Estimated risk assessment of the exposed to asbestos

Angela Sancini¹
Simone De Sio¹
Manuela Ciarrocca¹
Mario Fioravanti²
Giorgia Andreozzi¹
Ottavio Sarlo³
Raffaele D’Amelio³
Alessio Anselmi⁴
Enrico Mascia⁵
Giuseppe De Lorenzo⁶
Enzo Ferrante⁷
Fabio Gaudioso⁸
Alessandro Ruocco⁹
Vittorio Zelano³
Teodorico Casale¹
Roberto Giubilati¹
Benedetta Pimpinella¹
Francesco Tomei¹
Gianfranco Tomei²

¹Department of Anatomy, Histology, Medical-Legal and the Orthopaedics, Unit of Occupational Medicine, “Sapienza” University of Rome, Italy
²Department of Neurology and Psychiatry, “Sapienza”. University of Rome, Italy
³General Direction of Military Health
⁴Aesenal M.M. – La Spezia (CO.CE. R – Interforce)
⁵Second Istance Medical Commission MM, Bari, Italy
⁶Armed Force General Command CC – Health Department
⁷Respiratory Pathophysiology Service-Cardiorespiratory Disease Department - Policlinico Militare Rome
⁸Sanitary Department Naval Base-Augusta
⁹Primary Nursing A.M.

Corresponding Author:
Gianfranco Tomei
Department of Neurology and Psychiatry, “Sapienza” University of Rome
E-mail: gianfranco.tomei@uniroma1.it

Summary

Objectives: the purpose of this study is the develop of an algorithm based on the findings of occupational anamnestical information provided by a group of workers.

Methods: four dimensions are analyzed and described: 1) present and/or past occupation; 2) type of materials and equipment used in performing working activity; 3) environment where these activities are carried out; 4) period of time when activities are performed.

Results: from the combination of the four identified dimensions it is possible to have 108 ELSA codes divided in three typological profiles of estimated risk of exposure.

Conclusions: the application of the algorithm offers some advantages compared to other methods used for identifying individuals exposed to asbestos because the ELSA Code takes in account other indicators of risk besides those considered in the Job-Exposure Matrix (JEM).

KEY WORDS: asbestos, algorithm, exposure, environment.

Introduction

The term asbestos indicates a number of fibrous silicates that belong to two different metamorphic rocks: serpentine and amphibole (1, 2). Both the serpentine and the amphibole can release fibers that are pathogenic to humans, mostly causing non-neoplastic lung diseases such as pleural plaques, pleural effusions, round-ed alektasis, specific fibrotic disease (asbestosis), damaged lung function but also cancers in different areas (e.g. pleural mesothelioma, lung cancer) (3-10).

Asbestos was declared a carcinogenic agent to humans by the U.S Environmental Protection Agency (11), and the International Agency for Research on Cancer (12), its dangerous effect has been strongly documented in scientific literature. After these evidences, many countries have banned the use of such material (13).

Different methods are used in literature about the risk assessment of exposure to asbestos, but none of these appears to be universally shared by researcher on this issue. These methods consist of: 1) assessment by an expert, 2) evaluation of aero-dispersed fibers in the workplace (14-16), 3) administration of aimed questionnaires (17-19), 4) analysis of the working life by the construction of exposure matrices (20, 21).

1. The expert evaluation is based on different parameters like the performance of a task in a specific industry (18, 22), the arbitrary assigning, often not supported by reliable data, of a score for the intensity of exposure during the task (23), the duration of the job at risk (24).

2. As to the procedures for the evaluation of aero-dispersed fibers in the workplace, although objective, they show restrictions linked to the time and to the space of execution and they do not include individual
exposures of subjects. While taking into account individual exposures, individual dosimetry is the measure of a limited period of time and is not useful to observe long exposures such as the ones asbestos requires (15, 25, 26).

3. As to questionnaires, they appear to be highly heterogeneous both for the modalities and accuracy of collecting information (14, 17, 27-30). In studies using questionnaires, the classification of acquired information is usually based on the individual expert evaluation which is a procedure poorly reproducible and repeatable (27, 30-33).

4. The assessments based on the construction of the employment matrices (Job-Exposure Matrix JEM) correlate the level of asbestos exposure not only to the task, but also to the productive sector where it is performed and they are typically constructed around two dimensions: the specific job and the exposure. The exposures considered may be expressed in different ways, by exposure class or by another simple criteria that is the “present / not present” exposure, depending on the purpose for which any matrix is constructed. In literature, the professions and the economic activities are often classified by using international standard codes (e.g. ISIC International Standard Industrial Classification). JEM are usually made on these codes and associate each occupation with the corresponding evaluation of exposure to any particular substance: all this in order to facilitate the use of JEM in the international standard method. The exposure assessments of each substance are based on measurements and/or data present in the literature, studied and evaluated by special groups of occupational medicine experts.

There are different JEM, created and available from various organizations of different countries, their use is very common for the identification of exposed and unexposed personnel, in order to execute epidemiological studies, which are an instrument ready to use, providing an initial estimation of the correlation between the profession and exposure to each specific substance, in the absence of data on concentration measures (environmental sampling and / or personal) (6, 8, 21, 34-37). It should be noted that JEM take into account only marginally other risk factors such as materials and equipment used while performing the work. In addition, it is important to notice that: a) the revision of data present in scientific literature indicates that the latent period for asbestos-related disease onset is variable, but anyway long-term, even 30-40 years for the onset of mesothelioma of the pleura (1, 9, 10, 38) b) there are many data reported in scientific literature about the excess of diseases in workers exposed to asbestos (39-41); c) the Italian Armed Forces sensitive to these issues, have thought it necessary to undertake and finance a research project with the University of Rome “Sapienza” for monitoring the effects on the health of its workers exposed to asbestos; this research project entitled “Study of indicators for Asbestos Related Diseases In the Armed Forces working categories” is addressed to the military and civilian staff who voluntarily, want to join; d) considering the length of latency periods the attention of researchers, doctors and everyone involved in this issue, is aimed to find a method to evaluate the probability and the amount of exposure over the years, in order to carry out an adequate “monitoring” the exposed workers’ health.

On the base of critical review of the works on exposure matrices we thought it necessary to develop a method which could include other elements of risk assessment gathered from the examination of international scientific literature already published (42).

The aim of our work is to build an algorithm, constructed on the results of anamnestic information provided by workers through a specially designed questionnaire. The algorithm is intended to discriminate in a probabilistic way, the risk of exposure by assigning a code to every worker (ELSA code - Exposure to Asbestos Estimated Work). The construction of the algorithm has been performed in order to minimize the possibility that a more exposed subject is classified as less exposed and vice versa.

This algorithm will be useful in conducting retrospective studies on previous exposures and in the evaluation of current exposures. Although the construction of this algorithm comes from the project sponsored by the Armed Forces it can be adapted to evaluate the risk of asbestos in other working situations.

Methods

We conducted a search of articles published from 1953 until July 2008, on the major on line search engines available, such as Pubmed, Toxline, EMBASE, Scopus, Google Scholar, Biomed Central, Biosafety-2, and consulted the conference proceedings organized by the national SIMLII (Italian Society of Occupational Medicine and Industrial Hygiene), INAIL (National Institute for Insurance against Accidents at Work) and ReNaM (National Register of Mesothelioma), in order to establish a database containing all studies present in literature on occupational exposure to asbestos. This search, of more than thousand articles, allowed to create a database containing about 650 articles.

Later, we made two meta-analysis and a synthetic-critical analysis of the information included in the database (9,10). All elements were synthesized in a questionnaire made of 90 anamnestic and clinical items, administered to the employees of the Armed Forces joining the project. Most of these items were aimed to get information on health status, on habits and lifestyle, on working history, etc., and 9 items were specific to the construction of the algorithm.

To organize the algorithm, we investigated risk factors such as: 1) the task, 2) the risk concerning the equipment and the materials used for performing the task, 3) the risk in the environment where the task was carried out and 4) the duration of task. This information is obtained with administration of a specially designed questionnaire and is organized in the four different areas identified above. Each information obtained from one of the four areas, is summa-
rized in the four dimensions which compose the ELSA code. A binary or ternary code to fix each dimension, was used according to the nature of the variables that determine the size of the risk.

The ELSA code thus obtained, is allocated in one of the following 3 profiles of estimated exposure risk:

1. Present Systematic risk;
2. Present Unsystematic risk;
3. Little risk or no risk at all.

In the typological profile "present Systematic risk", we will include only ELSA codes for which the risk of the presence of asbestos in each dimension cannot be defined to be low or absent, in the typological profile "no risk or low-density" we will include ELSA codes where the risk of the presence of asbestos in each of the dimensions can not be considered high.

The code is unique for each current and/or previous task carried out, and for this reason if a worker carries out more than one work, he will be associated to as many ELSA code as the number of tasks performed. To protect the health from the effects induced by exposure to asbestos the most risky ELSA code will be considered in giving the worker his typological profile.

Each of the four dimensions of the ELSA code are now analyzed and described.

2.1 First dimension of the ELSA code – task

To identify the first dimension of ELSA code, we carried out the analysis of the information in our database and the consultation of the occupational exposure matrix (JEM Job Exposure Matrix).

The JEM are databases designed to evaluate and quantify the correlations between occupations, work activities and tasks with the risks of exposure to any substances.

They are typically constructed around two dimensions, the occupation and the exposure, and are represented by alphanumeric codes.

Among the various available JEM, we consulted:

- Evalutil, developed by the French Institute of Public Health, Epidemiology and Development (Institut de Santé Publique de Developpement et d’Epidemiology ISPED) with the University Victor Segalen Bordeaux 2, in Bordeaux (43,ISPED; INVS), which analyzes in the specific asbestos section thousands of literary studies, evaluating for each task the percentage of exposed, exposure intensity and duration of exposure as a percentage of total working time;
- FINIJEM, developed by the Finnish Institute of Occupational Health (Finnish Institute of Occupational Health FIOH) with the aim of assessing occupational exposures within epidemiological studies (DORS, 44, FIOH);
- Aloha, developed by the Institute for Risk Assessment Sciences, Utrecht University, to evaluate exposure to various substances involved in the onset of respiratory disorders (DORS);
- CAREX, prepared by the European Union to provide an estimation of the number of workers exposed to carcinogenic agents in the different EU countries (45, 46);
- Matlin Prior, financed by the Regional Centre for Epidemiology and Environmental Health of the Region of Piemonte (DORS; Matlin);
- AMYANT, prepared by INAIL CONTARP, and developed to calculate a presumed annual exposure in ft²/ cc according to two dimensions: exposure time and specific work carried out. The exposure for each process is derived from scientific literary data or from environmental assessments "in the field", often conducted by INAIL-CONTARP;
- U.S. N.O.E.S. (National Occupational Exposure Survey USA) by the NIOSH, aimed to provide an estimation of the number of workers for each economic activity and exposed to each detected substance (DORS; NOES).

It is evident that the consultation of the JEM is useful to estimate "theoretical" risk of exposure for each work task. In our study we decided to use the information of the JEM together with the news of our database, in order to construct the first dimension of ELSA code. For instance, the task "administrative," which is a "not risky function", according to JEM analysis and to our database, was classified as “1”.

Same criteria were adopted for the classification of other tasks.

In the questionnaire, the worker is asked, the type of task present and/or past carried out; then tasks are classified by assigning number (1-2-3-4) increasing according to the probability of exposure to asbestos. So, for instance, a worker who is or was assigned to administrative activities of VDT is rated “1", a worker who is or was assigned to the activity of stocking and inventory of goods is rated “2”, a worker who is or has been assigned to the task of mechanical engines of heavy vehicles “3", a worker who is or has been assigned to manufacturing thermal insulating material for thermal insulation “4". The actual exposure will be evaluated: e.g., if a worker is or was a mechanic of heavy vehicles produced after asbestos was banned, his task will be classified as “1", “2" instead of “3" or vice versa.

To determine the first dimension of the code, the number correlated to the job (or tasks) with the highest risk class will be taken into account (if a worker carries out the job of Employee of the administrative department in charge of correspondence - risk class 1 - and also the task of insulated tubing Employee - risk class 4 -, the first dimension of the code that will be assigned to employee will be number 4).

Later on the Technical Committee, in order to adapt the algorithm to the working environment of the Armed Forces, made the correspondence of the task of military personnel to those classified as above, for instance the mansion administrative officer of employee VDT was paired to the task of computer operator and classified “1”; similarly personnel employed in the manufacturing of thermal insulating materials was paired the task of “equipment technician", and classified “4".

Tasks classified as “4" are those where the exposure to asbestos can not be excluded, and therefore, they are the highest category of risk.

2.2 The Second dimension of ELSA code-RISK “environmental"

To the identify the second dimension of ELSA code, the questionnaire includes items that provide information about:
Table 1 - The second dimension of ELSA code-RISK: “environmental”.

<table>
<thead>
<tr>
<th>Presence of Dust</th>
<th>Probability of Exposure</th>
<th>Probability of Exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>P+ (presence of dust)</td>
<td>E+ (high)</td>
<td>E- (low)</td>
</tr>
<tr>
<td>P- (absence / minimal presence of dust)</td>
<td>E+ (M)</td>
<td>E- (M)</td>
</tr>
</tbody>
</table>

Table 2 - The third dimension of ELSA code - risk of equipment, materials and maintenance.

<table>
<thead>
<tr>
<th>Machinery</th>
<th>Maintenance</th>
<th>Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>M+</td>
<td>M-</td>
<td>Am+Am-</td>
</tr>
<tr>
<td>M+</td>
<td>M-</td>
<td>Am+Am-</td>
</tr>
<tr>
<td>1</td>
<td>1M + Am+ (A)</td>
<td>1M - Am+ (M)</td>
</tr>
<tr>
<td>1</td>
<td>1M + Am- (B)</td>
<td>1M - Am- (B)</td>
</tr>
<tr>
<td>2</td>
<td>2M + Am+ (A)</td>
<td>2M - Am+ (M)</td>
</tr>
<tr>
<td>2</td>
<td>2M + Am- (B)</td>
<td>2M - Am- (B)</td>
</tr>
</tbody>
</table>

- for maintenance and / or repair of equipment or materials containing asbestos such as crushing for elimination of asbestos, or containment and encapsulation activities classified M+; 
- no maintenance carried out, classified M-.

2.4 The fourth dimension of time-code ELSA

Once the first 3 dimension codes are fixed the algorithm requires the identification of the fourth dimension, that is the duration of exposure. The exposure period is calculated in months, summing exposure time of the tasks performed with the highest risk class (corresponding to the code assigned to the employee for his task, according to the criteria described above, the same is done, for the second dimension (work environment) and the third dimension (Machinery and Materials).

E.g. if an employee with ELSA code 4A1M2- performed 3 tasks (ONE SIZE): the first at risk 4 for 24 months, the second at risk 1 for 10 months and a third one at risk 4 for 12 months, the duration of exposure on the first dimension (work) is the sum of tasks performed at risk class 4 – in this example the duration will be 36 months, in the same way all months he spent in a workplace with risk class A (second dimension) (e.g. 24 months) and used equipment and materials with M class of risk (third dimension) (e.g. 12 months) are summed.

At the end of this evaluation process, we have “3 times” duration, 36 months for the job, 24 months for the environment; 12 months for machinery and materials. Only the longest duration at the highest risk (36 months) will be taken into consideration. This period determines the FOURTH DIMENSION according to these principles: Class A3 for duration > 10 years (high duration), Class M3 for duration between 2 and 10 years (average), Class B3 for exposure duration < 2 years (low duration).

In this case is class M3. So the final code assigned to the employee of the example above is: 4AMM. In case the duration taken into consideration for the assignment of the code is classified on a minimum level...
of risk dimension, the code assigned to this duration is always B.

For the time used in performing the task (for short “duration of task”), we identified three conventional classes: Class A job length > 10 years (high duration of the task) (Decree Ministry of Labour and Social Policy No. 16179 of October 27, 2004; 51), Class M job length between 2 and 10 years (average duration of job), Class B job length <2 years (low duration of the task) (52-54).

No ELSA code class of duration of exposure “B” is included in the profile “present systematic risk”, differently, the profile “little risk or no risk at all” can include ELSA codes with class duration of exposure “A”, as long as it is associated to risk of the task “1” and no risk class “A” is in the other two dimensions.

Furthermore, for subjects with more tasks, the duration of exposure becomes cumulative for the tasks in the same class of risk, (that is the durations of exposure of each task are to be summed).

To identify the fourth dimension of ELSA code it is necessary to make some considerations about the mesothelioma. Some studies in literature say that the process by which the inhalation of fibers influences the development of mesothelioma occurs shortly after the beginning of exposure, that subsequent exposures give a relatively little increment to the risk, and that the first two years of working exposure are sufficient to trigger the mesothelioma (52-54).

Other authors suggest, on the contrary, that with the increasing of exposure incidence of mesothelioma grows too; that is doses of exposure are cumulative (55, 56).

At present, only for the pleural mesothelioma disease some authors give no importance to duration exposure. Epidemiological data is underline how important the duration of the interval between exposure and the detection of the clinical condition of the employee is as a risk factor. Latency time between the contact with asbestos fibers and the onset of mesothelioma is quite long (51).

Results

From the combination of the four dimensions 108 ELSA codes can be identified. These codes are divided in three typological profiles of estimated risk of exposure (Tab. 3): little risk or no risk at all, non-systematic risk, systematic risk present.

Discussion

There is not a generally shared method in literature by which it is possible the identification of individuals exposed to asbestos and the classification into classes of exposure intensity. Most of the studies identify exposed to asbestos through questionnaires and through assessment of an expert (27, 30, 31, 57-59).

ELSA code was obtained through a synthesis of information that international scientific literature identifies as most predictive for the onset of asbestos-related disorders such as type of job performed (present and/or past), type of materials and equipment used at work, environment where work takes place and span of time when work is done. Although this information is obtained subjectively by administering a specially constructed questionnaire to the employee, the process by which a worker is allocated in one of three categories of risk exposure is objective because based on a systematic evaluation of the presence

Table 3 - The combination of the four dimensions 108 ELSA codes can be identified.
of asbestos in each of the four investigated areas of risk. A worker is placed in the category “systematic risk” only if each one of the four dimensions can be considered positive with reasonable certainty. So a worker is classified in the category “little risk or no risk at all” when exposure is little, with absolute certainty, for each of the four dimensions considered. Therefore we consider the first subject “positive” for exposure and the second “not positive” for exposure. The algorithm allows to identify ELSA codes for any different task performed by the worker and therefore to attribute the highest risk code to the worker. According to further studies, for the validation of the algorithm, it could be possible a graduation of risk and the possibility to give different weight to the four dimensions that make up the algorithm.

Conclusions

We believe that the application of our algorithm allows to obtain some advantages over methods that are currently used in scientific literature for the identification of people exposed to asbestos and can be summarized as follows:

examples of application of the ELSA code: a code 4AAA is a worker who carried or has carried out a job at high risk of exposure to asbestos (a maintenance and custody Officer of structures containing asbestos), with a high degree of environmental risk (a worker in shipyard, with the presence of dust), with a high degree of risk associated with materials and equipment used (containing asbestos) and whose activity has gone on for more than 10 years;
1. the application of the algorithm can be made in situations of exposure to asbestos through retrospective evaluation of occupational anamnesis for present or previous exposures;
2. the classification of workers exposed to asbestos by assigning ELSA code is more detailed than that obtained through the use of the JEM, which we integrated from our database, because ELSA code takes in account other risk descriptors a part from task such as materials and equipment used, environmental risk and duration of exposure;
3. once validated and confirmed, ELSA code can be used for the purposes of epidemiological research on the development of diseases and / or asbestos-related disorders.

References


