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Agreement Between Company-Recorded and Self-Reported Estimates of Duration and Frequency of Occupational Fumigant Exposure

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Investigators must often rely on self-reported work history information collected with questionnaires. However, little is known about the agreement between self-reported estimates of exposure and records kept by companies. As part of a cross-sectional medical study of structural fumigation workers, self-reported work history information was collected on both duration and frequency of exposure using an interviewer-administered questionnaire. All company records available on these workers were also collected. Only 15 of 81 structural fumigation companies identified by study participants as current or past structural fumigation employers had records suitable for comparison. These 15 companies employed 32 of the workers who participated in the cross-sectional medical study. The exposure information provided by the 32 workers was compared to information obtained from company records. By examining the agreement between these two data sources, potential limitations were identified in both the self-reported and company-recorded exposure data. By recognizing these limitations in the exposure data, we identified the most appropriate exposure measures to be used in subsequent data analyses. This exercise also demonstrated the difficulties in undertaking these exposure comparisons in an industry consisting of many small, independent companies. Similar difficulties with assessing exposures may be experienced by investigators studying other service industries consisting of many small, independent companies (e.g., dry cleaning, auto repair). Am. J. Ind. Med. 32:364–368, 1997.

KEY WORDS: epidemiologic methods; data agreement; occupational exposure estimation; fumigation; pesticides, occupational health

INTRODUCTION

When conducting occupational epidemiologic studies, it may be preferable to obtain exposure information using records from the employer. Unfortunately, such information is often unavailable or incomplete. Therefore, investigators often rely on self-reported exposure information collected with questionnaires. However, little is known about the agreement between self-reported and company-recorded estimates of exposure [Harlow and Linet, 1989].

As part of a cross-sectional medical study of structural fumigation workers to investigate the association between fumigant exposure and effects on health, self-reported information was collected on both fumigant exposure duration (length of employment) and frequency (number and length of exposures over a given time period). Company records on these workers were then collected. The immediate objective was to assess the agreement between the self-reported and company-recorded exposure information. To our knowledge, this is the first report comparing exposure frequency estimates, and one of the few reports comparing

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duration estimates. Another objective was to determine whether reasonable summary measures of exposure could be calculated for each worker. Finally, the feasibility of validating exposures in a cohort of workers employed in an industry composed of many small, competing firms was assessed.

METHODS

During 1992–1993, a cross-sectional medical study was undertaken by the National Institute for Occupational Safety and Health (NIOSH) and the University of Miami to examine the health effects of occupational exposure to methyl bromide and sulfuryl fluoride among structural fumigation workers in Florida. In summary, this study compared health outcomes (nervous system, kidney, lung, and genotoxic effects) among workers employed as shooters (individuals responsible for introducing the fumigant into the structure) and tent crew workers (individuals responsible for raising and dismantling the tarps used to cover the fumigated structure) in the structural fumigation industry, with health outcomes in an unexposed comparison group. Fumigant exposure in this industry is intermittent and is considered to potentially occur when the fumigant is introduced (or shot) into the building, and when dismantling the tarps. The workers were employed at the time of the study at one of 40 fumigation companies located in the Miami and Tampa/St. Petersburg metropolitan areas of Florida.

Lifetime occupational and medical history information was obtained on each study participant through an interviewer-administered questionnaire. Information on each job held and information on exposure to specific substances were recorded beginning with the subject's 18th birthday. Detailed information on fumigation industry employment was also obtained for three time periods of interest: the 2 weeks preceding the worker's examination, the year preceding the worker's examination, and the worker's entire duration of employment in the fumigation industry. The time periods were selected to determine if adverse health effects were associated with short-term (2-week exposure), intermediate-term (1 year exposure) and/or long-term fumigant exposure.

In 1993, we collected company records on the structural fumigation workers participating in the study. Review of the work histories of the 123 participating workers revealed that 81 different structural fumigation companies provided current or past employment. Phone calls and site visits were made to each of these employers and all available records were copied. The types of records that we attempted to collect included personnel files, daily work schedules (containing detailed information on each of the fumigation jobs conducted on a given day), payroll records, fumigant usage logs or diaries (used to inventory the amount of fumigant used), and customer files. According to rules of the Florida Department of Health and Rehabilitative Services (Chapter 10D-55, amended October 25, 1990), fumigation companies are required to maintain for a period of at least 2 years operation records that contain information on ''kinds (names), amounts, uses, dates, and places of application of restricted-use pesticides.'' Methyl bromide and sulfuryl fluoride are considered restricted-use pesticides. Unfortunately, the names of the shooter and tent crew workers participating in each specific fumigation job are not required to be included in these records.

For each time period of interest, company records suitable for validation had to contain the number of fumigation jobs performed and for each specific fumigation job the following information had to be available: the type (methyl bromide versus sulfuryl fluoride) and amount of fumigant used, the names of the shooters and tent crew workers, and the date. Based on these criteria, 15 of 81 companies were determined to have records suitable for assessing agreement with the self-reported work history for the 2 weeks preceding the worker's examination. These 15 companies employed 32 of the 123 participating workers. In addition, the agreement for lifetime years of employment in the fumigation industry was assessed for workers of the 15 companies when dates of hire and termination were available from the worker's current and all former employers. There are no plans to assess agreement for the other two time periods of interest (1-year, and lifetime) because of the enormous efforts that this assessment would require. However, because workers often change employers and because many employers kept poor records, it is reasonable to assume that suitable employer records for these two time periods would be available for even fewer than 32 workers.

Information on the 2 weeks preceding the interview for each of the 32 workers was abstracted from the company records. The information related to frequency of exposure included: days worked; the proportion of jobs using methyl bromide versus sulfuryl fluoride; mean number of jobs shot per day; mean number of tarp dismantling jobs per day; and mean pounds of fumigant used per fumigation job (shooters only). As for assessing duration of exposure, information was abstracted from the company records to calculate each worker's lifetime years of employment in the fumigation industry. Comparable self-reported data were obtained for each worker from the questionnaire.

Adjustments were made to the ''days worked'' estimates obtained from company records. This is because the company records often only indicated the date that fumigation jobs began. However, because a fumigation job involves work on 2 days (on the first day, the structure is covered with tarps and the fumigant is released into the structure; on the second day, the tarps are removed, and the shooter measures residual levels of fumigant in the structure) information regarding the second day often did not exist in the company records. To circumvent this problem, an additional day of

employment was assumed to occur after a fumigation job was documented to have begun. If the next day had no fumigation jobs scheduled and if it was not a major holiday or a weekend day on which the fumigation company was known to be closed (usually Sunday), then we added a day of employment to the worker's company record. If the fumigation company was known to be closed on the next day, a day of employment was added to the worker's company record only if there were no fumigation jobs scheduled on the next day the company was open for business.

Data Analysis

To determine the extent of agreement between company-recorded and self-reported estimates, Pearson correlation coefficients, and nonparametric Spearman correlation coefficients were calculated. *A priori*, it was determined that correlations of ≥ 0.5 would be considered evidence of adequate agreement. (Although this cutpoint is somewhat arbitrary, we think that using 0.5 as a minimum acceptable level of agreement was reasonable for our epidemiologic study). Because the findings were similar for the Pearson and Spearman correlations, in general, only the Pearson correlation coefficients are provided. However, Spearman correlations are provided whenever they and the Pearson correlation fell on opposite sides of 0.5. The extent of agreement between company records and self-reported estimates was also assessed by calculating the *P*-value for paired comparisons. The paired t-test was used when the differences appeared to be distributed normally, and the nonparametric sign test was used when there was evidence that the differences were not normally distributed. All analyses were performed using SAS procedures (SAS Institute, Cary, NC).

RESULTS

Table I provides demographic information on the workers participating in this agreement study. Ten of the 32 workers reported working as a shooter and 28 reported working as a tent crew worker during the two weeks preceding their examination (six workers were employed in both capacities). One worker reported working as both a shooter and tent crew worker; company records did not confirm that he was a shooter. He was considered a tent crew worker, and not a shooter, for the purposes of this paper.

Table II provides the correlations and the paired comparison *P*-values that assess agreement between the self-reported and company-recorded occupational exposure information. The results suggest that the self-reported and company-recorded data have adequate correlation, except for the tent crew worker estimates of days worked over the 2 weeks preceding the examination. The Pearson and Spearman correlations for days worked as a tent crew worker were 0.46 and 0.51, respectively. Additional evidence of poor agreement for the days worked variable among tent crew workers can be found in the statistically significant paired differences between self-reported and company-recorded estimates. In addition, there were three other variables (total years employed in the fumigation industry, days worked by shooters, and mean tarp dismantling jobs performed per day by tent crew workers) with statistically significant differences, although the correlations for these variables were adequate.

TABLE I. Characteristics of the Exposed Study Participants for Whom Company Records Were Available

	Parameter value (n = 32)
Mean age (yr) (range)	31 (20–53)
Mean years of education (range)	12 (8–16)
Race	
White	21 (66%)
Black	8 (25%)
Hispanic	3 (9%)
Mean self-reported years of structural fumigation employment (range)	5.9 (0.6–32)
Alcohol status	
Current drinker	21 (66%)
Former drinker	9 (28%)
Never drank	2 (6%)
Mean alcohol-years[a] (range)	19 (0–132)

[a]Calculated by multiplying the average number of alcoholic drinks consumed per day by the number of years alcohol was consumed.

DISCUSSION

This study represents one of the first investigations to compare self-reports and company records of duration and frequency of occupational exposures. It also demonstrates the great difficulty with validating exposures among a cohort of workers in an industry comprised of many small, independent firms, where there is high employee turnover and a high level of mobility of workers between competing companies. We found that several estimates of exposure were correlated. These included total years of employment, a finding that was observed by several other investigators [Weiss and Davis, 1960; Stewart et al., 1987; Baumgarten et al., 1983], daily frequency of fumigation activities, and type of fumigant used. We were interested in the effect that age and duration of employment may have had on agreement; however, the lack of spread of these factors precluded such a determination.

It was surprising to find that among tent crew workers, there was relatively poor agreement between the self-

TABLE II. Work History Information Obtained from Self-Reports and Company Records—Means and Correlations

Variable	n	Mean self-reported (SD)	Mean company records (SD)	Pearson correlation coefficient	*P*-value for paired comparison[a]
Years employed in structural fumigation[b]	20	3.6 (3.7)	3.2 (3.6)	0.97	0.02[c]
Shooter—2 weeks preceding the examination					
Days worked	10	9.6 (2.6)	10.6 (2.0)	0.69	0.13[d]
Mean jobs shot per day	10	2.1 (1.5)	1.6 (0.6)	0.82	0.21[d]
Percentage of jobs that used methyl bromide	10	11 (21)	15 (23)	0.88	0.99[c]
Percentage of jobs that used sulfuryl fluoride	10	89 (21)	85 (23)	0.88	0.99[c]
Mean pounds of fumigant used on a methyl bromide job	4	28.7 (14.4)	25.8 (13.0)	[e]	[e]
Mean pounds of fumigant used on a sulfuryl fluoride job	10	22.5 (10.4)	25.0 (9.7)	0.68	0.35[d]
Tent crew—2 weeks preceding the examination					
Days worked	28	10.9 (3.0)	9.7 (2.8)	0.46	0.04[d]
Mean tarp dismantling jobs per day	28	2.3 (1.1)	1.7 (0.7)	0.60	0.001[d]
Percentage of jobs that used methyl bromide	28	12.5 (19.6)	8.7 (19.7)	0.66	0.11[c]
Percentage of jobs that used sulfuryl fluoride	28	87.5 (19.6)	91.3 (19.7)	0.66	0.11[c]

SD, standard deviation.
[a]The paired comparison involves computing the difference between the paired self-reported and company-recorded exposure estimates.
[b]The means are for those workers for whom dates of hire and termination were available for their entire duration of fumigation employment.
[c]Obtained using the nonparametric sign test.
[d]Obtained using Student's t-test.
[e]The sample size was too small to perform meaningful statistical analyses.

reported and company-recorded estimates for days employed over the previous 2 weeks. We were unable to conclusively determine whether the self-reported or the company-recorded estimates, or both, were to blame. As noted earlier, the company-recorded estimates for days-worked were sometimes incomplete and required adjustment to include the second day of a fumigation job. This finding supports the observation made elsewhere [Bond et al., 1991], that company records may not always be precise. It should be noted that ''days worked'' is not information that fumigant companies are mandated to maintain by Florida law.

By contrast, data for several of the exposure variables (the number of fumigation jobs shot per day, the type of fumigant used, and the amount of fumigant used) are recorded at the time of occurrence by the fumigation companies as required by Florida state law. If the assumption is made that these data are accurate because they are legally mandated, the measures of agreement using these data can be defined as measures of validity. Agreement for the number of tarp dismantling jobs performed per day can also be considered a measure of validity because this exposure measure is equivalent to the number of jobs shot per day, a measure that a company is required to maintain according to Florida law.

Constructing Reasonable Exposure Measures

Based on the agreement we found for exposure information, we identified reasonable exposure measures to be used to examine the association between health effects and fumigant exposure. We preferred to use a separate measure of exposure for each of the two fumigants of interest. We also preferred an exposure measure that would permit examination of exposure-response relationships.

Our preference was to calculate summary exposure measures consisting of the number of minutes of methyl bromide exposure and sulfuryl fluoride exposure during each time period of interest. However, these summary measures required the use of the self-reported ''days worked'' variable, the variable found to have poor agreement with company records. To overcome this problem, other measures were identified using self-reported input variables having adequate agreement with company-recorded data.

As estimates of lifetime exposure, we calculated years employed as a methyl bromide worker and years employed as a sulfuryl fluoride worker. These fumigant-specific years of employment were calculated by multiplying duration of employment in the fumigation industry by the self-reported proportion of lifetime jobs that used the specific fumigant.

For example, years employed as a methyl bromide fumigation worker was derived by multiplying the duration of employment in the fumigation industry by the proportion of lifetime jobs that used methyl bromide. The exposure variables used to calculate these exposure measures are thought to have adequate agreement. Although the self-reported and company-recorded estimates for years of fumigation employment were statistically significantly different, the correlation between the two data sources was extremely strong (correlation = 0.97). The high correlation indicates that the self-reported estimate accurately ranks subjects along the exposure gradient, which makes the estimate useful for assessing the exposure-response gradient. We did not measure the agreement of the self-reported lifetime proportion estimates; however, because painstaking efforts were made to obtain accurate estimates, and because we found agreement for the 2-week proportion estimates, we think these lifetime estimates are appropriate.

To determine whether fumigant exposure over the intermediate term was associated with health effects, we used the self-reported fumigant proportion estimates for the year preceding examination. Using these estimates, workers were defined as having either high sulfuryl fluoride exposure (if the worker used sulfuryl fluoride on more than 50% of jobs during the previous year) or high methyl bromide exposure.

Finally, to assess whether short-term exposure to methyl bromide was associated with genotoxicity (no other health effects were hypothesized to be associated with short-term exposure), we estimated the number of minutes of methyl bromide exposure during the 2 weeks preceding examination. Because calculation of this exposure measure required the use of the self-reported ''days worked'' variable, a cautionary caveat will be provided when reporting our analytic findings. Another methyl bromide-specific exposure measure that used only input variables with adequate agreement could not be identified.

CONCLUSION

Both self-reported exposure data and data from company records have potential limitations. By examining agreement between data from these two sources, these limitations can be assessed and the most appropriate exposure measures to be used in subsequent data analyses can be identified. Our efforts also underscore both the difficulty of validating exposures within cohorts of workers employed in industries characterized by small, independent firms, and the need for improved collection and maintenance of job history records by firms in these industries. Recognizing the limitations of both self-reported and company data, other methods to estimate exposure should also be considered. These other methods include direct observation and industrial hygiene sampling of the work activities during the time period of interest, or measurement of appropriate markers of internal dose (e.g., blood or urine measurement of the exposure agent).

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