

Incidence of cancer in the mineral-wool producing industry in Norway

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ANDERSEN A, LANGMARK F. Incidence of cancer in the mineral-wool producing industry in Norway. *Scand J Work Environ Health* 12 (1986): suppl 1, 72-77. This study concerned the Norwegian phase of a European collaborative investigation on workers in man-made mineral fiber production. A study population of 2 361 men from four Norwegian plants was examined for mortality and cancer incidence, especially lung cancer, based on a comparison of observed and expected figures, the latter determined according to the five-year age-specific mortality and incidence rates for the entire country. Violent deaths among workers with less than one year of employment represented the only significant mortality excess. A borderline, statistically significant excess risk was found for cancer of the buccal cavity and pharynx, but the fact that the excess occurred in one factory only led to the assumption that the risk was associated with factors other than mineral wool. An excess risk for lung cancer was also found among those with 20 years or more since first exposure (9 observed and 4.36 expected). The risk that emerged was presumably initiated before 1960, when the environmental conditions were more hazardous than later.

Key terms: cohort, lung cancer, mortality.

Mineral wool has been produced in Europe since the beginning of this century and in Norway since 1935. At present there are five factories in the country, three producing rock wool and two producing glass wool. The mineral-wool producing industry in Norway makes products only for the national market, and the production is mostly used as insulation material in houses and in the ground. The total production is 50 000 t per year, which represents about 5 % of the total production in Europe. Today a total of 1 000 persons are working in the industry, and the number of workers represents less than 1 % of the total occupational active male population.

Since the beginning of the 1970s various studies with experimental animals have shown that mineral wool causes cancer when glass fiber is injected as presented by Stanton et al (11). In a recent study by Pott et al (8) instillation of fiber into the trachea also showed cancer development. Inhalation, in rats, however, which has been studied by Wagner et al (12), did not show a significant excess risk of cancer.

Several epidemiologic studies have shown an increased risk of lung cancer in the mineral-wool producing industry. In a study by Enterline & Marsh (5) an excess risk of lung cancer was seen among workers with 30 years or more since first employment. Olsen & Møller Jensen (7) have also shown an excess risk of lung can-

cer among workers with 20 years or more since first employment.

Most of the factories in this industry are small with only a few hundred employees. Therefore a broader investigation was undertaken in which most of the European plants were invited to participate. The present investigation started as a European collaborative study involving 13 factories in seven countries, including the four oldest plants in Norway. The study has, since the beginning, been coordinated by the International Agency for Research on Cancer. The first results were presented in 1982 and were published by Sarraci et al in 1984 (9). The study concluded that for all plants combined there was a statistically significant excess of lung cancer for those with 30 years or more since first employment. This report is based on results from the four Norwegian plants which started production between 1935 and 1952.

Subjects and methods

Many years may elapse before an occupational cancer hazard is seen. One man-made mineral-wool producing factory in Norway did not start production until 1964 and was therefore not included. From the four remaining factories we received lists with names of all employees, dates of birth, all periods of employment, as well as work sites within the factory. The data provided a basis for coding each worker's departments and months of employment in these departments. Information concerning previous occupational histories and smoking habits was unfortunately not available in the personnel records at the factories.

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The codes for jobs and departments were given by the Institute of Occupational Medicine in Edinburgh, and the same codes have been used for all the plants in the European study. The levels of airborne fibers from the process operation were estimated by the Edinburgh Institute on the basis of products from the individual factories, and the factories have also completed a questionnaire about production. The results of this part of the investigation have been published separately (3).

The study population in the present investigation was confined to 2 361 men, all with first employment before 1978 and all alive at the beginning of the follow-up period in 1953. From table 1 it is seen that more than 50 % of the employees had a total time of employment of less than one year. The two groups, those with less than one year and those with one year or more of total employment, have been tabulated separately. From the factories we also received information for 208 female employees, most of whom were office workers. These women, due to their small number, were excluded from the analysis. Another 25 male workers were excluded because of missing date of birth or date of first entry into man-made mineral-wool production. In one factory polystyrene was produced, as well as mineral wool. Workers ever employed in polystyrene production were also excluded.

The study population has been followed for mortality and cancer incidence from 1953 to the end of 1983. A person was under follow-up from the beginning of 1953 or, if he was first employed at a later date, from the date of first employment. The Cancer Registry has records of all new cases of cancer in Norway since 1953. The registration is based on compulsory reporting from hospitals and histopathological laboratories, and only less than 1 % of the cases is based on death certificates alone. All death certificates in the country are coded by the Central Bureau of Statistics.

From the census in 1960 a personal identification number has been allocated to all inhabitants in the

country. This number was also used in this study, and the matching of all deaths and the cancer morbidity was thereby fully automated after 1960, but had to be done manually for the preceding years. The information included in all actual records was date of diagnosis, clinical and histological diagnosis, and date and cause of death.

The study was based on a comparison of observed and expected mortality and incidence of cancer for the period 1953—1983. A modified life-table procedure was used to calculate person-years at risk, expected number of deaths, and expected number of cancer cases (4). For the estimation of the expected number of deaths or cancer cases the five-year age-specific mortality and incidence rates for five-year periods, based upon data on the whole country, were used.

Results

The workers from rock-wool plants comprised 77 % of the total material, and workers from the glass-wool factories 23 %. In table 2 the number of observed and expected deaths from all causes and from major forms of causes of death are shown. In the total cohort 286 deaths from all causes occurred during the follow-up period, and the expected number was 277. Among workers with more than one year of total employment

Table 1. Total number of male employees by factory in the mineral-wool producing industry.

Plant and production	Length of employment (years)		Total cohort
	< 1	≥ 1	
Plant 1, rock wool	279	198	477
Plant 2, rock wool	223	233	456
Plant 3, rock wool	486	396	882
Plant 4, glass wool	224	322	546
Total	1 212	1 149	2 361

Table 2. Observed (O) and expected (E) number of deaths by major causes of death — Follow-up 1953—1983. (SMR = standardized mortality ratio)

Cause of death ^a	Length of employment (years)						Total cohort		
	< 1			≥ 1					
	O	E	SMR	O	E	SMR	O	E	SMR
All malignant neoplasms (140—209)	20	16.41	122	51	44.95	113	71	61.36	116
Circulatory system (390—458)	24	33.09	73	93	100.00	93	117	133.09	88
Respiratory system (460—519)	5	3.61	139	10	12.28	81	15	15.89	94
Accidents, poisoning and violence (E800—E999)	23	10.04	229**	14	14.54	96	37	24.58	151*
Other diseases	15	11.48	131	31	31.07	100	46	42.55	108
All causes (000—999)	87	74.63	117	199	202.84	98	286	277.47	103

^a Code of the International Classification of Diseases, eighth revision, in parentheses.

* $p < 0.05$, ** $p < 0.01$.

time, 199 deaths were observed and 203 expected, while, among those with the shortest duration of total employment, there were 87 observed and 75 expected. For accidents, poisoning, and violence (E800—E999) a statistically significant excess was observed for those with the shortest duration of employment (23 observed versus 10 expected). Among those with a longer duration of employment time there was no such excess risk.

The following data are confined to cancer incidence only. During the 31 years of follow-up 113 new cases of cancer (excluding nonmelanoma skin cancer) were observed against the expected number of 106.65. In

table 3 results have been given for selected forms of cancer. A borderline statistically significant excess was seen for cancer of the buccal cavity and pharynx among workers with one year or more of total employment (7 observed and 3.0 expected). The specific sites were three cases on the lip, one case on the tongue, and three cases in the mouth (not presented in the table). In the same subcohort an excess incidence, not statistically significant, was found for cancer of the intestine [standardized incidence ratio (SIR) 151], cancer of the trachea, bronchus and lung (SIR 151), and cancer of the bladder (SIR 146).

Table 3. Observed (O) and expected (E) number of cases of selected forms of cancer among male employees for all factories combined — 1953—1983. (SIR = standardized incidence ratio)

Types of cancer ^a	Length of employment (years)						Total cohort		
	<1			≥1					
	O	E	SIR	O	E	SIR	O	E	SIR
Buccal cavity and pharynx (140—148)	—	1.16	0	7	3.00	233	7	4.16	168
Stomach (151)	2	2.85	70	6	8.45	71	8	11.30	71
Intestine (152—154)	2	3.78	53	15	9.93	151	17	13.71	124
Trachea, bronchus and lung (162—163)	4	4.03	99	16	10.31	151	20	14.34	139
Prostate (177)	6	4.12	146	11	12.35	89	17	16.47	103
Bladder (181)	1	1.89	53	7	4.78	146	8	6.67	120
Other sites	16	12.76	125	20	27.24	73	36	40.00	90
All types (140—205)	31	30.59	101	82	76.06	108	113	106.65	106

^a Code of the International Classification of Diseases, seventh revision, in parentheses.

Table 4. Cancer of the intestine (1953—1983) among employees with one year or more of total employment in the rock-wool and glass-wool industry, by period of first employment and time since first exposure (1953—1983). (O = observed number of cases, E = expected number of cases, SIR = standardized incidence ratio)

Period of first employment	Years since first exposure						Total cohort		
	1—19			≥20					
	O	E	SIR	O	E	SIR	O	E	SIR
<i>Rock-wool production</i>									
Before 1960	3	1.78	169	5	2.90	172	8	4.68	171
1960—1977	5	2.20	227	1	0.26	385	6	2.46	243
<i>Glass-wool production</i>									
Before 1960	—	0.50	0	—	1.07	0	—	1.57	0
1960—1977	1	1.12	89	—	0.10	0	1	1.22	82

Table 5. Observed (O) and expected (E) number of cases of lung cancer, 1953—1983, among employees in each of the four plants. (SIR = standardized incidence ratio)

Plant and production	Length of employment (years)						Total cohort		
	<1			≥1					
	O	E	SIR	O	E	SIR	O	E	SIR
Plant 1, rock wool	1	0.58	173	—	1.36	0	1	1.94	52
Plant 2, rock wool	—	0.61	0	8	2.07	386**	8	2.68	299*
Plant 3, rock wool	3	2.55	118	6	3.98	151	9	6.53	138
Plant 4, glass wool	—	0.29	0	2	2.90	69	2	3.19	63
Total	4	4.03	99	16	10.31	155	20	14.34	139

* $p < 0.05$, ** $p < 0.01$.

Table 6. Lung cancer (1953–1983) among employees with one year or more of total employment in the mineral-wool producing industry, by period of first employment and time since first exposure (1953–1983). (O = observed number of cases, E = expected number of cases, SIR = standardized incidence ratio)

Period of first employment	Years since first exposure									Total cohort		
	1–9			10–19			≥20					
	O	E	SIR	O	E	SIR	O	E	SIR	O	E	SIR
1935–1949	—	0.06	0	—	0.30	0	4	1.76	227	4	2.12	189
1950–1959	—	0.48	0	2	1.46	137	4	2.27	176	6	4.21	143
1960–1969	2	0.99	202	2	1.90	105	1	0.33	303	5	3.22	155
≥1970	1	0.65	154	—	0.11	0	.	.	.	1	0.76	132
Total	3	2.18	138	4	3.77	106	9	4.36	206	16	10.31	155

Table 7. Lung cancer among employees in the mineral-wool producing industry (1953–1983) by type of work and time since first exposure. (O = observed number of cases, E = expected number of cases, SIR = standardized incidence ratio)

Total employment	Production workers			Nonproduction workers			Total		
	O	E	SIR	O	E	SIR	O	E	SIR
Less than one year									
≤19 years since first exposure	3	2.73	110	—	0.14	0	3	2.87	105
≥20 years since first exposure	1	1.06	94	—	0.10	0	1	1.16	86
One year or more									
≤19 years since first exposure	6	5.06	119	1	0.89	112	7	5.95	118
≥20 years since first exposure	7	3.47	202	2	0.89	225	9	4.36	206
Total									
≤19 years since first exposure	9	7.79	116	1	1.03	97	9	8.82	102
≥20 years since first exposure	8	4.53	177	2	0.99	202	11	5.52	199

Table 4 presents data for cancer of the intestine in relation to time since first exposure for the workers with more than one year of total employment in rock-wool and glass-wool production. When both periods are combined for rock wool, the table shows 14 cases observed and 7.14 expected, a result which is statistically significant. The highest SIR was however seen for workers with their first employment after 1960, and the table does not show any trend in SIR with years since first exposure. For glass wool only one case was observed during the follow-up period.

The observed and expected numbers of lung cancer for each of the four plants are presented in table 5. For all factories combined there were 20 observed and 14.34 expected cases. Among employees with the longest duration of total employment, the SIR was 155; 16 cases were observed in this group versus 10.31 expected. A large proportion of this excess was found in plant 2, the SIR being 386, that is 8 observed cases and 2.07 expected among workers with one year or more of total employment. For those who had worked less than one year, the observed and expected numbers were 4 and 4.03, respectively.

Table 6 shows the SIR for lung cancer according to period of first employment and years since first exposure. No excess risk was observed the first 19 years of follow-up. Among those with 20 years or more since first exposure, however, 9 cases were observed, and 4.36 were expected. When all periods were combined,

the highest SIR was seen among those with first entry before 1950 (4 observed and 2.12 expected).

The incidence of lung cancer among production and nonproduction workers is presented in table 7. Nonproduction consisted of maintenance workers, internal transport drivers, storemen, office workers, and also those with an unknown work history. Both for production and nonproduction workers with one year or more of total employment and 20 years or more since first exposure there was a risk of lung cancer with an SIR of 225 and 202, respectively.

Discussion and conclusion

The results of the present investigation on mortality and cancer morbidity show no consistency across the four factories included in this study. The standardized mortality ratio for total mortality was the highest among those with the shortest duration of total employment. A significant excess of deaths of violent nature was found within this group (23 observed and 10.04 expected). Most of the deaths occurred during the first years after the first employment. Thus during the nine first years of follow-up 18 deaths were observed, and the expected number was 6.75 (not presented in the tables). Thereafter no excess risk was observed.

For cancer morbidity, the results of the present study are based on a few cancer cases associated with each of the factories. In most of the tables the results have therefore been combined. A borderline statistically significant excess risk was found for cancer of the buccal cavity and pharynx. The observed number exceeded the expected number also for cancer of the intestine, cancer of the trachea, bronchus and lung, and cancer of the bladder. For cancer of the buccal cavity and pharynx, the excess risk was observed in one factory only, with six out of seven observed cases in the total material. Since the excess risk was observed in one plant only, it is reasonable to assume that the risk is associated with factors other than mineral wool. Up to now, there is no evidence of an excess risk of cancer in these sites from animal experiments or other epidemiologic studies based on fiber.

In several studies (6) an increased risk of cancer of the intestine has been observed among workers exposed to asbestos. The highest SIR in the present study on mineral wool was observed among those with first entry to this industry after 1960 without a specific trend in incidence. The results have therefore been assumed to express random variation or may be attributed to the selection of rates for the calculation of expected numbers. In the other countries in the European collaborative study (9), similar results were not reported.

The major objective of the present study was to evaluate whether an association exists between exposure to mineral wool and lung cancer. In only two of the four factories the observed number exceeded the expected, and only in one factory was the difference statistically significant. At plant 2, where the highest SIR was observed (table 5), a case-inquiry study based on the five lung cancer cases diagnosed before 1978 has been carried out (2). The authors concluded that, as several well-known carcinogens have been used in this industry, the proved excess risk of lung cancer might also be associated with such factors. The higher observed number than expected was seen among those with one year or more of total employment (16 observed and 10.31 expected), and the excess risk was only demonstrated among those with 20 years or more since first exposure (9 observed and 4.36 expected). This result is in line with the findings of two other major studies, the European collaborative study (9) and the study by Enterline & Marsh (5). In the second follow-up of the European collaborative study (10) the risk was found to be confined to the early technological phase of production. In the present study only two cases of lung cancer were observed in the glass-wool plant. These cases were observed in the group 20 years or more since first exposure.

In other occupational studies in Norway, an excess risk of lung cancer has generally been observed among unskilled workers with a short time of total employment (1). From the mineral-wool industry an excess risk of lung cancer was reported by Olsen & Møller Jensen (7) among those with a short duration of

employment. This phenomenon was not observed in the present study. There have been several changes in the production processes in this industry, and from the end of the 1950s the rock-wool factories have had modern mechanized processes in Norway. Among those with first entry in the modern technological phase (after 1960), only one case of lung cancer was observed. For this group of employees, however, one must wait another 10 years before conclusive data become available.

The material was also tabulated according to duration of employment, but no positive association between incidence of lung cancer and workers' duration of employment was found. The large technological changes which have taken place may play a role. If the material had shown an association between increasing lung cancer risk and length of employment, it would have contributed to the evidence of a causal association. No difference in risk was observed between production and nonproduction workers. We believe, however, that such a classification is very difficult to make, as workers have often worked in more than one section, and this information is not always recorded. One of the lung cancer cases among the nonproduction workers in the group 20 or more years since first employment had in fact been a production worker for several years in the first technological period with a dusty environment.

In a retrospective cohort study it is difficult to evaluate the confounding factors and their influence on risk estimates. Smoking is the most important single cause of lung cancer in humans, and the absence of information on smoking habits in the study is certainly a limitation. Other confounding factors may be related to occupational exposure outside the mineral-wool industry.

Another problem is the selection of a reference population for the estimation of the expected rates. In this study we have used the total male population as the reference population. The four factories are located in three different counties. The incidence rates for lung cancer in these counties varied from 90 to 124 % of that for the total population. If the calculations had been based on data from the counties where the plants are located, the expected number would have increased by 10 %, but the trends would have been the same. Another problem is that most of the workers in this industry are unskilled workers, who usually have a higher risk of lung cancer than the total population.

In conclusion the lung cancer risk that has emerged from this study was presumably initiated before 1960 when the environmental conditions were more hazardous than after 1960. Among those with first exposure to mineral wool before 1960 the study showed a borderline, statistically significant risk for lung cancer among workers with first employment before 1960 and 20 years or more since first exposure.

For the other types of cancer with an increased incidence, no firm explanations can be given.

References

1. Andersen A, Dahlberg BE, Magnus K, Wannag A. Risk of cancer in the Norwegian aluminium industry. *Int J Cancer* 29 (1982) 295—298.
2. Astrup EG, Lutzow-Holm JP. Case-inquiry study of 5 cases of lung cancer in the Norwegian mineral wool industry. Presented at International Seminar of Monitoring Human exposure to Carcinogenic and Mutagenic Agents, Finland 12—15 December 1983.
3. Cherrie J, Dodgson J. A historical environmental investigation at 13 European man-made mineral fibre production plants. Institute of Occupational Medicine, Edinburgh 1985.
4. Coleman M, Hermon C, Peto J. Cohort study analysis with a fortran computer program. *Int J Epidemiol* (in press).
5. Enterline PE, Marsh GM. The health of workers in the MMMF industry. In: Guthe T, ed. Biological effects of man-made mineral fibres: Proceedings of a WHO/IARC conference in association with JEMRB and TIMA Copenhagen, 20—22 April 1982. Volume 1. World Health Organization, Regional Office for Europe, Copenhagen 1984, pp 311—323.
6. Hilt B, Langård S, Andersen A, Rosenberg J. Asbestos exposure, smoking habits and cancer incidence among production and maintenance workers in an electrochemical plant. *Am J Ind Med* 8 (1985) 565—577.
7. Olsen JH, Møller Jensen O. Cancer incidence among employees in one mineral wool production plant in Denmark. *Scand J Work Environ Health* 10 (1984) 17—24.
8. Pott F, Ziem U, Mohn U. Lung carcinomas and mesotheliomas following intratracheal instillation of glass fibres and asbestos. Presented at the 6th International Pneumoconiosis Conference, Bochum, September 1983.
9. Saracci R, Simonato L, Acheson ED, Andersen A, Bertazzi PA, Claudi J, Charnay N, Estève J, Frentzel-Beyme RR, Gardner MJ, Jensen OM, Massing R, Olsen JH, Teppo L, Westerholm P, Zocchetti C. Mortality and incidence of cancer of workers in the man made vitreous industry: An international investigation at 13 European plants. *Br J Ind Med* 41 (1984) 425—436.
10. Simonato L, Fletcher AC, Cherrie J, Andersen A, Bertazzi PA, Charnay N, Claude J, Dodgson J, Estève J, Frentzel-Beyme R, Gardner MJ, Jensen OM, Olsen JH, Saracci R, Teppo L, Winkelmann R, Westerholm P, Winter PD, Zocchetti C. The man-made mineral fiber European historical cohort study: Extension of the follow-up. *Scand J Work Environ Health* 12 (1986): suppl 1, 34—47.
11. Stanton MF, Layard M, Tegeris A, Miller E, May M, Kent E. Carcinogenicity of fibrous glass: Pleural response in rat in relation to fiber dimension. *J Natl Cancer Inst* 58 (1977) 587—603.
12. Wagner JC, Berry GB, Hill RJ, Munday DE, Skidmore JW. Animal experiments with man-made mineral (V) F-effects of inhalation and intrapleural inoculation in rats. In: Guthe T, ed. Biological effects of man-made mineral fibres: Proceedings of a WHO/IARC conference in association with JEMRB and TIMA Copenhagen, 20—22 April 1982. Volume 2. World Health Organization, Regional Office for Europe, Copenhagen 1984, pp 209—233.