

## Choice of rating method for assessing occupational asbestos exposure: study for compensation purposes in France

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**Conflict of interest:** none

**Number of words:** abstract: 248; text: 3 901

## **ABSTRACT**

### **Background**

In the course of setting up the National Mesothelioma Surveillance Program (PNSM), established in France in 1998, the question arose as to the most suitable method of assessing occupational exposure. The aim of this study was to define the most suitable rating method for assessing occupational asbestos exposure in order to assess medico-social care.

### **Method**

The study included 100 subjects — 50 cases of mesothelioma and 50 controls — randomly selected and representing 457 jobs held. Job asbestos exposure was assessed by a six-expert panel using two methods: “by job” rating, where all the jobs in were assessed regardless of the subjects; and “by subject” rating, where all the jobs of a subject were assessed at the same time. Consensus was obtained and subjects’ exposure was calculated for each rating. Then, two internal experts assessed job asbestos exposure with the “by subject” rating. Kappa coefficients were used to measure agreement between the ratings.

### **Results**

Agreement between “by job” and “by subject” ratings was very good for subject probability of exposure (kappa=0.84) and cumulative exposure index (kappa=0.80). Agreement between the six-expert panel and the two internal experts was good for subject exposure (kappa for probability=0.71; kappa for cumulative exposure index= 0.68).

### **Conclusion**

This study shows that the two rating systems have good or very good agreement. These results validate the routine use in the PNSM of the “by subject” rating, with the advantage of being convenient and quick to provide feedback on occupational asbestos exposure to mesothelioma cases for compensation.

**Key words:** rating method, occupational exposure, asbestos, experts, kappa coefficient

## INTRODUCTION

In case-control studies using questionnaires, occupational exposure to harmful substances can seldom be quantified from industrial hygiene samples. To date, three main methods for the retrospective assessment of occupational exposure have been considered acceptable: assessment of job history by one or several experts, application of a job-exposure matrix and self-reporting by the subject. Several earlier comparative studies concluded that assessment was more valid when based on information given by the subject regarding his job history and knowledge provided by industrial hygiene experts [McGuire, et al. 1998; Nam, et al. 2005; Teschke, et al. 2002]. Using only the subject's self-report was also judged insufficient for an assessment [Fritschi, et al. 1996] while the job-exposure matrix was not as effective as the experts in producing an assessment of standard exposure without also taking into account the detailed job description given by the subject [Kauppinen 1994].

In 1998, the National Mesothelioma Surveillance Program (PNSM) was set up in France. One of its aims was to assess medico-social care. [Goldberg, et al. 2006]. In France, mesothelioma is recognized as an occupational disease by the social services if the case was occupationally exposed to asbestos. In the context of PNSM, all incident cases of mesothelioma are interviewed using a standardized questionnaire to assess occupational exposure. When the PNSM protocol was defined, the question arose as to the most suitable method of assessing occupational exposure, taking into account both the validity of exposure assessments and practical matters, such as the complexity of the procedures and the optimal use of limited industrial hygiene expertise resources.

A method was needed that was reliable and that provided quick feedback on occupational exposure to mesothelioma cases for compensation. As the PNSM collected detailed job histories, we decided to test two assessment methods using a case-by-case assessment by a panel of six experts: (a) rating "by job" which has been used in a previous study [Iwatsubo, et al. 1998] but requires assessment to be done at the end of the data collection, and (b) rating "by subject", in which information is assessed as soon as it is collected so that the subjects may be informed of their status as quickly as possible.

A second objective was to compare the result obtained using the rating "by subject" according to the same panel of six experts versus a panel of two internal experts of our laboratory.

To our knowledge, no study to date has compared the exposure assessment performance of these two rating methods. The aim of this paper was to study agreement in assessment of occupational

asbestos exposure between these two methods in order to define the most suitable routine method for the PNSM.

## **MATERIAL AND METHODS**

### **Study design**

The PNSM and the case-control study have already been described in previous articles [Goldberg, et al. 2006; Rolland, et al. 2010]. Data were collected in two stages. First, a self-assessment questionnaire was mailed so that subjects could provide details of their job history, places they had lived and schools they had attended. For each job, information was collected on the industry and the subject's occupation. A job was defined by occupation and industry: for example, welder in shipbuilding. Next a trained interviewer went to the subject's home to complete the self-assessment questionnaire. The subject described the tasks carried out and the materials used for each job he/she did. The subject was then interviewed using a second more specific questionnaire, which included questions on the use of specific materials (man-made mineral wools, asbestos, etc.) and on performing specific tasks (insulating, using friction materials, etc.). Each affirmative response was linked to the jobs where the materials were used or the tasks were performed. Finally, the interviewer noted the subject's medical history and that of his/her family. The subjects' job histories were coded according to national and international classifications: occupations according to the French nomenclature of occupations and socioprofessional categories (PCS, 1994 edition) [INSEE 1994] and the International Standard Classification of Occupations (ISCO, 1968 edition) [ILO 1968]; and industries according to the French nomenclature of activities (NAF, 1992 edition) [INSEE 1992] and the International Standard Industrial Classification (ISIC, revision 2) [UNSO 1968]. Questionnaires were coded on their quality of completion and the quality of reported information with three levels of each indicator: 1: poor; 2: moderate; 3: good.

### **Sample**

We conducted the study with 100 subjects — 50 cases of mesothelioma and 50 controls — randomly selected by drawing lots from the 371 cases and 732 controls included in our case-control study [Rolland, et al. 2010]. Two controls per case were selected from the electoral rolls matched for sex, age and district of residence. Informed consent was obtained from participants to be included in

PNSM. These 100 subjects represented a total of 457 jobs in all (248 jobs of cases and 209 jobs of controls).

## **Ratings**

Two retrospective rating methods were used on the same questionnaires. These are shown in Figure 1. The rating “by job”, which was carried out first, was selected as the method of reference as it had been used in an earlier study performed by our team [Iwatsubo, et al. 1998]. This rating consisted in assessing all occupations within an industry independently of the subjects. Jobs were sorted in increasing order according to the ISIC code, and then according to the ISCO code. For example, welders in the boiler industry were assessed together, then welders in shipbuilding. With this method, the expert was able to establish a “standard” exposure assessment for each job, then to adjust it depending on the complementary information available in the questionnaire given by the subject.

The second rating “by subject” was the method tested here. It consisted in assessing the full job histories of the subjects one after another. Jobs were sorted in chronological order for each subject.

## **Assessment of exposure**

In a first step, a panel of six experts was formed for the purpose of the study: two industrial hygienists, two occupational physicians, an ergonomist and a toxicologist. They were chosen because they had a number of years' experience in assessing different types of occupational exposure. The etiological factors assessed were: asbestos, man-made mineral wools, refractory ceramic fibers and ionizing radiation. This paper covers only results relating to the assessment of occupational exposure to asbestos.

The two rating methods were implemented by experts blinded to the case-control status of the subjects and using the same procedure of exposure assessment. Each rating was done in two days one month apart. Two coordinators directed the procedure. The consensual assessment of a job was carried out in four stages; 1: coordinator no.1 described the job to the experts and at the same time coordinator no. 2 noted the main information on a board; 2: each expert filled in an individual assessment form; 3: one by one the experts gave their individual assessments orally; 4: consensus could be obtained in two ways based on the individual assessments: the majority view or in case of disagreement, discussion between the experts to reach a consensus (Figure 1).

For each job, the exposure metrics evaluated were the following: probability of exposure: not exposed, possible (>0-0.5), probable (>0.5-0.9), definite (>0.9-1); main type of exposure: direct (the subject handles the material), indirect (the subject was next to someone who handles the material), passive (work in a sprayed area or near a plant manufacturing asbestos products); frequency: irregular (>0-5% of the time), intermittent (>5-30% of the time), frequent (>30-70% of the time), continuous (>70-100% of the time) and average intensity (estimated by the expert): low (>0-0.1 f/ml), medium (>0.1-1 f/ml), high (>1-10 f/ml), very high (>10 f/ml).

For each subject, the exposure was calculated according to the metrics assessed for his/her jobs. All the subjects who had at least one job with a non-null probability of exposure were then considered as having had occupational exposure to asbestos. A subject's occupational exposure was defined according to the maximal probability of exposure found in his/her entire career and by a cumulative exposure index (CEI). The CEI was the sum total of probability, frequency, intensity and duration of exposure for each of the subject's jobs. For this, a weighting was applied to each metric; probability of exposure: not exposed = 0, possible = 0.5, probable and definite = 1; frequency: irregular = 0.025, intermittent = 0.25, frequent and continuous = 0.75; intensity: low = 0.1, medium = 1, high = 10, very high = 100 [Iwatsubo, et al. 1998]. Exposure duration was given in years.

As it was not possible to have a six external expert-panel during all the PNSM we wanted to test an alternative method. Therefore, in a second step, two internal experts from our laboratory (an industrial hygienist and an occupational physician who were not part of the six-expert panel) assessed occupational exposure to asbestos on the same questionnaires with the "by subject" rating without a coordinator being present. Each questionnaire was rated by both experts and immediate consensus was reached. The same exposure metrics (probability, main type of exposure, frequency, and intensity) were assessed for all the jobs and the same exposure parameters (probability and CEI) were calculated for all the subjects.

The French National Commission for Information Processing & Civil Liberties approved the procedures used by the PNSM.

### **Statistical analyses**

To measure agreement, in the first step, between two ratings, the kappa coefficient was used. To measure the intrinsic qualities of the method to be tested, sensitivity and specificity of one of the methods ("by subject" rating) against the other ("by job" rating) were calculated. The same strategy

was applied for the second step comparing the six-expert panel and the two internal experts. The kappa coefficient is used to measure agreement between two tests when the variables are qualitative [Fleiss 1981]. The coefficient ranges from -1 (total disagreement) to 1 (total agreement), with agreement generally described as “very poor” ( $\leq 0$ ), “poor” (0.01-0.20), “fair” (0.21-0.40), “moderate” (0.41-0.60), “good” (0.61-0.80) or “very good” ( $> 0.80$ ) [Landis and Koch 1977].

Agreement was calculated for occupational asbestos exposure of the jobs, then for exposure of the subjects. To calculate agreement according to the CEI, distribution of the variable was categorized: not exposed,  $> 0-0.01$ ,  $> 0.01-0.1$ ,  $> 0.1-1$ ,  $> 1-10$  and  $> 10$ . Agreements according to the main type of exposure, the frequency and the intensity were investigated only for jobs exposed. The modalities of these variables were pooled: main type of exposure: direct, indirect (including passive); frequency: irregular (irregular and intermittent), continuous (frequent and continuous) and intensity: low (low and medium), high (high and very high).

Two computation methods were performed: a non-weighted kappa coefficient where only perfect agreement (the diagonal) was used and a weighted kappa coefficient to minimize minor disagreements and maximize severe disagreements [Cohen 1968]. Cicchetti-Allison weights were used [Cicchetti and Allison 1971]. In addition, the individual assessments of the six experts allowed us to measure the intra-expert agreement between the two ratings — “by job” and “by subject” — for each expert. Weighted kappa coefficients were calculated for probability of job exposure, probability of subject exposure and CEI of subjects. Intra-expert agreement was not calculated for the two internal experts.

Sensitivity represented the proportion of subjects/jobs assessed by the method being tested as being exposed compared with all the subjects/jobs that were actually exposed (determined by applying the reference method). Specificity corresponded to the proportion of subjects/jobs assessed by the method being tested as being not exposed compared with all the subjects/jobs that were not actually exposed (determined by applying the reference method). In the first step, the reference method was rating “by job” and in the second step, the six-expert panel.

Data analysis was carried out using SAS 9.1<sup>®</sup> software.

## **RESULTS**

### **Description**

Eighty percent of the 50 cases and 50 controls were men. There was no statistically significant difference between cases and controls in average age, which was 70 years ( $p=0.99$ ), nor in level of education (38.0% of the cases and 46.0% of the controls had reached secondary education;  $p=0.41$ ). The cases and controls differed, however, in their socioeconomic status, with 40.0% of laborers among the cases and 16.0% among the controls ( $p<0.01$ ). The industries that were most represented were the service sectors (26.7%), manufacturing (26.5%), and the construction industry (14.2%). Among cases, the industry most represented was manufacturing (31.1%) and among controls the service sectors (36.4%). Almost half the occupations represented in the study were non-agricultural laboring jobs and transport equipment operators (57.7% among the cases and 36.4% among the controls). (Table I)

Questionnaires were generally filled out correctly (moderate: 42.3%; good: 55.7%) and the information they contained was moderate to good in 97.9% of them (data not shown).

#### **Intra-expert agreement for the six panel experts (first step)**

The results of intra-expert agreement are shown in Table II. Regarding probability of job exposure, intra-expert agreement between “by job” and “by subject” rating was good for each expert with kappa coefficients ranging from 0.69 to 0.76. Regarding subject exposure, the results were good to very good for agreement on the probability of exposure (kappa coefficients ranged from 0.74 to 0.81), while the results for the agreement on CEI were lower (kappa coefficients ranged from 0.55 to 0.76).

#### **Description of the two ratings for job and subject exposure by the six-expert panel (first step)**

Table III shows jobs according to probability of asbestos exposure based on the two rating methods. Among the disagreements, 36 jobs (7.9%) were classified as exposed (including 6 ‘definite’ attributions) in the “by job” rating, whereas the “by subject” rating classified them as not exposed. On the other hand, 6 jobs (1.3%) were classified as exposed (all with a ‘possible’ attribution) by the “by subject” rating, but as not exposed in the rating “by job”.

The results for exposure attributed to the subjects were similar (Table IV). “By job” rating classified six exposed subjects (6.0%) as ‘possible’ and ‘probable’ whereas “by subject” rating classified them as ‘not exposed’. “By subject” rating classified two exposed subjects (2.0%) as ‘possible’ while “by job”

rating classified them as 'not exposed'. Table V shows the distribution according to CEI. For 71% of subjects, the two ratings were in agreement.

#### **Agreement between the two ratings for job exposure by the six-expert panel (first step)**

There was good agreement for the probability of job exposure between the two ratings: kappa=0.63 (95% CI=0.57-0.98); weighted kappa=0.79 (95% CI=0.75-0.83) (Table VI). For the other exposure parameters, agreement was good for type of exposure (kappa=0.77; 95% CI=0.66-0.88) and for average intensity (kappa = 0.71; 95% CI=0.57-0.86) whereas it was moderate for frequency of exposure (kappa=0.50; 95% CI=0.32-0.68) (data not shown). With regard to assessment of job asbestos exposure, sensitivity and specificity of "by subject" rating against "by job" rating were 82.3% and 97.6% respectively.

#### **Agreement between the two ratings for subject exposure by the six-expert panel (first step)**

The agreement was good for the probability of subject exposure with a kappa coefficient of 0.69 (95% CI=0.58-0.79) and very good when the weighted computation method was used (weighted kappa=0.84; 95% CI=0.78-0.91) (Table VI). The agreement concerning the CEI was good with a kappa coefficient of 0.62 (95% CI=0.51-0.74), and the weighted computation method gave the best result with a weighted kappa coefficient of 0.80 (95% CI=0.72-0.88). For assessment of subject occupational asbestos exposure, the sensitivity and specificity of the "by subject" rating against the "by job" rating were 91.0% and 93.9%, respectively.

#### **Agreement between the six-expert panel and the two internal experts using the "by subject" rating (second step)**

In the second step, there was good agreement between the six-expert panel and the two internal experts for the probability of job exposure: kappa=0.61 (95% CI=0.55-0.68); weighted kappa=0.72 (95% CI=0.67-0.77) (Table VII). The job asbestos exposure assessment by the two internal experts had a high sensitivity (86.2%) and a high specificity (85.5%).

Agreement for the probability of subject exposure was equivalent to that for job exposure: kappa=0.58 (95% CI=0.46-0.71); weighted kappa=0.71 (95% CI=0.61-0.81). Weighted kappa for the CEI was also good (weighted kappa=0.68; 95%CI=0.59-0.77) while kappa was fair (kappa=0.37; 95% CI=0.25-

0.48). With regard to subject occupational asbestos exposure, sensitivity and specificity of the two-expert assessment against the six-panel assessment were 87.3% and 86.5% respectively.

## **DISCUSSION**

The “by subject” rating carried out by the six experts was in agreement with the “by job” rating, which was used as the method of reference, in relation to the probability of occupational asbestos job exposure, and both the probability and the CEI of occupational asbestos subject exposure. Assessment of two internal experts using the “by subject” rating had good sensitivity and specificity versus assessment of the six-expert panel using the “by subject” rating.

To our knowledge, this is the first study to compare the agreement between “by subject” and “by job” exposure assessment methods. Published concordance studies are summarized in Table VIII. They compared the three main methods for the retrospective assessment of occupational exposure: industrial hygienist assessment, self-reporting, and job-exposure matrix. Agreement between self-reporting by the subject and industrial hygienist assessment and agreement between industrial hygienist assessment and a job-exposure matrix were poor to moderate. When industrial hygienist assessment was compared with industrial hygiene measurements, agreement and sensitivity were very good [Fritschi, et al. 2003]. The reproducibility of the exposure assessment was characterized by intra-expert agreement. In previous studies, intra-expert agreement varied from 0.26 to 0.71 [Benke, et al. 2001; Rybicki, et al. 1998]. The reliability of exposure assessment can also be measured by inter-expert agreement. In the study by Rodelsperger *et al.* where exposure assessment of asbestos was involved, the agreement was good ( $\kappa=0.72$ ) [Rodelsperger, et al. 2001]. All these data confirm the validity of using industrial hygienist assessment to assess exposure compared with other methods and also the reliability of this method, especially when dealing with asbestos exposure.

In our study, there was a wide range in the distribution of the 457 jobs among industries and occupations. This distribution was similar to the distribution of jobs across the entire case-control study in the PNSM, which included a total of 7134 jobs.

Rating “by job” was chosen as the reference rating [Iwatsubo, et al. 1998]. The advantage of this method was that the expert was not influenced by the asbestos exposure assessment of a subject’s previous job. It also ensured that homogeneous assessments could be obtained for occupational exposure for the same job. Although, the assessment of each job was then adjusted according to what the subject said, this rating would minimize differential misclassification. The main disadvantage of this method was to set it up in practice. Rating “by job” could only be done after all the data had been collected, so a sorting process had to be carried out beforehand. All the jobs had to be sorted in increasing order according to the ISIC code, then the ISCO code.

“By subject” rating was the method being tested. With this method, job histories could be assessed just after the questionnaires were collected and results of the exposure assessment for a given subject could be acted upon quickly. In the context of the PNSM, the result of the occupational exposure assessment determines recognition of an occupational disease; this rating is easy to implement. It was therefore essential to be able to set it up quickly: there was no sorting to be done beforehand, subjects were rated one after the other, jobs were presented in chronological order, and the order was established by the subjects themselves when they filled in the questionnaire. However, “by subject” rating may lead to a bias in each job assessment of a given subject according to its entire job history: specific job assessment could be influenced by the assessment of the other jobs of the same subject. Indeed mesothelioma cases would look for every job in which they have had potential asbestos exposure, while untreated controls may not. This could lead to differential misclassification. This recall bias can lead to overestimation of exposure but in the PNSM, whose goal was to establish whether or not financial compensation should be provided, overestimation of exposure was less important. Indeed, the French compensation system is based only on qualitative assessment (exposed versus non exposed subject). Furthermore, the “by subject” rating is difficult for experts to apply as they move from one job to another and start afresh with a new train of thought for each job. On the other hand, it is simple to set up in organizational terms.

The intra-expert agreement in our study demonstrates the good reliability of the experts. Kappa coefficients were higher for the probability of jobs and subjects exposure than those in the study by Benke *et al.* where kappa coefficients for three experts were 0.60, 0.64 and 0.71 for all chemical

exposure [Benke, et al. 2001]. Kappa coefficients for CEI were lower but the confidence intervals were in the same order of magnitude. In the study by Siemiatycki *et al.*, which studied the reliability of expert assessment of occupational exposure to chemical substances [Siemiatycki, et al. 1997], very good intra-expert agreement was obtained with the consensus of two experts ( $\kappa=0.80$ ). The time interval between two assessments can also influence reliability. In the first study [Benke, et al. 2001], the time between the two assessments was three months as opposed to four years in the second [Siemiatycki, et al. 1997]. Because of a time lag of one month in our study, we cannot exclude a recall bias. Nevertheless, the rating procedure should minimize this bias because only coordinators handled the questionnaires during the ratings in order to avoid visual memory of the questionnaires by the experts. The presence of coordinators would also minimize this bias, since a coordinator described the job to the experts and at the same time another coordinator noted the main information on a board.

In reality, it is quite complicated for six experts and two coordinators to meet regularly. It was for this reason that we compared the assessment of the “by subject” rating of the six-expert panel with the assessment of the “by subject” rating of two internal experts. The good agreement between the two internal experts and the six-expert panel, and the good sensitivity and specificity of the assessment of the two internal experts suggest that occupational asbestos exposure assessment could be performed by our two internal experts.

We decided to calculate kappa coefficients and weighted kappa coefficients since we were using a variable with more than two levels. This technique demonstrates the degree of disagreement by attributing greater weight to large differences between ratings than smaller ones [Cohen 1968]. In our study, the weighted kappa coefficients were slightly higher than the non-weighted ones. Disagreements were minor and were usually confined to exposed jobs/subjects and less frequently to exposed/not exposed status. In table III, 42 jobs (9.2%) were affected by a disagreement about the exposed/not exposed status of the job, whereas 59 exposed jobs (12.9%) were involved in a disagreement over probability of exposure. In tables IV and V, 8.0% of the subjects had an exposed/non-exposed status that differed on the two ratings, whereas the disagreement over probability of exposure involved 13.0% and the disagreement over the CEI 21.0% of subjects.

## **CONCLUSION**

These findings provide new insights into the choice of rating procedure when assessing retrospective occupational exposure. As the results of the “by subject” rating were in good or very good agreement with those of the “by job” rating, we decided to use the first method, involving two internal experts only, to assess occupational asbestos exposure routinely in the PNSM. The method is very practical in studies requiring quick feedback on occupational exposure for compensation.

## **ACKNOWLEDGEMENTS**

The authors thank the PNSM Scientific Committee (P Boffetta, E Chailleux, J Esteve, J Faivre, and D Hemon). The PNSM is supported by the National Institute for Public Health Surveillance (InVS), the Ministries of Labour and Health, and the Foundation for Medical Research (one-time grant).

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