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MESOTHELIOMAS FOLLOWING EXPOSURE TO ASBESTOS USED IN RAILROADS: 130 ITALIAN CASES

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Mesoteliomi da esposizione all'amianto usato nelle ferrovie: 130 casi italiani. Vengono brevemente passati in rassegna: le conoscenze disponibili sui rischi organici da amianto, i dati sugli usi di amianto nelle ferrovie, con particolare riguardo alle Ferrovie dello Stato italiane (FS) ed i gruppi di lavoratori a rischio in seguito all'esposizione ad amianto usato nelle ferrovie. Vengono riassunti anche i dati della letteratura disponibili sugli effetti patologici di tale esposizione, e soprattutto sull'insorgenza di mesoteliomi tra i meccanici e gli altri lavoratori delle ferrovie. Sono quindi riportati 130 casi di mesotelioma (122 pleurici, 1 pericardico, 6 peritoneali ed 1 pleuro-peritoneale), dovuti all'esposizione all'amianto usato nelle ferrovie, osservati in varie regioni italiane. Cinquantatré di questi casi (tra cui 49 riportati nella Regione Emilia Romagna) sono stati sottoposti ad una analisi dettagliata presso l'Istituto di Oncologia di Bologna. Settanta-sette casi di mesotelioma sono insorti tra lavoratori delle FS esposti professionalmente (soprattutto meccanici): 45 casi sono insorti tra meccanici di rotabili e lavoratori impiegati nella riparazione e demolizione di linee ferroviarie, in officine non appartenenti alle FS; 3 casi sono insorti tra impiegati non appartenenti alle FS, viaggianti su rotabili; e infine 5 casi sono insorti nei familiari (1 figlia, 3 mogli e 1 sorella) di lavoratori delle ferrovie. Questa serie di casi, insieme a casi simili riferiti nella letteratura, prova che l'amianto usato nelle ferrovie costituisce un rischio importante per la salute, e sottolinea la gravità di tale rischio. Sulla base dei dati disponibili, sono considerate necessarie le seguenti azioni: la promozione di studi epidemiologici sistematici, l'adozione di misure di prevenzione, l'attuazione di una sorveglianza medica oncologica, ed il risarcimento automatico per i tumori insorti in seguito all'esposizione all'amianto usato nelle ferrovie.

Key words: mesothelioma; asbestos; railroads

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INTRODUCTION

To present, 130 cases of mesothelioma among people exposed to asbestos used in the Italian State Railroads (Ferrovie dello Stato-FS) (mainly workers because of their job) have been ascertained. To our knowledge, this is the largest single series of cases of mesothelioma due to such exposure, worldwide. This report refers the main epidemiological, clinical and pathological data dealing with these cases.

The oncogenic risks related to asbestos exposure

From the beginning of this century, tens of millions of tons of asbestos, in various mineral forms (mainly chrysotile, crocidolite and amosite) have been quarried and utilized for an enormous range of uses, which include: the production of asbestos-cement, of manufactured products for the building industry, and of pipes; the insulation of buildings and means of transportation by both land and sea; the construction of brakes, etc. It has been estimated that there are about 3,000 uses of asbestos (8).

The association between exposure to asbestos and malignant tumours was established for the first time by Lynch and Smith (1935) (9), who described a case of lung carcinoma associated to asbestosis. Since then, asbestos has been shown to produce, in humans, carcinomas of the lung and mesotheliomas of the pleura and peritoneum, and an increase in the carcinomas of the upper respiratory tract, of the oesophagus, stomach, intestine, and gall-bladder/bile ducts and of the kidney (8, 72, 73).

The carcinogenicity of asbestos has been confirmed by experimental data:

asbestos produces, in laboratory rodents, tumours of the lung and mesotheliomas of the pleura and peritoneum (8, 17, 72).

The following population groups are at risk for diseases related to asbestos: workers occupationally exposed to this material (because of their job, or because of the contamination in the workplace), family members of these workers (who bring home traces of the mineral in their clothes, in their hair and on their bodies), and those citizens who live near places where asbestos is quarried and utilized, or in any other places where asbestos is present for some reason.

Uses of asbestos in railroads, with particular regard to Italy

Asbestos has been employed in the railroads of many countries for a variety of uses: 1) for a long time (since the '30s) as material for insulating boilers and water and steam mains; 2) subsequently, for the insulation of locomotive driving cabins and carriages; and 3) in more or less recent times, for the production of asbestos-cement ties, which substituted those made of wood.

In Italy, since the '40s, asbestos has been utilized, generally in the form of boards and bands, to insulate boilers and mains. In the '60s asbestos was used to insulate driving cabins of a particular type of locomotive. From the '50s to the '70s asbestos was widely used to insulate the newly-built carriages, and to replace inflammable insulating materials (such as cork) in older carriages. The quantity of asbestos employed to insulate a carriage was high: up to 1,000 kg per carriage. The systematic substitution of wood ties with asbestos-cement ties has been carried out since the '70s. Chrysotile was the type of

s, in laboratory rodents, lung and mesotheliomas of the pleura (8, 17, 72). Population groups are at risk related to asbestos: workers exposed to this material in their job, or because of their residence (who bring the mineral in their air and on their bodies), and those who live near places where asbestos is quarried and utilized, or where asbestos is present.

On railroads, with particu-

men employed in the railroads for a variety of reasons (since the '30s) as follows: 1) repairing boilers and water tanks; 2) subsequently, for the maintenance of driving cabins; 3) in more or less reduction of asbestos-substituted those made

in the '40s, asbestos has been used in the form of asbestos to insulate boilers and steam engines of a particular type in the '50s to the '70s to insulate the walls, and to replace insulating materials (such as asbestos). The quantity of asbestos to insulate a carriage is 100 kg per carriage. The substitution of wood ties with asbestos has been carried out and asbestos was the type of

asbestos prevalently used in the Italian railroads.

About 10-12 years ago, for health reasons, the removal of asbestos from carriages was started in a systematic way. Such removal has been performed partly in the workshops of the FS, and partly in private workshops, with no adequate protection conditions particularly in the private facilities. The pollution resulted, therefore, particularly high in private workshops. Removal of asbestos in such conditions, may have caused additional risks of asbestos diseases among a wide, although not defined, working population. Asbestos was and still is replaced in carriages with glass fibres, in the past used "freely", and at present wrapped in plastic containers; on the basis of scientific information, this type of substitution may represent a problem of occupational and environmental health in the near future.

Groups of populations at risk due to exposure to asbestos used in the railroads, with particular regard to the Italian situation

The following population groups are potentially exposed to the asbestos used in railroad rolling-stock:

Workers of the FS, especially machinists (occupational exposure):

A. workers engaged in the repair, demolition, technical control and maintenance of rolling-stock, and in the removal of asbestos from rolling-stock ("machinists");

B. workers engaged in the collection, transportation and stockage of waste containing asbestos;

C. workers engaged in the cleaning of carriages;

D. workers who are engaged in repairing, demolishing the rails and correlated structures, and in manoeuvring the points, since both the rails and the points can be contaminated by the asbestos dropped from the rolling-stock; and

E. engine-drivers who work in locomotives which contain structures insulated with asbestos.

Rolling-stock machinists and workers engaged in the repair and demolition of the rails, of workshops not belonging to the FS (occupational exposure):

A. workers engaged in the construction, repair and demolition of rolling-stock, and the removal of asbestos from rolling-stock ("machinists");

B. workers engaged in checking, repairing and demolishing the rails and correlated structures; and

C. workers engaged in the collection, transportation and stockage of waste containing asbestos.

Personnel working on rolling-stock, belonging and not belonging to the FS (workplace pollution: environmental exposure):

A. the travelling staff of the FS, due to the great quantities of asbestos used to insulate certain types of rolling-stock;

B. the staff of companies which run the restaurant and sleeping-cars;

C. post-office employees who travel in postal carriages;

D. railroad policemen;

E. soldiers;

F. porters; and

G. others.

Family members of exposed workers of the FS and of workshops not belonging to the FS (family contact)

Commuters.

In Italy, railroad machinists work in the Major Repair Workshops (MRW), in Locomotive Depots (LD), and in Elevation Squads (ES), and also in the stations and along the lines for checking and emergency repairs.

It has been estimated that there are more than 15,000 Italian FS machinists presently at work, of which more than 8,000 are employed in the MRWs. It has also been calculated that the total number of FS machinists, who worked for periods of various lengths on the railroads from 1950 to date (inclusive of those dismissed, retired, deceased and still working, which means the entire cohort at risk), amount to about 50,000 individuals (25,000 of whom at work continuously or periodically in the MRWs).

Moreover, it is estimated that an equal number of rolling-stock machinists, with various types of jobs, worked and are still working in railroad workshops not belonging to the FS. It can therefore be estimated that in our country the railroad machinists considered to be at risk because of exposure to the asbestos used in the railroads, from 1950 to date, amount to about 100,000. This estimate does not include the workers of private workshops recently engaged in the removal of asbestos from carriages.

Extrapolating from the Italian data the number of rolling-stock machinists at a European and world level, considering the other groups, occupationally or not potentially exposed, and taking into account furthermore the available information on the asbestos-correlated pathology ob-

served in railroad machinists, the risks due to asbestos used for insulating the rolling-stock reach the dimension of an extremely severe and ubiquitous public health problem.

The available information on the oncogenic effects of asbestos used in the railroads at world level

Since 1960 (82), cases of asbestosis and tumours (particularly mesotheliomas) correlated to exposure to asbestos used in railroads have been reported in several countries. The previously available data are listed in table 1.

The table includes the findings reported by Mancuso (40, 41), which greatly contributed in drawing the attention of the international scientific community to the health risks due to exposure to asbestos among railroad machinists. The table also includes the Italian series of mesotheliomas.

THE ITALIAN CASES

At present, 130 cases of mesothelioma following exposure to asbestos used in railroads have been found in various Italian regions. The series of the cases is not the result of a systematic epidemiological investigation, but rather of clinical and pathological observation and anecdotal information.

For the 53 cases directly diagnosed/studied at the Bologna Institute of Oncology, a systematic collection of all the available information and raw materials on the occupational history, on the diagnostic ascertainment, and on the treatment and the clinical evolution, was carried out. In particular all the available cytological and

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Table 1 - Cases of asbestosis, lung carcinomas, mesotheliomas and other pathologies due to asbestos used in railroads, reported in the inter-
 national scientific literature

Reference	Country	Pathology (No. of cases)				
		Asbestosis	Lung carcinomas (a)	Pleural Pericardial	Mesotheliomas Peritoneal	Others
					Other/ unspecified site	Total
Wagner (82), 1960	South Africa		2			2
Thiruvengadam (79), 1966	India	1				
Collins (8), 1967	South Africa	1				
Green (6), 1974	USA					
Webster (83), 1975-76 (b)	South Africa	2		2		2
Punbona (66), 1976	Italy			1		1
Cochrane (4), 1978 (b)	South Africa			16		16
Mosher (43), 1979	Rhodesia	4		2		2
Andrion (1), 1983	Italy					
Mancuso (40), 1983 (c)	USA			46 (d)		46
Saitoh (69), 1983	Japan					
Martensson (42), 1984 (e)	Sweden			1		1
Ohlson (44), 1984 (e)	Sweden		37.0 observed 31.8 expected	5		5
Chung (3), 1985	Canada					
Malke (11), 1985 (e)	Sweden			11		11
Oliver (45), 1985	USA				1	1
						86 pleural thickenings

(continued)

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(Continued table 1)

Reference	Country	Pathology (No. of cases)						Others	
		Asbestosis	Lung carcinomas (a)	Mesotheliomas			Total		
				Pleural	Pericardial	Peritoneal			Other/ unspecified site
Von Rüttner (81), 1985	Switzerland			14				14	
Magrini (10), 1986	Italy		11.0 observed 12.7 expected						1 "pleuro- peritoneal carcinosis"
Maltoni (14), 1986 (f)	Italy			7				7	
Shenker (70), 1986	USA			4			16	20	
Hjorberg (7), 1988	Sweden								87 pleural plaques
Manento (41), 1988 (b)	USA			13			1	14	
Maltoni (24), 1989 (f)	Italy			31				31	
Blignen (2), 1990	France						49 (g)	49	
Maltoni (19), 1990 (f)	Italy			78	1	4		83	
Walker (12), 1990 (e)	Sweden			11			8	19	
Maltoni (31), 1991 (f)	Italy			80	1	4		85	
Maltoni (23), 1994 (f)	Italy			114	1	6	1 (h)	122	

(a) Cases of lung carcinoma were reported in several publications; in this table however data are only listed when both observed and expected numbers were indicated

(b) These 2 different reports seem to deal with the same South African cases

(c) These 2 different reports seem to deal with the same US cases

(d) 42 mesotheliomas, 2 "endotheliomas" and 2 "cancers" of the pleura

(e) These 3 different reports seem to deal with the same Swedish cases

(f) These 5 different reports deal with the same Italian cases

(g) 33 cases with asbestos exposure exclusively in railroad industries; 16 cases with asbestos exposure and in outside railroad industries

(h) Pleuro-peritoneal mesothelioma

histological slides were examined and the mesotheliomas classified by histotypes, following the rules of the Italian National Panel on Mesotheliomas, of the Italian Society for Tumour Prevention, Diagnosis and Therapy (46). These 53 cases are distributed as follows:

- 49 cases in the Emilia-Romagna Region, of which 41 cases in Bologna (32 among workers of the FS, 6 among rolling-stock machinists and workers engaged in the repair and demolition of the rails in workshops not belonging to the FS, and 3 in family members of FS workers); 2 cases in Rimini (among FS workers); 6 cases in Reggio Emilia (among workers of workshops not belonging to the FS);
- 1 case in the Abruzzo Region, in Sulmona (in an FS worker);
- 1 case in the Liguria Region, in Genova (in an FS worker);
- 1 case in the Lombardia Region, in Milano (in a non FS worker); and
- 1 case in the Veneto Region, in Vicenza (in an FS worker).

One hundred and twenty-six of the total 130 cases have been previously published (13-16, 19-24, 26-39, 47-64, 67, 68, 74, 75, 80).

The distribution of the 130 observed cases, by categories of exposed population, and by site of the mesotheliomas, is reported in table 2: the great majority of the cases (122 out of the total 130) were located in the pleura. The distribution of the 54 cases observed in the Emilia Romagna Region, by categories of exposed population and by site of the mesothelioma, is presented in table 3: 52 out of the 54 cases were localized in the pleura.

The distribution by Italian regions of the 122 cases of mesothelioma due to job asbestos exposure is presented in table 4. Fifty-one cases out of the 122 (41.8%) were found in the Emilia Romagna Region. The inhabitants of the Emilia Romagna Region account for the 6.9% of the Italian population (about 4 out of 58 millions). The fact that a high percentage of our series of cases of mesothelioma come

Table 2 - 130 Italian cases of mesotheliomas due to asbestos used in railroads: distribution according to the category of population exposed and to the site of the neoplasia

Category	No. of cases of mesotheliomas				Total
	Pleural	Pericardial	Peritoneal	Pleuro-peritoneal	
Asbestos exposure due to job assignments					
- Workers of the FS (a), especially machinists	74	1	1	1	77
- Rolling-stock machinists and workers engaged in the repair and demolition of the rails, of workshops not belonging to the FS	40	0	5	0	45
- (Total)	(114)	(1)	(6)	(1)	(122)
Asbestos exposure due to workplace pollution					
- Personnel working on rolling-stock, not employed by the FS	3	0	0	0	3
Asbestos exposure due to family contact					
- Family members of exposed workers of the FS and of workshops not belonging to the FS	5	0	0	0	5
Total	122	1	6	1	130

(a) FS=Ferrovie dello Stato (Italian State Railroads)

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Table 3 - 54 Emilia Romagna cases of mesotheliomas due to asbestos used in railroads: distribution according to the category of population exposed and to the site of the neoplasia

Category	No. of cases of mesotheliomas				Total
	Pleural	Pericardial	Peritoneal	Pleuro-peritoneal	
Asbestos exposure due to job assignments					
- Workers of the FS (a), especially machinists	34	0	0	1	35
- Rolling-stock machinists and workers engaged in the repair and demolition of the rails, of workshops not belonging to the FS	15	1	0	0	16
- (Total)	(49)	(1)	(0)	(1)	(51)
Asbestos exposure due to workplace pollution					
- Personnel working on rolling-stock, not employed by the FS	0	0	0	0	0
Asbestos exposure due to family contact					
- Family members of exposed workers of the FS and of workshops not belonging to the FS	3	0	0	0	3
Total	52	1	0	1	54

(a) FS=Ferrovie dello Stato (Italian State Railroads)

Table 4 - 122 Italian cases of mesotheliomas due to asbestos exposure because of the job assignments (77 workers of the FS and 45 workers not belonging to the FS): distribution by region

Region	Cases		Total
	FS	Not FS	
Abruzzo	1	0	1
Campania	2	9	11
Emilia Romagna	35	16	51
Friuli-Venezia Giulia	2	9	11
Lazio	0	3	3
Liguria	2	4	6
Lombardia	3	1	4
Marche	1	0	1
Piemonte	9	2	11
Puglia	4	0	4
Sicilia	2	0	2
Toscana	7	8	15
Trentino	1	0	1
Umbria	1	0	1
Veneto	7	0	7
All regions	77	45	122

from the Emilia Romagna Region may be explained by 2 factors: 1) for a long time, large FS and non-FS railroad workshops have been located in this region, and 2) moreover the cases of mesothelioma are systematically diagnosed, described and registered with particular diligence in this area of Italy, by our institutions.

The job assignments and their frequency among these 122 cases are reported in table 5. The average latency period (the time elapsed between the start of the exposure and diagnosis) of these cases is 31.0 years.

The years of diagnosis, the period of latency, the survival times (period elapsed between the first signs/symptoms and death) and the age at death of 46 out of the 52 cases of mesothelioma due to asbestos exposure because of job assignments in the Emilia Romagna Region, are given in table 6. The average period of latency

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Table 5 - 122 Italian cases of mesotheliomas due to asbestos exposure because of the job assignments (77 workers of the FS and 45 workers not belonging to the FS): frequency of job assignments

Decreasing order of frequency	Job assignments
1	Insulators and painters
2	Electricians and electro-mechanics
3	Labourers
4	Mechanical repairers
5	Engine drivers
6	Joiners
7	Pipefitters
8	Mechanical controllers
	Welders
9	Boiler repairers
	Pointsmen
	Sheet metal workers
	Upholsterers
10	Foremen
	Insulating board makers
	Mechanics
	Shunters
11	Brakesmen
	Engineers
	Controllers
	Fitters
	Millers
	Rail inspectors
	Riggers
	Superstructure mechanics
	Supplies and station workmen
12	Carriage strippers
	Compressor operators
	Drivers
	Finishers
	Insulation removers
	Lappers
	Messengers
	Pollshers
	Railroad lines machinists
	Skilled workmen

is 30.5 years (ranging from 12 to 49 years); the average age at death is 61 years (ranging from 39 to 77 years); the average survival time is 15.8 months (ranging from 3 to 53 months).

The job and the year of diagnosis of the 3 mesotheliomas due to workplace pollution are given in table 7.

The kinship, job assignments of the exposed workers belonging to the family and the year of diagnosis of the 5 cases of mesothelioma due to asbestos exposure by family contact are given in table 8.

The distribution by death quinquennium of 107 of the 130 observed Italian cases is given in figure 1. In the 2 decades, between 1970 and 1989, there is a clear-cut trend toward an increase in mortality. The trend toward mortality increase is even sharper when one considers the cases of the Emilia Romagna Region, which must be considered to more accurately reflect the natural situation (figure 2). Over and above the 130 cases herein reported, nine new cases of probable mesothelioma among machinists of FS and not FS workshops are now being studied in our Institute.

CONCLUSIONS

From the reported data, some conclusions can be drawn.

1. The series of Italian cases of mesothelioma due to asbestos used in the railroads definitively confirms the high carcinogenic risk of this exposure.

2. Cases of mesothelioma correlated to exposure to asbestos used in the railroads have been observed in 15 out of the 20 Italian regions; this means that in Italy the problem is ubiquitous.

(1) These 3 clinical regions were with the same natural levels
(g) 33 cases with asbestos exposure exclusively in railroad industries; 16 cases with asbestos exposure and in outside railroad industries
(h) Pleuro-peritoneal mesothelioma

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Table 6 - 46 (a) Emilia Romagna cases of mesotheliomas due to asbestos exposure because of job assignments (34 workers of the FS and 12 workers not belonging to FS): years of diagnosis and period of latency (46 cases), and time elapsed between start of exposure and death, time elapsed between the first signs and/or symptoms and death, i.e. survival time and age at death (40 cases)

Category	N.			Years of diagnosis	Period of latency (years)		Time elapsed between start of exposure and death (years)		Survival time (months)		Age at death (years)	
	Total	Dead	Still alive		Average	Range	Average	Range	Average	Range	Average	Range
FS workers	34	30	4	1976-95	31.1	16-49	33.3	17-49	15.1	3-44	60.7	39-77
Not FS workers	12	10	2	1985-93	28.6	12-39	31.5	26-41	17.9	4-53	61.5	45-77
Total	46	40	6	1976-93	30.5	12-49	32.9	17-49	15.8	3-53	61.0	39-77

(a) Out of the 51

Table 7 - 3 Italian cases of mesotheliomas due to asbestos exposure because of workplace pollution (workers not belonging to the FS): job and year of diagnosis

Cases	Job	Year of diagnosis
1	Military radar operator	1989
2	Post office clerk	1989
3	Sleeping-car attendant	1989

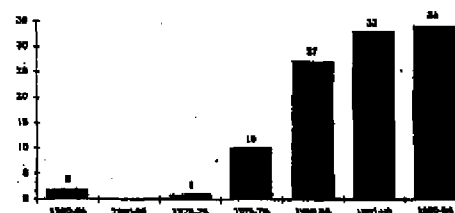


Fig. 1 - 107 Italian cases (out of 130 observed) of mesotheliomas following exposure to asbestos used in railroads: distribution by death quinquennium

Table 8 - 5 Italian cases of mesotheliomas due to asbestos exposure by family contact: kinship, job assignments of the exposed workers within the family and year of diagnosis

Cases	Kinship	Job assignments of the exposed workers	Year of diagnosis
1	Daughter	Pointsman (FS)	1988
2	Wife	Engine driver (FS)	1989
3	Wife	Machinist (FS)	1994
4	Wife	Machinist (not FS)	1993
5	Sister	Machinist (FS)	1995

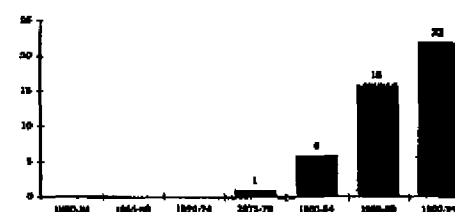


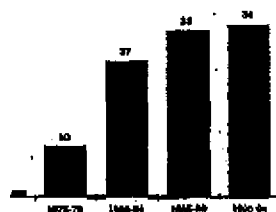
Fig. 2 - 45 Emilia Romagna cases (out of 54 cases) of mesotheliomas following exposure to asbestos used in railroads: distribution by death quinquennium (of 1 patient the date of death is not known and 8 patients are still alive)

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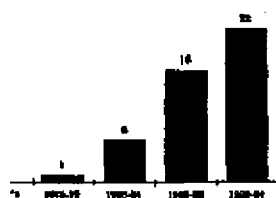
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ns exposure because of job as-
ars of diagnosis and period of
time elapsed between the first
(es)

Survival time (months)	Age at death (years)
Average Range	Average Range
15.1 3-44	60.7 39-77
17.9 4-53	61.5 45-77
15.8 3-53	61.0 39-77



cases (out of 130 observed) of
ing exposure to asbestos used
on by death quinquennium



Emilia Romagna cases (out of 54 cases)
following exposure to asbestos
distribution by death quinquennium
date of death is not known
alive)

3. The majority of cases have been observed in the Emilia Romagna Region. This finding may be the effect of a peculiar local situation of risk, which should be better assessed, and/or of a more accurate registration of the cases.

4. The great majority of reported cases of mesothelioma occurred after 1980, with an historical trend which indicates a sharp tendency to increase, both at the national level and in the Emilia Romagna Region (figure 1, 2).

5. The reported mesotheliomas occurred, following occupational exposure among machinists and other FS workers, among machinists of rolling-stock workshops not belonging to the FS, following environmental workplace exposure, among workers non employed in the FS, but whose job was carried out on rolling-stock, and among family members of exposed workers. These observations demonstrate the real carcinogenic risk which exists in the various categories potentially exposed (listed above). The problem of travelling employees and of travellers in general, mainly those who spend several hours daily on trains, will be further investigated by the European Ramazzini Foundation and by the Bologna Institute of Oncology, utilizing the data of the local cancer registry.

6. The great majority of mesotheliomas is localized in the pleura. However, the onset of some cases of mesothelioma of the peritoneum and pericardium must induce us to take into careful consideration these sites also. This care must be even greater, because the diagnosis of peritoneal and pericardial mesothelioma may be more difficult per se, and also because there are not, for these sites, specific departments, as is the case for pleural mesotheliomas (departments of pneumology

and thoracic surgery), which facilitate both diagnosis and registration.

7. The average latency period of this neoplasia, following job exposure among workers of the FS and among workers of workshops not belonging to the FS, is 31.0 years at the national level (30.5 years for the Emilia Romagna cases). This period is shorter than that reported by Mancuso (40) (about 45 years) and by Schenker (70) (about 39 years): these data suggest a possibly heavier exposure of the Italian workers.

8. The data on survival (table 6) further confirm the poor prognosis of mesothelioma. In our experience the natural history (clinical evolution) of mesotheliomas is not objectively modified by any type of therapy: the difference in the time progression, and therefore in survival, observed among different cases, on the basis of preliminary results of a study in which we evaluated the correlation between the pathological characteristic of mesothelioma and the prognosis, may be due rather to the biological features of the different types of mesothelioma, which should be better assessed.

9. The reported cases demonstrate, but do not quantify, the risk due to exposure to asbestos used in the railroads. Our series of cases of mesothelioma is not the result of a systematic epidemiological investigation, but, as already stated, of occasional clinical observations and information. It is logical to think, therefore, that the number of the cases reported by us is inferior to the real one, so underestimating the actual risk situation. Furthermore, it must be considered that, on the basis of available scientific knowledge (71) for each case of mesothelioma, other cases of tumours of different site/type due to the same exposure to asbestos can be expected.

ted. In conclusion, only a systematic epidemiological investigation can provide us with correct information on the real burden of the risk brought about by the past use of asbestos in railroads.

The data which have been presented and the information given in the literature call for a series of actions which, in consideration of the extent and gravity of the problem, should not be procrastinated, i.e.:

1. the promotion of systematic epidemiological investigations on railroad workers (particularly machinists). Mortality studies by cohort are easily feasible in the cases of the Italian FS workers, since the employing administration has kept all the records of its employees. A mortality study by cohort on the machinists of the FS, who had worked and are working in the FS Compartment of the Emilia Romagna Region, is now being performed by our Foundation and Institute;

2. the promotion and achievement of measures of primary prevention, to lower or eliminate the exposure to asbestos, such as: removal (in controlled conditions) of asbestos, its substitution with other materials (which must, however, be proven safe), and measures of protection in the workplace. The choice of alternative material is a difficult problem. The use of glass fibres, which has been going on for many years, in conditions often not sufficiently controlled, has been a choice which deserves further and prompt reconsideration. The experimental data have shown that glass fibres produce mesotheliomas in experimental rodents (65, 77, 78). An epidemiological investigation performed by the International Agency for Research on Cancer (IARC), with the collaboration of European glass fibre manufacturers, has indicated an increased incidence of lung carcinomas among workers exposed to glass fibres

(76). Recently, we have described 2 cases of mesothelioma (1 pleural and 1 peritoneal) in workers exposed to glass fibres, in whose occupational history there was no trace of asbestos exposure (18, 25).

3. the alerting of all workers of the FS, and of the machinists of rolling-stock workshops not belonging to the FS, about the syncarcinogenic effect of asbestos and tobacco smoking, with respect to lung carcinoma, and about the benefit of giving up smoking;

4. the provision of medical surveillance to all workers of the FS and to the machinists of rolling-stock workshops not belonging to the FS, for the early detection of those tumours due to asbestos (such as carcinomas of the upper respiratory tract, carcinomas of the gastrointestinal tract, and carcinomas of the kidney), which, if diagnosed at an early stage, can benefit from therapy.

The reported cases definitively demonstrate the carcinogenic risk of the groups of workers exposed to asbestos used in railroads. This knowledge should bring about the recognition of the tumours known to be correlated to asbestos exposure, observed in these groups (including people environmentally exposed in the workplace), as being occupational diseases and therefore eligible for compensation. The possibilities of compensation for mesotheliomas following familial exposure deserve prompt consideration.

SUMMARY

The available knowledge on the oncogenic risks of asbestos, the data on the uses of asbestos in railroads, with particular regard to the Italian State Railroads (Ferrovie dello Stato=FS), and the groups at risk due to the exposure to asbestos

we have described 2 cases (1 pleural and 1 peritoneal) exposed to glass fibres, in the medical history there was no exposure (18, 25).

For all workers of the FS, the medical history of rolling-stock workers belonging to the FS, about the effect of asbestos and to the benefit of giving up

the medical surveillance of the FS and to the medical surveillance of rolling-stock workers not belonging to the FS, for the early detection of diseases due to asbestos (such as the upper respiratory tract, the gastrointestinal tract, the kidney), which, if in an early stage, can benefit

from the medical surveillance of these groups. The knowledge of the occupational risk of the groups exposed to asbestos used in the knowledge should bring attention of the tumours related to asbestos exposure in these groups (including the occupational diseases eligible for compensation). The knowledge of compensation for mesothelioma following exposure consideration.

The knowledge on the occupational risk of asbestos, the data on the exposure in railroads, with particular reference to the Italian State Railroads (FS), and the groups exposed to asbestos

used in railroads were briefly reviewed. The available data on the pathological effects of such exposure, and particularly on the onset of mesotheliomas among machinists and other railroad workers, were also summarized. One hundred and thirty cases of mesothelioma (122 pleural, 1 peritoneal, 6 peritoneal and 1 pleuro-peritoneal), related to the exposure to asbestos used in railroads, observed in various Italian regions, were reported. Fifty-three of these cases (among which 49 reported in the Emilia Romagna Region) were submitted to a detailed study at the Bologna Institute of Oncology. Seventy-seven cases of mesothelioma occurred among occupationally exposed FS workers, in particular machinists; 45 cases occurred among rolling-stock machinists and workers engaged in the repair and demolition of the rails of workshops not belonging to the FS; 3 cases occurred among travelling workers of rolling-stock, not belonging to the FS; and 5 cases were found in family members (1 daughter, 3 wives and 1 sister) of railroad workers. This series of cases, together with similar data from the literature, proves the existence of an actual health risk due to asbestos used in railroads, and indicates its gravity. On the basis of the available data, the following steps are considered necessary: the promotion of systematic epidemiological investigations, the adoption of preventive measures, the performance of medical oncological surveillance, and the automatic compensation for tumours following the exposure to the asbestos used in railroads.

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