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Cancer mortality and morbidity among Lithuanian asbestos-cement producing workers

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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.
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 Daugelai 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/m³, and in 1990–1993 the corresponding value was 1.2–2.2 mg/m³.

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...
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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 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

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) | N % | N % | Total |
| Factory workers                | 628       | 296       | 1344   | 519       | 1972 | 100 | 815   | 100 | 2787 | 100 * |
| 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    | 59        | 382  | 19.4| 119   | 14.6| 502  | 18.0  |
| Dead before 1978               | 18        | 5         | 18     | 2         | 38   | 1.9 | 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  |

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

Table 1. Description of the cohort from two Lithuanian asbestos-cement factories.
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 0.8–4.3, 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 | Time since first exposure | Observed | SIR | Observed | SIR | Observed | SIR | Observed | SIR | 95% CI  |
|---------------|--------------------------|---------|-----|---------|-----|---------|-----|---------|-----|---------|
|               | <14 years | 15–24 years | >25 years | Total |
| 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 |

* Code of the 9th revision of the International Classification of Diseases in parentheses.

a Expected numbers in brackets when no case was observed.
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

### 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 | Exposure level fibers/ml | Type of asbestos used |
|-----------------|--------------|--------------------|---------------------|-----------|-------------------|---------------------|------------------------|----------------------|
| 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)   | 90% chrysotile, crocidolite and amosite |
| Lacquet et al, 1980 (8) | Belgium      | 1963               | 1 year              | 1963–1977 | 22                | 1.0                 | 1 0.4–100               | Chrysotile            |
| 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                | 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 |
| Albín et al, 1990 (10) | Sweden       | 1929               | 3 months            | 1927–1986 | 35                | 1.8                | 13 0.3–6.3 (41% of samples) | 98% chrysotile |
| Raffn et al, 1989 (23) | Denmark      | 7996               | 1943–1984           | 162       | 1.8               | 10 >2 (in 1973)    | 92% chrysotile, crocidolite and amosite |
| Ulvestad et al, 2002 (20) | Norway       | 541                | 1 year              | 1953–1999 | 33                | 3.1                 | 18 <5 (after 1973)      | Chrysotile and crocidolite |
| Finkelstein, 1983 (21) | Canada       | 241                | 9 years             | 1960–1980 | 20                | 6.1                 | 10 (in 1949) (in 1969) | Chrysotile and crocidolite |

* Respiratory cancer including mesothelioma.
* After adjustment for smoking.
* Relative risk.
* Including peritoneal mesotheliomas.
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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.

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