Mesothelioma Surveillance to Locate Sources of Exposure to Asbestos

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ABSTRACT

To determine whether there were previously unrecognized sources of asbestos exposure in British Columbia, incident mesothelioma cases (n=519) and population-based controls (n=1354) were interviewed about their occupational histories and asbestos exposure. The following occupations were at elevated risk: chemical workers (OR=9.6, 95% CI: 1.5-106); carpenters and papermakers (OR=8.3, 95% CI: 1.5-86); shipbuilding workers (OR=5.0, 95% CI: 1.2-23); painters (OR=4.5, 95% CI: 1.0-24); welders (OR=3.9, 95% CI: 0.8-22); gardeners (OR=3.9, 95% CI: 0.8-22); bricklayers (OR=3.5, 95% CI: 0.9-14); miners (OR=3.4, 95% CI: 0.9-13); machinists (OR=3.2, 95% CI: 1.0-11); construction foremen (OR=3.1, 95% CI: 0.9-11); and demolition workers (OR=3.0, 95% CI: 0.8-12). Further analyses excluding subjects who worked in occupations or processes considered strongly or probably risky for three groups remained elevated: miners (non-asbestos miners (OR=9.6, 95% CI: 1.8-53), bricklayers (OR=5.4, 95% CI: 1.0-28), and construction labourers (OR=2.8, 95% CI: 0.7-10.6).

ABRÉGÉ

Pour déterminer l'existence ou non de sources inconnues non identifiées d'exposition à l'amiante en Colombie-Britannique, on a fait passer des interviews à des personnes atteintes de mésothéliome (n=519) et à des témoins représentatifs (n=1354) au sujet de leurs antécédents de travail et de leur exposition à l'amiante. Les professions suivantes sont apparues comme présentant un risque élevé: ouvriers chimiques (RR=9.6, 95 % IC : 1.5-106); plombiers et tuyauteurs (RR=5.0, 95 % IC : 1.2-23); peintres (RR=4.5, 95 % IC : 1.0-24); soudeurs (RR=3.9, 95 % IC : 0.8-22); jardiniers (RR=3.9, 95 % IC : 0.8-22); briqueteurs (RR=3.5, 95 % IC : 0.9-14); mineurs (RR=3.4, 95 % IC : 0.9-13); machinistes (RR=3.2, 95 % IC : 1.0-11); contremaîtres de construction (RR=3.1, 95 % IC : 0.9-11); et démolisseurs (RR=3.0, 95 % IC : 0.8-12). Une nouvelle analyse, excluant cette fois les sujets ayant exercé des métiers ou effectué des activités considérés a priori comme présentant un risque élevé, a fait ressortir trois groupes : les mineurs dans un secteur autre que l'amiante (RR=9.6, 95 % IC : 1.8-53), les briqueteurs (RR=5.4, 95 % IC : 1.0-28) et les manœuvres d'entreprises de construction (RR=2.8, 95 % IC : 0.7-10.6).

Cancers generally have long latency periods, so sources of carcinogen exposure may no longer exist when a diagnosis is made. However, recent studies of mesothelioma cases have led to the discovery of previously unrecognized current asbestos exposure sources. Paci et al[1] found a large excess of mesothelioma cases among textile workers in Italy. An industrial hygiene investigation found that rags in the reprocessed textile industry were wrapped in bags that had contained asbestos.[2] Jarvholm et al[3] found an elevated risk of mesothelioma in Swedish pulp and paper workers; 18 of 25 cases were found to have had certain or probable asbestos exposure, most during maintenance work.

These studies suggest that even though asbestos is one of the best known carcinogens of this century,[4] there may still be value in mesothelioma surveillance to locate previously unrecognized current sources of exposure. We compared the occupational histories of mesothelioma cases to those of population controls to determine whether unrecognized sources of exposure to asbestos existed in British Columbia (BC). The study was part of a larger investigation that included nasal and bladder cancer cases.[5]

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MATERIALS AND METHODS

Identification of cases and controls

All persons with histologically confirmed primary malignant tumours of the pleural mesothelium (International Classification of Diseases for Oncology, 1976, topography code 163 and histology code 905) aged 19 or more and registered by the British Columbia Cancer Agency (BCCA) from September 1, 1990, to August 31, 1992, were considered eligible for the study. A BCCA pathologist (Dr. Ann Milner), not blinded to the initial diagnosis, reviewed tissue samples for every case initially identified as eligible.

Control subjects were randomly selected from five-year age and sex strata of the provincial voters list and frequency matched to the age and sex distribution of cases of all three types of cancer included in the study.

Interviews

The subject contact methods were approved by the University of British Columbia Behavioural Sciences Screening Committee. All subjects living within about six hours' surface travel time of Vancouver (one way) were interviewed either in person or by telephone, at their convenience. Subjects living elsewhere in BC were interviewed by telephone.

If a subject did not speak English well or had trouble recalling events in his or her life, a relative chosen by the subject was asked to help with the interview. If the subject was dead, the surviving next-of-kin who had most recently lived with the subject was contacted for interview. We attempted to frequency match next-of-kin interviews of cases and controls within age-sex strata.

Interviews were conducted using a standardized questionnaire, which included occupational, residential, smoking, and medical histories, and an exposure history aimed at identifying exposures considered by the International Agency for Research on Cancer to be "known" or "probably" carcinogenic.[4]

All interviews were conducted by a registered nurse who was aware of the case/control status of the subjects, and were then reviewed for completeness by an industrial hygienist (KT), who was not.

Case-control analysis

All occupations and industries were coded to the fourth digit of the Standard Occupational and Industrial Classifications.[6,7] In total, 5,951 separate jobs were listed by the interviewees, representing over 300 occupational and 500 industrial codes. For analysis, a study-specific occupational grouping scheme was developed, which assigned all job listings to one of 57 occupational groups.

Odds ratios (ORs) and 95% confidence limits were calculated for ever employed (for six or more months) versus never employed in each occupational group. Effect estimates were also calculated for two categories of duration of employment: 6 months to less than 10 years, and 10 years or more. Latency analyses were conducted for all occupational groups, with the most recent 20 years of employment removed. All OR estimates were adjusted for sex and age (in three strata: <60 years; 60-69 years; and ≥70 years).

Initial analyses were conducted including all cases and controls. To detect new occupational groups with potential exposures to asbestos, reanalyses were done after excluding case and control subjects who had held occupations or worked in processes known *a priori* to have consistent strong associations with mesothelioma and confirmed in this study.

Exact methods were used to summarize ORs across all strata and calculate confidence intervals[8,9] (Egret, Statistics and Epidemiology Research Corporation, Seattle, WA, 1993).

An occupational group was considered for asbestos surveillance follow-up if 1) it had an OR of at least 3.0 in the reanalysis, or an OR greater than 1.2 if it was considered *a priori* at risk based on a literature review and 2) at least three cases in the occupational group had a pattern of similar job duties or exposures.

TABLE I
Response Characteristics of Mesothelioma Cases and Population Controls, and Descriptive Characteristics of Interviewees

	Cases	Controls
Total registered by BC Cancer Agency	71	N/A
Ineligible site or histology	11	N/A
Not histologically confirmed	2	N/A
Total eligible (histologically confirmed)	58	190
Physician refusal	3	N/A
Unable to contact	1	1
Case/control refusal	0	33
Interview complete (% of eligible)	51 (87.9)	154 (81.0)
Male (%)	47 (92.2)	126 (81.8)
Mean age, in years (standard error)	67.4 (1.5)	66.1 (0.7)
Range	41-85	40-87
Next-of-kin interviews (%)	17 (33.3)	21 (13.6)
Cigarette smoking, mean pack-years (standard error)	25.5 (5.0)	28.2 (2.9)
Range	0-190	0-183

N/A = not applicable

RESULTS

Comparability of cases and controls

Table I lists the total number of cases and controls finally considered eligible for the study and selected descriptive characteristics of the subjects. The proportion of eligible controls who participated was 81%, 7% lower than among cases. The proportion of male cases was 10% higher than among controls, because of the higher proportion of men with mesothelioma compared with the other cancer sites (bladder and nasal) to which controls were also matched. The greater proportion of next-of-kin interviews among cases is partly attributable to the shorter survival for mesothelioma than the two other cancer sites, but in addition some controls randomly selected to have next-of-kin interviews were reluctant to participate if others would be answering questions on their behalf.

Occupational associations, all cases and controls

Table II lists ORs and confidence intervals for associations between each occupational group and mesothelioma. Three occupational groups had ORs of 5.0 or greater in the initial analysis: sheet metal workers, plumbers and pipefitters, and shipbuilding workers, not elsewhere classified. All these ORs were statistically significant and followed the expected trend of increased relative risk with increasing duration of employment (OR 10+ years = infinite, all three groups).

Eight other occupational groups had ORs of 3.0 or higher: painters; welders; gardeners; bricklayers, plasterers, and cement workers; miners, drillers, and blasters; machinists; construction foremen; and electricians and electrical equipment installers. Several other occupational groups that might be considered *a priori* at risk had elevated ORs: industrial mechanics; stationary engineers and boilermakers; construction labourers; and transport engineers and firemen. One *a priori* at-risk occupation had a reduced risk estimate: vehicle mechanics.

Associations with asbestos exposure and specific processes, all cases and controls

Table III shows the ORs for associations between mesothelioma and occupational asbestos exposure or specific occupational processes queried in the exposure history section of the questionnaire. Strongly elevated ORs were found for asbestos

TABLE II

Odds Ratios* Showing Associations Between Occupational Groups and Pleural Mesothelioma, All Cases (n = 511) and Controls (n = 154) Included

	Ever Employed			Most Recent 20 Years Removed		
	Number of Cases/ Controls	Odds Ratio Ever Employed	95% Confidence Interval	Number of Cases/ Controls	Odds Ratio Ever Employed	95% Confidence Interval
Occupational Groups with OR ≥ 2.0						
Sheetmetal workers**	6/25	0.6	0.1-3.6	6/2	0.6	0.1-3.6
Plumbers and pipefitters*	7/2	8.3	0.5-86.3	6/2	7.0	0.2-75.1
Shipbuilding workers, nec**	7/5	5.0	1.2-22.7	5/4	6.9	1.5-37.1
Painters**	6/4	4.5	1.0-23.2	5/3	5.4	0.9-39.3
Welders**	5/4	3.9	0.8-21.8	35/3	4.9	0.9-34.5
Gardeners*	5/4	3.9	0.8-21.9	3/4	2.5	0.3-16.8
Bricklayers, plasterers, & cement workers**	7/6	3.5	0.9-14.0	7/5	4.5	1.1-19.8
Miners, drillers, & blasters**	7/6	3.4	0.9-13.1	7/7	3.4	0.9-13.1
Machinists**	6/8	2.2	1.0-11.1	4/7	3.9	1.1-13.2
Construction foremen*	8/7	3.1	0.9-11.0	7/5	3.7	0.9-16.0
Electrical & electronic equipment installers*	6/8	2.0	0.8-11.6	6/7	3.7	0.9-15.6
Other Suspect Occupational Groups						
Industrial mechanics**	7/9	2.3	0.7-8.2	6/9	2.1	0.6-7.3
Stationary engineers & boilermakers*	6/11	1.8	0.5-5.9	6/11	1.8	0.5-5.9
Construction labourers*	11/22	1.5	0.6-3.8	10/19	1.5	0.6-3.9
Transport engineers & firemen*	2/6	1.3	0.1-8.6	2/6	1.3	0.1-9.1
Vehicle mechanics*	6/20	0.8	0.2-2.9	6/20	0.8	0.2-2.9
Other Occupational Groups						
Administrators, managers	4/22	0.6	0.1-1.8	4/17	0.4	0.1-1.9
Travelling managers & salesmen	6/33	0.5	0.2-1.3	5/26	0.5	0.2-1.2
Accountants, bookkeepers	2/20	0.3	0.1-1.3	2/19	0.5	0.1-2.4
Engineers, designers	2/7	0.8	0.1-4.8	1/5	0.6	0-5.5
Teachers, librarians	4/14	1.0	0.2-3.2	3/10	1.3	0.2-5.7
Sales clerks	11/40	0.9	0.4-2.1	9/34	0.8	0.3-2.0
Office clerks & secretaries	9/26	1.3	0.5-3.5	9/25	1.3	0.5-3.6
Healthcare workers	2/9	1.0	0.1-5.3	2/8	1.3	0.1-6.9
Chemical & biological lab personnel	2/8	0.7	0.1-4.0	2/7	0.8	0.1-4.7
Radio operators*	1/9	0.2	0-1.9	1/9	0.2	0-1.9
Surveyors, prospectors, trappers*	1/8	0.4	0-2.9	1/8	0.4	0-2.9
Warehouse clerks & labourers	5/14	0.4	0-1.0	5/28	0.5	0.1-1.1
Delivery personnel, unmotorized	8/30	0.5	0-1.3	8/34	0.6	0.2-1.4
Firefighters*	2/3	1.1	0.1-7.1	2/5	1.1	0.1-7.3
Guards, police	2/8	0.6	0.1-3.5	2/12	3.1	0.2-47.5
Armed forces personnel, nec*	10/37	0.7	0.3-1.6	10/37	0.7	0.3-1.6
Janitors	2/13	0.6	0.1-3.1	2/8	1.0	0.1-5.7
Housekeepers*	1/12	0.6	0-9.1	1/11	0.6	0-9.5
Handymen & apartment caretakers	2/15	0.4	0-1.9	0/5	0	0-3.9
Sundry personnel	1/4	1.0	0-10.8	0/4	0	0-7.9
Hairdressers, barbers**	0/1	0	0-19.8			
Textile workers*	0/3	0	0-12.8			
Shoe & leather workers	0/6	0	0-3.2			
Cooks	4/11	1.2	0.3-4.6	3/9	1.1	0.2-4.8
Food service personnel	4/22	0.7	0.2-2.3	4/18	0.9	0.2-3.0
Food processors	4/21	1.0	0.4-2.7	4/21	1.0	0.4-2.7
Farmers & farm labourers	19/43	1.4	0.6-3.0	18/42	1.3	0.6-2.8
Fishermen*	2/4	1.5	0.1-11.4	2/3	2.3	0.2-22.1
Forestry & logging workers*	4/13	0.6	0.2-2.8	4/12	0.9	0.2-3.3
Sawmill workers**	9/21	0.9	0.3-2.3	7/20	0.8	0.3-2.1
Pulp and paper mill workers**	1/3	0.6	0-8.2	1/3	0.6	0-8.2
Smelter and foundry workers**	6/8	2.0	0.5-7.2	6/7	2.7	0.7-10.6
Chemical & petroleum workers*	6/8	2.4	0.6-9.0	6/7	2.7	0.7-10.4
Carpenters & wood workers, nec*	8/27	0.8	0.3-1.9	7/25	0.7	0.3-1.98
Heavy equipment operators**	5/7	2.5	0.6-10.5	5/7	2.5	0.6-10.5
Motor vehicle operators	15/28	1.2	0.6-3.9	13/24	1.9	0.8-4.4
Pilots, aircraft crew**	0/7	0	0-1.3			
Railway transport workers, nec*	1/8	0.4	0-3.4	1/7	0.5	0-3.9
Ship transport workers, nec*	8/12	2.1	0.7-6.2	8/12	2.1	0.7-6.2
Service station attendants & mngrs**	7/10	1.1	0.4-3.0	7/15	1.4	0.4-4.2
Small equipment repairers*	6/10	1.9	0.5-6.5	3/9	1.1	0.2-4.7

* Adjusted for sex and age (in 3 strata: <60, 60-69, and ≥70 years)
** All exposed cases and controls were male
* All exposed cases and controls were female
– No cases, no further analyses done; nec, not elsewhere classified

TABLE III

Odds Ratios Showing Associations Between Specific Exposure Agents or Processes and Pleural Mesothelioma, All Cases (n = 51) and Controls (n = 154) Included

	Ever Employed			Most Recent 20 Years Removed		
	Number of Cases/ Controls	Odds Ratio Ever Employed	95% Confidence Interval	Number of Cases/ Controls	Odds Ratio Ever Employed	Confidence Interval
Exposure Agents						
Asbestos	30/25	9.3	4.0-23.8	30/23	10.8	4.4-28.6
Processes						
Ship building, repair or demolition	10/11	7.1	2.8-19.2	10/8	9.9	3.5-31.6
Installing insulation	10/7	5.8	1.9-19.4	10/7	5.2	1.7-16.4
Plumbing, pipefitting, or heating repair	16/12	9.6	3.8-12.2	14/7	7.0	2.4-23.0
Furnace or boiler installation or repair	13/11	4.5	1.6-13.0	13/11	4.5	1.6-13.0
Building demolition or renovation	13/17	2.4	0.9-6.1	12/13	2.8	1.1-7.9
Brake lining installation or repair	2/17	0.3	0-1.4	2/17	0.3	0-1.4

TABLE IV

Odds Ratios Showing Associations Between Selected Occupational Groups and Pleural Mesothelioma, Cases and Controls Removed if Individual Ever Held Certain At-Risk Occupations or Performed Certain At-Risk Processes*

(Remaining Cases n = 19; Remaining Controls n = 128)

	Ever Employed			Most Recent 20 Years Removed		
	Number of Cases/ Controls	Odds Ratio Ever Employed	95% Confidence Interval	Number of Cases/ Controls	Odds Ratio Ever Employed	Confidence Interval
Occupational groups with OR >3						
Gardeners**	2/2	11.5	0.7-203	2/2	11.5	0.7-203
Miners, drillers, & blasters**	3/5	9.6	1.8-53.0	3/5	9.6	1.8-53.0
Industrial mechanics**	2/3	6.2	0.5-66.4	2/3	6.2	0.5-66.4
Painters	2/3	5.5	0.4-52.8	2/2	10.2	0.7-154
Bricklayers, plasterers & cement workers**	4/6	5.4	1.0-27.5	4/5	6.8	1.2-38.6
Chemical & petroleum workers**	2/3	5.3	0.4-55.0	2/4	6.1	0.5-71.2
A *priori* suspect occupational groups						
Construction labourers**	5/15	2.8	0.7-10.6	5/14	2.9	0.7-11.3
Construction foremen**	2/6	1.8	0.2-12.4	1/5	1.0	0-10.8
Machinists**	1/6	1.3	0-12.1	1/5	1.8	0-19.2
Vehicle mechanics**	1/15	0.4	0-3.2	1/15	0.4	0-3.2
Welders**	0/1	0	0-4.9	—	—	—
Transport engineers & firemen**	0/1	0	0-4.9	—	—	—
Stationary engineers, boilermakers**	0/2	0	0-3.5	—	—	—
Electricians & electrical equipment installers**	0/8	0	0-5.3	—	—	—

* Excluded occupations were sheet metal workers, plumbers and pipefitters, and shipbuilding workers; excluded processes were furnace or boiler installation or repair, plumbing, pipefitting or heating repair, and shipbuilding, repair or demolition.
** All exposed cases and controls were male.
— No cases, no further analyses done.

exposure; shipbuilding, repair or demolition; installing insulation; plumbing, pipefitting or heating repair; furnace or boiler installation or repair; and building demolition or renovation. In most cases, point estimates of risk were higher with increased duration of exposure and with the 20-year latency period taken into account. As with vehicle mechanics in the occupational analysis, a history of brake lining installation or repair had a risk estimate below 1.0.

Occupational and process associations, *a priori* at-risk groups removed

To determine whether there were asbestos-exposed occupational groups that were not detected in the first analysis because of the strong association between mesothelioma and certain occupations, a reanalysis was conducted after eliminating case and control subjects who had been in occupational groups or performed processes considered *a priori* to be strongly at risk and confirmed in the first analysis. Individuals ever employed as sheet metal workers, plumbers and pipefitters, or shipbuilding workers were excluded, as were those who performed related processes (furnace or boiler installation or repair; plumbing, pipefitting or heating repair; and shipbuilding, repair or demolition).

Two of the occupational groups with strongly elevated ORs in the first analysis – welders, and electricians and electrical equipment installers – had no cases left once the three occupational groups and the

comparable processes were removed. The ORs of two others were considerably reduced: construction foremen and machinists (Table IV). This suggests that these jobs had elevated risks by virtue of asbestos exposure in the processes that were eliminated for this analysis.

Six occupational groups that had elevated ORs in the initial analysis were found to have increased risk estimates, indicating potential for exposures independent of the eliminated jobs or processes: gardeners; miners, drillers and blasters; industrial mechanics; painters; bricklayers, plasterers and cement workers; and chemical and petroleum workers (Table IV). Among the remaining occupations considered at risk *a priori*, the ORs for construction labourers had increased to nearly 3.0; vehicle mechanics continued to have a relative risk estimate below 1.0, and no cases remained for transport or stationary engineers.

Of the occupations of interest, only in three—the miners, bricklayers, and construction labourers—were there more than three cases remaining in this analysis. Some of the case subjects in these jobs recalled asbestos exposures. In the miners group, none mined asbestos. However, one miner's next-of-kin suggested that there may have been asbestos in the ores a mine assayer remembered using asbestos cloth in the lab; and another miner said the pipes in the mine were lagged with asbestos. In the bricklayers group, a next-of-kin thought the subject may have used asbestos when laying fireplace bricks. Two individuals from this group were bricklayers, the other two were concrete mixers, and all were exposed to cement aggregate (compared with four controls). Although they did not recall exposure, three of the construction labourers worked in jobs that may have entailed asbestos exposure: building demolition, and sewer and water main construction (compared with no controls). The cases in these three occupational groups overlapped: all of the bricklayers group and three of the construction labourers were in the miners group.

A reanalysis was also done for asbestos exposure and specific processes. No case subjects remained who had installed insulation at work, suggesting that the insulation work at risk was included in the processes or occupations that had been eliminated from this analysis. Occupational building demolition or renovation had an increased risk (OR = 2.8, 95% confidence interval [CI]: 0.6-11.9) compared with the first analysis and with the 20-year latency taken into account, the estimate was 4.6 (95% CI: 0.9-22.1). As in the previous analysis, brake installation and repair did not appear to be associated with mesothelioma.

DISCUSSION

Many of the jobs associated with mesothelioma in this study have been identified previously in the scientific literature: shipbuilders;[9,12] sheet metal workers;[10,13] insulation workers;[14,15] heating tradespeople, including boiler and furnace installation, and plumbing and heating;[11,13,15] and construction workers, including electricians, bricklayers, painters, welders, and building demolition workers.[11-13,15,16] One painter in this study had direct asbestos exposure through sanding of asbestos-containing autobody filler; vehicle body workers have recently been shown elsewhere to be at risk.[13] Forty-four (86%) of the case subjects had held jobs in these categories.

None of the case subjects in this study was an asbestos lagger, although some had performed asbestos insulation work as part of their jobs as pipefitters or sheetmetal workers. The burden of asbestos disease in British Columbia may be shifting from the insulators themselves to other tradespeople.

Several occupations that have never or rarely been associated with mesothelioma were detected in the reanalysis with high risk groups removed: gardeners, non-asbestos miners, and chemical and petroleum workers. One previous study found associations with horticultural work,[1] and an Ontario study recently found elevated risks of mesothelioma among refinery workers.[17] There do not appear to have been reports of mesothelioma in miners other than asbestos miners. Except for the miners, none of these occupations showed common patterns of duties in three or more workers, and for some of the cases, alternative sources of asbestos exposure were reported in the interview. The jobs held by the gardener cases in this study (a horticulturist and a garden digger) did not suggest common activities or exposure, except possibly soil constituents. The chemical and petroleum workers both worked in the gas and oil industry, one as a safety man, the other in an unknown occupation (next-of-kin interviewee).

The small size of this study means that risk estimates were imprecise for some of the occupational groups. In addition, grouping of occupations was likely to result in non-differential misclassification, usually biasing risk estimates to the null value. Despite these potential problems, the major occupations at risk for mesothelioma were easily detected in this study. Accruing cases over additional years would allow more specific occupational groups to be separately analyzed, and would determine whether any less prevalent occupations with elevated risks had been missed by this study.

About one-third of case interviews and one-seventh of control interviews were with next-of-kin. Exposure data and dates were less well known by these interviewees. In addition, on average, about 19% fewer jobs were recalled by next-of-kin interviewees than by the subjects themselves. A review of the next-of-kin interviews suggests that missing information tended to be from early in the life of the subject. Relative risk estimates for such jobs and exposures would be expected to be biased downward whenever there was a smaller proportion of next-of-kin interviews among controls.

Biased recall of asbestos exposure was a potential problem, because many physicians know the association between asbestos and mesothelioma. Two mesothelioma case subjects in this study indicated that their physician had told them asbestos caused their disease, even though they felt their exposure had been trivial. A similar bias may occur if physicians were more likely to diagnose mesothelioma in patients reporting asbestos exposure.

Mesothelioma is a rare cancer with one major etiologic exposure, therefore surveillance using each case as a sentinel event might seem more reasonable for this disease than for cancers with multifactorial causation. However, control comparisons

are still useful to help distinguish which of multiple occupations provide exposures important to the etiology of the case. In addition, many individuals may not recall asbestos exposure; comparisons with control groups are useful to help locate sources of exposure. Twenty-one mesothelioma case subjects in this study did not recall occupational asbestos exposure; 14 of these had held jobs identified in the case-control analyses as having high relative risks.

Most of the mesothelioma cases in this study were explainable by sources of asbestos exposure well known in the literature; ship building, repair, or demolition; installing insulation; plumbing, pipefitting, or heating repair; and construction work, including bricklaying, plastering, painting, welding, and electrical work. These occupations are also recognized by local regulatory authorities as involving asbestos exposure. Several occupations and exposure scenarios were identified that had not previously been linked to mesothelioma. All except non-asbestos mining involved small numbers, therefore judgements about whether these associations were causal would be speculative.

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