposure measures as the basis for comparisons in our analyses of sensitivity and specificity, this does not presume that either forms a "gold standard." The 16-item battery was far from exhaustive. For example, although chlorine and ammonia were specifically included as irritants, generic cleaning products were not alluded to in this questionnaire item, nor did we ascertain latex exposure or other high molecular weight or low molecular weight sensitizers. Indeed, the survey upon which this analysis is based was originally carried out to study COPD, not adult-onset asthma. In terms of the JEM-based analysis, the classification scheme that we employed lacks the sophistication of approaches that modify status based on open-ended survey responses, a approach we did not utilize. More fundamentally, only detailed exposure records, including personal breathing zone assessments verified through industrial hygiene monitoring at all jobs and work duties, would truly constitute a definitive gold standard.

The PAR% based on the JEM was lower than that estimated using either the single VGDF item of the 16-exposure battery, alone or in combination. In an earlier analysis of COPD risk based on this cohort (excluding the subjects with asthma alone that were studied here), we also observed a lower risk with JEM-based exposure compared with subject report of exposure to VGDF [Trupin et al., 2003]. This pattern has also been observed in other studies that have directly compared the risk of asthma or chronic bronchitis associated with self-reported VGDF exposure compared with a JEM approach, although studies assessing pulmonary function have demonstrated a more mixed set of results [Le Moual et al., 2000; Hsairi et al, 1982; Sunyer et al., 1998; Kogevenis et al., 1999; Zock et al., 2001].

In summary, measures of exposure based on JEM categorizations are effective, particularly when targeting specific occupations or industries, but they need not substitute for direct respondent-based ascertainment of exposure. Although extensive checklists of specific exposures are useful, they may not always be feasible within the context of larger survey designs. We found that a global question on work-related conditions in the form of a single item assessing self-reported exposure to vapors, gas, dusts, or fume on the job effectively measures exposure.

Acknowledgements

This research was supported by the U.S. National Institutes of Health (NHLBI) grant HL607438.

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Figure 1. Percent of subjects reporting each of 16 individual exposures (Specific VDGF Exposure), including overlap with a single item eliciting exposure to vapors, gas, dust or fumes (global exp) on the longest held job and “no global” VGDF exposure.

Table I
Specific Exposures Elicited in Survey by Inhalant Class

Exposure Class	Specific Exposures as Elicited*
Irritants	Irritant gases, such as chlorine or ammonia
	Fire, smoke, or other combustion products
	Incinerators, boilers, or oil refineries
	Indoor fuel powdered motors, compressor, or engines
	Diesel engine exhaust
Organic dusts	Explosives or blasting fumes
	Wheat flour or other grain dusts
	Animal feeds or fodder
	Cotton dust or cotton processing
Inorganic dusts or fumes	Wood dust or sawdust
	Coal dust or powder
	Silica or sand or concrete or cement dust
	Cadmium fumes or batteries or silver solder
	Other metal dusts or metal fumes
	Welding or flame cutting
	Fiberglass or other man-made mineral fibers

* Referring to longest held job, subjects were asked if they had “regular contact with any of the following specific examples of vapors, gas, dust or fumes”

Table II
 Characteristics of Longest Held Job Among 1,876 Subjects

Characteristic	Frequency	
	n	(%)
Occupational group		
Professional, managerial, administrative, sales	1071	(57%)
Technician, service, trades, agricultural	805	(43%)
Exposure likelihood by asthma or COPD JEM [*]		
Low likelihood of exposure	1194	(64%)
Intermediate exposure likelihood	321	(17%)
High likelihood of exposure	361	(19%)
Reported exposure to vapors, gas, dust, or fumes (VGDF)	744	(40%)
Reported specific exposure to any of 16 inhalants	899	(48%)
VGDF exposure if specific exposure (sensitivity)	624	(69%) [†]
No reported specific exposure to any of 16 inhalants	977	(52%)
No VGDF exposure if no specific exposure (specificity)	857	(88%) [†]
Both reported specific exposure and VGDF exposure	624	(33%)
Either reported specific exposure or VGDF exposure	1019	(54%)

^{*} JEM = Job exposure matrix. Exposure rank is the highest by either the COPD or asthma JEM (see Methods)

[†] Percent of n from preceding row

Table III
Global VGDF and Exposure Agreement by Subject Characteristics

Study Strata	Strata Frequencies		VGDF Exposure (%)	Classification Agreement (kappa score)	
	n	(%)		16 items	JEM
All subjects	1876	(100%)	(40%)	0.58	0.37
Gender					
Men	830	(44%)	(50%)	0.60*	0.46*
Women	1046	(56%)	(31%)	0.51	0.23
Age					
Age 55–59 years	574	(31%)	(43%)	0.59	0.39
Age 60–64 years	454	(24%)	(43%)	0.75	0.37
Age 65–75 years	848	(45%)	(35%)	0.59	0.37
Race and ethnicity					
White, non-Hispanic	1622	(86%)	(40%)	0.58	0.40*
Other race, ethnicity	254	(14%)	(40%)	0.55	0.24
Education					
High school education or less	757	(40%)	(47%)	0.59	0.36*
Some college	594	(32%)	(38%)	0.58	0.38
College degree or higher	525	(28%)	(30%)	0.51	0.22
Cigarette smoking status					
Never smoked	720	(38%)	(31%)	0.51*	0.29
Former smoker	368	(20%)	(48%)	0.64	0.43
Current Smoker	768	(41%)	(43%)	0.64	0.39
Airway disease					
Any COPD or asthma	465	(25%)	(52%)	0.58	0.40
No airway disease	1411	(75%)	(36%)	0.57	0.36

* p<0.05, kappa statistic difference across strata

Table IV

Occupational risk for adult-onset asthma by various exposure measures among 1,482 subjects.

Exposure Measure	OR (95% CI)	PAR% (95% CI)
Vapors, gas, dust, or fumes (VGDF)	1.7 (1.03 to 2.8) [*]	17% (0% to 32%)
Any of 16 specific exposures	1.6 (0.98 to 2.7) [†]	19% (−3% to 36%)
Either VGDF or any of 16 exposures	1.7 (1.0 to 2.8) [*]	24% (0% to 42%)
Both VGDF and any of 16 exposures	1.7 (1.0 to 2.9) [†]	14% (−2% to 22%)
Asthma JEM, intermediate–high exposure	1.2 (0.7 to 2.1)	5% (−11% to 19%)

^{*}OR $p \leq 0.05$ [†]OR $0.05 < p < 0.10$

N=1,482 after exclusion of subjects reporting COPD, chronic bronchitis, emphysema, or asthma with onset prior to age 18. See Methods.

Multiple logistic regression analysis includes age, gender, race, and smoking status

OR = Relative odds. CI = Confidence interval. JEM = job exposure matrix