Original article

Scand J Work Environ Health 2004;30(1):64–70

Cancer mortality and morbidity among Lithuanian asbestos-cement producing workers

by Giedre Smailyte, MSc,[1] Juozas Kurtinaitis, PhD,[1] Aage Andersen[2]

Smailyte G, Kurtinaitis J, Andersen A. Cancer mortality and morbidity among Lithuanian asbestos-cement producing workers. *Scand J Work Environ Health* 2004:30(1):64–70.

Objectives This study investigated the incidence of cancer and cause-specific mortality among workers in the two Lithuanian asbestos-cement factories.

Methods The study included 1887 asbestos-cement workers, 1285 men and 602 women, and 37 000 person-years. The two factories were active from 1956 (A) and 1963 (B), and the workers were observed from 1978 to 2000. The analysis was based on a comparison between the observed and expected numbers of cancer and causes of death. The observed numbers of cancer were obtained through linkage with the national cancer registry. The date and causes of death were obtained from two different sources. The expected numbers were calculated on the basis of gender- and age-specific incidence and mortality rates in 5-year periods from the whole country. Standardized incidence ratios (SIR) and standardized mortality ratios (SMR) and 95% confidence intervals (95% CI) were calculated. Duration of employment and time since first exposure were used as indicators of exposure.

Results During the follow-up, 1978–2000, 473 deaths were observed versus 489 expected. There was no excess risk of deaths from nonmalignant respiratory diseases, except for an elevated risk of mortality in relation to the digestive organs other than cancer, 18 observed versus 12.2 expected (95% CI 0.9–2.3). There was no excess risk for any types of cancer, except for colorectal cancer in men, 17 observed cases (SIR 1.6, 95% CI 1.6–2.6) and one case of mesothelioma in a woman.

Conclusions This study on asbestos-exposed workers did not show any excess risk of respiratory cancer or deaths of pneumoconiosis.

Key terms asbestos-cement workers, cancer incidence, chrysotile, mortality.

The potential ill-health effects of exposure to asbestos have been recognized for many years, and irrefutable evidence is found for human cancer of the lung and pleura (1–3). A mortality study from Wales found no excess risk of respiratory cancer death among asbestos-cement workers employed after 1936 (4). Also from other countries, like Sweden, England, Austria, and Belgium, no elevated risk of mesothelioma or lung cancer has been reported (5–8), and some studies have even indicated a lower mortality from lung cancer in the asbestos-cement industry than in other industries in which asbestos has been handled (9). A possible explanation of these results could be the predominant use of the chrysotile type of asbestos in production. However, in other studies excess mortality due to respiratory cancer and pleural neoplasms has indeed been found among asbestos-cement workers mainly exposed to chrysotile fibers (10–12).

There have been indicators of increased risk of other cancers as well, including larynx cancer (13,14) and gastrointestinal cancers (6–8). The proportion attributed to asbestos exposure is probably lower, and the evidence for a causal association is not strong. Diverging opinions on this relationship have therefore been reported (15,16).

The question of whether different fiber types possess different carcinogenic potential remains largely unanswered and controversial, as the mixed nature of most fiber exposures makes the interpretation more complicated. The worldwide consumption and production of asbestos peaked in 1978–1979 (17). In Lithuania, however, asbestos use on industrial sites continued at very high levels until 1990. There are two factories that have manufactured asbestos-cement pipes and plates in this country. In both plants only chrysotile asbestos was used, and the asbestos came from mines in the Ural area

1 Lithuanian Cancer Registry, Oncology Institute of Vilnius University, Lithuania.
2 The Cancer Registry of Norway, Montebello, Oslo, Norway.

Reprint requests to: Giedre Smailyte, Lithuanian Cancer Registry, Polocko 2, Vilnius, Lithuania, 2007. [E-mail: giedresm@one.lt]

of Russia and Kazakhstan. The content of tremolite fibers in Russian asbestos is much lower than in Canadian chrysotile (18), and a Swedish study (5) concluded that a relatively low risk of lung cancer was seen when only chrysotile was used in production.

We undertook our study to investigate the incidence of cancer and mortality among workers at the two asbestos-cement factories in Lithuania. This is the first study on workers exposed to asbestos in asbestos-cement production through a period of almost 50 years in Lithuania. It was also aimed at estimating the risk by duration of employment as an exposure surrogate and by period of employment and time since first exposure. We also widened the scope to provide further information on cancer risk associated with chrysotile asbestos only.

Material and methods

Description of the factories

There are two asbestos-cement factories in Lithuania, situated in the northwestern part of the country. The Daugeliai Building Products Factory had used asbestos from 1956 for producing asbestos-cement plates (factory A). The Akmene Cement Factory (factory B) had produced asbestos-cement plates and pipes since 1963. Two production lines, one for pipes and one for plates, were located in one building and in the same hall. Both factories ran a wet type of process, and the products contained about 15% asbestos by weight. The main asbestos emissions occurred when asbestos was added to the cement-water mix and during the preparation of the final products. The asbestos was delivered in sacks, which were manually opened before the content was dumped into the mill. There has been no essential change in the process during the history of the two factories.

Altogether, almost 600 000 tonnes of raw asbestos were used from 1956 to 2000 with a maximum of 20 000 tonnes per year in the period 1986–1990. The asbestos consumption in both factories remained at the same level up to 1990, when it started to decline. The use of asbestos stopped in 1997 in factory A and in 2000 in factory B.

Exposure

The exposure data from the two plants are scanty, and from factory A no exposure data were available. For factory B data on annual dust mass measurements exist for each year from 1975 to 1993, and, for a more recent period, 1996–1998, measurements on fibers (f) per milliliter are available. In the period 1975–1989, the time-weighted average measurements of chrysotile asbestos and total asbestos-cement dust varied from 1.9 to 4.0 mg/m^3, and in 1990–1993 the corresponding value was 1.2–2.2 mg/m^3. In 1996–1998 the fiber concentration showed the highest levels for workers who fed the mill with asbestos from sacks and for those involved in sawing the end products. The exposure level for these two groups was 0.5–1.0 f/ml, while most of the other workers were exposed to 0.1–0.5 f/ml. The preparation and handling of the asbestos-cement products were similar during the whole production period, but some improvement in the ventilation was made. Respirators had been recommended since 1970, and they became mandatory in the last decade.

Study cohort

A cohort of all male and female workers from the two asbestos-cement factories was established with identification of production and maintenance workers, laboratory workers who examined the end products, and technologists. For all the workers, we received the following information: name, date of birth, department (factory B), and the beginning and ending dates of all employments, even for those who had been employed more than once. Six workers had worked in both factories, and for them we used total employment data from both factories. Included in the study were all the workers employed 3 months or more before 1986, from 1956 in factory A and from 1963 in factory B. The year 1985 was chosen as the last year for entry because asbestos-related cancers have a long induction period, seldom less than 15 years. The study was confined to workers alive at the beginning of the follow-up period on 1 January 1978. We received information on 2787 workers, 1972 men and 815 women (table 1), but only 1887 workers met the criteria for inclusion in the study and contributed with 36 703 person-years. Excluded from the study were 18% because of first entry after 1985, and another 9% were excluded because of the total employment time was less than 3 months. Ninety-nine persons (3.6%) of the workforce were lost to follow-up before 1978 and were also excluded from the study.

Methods

The study population was followed for cancer incidence, date of emigration, and date of death from the beginning of 1978 to the end of 2000 in the local migration office and in the Bureau of Addresses of the Central Population Register. Members of the study not identified from these two sources were traced through the Registry Department of the Lithuanian National History Archive for date of death.

The cancer cases in the cohort were identified in the Lithuanian Cancer Register through linkage procedures by name and date of birth. In Lithuania, the registration of cancer incidence is based on compulsory reporting

Table 1. Description of the cohort from two Lithuanian asbestos-cement factories.

Status	Factory A		Factory B		Total					
	Men (N)	Women (N)	Men (N)	Women (N)	Men		Women		Total	
					N	%	N	%	N	%
Factory workers	628	296	1344	519	1972	100	815	100	2787	100 [a]
Excluded from the study										
Employed less than 3 months	13	2	187	46	200	10.1	48	5.9	248	8.9
First entry after 1985	93	61	290	58	383	19.4	119	14.6	502	18.0
Dead before 1978	18	5	18	2	36	1.8	7	0.9	43	1.5
Emigrated before 1978	1	0	5	2	6	0.3	2	0.2	8	0.3
Lost to follow-up before 1978	13	18	49	19	62	3.1	37	4.5	99	3.6
Included in the study	490	210	795	392	1285	65.2	602	73.9	1887	67.7

[a] Six workers who worked in both factories have been included in the number of factory B workers.

of all new cancer cases from all hospitals. The data were available in a computerized database from 1978 on. The cancer diagnoses and causes of death were coded according to the 9th revision of the International Classification of diseases (ICD-9). Five cancer cases diagnosed before 1978 were not included among the observed cases.

Copies of death certificates were obtained from the Archive Department of the local municipality and the Registry Department of the Lithuanian National History Archive and coded at the Cancer Registry. Between 1978 and 1993, the causes of death in Lithuania were coded according to the Soviet modification of the ICD-9 and the conventional ICD-9 for 1994–1996. From 1997 on, the causes of death were registered with ICD-10 codes and recoded to ICD-9 codes. The cancer deaths in the cohort were compared with the cancer incidence data. For two workers the cancer diagnoses on the death certificates were the only information, and the one case of lung cancer and one case of colon cancer were not added to the cancer incidence data.

The study was based on a comparison of observed and expected numbers of cancers and deaths. Standardized incidence ratios (SIR) and standardized mortality ratios (SMR) were calculated by the person-years method, STATA (19), with expected numbers of cancer cases and deaths based on gender-specific rates in 5-year age groups and 5-year observation periods for the total Lithuanian population. The follow-up started after 3 months of total employment for those with first entry after 1 January 1978. Workers who died or emigrated were followed until the time of these events, while all others were followed to the end of 2000. For six workers lost to follow-up after 1978, person-years were calculated up to the end of employment at the factory. For all SIR values and SMR values, 95% confidence intervals (95% CI) were calculated on the assumption of a Poisson distribution for the observed number of cancer cases. If the observed number was zero, we have given the expected number in brackets in the table.

Results

During the 23 years of follow-up, 473 deaths were observed versus 489 expected (table 2). For the men, a low risk of mortality of nonmalignant respiratory diseases was observed (SMR 0.6, 95% CI 0.4–1.0). Accidents and violence among the men caused 75 deaths versus 81.3 expected (SMR 0.9, 95% CI 0.7–1.1). The mortality rates for this cause of death were much higher for the men than the women, but the results are close to the expected values from the general population. In addition, a nonsignificantly elevated risk of mortality of nonmalignant diseases in the digestive organs was found for the men, 18 observed versus 12.2 expected (SMR 1.5, 95% CI 0.9–2.3). This finding was mainly due to a significant increase in mortality from cirrhosis of the liver (SMR 2.0, 95% CI 1.1–3.6), based on 11 observed cases. No excess mortality was observed for other causes of death. No death of pneumoconiosis was identified.

There was no increased incidence for all cancers combined, 170 cases observed and 171 expected (table 3). No case of mesothelioma was found among the men, and only one had occurred among the women. The latter was found in a 66-year-old woman with 14 years since first employment in asbestos-cement plate production. Furthermore, our study showed 29 observed cases of lung cancer versus 31.1 expected (SIR 0.9, 95% CI 0.7–1.3) for the men, and 7 observed cases of laryngeal cancer (SIR 1.4, 95% CI 0.7–2.9). However, a significant excess risk was observed for cancer in the large intestine among the men (SIR 1.6 based on 17 cancer cases, 95% CI 1.0–2.6).

Table 4 shows the observed numbers of selected types of cancer by duration of employment and latency period. For lung cancer there was an excess risk for those with the shortest duration of employment (SIR 1.5, 95% CI 0.7–2.6) and no increasing trend in risk by duration of employment or latency periods. For laryngeal cancer no case was observed the first 14 years or among those with less than 1 year of total employment. The risk

Table 2. Observed number of deaths and standardized mortality ratios (SMR) for the Lithuanian asbestos-cement workers during the follow-up period, 1978–2000. (95% CI = 95% confidence interval)

Cause of death [a]	Men			Women		
	Observed	SMR	95% CI	Observed [b]	SMR	95% CI
All causes (001–999)	391	1.0	0.9–1.1	82	1.0	0.8–1.3
Infectious diseases (001–139)	7	0.9	0.4–1.8	[0.9]	..	..
Malignant neoplasms (140–208)	91	1.0	0.8–1.3	27	1.1	0.8–1.6
Circulatory diseases (390–459)	175	1.0	0.9–1.2	37	1.0	0.7–1.4
Respiratory diseases (460–519)	14	0.6	0.4–1.0	[2.7]	..	..
Diseases of the digestive system (520–579)	18	1.5	0.9–2.3	4	1.3	0.5–3.3
Cirrhosis of liver (571)	11	2.0	1.1–3.6	2	1.5	0.4–6.0
Diseases of the genitourinary system (580–629)	3	0.6	0.2–1.8	1	0.7	0.1–4.8
Accidents and violence (800–999)	75	0.9	0.7–1.1	8	0.9	0.5–1.8
Other causes of deaths	8 [c]	0.5	0.2–0.9	5	0.9	0.4–2.3

[a] Code of the 9th revision of the International Classification of Diseases in parentheses.
[b] Expected numbers in brackets when no case was observed.
[c] Three unknown causes of death.

Table 3. Observed number of new cancer cases and the standardized incidence ratios (SIR) for the asbestos-cement workers during the follow-up period, 1978–2000. (95% CI = 95% confidence interval)

Cancer site [a]	Men			Women		
	Observed [b]	SIR	95% CI	Observed	SIR	95% CI
All malignant neoplasms (140–208)	122	1.0	0.8–1.2	48	1.0	0.7–1.3
Stomach (151)	14	0.9	0.5–1.5	4	1.2	0.4–3.2
Colon and rectum (153, 154)	17	1.6	1.0–2.6	3	0.8	0.1–1.8
Lung (162)	29	0.9	0.7–1.3	1	0.7	0.1–4.6
Pleura (163)	[0.3]	..	..	1	20.1	2.9–142.3
Breast (174, 175)	[0.3]	..	..	8	0.8	0.4–1.6
Female genital organs (179–184)	..	..	..	14	1.2	0.7–2.0
Alcohol-related cancers [c]	14	1.0	0.6–1.7	1	1.1	0.2–5.9
Other types of cancer	48	0.9	0.7–1.2	16	0.8	0.5–1.3

[a] Code of the 9th revision of the International Classification of Diseases in parentheses.
[b] Expected numbers in brackets when no case was observed.
[c] Includes cancers of tongue, mouth and pharynx (141–149), oesophagus (150), liver (155) and larynx (161).

of laryngeal cancer in the group of workers with more than 10 years of employment was lower (SIR 1.3, 95% CI 0.4–5.7) than in the groups with shorter employment. The highest SIR values for colorectal cancer were found among the workers with the shortest employment time (SIR 2.2, 95% CI 0.8–5.7, based on 4 cases) and among the workers with a duration of employment of more than 10 years (SIR 2.4, 95% CI 1.2–4.7). There was no clear trend by duration of employment or latency periods. For lung cancer, the material was explored by period of first exposure, but no clear risk pattern was found.

Discussion

Our study of asbestos-cement workers from Lithuania did not indicate any work-related excess in the causes of death or incidence of cancer expected from asbestos exposure. Only one case of pleural mesothelioma was found, and, furthermore, the study showed no deaths from pneumoconiosis.

The cohort was small and included 37 000 person-years, and it is therefore difficult to draw firm conclusions. However, the cohort included many long-term workers, as 29% of the cohort had 10 years or more of total employment in an asbestos-cement industry and 96.4% showed completeness in follow up. Individual and reliable exposure measurements were lacking. From one of the factories some exposure data existed from 1975 and thereafter, and we therefore used the number of years of employment as a surrogate measure for cumulative exposure.

Both factories have used chrysotile asbestos only, imported from the Sverdlovsk region of Russia, and the measured airborne dust was low compared with that of other asbestos-cement factories (table 5). However, we assumed that the levels of exposure were somewhat higher in the period before 1990, because the gravimetric dust measurements were shown to be higher than for

Table 4. Observed numbers of selected types of cancer and the standardized incidence ratios (SIR) for the male asbestos-cement workers by duration of employment and time since first exposure. (95% CI = 95% confidence interval)

Type of cancer [a]	Time since first exposure								
	<14 years		15–24 years		>25 years		Total		
	Observed [b]	SIR	Observed [b]	SIR	Observed [b]	SIR	Observed [b]	SIR	95% CI
All sites (140–208)									
<1 years	1	0.3	12	1.4	9	0.9	22	1.0	0.7–1.5
1–4 years	6	1.1	15	0.9	27	1.3	48	1.1	0.8–1.4
5–9 years	4	1.2	12	1.5	8	1.1	24	1.3	0.9–2.0
≥10 years	1	0.7	20	1.3	7	0.3	28	0.7	0.5–1.1
Total	12	0.8	59	1.2	51	0.9	122	1.0	0.8–1.2
Stomach (151)									
<1 years	[0.5]	..	1	0.8	[1.1]	..	1	0.4	0.1–2.6
1–4 years	1	1.2	4	1.6	3	1.3	8	1.4	0.7–2.8
5–9 years	[0.5]	..	1	1.1	1	1.3	2	0.8	0.2–3.3
≥10 years	[0.4]	..	3	1.4	[2.7]	..	3	0.6	0.2–1.9
Total	1	0.5	9	1.3	4	0.6	14	0.9	0.5–1.5
Colon and rectum (153, 154)									
<1 years	[0.2]	..	2	2.8	2	2.2	4	2.2	0.8–5.7
1–4 years	[0.4]	..	[1.4]	..	2	1.2	2	0.5	0.2–2.1
5–9 years	2	7.1	1	1.4	[0.7]	..	3	1.8	0.6–5.6
≥10 years	[0.2]	..	5	4.2	3	1.5	8	2.4	1.2–4.7
Total	2	1.8	8	2.0	7	1.6	17	1.6	1.0–2.6
Larynx (161)									
<1 years	[0.2]	..	[0.4]	..	[0.4]	..	[0.9]	..	..
1–4 years	[0.3]	..	1	1.2	2	2.4	3	1.6	0.5–4.8
5–9 years	[0.1]	..	1	3.3	1	4.2	2	3.0	0.8–12.5
≥10 years	[0.2]	..	2	3.0	[0.7]	..	2	1.3	0.4–5.7
Total	[0.7]	..	4	1.9	3	1.4	7	1.4	0.7–2.9
Lung (162)									
<1 years	1	1.3	4	1.8	3	1.2	8	1.5	0.8–3.0
1–4 years	1	0.7	5	1.1	4	0.7	10	0.9	0.5–1.7
5–9 years	1	1.1	3	1.6	3	1.7	7	1.5	0.7–3.2
≥10 years	[0.7]	..	3	0.8	1	0.2	4	0.4	0.2–1.1
Total	3	0.8	15	1.2	11	0.7	29	0.9	0.7–1.3

[a] Code of the 9th revision of the International Classification of Diseases in parentheses.
[a] Expected numbers in brackets when no case was observed

the period after 1990. But still these concentrations were low compared with the airborne dust levels reported in other studies. In a recent paper from Norway the gravimetric data shoved concentrations of 0.2–22.8 mg/m^3, and the fiber concentrations were estimated to be between 100 and 1900 f/ml in 1964, with less than 5 f/ml for later years (20). In the Norwegian study no case of mesothelioma was found among those with less than 5 years of employment. Nor was any increased risk of malignant mesothelioma found in other studies in which chrysotile asbestos was used in production (4–6). In a study from Canada (21), the asbestos-cement board production workers used chrysotile only, while another group of workers produced pipes with crocidolite in addition to chrysotile. The latter group showed a considerable increase in mesothelioma risk, while no cases of mesothelioma were found among the board production workers. Mesothelioma has mainly been associated with exposure to amphiboles (22). No amphiboles were added to the Lithuanian asbestos-cement production; however, our study is noninformative concerning asbestos exposure and mesothelioma risk, with one observed case and 0.3 expected.

We found no excess risk of lung cancer, and no clearer picture emerged when the data were tabulated according period of employment or number of years since first exposure. The use of national cancer incidence rates as reference may be inappropriate and may have biased the estimates. The lung cancer incidence rates for the districts in which the factories are located averaged 120% of the national rates in 1993–1997. The low risk of lung cancer for asbestos cement workers

Table 5. Results of cohort studies on asbestos-exposed workers the asbestos-cement industry. (SMR = standardized mortality ratio, SIR = standardized incidence ratio)

Study	Country	Number of subjects	Employment (length)	Follow-up	Lung cancer cases		Mesothelioma cases (N)	Exposure level (fibers/ml)	Type of asbestos used
					Cases	SMR or SIR			
Thomas et al, 1982 (4)	United Kingdom	1592	6 months	1936–1977	30	0.93	2	<2 (after 1972)	Chrysotile
Ohlson & Hogstedt, 1985 (5)	Sweden	1176	3 months	1951–1982	11	1.23	-	2	Chrysotile
Gardner et al, 1986 (6)	England	1510	..	1941–1984	35	0.92	1	<1 (after 1970)	Chrysotile
Lacquet et al, 1980 (8)	Belgium	1963	1 year	1963–1977	22 [a]	1.0	1	0.4–100	90% chrysotile, crocidolite and amosite
Szeszenia-Dabrowska et al, 1997 (24)	Poland	3563	3 months	1945–1991	41	0.97	5	..	85% chrysotile, crocidolite and amosite
Neuberger & Kundi, 1990 (7)	Austria	2816	3 years	1950–1987	49	1.04 [b]	7	..	Chrysotile and crocidolite
Tulchinski et al, 1999 (11)	Israel	3057	1 month	1978–1992	28	1.35	21	0.3–40.0	90% chrysotile and crocidolite
Albin et al, 1990 (10)	Sweden	1929	3 months	1927–1986	35	1.8 [c]	13	0.3–6.3	>95% chrysotile
Raffn et al, 1989 (23)	Denmark	7996	..	1943–1984	162	1.8	10	>2 (in 1973) (41% of samples)	89% chrysotile, crocidolite and amosite
Ulvestad et al, 2002 (20)	Norway	541	1 year	1953–1999	33	3.1	18	<5 (after 1973)	92% chrysotile, crocidolite and amosite
Finkelstein, 1983 (21)	Canada	241	9 years	1960–1980	20	6.1	10 [d]	40 (in 1949) 20 (in 1969)	Chrysotile and crocidolite

[a] Respiratory cancer including mesothelioma.
[b] After adjustment for smoking.
[c] Relative risk.
[d] Including peritoneal mesotheliomas.

seems to be unrelated to this difference. The short-term workers in our study had a higher incidence rate from lung cancer and a higher risk compared with the group of long-term workers. Such patterns have been observed in other studies, and it is probably due to life-style factors with smoking as the strongest candidate. The low lung cancer risk among the workers employed more than 10 years remains unexplained, and an extension of the follow-up time would be of value. The smoking habits of the cohort members were not known. The Norwegian study (20) showed an excess risk of lung cancer, but no trend in risk by duration of employment. This lack of dose–response relationship is in accordance with the results of other Nordic studies from the asbestos-cement industry with duration of exposure as a dose surrogate (20, 23).

The type of fibers may also be relevant for lung cancer, as workers making asbestos-cement products from chrysotile have shown lower rates than those working with other types of asbestos (4–6). Ohlson & Hogstedt (5) postulated that the fiber types used in the factories could also explain the different results in lung cancer risk. In three studies of asbestos-cement workers, in which chrysotile was almost exclusively used (4–6), the combined results of the asbestos-cement workers showed overall 76 deaths from lung cancer compared with 80.2 expected (SMR 0,95, 95% CI 0.8–1.2) (6). The exposure levels reported in these studies on chrysotile-exposed workers were generally lower than in other asbestos-cement studies, with average fiber concentrations of 1 to 2 f/ml (4–6). In the study from Denmark, an increased lung cancer risk was found with fiber concentrations of 10–100 f/ml until 1973, and 41% of the measurements were above 2 f/ml after 1973 (23). Even studies in which chrysotile and amphiboles were used in asbestos-cement production have reported a lack of elevated lung cancer risk (7, 8, 24). In the study from Austria, excess mortality from lung cancer was shown to be related to higher tobacco consumption among the asbestos-cement workers (7). From Poland, where Russian chrysotile was used, an absence of lung cancer risk was reported in a study from four asbestos-cement factories (24).

The amount and type of asbestos fibers have been determined from lung tissue samples of workers at the largest asbestos mine in the world, at Asbest in Russia. In workers exposed to Russian chrysotile, there was less than 10% tremolite, while 50% tremolite was found in a Canadian study of tissue samples (18). In addition, the tremolite fibers from the Russian samples were much thicker than the chrysotile fibers from Canada. It may also be of importance that most chrysotile fibers are cleared from the lungs within weeks or months. This type of chrysotile seems to be less carcinogenic than other types of asbestos fibers.

In our study, the standardized incidence ratio of colorectal cancer was elevated, but there was no clear trend by latency period (table 4). Some epidemiologic studies have also shown an excess of gastrointestinal carcinomas among asbestos-exposed workers, especially

of colorectal cancers (10, 25, 26). However, the association between asbestos exposure and gastrointestinal cancer is not definite. In our study no association with duration of employment and time since first exposure was found.

In Lithuania asbestosis is not registered as a separate disease; instead it is included in the group of pneumoconioses. The registered number of deaths from pneumoconiosis is less than 10 per year; however, the underreporting of pneumoconiosis (asbestosis) as a cause of death in Lithuania may not contribute to the study results.

Our study did not show any excess risk of respiratory cancer or death of pneumoconiosis, and for total mortality the results were at the same level as for the total population. The low incidence rates of lung cancer in our study are somewhat remarkable. This type of chrysotile without any amphiboles and a small amount of tremolite is possibly less carcinogenic than other types of asbestos. Relatively low exposure levels at both factories and the use of chrysotile asbestos only were possible explanations of the nonpositive outcome.

Acknowledgments

We would like to thank the administration of the factories in Akmene and Daugeliai and the staffs of the local migration offices for all their practical help with the construction of the cohort and the identification of the study cohort. We also thank the Thoracic Department of the Oncology Institute for the validation of the diagnosis of mesothelioma.

References

1. Selikoff IJ, Chung J, Hammond EC. Asbestos exposure and neoplasia. J Am Med Assoc 1964;188: 22–6.
2. Wagner JC, Sleggs CA, Marchand P. Diffuse pleural mesothelioma and the asbestos exposure in the North Western Cape Province. Br J Ind Med 1960;17:260–71.
3. Doll R. Mortality from lung cancer in asbestos workers. Br J Ind Med 1955;12:81–6.
4. Thomas HF, Benjamin IT, Elwood PC, Sweetnaam PM. Further follow-up study of workers from an asbestos cement factory. Br J Ind Med 1982;39:273–6.
5. Ohlson CG, Hogstedt C. Lung cancer among asbestos cement workers: a Swedish cohort study and a review. Br J Ind Med 1985;42:397–402.
6. Gardner MJ, Winter PD, Pannett B, Powell CA. Follow up study of workers manufacturing chrysotile asbestos cement products. Br J Ind Med 1986;43:726–32.
7. Neuberger M, Kundi M. Individual asbestos exposure: smoking and mortality—a cohort study in the asbestos cement industry. Br J Ind Med 1990;47:615–20.
8. Lacquet LM, Van der Linden L, Lepoutre J. Roentgenographic lung changes, asbestosis and mortality in a Belgian asbestos-cement factory. In: Wagner JC, editor. Biological effects of mineral fibres. Lyon: International Agency for Research on Cancer, 1980. Scientific publication no 30.
9. Advisory Committee on Asbestos. Health and Safety Commission, volume 1. London: Her Majesty's Stationery Office, 1979. Final report.
10. Albin M, Jakobsson K, Attewell R, Johansson L, Welinder H. Mortality and cancer morbidity in cohorts of asbestos cement workers and referents. Br J Ind Med 1990;47:602–10.
11. Tulchinsky TH, Ginsberg GM, Iscovich J, Shihab S, Fischbein A, Richter ED. Cancer in ex-asbestos cement workers in Israel, 1953–1992. Am J Ind Med 1999;35:1–8.
12. Raffn E, Villadsen E, Engholm G, Lynge E. Lung cancer in asbestos cement workers in Denmark. Occup Environ Med 1997;54:143.
13. Chan CK, Gee BL. Asbestos exposure and laryngeal cancer: an analysis of the epidemiologic evidence. J Occup Med 1988;30:23–7.
14. Piolatto G, Negri E, La Vecchia C, Pira E, Decarli A, Peto J. An update of cancer mortality among chrysotile asbestos miners in Balangero, northern Italy. Br J Ind Med 1990; 47:810–4.
15. Brown K, Gee JB. Asbestos exposure and laryngeal cancer. Ann Occup Hyg 2000;44:239–50.
16. Homa DM, Garabrant DH, Gillespie BW. A meta-analysis of colorectal cancer and asbestos exposure. Am J Epidemiol 1994;139:1210–22.
17. Asbestos Institute (Montreal). Favourable growth prospects for asbestos in Asia. Asbestos 1985;1:4–5.
18. Tossavainen A, Kovalevsky E, Vanhala E, Tuomi T. Pulmonary mineral fibers after occupational exposure to asbestos in the Russian chrysotile industry. Am J Ind Med 2000;37:327–33.
19. StataCorp. Stata Statistical Software: release 7.0. College Station (TX): Stata Corporation, 2001.
20. Ulvestad B, Kjærheim K, Martinsen JI, Damberg G, Wannag A, Mowe G, et al. Cancer incidence among workers in the asbestos-cement producing industry in Norway. Scand J Work Environ Health 2002;28(6):411–7.
21. Finkelstein MM. Mortality among long-term employees of an Ontario asbestos-cement factory. Br J Ind Med 1983; 40:138–40.
22. Britton M. The epidemiology of mesothelioma. Semin Oncol 2002;29:18–25.
23. Raffn E, Lynge E, Juel K, Kongsgaard B. Incidence of cancer and mortality among employees in the asbestos cement industry in Denmark. Br J Ind Med 1989;45:283–91.
24. Szeszenia-Dabrowska N, Wilczynska U, Szymczak W. Ryzyko choroby nowotworowej w premysle azbestovo-cementowym w Polsce [Cancer risk in asbestos-cement industry workers in Poland]. Med Pr 1997;48:473–83.
25. McDonald JC, Liddell FDK, Gibbs GW, Eyssen GE, McDonald AD. Dust exposure and mortality in chrysotile mining, 1910–75. Br J Ind Med 1980;37:11–24.
26. Enterline PE, Hartley J, Henderson V. Asbestos and cancer: a cohort followed up to death. Br J Ind Med 1987;44:396–401.

Received for publication: 31 December 2002