Mortality among asbestos cement workers: the cohort of the S.A.C.A. plant in Cavagnolo (Italy)

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Summary

Objectives. We describe mortality (1965-2003) and mesothelioma incidence (1990-2001) among workers employed at the S.A.C.A. plant, a medium-sized asbestos cement production facility in Cavagnolo, Italy.

Methods. The cohort included 868 workers (585 men and 283 women). The follow up ended on April 30, 2003. Analyses were based on the computation of standardized mortality and incidence ratios. Cause-specific mortality and incidence of mesothelioma in the cohort were compared to corresponding rates for the population of the Italian region of Piedmont.

Results. Follow up was completed in 97.4% of the cohort and the cause of death was known for 96.4% of the deceased subjects. In both men and women, mortality from all causes and from all malignant neoplasms was higher than expected but the increase did not reach statistical significance. A reduction in mortality from cardiovascular diseases was observed in the men, compatible with the healthy worker effect. Mortality from both pleural and peritoneal neoplasm was increased (both sexes: pleural neoplasm: 5 observed vs 0.9 expected; $p<0.05$; peritoneal neoplasm: 3 observed vs 0.5 expected; $p<0.05$). Similar results were observed for the incidence of pleural (both sexes: 3 obs vs 0.41 exp; $p<0.05$) and peritoneal mesothelioma (both sexes: 2 obs vs 0.04 exp). Both sexes also showed an increased mortality for asbestosis. Mortality from lung cancer did not exceed expectation.

Conclusions. This study contributes to our understanding of the impact of asbestos-related diseases among asbestos cement workers in Italy: the pattern of disease occurrence is similar to that observed in larger cohorts, with the exception of the lack of an increase in lung cancer mortality.

KEY WORDS: *asbestos, asbestosis, lung cancer, mesothelioma, mortality, standardized mortality ratio (SMR).*

Introduction

In Italy, as elsewhere in the world, the asbestos cement industry has, over the years, been the largest user of asbestos with the largest number of exposed workers. Asbestos cement production in Italy was carried out both in large and medium-sized factories. The latter factories accounted for a considerable proportion of total asbestos cement production in Italy and it is therefore important to carry out specific studies on their workers in order to obtain a full picture of the health impact of asbestos cement production in this country. Several such studies have already been published (for a review, see 1).

The S.A.C.A. (Società Anonima Cemento Amianto)

plant was a medium-sized asbestos cement factory active from 1947 to 1982. This study provides data on mortality from specific causes and on the incidence of mesothelioma among workers at the plant, exploring in particular the influence of duration of exposure and latency (i.e. the period between starting work at the plant and the end of the follow up).

Material and Methods

The plant

The S.A.C.A. plant was located in Cavagnolo, a small town near Turin, Italy. The factory became operational in 1947 and in 1981 was merged with the Casale Monferrato-based Eternit plant, one of the most important asbestos cement plants in Italy (2). The factory ceased production on June 30, 1982.

The plant produced mainly asbestos cement corrugated and flat sheets, chimney flues, tanks and water pipes. It is known that both chrysotile and crocidolite were used, but no additional information is available on the amounts of asbestos used or on fibre concentrations.

Throughout the 1950s, an average of 350 blue-collar workers worked at the plant. The factory mainly employed workers living nearby and in the first years of its activity employee turnover was high.

Cohort description

The cohort comprised 879 workers (595 men and 284 women), hired from 1947 to 1981, identified on the basis of the factory rosters, which recorded the date of hiring and the date of end of employment for each worker. No selections were applied.

Vital status was ascertained through register office records; the cause of death for decedents was established from the same source. The follow up, which included 868 workers (585 men and 283 women), was completed on April 30, 2003. Eleven subjects were excluded because of incomplete data. All subjects contributed person-years until their most recent date of observation. Causes of death were coded by two of the investigators (C.M. and A.T) according to the International Classification of Disease, 8th or 9th Revision, depending on which one was in use at the time person died (3).

Analyses were based on computations of numbers of person-years and of standardized mortality ratios (SMRs). The number of expected deaths in the cohort was estimated (by sex, five-year age groups, and by calendar periods) on the basis of mortality rates for Piedmont, available for the period 1970-2002. Mortality analyses were performed for the period 1965-2003: for 1965-1969 we applied the 1970-1974 rates, while the 2000-2002 rates were applied to 2003.

Person-years, expected deaths, plus SMRs with relative 95% confidence intervals (95%CIs) were computed using the OCMAP-PLUS, v3.10 software (4). As is customary, SMRs are reported taking the value among the general population as 100.

The 95%CIs were estimated assuming the Poisson distribution of the number of observed deaths (5). An SMR was considered to be statistically significant ($p<0.05$) when the 95%CI did not include 100.

Mortality analyses were conducted by duration of exposure and latency (the period elapsing between the time of first exposure and the end of the follow up). For those workers who left the plant and were hired again later, the duration of exposure was computed as the sum of the duration of each working period.

Incident cases of malignant mesothelioma (MM) were identified by record linkage with the Mesothelioma Registry of Piedmont (6). Only incident cases confirmed by histological or cytological examination were considered. The expected number of incident cases was estimated on the basis of the incidence rates of mesothelioma in Piedmont available for the period 1990-2001, data again sourced from the Mesothelioma Registry of Piedmont (6).

Results

Table 1 describes the cohort by year, age and duration of employment, vital status at the end of follow up, number of working periods, and duration of follow up among those still alive. The cohort included 585 men (67.4%) and 283 women (32.6%). The frequency distribution by year of employment was different between the sexes: a greater proportion of

Table 1. Cohort study of asbestos workers from the S.A.C.A. factory in Cavagnolo (province of Turin, North West Italy). Descriptive data.

	Men		Women	
	N	%	N	%
Year of first exposure				
1947-1956	283	48.4	167	59.0
1957-1966	169	28.9	77	27.2
1967-1976	102	17.4	30	10.6
1977-1980	31	5.3	9	3.2
Total	585	100.0	283	100.0
Age when first exposed				
<20	101	17.3	88	31.1
20-29	215	36.8	112	39.6
30-39	147	25.1	61	21.5
40-49	79	13.5	20	7.1
50-59	40	6.8	2	0.7
>60	3	0.5	0	0.0
Duration of exposure, stratified by period of first exposure	Mean	SD	Mean	SD
1947-1956	8.2	9.6	8.6	9.3
1957-1966	5.1	6.7	6.1	7.0
1967-1976	3.0	4.2	5.5	4.5
1977-1980	2.1	1.7	4.3	2.3
Status at the end of follow up				
alive	305	52.1	214	75.6
deceased*	269	46.0	68	24.0
emigrated**	9	1.5	0	0.0
lost to follow up	2	0.4	1	0.4
Number of working periods				
1	479	81.9	193	68.2
2	89	15.2	73	25.8
3	14	2.4	12	4.2
4+	3	0.5	5	1.8
Duration of follow up for subjects still living (years)				
20-29	57	18.7	25	11.7
30-39	105	34.4	23	10.7
40-49	85	27.9	105	49.1
50+	58	19.0	61	28.5

* 15 deceased before 1965; ** 3 emigrated before 1965.

women (59.0%) than men (48.4%) was employed in the first ten years of the plant's activity. Women were also hired at younger age.

Follow up was completed for 98.6% of the subjects and the cause of death was known for 96.4% of those deceased. In the period before 1965, fifteen subjects had died and three had moved abroad. The mean number of working periods was 1.2 for men and 1.4 for women; 81.9% of men and 68.2% of women had only one working period.

In the period 1965-2003, the men in the cohort contributed 16,108 person-years and the women 9,315 person-years.

Fifty-six subjects also worked in the Eternit plant in

Casale Monferrato (37 men and 19 women). These subjects were not considered separately in the analyses.

Table 2 shows the SMRs for the main causes of death, separately by sex. Among the men, we observed an increase in mortality from all causes (256 observed [obs] vs 225.8 expected [exp]) and from all malignant neoplasms (93 obs vs 75.6 exp), these increases being at the limits of statistical significance. Three deaths from pleural neoplasm were observed vs the 0.7 expected. A statistically significant increase in mortality from respiratory diseases (29 obs vs 14.1 exp; p<0.01) was also observed in the men: in particular from bronchitis, emphysema and asthma (15 obs vs 7.7 exp; p<0.05) and from asbestosis (6 obs vs 0.06 exp; p<0.01). Mortality from cardiovascular diseases (65 obs vs 85.3 exp; p<0.05) and ischaemic cardiac disease (20 obs vs 33.5 exp; p<0.05) was significantly decreased, whereas a greater than expected number of deaths from unspecified causes and from malignant neoplasms of unspecified site was observed.

Among the women, observed deaths from all causes numbered 66 vs the 60.5 expected (not statistically significant), while 29 deaths from all malignant neoplasms were observed vs the 22.2 expected (not statistically significant). A statistically significant increase in mortality was found for pleural neoplasms (2 obs vs 0.2 exp; p<0.05) and for asbestosis (1 obs vs 0.01 exp; p<0.05).

Analyses combining the sexes were conducted for asbestos-related causes of death. Mortality from pleural malignancies was increased (5 obs vs 0.9 exp; SMR=551.3; 95% CI: 178.9-1286.4). Two neoplasms were histologically confirmed and one was cytologically confirmed; no clinical documentation was available for the remaining two. Three deaths from peritoneal malignant neoplasm were observed vs the 0.5 expected (SMR=623.6; 95%CI: 128.7-1822.4). Two of these were histologically confirmed. Mortality from lung cancer was close to the expected rate (26 obs vs 24.9 exp). Seven deaths (vs 0.07 exp) were attributed to asbestosis, and fifteen (vs 8.7 exp) were attributed to acute respiratory diseases (ICD-9: 490.0-493.9; clinical records could not be reviewed and therefore possible misdiagnoses of cases of asbestosis cannot be excluded).

The standardized incidence ratio (SIR) for pleural mesothelioma for both sexes in the period 1990-2001, computed on the basis of incidence rates for

Table 2. Cohort study of asbestos workers from the S.A.C.A. factory in Cavagnolo (province of Turin, North West Italy). Mortality for the major causes of death in the period 1965-2003, by sex.

	Men					Women				
Cause of death	Obs	Exp	SMR	CI 95%		Obs	Exp	SMR	CI 95%	
All causes	256	225.8	113.4	99.9	128.2	66	60.5	109.0	84.3	138.7
All malignant neoplasms (MN)	93	75.6	123.0	99.3	150.7	29	22.2	130.4	87.3	187.2
MN digestive organs and peritoneum	29	25.6	113.3	75.9	162.8	10	7.3	137.6	66.0	253.0
MN intestine and rectum	10	7.4	135.9	65.2	249.9	3	2.5	120.8	24.9	353.0
MN rectum	5	2.6	193.8	62.9	452.3	0	0.8	---	0.0	484.4
MN peritoneum	2	0.3	684.3	82.8	2472.0	1	0.2	529.6	13.2	2951.2
MN respiratory organs	33	27.0	122.9	84.6	172.6	4	2.1	191.6	52.2	490.6
MN lung	24	23.1	104.0	66.7	154.8	2	1.8	113.8	13.8	411.2
MN pleura	3	0.7	422.2	87.1	1233.8	2	0.2	1017.9*	123.2	3677.2
MN nervous system	2	1.6	124.7	15.1	450.3	1	0.6	168.4	4.2	938.1
MN unspecified	5	1.9	258.7	84.0	603.6	1	0.6	172.8	4.3	962.8
Cardiovascular diseases	65	85.3	76.2*	58.8	97.1	14	21.9	63.8	34.9	107.1
Ischemic cardiopathy	20	33.5	59.7*	36.5	92.3	1	5.6	17.9*	0.4	99.9
Respiratory diseases	29	14.1	205.3**	137.5	294.8	4	2.5	162.9	44.4	417.0
Bronchitis, emphysema, asthma	15	7.7	193.8*	108.4	319.6	0	1.0	---	0.0	352.5
Asbestosis	6	0.06	9318.5**	3419.9	20281.7	1	0.01	18200.0*	455.0	101410.5
Unspecified	11	1.5	751.3**	375.0	1344.2	1	0.4	225.8	5.6	1257.9

(*) p<0.05 (**) p<0.01.

Piedmont, was 740.4 (3 obs vs 0.41 exp) (95% CI:152.8-2163.7). For peritoneal mesothelioma, it was 5030.5 (2 obs vs 0.04 exp) (95% CI: 608.7-18172.7).

Table 3 shows mortality analyses for selected causes of death in men by duration of exposure. In both classes of duration of exposure (<10 years and ≥10 years), a statistically significant increase in mortality was observed for respiratory diseases and for asbestosis. Malignant neoplasms were more frequent than expected ($p<0.05$) in patients exposed for 10 years or longer, while unspecified causes of death were considerably more common than expected ($p<0.05$) among workers with a short exposure duration.

Table 4 presents the SMR analyses by latency in men. The SMRs for diseases of the respiratory system, asbestosis and unspecified causes showed a statistically significant increase in subjects with latencies of less than 30 years, while the SMR for pleural malignancies became statistically significant among those with longer latencies (≥30 years), even though one death was observed in a subject with a shorter latency. No deaths from peritoneal neoplasm were observed in subjects with latencies of less than 30 years.

Separate analyses were conducted in both sexes together for deaths from pleural neoplasms. The SMRs by duration of exposure were: <10 years: 3 obs vs 0.7 exp (450.3; 95% CI: 92.9-1316.1); ≥10 years: 2 obs

Table 3. Cohort study of asbestos workers from the S.A.C.A. factory in Cavagnolo (province of Turin, North West Italy). Mortality for selected causes of death by duration of exposure in men.

	Duration of exposure									
	< 10 years					≥ 10 years				
Men	Obs	Exp	SMR	CI 95%		Obs	Exp	SMR	CI 95%	
All causes	183	165.7	110.4	89.9	134.3	73	60.0	121.7	95.4	153.0
All malignant neoplasms (MN)	59	55.7	105.9	80.6	136.6	34	19.9	170.9	118.3	238.8
MN peritoneum	1	0.24	416.7	10.4	2321.7	1	0.08	1250.0	31.3	6965.0
MN lung	14	17.0	82.4	45.0	138.2	10	6.0	166.7	79.9	306.5
MN pleura	2	0.5	400.0	48.4	1445.0	1	0.2	500.0	12.5	2786.0
Cardiovascular diseases	52	61.8	84.1	62.8	110.3	13	23.5	55.3	29.5	94.6
Respiratory diseases	19	10.1	188.1	113.3	293.8	10	4.0	250.0	119.9	459.8
Asbestosis	2	0.05	4000.0	484.0	14450.0	4	0.02	20000.0	5450.0	51210.0
Unspecified	11	1.1	1000.0	499.2	1789.3	0	0.4	0.0	0.0	922.3

Table 4. Cohort study of asbestos workers from the S.A.C.A. factory in Cavagnolo (province of Turin, North West Italy). Mortality for selected causes of death by time since first exposure (latency) in men.

	Latency									
	< 30 years					≥ 30 years				
Men	Obs	Exp	SMR	CI 95%		Obs	Exp	SMR	CI 95%	
All causes	119	109.1	109.1	88.7	132.7	137	116.6	117.5	95.6	142.9
All malignant neoplasms (MN)	39	34.1	114.4	81.3	156.3	54	41.5	130.1	97.7	169.8
MN lung	10	10.0	100.0	48.0	183.9	14	13.1	106.9	58.4	179.3
MN pleura	1	0.3	333.3	8.3	1857.3	2	0.4	500.0	60.5	1806.3
MN peritoneum	0	0.15	0.0	0.0	2459.3	2	0.14	1428.6	172.9	5160.7
Cardiovascular diseases	24	40.1	59.9	38.3	89.1	41	45.2	90.7	65.1	123.1
Respiratory diseases	16	6.1	262.3	149.9	426.0	13	8.0	162.5	86.5	277.9
Asbestosis	3	0.03	10000.0	2063.3	29223.3	3	0.04	7500.0	1547.5	21917.5
Unspecified	8	0.7	1142.9	493.4	2251.9	3	0.8	375.0	77.4	1095.9

vs 0.2 exp (830.3; 95% CI: 100.5-2999.5), while the SMRs by latency were: <30 years: 1 obs vs 0.3 exp (302.4; 95% CI 7.6-1685.1); ≥30 years: 4 obs vs 0.6 exp (694.0; 95% CI 189.1-1777.0).
The small number of cases precluded further analyses using multivariate methods.

Discussion

This study examines mortality in workers from the S.A.C.A. plant, a medium-sized asbestos cement factory active from 1947 to 1982. We will compare our results with those obtained in previous studies on medium-sized, Italian asbestos cement plants, focusing on the most recent reports, as well as with the recently published update of the Eternit cohort, since the S.A.C.A. plant in Cavagnolo and the Eternit plant in Casale Monferrato shared technologies long before they eventually merged (2).
The cohort was based on the official rosters of the factory and 98.6% of the subjects were successfully followed up, making major biases unlikely. Local mortality and incidence rates were used in order to increase comparability between the cohort and the reference rates.
The cohort was characterized by a decrease in mortality for cardiovascular diseases in both sexes. The trend of mortality by latency found in the men is compatible with the healthy worker effect (7).
In both sexes, a statistically significant increase in the number of deaths attributed to asbestosis was observed. In the most recent Italian studies, a statistically significant increase in mortality from asbestosis was reported by Luberto et al. (8) in asbestos cement workers in Emilia Romagna, by Coviello et al. (9) in a cohort study of asbestos cement workers in Bari, and by Raffaelli et al. in a similar cohort in Carrara (10). In the cohort study of the Eternit plant in Casale Monferrato (2) an increase in mortality from asbestosis was observed in both sexes (men: 162 obs vs 0.3 exp; p<0.01; women: 24 obs vs 0.02 exp; p<0.01).
A statistically significant increase in mortality was observed for pleural and for peritoneal neoplasms. The analysis of mesothelioma incidence also showed a statistically significant increase. For both pleural and peritoneal mesothelioma, SMRs increased in relation to duration of exposure and latency. All peritoneal neoplasms occurred after a latency from exposure of at least 30 years, while one case of pleural neoplasm with shorter latency was observed. The most recent Italian studies on asbestos cement workers found increased SMRs for pleural (1,8-10) and peritoneal (1,8-9) neoplasms. Compared to the present cohort, subjects in the Eternit cohort had longer latency and duration of exposure and showed higher relative risks for both pleural and peritoneal neoplasms in both mortality and incidence analyses (2).
Contrary to expectation (11), we did not observe a statistically significant increase in pulmonary malignancies, even though the SMRs for lung malignancies increased with duration of exposure. Instead, a large increase in lung neoplasm mortality was observed in the Eternit cohort (2). Possible reasons for this difference could be the fact that the factory was located in an agricultural area, with a presumably lower prevalence of cigarette smokers, especially in the 1950s and 1960s, and the possible selection of non-smokers in the workforce (we had no data on the smoking habits of the S.A.C.A. cohort members). Misclassification of the cause of death and simple random variation could also have played a role.

Conclusion

The present study contributes to our knowledge of the effects of asbestos exposure associated with the production of asbestos cement in Italy. Albeit based on a relatively small cohort, and therefore having limited statistical power, our analyses showed that mortality from asbestosis and mesothelial neoplasms increased with duration of exposure and latency in both sexes. Lung cancer in men increased with exposure duration, but without this difference reaching statistical significance.

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