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Mortality due to asbestos-related causes among railway carriage construction and repair workers

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The objective of this study was to further clarify the cancer risk associated with asbestos exposure in railway carriage construction and repair. The cohort included 734 subjects employed between 1 January 1945 and 31 December 1969. Vital status was ascertained at 31 December 1997. Mortality was investigated in the time span 1970–97. Forty-two subjects (6%) were lost to follow-up and eight causes of death (4%) could not be ascertained. The overall mortality was not above the expected value. Among neoplastic diseases, excesses were observed for lung [standardized mortality ratio (SMR) = 124; 90% confidence interval (CI) = 87–172; 26 obs), pleura (SMR = 1,327; CI = 523–2,790; 5 obs), larynx (SMR = 240; CI = 95–505; 5 obs), liver (SMR = 241; CI = 126–420; 9 obs), pancreas (SMR = 224; CI = 98–443; 6 obs) and multiple myeloma (SMR = 429; CI = 117–1,109; 3 obs). The observed excess of lung and pleural neoplasms can be causally related to asbestos exposure in the manufacture of railway carriages. A causal role of asbestos exposure in the raised SMRs from laryngeal and pancreatic neoplasms and multiple myeloma cannot be conclusively proven.

Key words: Asbestos; laryngeal cancer; lung cancer; multiple myeloma; pancreatic cancer; pleural mesothelioma.

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INTRODUCTION

Construction and maintenance of railway carriages in the 1940s through to the 1970s involved extensive use of asbestos in many countries. Initially, asbestos was essentially used to insulate boilers, mains and gaskets; subsequently, it was employed to insulate the entire carriage.

The first report of cases of mesothelioma in railway machinists (*i.e.*, mechanical workers active in construction and repair of railway carriages) was presented by Wagner *et al.*,[1] followed by several authors from various countries (for a recent review, see Maltoni *et al.*[2]) Mancuso[3–4] studied a cohort of US retired railway machinists hired between 1920 and 1929 and showed that 61% of cancer deaths among them were due to lung cancer and mesothelioma. Increased mortality from both pleural and lung neoplasms was detected among Italian railway carriage construction workers[5] and Swedish railway maintenance shop workers,[6] taking into account a latency time of 20 and 30 years respectively. A case–control study by Schenker *et al.*[7] detected a relative risk of 7.2 for pleural mesothelioma among US railway workers with previous exposure to asbestos.

The present study deals with the cause-specific mortality experience of a cohort of railway carriage construction and repair workers, with the aim of further clarifying the cancer risk associated with asbestos exposure in this occupation, over a 50-year time span.

MATERIALS AND METHODS

The plant which was studied was in operation from 1906–69, but ceased between 1943 and 1945 due to

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wartime destruction. Production included railway and tramway carriages, locomotives, industrial and agricultural machines; rolling stock was also repaired and eventually demolished in an area of the factory.

In the main work areas, forging, pressing, metal construction, assembling (which included joinery and upholstery), finishing repair and painting were performed, and were located in large sheds where four to eight carriages could be concurrently processed. The only openings were the accesses for carriages.

The use of asbestos as an insulating agent in railway carriages started in the 1940s, with the application of chrysotile boards in specific parts, *e.g.*, around the heating system. Starting from the 1950s, crocidolite-containing mixtures were sprayed on the entire internal surface of the carriage. Insulation workers were employed by specialized companies and wore protective equipment, but they often operated while other workers, with no protective equipment, were engaged in different tasks. Exposure to asbestos could thus be caused both by the work process itself (especially for assemblers, finishers, joiners, upholsterers, electricians, maintenance workers and cleaners), or by ambient air contamination (for an extensive historical study on the use of asbestos in Italian railways see Merler *et al.*[8])

No measurements of asbestos fibre concentration are available, because at the time this was not recognized as an occupational risk.

The cohort, based on company files, included 734 subjects hired between 1 January 1945 and 31 December 1969. Vital status was ascertained at 31 December 1997 from the Registrar Offices of the municipalities of residence of cohort members, which also provided information on causes of death. The mortality experience of the cohort was studied for the period 1970–97, since the quality of death registration prior to 1970 was not adequately known, and no regional mortality rates were available. Causes of death were coded according to the International Classification of Disease, using the 8th Revision for 1970–79, and the 9th Revision for 1980–94.

The observed mortality was contrasted to expected figures obtained by applying Tuscany Region cause-, sex-, age- and calendar year-specific mortality rates to the cohort's person years, using the OCMAP statistical package.[9] Confidence intervals (CI) were computed on the assumption of Poisson distribution; 90% levels were used not only in order to reduce type two statistical error, but also because the causal relation between asbestos exposure and cancer risk is known *a priori*, and the hypothesis being tested was only that of an increased mortality.

Besides mortality analysis based on death certificates, a 'best evidence' approach based on the acquisition of all available clinical and pathological material for every deceased person was undertaken, according to the guidelines provided by Selikoff *et al.*[10]

RESULTS

The cohort consisted of 734 male workers whose mean age at hiring was 29 years. The vital status of the cohort was ascertained at the end of follow-up (31 December 1997); at that date 449 subjects were alive and 243 were deceased. Forty-two subjects with vital status unknown, corresponding to 6% of the cohort, contributed to the total number of person-years till their last day of employment. Forty-four subjects died between 1945 and 1969, and were excluded from the mortality analysis, while the remaining 199 died from 1970 onwards. Eight causes of death were not ascertained, corresponding to 4% of the deceased subjects.

The cohort's mortality experience in the years 1970–97 is shown in Table 1. The overall observed mortality was close to the expected value, as a result of a significant increase in the deaths due to some causes and a slight decrease of all other causes. Among neoplastic diseases, excesses were observed for respiratory tract cancer (lung, pleura and larynx), digestive tract cancer (liver and pancreas) and for multiple myeloma.

As shown in Table 2, the excess of respiratory neoplasms was evenly distributed between those subgroups with 21–30 years and over 31 years since first exposure.

The best evidence procedure provided some further information of interest. Clinical records were available for 109 of the 199 deceased subjects and among them for 54 of the 99 cancer cases, with histological diagnoses in 27out of 54. Four out of the five deaths from malignant pleural neoplasms were due to confirmed cases of mesothelioma, (three of them with histological diagnoses and one with clinical records only). Of the five subjects, one had been a welder, one a joiner and there were also two painters. The fifth worker had been employed as a joiner, welder and painter, while two more mesothelioma cases, a welder and an electrician, were alive at the end of the study.

DISCUSSION

The present study showed a significant increase in mortality from lung and pleural neoplasms, which is consistent with the established effects of asbestos exposure.[11] The excess mortality was observable only after 20 years since first employment, which is in agreement with findings from other authors.[12–14] The quality of death registration for these neoplasms in Italy has been previously assessed. Death certification for lung cancer is consistent with clinical data (over 80%), but it underestimates the actual number of cases when compared with autopsy data.[15] A national survey has shown that about 75% of established cases of pleural mesothelioma are correctly coded at death;[16] an autopsy-based study performed in Trieste has estimated a much higher proportion of false negatives (80%) and 20% of false positives.[17] In light of these findings, it can be estimated that misclassification may have, at most, implied some underestimation of lung and pleural cancer mortality in the present cohort; four (out of five) observed deaths from malignant pleural neoplasms, as has been shown, were confirmed by the best evidence procedure.

Table 1. Cause specific mortality of railway carriage construction workers

	Observed deaths	Expected deaths	SMR[a]	90% CI[b]
All causes	199	199.37	100	89–112
Circulatory disease	55	75.11	73	58–92
Malignant neoplasms	99	70.49	140	118–166
Mouth and pharynx	3	1.13	265	72–686
Digestive tract	39	26.80	146	109–190
Stomach	13	9.95	131	77–208
Intestine and rectum	6	6.45	93	41–184
Liver	9	3.74	241	126–420
Pancreas	6	2.67	224	98–443
Respiratory tract	36	23.83	151	112–196
Larynx	5	2.08	240	95–505
Lung	26	20.99	124	87–172
Pleura	5	0.38	1,327	523–2,790
Lymphoemopoietic system	6	4.27	141	61–277
Multiple myeloma	3	0.70	429	117–1,109
Other malignant neoplasms	15	14.46	104	64–160
Respiratory disease	11	12.77	86	48–143
Digestive tract disease	8	12.05	66	33–120
Violence	6	12.05	50	22–98
Other and ill-defined causes	12	16.90	71	41–115
Missing causes	8			

[a] SMR = standardized mortality ratio.
[b] 90% CI = 90% confidence interval of the estimated SMR.

Table 2. Mortality from malignant neoplasms of respiratory tract by duration of employment and time since first exposure among railway carriage construction workers

Time since first exposure (yrs)	Duration of employment (yrs)				Total
	≤10	11–20	21–30	31+	
≤10					
obs	0	–	–	–	0
exp	0.15	–	–	–	0.15
SMR	–	–	–	–	–
p-years	899	–	–	–	899
11–20					
obs	0	1	–	–	1
exp	0.95	0.89	–	–	1.84
SMR	–	112	–	–	54
p-years	2,160	1,976	–	–	4,135
21–30					
obs	4	5	4	–	13
exp	3.15	3.12	1.08	–	7.35
SMR	127	160	370	–	177
p-years	2,590	2,201	822	–	5,614
31+					
obs	2	13	6	1	22
exp	4.75	4.64	4.48	0.63	14.49
SMR	42	280	134	160	152
p-years	1,922	1,685	1,257	192	5,056
Total					
obs	6	19	10	1	36
exp	9.00	8.65	5.56	0.63	23.83
SMR	67	220	180	160	151
p-years	7,572	5,862	2,079	192	15,705

Key: obs = observed deaths; exp = expected deaths; SMR = standardized mortality ratio; p-years = person years of observation.

The increased mortality for laryngeal cancer reported in the present study may in principle be attributed to asbestos exposure,[18] even if some authors tend to disregard this association.[19–20] On the basis of a thoroughly designed case–control study, Muscat and Wynder[21] suggest a relative risk of 1.3, allowing for other risk factors of laryngeal cancer.

The observed increase in mortality for liver and pancreatic neoplasms requires some comment. Pancreatic cancer has been suggested by some authors to be associated with asbestos exposure,[22–24] even if there is awareness of a possible misclassification due to peritoneal mesothelioma. Recently, though, Kauppinen *et al.*[25] did not confirm this finding in a nation-wide case–control study. While the attribution to asbestos of the reported increase in pancreatic cancer remains problematic, the increase in liver cancer mortality could be disregarded as probably reflecting metastases to the liver from lung cancer, which is certainly in excess in this cohort.[24]

The issue of multiple myeloma in asbestos workers was raised in the 1970s by some authors who reported cases of lymphopoietic malignancies in patients with asbestosis, or in subjects who were heavily exposed to asbestos.[26–29] Support for this etiological hypothesis came from some case–control studies performed in the US,[30] UK[31] and Italy,[32] while other case–control studies from the US[33–35] and Sweden[36] provided no evidence of an association. The small increase in mortality from multiple myeloma reported in the present study is consistent with the aforementioned positive studies; it should be stressed, though, that a large cohort study of Italian workers compensated for asbestosis did not show any increased risk for this neoplasm.[37]

In conclusion, therefore, the present study confirmed the expected causal connection between exposure to asbestos in the manufacture of railway carriages, and occurrence of lung cancer and pleural mesothelioma in railway workers. Raised SMRs from laryngeal and pancreatic neoplasms and multiple myeloma were also

detected, although a causal role of asbestos exposure in such cases could not be conclusively proven.

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