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UNIVERSITÀ DEGLI STUDI
ISTITUTI CLINICI DI PERFEZIONAMENTO

CLINICA DEL LAVORO "LUIGI DEVOTO"

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Research Project: Epidemiological Study on the Biological Effects of Asbestos Dust at the Balangero Mine and among the Port of Genoa and La Spezia Arsenal Insulation Workers

The problem of the biological effects of the inhalation of asbestos dust has now taken on a significantly greater importance than in the past owing to the fact that it is now recognized that asbestos can cause an increased incidence of lung cancers and mesotheliomas of the pleura. Many epidemiological studies have confirmed the relationship between inhalation of asbestos dust and development of lung tumours and mesotheliomas; but it is not yet clear whether there is a substantial difference between the various qualities of asbestos in relation to their carcinogenic action.

We have for some years been making an epidemiological study of asbestos workers to ascertain the causes of death with particular regard to asbestosis, lung cancer and mesotheliomas of the pleura. At the same time and where it was possible we made a clinical study of the effects of inhalation of asbestos on the lungs. The studies were carried out on chrysotile asbestos miners; on workers in industries using various types of asbestos; and on workers in the Genoa shipyards. A preliminary study was also made on some workers of the Taranto shipyards.

The following report sets out the results of our studies.

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A. Asbestos Mine of Balangero

The Balangero mine is located in Piedmont, about 30 km from Turin, and is the most important chrysotile deposit in Western Europe. It is situated on the top of a hill and on its slopes, below the quarry floor, is the mill where the asbestos is processed. Production amounts to about 100,000 tons of asbestos per year. The average asbestoid chrysotile content in the main body of the deposit is 5-6%. The free silica content of the serpentine rock is low, i.e., below 0.4%.

The deposit was already known in the 19th century but exploitation on an industrial scale only began after the first World War. The present owners of the mine (Amiantifera di Balangero S.p.A.) started operations in 1932, when mining with high return methods was started.

1) Study of Airborne Dust

1a) Air Pollution in the open pit mine and mill

The concentration of dust and fibres in the air of the various working environments was studied using membrane filters and counting the particles and fibres on the filters with phase contrast microscope at 500 X. The sampling time was always short, about 15 min. per sample. In addition, samples of total dust were taken using the electrostatic precipitators to obtain weighted dust measurements. The criteria followed for the whole study and in particular the procedures for fibre exposure evaluation are those recommended by the Sub-Committee on Asbestosis of the Permanent Commission and International Association on Occupational Health contained in "Evaluation of Asbestos Exposures in the Working Environment".

Between Summer 1968 and February 1970, 140 samples were taken in the various departments of the mine and mill in different seasons of the year. The results of the dust counts are shown in Table 1. Analysis of the data confirms that the quarry workers are less exposed to inhalation of asbestos than the mill workers.

1b) Air Pollution in the area surrounding the asbestos mine

A comprehensive report on this study was submitted in June 1971.

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2) Epidemiological Study

A card index was set up to cover all workers who had started working after 1932 and who had worked at the mine for at least one month. As at 31 March, 1970, the population under consideration was composed of 1,098 subjects (including only 5 females) of whom 242 were then at work. For each worker it was necessary to make specific investigations at the Municipal Offices to ascertain the place of birth and subsequent removals, whether the subjects was still alive or dead, present address or address of surviving relatives, place and cause of death.

As can be seen in Table 2, where the population has been divided into cohorts according to year of birth, for 100 ex-workers it was not possible to obtain any information whatsoever, while of the remaining 998, 270 had died.

For the 998 subjects covered by the card index and for whom it was possible to ascertain whether they were alive or dead at 31 March, 1970, the occupational history was reconstructed (length of service, department and job) on the basis of company records, data from pension files of the Social Insurance Institute, and through direct interviews or interviews by correspondence with the subjects themselves or with their surviving relatives. Knowledge of the job done was the primary element in forming an evaluation of the risk of exposure to asbestos. On the basis of the information obtained an attempt was made to classify each worker according to a "risk index" expressed in numerical terms. It should be borne in mind that every effort to make such a classification bears a considerable margin of doubt since, to evaluate the amount of asbestos breathed it would be necessary to know in detail the concentration of airborne fibres for each single working environment and for the duration of the job, and also the pulmonary ventilation of each subject in relation to the physical effort exerted at work.

Unfortunately, during the period considered in the epidemiological investigation, no airborne dust measurements were ever made at the Balangero mine so that the only data available are those already mentioned, which refer to the period 1968-1970. These data also have little significance as regards the situation in the past since the technological progress in modernization of the plant and machinery has resulted in continual modification and substantial improvement in the environmental hygiene

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conditions, especially in the last 15 years. So, in rather empirical terms, on the basis of the available data, the data obtained by temporarily reconstructing old working conditions now improved, and discussions with technicians and workers, we attempted to make a classification according to a "risk index", calculated by giving each job a numerical coefficient and multiplying it by the number of years the worker did the job. Table 3 gives the coefficients used to calculate the risk index. It should be noted that this "risk index" has been used both in the study of the causes of death and in the clinical study.

2a) Causes of death among the Balangero miners

Verification of the cause of death began by examining the records of the municipal registry offices which, however, only occasionally gave the cause of death classified as initial, intermediate or terminal, as is done for the death certificate. It was necessary to supplement these data with information obtained from surviving relatives, family doctors, and hospital medical records if death had occurred in hospital or within one year of discharge. For 35 workers compensated for asbestosis we also used information from the medical records of the Insurance Institute. In this way, in 253 of the 270 deaths we were able to establish the cause of death with a considerable degree of accuracy.

In the investigation of the effects of exposure to asbestos on the mortality of ex-workers of the Balangero mine, we were faced with serious difficulties. In the first place it was impossible to obtain mortality data relating to the general population of the area concerned that could be compared with the mortality of the working population being studied. The impossibility of making a statistical calculation between the mortality of the sample of workers and that of a control population could have been overcome by comparing the mortality rates of the workers more exposed to asbestos dust with those of the less exposed; for this purpose we could have used the risk index, dividing the working population into cohorts of 5 years according to the date of birth, and calculating the equivalent average death rates for each age group. As can be seen in Table 4, this method cannot be correctly applied because the number of subjects with different risk indices is too large and dissimilar in each cohort.

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It was impossible to apply any other method of epidemiological statistics due to the necessity of manual elaboration of the data, since transformation of the data for mechanical elaboration was neither contemplated nor done.

However, the mortality evaluated by means of equivalent average death rates was significantly higher in the groups of workers with a low risk index and with short periods of exposure. The explanation for this rather surprising finding probably lies not only in the "age" factor but must be attributed to other variables which might have caused a particular selection in the population.

In this connection, it should be remembered that the Alpine valleys, from which the majority of the Balangero work-force comes, are an economically depressed area where the average standard of living is still relatively low. Moreover, in the years 1943-45 this area was the scene of some of the most intense partisan struggles with a very high number of war victims. This may partly account for the high incidence of deaths labelled as due to "accident", which amount to 22% of all deaths. The interference of many variables, which could at the most suggest a positive selection of the workers with longer service in the mine, makes it extremely difficult to draw any significant conclusions from a retrospective epidemiological study such as we have carried out. Once again, only a direct comparison between the population under consideration and a control population might solve the questions raised; but, as has been seen, this has not been possible up to now.

In order to obtain data on the oncogenic action of chrysotile it may, however, be significant to analyze only the group of deceased subjects and study their causes of death.

From Table 5 it can be seen that among the 270 deceased workers, lung tumours were relatively rare. In order to have an idea of the significance of the prevalence of lung tumours among the mine workers, a comparison was made between the causes of death of the male inhabitants of the two villages of Balangero and Corio who died over the age of 35 years in the same period of time (Table 6). Lung tumours do not appear among the causes of death of miners who died before 1960; all 6 cases of lung tumour were in fact diagnosed between 1960 and 1969. This may be due to insufficient diagnostical

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research into the cases of death before 1959, or may represent a real increase in lung tumours among the miners in the last decade. Nevertheless, the deaths due to cancer of the lung among the male inhabitants of the villages of Balangero and Corio did not show any significant difference with respect to those observed among the miners ($X^2 = 1.36$). It should also be noted that while for each deceased miner an accurate investigation as possible was made to ascertain the cause of death, for the inhabitants of Balangero and Corio only the municipal records were considered. No case of mesothelioma of the pleura or peritoneum was found among the miners; one doubtful case defined as "tumour of the pleura" was found among the inhabitants of Corio. On the other hand, the average age at death of the miners was considerably lower than that of the inhabitants of Balangero and Corio, which may be of significance in relation to the probability of occurrence of lung tumours.

In order to have further information on the prevalence of lung tumours among the male population of the areas considered, we collected the clinical diagnoses of all male patients over 35 years of age admitted to the internal medicine departments of the Hospitals of Lanzo and Cirië from 1956 to 1959 and from 1967 to 1969. Lanzo Hospital is rather old and relatively poorly equipped, while Cirië Hospital has been recently built and is very well organized. The percentage of lung tumours among patients was 1% in the two hospitals between 1957 and 1959; this percentage rose to 2% among patients of Cirië Hospital between 1967 and 1969.

The 6 cases of lung tumour found among Balangero ex-workers are summarized in Table 8. Five subjects had no radiological asbestosis, and were smokers; one received compensation for asbestosis and was a non-smoker. The length of exposure to asbestos varied from one to 21 years. The period of time which elapsed between the beginning of exposure and death was in all cases more than 20 years.

3) Clinical Study

All workers still alive who had worked for more than one year were examined. The clinical examination consisted of:

- a complete medical examination during which the examining doctor completed a respiratory questionnaire identical to the one used in the Quebec asbestos survey in Canada

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- a 35 x 35 cm chest X-ray
- an electrocardiogram at rest and immediately after exercise of 100 watt
- lung function test at rest with measurement of vital capacity and 1 sec. forced expiratory volume
- measurement of transfer factor at rest and during exercise of 50 and 100 watt.

The medical examinations were carried out at the mine's medical department where a laboratory for lung function tests was set up and equipped with the following instruments:

- a Godard Diffusiontest permitting measurement of vital capacity, 1 sec. forced expiratory volume, and CO lung diffusion capacity with the steady state method
- a cycloergometer.

Initially, until May 1969, the chest X-rays were taken at Ciriè Hospital but subsequently, mainly due to the fact that it was impossible to obtain good radiographs, Amiantifera di Balangero S.p.A. equipped its medical department with an X-ray apparatus giving 500 mA and 120 KV, and also a dark room.

From the Company's records, the working population with more than one year's service totalled 894 subjects. Investigation of municipal records showed that of this number, 624 were alive and 221 were dead as at 31 March, 1970, while in 49 cases (5.6%) no information could be obtained.

Three hundred and ninety-five subjects, i.e. 63.3% of the workers still alive and with more than one year's service at 31st March, 1970, were given a medical examination at the mine's medical department; they were all given an electrocardiogram and, with the exception of a few un-cooperative subjects, a lung function test.

3a) X-Ray Study

The classification of the chest X-rays was made according to the 1968 Cincinnati Classification. Each radiograph was classified on the basis of the opinions of two independent readers; if there were only small divergencies, the radiograph was classified with the lower grade. If there was clear disagreement between the two readers, the radiograph was viewed again and discussed by four physicians together (two radiologists and two non-radiologists) and was subsequently classified according to majority opinion.

This group of four readers had previously made an accurate study of the Cincinnati Classification criteria and did pratical exercises in reading ~~once~~ groups of radiographs of subjects with varying grades of asbestosis admitted to the Clinica del Lavoro in the last five years. These readings were repeated several times so that an idea could be formed of the accuracy of each reader and of the group as a whole.

Table 9 gives the radiological findings of 474 Balangero workers, divided according to risk index. The radiological classification refers only to the profusion of the images; no account was taken of the type and site of the alterations and it must be pointed out that only profusion of irregular small opacities was considered here; only 3 cases of rounded small opacities were observed. The group of radiographs considered includes all those that could be read with the above method. In addition to the 395 radiographs taken at the mine's medical department, the group includes a further 79 radiographs of 79 ex-workers whom we could not examine ourselves directly; these were obtained from the medical records of the Insurance Institute (INAIL).

It can be observed from the table that about 30% of the subjects had an abnormal radiological picture (grades 1, 2 and 3), and this percentage increases in the various groups with the increase in risk index.

Fifteen subjects of the least exposed group had abnormal radiological pictures and no explanation of these cases was found in the overall clinical findings.

Pleural thickenings could be studied only on the 395 radiographs taken at the mine's medical department. In listing the alterations, only standard radiographs were considered (postero-anterior projection) even though in some a lateral projection was also made. Pleural thickenings were observed in 51 cases. In Table 10 these alterations have been recorded according to the Cincinnati Classification. The maximum percentage of pleural thickenings was observed in the group with highest exposure to asbestos. Pleural calcifications were present in 2.5% of the X-rayed miners.

4) Lung Function Studies

Of the 395 subjects with more than one year of service at the Balangero mine, 378 underwent lung function tests. In the remaining 17 cases it was impossible to have sufficient co-operation for a reliable interpretation of the results.

As reported, the spirographic values of vital capacity (VC) and 1 sec. forced expiratory volume (FEV_1) were obtained using a spirograph inserted into the Godard Diffusiontest, which was also used to measure transfer factor. Spirographic measurements were made at rest and at least three times consecutively; the highest value was retained. Each case was discussed together with the head of the Physiopathology Laboratory of the Clinica del Lavoro.

Transfer factor, studied with the Godard Diffusiontest, was evaluated by the CO steady state method. As a preliminary, a limited sample of control subjects was studied to check the reproducibility of the measurements. Table 11 gives the D_{LCO} values expressed in ml/min/mm Hg of 14 subjects who, upon first examination, showed transfer factor abnormalities and on whom it was possible to make further checks after a certain time interval. Statistical evaluation, by analysis of the variance for repeated measures, showed that the variations between determinations are not significant ($F = 0.09$).

The results of the lung function tests are summarized in Table 12, giving the percentages of subjects with deficit in CV, FEV_1 and D_{LCO} at rest and during exercise and compared with the X-ray finding. In preparing this table reference was made to the following "normal" values: for VC and FEV_1 the data supplied by the European Coal and Steel Community for the European population, while for D_{LCO} a preliminary investigation was made on a sample of adult male subjects not exposed to asbestos. The results of the latter study (Sartorelli et al., in press) give the lower limits of normal values as 11.6, 24.4, 31.0 ml/min/mm Hg of D_{LCO} respectively at rest, and during exercise of 50 and 100 watts. For each single subject examined, the percentage reduction of VC and FEV_1 was calculated with respect to the normal value consideraing age, weight and height (European Coal and Steel Community data).

Table 13 gives the mean values of these reductions in the groups with normal (0/0, 0/1) and abnormal (1 - 2 - 3) X-ray findings. The subjects with a normal X-ray picture were further stratified according to the duration of exposure (up to 10 years and more than 10 years).

The mean values of transfer factor at rest and during exercise in the control (unexposed) groups and in the groups of workers exposed to asbestos are given in Table 14. Statistical analysis of the results of D_{LCO} at rest revealed no significant differences between the

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control group (column a) and the group exposed for up to 10 years (column b), while the differences are highly significant ($p < 0.001$) between the control group (column a) and the group of workers with normal radiographs and exposure over 10 years (column c). However, during exercise both of 50 and 100 watts, also the group of workers with normal radiographs and with exposure up to 10 years (column b) revealed a significant difference compared with the control group (column a). Analysis of the data in the table is completed by the observation that the statistical comparison of the D_{LCO} values, both at rest and during exercise, between the group of subjects with normal radiographs and exposure over 10 years (column c) and the group of subjects with abnormal radiographs (column d) showed no significant differences.

The prevalence of chronic bronchitis is reported in Table 15, in which the cases have been divided according to the chest X-ray picture and the time elapsed since the beginning of exposure to asbestos. Diagnosis of chronic bronchitis was made taking into consideration the anamnesis (from the questionnaire), objective clinical findings and the spirographic results. Analysis of the table reveals a progressive increase in the prevalence of chronic bronchitis as the interval from start of work increases; this increase is probably related to the age of the subjects. In Tables 16 and 17, in fact, where the cases are divided according to the risk index and duration of exposure, no positive correlation can be observed.

In Table 18 the frequency of chronic bronchitis has been analyzed in relation to the X-ray film grade and the number of cigarettes smoked. From this table it appears that there is a lower percentage of bronchitic subjects among those who said they smoked more than 15 cigarettes per day, compared with those smoking less than 15 per day, and this observation is difficult to interpret. It may be that the anamnestic data regarding smoking are not reliable since the workers might have instinctively minimized their answers. Or there may be some other cause not taken into consideration (e.g., exposure to atmospheric factors causing some selection of the cases.

During the clinical examination, particular attention was given to fine râles; this finding was considered positive if bilateral, could be heard in both standing and sitting position and persisted after cough and after deep breathing. In Tables 19, 20 and 21, the prevalence of thoracic râles is compared with both the X-ray film grade, the risk index, the duration of work with asbestos and with the period elapsed from the beginning of exposure.

B. Port of Genoa

The Port of Genoa has a shipyard specialized in the refitting and repair of ships. The number of men working in direct contact with asbestos is relatively low: in practice only about 30 insulation workers. Pleuro-pulmonary alterations due to asbestos were, however, observed also in other men, not insulation workers, doing different jobs afloat. This confirms the finding, made also by other research workers, that there is a real possibility of more or less intermittent or intense exposure to asbestos everywhere on board ships undergoing repair. For insulation work on board, in the last 30 years chrysotile, amosite and crocidolite have been and are still used. Crocidolite consumption represents about 5% of the total asbestos consumption. Use of the various types of asbestos has, however, varied considerably according to particular situations of supply and demand for each type. In the last 15 years, extensive use has been made of the sprayed asbestos insulation process, using materials produced in England.

Considering that the most important consequences of exposure to asbestos are asbestosis and pleuro-pulmonary cancer which, even with a very long latency period, can shorten life or be the direct cause of death, a prospective type of investigation was made of the causes of death in the cohort of dock workers employed on ship refitting and repairs in the Port of Genoa (Industrial Sector) at work or retired and alive at 31st December, 1959, obtaining a posteriori data concerning the subjects who died in the subsequent 10 years, i.e., from 1st January, 1960, to 31st December, 1969.

As a control group a cohort of dock workers was chosen who were employed on goods transport in the Port of Genoa (Commercial Sector) at work or retired at 31st December, 1959. For this population group the same data as for the preceding group were obtained regarding deaths in the decade 1960-1969. The reason for the choice of this group as controls was that it is composed of workers not exposed to the inhalation of asbestos; secondly, for this population group it was possible to collect the same data and with the same methods as the exposed group; thirdly, the workers in the Commercial Sector can be considered perfectly identical to those of the Industrial Sector as regards socio-economic conditions, housing area, habits, and system of employment (on call, piecework, etc.).

The data concerning the composition of the cohorts, i.e., the numbers for each age group year by year (year of birth) for subjects at work and retired subjects, were obtained from the records of the "Ufficio Ruoli del Consorzio Autonomo del Porto di Genova" (Port of Genoa Institute for Dock Workers.

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Preliminary data on the causes of death were obtained from the records of the Insurance Institute for Dock Workers of the City of Genoa, which receives data on all retired or deceased workers registered under the various categories of dock workers. On the basis of these data we then traced the causes of death such as recorded in the death registers of the municipal registry offices of Genoa and the towns of the Province of Genoa and of other provinces.

It was not possible to obtain any information on the cause of death for 114 cases, some of whom had died abroad or in other provinces. In all, 1863 cases are registered, 660 of whom work in the Industrial Sector and 1203 in the Commercial Sector. Further personal and occupational data were obtained from the medical records kept at the Preventive Medicine Centre for Dock Workers, where the Industrial Sector workers are examined, and from the medical records kept by the Sickness Fund for Dock Workers and by the National Health Insurance Institute (INAM), and from the medical files of the town hospitals. Other information, when required, was obtained through interviews with relatives and family doctors.

For each case, therefore, the following data were recorded and transferred on to punched cards: 1) year of birth, 2) year of commencement of work, 3) year of cessation of work, 4) year of death, 5) age at commencement of work, 6) age at cessation of work, 7) age at death, 8) duration of work in years, 9) time elapsed between commencement of work and death in years, 10) time elapsed between cessation of work and death in years, 11) occupational category, 12) smoking habits, 13) source of diagnosis, 14) presence of asbestosis, 15) cause of death.

1) General Mortality

Investigation of mortality for all causes of death, including those unknown, was made for age groups of 10 years for ages from 50 to 79 years, and for groups of about 20 years for ages up to 49 and from 80 years upwards (Table 22).

The death rate per thousand in the subsequent 10 years (1st January, 1960 to 31st December, 1969) appears higher in the Industrial Sector for all age groups except those over 80; the difference between the two population groups is statistically significant (calculation of X^2 with Yates correction) for all age groups except those over 80, and for the general totals. The Cochran test is also positive ($P < 0.05$).

2) Causes of Death

The cause of death was established from the municipal death registers of the City of Genoa (ISTAT Cards (Istituto Centrale di Statistica)) and were further checked, investigate

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and if necessary modified on the basis of information and records traced in hospitals, among relatives and family doctors. We traced in particular the hospital records for all cases of death occurring in hospital due to chronic respiratory diseases, chronic heart disease, pulmonary tuberculosis, cancer of undefined origin, accidents, unknown or insufficiently defined causes. For deaths occurring at home for these same causes, wherever possible we interviewed first of all relatives and family doctors and afterwards examined any available health insurance or hospital records.

These investigations led to the assessment of diagnoses on the basis shown in Table 23. The causes of death are shown in Table 24. Among the causes of death there are 6 cases of asbestosis in insulation workers of the Industrial Sector. Another 4 insulation workers had developed asbestosis but they had died from other causes (one of these from tuberculosis and one from broncho-pulmonary cancer).

There are also 14 cases of pleural tumours, 7 for each of the two groups; the diagnosis was confirmed in 4 of these cases (2 per group) by post mortem findings (direct, not microscopic examination) and in the remaining cases by clinical and radiological findings.

The distribution of the causes of death is almost identical in the two population groups considered, since from statistical comparison the differences are not significant, with the exception of asbestosis and broncho-pulmonary and pleural tumours taken together ($P < 0.05$).

By constructing an abbreviated mortality table (Table 25) the incidence of broncho-pulmonary and pleural tumours is significantly higher in the Industrial Sector for the age group 70-79 years and for the entire cohort with calculation of X^2. The Cochran test is positive ($P < 0.05$) calculating only the three age groups above 60 years.

These significant differences, which appear both in the total of the causes of death and in the mortality rate, take on an even greater importance when compared with the frequency of pluero-pulmonary tumours among the causes of death in the general male population over the age of 25 years of the City of Genoa in the same decade 1960-1969:

Population of Genoa:	6.07%	Percentage of deaths due to pleuro-pulmonary tumours
Commercial Sector workers:	5.90%	
Industrial Sector workers:	8.48%	

The categories of workers of the Industrial Sector in whom the percentage of pleuro-pulmonary tumours is clearly higher than average are: riveters (picchettini), fitters

aggiustatori), assistant boilermakers (aiutanti metallurgici), joiners (carpentieri), painters (coloritori). Except for the painters, all other workers may have had a more or less intense or prolonged exposure to asbestos fibres during the course of their working life. It should also be noted that in the other job categories of the Industrial Sector, too, the workers may have been exposed to the inhalation of asbestos to a more or less high extent, and probably, on the whole, no less than the more affected categories.

C. La Spezia Naval Arsenal

The planning of a clinico-epidemiological study among the workers of the Naval Arsenal at La Spezia has so far met with unsurmountable difficulties, due above all to the fact that it has proved impossible to obtain the co-operation of physicians and social workers capable of carrying out the research.

D. Taranto Naval Arsenal

Prof. Luigi Ambrosi, Director of the Institute of Occupational Health of the University of Bari, has carried out an epidemiological investigation at the Naval Arsenal of Taranto. At present, about 500 workers are employed at the arsenal on board ships undergoing repair. These workers were divided into three groups: 1) with high risk of asbestosis; 2) with intermittent risk of asbestosis; 3) with minimal or occasional risk. One hundred and ninety-three (193) subjects from the first group have been given chest X-rays, which have been graded according to the Cincinnati Classification. The results are shown in Table 26.

The investigation of the causes of death of workers who had worked at the arsenal has proved very difficult due to the fact that it was impossible to obtain sufficient information from the administrative offices to form the basis of the research. In the last 10 years about 250 workers who had worked on board the ships left their jobs; 32 of these have been traced and they or their relatives interviewed at their homes; 13 have died, none of whom with lung or pleural cancer. An investigation was also made at the municipal offices of Taranto: out of 21 people who died from lung cancer in 12 consecutive months, 7 had worked for more or less long periods at the Naval Arsenal.

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TABLE 1

RESULTS OF NUMERICAL COUNTS OF ASBESTOS FIBRE CONCENTRATIONS IN THE VARIOUS DEPARTMENTS OF THE BALANGERO MINE AND PLANT (1968 – 1970)

Department	Total No. samples	No. Samples			Fibres/ml		
		< 2 fibres/ml	from 2 to 12 fibres/ml	> 12 fibres/ml	Max.	Min.	Arithmetical mean of counts
Mine	36	18	8	10	60	0.2	12.6
Crushing	5	-	2	3	66	5	22.9
Drying	11	-	4	7	42	7	19.4
Plant:							
Grinding	14	-	-	14	156	13	36.5
Filtering & Sieving	29	-	9	20	48	8	20.4
Storage	9	-	1	8	62	12	34.2
Present automatic bagging	28	-	15	13	38	3	23.4
Former manual bagging (reconstructed)	8	-	-	8	109	20	59.1

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TABLE 2

WORKING POPULATION OF BALANGERO MINE WITH MORE THAN ONE MONTH OF SERVICE DIVIDED ACCORDING TO YEAR OF BIRTH

Year of birth	No. workers	No. workers traced (90.8% of total)	No. workers dead	% of deaths in traced workers
Up to 1895	98	88	68	77.3
1896 - 1905	180	166	91	54.8
1906 - 1915	268	242	59	24.4
1916 - 1925	317	276	35	12.7
After 1925	235	226	17	7.5
Total	1098	998	270	26.8

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TABLE 3

NUMERICAL COEFFICIENTS USED TO EVALUATE "RISK INDEX"

Technical Staff	1
Quarry Workers	3
Crushing Department Workers)	
Drying " ")	6
Grinding " ")	
Filtering " ")	
Mixing Department Workers)	
Bagging " ")	10
Fibre Storage " ")	

The "risk index" is obtained by multiplying the length of service (years) by the coefficient of the department in which the worker has worked and adding together the products in the case of subsequent multiple jobs.

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TABLE 4

TRACED WORKERS AND EX-WORKERS OF BALANGERO MINE STRATIFIED BY YEAR OF BIRTH AND RISK INDEX

	Risk Indices						
Year of birth	1 - 10	11 - 20	21 - 40	41 - 80	81 - 160	>160	Total
Before 1890	14	10	5	6	6	-	41
1891 - 1895	14	8	8	8	9	-	47
1896 - 1900	19	4	8	14	12	3	60
1901 - 1905	25	15	18	22	21	5	106
1906 - 1910	28	10	17	20	27	13	115
1911 - 1915	40	15	14	20	27	11	127
1916 - 1920	31	9	12	18	19	15	104
1921 - 1925	74	10	10	29	31	18	172
1926 - 1930	23	10	9	26	27	8	103
After 1930	28	16	11	49	17	2	123
Total	296	107	112	212	196	75	998
Equivalent average death rates per 1000 men - all causes	310.8	411.2	383.9	254.7	147.9	106.6	270.5

TABLE 5

CAUSES OF DEATH AMONG 270 EX-WORKERS OF THE BALANGERO MINE (1932 - 1970)

Cause of death	No.	%
1) Respiratory diseases (except TB & malignancies	34	12.5
2) Tuberculosis	21	7.7
3) Cardio-vascular diseases	71	26.3
4) Malignancies+ a) lung	6	2.2
b) G.I. tract	11	4.1
c) other sites	13	4.8
5) Gastro-intestinal diseases	32	11.8
6) Accidents	59	21.8
7) Other causes	12	4.4
8) Unknown	11	4.1
Total	270	100.0
Mean age	54.2 ± 15.5 (min. 19 y. - max. 86 y.)	

+no cases of mesothelioma

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TABLE 6

COMPARISON BETWEEN CAUSES OF DEATH AMONG EX-MINERS AND AMONG MALE POPULATION OVER 35 YEARS OF BALANGERO AND CORIO FOR THE PERIOD 1960 - 1969

Causes of death	Ex-miners No.	%	Balangero (2874 inhabitants) No.	%	Corio (3003 inhabitants) No.	%
1) Respiratory diseases (except TB & malignancies)	12	9.7	28	16.4	.4	6.1
2) Tuberculosis	4	3.2	-	-	2	0.9
3) Cardio-vascular diseases	49	38.3	87	51.1	151	65.8
4) Malignancies a) lung	6+	4.9	4+	2.3	5++	2.3
b) G.I. tract	6	4.9	5	3.0	7	3.0
c) other sites	8	6.3	18	10.9	17	7.4
5) Gastro-intestinal tract	20	16.0	15	8.8	20	8.7
6) Accidents	13	10.3	3	1.7	5	2.3
7) Other causes	5	4.0	8	4.6	7	3.0
8) Unknown	3	2.4	2	1.2	1	0.5
Total	126	100.0	170	100.0	229	100.0
Mean Age	60.1 ± 12.8 (range 35 - 86)		70.2 ± 11.8 (range 35 - 102)		72.4 ± 10.9 (range 37 - 100)	

+ no cases of mesothelioma

++ 1 case of "tumour of the pleura"

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TABLE 7

LUNG TUMOURS AMONG MALE PATIENTS OVER 35 YEARS ADMITTED TO MEDICAL DEPARTMENTS OF LANZO AND CIRIE HOSPITALS

	1957 - 1959			1967 - 1969		
	No.	With lung tumour		No.	With lung tumour	
		No.	%		No.	%
Lanzo	274	3	1.1	552	6	1.1
Ciriè	209	3	1.0	1040	21	2.0

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TABLE 8

SUMMARY OF DATA CONCERNING 6 CASES OF DEATH FROM LUNG TUMOUR

Case	Age Years	Length of Exposure Years	Interval between start of exposure and death Years	Risk Index	No. cigarettes/day
D.E.	52	7	22	42	> 15
C.V.N.	60	21	25	126	< 15
B.F.	58	2	27	12	< 15
A.G.B.	66	2	27	12	< 15
F.P.E.	50	1	20	4	< 15
V.T.M. +	65	20	25	40	0

+INAIL compensation (45%) for asbestosis; X-ray 1957 = cat. 1/1

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TABLE 9

X-RAY FILM GRADING (CINCINNATI CLASSIFICATION) OF 474 BALANGERO MINERS
(1968 - 1970)
DIVISION BY RISK INDEX

X-ray Category	Risk Index								Totals	
	1 - 20		21 - 80		81 - 160		above 160			
	No.	%	No.	%	No.	%	No.	%	No.	%
0	59	59.6	85	50.6	45	32.8	11	15.7	200	42.3
0/1	24	24.3	42	25.1	41	29.9	25	35.7	132	27.9
1	13	13.1	33	19.7	46	33.7	30	42.9	122	25.7
2	3	3.0	7	4.1	5	3.6	3	4.3	18	3.7
3	-	-	1	0.5	-	-	1	1.4	2	0.4
Totals	99	100.0	168	100.0	137	100.0	70	100.0	474	100.0

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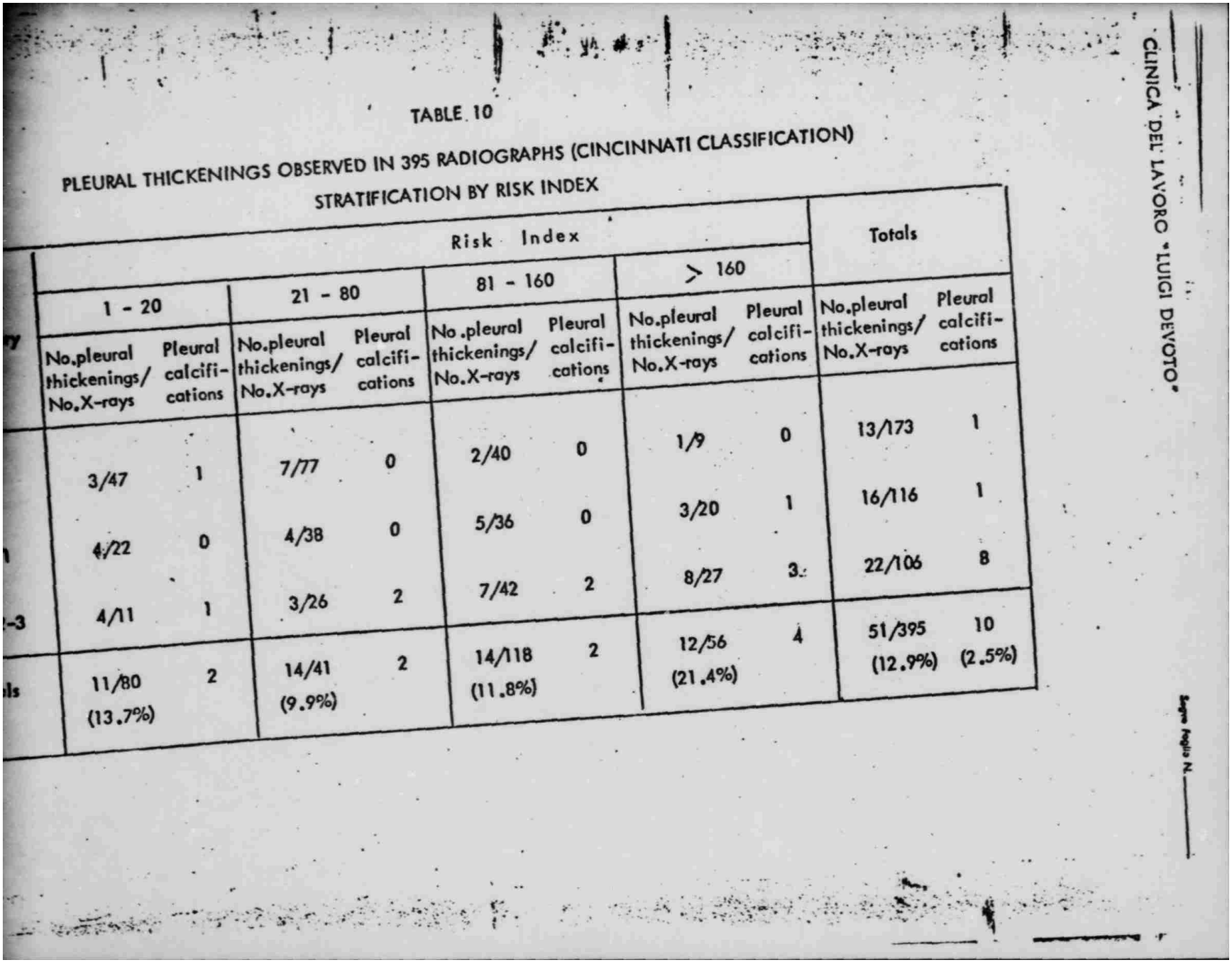


TABLE 10

PLEURAL THICKENINGS OBSERVED IN 395 RADIOGRAPHS (CINCINNATI CLASSIFICATION)

STRATIFICATION BY RISK INDEX

	Risk Index								Totals	
	1 - 20		21 - 80		81 - 160		> 160			
	No.pleural thickenings/ No.X-rays	Pleural calcifi-cations	No.pleural thickenings/ No.X-rays	Pleural calcifi-cations	No.pleural thickenings/ No.X-rays	Pleural calcifi-cations	No.pleural thickenings/ No.X-rays	Pleural calcifi-cations	No.pleural thickenings/ No.X-rays	Pleural calcifi-cations
	3/47	1	7/77	0	2/40	0	1/9	0	13/173	1
	4/22	0	4/38	0	5/36	0	3/20	1	16/116	1
-3	4/11	1	3/26	2	7/42	2	8/27	3	22/106	8
ls	11/80 (13.7%)	2	14/41 (9.9%)	2	14/118 (11.8%)	2	12/56 (21.4%)	4	51/395 (12.9%)	10 (2.5%)

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TABLE 11

SUMMARY OF D_{LCO} RESULTS IN 14 SUBJECTS UNDERGOING REPEATED TESTS

(SUBJECTS WITH D_{LCO} BELOW NORMAL VALUES AT FIRST TEST)

	D_{LCO}						
	At rest			50 Watt		100 Watt	
	1st	2nd	3rd	1st	2nd	1st	2nd
M.B.	8.3	7.7	8.2	24.6	-	35.8	30.4
M.D.	14.4	9.2	8.1	30.3	-	29.6	30.4
V.B.	10.5	9.5	9.7	27.2	-	31.4	28.3
B.C.P.	9.1	9.9	10.6	-	-	-	-
R.G.	11.2	12.8	13.0	29.7	-	30.3	34.0
C.F.	8.2	10.1	12.6	23.8	-	33.7	29.5
M.T.	10.0	7.4	8.5	20.0	-	33.6	24.7
L.G.	17.8	12.0	12.8	30.0	-	28.1	27.4
M.P.	10.0	10.8	11.5	-	-	-	-
A.V.	10.3	8.9	8.2	-	-	-	-
R.R.P.	10.8	12.2	10.7	22.0	-	-	-
V.G.	10.0	10.1	9.8	28.7	-	25.6	-
M.R.	13.3	16.5	15.8	27.5	-	31.5	30.2
L.G.	11.3	14.2	13.3	24.8	24.0	-	-

Between the 1st and 2nd test, interval of over 6 months; between the 2nd and 3rd test, interval of 24 hours on average.

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TABLE 12

PERCENTAGE OF SUBJECTS WITH DEFICIT IN VC, FEV_1, D_{LCO} AT REST AND DURING EXERCISE.

X-ray Category	VC		FEV_1		D_{LCO} at rest		D_{LCO} 50 Watt		D_{LCO} 100 Watt	
	No. cases	% with deficit	No. cases	% with deficit	No. cases	% with deficit+	No. cases	% with deficit+	No. cases	% with deficit+
0	162	21.6	162	22.2	164	11.6	136	5.9	124	7.2
0/1	114	34.2	114	36.8	113	13.3	87	5.7	71	11.3
1	91	46.2	91	48.4	92	18.5	70	17.3	56	19.6
2 - 3	11	100.0	11	81.8	11	54.5	4	50.0	4	25.0

+ Subjects with D_{LCO} values below lower normal limits according to Sartorelli et al., respectively: 11.6 (at rest), 24.4 (50 W), 31.0 (100 W) ml/min/mm Hg.

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TABLE 13

MEAN AND STANDARD DEVIATION OF AGE, OF DURATION OF EXPOSURE, AND OF REDUCTION % IN VC AND FEV_1

X-Ray Category	0/0 - 0/1	0/0 - 0/1	1 - 2 - 3
	Exposure $\leq$ 10 y.	Exposure $>$ 10 y.	
Age	43.0 ± 13.4 (n = 124)	49.6 ± 9.8 (n = 143)	52.2 ± 10.4 (n = 100)
Duration of Exposure	5.6 ± 2.8 (n = 124)	22.1 ± 6.2 (n = 143)	18.9 ± 10.3 (n = 100)
Reduction % VC	- 10.4 ± 10.4 (n = 123)	- 17.9 ± 12.4 (n = 143)	- 21.3 ± 10.7 (n = 98)
Reduction % FEV_1	- 10.5 ± 10.9 (n = 123)	- 19.3 ± 16.7 (n = 143)	- 20.4 ± 10.1 (n = 98)

TABLE 14

MEAN AND STANDARD DEVIATION OF DURATION OF EXPOSURE AND OF D_{LCO} VALUES

(in ml/min/mm Hg)

X-Ray Category		0/0 - 0/1		1 - 2 - 3
	Non-exposed (controls) a	Exposure ≤ 10 y. b	Exposure > 10 y. c	d
Age	-	43.0 ± 13.4 (n = 124)	46.6 ± 9.8 (n = 143)	52.2 ± 10.4 (n = 100)
Duration of Exposure	0	5.6 ± 2.8 (n = 124)	22.1 ± 6.2 (n = 143)	18.9 ± 10.3 (n = 100)
D_{LCO} at rest	21.0 ± 7.0 (n = 123)	20.5 ± 7.9 (n = 122)	17.7 ± 7.4 (n = 142)	16.7 ± 6.8 (n = 99)
D_{LCO} 50 W	39.7 ± 7.5 (n = 123)	36.4 ± 9.0 (n = 103)	33.1 ± 7.4 (n = 110)	31.9 ± 8.8 (n = 71)
D_{LCO} 100 W	49.3 ± 8.4 (n = 123)	44.8 ± 9.7 (n = 96)	40.3 ± 7.9 (n = 139)	39.3 ± 8.9 (n = 58)

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TABLE 15

PERCENTAGE OF CASES OF CHRONIC BRONCHITIS STRATIFIED BY X-RAY FILM CATEGORY AND TIME ELAPSED SINCE BEGINNING OF EXPOSURE

X-ray category	Time elapsed				Totals
	1 - 10 y.	11 - 20 y.	21 - 30 y.	over 30 y.	
0	3.3	-	27.4	41.1	19.0
0/1	5.2	18.1	33.9	43.3	30.1
1-2-3	22.2	22.2	29.3	40.0	31.1
Totals	5.7	10.5	30.1	41.4	25.5

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TABLE 16

PERCENTAGE OF CASES OF CHRONIC BRONCHITIS STRATIFIED BY X-RAY FILM CATEGORY AND RISK INDEX

X-ray category	Risk Index				Totals
	1 - 20	21 - 80	81 - 160	> 160	
0	12.7	16.8	32.5	11.1	19.0
0/1	13.6	23.6	30.5	60.0	30.1
1-2-3	9.0	26.9	43.8	25.9	31.1
Totals	12.5	20.3	35.5	35.7	25.5

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TABLE 17

PERCENTAGE OF CASES OF CHRONIC BRONCHITIS STRATIFIED BY X-RAY FILM CATEGORY AND DURATION OF EXPOSURE

X-ray Category	Duration of Exposure				Totals
	up to 10 y.	11 - 20 y.	21 - 30 y.	over 30 y.	
0	13.4	17.8	30.2	40.0	19.0
0/1	9.5	40.0	40.0	75.0	30.1
1-2-3	21.4	38.0	31.1	41.0	31.1
Totals	13.7	31.8	33.8	47.6	25.5

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TABLE 18

SMOKING HABITS AND CHRONIC BRONCHITIS
STRATIFIED BY X-RAY FILM CATEGORY

X-ray category	Non-smokers		Smokers				Totals	
			Up to 15 cig/day		Over 15 cig/day			
	No.	% bronchitics	No.	% bronchitics	No.	% bronchitics	No.	% bronchitics
0	61	8.1	79	26.5	33	21.2	173	19.0
0/1	43	25.5	57	35.0	16	25.0	116	30.1
1-2-3	38	26.3	53	35.8	15	26.6	106	31.1
Totals	142	18.3	189	31.7	64	23.4	395	25.5

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TABLE 19

PERCENTAGE OF CASES WITH RALES STRATIFIED BY X-RAY FILM CATEGORY AND RISK INDEX

X-ray category	Risk Index				Totals
	1 - 20	21 - 80	81 - 160	over 160	
0	4.2	3.8	15.0	22.2	7.5
0/1	9.0	3.1	16.6	45.0	18.9
1-2-3	9.0	19.2	28.5	40.7	27.3
Totals	6.5	9.2	20.3	39.2	16.2

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TABLE 20

PERCENTAGE OF CASES WITH RALES STRATIFIED BY X-RAY FILM CATEGORY AND DURATION OF EXPOSURE

X-ray category	Duration of Exposure				Totals
	up to 10 y.	11 - 20 y.	21 - 30 y.	over 30 y.	
0	4.1	7.1	11.6	40.0	7.5
0/1	4.7	20.0	33.3	-	18.9
1-2-3	10.7	28.5	31.1	50.0	27.3
Totals	5.3	17.5	25.5	38.0	16.2

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TABLE 21

PERCENTAGE OF CASES WITH RALES STRATIFIED BY X-RAY FILM CATEGORY AND TIME ELAPSED SINCE BEGINNING OF EXPOSURE

X-ray category	Time elapsed				Totals
	up to 10 y.	11 - 20 y.	21 - 30 y.	over 30 y.	
0	1.6	5.5	12.9	8.8	7.5
0/1	-	9.0	23.2	26.6	18.9
1-2-3	-	33.3	25.8	36.6	27.3
Totals	1.1	13.1	20.4	23.4	16.2

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TABLE 22

MORTALITY FOR ALL CAUSES

31 December 1959	Commercial Sector					Industrial Sector					Values of P
	Mean Age at 31 December 1959	Number	% of Total	Deaths 1960-1969	Equivalent average death rates per 1000 men - 1960-1969	Mean Age at 31 December 1959	Number	% of Total	Deaths 1960 - 1969	Equivalent average death rates per 1000 men - 1960-1969	
- 49	37.98	2440	43.61	37	15.16	40.25	907	36.54	26	28.66	0.025
- 59	54.76	1211	21.64	165	136.25	54.68	676	27.23	125	184.91	0.01
- 69	63.59	1097	19.61	405	369.18	63.99	527	21.24	230	436.43	0.025
- 79	75.56	643	11.49	415	645.41	73.73	265	10.68	190	716.98	0.05
+	83.14	204	3.65	181	887.25	82.91	107	4.31	89	831.77	N.S.
ls	52.60	5595	100.00	1203	215.01	54.63	2482	100.00	660	266.31	0.001

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TABLE 23

SOURCE OF DIAGNOSES

	Commercial Sector		Industrial Sector	
	No.	%	No.	%
ISTAT Cards	786	63.34	314	56.42
Hospital Files	263	21.86	214	32.42
Post Mortem Findings	40	3.33	41	6.21
Information from family doctor	4	0.33	2	0.30
Information from relatives	23	1.91	2	0.30
Undefined diagnoses	87	7.23	31	4.70
	1203	100.00	660	100.0

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TABLE 24

DISTRIBUTION OF CAUSES OF DEATH

Cause of Death	Commercial Sector		Industrial Sector	
	No.	%	No.	%
Asbestosis	-	-	6	0.91
Pulmonary TB	32	2.66	17	2.53
Malignancies:				
Lung	64	5.32	49	7.42
Pleura	7	0.58	7	1.06
Mouth, nose, pharynx, larynx	26	2.16	13	1.97
G.I. tract	91	7.56	53	8.03
Undefined abdominal	5	0.42	7	1.06
Other sites	74	6.15	45	6.82
Chronic respiratory diseases	67	5.57	31	4.70
Acute respiratory diseases	72	5.99	32	4.85
Cardiovascular diseases	513	42.64	280	42.42
Accidents	25	2.08	16	2.42
Other causes	138	11.47	69	10.46
Unknown causes	89	7.40	35	5.30
Total	1203	100.00	660	99.93

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TABLE 25

MORTALITY FROM BRONCHO-PULMONARY AND PLEURAL TUMOURS

Age Groups at 31 December 1959	Commercial Sector			Industrial Sector			Values of P
	Number	Deaths 1960-1969	Equivalent average death rates per 1000 men - 1960 - 1969	Number	Deaths 1960-1969	Equivalent average death rates per 1000 men - 1960-1969	
≤ 49	2440	1	0.40	907	-	-	N.S.
50 - 59	1211	31	25.59	676	20	29.58	N.S.
60 - 69	1097	29	26.43	527	18	34.15	N.S.
70 - 79	643	9	13.99	265	15	56.60	<0.001
80 +	204	1	4.90	107	1	9.34	N.S.
Totals	5595	71	12.69	2482	54	21.76	<0.01

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TABLE 26

X-RAY FILM GRADING OF 190 WORKERS AT TARANTO NAVAL ARSENAL

X-ray Category	Total Cases No.	%	With pleural calcif. No.
0, 0/0, 0/1	107	56.4	1
1/0, 1/1, 1/2	66	34.7	4
2/1, 2/2, 2/3	17	8.9	1
Total	190	100.0	6

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