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VALIDATION OF WORK HISTORIES OBTAINED FROM INTERVIEWS

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There have been few attempts to assess the validity of occupational histories obtained from interviews. A nested case-control study of lung cancer conducted in 1985 among a cohort of 19,608 male workers at a Texas chemical production facility provided such an opportunity. Telephone interviews were attempted with 308 lung cancer patients and 588 matched controls or their next of kin in order to gather information on tobacco use, diet, places of residence, and occupations. Interview data from 734 respondents (143 subjects and 591 next of kin) were then compared with the records of work area assignments maintained by the company and with exposure profiles developed by an industrial hygienist. Respondents recalled 48.4 per cent of all documented work area assignments, but only 2.6 per cent of the chemical agents judged as likely exposures. Recall of usual work area assignment was 70.8 per cent. Among the factors found to have most influenced recall were the number and durations of assignments, a subjective assessment of the quality of the interview, and the relationship of the interview respondent to the subject. The elapsed time from job assignment to interview was also found to affect recall of the longest assignment of the subject.

epidemiologic methods; occupational diseases; questionnaire; retrospective studies; sensitivity and specificity (epidemiology)

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Questionnaires are often the sole source of occupational exposure data for epidemiologic studies, particularly for many of the large institution- or population-based case-control studies of cancer. The validity of underlying data depends on accurate recall by respondents. Misclassification of subjects can lead to over- or underestimates of risk, depending on whether cases are impacted differently than controls (1, 2). There have been few attempts to validate work histories obtained by interview. Although a number of investigators have tried to confirm occupational data by contacting reported employers (3–8), such studies can estimate only the degree of overreporting of jobs and cannot evaluate biases due to underreporting. Baumgarten et al. (9) recently compared employer names obtained from interviews with those recorded in a Canadian government data bank. Although the authors found good agreement between the two sources (82 per cent), only a recent 13-year time period was examined. Fur-

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thermore, the authors noted the limitations of using employer name as a surrogate measure of occupational exposure data.

A nested case-control study of lung cancer conducted among a large cohort of chemical workers (10, 11) provided the opportunity to assess the validity of occupational histories obtained by interview. This report examines the frequency of recall errors and their relation to specific characteristics of the study design and interview respondents. One advantage of this study over previous investigations was the opportunity to assess recall accuracy of jobs held as long ago as 40 years. In addition, the dependent variables were specific work area assignments and chemical or physical exposure agents, measures particularly applicable to case-control studies designed to identify occupational hazards.

MATERIALS AND METHODS

Lung cancer study

A nested case-control study was recently conducted among a cohort of 19,608 male chemical workers who had one or more years of service at a Texas production facility and who were followed from 1940 through 1980 (10, 11). These workers had been identified as possibly being at increased risk of lung cancer (12), for which an occupational etiology was considered. Cases were defined as those subjects who met the criteria for inclusion in the cohort (11, 12), who died before 1981, and whose death certificates listed primary lung cancer anywhere on the document. Two control groups, one a decedent and one a "living" series, were chosen from among all other cohort members who did not have lung cancer. Controls were individually matched to cases on race, sex, year of birth, and year hired.

Employees' documented work history records maintained by the company served as the starting point for categorizing workplace exposures. The records supplied demographic data and identified details of each job and department assignment at the facility, including dates of job changes. Since these records were updated at the time of assignment changes, they present accurate accounts of job mobility that are suitable for validation purposes.

The two measures used to characterize employee exposures, work area and chemical or physical exposure agent profiles (13–15), were developed independently. For the first, 50 homogeneous work area classifications were condensed from more than 400 departmental titles used by the personnel office by grouping departments with similar exposure conditions. For the second, chemical and physical agent profiles were developed for each subject by one of the authors (G. H. F.), a certified industrial hygienist. Work history records for each person were reviewed by the industrial hygienist, who was blinded to case or control status, and all agents each worker was likely to have encountered on any job were listed. Every attempt was made to include all agents that would have presented a reasonable potential for exposure, and considered such factors as amount handled, handling procedures, and vapor pressure of the material.

In the nested study, telephone interviews were attempted with 308 cases and 588 matched controls or their next of kin in order to gather data on potential confounders. Among other items, the questionnaire included a series of open-ended questions designed to elicit a chronologic listing of all jobs, department assignments, and agent exposures pertinent to the subject's career at the facility. In order to confirm the identity of the subject and to solicit cooperation, the respondent was reminded that the subject had worked for the company, and the dates of first and last employment were supplied prior to beginning the interview. Respondents were prompted to list chemical exposures; however, at no time did the interviewers suggest job titles, departments, or specific agents. (A copy of the questionnaire may be obtained from the authors upon request.) An attempt was made to interview the person expected to be most knowledgeable about the subject

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during his adult lifetime. The subject himself was preferred, or, if he was deceased or otherwise incapacitated, a spouse, an offspring, a sibling, another relative, or a friend was contacted, in that order. Most of the interviews (89 per cent) were completed by one of three interviewers, with the remainder conducted by two supervisors. The interview sessions ranged in length from five minutes for partial interviews to 94 minutes and averaged about 28 minutes. There was essentially no difference in means for length of the interview between the cases (27.3 minutes) and the controls (decedents = 26.3 minutes; living controls = 31.3 minutes).

Validation study

Interviews were successfully completed with 734 (82 per cent) respondents between March 13 and August 27, 1984. Failure to locate the subject or a suitable proxy was the major reason for a less-than-complete response, since participation among those contacted for interview was excellent (96 per cent). In comparing the participants with the nonparticipants, we found that the former were more likely to have been longer term employees and to have been hired more recently than the latter. Other factors examined (age at hiring, year of death, educational level, and job category) revealed only negligible differences.

Work histories obtained by interview were coded according to the same scheme as that used for documented company work histories and were input into the computer using a display management system, incorporating a number of quality assurance steps and edit checks (11).

Respondents listed 248 separate department titles, 242 jobs, and 96 chemical or physical agents as exposures for the 734 subjects. When these were compared with the 417 department titles and 542 job titles listed in company records and the 171 agents catalogued by the industrial hygienist for those subjects, it was obvious that the respondents were not able to provide the same level of detail. Recognizing that such detail may not be required to classify exposures correctly, we grouped department titles listed by the respondents into the 50 work areas described earlier. Where in the 50 areas a subject had been classified as having worked was then checked against the company records using the records as a standard. An employee may have contributed data to multiple work areas, but was counted only once for each area.

Accuracy of respondent recall was measured by two dependent variables: recall of all work area assignments listed in the company records and recall of exposures to chemical or physical agents. A variation of the recall of "usual" work area assignments (defined as the one work area to which the subject had been assigned for the longest continual period of time) was also used. False positives, in which the respondent reported assignments or agents not derived from the record, were rare; thus, specificity of the interview data can be regarded as nearly 100 per cent. The focus of the analysis was therefore the sensitivity rate, i.e., the degree to which respondents correctly recalled assignments or agent exposures as they appeared in the documented company record.

Study results were tabulated and analyzed by packaged procedures in the Statistical Analysis System (16). Since it was suspected that the recall of the respondents might be influenced by a variety of characteristics, sensitivity rates were examined for various subsets of the sample of subjects. The relative strength with which these factors may have affected recall was further evaluated by logistic regression with stepwise model-building procedures and likelihood ratio statistical tests. The seven factors that were regarded as potential determinants of recall are outlined in table 1. These included characteristics of the work history (elapsed time from the end of an assignment to the interview, cumulative duration of the assignment, and number of assignments), the subject (group membership), and the interview (relationship of the respondent to the subject, qual-

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TABLE 1

Percentage of recorded work assignments reported in interviews, by selected characteristics, study of lung cancer among chemical workers in a Texas production facility, 1940–1980

Characteristic	No. of work area assignments		Usual work area assignment*	
	Company records	Respondents (%)	Company records	Respondents (%)
Relationship of respondent to subject				
Self	358	50.6	143	76.2
Spouse	811	47.8	361	72.0
Other	429	47.6	228	65.4
Elapsed time from assignment to interview (years)				
<15	275	58.9	151	82.1
15–29.9	544	48.5	269	68.4
≥30	785	44.6	314	67.5
Duration of assignment (years)				
<1	436	24.8	38	44.7
1–4.9	626	49.8	296	70.9
≥5	542	65.7	400	73.2
No. of assignments				
1	281	80.4	281	80.4
2 to 3	808	46.3	343	66.8
≥4	515	34.2	110	59.1
Quality of interview				
High	1,021	49.6	446	77.1
Adequate	467	48.8	229	65.9
Questionable or unsatisfactory	112	35.7	57	40.4
Principal interviewer				
A	547	50.1	243	73.3
B	531	49.9	259	68.7
C	346	47.7	154	74.0
Group membership				
Cases	519	49.5	245	71.8
Decedent controls	526	47.0	251	70.5
Living controls	559	48.7	238	70.2

* Defined as work area assignment of longest duration, according to company records. (Note: Total counts for some characteristics may vary because of missing data.)

ity of the interview, and principal interviewer). Interview quality was a subjective appraisal made by the interviewer regarding the respondent's willingness and ability to furnish information about the subject.

RESULTS

Overall, respondents recalled 48.4 per cent of all work area assignments and 70.8 per cent of usual assignments, but only 2.6 per cent of the chemical or physical agents listed as exposures by the industrial hygienist.

Sensitivity rates for recall of work area assignments are shown in table 1 for the sample as a whole and for subsets of subjects classified by various potential recall determinants. It can be seen that correct responses diminished with the number of jobs and with elapsed time, but increased with longer duration jobs. Better recall was obtained in higher quality interviews, i.e., those in which the respondent was more cooperative and more familiar with the employee's career.

In the case of usual work assignments, there appeared to be small differences in recall associated with the relationship of the respondent to the subject. These differences were not found when all work area assignments were considered.

Table 1 also presents recall sensitivity separately for the cases and the two control series. Fewer than three percentage points

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difference were seen among the groups for recall of either all or usual work assignments, providing little evidence for any degree of bias based on disease state or vital status of the study subjects in this investigation.

The relative importance of the factors that determined recall and the dependencies among them were investigated by building prediction models. Moderately complex logistic models for the seven main effects listed in table 1 and in first-order interactions were considered. Model factors were defined somewhat differently than in the crude tabulations. Elapsed time to interview, duration of assignment, and number of assignments were tested as continuous variables. On the basis of statistical evaluation of preliminary modeling results, the number of levels of some factors was reduced. Thus, the relationship of the respondent to the subject was found to be adequately described by the dichotomy "self" versus "other." Interview quality was redefined as "high or adequate" versus "questionable or unsatisfactory," and, for exposures to physical or chemical agents, the choice of interviewer was regrouped as "interviewer A" versus "others."

Some examples of model estimates for recall of work area are given in table 2. The procedure identified many of the same determinants noted in table 1 as important (or unimportant). The number of assignments and interview quality were shown to be critical to recall accuracy of both usual work area assignment and all work assignments. No evidence of effects due to interview differences or to subjects' group status was seen.

TABLE 2

Percentage of recall of recorded work assignments predicted by logistic models, study of lung cancer among chemical workers in a Texas production facility, 1940–1980

Quality of interview	Model parameters—all work area assignments				
	Relationship of respondent	Duration of assignment (years)	No. of assignments		
			1	2	3
High or adequate	Self	2	62.2	53.7	45.1
		5	66.7	59.8	52.4
		10	73.6	69.1	64.2
	Other	2	65.4	51.9	38.1
		5	69.7	58.0	45.2
		10	76.2	67.5	57.4
Questionable or unsatisfactory	Self	2	23.9	29.5	35.8
		5	27.2	34.9	42.8
		10	34.8	44.7	54.9
	Other	2	26.6	28.0	29.4
		5	30.6	33.2	35.9
		10	38.0	42.8	47.8
	Model parameters—usual work area assignments*				
	Elapsed time from assignment to interview (years)		No. of assignments		
			1	2	3
High or adequate	1		88.5	88.6	88.6
	5		87.8	86.9	86.0
	10		86.7	84.5	82.1
Questionable or unsatisfactory	1		64.7	64.8	64.9
	5		62.9	61.1	59.3
	10		60.7	56.4	52.1

* Defined as work area assignment of longest duration according to company records.

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A few differences between the model and the crude tabulations were noted. The relationship of the respondent to the subject had a stronger effect on recall in the all work areas model than in the usual work area model, the reverse of what is apparent from table 1. Although elapsed time to interview appeared to be a strong factor in table 1, its influence in the all work areas recall model was overshadowed by another factor with which it was highly correlated, duration of assignment. However, for usual assignments, presumably all of considerable and more uniform duration, the elapsed time effect was seen to emerge.

A substantial degree of interaction can be seen in table 2, all because of the influence of the factor number of assignments on the other independent variables. Only interview quality in the usual work areas model was unaffected. In both work area models, an increase in assignments was associated with poorer recall. Increase in assignments also acted to magnify the effects of elapsed time to interview, the relationship of the respondent to the subject, and the duration of assignment, but diminished the advantage of high-quality interviews.

Recall of some work areas was better than others. Table 3 shows that, according to company records, recall sensitivity varied by about 40 percentage points for the most frequently occurring work area assignments of the study sample, and by as much as 60 points when only usual assignments were considered. To determine how much of this variation was due to the factors already examined, we included work area as the last term in each of the above models. Even after adjustment for the factors in table 2, both models showed significant differences among the five most common work areas (magnesium, maintenance, pipe shop, administration, and paint shop) and all others.

Recall rates for physical and chemical agents were considerably lower than were those for work assignments, and modeling procedures identified a different set of determinants. As was found for the work area analyses, duration of assignment and the relationship of the respondent to the subject affected recall; however, some bias because of differences among interviewers and the study group membership of the subject was evident. The interpretation of these two factors is complicated by a significant interaction found between them.

It was also found that recall of some agents was considerably better than that of others, although none approached the same levels obtained for work areas. Among the eight most common agents derived from the company records of the study sample, the highest recall rates were found for chlorine (10.7 per cent) and asbestos (8.6 per cent), and the lowest for sulfur dioxide (0.7 per cent) and heat (0.5 per cent). Significant differences among the agents were also noted in the logistic model, even after adjustment for the other factors named

TABLE 3

Percentage of recorded work assignments expected in interviews by selected work areas, study of lung cancer among chemical workers in a Texas production facility, 1940–1980

Work area	No. of work area assignments		Usual work area assignment*	
	Company records	Respondents (%)	Company records	Respondents (%)
Magnesium	223†	69.1	122‡	82.8
Construction	36	30.6	5	40.0
Power	46	65.2	26	80.8
Styrene	29	48.3	11	72.7
Chlorine	56	46.4	25	60.0
Maintenance	143	28.7	42	45.2
Machine shop	40	47.5	21	61.9
Pipe shop	135	55.6	85	64.7
Administrative	204	59.3	112	79.5
Vinyl-vinylidene chloride	11	72.7	8	100.0
Paint shop	97	55.7	52	82.7
Overall	1,604§	48.4	734	70.8

* Defined as work area assignment of longest duration, according to company records.

†Number of subjects with work area assignment recorded in company work history.

‡ Number of subjects for whom this was the usual assignment.

§ Number of total work area assignments (sum of number of assignments held by each subject).

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above. Thus, as with work areas, there were apparently some factors not specifically studied that were operating to affect recall.

Discussion

The results from this validation study indicate that a fair amount of underreporting of work histories can be expected when data are obtained from interview, but that some job characteristics are associated with better recall than others. Not surprisingly, recall of usual assignments was better than recall of all assignments in general. A job is more likely to be considered a usual assignment as its duration increases. It was found that when only assignments of at least five years duration were considered, recall of all work areas improved from 48.4 to 65.7 per cent. This approached the overall 70.8 per cent recall of usual assignments, which averaged about 5.9 years of duration. Recall of usual work areas increased only modestly to 73.2 per cent when assignments of less than five years were ignored. Failure to recall assignments of short duration is probably not critical to many study designs if the operation of a dose-response mechanism is expected. In fact, it may be easier to detect an occupational effect among workers exposed for longer periods of time, without the diluting influence of inconsequential exposures.

Multiplicity of jobs remains a definite concern to occupational epidemiology studies based on interview data. It can be expected that more exposures will be overlooked by the respondent as the number of assignments increases. The findings of this study agree with results obtained by Baumgarten et al. (9) who found significantly better agreement between the report of the respondent and company records among respondents who reported fewer than two jobs than among those who reported two or more jobs.

Elapsed time between the end of an assignment and the interview had a substantial effect on recall, especially as the number of assignments increased. This consideration is important to cancer studies in particular, since the job assignments of greatest relevancy to disease incidence are often those that were held sufficiently long ago for an adequate latency period to have been passed.

The fact that agreement on work areas was found to be almost identical for cases and controls argues against the presence of any differential misclassification in these data. Nondifferential misclassification, such as that due to underreporting of exposure and to some study design features (2), has been shown not to change the direction of the risk estimate, but rather to bias it toward the null value (1). It can be demonstrated that the bias is particularly severe when the exposure rate among the controls is high. Since investigators tend to select study populations with inherently high rates of exposure, low recall sensitivity should be perceived as a definite problem.

Investigators often make an effort to match dead controls with dead cases in order to achieve similar interview circumstances, even though this requires that interview data be obtained from proxies. Gordis (17) has argued against the use of dead controls, contending that proxies are often able to provide data of a quality comparable with that supplied by the subjects themselves. The results obtained from validation of work area recall in this study tend to support that contention. Only for more complicated work histories was the relationship of the respondent to the subject seen to be a factor.

Overall, free recall of specific physical or chemical agent exposures was poor (less than 3 per cent). This occurred in spite of the fact that employees at this facility have been apprised repeatedly of the materials with which they work as part of their safety training. This program, which has been evolving since the early 1960s, involves identification of the materials in the work environment of the employee and discussion of chemical toxicity, safe handling practices, and emergency response procedures. It should be noted that some considerations may have mediated the effect of

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the training program on recall. The majority (81 per cent) of the exposures of the subjects in this study predate the formal inception of the program. Moreover, most of the interviews (82 per cent) were conducted with a surrogate respondent instead of the subject. The results of this investigation would argue that, in at least some instances, free recall is not a viable tool upon which to classify chemical exposures. It would be preferable for investigators who conduct interview-based occupational health studies to consult with industrial hygienists to develop a specific chemical agent exposure classification scheme through the use of job titles and work duties.

Some important considerations gleaned from the modeling process are that the determinants of recall are numerous, that they act and interact in complex ways, and that they are to some degree dependent upon study design. The large differences in recall of common work areas and chemical or physical agents, even after adjusting for known factors, hints that many important factors have not been evaluated in this study. This is further indicated by the fact that the per cent variation explained by the models was low in all cases (all work areas, $R^2 = 13$ per cent; usual work areas, $R^2 = 8$ per cent; physical and chemical agents, $R^2 = 7$ per cent), although it is unlikely that more complex model structures would have helped.

For the response variables of all work area assignment recall and physical or chemical agent recall, almost all subjects contributed multiple responses to the analysis, whereas the statistical design ignored these potential intrasubject dependencies. (We note, however, that this situation is not dissimilar to the prevalent use of person-year as the sampling unit in other types of epidemiologic research.) A completely acceptable framework for such an analysis was not apparent. On the other hand, the analysis of recall of usual work area was not burdened by such dependencies, since by definition there is only one usual assignment per subject. The similarities in outcome for usual assignments and all assignments lessens any concern for violations of assumptions of independence in this study.

Some unique features of this study may limit the inferences that can be drawn from it. First, the validation of work histories was limited to one employer. (Although interviews furnished data on other exposures and occupations, these could not be validated with company resources.) Work conditions or demographic characteristics of employees at other facilities might differ sufficiently to render different results or to contribute substantial additional variability to interindustry studies.

The comparisons made were limited to specific work area assignments as well as to chemical and physical agents, as opposed to job titles. This approach was taken because work areas and chemical and physical agent exposures have been the primary variables upon which case-control studies of workplace hazards at this facility have focused (13–15). To some extent, recall or lack of recall may be attributed to the particular classification schemes used in this study and may differ under another approach. However, many of the work areas imply job titles, e.g., machine shop, paint shop, electric shop, and pipe shop. Furthermore, even chemical production work areas imply job titles, since nearly all employees assigned to such areas can be classified as operators.

The interviews were administered by telephone. Face-to-face interviews were not feasible because of substantial migration of former employees and their next of kin from the area. By necessity, telephone interviews are brief, and it may not be possible to obtain the complete attention of the respondent. The respondent is also less able to consult with records or other sources to stimulate his or her memory. It might be expected that better agreement may have resulted from face-to-face interviews, although this is a matter yet to be confirmed by investigation.

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Although this questionnaire employed open-ended questions to elicit complete responses, we recognize that the use of closed-ended questions, such as a list of occupations or chemical agents of interest, might have stimulated recall and improved the performance of the respondents. On the other hand, such an instrument may introduce significant recall bias. This, too, is a matter to be resolved by further study.

Finally, there were few demographic data collected on the respondents (as opposed to the subjects). Although one might expect recall to be influenced by such factors as the age, education, or income level of the respondents, Baumgarten et al. (9) did not find that these factors affected agreement in their study.

It is clear from this investigation that a real potential for recall bias and exposure misclassification exists in interview-based occupational case-control studies and that the effects on risk estimation can be serious. While some factors that influence recall can be identified and adjusted for during analysis, others are best handled by careful decision-making during the design stage of a study. Because so few of the determinants of recall have yet been adequately examined, there is good reason to use caution in the interpretation of such interview-based research.

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