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Risk of neuropsychiatric disability among painters in the United States

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BRACKBILL RM, MAIZLISH N, FISCHBACH T. Risk of neuropsychiatric disability among painters in the United States. *Scand J Work Environ Health* 1990;16:182—8. Scandinavian studies have suggested that working with solvents is associated with chronic neuropsychiatric disease. In the United States the Social Security Administration's records of white male recipients of disability compensation were used in a case-referent study on this topic. The cases were defined as men with any one of several neuropsychiatric diseases, and the referents as men with other disabling conditions. The men were considered exposed if they had worked as a painter prior to disability and unexposed if they had worked as a bricklayer. A job-exposure matrix verified the painters' potential exposure to solvents and the bricklayers' lack of potential exposure. The painters had a significant excess of neuropsychiatric disability [adjusted odds ratio (OR) 1.42, 95 % confidence interval (95 % CI) 1.04—1.94]. Construction painters had an excess of neuropsychiatric disability [OR 1.47 (95 % CI 1.07—2.02)] in contrast to spray painters [OR 0.77 (95 % CI 0.38—1.54)]. The limitations of the data are discussed, including potential diagnosis bias and exposure misclassification.

Key terms: case-referent study, central nervous system, disability, diseases, epidemiology, occupational, physical, solvents.

Both clinical and epidemiologic studies, primarily originating from Scandinavia, suggest that painters have an elevated risk of neurological deficits and possibly chronic neuropsychiatric disorders (1—12). However, outside Scandinavia, few if any studies have been done to evaluate the risk of chronic neuropsychiatric disease among painters.

Clinical studies have reported electrophysiological abnormalities among painters (1) and paint-producing workers (2); these abnormalities can persist years after a person has been removed from exposure (3). Moreover, deficits in visual intelligence and memory have been associated with organic solvent exposure (3—5). These impairments among painters were also found two years after the initial diagnosis (6) or were present when diagnosed five or more years after the termination of the solvent exposure in question (7).

Some recent clinical studies have not found evidence for intellectual or behavioral deficits due to solvent exposure (13—17). Maizlish et al (15) found only mild sensory deficits among workers exposed to solvents from office furniture, automotive parts, and printing plants, and no evidence of a dose-response relationship. In addition deficits on verbal and nonverbal psychometric tests were not apparent for people previously exposed to solvents when preexposure intelligence and postexposure intelligence measures were equalized (13, 14, 16, 17).

Epidemiologic studies have found an excess of chronic neuropsychiatric diseases among disabled men who had been employed in solvent-exposed occupations, including painting (8—12). Three of these studies were of a case-referent nature (8, 10, 11), and two were cohort studies that selected cases from union files (9, 12). In addition, the cases were defined by the medical diagnosis of presenile dementia, cerebral atrophy, and other neuropsychiatric disorders that were not congenital or due to trauma. Moreover, exposure was quantified by years employed in painting, varnishing and carpetlaying (8), a job-exposure matrix (12), and an exposure history (10). Again, these studies used different definitions of nonexposure, which included skilled workers (8), bricklayers (9), unexposed occupations according to a job-exposure matrix (12), nonexposure to solvents according to questionnaire data (10), or occupations other than painters or carpetlayers in the construction industry (11).

Among these studies only Axelson et al (8) reported a significant odds ratio (OR) for all combined cases of neuropsychiatric diseases among painters. Three studies, however, reported a "dose-response" relationship between exposure and the estimated risk of dis-

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ability from neuropsychiatric disease (8, 10, 12). Specifically, the following exposed groups had the highest risk of disabling neuropsychiatric disease: painters, varnishers and carpetlayers who had been employed more than 30 years [age-adjusted OR 2.2] (8), carpenters and cabinet-makers who had worked more than 4000 h lacquering and gluing (OR 2.8) (10), and "always exposed" painters (OR 3.1) (12). In two studies, the exclusion of cases of alcoholism resulted in larger risk estimates (9, 12).

Importantly, these epidemiologic studies did not uniformly define their cases. For instance, Axelson et al (8) included the diagnoses of neuroses, in contrast to their exclusion by Rasmussen et al (12). It may be critical to include neuroses cases because Lindström et al (13) reported a significant odds ratio of 5.5 for neuroses. In addition, Rasmussen et al (12) included questionable neuropsychiatric conditions in their case definition, such as alcoholic psychoses, cerebrovascular diseases of hypertensive encephalopathia, and ischemic cerebral atherosclerosis. Olsen & Sabroe (10) were also nonspecific in their case definition by using the mention of dementia in medical records to determine the inclusion of cases. These studies were also vague about the relevance of alcoholism in their case definitions. It was not clear whether disability due to alcoholism ought to be included in the case definition because it may be a misdiagnosis of chronic neuropsychiatric disability or it may be that painters are at a higher risk of alcoholism for reasons other than solvent exposure.

The major objective of the present study was to evaluate the hypothesis that painters in the United States (US) have an excess risk of chronic neuropsychiatric disease. Information on persons receiving disability pensions from the US Social Security Administration was used for this purpose. We employed approximately the same coding categories of the International Classification of Diseases (eighth revision) as Axelson et al (8) for operationally defining chronic neuropsychiatric disease. Thus, cases were pension recipients who had been disabled by any one of several chronic neuropsychiatric conditions. The referents were disabled with conditions other than chronic neuropsychiatric diseases. The exposure under study was employment as a painter (defined by occupation title) prior to the application for disability. We defined nonexposure as employment as a bricklayer (a skilled occupation with an education level similar to that of painters) prior to disability. In his study Mikkelsen (9) used bricklaying work as a definition of nonexposure, and Axelson et al (8) used other "skilled occupations" in his case-referent analysis.

We also used information from the National Occupational Hazard Survey to verify the probable presence of solvents in the workplace of painters and the lack of such exposure among bricklayers (18). This was exposure information in addition to the assessments made on the basis of occupation coding categories.

Methods

Data sources

Social security disability data. The cases and referents were selected from a longitudinal file, ie, the continuous disability history file, of the US Social Security Administration Disability Insurance Program. Specifically, this file was a 20 % sample of individuals who qualified for disability benefits for a given year. In this study we used 94 889 white male recipients of such benefits for 1969 to 1973 and 1975 to 1976 who were at least 35 years old and who were employed as blue-collar workers [codes 600—900 of the *Dictionary of Occupational Titles* (19)] prior to being disabled. Data were not available for 1974 due to a change in the computer processing of the file.

Applicants were allowed benefits on the basis of the following administrative and medical or vocational criteria: (i) an unemployed applicant must have had an insured status in covered employment in 40 quarters (one quarter equaling three months) prior to application for benefits; (ii) the applicant then must have had a medically determinable physical or mental impairment, which can be expected to result in death or which has lasted or can be expected to last for a continuous period of not less than 12 months. The characteristics of the Social Security disability benefit system have been reviewed by Popick (20).

Additional exposure information. We used a job-exposure matrix based on the 1972—1974 National Occupational Hazard Survey (population different from that of the continuous disability history file) for characterizing solvent exposure among the painters and bricklayers (18). The Survey was a walk-through survey of 4656 establishments, which represented 639 codes of the Standard Industrial Classification. Exposure was defined as a chemical, physical, or biological agent that in one or more forms (vapor, liquid, or solid) was likely to contact the body of the employee. Either the actual chemical or their tradenames were noted. Occupation was coded according to the occupation codes of the 1970 census.

For the purposes of our analysis, the job-exposure matrix provided an estimated number of people exposed to specific hazards (numerator) and an estimated number of workers surveyed in specific occupations and industries (denominator). The ratio of these two values provided an estimate of the percentage of workers in painting and bricklaying observed to be working in the presence of solvents (percentage observed).

Analysis

Definition of cases and referents. The cases had the following medically diagnosed set of primary conditions, coded to the eighth revision of the International Classification of Diseases (ICD): (i) presenile dementia (ICD 290); (ii) alcoholism (ICD 291 and 303), (iii)

affective psychoses (ICD 296—297), (iv) neurosis (ICD 300), (v) personality disorders (ICD 301), (vi) other diseases of the brain (ICD 347) (21).

We were only able to duplicate the ICD codes of Axelson et al (8) at the three-digit level so that our selection of cases was not as precise as theirs (8), which used a five-digit ICD code. For instance, we could not select vertigo (ICD 780.50) or encephalopathy (ICD 781.70) cases, which are not differentiable from other disorders coded as ICD 780 or 781 (symptoms referable to the nervous system). We did not select nervousness (ICD 790) cases because we could not exclude debility (ICD 790.19). We did include the major category of affective disorders (ICD 296 and 297), although Axelson et al (8) was able to exclude organic brain disorders such as manic depression (ICD 296.1) and manic depression psychoses, circular type (ICD 296.3). On the other hand, whereas Axelson et al (8) did not differentiate between neurosis (ICD 300) and personality disorder (ICD 301), we separated these two disease classifications.

The reference diseases were all other diseases, excluding nonaffective psychoses (ICD 297—298), sexual deviancy (ICD 302), psychoses associated with drug dependence (ICD 304—309), mental retardation (ICD 310—315), inflammatory diseases of the nervous system (ICD 320—324), hereditary diseases of the nervous system (ICD 330—333), multiple sclerosis (ICD 348), and peripheral nervous system diseases (ICD 350—358). These disorders were excluded primarily because they may have had organic or trauma causation. Diseases of the peripheral nervous system were not included because our outcome of interest was disorders of the central nervous system.

Definition of exposure and nonexposure status. Exposure status was given to those recipients of disability pensions who had been employed as painters prior to application for disability. The painting occupations chosen included brush painters (DOT 740), spray painters (DOT 741), construction painters (DOT 840), and transportation painters (DOT 845). [See the *Dictionary of Occupational Titles* (19) for a more detailed description of these occupations.] Nonexposure status was given to those beneficiaries employed as a bricklayer (DOT 861) prior to application.

Definition of covariates. The case and reference groups were stratified into the age groups of <40, 40—44, 45—49, 50—54, 55—59, 60—64, and >64 years of age at the time the disability pension was awarded. Education was stratified into 1—8, 9—12, 15—16, and >16 years of education. We also employed the time period as a third covariate because the 1969—1973 and 1975—1976 continuous disability history samples could be considered separate data files, with data for 1974 missing.

Statistical analysis. We used the Mantel-Haenszel method for calculating the summary odds ratios and the Cochran-Mantel-Haenszel statistic for evaluating the association between case-referent and exposure status (22). We could have used unweighted or weighted observations for calculating the case-referent odds ratios. The weights represent the inverse of the sampling fraction for the individual states (of the United States), which varied between 10 and 100 % (23). We knew from previous work that weighted and unweighted methods produced very similar statistical results; the odds ratios were roughly equivalent statistically, both in terms of point estimate and significance level. Therefore, for simplicity, we chose to do our analysis using unweighted observations and thereby combined the states and ignored the sample information.

The Breslow-Day test for the homogeneity of odds ratios was used to evaluate the effects of age and education (22).

The Mantel-Haenszel summary odds ratios, which were adjusted for age, education, and time period, were considered significantly greater than unity at the 5 % alpha level.

Inclusion of the job-exposure matrix. The job-exposure matrix helped to verify the relative solvent exposure for construction painting, spray painting, and bricklaying occupations for the relative presence (percentage of potential exposure observed) of organic solvents in the workplaces.

The organic solvent hazards used to characterize the painters and bricklayers were chosen by two criteria. First, they had to be organic solvent hazards specifically observed (in the National Occupational Hazard Survey) in painting occupations, and, second, they had to be organic solvents that were reported in the literature (3). These included white spirit or petroleum spirit, toluene, xylene, ketone, acetone, butanol, and butanone-2.

The job-exposure matrix was used to characterize the exposed and unexposed occupations (ie, construction painters, spray painters, and bricklayers) by ranking these occupations against all other occupations according to the percentage of time observed working in the presence of the specific solvents. The rank for each of the solvents has been reported in percentiles.

Results

General characteristics

The referents were on the average 2.5 years older than the cases, but had fewer years of education. See table 1 for a summary of the age and education covariates for the cases and referents.

In addition, those who were employed as painters (N = 4291) prior to being disabled had slightly less education than all the other disabled persons who had been

employed as blue-collar workers (N = 86 672), but the same number of years of education as bricklayers (N = 1641).

Table 2 shows that neuroses, alcoholism, and other brain diseases accounted for 81 % of the cases. Presenile dementia was much less common in our study than in that of Axelson et al (8), whereas the prominence of neuroses and alcoholism disability was comparable.

As would be expected, disabilities due to circulatory disease and musculoskeletal disease were the most common diagnoses among the referents (table 3).

Organic solvent exposure Construction painters and spray painters were given a high ranking relative to other occupations surveyed for various solvents (table 4). In contrast bricklayers ranked low percentile-wise for all but one of the solvents shown in table 4.

Overall, both the construction and spray painters had a relatively high opportunity for exposure to various types of solvents, at least according to the 1972—1974 exposure survey. In addition, those employed as bricklayers prior to being disabled had a relatively small potential of solvent exposure according to the same survey.

Case-referent analysis

After adjustment for age, education, and time period, the results for neuropsychiatric disease (all diagnostic entities) showed a positive and significant association with the painting occupation [OR 1.42, 95 % confidence interval (95 % CI) 1.04 1.94]. The odds ratios for each of the other neuropsychiatric disease categories exceeded unity except for presenile dementia (table 5).

There was no apparent interaction between age and education with exposure status, as the odds ratios were homogeneous across both the age and education strata. Specifically, for age the Breslow-Day test for the homogeneity of odds ratios was not significant [$X^2 = 3.15$, degrees of freedom (df) 6, $P = 0.789$]. Nor was it significant for education ($X^2 = 3.08$, df 4, $P = 0.545$).

We also calculated the odds ratios, as adjusted for age, education, and time period, for specific exposure occupations. Construction painters, which accounted for about 88 % of the exposed painters, had a significant odds ratio of 1.47. Spray painters, who comprised

Table 1. Summary of age and education covariables for the cases and referents (from the continuous disability history file, 1969—1976).

	N	Age (years)			Education (years)	
		Mean	SD	Median	Mean	SD
Cases	3565	52.6	7.4	54	7.9	3.6
Referents	83245	55.3	7.1	57	7.7	3.5

Table 2. Number and percentage distribution of specific neuropsychiatric disease cases (from the continuous disability history file, 1969—1976).

Disease[a]	Number	Percentage
Pre-senile dementia (ICD 290)	96	2.7
Affective psychoses (ICD 296, 297)	380	10.7
Neuroses (ICD 300)	1663	46.6
Personality disorders (ICD 301)	200	5.6
Other diseases of brain (ICD 347)	481	13.5
Alcoholism (ICD 291, 303)	745	20.9
Total	3565	100.0

[a] Code of eighth revision of the International Classification of Diseases in parentheses.

Table 3. Number and percentage distribution of major disease categories for the referents (continuous disability history file, 1969—1976).

Disease[a]	Number	Percentage
Infectious diseases (ICD 1—139)	1481	1.8
Neoplastic diseases (ICD 140—239)	9660	11.6
Musculoskeletal diseases (ICD 710—738)	10633	12.8
Circulatory diseases (ICD 310—358)	34606	41.6
Respiratory diseases (ICD 460—519)	10109	12.1
Other	16756	20.1
Total	83245	100.0
Excluded disease cases	6689	

[a] Code of eighth revision of the International Classification of Diseases in parentheses.

Table 4. Percentile rank of the occupations used in the case-referent analysis for selected organic solvents, based on the job-exposure matrix, 1972—1974.

Occupation	Acetone	Butanol	Butanone	Ethyl acetate	Petroleum spirits	Toluene	Xylene
Construction and maintenance painters	53.4	81.1	83.2	81.4	78.2	90.2	87.2
Paint spraying machine operators	74.7	75.0	75.8	58.6	76.3	90.2	85.5
Bricklayers	..	97.6	10.3	..	3.3	3.2	6.7

Table 5. Mantel-Haenszel summary odds ratios, adjusted for age, education and time period, for all diseases and specific neuropsychiatric diseases. (OR = odds ratio, 95 % CI = 95 % confidence interval)

Case definition[a]	OR	95 % CI
All diseases	1.42	1.04—1.94
Presenile dementia (ICD 290)	0.44	0.18—4.79
Affective psychoses (ICD 296, 297)	2.41	0.80—7.21
Neuroses (ICD 300)	1.50	0.89—2.52
Personality disorders (ICD 301)	1.27	0.43—3.82
Alcoholism (ICD 291, 303)	1.20	0.67—2.13
Other diseases of the brain (ICD 347)	1.47	0.73—2.98

[a] Code of the eighth revision of the International Classification of Diseases in parentheses.

Table 6. Summary odds ratio (OR) adjusted for age, education, and time period for specific exposed occupations. (95 % CI = 95 % confidence interval)

Occupation[a]	Number of exposed	Number of exposed cases	OR	95 % CI
Brush painters (DOT 740)	22	1	1.74	0.24—12.93
Spray painters (DOT 741)	358	9	0.77	0.38—1.54
Construction painters (DOT 840)	3776	173	1.47	1.07—2.02
Transportation painters (DOT 841)	135	7	1.58	0.70—3.60
Total	4291	190	..	..

[a] 1967 code of the *Dictionary of Occupational Titles* in parentheses.

about 8 % of the exposed men, formed the only group that had odds ratios that were less than unity (table 6).

Discussion

There have been no previous reports of an increased risk of chronic neuropsychiatric disease among painters in the United States. Previous work has been primarily done in the Scandinavian countries of Sweden, Denmark, and Finland. Our overall estimate (ie, for all cases) of an odds ratio of 1.42 for chronic neuropsychiatric disabling conditions among workers previously employed as painters compares favorably with other statistically significant overall odds ratios. For instance, Cherry et al (24) obtained a significant overall odds ratio of 1.46 for a disabled Canadian population, and Axelson (8) reported an overall odds ratio of 1.8. However, unlike other epidemiologic studies, we did not obtain an odds ratio greater than unity for presenile dementia. The small number of cases of presenile dementia in the sample of disabled persons in the United States limited our ability to draw conclusions. On the other hand, we obtained a positive association between painting occupations and each of the other specific diagnostic categories, including alcoholism.

We also found that brush painters, construction painters, and transportation equipment painters had a significant excess of disabling neuropsychiatric diseases as compared with spray painters, who had an odds ratio that was less than unity. Previous epidemiologic studies did not report odds ratios for specific painting occupations, albeit spray painters and construction painters, so that our finding is singular. Our result is provocative in reference to the use of protective equipment used by spray painters (25). However, further investigation of whether there is a difference in amount or type of solvent exposure between spray painters and construction painters would need to be done before we can fully understand this finding.

Previous findings in regard to the relationship between alcoholism and solvent exposure are inconsistent. Mikkelsen (9) found that, when alcoholism cases were excluded from their case definition, the odds ratios were increased. On the other hand, Cherry et al (24) obtained an odds ratio of 5.7 for disabled alcoholic cases who had been previously employed as painters. In a separate analysis, we obtained a significant odds ratio, adjusted for age, education, and time period, of 1.51 (95 % CI 1.13—2.02) for alcoholism, when nonexposure was defined as work in blue-collar occupations other than painting.

A number of mechanisms may be contributing to the association between disabling alcoholism and employment as a painter. First, the diagnosis of alcoholism may in fact be a diagnostic misclassification for other neuropsychiatric diseases, particularly affective and neurotic disorders. On the other hand, nonartifactual mechanisms may be occurring. For instance, painters consume more alcohol and, thus, are more likely to become alcoholic. However, at least one study reported that painters did not consume more alcohol than other types of workers in the construction industry (10). It may be possible that solvent-induced neuropsychiatric diseases are an intermediate step to alcoholism, such that people with other personality disorders are at a higher risk for developing alcoholism or alcoholics are at a higher risk for solvent-induced neuropsychiatric disability. Thus diagnosed alcoholism, which was the disabling condition for some of the cases, may be one of several neuropsychiatric disorders these cases possess. Finally, exposure to solvents may directly induce alcoholism.

An important difference between our study and the Scandinavian investigations was that the diagnosis of presenile dementia was the least common among the disabled population in the United States (2.5 %) compared with, eg, 16 % in the Axelson et al study (8). Neuroses was the most commonly diagnosed class of

neuropsychiatric disease among the disabled US workers, followed by alcoholism, other brain diseases, and affective psychoses. A difference in the distribution of disorders between the Scandinavian studies and ours may not reflect a difference in the prevalence of disabling diseases in different countries, but rather a difference in the diagnostic nomenclature or guidelines in medical or psychiatric diagnosis. Nonetheless, neurotic and psychotic disorders have increased irritability, inappropriate affect, compulsive or perseveration behavior, and intellectual deficiency as symptoms (26). The psychological profiles of the individuals exposed to solvents were also found to include some of these cognitive, emotional, and behavioral changes, particularly those associated with memory and emotional reactivity [eg, Ørbæk et al (16)]. Moreover, the categories for the "clinical evaluation of patients" who had been exposed to solvents includes "sustained personality or mood changes" (type 2A) and "impairment of intellectual function" (type 2B) (27). These two categories encompass symptoms for the diseases used in our case definition for operationally defining chronic neuropsychiatric disease.

There are several possible limitations when one generalizes from a disabled population to the entire population at risk. One is that the disabled population is different from the general population. For instance, people who apply for disability may have other risk factors that increase their vulnerability to neuropsychiatric disorders. We would have to assume that those factors are distributed evenly across occupational groups. A second limitation is that the probability for application or award for disability is influenced by factors other than medical criteria or work history eligibility, particularly the occupation prior to being disabled. A recent study, however, showed that occupation was not related to an awareness of government disability benefits or the decision to apply for disability (28). Third, our odds ratio, which is really a "disability odds ratio," would be affected by the proportion of other diseases. For example, bricklayers may be more disabled by musculoskeletal disorders than painters, neuropsychiatric disability being therefore proportionately reduced among bricklayers.

Another disadvantage of our case-referent study is that we did not have access to medical records to verify the diagnoses, and we relied on a decentralized data collection system that was meant primarily for administrative evaluation of the Social Security disability benefit program. We agree with Baker & Fine (29) that using a case definition, such as ours, for chronic neuropsychiatric disease may not adequately capture neuropsychiatric deficits that result from long-term solvent exposure. However, no one has precisely elucidated the exact nature of the effect of solvents on the central nervous system. Moreover, without knowing the type of solvents actually involved in the exposure, it would probably have been inappropriate to restrict our case definition. Given our lack of control of the data collection and coding, the optimum approach was designing a study that was most likely to select disability cases that would have resulted from solvent exposure.

We also had to rely on job titles for defining exposure. Other epidemiologic studies, such as those of Olsen & Sabroe (10) and Shalat et al (30) were able to collect a work history to establish previous solvent exposure. In a discussion of the issue of misclassification, Rasmussen et al (12) concluded that basing exposure classification on job titles probably biases the estimated odds ratio towards unity. Regardless, our job-exposure matrix indirectly supported the relative potential solvent exposure of exposed painters and lack thereof for unexposed bricklayers.

The results of our analysis provide additional evidence that there may be a relationship between occupational exposure to organic solvents and chronic disabling neuropsychiatric diseases. However, our analysis does not stand alone, given the inherent biases and data quality issues associated with an existing administrative data source. The strength of our findings using disability data of the Social Security Administration is the internal consistency of the results and the agreement with the European studies. Nonetheless, the interpretation of these results may not only apply to the risk for painters per se for neurological damage from long-term solvent exposure, but also for any worker who is exposed to solvents in the workplace.

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