

TOTAL AND CAUSE-SPECIFIC MORTALITY IN COHORTS OF
ASBESTOS-CEMENT WORKERS AND REFERENTS
BETWEEN 1907 AND 1985

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Total and cause-specific mortality data for the 1907–1985 period were compared between cohorts of male asbestos-cement workers (N=1908) and referents (N=726), using Poisson regression modelling. The rate ratio (RR) for total mortality was significantly increased (1.3) among the exposed workers, as was mortality from non-malignant respiratory disease (RR=2.2). Numerically, but not statistically significantly, raised ratios were found for respiratory (RR=1.6) and gastrointestinal (RR=1.3) cancers. The trend in the rate ratio for total mortality with time was better fitted with a curved line, than with a monotonic one, because of a period of increased risk up to the 1950s, and another one starting after 1970.

The information on dose-response relationships for asbestos-related disease is still insufficient, especially in the low-dose area. Moreover, several studies imply important differences, at the same exposure intensity, between various branches of industry (1). Even within the asbestos-cement industry, striking differences in the slope of the dose-response curve can be found in different plants. The reason for this is still unclear, but the matter is of considerable interest, since this branch currently consumes 70% of the world asbestos production (2) and is still expanding.

For studies in the low-dose area, presumably dealing with small increases of risk, validity in comparison between exposure and non-exposure is vital. Therefore, the general population is probably not an adequate cohort for comparison. Moreover, rates for such a comparison are generally available only for the latest decades, and thereby important information about the mortality experience over time may be lost. This paper presents data on total and cause-specific mortality in the period 1907–1985, comparing cohorts of asbestos-cement workers with industrial workers not exposed to asbestos cement.

Table 1
 Vital status in the asbestos-cement and the referent cohorts as at December 31, 1985

	Asbestos-cement workers												Referents					
	All				Swedish				Non-Swedish				All		Swedish		Non-Swedish	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Alive	1510	52.5	1069	56.0	441	45.7	592	65.9	494	68.0	98	56.6						
Dead	857	29.8	801*	42.0	56	5.8	248	27.6	226**	31.4	20	11.6						
Emigrated	256	8.9	10	0.5	246	25.5	44	4.9	2	0.3	42	24.3						
Untraced	251	8.7	28	1.5	223	23.1	15	1.7	2	0.3	13	7.5						
Total	2874	100.0	1908	96.6	100.0	899	100.0	726	100.0	173	100.0	100.0						

* Only 800 deaths were included in the comparison between the cohorts because of missing information for one person.

** Only 227 deaths were included in the comparison between the cohorts because of missing information for one person.

SUBJECTS AND METHODS

Exposed cohort

The plant produced asbestos-cement products from 1907 to 1977. Asbestos use and dust levels are discussed elsewhere (3). Lists were made, including all employees registered in the company personnel records between 1907 and 1977. Male workers employed for at least three months were included in the cohort (2,874 persons). Individual dose estimates were calculated for two thirds of the cohort, the median intensity was around 1 f/ml. Vital status was determined on December 31, 1985 (Table 1). Death certificates were obtained and recoded according to ICD-8 by the National Swedish Central Bureau of Statistics, which is responsible for the coding of all Swedish death certificates.

Referent cohort

A referent cohort was formed by combining four different subcohorts (altogether 899 persons) of industrial workers (fertilizer production, slaughter-house, wool and polyester textile, and metal industries), fulfilling the same requirements as the asbestos-cement cohort, but without known exposure to asbestos-cement dust. Vital status was established and death certificates coded in the same way as for the exposed cohort.

Statistical analysis

The asbestos-cement workers were born slightly earlier than the referents (medians 1923 vs 1926, Table 2) and had a shorter median duration of employment (medians 1.1 vs 2.4). There was a substantially higher proportion of immigrant workers in the asbestos-cement cohort than in the referent one (34 vs 19%). The immigrant workers were also lost to follow-up to a much higher degree than the Swedish subjects. To improve the validity of comparison, the analysis was therefore restricted to include only Swedish workers (1,908 asbestos-cement workers and 726 controls).

The mortality in the two cohorts was compared with that in the general population in the country, using the annual rates available (1958-1985), grouped in five-year age intervals. A direct comparison between the cohorts of the incidence density (deaths per person-year) over calendar time and age, grouped in five-year intervals, was also performed using Poisson regression modelling (4). The 95% confidence intervals (CI) for the incidence density ratio was then calculated with simultaneous adjustment for possible confounding by age and calendar year. The ratio was also tested for possible trends over time.

RESULTS

Comparison with the general population

Both the exposed and reference cohorts were compared with the mortality in the general population in the country. Annual death rates were available only for the period

Table 2
*Median year of birth, duration and start of employment in the
asbestos-cement and referent cohorts*

	Asbestos- cement workers	Referents				
		All	Fertilizer production	Textile	Slaughter house	Metal
Number	2874	899	309	235	276	79
Year of birth						
Median	1923	1926	1923	1928	1922	1936
Employment duration (y)						
Median	1.1	2.4	2.0	2.1	3.8	1.9
Start year of employment						
Median	1955	1954	1956	1962	1947	1959

1958-1985, and comparison was therefore made only for these years.

The exposed cohort displayed a significantly increased overall, as well as cause-specific, mortality from malignant and other respiratory diseases, gastrointestinal cancers and external causes (Table 3). The referent cohort showed no significant deviation from the general population, but tended to have a lower than expected rate of non-malignant respiratory disease and an increased mortality from external causes. Because of this possible difference in the mortality pattern between industrial workers and the general population and in order to cover the complete mortality experience over time, a direct comparison was performed between the two cohorts.

Comparison between asbestos-cement workers and referents

A total of 800 deaths in the 55,336 person-years under observation occurred in the exposed cohort between 1907 and 1985, as compared to 227 deaths per 20,927 person-years among the referents. Taking into account the differences in age and calendar year of birth between the cohorts, the rate ratio was 1.3 (CI 1.1-1.5). The main excess was until 1954 and after 1970. The risk estimate for the early period is, however, rather uncertain, owing to a low contribution of person-years in this period from the referent cohort. The development of risk ratio over time was fitted to different models, and was significantly better approximated with a curved line, than with a monotonic one, showing first a decrease and then an increase ($p < 0.001$). The rate ratios were 2.6 (1907-1954), 1.1 (1955-1969), and 1.3 (1970-1985).

There was an excess risk of non-malignant respiratory disease (ICD 460-519) up to 1955. Thereafter the risk difference was smaller, but became evident again after 1970. The adjusted overall risk ratio was 2.2 (1.2-4.2), based on 68 deaths among the exposed and 11 among the referents.

Table 3
Total and cause-specific mortality in the asbestos-cement and reference cohorts as compared to the general population in the country in the 1958-85 period

	Asbestos cement workers (36265 person - yrs)				Referents (14710 person - yrs)			
	Observed	Expected	SMR	CI*	Observed	Expected	SMR	CI*
All causes	649	568	1.1	1.1-1.2	202	216	0.0	0.8-1.1
Gastrointestinal cancer	54	38	1.4	1.1-1.9	17	14	1.2	0.7-2.0
Non-malignant respiratory disease	51	34	1.5	1.1-2.0	10	14	0.7	0.3-1.3
Respiratory cancer	45	28	1.6	1.2-2.2	8	9	0.9	0.4-1.7
External causes	70	44	1.6	1.3-2.0	23	17	1.4	0.9-2.1

* 95% confidence interval

Deaths due to respiratory malignancies (lung cancer and mesothelioma; ICD 160–163) occurred in 49 persons in the asbestos-cement cohort and in 10 persons in the referent cohort. A numerical difference appeared after 1970. The rate ratio over the entire 1907–1987 period was 1.6 (0.8–3.3).

A total of 70 deaths due to gastro-intestinal malignancies (ICD 150–154) occurred in the exposed cohort and 19 among the referents, giving an overall rate ratio of 1.4 (0.8–2.3), and an age and calendar-year adjusted one of 1.3 (0.8–2.1).

In these two cohorts, 95 deaths from external causes (violent deaths and intoxications; ICD 800–999) among the exposed and 29 deaths among the referents were found, giving a slightly, but not significantly, raised adjusted rate ratio of 1.3 (0.8–1.9). The ratio was linked with age; the difference between the cohorts was most evident among the young persons, and decreased with age. It was also associated with calendar year, in the same way as the total mortality. As the calculations of the cause-specific mortality, even in the crude groups as given above, suffered from a large random variation, due to fewer observed cases in each cell, an even cruder group of diagnoses was assembled, including malignant and non-malignant respiratory diseases (ICD 160–163 and 460–519) and gastrointestinal cancer (ICD 150–154), i.e. all asbestos-related diseases.

In the exposed cohort, 187 deaths occurred due to these causes and 40 among the referents, giving an adjusted rate ratio of 1.6 (1.2–2.3). The change in risk over time tended to have the same curved shape as the total mortality, but such a model was not significantly better fitted than a straight line.

DISCUSSION AND CONCLUSIONS

In spite of a very low median intensity (approximately 1 f/ml) and duration (1.1 y) of exposure, an increased overall mortality was found in the exposed cohort. This is unusual, even in cohorts with high exposure. Further, the change in mortality over time showed a biphasic pattern, with a raised risk until 1955, then a minimum, and later another rise after 1970.

The astonishing increase in total mortality could only to a minor extent be explained by the use of a relevant reference cohort of other industrial workers, instead of the general population in forming the contrast between exposure and non-exposure. The possibility to explore the total mortality experience before 1950 by use of rates derived from a reference cohort may be more important, since the first phase in the biphasic increase of the total mortality occurred before the period for which rates for several populations are available (before the 1950s).

The results, however, require further analysis, including the use of estimates of individual exposure for dose-response relationships. It might be that the effect is entirely limited to a small fraction of workers, with an exposure far above the medians. The data should also be interpreted with caution, since the dose estimates before 1956 are based not on measurements, but only on the knowledge of the changes in technology of production, and ventilation, over time. The importance of the difference

in mortality between the cohorts should also be evaluated by calculation of loss of expected lifetime.

As this study was based on death certificates over a very long period (1907–1985), only crude groups of diagnoses were used. A significantly increased risk for non-malignant respiratory disease was found, and numerically, but not significantly, increased risks of respiratory and gastrointestinal malignancies. A detailed study of the cancer morbidity is planned to provide more accurate information on the cancer incidence, contrary to cancer deaths, which is important especially in the study of colon cancer.

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Sažetak

UKUPNI I SPECIFIČNI MORTALITET U RADNIKA IZLOŽENIH AZBESTU OD 1907. DO 1985. GODINE

Ukupni i specifični mortalitet za razdoblje od 1907. do 1985. godine uspoređen je u kohortama muških radnika koji su bili izloženi azbestu (N = 1908) s kontrolama (N = 726) pomoću Poissonove regresijske analize. Koeficijent regresije (RR) za ukupni mortalitet, kao i mortalitet od nemalignih respiratornih bolesti bio je statistički značajno viši i iznosio je 1,3, odnosno 2,2. Povećanje ovog koeficijenta nađeno je i za plućni (1,6) i gastrointestinalni karcinom (1,3), ali vrijednosti nisu statistički značajne.

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