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THE EPIDEMIOLOGY OF ASBESTOS-RELATED DISEASES IN QUEBEC

INSTITUT NATIONAL DE SANTÉ PUBLIQUE DU QUÉBEC

Québec

REPORT

THE EPIDEMIOLOGY OF ASBESTOS-RELATED DISEASES IN QUEBEC

SUB-COMMITTEE ON THE EPIDEMIOLOGY OF
ASBESTOS-RELATED DISEASES IN QUEBEC

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This report is presented to the *ministère de la Santé et des Services sociaux du Québec* by the *Comité aviseur sur l'amiante au Québec* sub-committee on the epidemiology of asbestos-related diseases in Quebec.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

SUMMARY

Under the auspices of the *Comité aviseur sur l'amiante au Québec* (asbestos advisory committee), the sub-committee on the epidemiology of asbestos-related diseases reviewed the available epidemiological data on these diseases in Quebec. The sub-committee also conducted various studies to fill in certain gaps identified during the analysis of available data. Here are the principal findings of this work.

Asbestos has three main effects on health: mesothelioma of the pleura and peritoneum, pulmonary cancer, and asbestosis. All these diseases appear after a latency period varying between 20 and 40 years depending on the pathology. Moreover, all types of asbestos have been associated with the three diseases.[1]

In Quebec, from 1982 to 1996, 832 people (655 men and 177 women) were newly diagnosed with mesothelioma of the pleura. This corresponds to an average annual incidence rate of 1.49 per 100,000 person-years among Quebec men and 0.32 per 100,000 person-years among Quebec women.[2] These rates are respectively 9.5 and 2 times higher than the rates observed among women in the rest of Canada (considered to have little or no exposure to asbestos), and these excesses are statistically significant.[3] In comparison to the international community, the situation among Quebec men is only surpassed in several counties in the United Kingdom, several states in Australia, and several regions in the Netherlands.[2]

Incidence rates of mesothelioma of the pleura rose significantly between 1982 and 1996 in Quebec's male population with a 5% average annual rate of increase. In the female population the rate of increase was 3% and is not statistically significant.[2] The increase among men occurred in the 60 years and over age group. Rates appeared stable among Quebec men under 60. The cohort of Quebec men born between 1930 and 1939, therefore those who started to work during the period when asbestos use was increasing, shows higher cancer rates than other cohorts of Quebec men. The data also suggest a reduced risk among cohorts born after 1940, but it is too early to draw conclusions because the people in these groups are still young.[3] Two regions in the province, Chaudière-Appalaches and Montérégie, show statistically significant excesses of mesothelioma of the pleura. They both have shipyards or had them in the past and in Chaudière-Appalaches, asbestos mines were also in operation in Thetford Mines and environs.[2]

Mesothelioma of the peritoneum is even less frequent than mesothelioma of the pleura and is associated with exposure to amphibole asbestos. Between 1984 and 1996, 63 Quebec men and 45 Quebec women were newly diagnosed with this cancer. Rates remained stable during the period of the study and no region showed excesses of this cancer.[2]

The mortality associated with these two cancers cannot be evaluated directly because Quebec's death certificates do not distinguish mesotheliomas from other histological types of cancer of the pleura and peritoneum. However, we note there was a statistically significant increase in death rates from cancer of the pleura among Quebec men between 1981 and 1996 and that an excess of deaths from this cancer was observed in the Chaudière-Appalaches region.[2]

Cases of mesothelioma and lung cancer whose occupational origin has been recognized by the committees set up by the *Commission de la santé et de la sécurité du travail* (*CSST*-a workers' compensation board) represent respectively only 22% and 0.3% of the cases recorded in the *Fichier des tumeurs du Québec* (Quebec's tumour registry).[4] Yet the medical literature shows that asbestos exposure is found in 70% to 90% of mesothelioma cases among men.[5] The literature also shows that the percentage of lung cancer cases attributable to asbestos exposure among men varies between 0.5% and 15% depending on the prevalence of the exposure in the populations studied.[6] We also observed that the 1,333 Quebec men and 53 Quebec women hospitalized for a first time between 1987 and 1996 with a primary or secondary diagnosis of asbestosis represented four times the number of cases of this disease recognized by the CSST during the same time period.[4]

Looking at the state of health of the population in asbestos mining regions, we found that diseases resulting from exposure to this fibre have been studied since the 1960s. The first studies showed higher incidences of these diseases, especially among men. The health of women was scarcely addressed in these studies.[7]

A series of recent studies has documented some aspects of the exposure and the health of women in these regions. Their cumulative level of exposure to asbestos over the last 50 years has been estimated on average at approximately 25 fibres/ml-years.[8,9] These data were used to test the U.S. Environmental Protection Agency's risk assessment models for mesothelioma and lung cancer deaths. These models were found to overestimate mesothelioma risk by a factor of approximately 60[10,11] and lung cancer risk by a factor of at least 10.[12]

A case-control study of women diagnosed with mesothelioma in Thetford Mines between 1970 and 1989 showed a very high risk (approximately 30) of developing this cancer following occupational exposure to asbestos. This risk was statistically significant but included a considerable margin of uncertainty. The study also showed that mesothelioma risk would increase from 2% to 5% per fibre/ml-year of exposure among these women with any measure of their exposure to asbestos (occupational, domestic, or residential).[13]

We have relatively complete information on asbestos-related diseases among workers exposed in Quebec's asbestos mines. However, data are incomplete for workers in asbestos processing and construction industries.

The respiratory health of Quebec's asbestos miners has been studied since 1958 and has been the subject of much scientific, political, and social debate. A cohort of nearly 11,000 workers in asbestos mines and mills and in one products fabrication factory located in the mining region was followed up for mortality to 1992. These workers showed an excess of mesothelioma deaths in comparison with the Quebec population and pulmonary cancer risk rose to 2 among the workers exposed to greater amounts of asbestos and for a longer time. Many cases of asbestosis were also documented among these workers.[7] The workers in these regions are currently subject to mandatory screening for asbestosis. However, data from these studies have not yet been analyzed by the sub-committee.

Data are more scarce for asbestos processing workers. Previous studies identified only four processing plants in Quebec: two plants that manufactured asbestos-containing gas mask filters during World War II (one in Montréal, the other in the town of Asbestos), one plant in Valleyfield that produced

asbestos-containing conveyor belts for paper mills, and one insulation and cement products plant in the Montréal area. All these enterprises generated asbestos-related disease cases.[14-17] Another study in the Montréal area also identified lung cancers and mesotheliomas.[17,18]

Between 1992 and 1997, a study of 23 asbestos processing plants in the Montréal area showed that seven of them (30%) presented problems related to exceeding asbestos exposure standards.[19] The screening for asbestosis carried out among 304 workers from four of the five problem plants revealed one confirmed and one possible case of asbestosis. In addition, a third worker had been diagnosed with this disease in 1990.[20]

In the construction industry, insulators were the first workers to be documented with asbestos-related diseases, as indicated in a 1981 study.[21] Screenings undertaken in 1995 and in subsequent years of approximately 1,500 workers from various construction trades identified more than twenty cases of radiological abnormalities compatible with a diagnosis of asbestosis and close to 25% of the workers had pleural abnormalities.[22,23]

The *Comité spécial des présidents* is a committee composed of three chest physicians charged with determining, in the case of a worker presenting a claim to the CSST for an asbestos-related disease, if the disease is of occupational origin. Between 1988 and 1997, the committee recognized an occupational origin to asbestos-related diseases among 691 workers (378 asbestosis, 191 mesothelioma, and 209 lung cancer cases). On analyzing these data, we learn that the mining sector still generates most cases of these diseases combined (35%), including most asbestosis (32%) and most lung cancer (62%). The high percentage of pulmonary cancer cases originating in mines suggests there may be a poor recognition of asbestos exposure in other sectors, by workers and doctors. This poor recognition may be due to the fact that it is easier to attribute a lung cancer to tobacco use, in a smoker, than it is to recognize asbestos exposure outside the mining sector.[24]

However, if the workers from construction industries (17% of cases) are pooled with the workers involved with maintenance and repair of asbestos-containing products and structures (25% of cases), these two groups together account for 42% of the total 691 cases and 53% of the mesothelioma cases, thus surpassing the mining sector.[24]

The number of claims increased between 1988 and 1997, particularly in the construction and maintenance and repair industries.

Finally, compensation costs to the CSST for the 691 workers studied amounted to at least 66.2 million dollars, undiscounted.[24] It would be worthwhile to conduct a more in-depth study to document the direct and indirect costs generated by asbestos-related diseases in Quebec.

Conclusions and recommendations may be consulted at the end of the document. Highlights of the studies conducted by the sub-committee are presented in the appendix.

1. INTRODUCTION

1.1. MANDATE

The mandate of the sub-committee on the epidemiology of asbestos-related diseases was to review available epidemiological data on mesothelioma, pulmonary cancers, and asbestosis in Quebec; evaluate the trends of these diseases; compare data from Quebec to those of other regions; and summarize current scientific knowledge on the effects of asbestos on health.[25]

1.2. OBJECTIVES

To achieve its mandate, the sub-committee set objectives to review available scientific data on the epidemiology of asbestos-related cancers and asbestos-related diseases in Quebec, if possible distinguishing between the cancers affecting workers and those arising in the general population. This was to be accomplished by analyzing data from the *Fichier des tumeurs du Québec* (Quebec's tumour registry), *ministère de la Santé et des Services sociaux* (MSSS-ministry of health and social services), compensation statistics from the *Commission de la santé et de la sécurité du travail* (CSST-a workers' compensation board), and regional data in collaboration with the *directions de santé publique* (public health departments) and by focusing on mesothelioma, lung cancers, and asbestosis among workers and the general population.[25]

1.3. HISTORY OF WORK

Since its formation in 1997, the sub-committee on the epidemiology of asbestos-related diseases has conducted various studies. In September 1998, the sub-committee submitted a progress report to the *Comité aviseur sur l'amiante au Québec* (asbestos advisory committee). This report contained, in part,

A. A review of the principal health effects of asbestos (*L'amiante et la santé humaine: le consensus dans la communauté scientifique*) (asbestos and human health: the consensus in the scientific community);

B. A list of research studies conducted in Quebec on health and asbestos (*Projets de recherche épidémiologique réalisés au Québec: une liste annotée*) (epidemiological research projects carried out in Quebec: An annotated list);

C. The results of analyses made at that time (*Distributions temporelles et géographiques de l'amiantose, des mésothéliomes de la plèvre et du péritoine, et des cancers de la plèvre et du péritoine, province de Québec, 1986-1996*) (temporal and geographic distributions of asbestosis, mesotheliomas of the pleura and peritoneum, and cancers of the pleura and peritoneum in Quebec, 1986-1996); and

D. A proposal for conducting several research protocols or analyses to document the situation in Quebec. After the progress report was submitted, the following analysis and research proposals were chosen:

   1. Descriptive epidemiology of mesothelioma and asbestosis in Quebec.
   2. Validation and comparative analysis of mesothelioma cases in Quebec.

3. Description of compensation and morbidity costs related to asbestos.
4. Analysis of cases accepted by the *Comité des maladies pulmonaires professionnelles* (committee on occupational pulmonary diseases) as asbestos-related occupational pulmonary diseases.
5. Mesothelioma risk among women residing in asbestos mining regions.
6. Mesothelioma and lung cancer risk associated with occupational exposure to asbestos based on type of fibre (Montréal, 1979-85).

The group then proceeded to update documents and implement research projects. Other studies published in the context of other activities, but pertinent to the subject of the current report, were also taken into consideration. The present report begins with a summary of the literature review and then describes asbestos-related diseases in the general population, in the mining region population, and among workers. This is followed by a presentation of costs and the findings from matching health records.

2. THE EFFECTS OF ASBESTOS ON HEALTH

2.1. WHAT IS A FIBRE?

The World Health Organization[26,27] and the United Kingdom Health and Safety Executive[28] define fibres subject to regulation (i.e. posing health risks) as particles > 5 micrometres (μm) in length, < 3 μm in diameter, with a length:width ratio > 3:1, measured by the standard method using optical phase contrast microscopy to count membrane filter samples. Industrialized countries use the same definition except that most do not have the diameter criterion. Regulatory health definitions differ from mineralogical definitions.

2.2. WHAT IS ASBESTOS?

According to the World Health Organization[26] the commercial term "asbestos" refers to several silicate minerals with fibrous crystal structures. Two basic families of asbestos, the serpentines and the amphiboles, have different morphological and mineralogical properties. Chrysotile (white asbestos) is the only member of the serpentine family, while crocidolite (blue asbestos), amosite (brown asbestos), actinolite, anthophyllite, and tremolite belong to the amphiboles.

Veins of different types of asbestos often occur side by side or interlaced in geological formations; so veins of tremolite may be found in some chrysotile mines in Quebec. The properties shared by the different types of asbestos and distinguishing them from other minerals are their crystal structure, fibrous appearance, tensile strength, flexural strength, and resistance to heat and to strong chemical bases. Nevertheless, these fibres differ sufficiently in these aspects to justify different industrial applications and different levels of toxicity.

2.3. WHAT ARE THE EFFECTS OF ASBESTOS ON HEALTH?

The health effects of asbestos were initially demonstrated in epidemiological studies conducted among workers before being observed in laboratory animal experiments at much higher doses than in the workplace. All sources seem to agree on the identification of risks. Opinions differ more on the quantification of risks. The health effects that will be reviewed below are asbestosis, pulmonary cancer, mesothelioma of the pleura and peritoneum, diffuse pleural effusion or benign asbestos-related pleuritis, pleural plaques, and some uncertain health effects.

2.3.1. Asbestosis[29-32]

Asbestosis is a diffuse bilateral interstitial pulmonary fibrosis brought on by the progressive fibrous thickening of the alveolar walls (over-accumulation of connective tissue), resulting in a progressive inability of the lung to deliver oxygen to the blood, which in turn leads to cardiac overload. Usually, documentation of a sufficient exposure to asbestos is part of a clinical diagnosis.

Asbestosis was identified in the 1920s. The incidence, stage, severity, and impact on the pulmonary and respiratory function of cases have been diminishing since the 1970s.[33] Furthermore, pathologists note that asbestosis is declining as a cause of death among asbestos workers. Asbestosis is observed instead in deaths from pulmonary cancers or other causes of death.[29,34]

Asbestosis usually occurs in the subpleural regions of the lower lobes of the lung. Its development is slow and generally irreversible, even after interruption of exposure.

However, asbestosis may sometimes regress. In fact, this may happen in approximately 7% of cases for whom intensity of exposure was lower than 2 fibres/ml over the 20 years prior to diagnosis.[29,35,36]

The disease may continue to progress even after exposure has ceased if there is active alveolitis, a possible effect even in the absence of radiological signs of fibrosis.[29,34]

It has not been determined if there is an interaction between tobacco use and asbestos exposure in the determination of asbestosis risk.[29,34]

The prevalence of pulmonary fibrosis in cohorts of workers is proportional to the cumulative asbestos exposure. It varies between 2% and 29% in cohorts with high exposure in the past.[29,36]

All types of asbestos may cause asbestosis, but the risk for an equivalent exposure is higher with amphiboles than with chrysotile.[5,29,37,38]

The relation between exposure and the prevalence of asbestosis also varies according to type of work and type of asbestos industry: pipe fitting > textile and insulation > asbestos cement > mines, mills, and fiberizing. The toxicity of a fibre would be one order of magnitude greater in asbestos processing industries than in the extraction industry.[33,36]

Epidemiological studies in the United States have not found cases of clinical asbestosis in the general population nor in the families of asbestos workers. Among asbestos cement workers in New Orleans, there was no radiologic asbestosis below an exposure of 30 fibres/ml-years. All risk assessments found that asbestosis risk was negligible at exposures below 25 fibres/ml-years, suggesting some sort of threshold.[34,38,39] Notwithstanding, some authors contest the existence of a threshold or the level of such a threshold, if it exists.[40] However, asbestosis usually results from a significant exposure to asbestos.

2.3.2. Pulmonary cancer (bronchial carcinoma)

This is an epithelial cancer of the upper and lower respiratory tracts. Asbestos-related pulmonary cancers are histologically indistinguishable from those caused by tobacco use, radon, or other etiologic factors.

Asbestos-related pulmonary cancer was identified in the 1950s and was recognized by the scientific community in the early 1960s. The latency period is at least 10 years and averages approximately 20 years.

Pulmonary cancer risk has been studied in some fifty cohorts of asbestos workers since the mid-twentieth century. According to the studies, the percentage of lung cancer risk attributable to occupational asbestos exposure among men in the general population varies from approximately 0.5% to 15%. The main fluctuation factor in this percentage is the variation in the prevalence of occupational asbestos exposure from one male population to another, this being from 2% to 29%.[6]

Asbestos and cigarette smoke have a synergistic effect: the combined action of the two factors is more than additive, but less than multiplicative.[5] Nonetheless, asbestos causes lung cancers among smokers and non-smokers.[6]

All types of asbestos have been implicated in the development of lung cancer, but whether or not there is a risk differential based on type of asbestos is a subject of controversy. Some literature reviews show low pulmonary cancer risks for cohorts of workers exposed exclusively to chrysotile, maximum risks for workers exposed to crocidolite, and intermediary risks for those exposed to fibre mixtures or to amosite fibres, controlling for the different types of industrial processes.[41-43] Other authors contest this interpretation.[40] Their position is that the data do not allow us to assert that lung cancer risk is lower following exposure to chrysotile than following exposure to amphiboles.[6,40] However, for each industry there is only a small number of studies with quantitative exposure data, risks vary between industries, control populations are often problematic, risks vary between cohorts in the same industry, and experts do not agree on the classification of cohorts by types of fibres.[44,45]

The 15 studies with quantified exposures were taken into consideration in recent risk assessments. Relative risk slopes vary from 0.00 to 0.04 per fibre/ml-year per cohort of workers. It is generally agreed that risk gradients differ considerably depending on the cohorts and the industrial processes (textile > insulation, mixed products and cement > mines, mills and friction products) and depending on the type of asbestos use.[6] The 15 studies are statistically compatible with a linear exposure-risk model. Furthermore, researchers have pointed out that models can be slightly infralinear or supralinear and even with threshold, provided that the threshold is lower than 40 fibres/ml-years.

Available epidemiological data show that the association between asbestos exposure and lung cancer risk is observed and statistically significant among subjects with no radiological signs of fibrosis.[46] In the current state of knowledge, the only information that may be provided by the presence of a sign of fibrosis in a subject occupationally exposed to asbestos and suffering from lung cancer, is that there is an increased plausibility of greater exposure to asbestos.[6,30] Asbestos exposure would approximately double a worker's risk of developing a lung cancer, the level of risk varying according to degree of exposure[6], industrial process, fibre size, and possibly type of asbestos.[34,38,41,47]

2.3.3. Mesothelioma of the pleura and peritoneum

Diffuse malignant mesothelioma is a rare neoplasm of serous linings, in particular of the pleura and peritoneum. Most cases are attributable to occupational exposures (direct or indirect) to asbestos. This effect of asbestos exposure was identified in 1960 and was recognized by the scientific community shortly thereafter. Malignant mesothelioma is rapidly fatal.

According to the literature reviews consulted, only 10% to 30% of cases among men show no association with such exposures. We do not know if these cases involve exposure to other substances, hidden asbestos exposure, or if this is the background incidence level of this tumour.[5]

Except in a few asbestos worker cohorts, the pleura is affected 5 to 10 times more often than the peritoneum. The latency period is 20 to 40 years or more, although cases with a shorter latency period have been described.[6]

For mesothelioma, there does not appear to be an interaction between asbestos exposure and tobacco use nor an independent mesothelioma risk attributable to tobacco use.

Most experts believe that the risk of developing a pleural mesothelioma is higher with amphiboles than with chrysotile.[6,34] The risk is higher with crocidolite than with amosite and it is lower with chrysotile. Tremolite toxicity could be higher than chrysotile toxicity and might be somewhere between that of crocidolite and amosite.[48] The highest mesothelioma risks have been observed in populations living near surface deposits of natural zeolite (erionite) mineral fibres or in houses constructed with materials incorporating these fibres.

However, scientists do not agree on the difference in the degree of risk between chrysotile and crocidolite, the lowest documented being 4[47] and the highest 500.[41] Estimates for the mesothelioma exposure-risk model have only been completed (i.e. for all the parameters) on one cohort. Mesothelioma incidence is approximately proportional to the third power of time since first exposure to asbestos.[5] We do not know how statistically precise these estimates are, but these are the estimates used in the various risk assessments.

Mesothelioma is also suspected of being triggered by low and sporadic exposures to asbestos, which is a major cause of concern due to its quasi ubiquity in the environment of industrialized countries.[6,49] Known “environmental” epidemics of mesothelioma seem to be characterized by heavy contaminations by amphiboles.[49-53]

Among the other possible causes of mesothelioma, mostly based on experimental data, we find: erionite-zeolite, ionizing radiations, and radiotherapy. A link was previously reported with refractory ceramic fibres. With respect to peritoneal dialysis, para-aramid fibres, virus SV-40, quartz, and genetic predisposition, a causal relation has not yet been demonstrated.

2.3.4. Diffuse pleural effusion or benign asbestos-related pleuritis and pleural plaques

Diffuse pleural effusion or benign asbestos-related pleuritis is characterized by a physiological accumulation of liquid between the visceral and parietal pleura. It is rare and usually resolves on its own. It may sometimes be painful and restrict pulmonary function.

Pleural plaques result from scarring of the lateral lining surrounding the lungs or from scarring of the upper diaphragm that may calcify and become visible by radiography after more than 20 years of occupational exposure. Parietal pleural plaques are found in people who have lived in proximity to asbestos mines or surface deposits. Pleural plaques are considered to be indicators of high asbestos exposure especially if they are bilateral. They do not appear to be pathologic in themselves.

2.3.5. More variable or uncertain effects

Cancers of the larynx[54] and the esophagus appear to be associated with occupational asbestos exposures, but have not been taken into consideration in large-scale governmental or paragovernmental risk assessments because these purported asbestos effects are much less frequent than broncho-pulmonary cancers and mesotheliomas. Moreover, epidemiological observations, while indicative, are not conclusive.[6,34,55,56]

Some epidemiological studies on asbestos workers suggest excesses of gastro-intestinal, kidney, and ovarian cancers, and Hodgkin's lymphomas. These observations are at variance with animal studies. Experts attribute these epidemiological observations either to insufficient statistical or epidemiological study data, or to diagnostic errors of broncho-pulmonary and mesothelial cancers. The possibility of such effects is not ruled out for heavy exposures, but is not sufficiently substantiated by scientific observations. No asbestos risk assessments have taken these risks into consideration.[5,34]

3. ASBESTOS-RELATED DISEASES IN THE GENERAL POPULATION

3.1. MESOTHELIOMA

The data available in Quebec and allowing us to document the extent of mesothelioma in the population come mainly from the *Fichier des tumeurs du Québec* (tumour registry), for incidence and from the *Fichier des décès* (death registry), MSSS, for mortality.

In the **Fichier des tumeurs du Québec,** mesothelioma cases can be traced under the names **mesothelioma of the pleura** and **mesothelioma of the peritoneum** because they are recorded by tumour site (the pleura or the peritoneum) and by histological type (a mesothelioma). They may also be included in the group of **cancers of the pleura** that includes, however, other histological types of tumour than mesothelioma.

In the **Fichier des décès,** mesotheliomas are found among the **cancers of the pleura** and the **cancers of the peritoneum** since this databank registers only tumour site (pleura or peritoneum) and not histological type. Therefore, mortality data include other histological types of cancer than mesothelioma. The proportion of mesotheliomas among cancers of the pleura is approximately 2:3 for women and 4:5 for men. Among cancers of the peritoneum, the proportion is 1:10 for women and 1:5 for men.[57] Therefore, we cannot estimate mortality from mesothelioma of the peritoneum from the data on cancers of the peritoneum.

3.1.1. Incidence

Number, male/female ratio, and age

In Quebec, between 1982 and 1996, 1,074 people were registered for the first time in the *Fichier des tumeurs du Québec* with a diagnosis of cancer of the pleura and 832 with mesothelioma of the pleura. Between 1984 and 1996, 108 people were diagnosed with mesothelioma of the peritoneum.

The ratio of the number of men to the number of women was 3:1 for cancers of the pleura, 3.7:1 for mesotheliomas of the pleura, and 1.4:1 for mesotheliomas of the peritoneum (Table 1).

In this section of the report, only data on the incidence of cancer of the pleura, mesothelioma of the pleura, and mesothelioma of the peritoneum as well as data on mortality from cancer of the pleura will be presented.[2]

Table 1: Incidence of cancer of the pleura (1982-1996), mesothelioma of the pleura (1982-1996), mesothelioma of the peritoneum (1984-1996), and mortality from cancer of the pleura (1981-1996). Quebec.

	INCIDENCE			MORTALITY
	Cancer of the pleura 1982-1996	**Mesothelioma of the pleura 1982-1996**	**Mesothelioma of the peritoneum 1984-1996**	**Cancer of the pleura 1981-1996**
No. ♂ / ♀	807/267	655/177	63/45	506/195
Ratio ♂ : ♀	3.02:1	3.70:1	1.40:1	2.59:1
Age-adjusted average annual rate / 100,000 person-years ♂ ♀	 1.86 0.48	 1.49 0.32	 0.14 0.08	 1.11 0.33
S.s.* annual trend and sex	Increase among ♂	Increase among ♂	-	Increase among ♂
S.s.* average annual increased rate and sex	+3.3% ♂	+5.5% ♂	-	+2.9% ♂
Region with a statistically significant excess and rate / 100,000 person-years	Chaudière-Appalaches: ♂: 3.12 ♀: 0.91 Montérégie: ♂: 2.35	Chaudière-Appalaches: ♂: 2.67 ♀: 0.74 Montérégie: ♂: 2.02	-	Chaudière-Appalaches: ♂: 2.33 ♀: 0.75

* S.s. = statistically significant at a level of 5%; n.s. = not significant at a level of 5%

Cancers of the pleura, mesotheliomas of the pleura, and mesotheliomas of the peritoneum are more frequent over 50 years of age (Figures 1 and 2).

Figure 1: Incidence rates (/100,000 person-years) by five-year age groups for cancer of the pleura, mesothelioma of the pleura (1982-1996), and mesothelioma of the peritoneum (1984-1996) among men. Quebec.

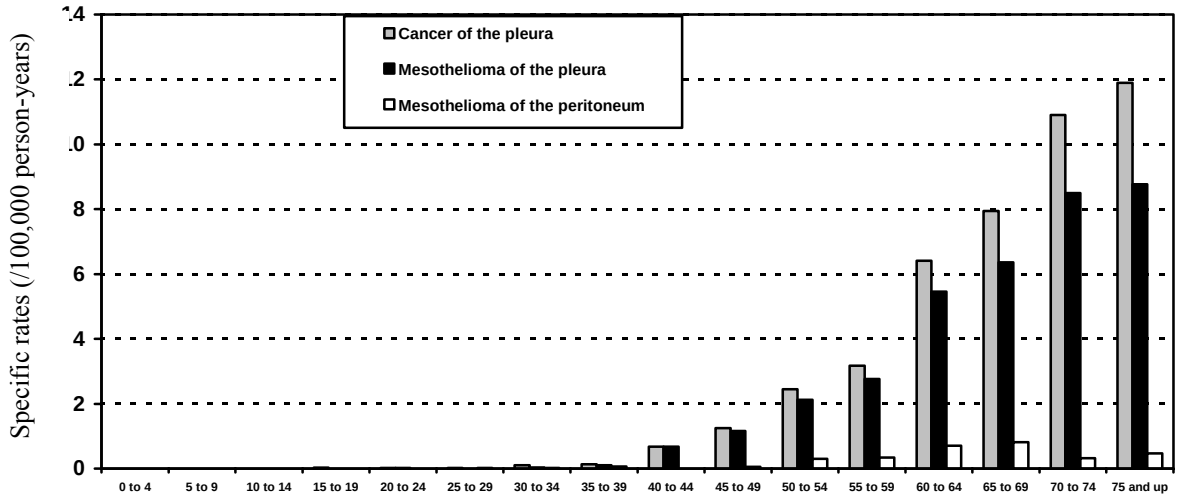
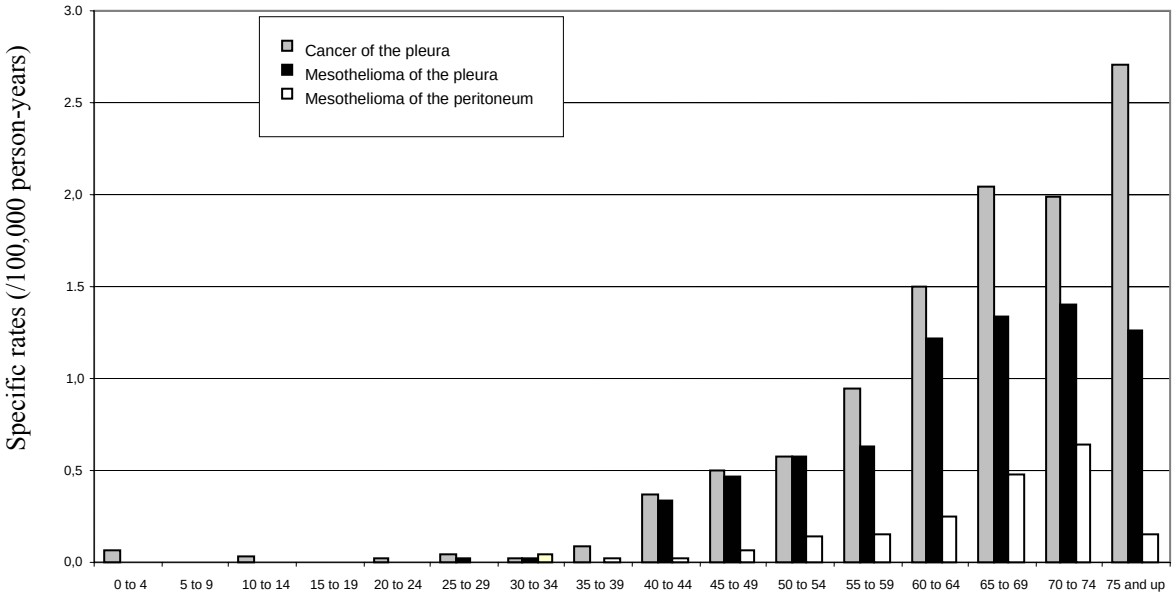


Figure 2: Incidence rates (/100,000 person-years) by five-year age groups for cancer of the pleura, mesothelioma of the pleura (1982-1996), and mesothelioma of the peritoneum (1984-1996) among women. Quebec.



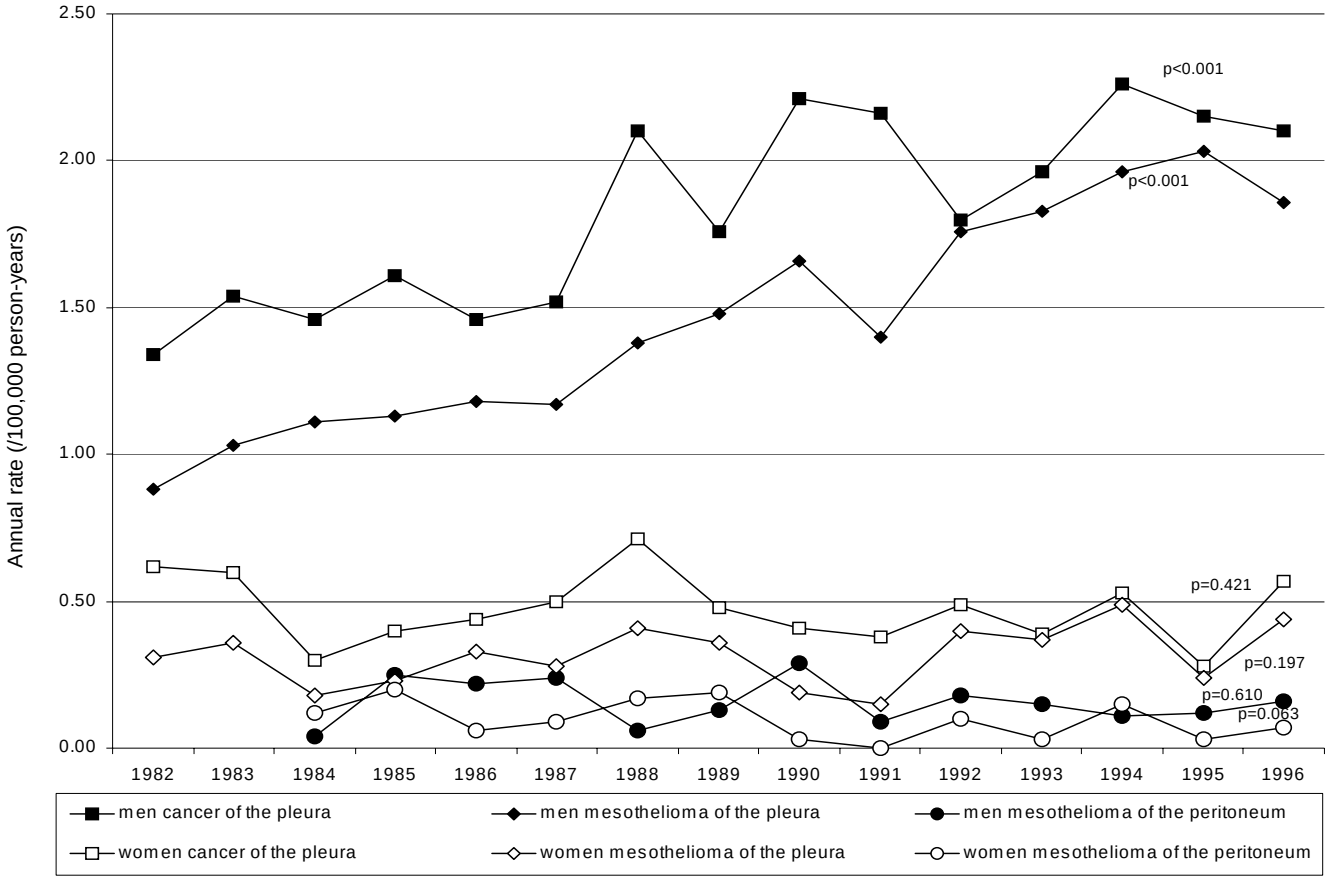
Rates

Among men, between 1982 and 1996, the age-adjusted incidence rates of cancer of the pleura and mesothelioma of the pleura and, between 1984 and 1996, of mesothelioma of the peritoneum, were respectively 1.86, 1.49, and 0.14/100,000 person-years. Among women these rates were lower at 0.48, 0.32, and 0.08/100,000 person-years[2] (Table 1).

Temporal change

Among men, during the period of the study, the age-adjusted incidence rates of cancer of the pleura and mesothelioma of the pleura showed a statistically significant increase, which is not the case for mesothelioma of the peritoneum. However, the observation with relation to mesothelioma of the peritoneum is based on small sample numbers. Among women, no significant time trend was observed during these years[2] (Table 1 and Figure 3).

Figure 3: Age-standardized annual incidence rate (/100,000 person-years) of cancer of the pleura, mesothelioma of the pleura, and mesothelioma of the peritoneum, province of Quebec, 1982-1996



Between 1984 and 1996, there was a downward trend in **peritoneal mesothelioma** incidence for both sexes together, with a non-significant average annual decrease of -5.5% (95% confidence interval (95% CI) = -9.3% to + 0.5%). However, the decrease among women was statistically significant: -8.9% (95% CI = -16.1% to -1.1%), but not among men: -1.5% (95% CI = -7.8% to +5.2%).[3]

In contrast, there was a significant rise in the average annual rate of increase in the incidence of **mesothelioma of the pleura** for both sexes together: +5.1% (95% CI = +2.9% to +7.1%). Among men, the rate of increase was +5.1% (95% CI = +2.8% to +7.4%) and among women +4.4% (95% CI = -0.0% to +9.1%).[3] These results are also consistent with the time trends analysis performed for the period from 1982 to 1996.[2]

The question is whether the trend observed between 1984 and 1996 will persist in future and if so, whether it will last for some time.

To answer this question, **first**, the situation of the Quebec population under 60 years of age and suffering from mesothelioma of the pleura was compared with that of Quebecers 60 years of age and over. The data in Table 2 suggest rates were stable among men and women under 60. Among persons 60 and over, there seems to be an increase, especially among men, from 1990 on.[3]

Table 2: Incidence rate of pleural mesothelioma / 100,000 persons by year, sex, and age (+/- 60 years). Quebec 1984-1996 (rates adjusted to the age distribution of the 1991 Quebec population)

Year	Men			Women		
	< 60 years	≥ 60 years	Total	< 60 years	≥ 60 years	Total
1984	0.53	4.25	1.09	0.05	0.97	0.19
1985	0.26	5.91	1.16	0.07	1.13	0.23
1986	0.23	6.23	1.18	0.23	0.94	0.33
1987	0.70	3.66	1.18	0.14	1.04	0.28
1988	0.63	5.15	1.38	0.18	1.72	0.42
1989	0.56	6.35	1.45	0.11	1.65	0.35
1990	0.48	7.74	1.64	0.17	0.32	0.19
1991	0.40	6.66	1.41	0.03	0.79	0.15
1992	0.43	8.81	1.77	0.13	1.86	0.40
1993	0.41	9.01	1.79	0.13	1.68	0.37
1994	0.53	9.61	2.00	0.19	2.24	0.51
1995	0.53	9.56	1.94	0.15	0.58	0.22
1996	0.33	9.86	1.84	0.20	1.86	0.44

A Poisson regression analysis confirmed the statistically significant increase in rates of mesothelioma of the pleura among men 60 years and over and stable rates among men under 60[3] (Table 3).

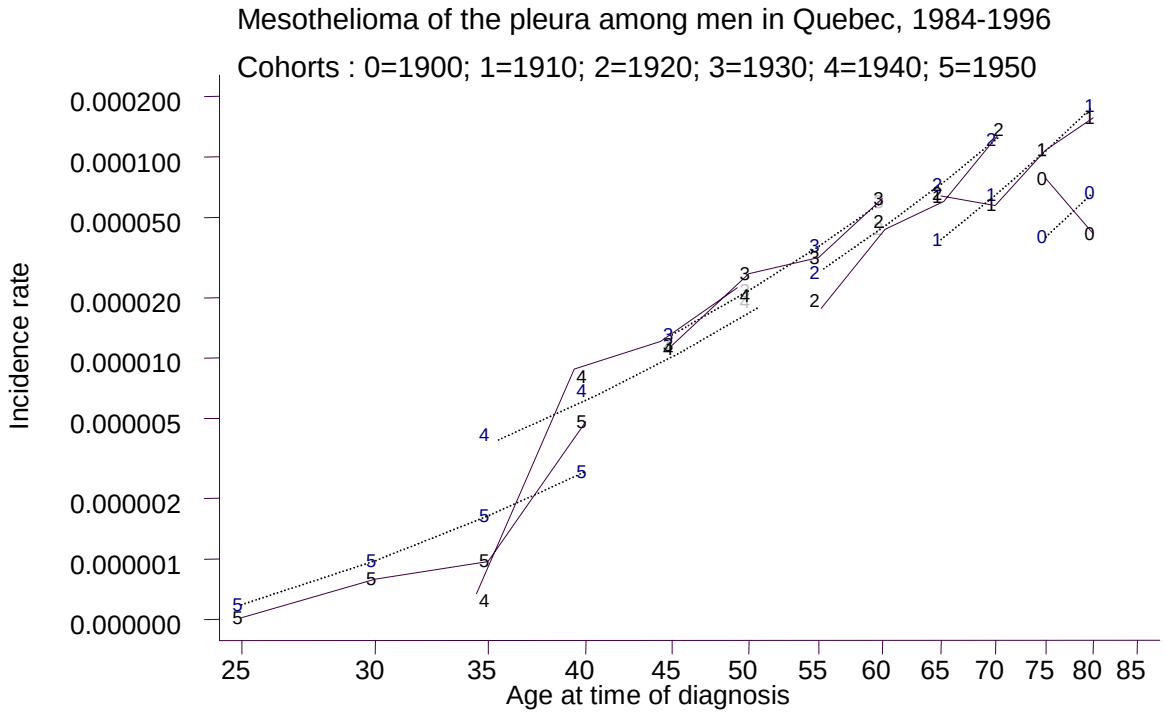
Table 3: Time trend in incidence of mesothelioma of the pleura from 1984 to 1996 by age (+/- 60 years) and by sex (rates adjusted to the 1991 Quebec population)

	ANNUAL INCREASE	95% CONFIDENCE INTERVAL	
Women			
Year*age<60 years	+1.5%	-3.0%	+6.1%
Year*age≥60 years	+2.8%	-0.6%	+6.3%
Men			
Year*age<60 years	-0.0%	-2.1%	+2.1%
Year*age≥60 years	+5.6%	+4.1%	+7.2%
Total			
Year*age< 60 years	+0.3%	-1.7%	+2.2%
Year*age≥ 60 years	+5.2%	+3.8%	+6.6%

Subsequently, a birth cohort analysis was performed. The purpose was to determine if, at the same age, the groups (or cohorts) born more recently would show a decreased incidence of mesothelioma of the pleura compared with groups born earlier. The following birth cohorts were defined: 1900 to 1909, 1910 to 1919, 1920 to 1929, 1930 to 1939, 1940 to 1949, and 1950 to 1959. The number of mesotheliomas of the pleura among women was too small to permit this type of analysis.

The analysis carried out among men suggested an increased mesothelioma risk in the first three cohorts, that is among those born between 1900 and 1930, and a decreased risk among those born in subsequent years. However, we must be cautious when interpreting the lower rates in cohorts born more recently, since they were still young during the period of observation from 1984 to 1996. Figure 4 shows that mesothelioma rates were higher in the male cohort born between 1930 and 1939, that is those who began to work after the Second World War, particularly from 1950 to 1960.[3]

Figure 4: Incidence of pleural mesothelioma per 1,000,000 men according to age, by birth cohort, Quebec, 1984-1996



Numbers joined by lines indicate birth cohorts by decade.
Solid lines represent observed data.
Dotted lines represent statistical estimates using Poisson regression.
On a log-log scale, the relation between incidence rates and age should be approximately linear for each cohort according to the multistage model for carcinogenesis.

If these trends are real and persist, the incidence rate of mesothelioma of the pleura among Quebecers could begin to decline in about 10 years, or around 2010. For Quebec men, these trends are consistent with the trends estimated in a larger and statistically stable U.S. population, but with a lag of 5 to 10 years.[3]

Geographic distribution

The distribution of cases by region of residence at the time of tumour diagnosis showed significant excesses in the incidence of cancer of the pleura and mesothelioma of the pleura among men and women in the Chaudière-Appalaches region and among men in Montérégie. For mesothelioma of the peritoneum, no region showed significant excesses among men or women[2] (Table 1).

3.1.2. Mortality

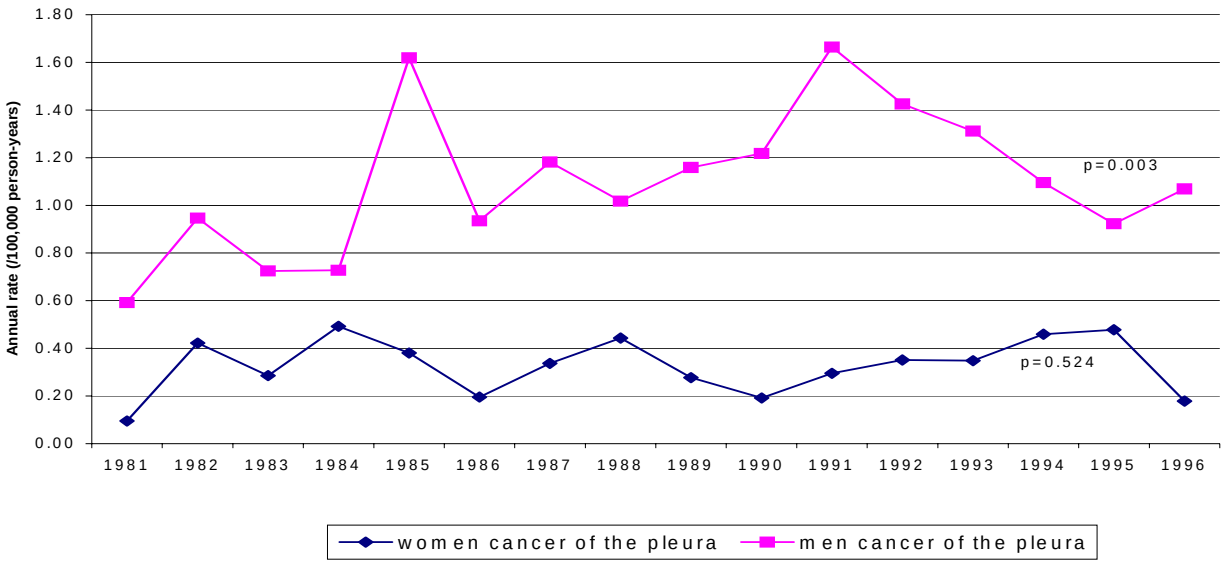
First, bear in mind that mortality data are available for **cancer of the pleura** and not for mesothelioma of the pleura.

Between 1981 and 1996, 701 deaths from cancer of the pleura were recorded in the *Fichier des décès*. The male:female ratio was 2.60:1 and deaths increased after the age of 50 among men and women alike.[2]

During the period of the study, the average mortality rate for cancer of the pleura was 1.11/100,000 person-years among men and 0.42/100,000 person-years among women[2] (Table 1).

Among men, annual mortality rates for cancer of the pleura, adjusted for age, showed a statistically significant upward trend between 1981 and 1996. Among women, there was no significant change[2] (Table 1 and Figure 5).

Figure 5: Age-standardized annual mortality rate (/100,000 person-years) for cancer of the pleura, province of Quebec, 1981 to 1996



Only one region in Quebec showed a significant excess in the adjusted mortality rate for cancer of the pleura among men and women equally-the Chaudière-Appalaches region[2] (Table 1).

3.1.3. National and international comparisons

3.1.3.1. National comparisons

The situation in Quebec was compared with that of other Canadian provinces in two ways.

In a first phase, the incidence rates of mesothelioma of the pleura and peritoneum in the Quebec population were compared with those in the population of the rest of Canada, for the period extending from 1984 to 1996.

Average adjusted incidence rates of **mesothelioma of the pleura** in Quebec men and Quebec women were respectively 1.32 (95% CI = 1.20 to 1.46) and 1.92 (95% CI = 1.56 to 2.36) times higher than those of Canadian men and women in all the other provinces combined[3] (Table 4).

Table 4: Incidence rate[1] (adjusted for age and year) of mesothelioma of the pleura 1984-1996 and incidence ratios[2] relative to incidence rate among Canadian women outside Quebec

	Women	Men	IR[2] M/W	
Canada outside Quebec	1.64/M IR= **1.00**	11.3/M IR= **7.01**	**7.01** *(6.09 – 8.08)*	
Quebec	3.14/M IR= **1.92**	15.3/M IR= **9.29**	**4.83** *(4.04 – 5.78)*	
IR[2]: Que. / Can. outside Que. *95 % confidence interval*	**1.92** *(1.56 - 2.36)*	**1.32** *(1.20 – 1.46)*	**0.69**[3] *(0.55 – 0.87)*	
				Que. Men **9.29**[3] *(7.96 – 10.84)*

Note 1: Rates per million are adjusted by direct standardization to the 1991 Quebec population, stratified by 5-year age groups and by year of observation. No age group was excluded for these calculations.

Note 2: IRs are shown in bold. These incidence ratios were estimated using Poisson regression stratified by 5-year age groups and by year of incidence, after excluding persons under age 25 and those 85 and over. These IRs estimated by regression do not correspond exactly to incidence rate ratios adjusted by direct standardization, since the same statistical method is not used and youngest and oldest age groups are excluded. IR confidence intervals are in italics.

Note 3: Incidence ratios are heterogeneous; the male/female IR is lower in Quebec than in the rest of Canada; the Quebec/"Canada outside Quebec" IR is lower for men than for women: 4.83 : 7.01 = 0.69 = 1.32 : 1.92. Consequently, the risk among Quebec men in comparison to that among Canadian women is = 7.01 * 1.92 * 0.69 = 9.29.

If we hypothesize that asbestos exposure for women living outside Quebec was low and that incidence did not vary between the sexes for all practical purposes except with relation to exposure, the incidence of mesothelioma of the pleura among these women might give an idea of the background concentration of this cancer, in other words, 1.6 cases per million person-years. In the scientific literature, this rate is usually estimated between 1 and 2 cases per million people per year. Mesothelioma incidence among Canadians outside Quebec, Quebec men, and Quebec women was respectively 7.01, 9.29, and 1.92 times higher than the background concentration. These excesses are all statistically significant at the 5% bilateral level. Continuing with the original hypothesis, approximately 5 out of 10 (48%) mesotheliomas would be attributable to asbestos among Quebec women. If there is no natural difference in mesothelioma incidence between men and women, we may also infer that approximately 9 out of 10 (89%) mesotheliomas of the pleura in Quebec men could be attributable to asbestos.[3]

The incidence ratio of **mesothelioma of the peritoneum** was on average 1.58 (95% CI = 1.25 to 2.00) times higher in Quebec than in the rest of Canada (Table 5). Making the same hypothesis as in the preceding paragraph, the background concentration of mesothelioma of the peritoneum would be 0.68 cases per million person-years. In that situation, only the rates among Quebec men would be significantly higher than the background concentration (IR = 2.28; 95% CI = 1.66 to 3.15).[3]

Table 5: Incidence rate[1] (adjusted for age and year) of mesothelioma of the peritoneum 1984-1996 and incidence ratios relative to incidence rate among Canadian women outside Quebec

	Women	Men	IR[2] M / W
Canada outside Quebec	0.68/M IR= **1.00**	0.85/M IR= **1.26** *(0.95-1.67)*	**1.40** *(1.12 – 1.76)*
Quebec	0.91/M IR= **1.33** *(0.92-1.91)*	1.61/M IR= **2.28** *(1.66-3.15)*	
IR Quebec/Can. outside Que.	**1.58**		
95% confidence interval	*(1.25 – 2.00)*		

Note 1: Rates per million are adjusted by the direct method to the 1991 Quebec population, stratified by 5-year age groups and by year of observation. No age group was excluded for these calculations.

Note 2: IRs shown in bold are relative to the rates among women outside Quebec. These incidence ratios were estimated using Poisson regression stratified by 5-year age groups and year of incidence, after excluding persons under age 25 and those 85 and over. These IRs estimated by regression do not correspond exactly to incidence rate ratios adjusted by the direct method. IR confidence intervals are in italics.

In a second phase, the Quebec situation was compared with that of the rest of Canada using the electronic database of the International Agency for Research on Cancer for the years 1988 to 1992. Taking the Quebec population as a reference population, expected numbers of incident mesotheliomas of the pleura and peritoneum combined were calculated for each Canadian province. According to this method, the standardized incidence ratios for men and women from the other provinces are all lower than those of Quebec[2] (Table 6). These results tally with the 1984-1996 Quebec/Canada comparison presented above.[3]

Table 6: Standardized incidence ratios of mesothelioma of the pleura and peritoneum by province and territory, Canada 1988-1992, compared with Quebec

Province / Territory	Number of cases observed	Number of cases expected	Standardized Incidence Ratio	CI 95%
A. Among women				
Quebec	**88**	**88.00**	**100.00**	
British Columbia	26	42.74	60.84	(39.73 - 89.15)
Ontario	77	129.04	59.67	(47.09 - 74.61)
Alberta	15	25.31	59.26	(33.19 - 97.74)
Saskatchewan	7	13.25	52.84	(21.21 - 108.84)
Newfoundland	3	5.82	51.57	(10.66 - 15.75)
Manitoba	7	14.65	47.77	(19.18 - 98.41)
Nova Scotia	5	11.64	42.95	(13.92 - 100.26)
New Brunswick	2	9.14	21.87	(2.62 - 78.97)
Northwest Territories*	0	0.46	0.00	(0.00 - 652.59)
Prince Edward Island*	0	1.69	0.00	(0.00 - 177.84)
B. Among men				
Quebec	**296**	**296.00**	**100.00**	
Manitoba	47	51.82	90.70	(66.64 - 120.61)
British Columbia	137	158.09	86.66	(72.75 - 102.46)
Nova Scotia	33	41.26	79.99	(55.07 - 112.32)
Alberta	75	95.06	78.90	(62.05 - 98.94)
Ontario	293	449.99	65.11	(57.87 - 73.02)
Newfoundland	12	22.70	52.86	(27.31 - 92.34)
New Brunswick	16	32.52	49.21	(28.14 - 79.90)
Saskatchewan	24	50.10	47.91	(30.70 - 71.28)
Prince Edward Island	2	6.15	32.53	(3.90 - 117.43)
Northwest Territories *	0	2.24	0.00	(0.00 - 134.03)

* 1983-1992

3.1.3.2. International comparisons

International comparisons were carried out in the same way as those between the provinces, using the electronic database of the International Agency for Research on Cancer for the years 1988 to 1992. Taking the Quebec population as a reference population, expected numbers of incident mesotheliomas of the pleura and peritoneum combined were calculated for some countries with national tumour registries. Among men, most counties in the United Kingdom, states in Australia, and regions in the Netherlands show statistically significant excesses of mesothelioma compared with Quebec (Table 7). Among women, no country shows significant excess (Table 8). We note however that the incidence of mesothelioma in Quebec is greater than that observed in the rest of Canada, and in Sweden, Norway, Israel, and several Eastern European countries.[2]

Table 7: Standardized incidence ratios of mesothelioma of the pleura and mesothelioma of the peritoneum among men, by country, 1988-1992, compared with Quebec

Country	Number of cases observed	Number of cases expected	Standardized Incidence Ratio (SIR)	(CI 95% of SIR)
UK, Scotland, West (1988-1992)	422	136.68	308.74	(279.99 – 339.67)
Western Australia (1988-1992)	183	64.51	283.66	(244.05 – 327.91)
South Australia (1988-1992)	167	68.17	244.98	(209.24 – 285.13)
UK, Wessex (1988-1992)	389	169.60	229.36	(207.14 – 253.34)
UK, Scotland (1988-1992)	570	259.13	219.97	(202.28 – 238.80)
The Netherlands, Maastricht (1988-1992)	85	41.97	202.51	(161.75 – 250.49)
The Netherlands (1988-1992)	1013	566.85	178.71	(167.87 – 190.06)
Australia, New South Wales (1988-1992)	454	264.52	171.63	(156.21 – 188.18)
UK, South Western (1988-1992)	308	195.26	157.74	(140.61 – 176.39)
UK, Mersey (1988-1992)	217	145.01	149.65	(130.40 – 170.96)
UK, South Thames (1988-1992)	522	365.84	142.68	(130.71 – 155.47)
UK, Yorkshire (1988-1992)	263	194.19	135.43	(119.56 – 152.84)
UK, North Western (1988-1992)	272	208.57	103.41	(115.38 – 146.88)
Australia, Victoria (1988-1992)	249	193.02	129.00	(113.48 – 146.07)
UK, East Anglia (1988-1992)	147	118.20	124.36	(105.07 – 146.19)
UK, Oxford (1988-1992)	150	122.17	122.78	(103.92 – 144.10)
The Netherlands, Eindhoven (1988-1992)	45	41.50	108.42	(79.08 – 145.07)
US, SEER : White (1988-1992)	872	851.40	102.42	(95.73 – 109.45)
Quebec (1988-1992)	**296**	**296.00**	**100.00**	
Denmark (1988-1992)	267	281.35	94.90	(83.86 – 107.00)
Australia, Tasmania (1988-1992)	19	21.01	90.42	(54.44 – 141.20)
Norway (1988-1992)	198	230.37	85.95	(74.40 – 98.80)
Sweden (1988-1992)	423	516.64	81.88	(74.26 – 90.07)
Canada, all provinces (1988-1992)	935	1205.69	77.55	(72.66 – 82.68)
Finland (1988-1992)	197	274.56	71.75	(62.08 – 82.51)
Germany, Eastern States (1988-1992)	187	295.50	63.28	(54.54 – 73.04)
US, SEER : Black (1988-1992)	43	73.82	58.25	(42.16 – 78.46)
Slovenia (1988-1992)	42	82.97	50.62	(36.48 – 68.42)
Estonia (1988-1992)	21	62.59	33.55	(20.77 – 51.29)
Israel : Jews born in America or Europe (1988-1992)	25	86.38	28.94	(18.73 – 42.72)
Poland, Warsaw City (1988-1992)	17	61.15	27.80	(16.19 – 44.51)
Czech Republic (1988-1992)	126	463.79	27.17	(22.63 – 32.35)
Israel : All Jews (1988-1992)	40	154.09	25.96	(18.55 – 35.35)
Slovakia (1988-1992)	46	207.22	22.20	(16.25 – 29.61)
Poland, Lower Selesia (1988-1992)	19	107.62	17.65	(10.63 – 27.57)
Belarus (1988-1992)	57	383.60	14.86	(11.25 – 19.26)
Yugoslavia, Vojvodina (1988-1992)	9	101.78	8.84	(4.05 – 16.78)

Table 8: Standardized incidence ratios of mesothelioma of the pleura and mesothelioma of the peritoneum among women, by country, 1988-1992, compared with Quebec

Country	Number of cases observed	Number of cases expected	Standardized Incidence Ratio (SIR)	(CI 95% of SIR)
Western Australia (1988-1992)	25	17.16	145.65	(94.27-214.98)
South Australia (1988-1992)	25	18.91	132.23	(85.58-195.17)
UK, Scotland, West (1988-1992)	55	43.32	126.97	(95.63-165.36)
Finland (1988-1992)	107	91.57	116.85	(95.76-141.23)
UK, Yorkshire (1988-1992)	65	58.91	110.34	(85.14-140.69)
UK, Scotland (1988-1992)	87	81.45	106.82	(85.55-131.80)
Quebec (1988-1992)	**88**	**88.00**		
UK, South Thames (1988-1992)	113	113.49	99.57	(82.06-119.74)
UK, North Western (1988-1992)	64	64.35	99.45	(76.58-127.05)
The Netherlands, Maastricht (1988-1992)	12	12.26	97.88	(50.57-170.96)
Germany, Eastern States (1988-1992)	103	108.50	94.93	(77.48-115.16)
The Netherlands, Eindhoven (1988-1992)	11	11.72	93.82	(46.83-167.86)
Denmark (1988-1992)	73	80.88	90.26	(70.74-113.53)
The Netherlands (1988-1992)	151	167.99	89.88	(76.12-105.44)
US, SEER : White (1988-1992)	219	254.64	86.00	(74.99-98.19)
Australia, New South Wales (1988-1992)	62	73.03	84.90	(65.08-108.89)
Poland, Warsaw City (1988-1992)	18	21.73	82.82	(49.09-130.89)
UK, East Anglia (1988-1992)	27	33.87	79.71	(52.52-115.97)
UK, Wessex (1988-1992)	39	51.04	76.41	(54.33-104.44)
UK, South Western (1988-1992)	45	58.91	76.38	(55.71-102.20)
Australia, Victoria (1988-1992)	40	53.71	74.47	(53.21-101.41)
Czech Republic (1988-1992)	109	152.22	71.61	(58.79-86.40)
Canada, all provinces (1988-1992)	230	341.69	67.31	(58.89-76.60)
Norway (1988-1992)	43	65.61	65.54	(43.43-88.28)
UK, Oxford (1988-1992)	22	35.14	62.61	(39.24-94.79)
Israel : Jews born in America or Europe (1988-1992)	15	24.40	61.48	(34.43-101.41)
Sweden (1988-1992)	87	143.49	60.63	(48.56-74.81)
US, SEER : Black (1988-1992)	14	24.01	58.31	(31.86-97.84)
Slovenia (1988-1992)	16	28.37	56.41	(32.26-91.59)
UK, Mersey (1988-1992)	19	35.20	53.98	(32.50-84.30)
Belarus (1988-1992)	70	152.64	45.86	(35.74-57.96)
Israel : All Jews (1988-1992)	19	42.45	44.76	(26.95-69.89)
Estonia (1988-1992)	11	24.89	44.20	(22.06-79.07)
Yugoslavia, Vojvodina (1988-1992)	13	31.18	41.69	(22.19-7129)
Australia, Tasmania (1988-1992)	2	5.72	34.99	(4.20-126.32)
Slovakia (1988-1992)	22	65.81	33.43	(20.95-50.61)
Poland, Lower Selesia (1988-1992)	7	36.05	19.42	(7.79-40.00)

3.2. ASBESTOSIS

To describe the frequency of asbestosis in Quebec, we have three sources of information: data on cases **hospitalized** with a diagnosis of asbestosis drawn from MED-ECHO (a hospitalization data file), data on asbestosis **deaths** in the *Fichier des décès*, and cases of asbestosis determined to be of occupational origin by the *Comité spécial des présidents* for **CSST** compensation purposes. Information from this last source of data will be reviewed in section 5 of this report.

Between 1987 and 1996, in Quebec, 1,333 men and 53 women were **hospitalized** for a first time with a primary or secondary diagnosis of asbestosis. The male to female ratio was 25:1 and hospitalizations were more frequent among people 50 years of age and older. The average hospitalization rate during

the period was 4.41/100,000 person-years among men and 0.13/100,000 person-years among women. Among men, we observed a statistically significant downward trend in annual rates ($p < 0.001$). Among women, no significant variation in annual rates was observed[2] (Table 9).

Table 9: Asbestosis in Quebec: Incidence of hospitalizations (1987-1996) and mortality (1981-1996)

	Hospitalizations 1987-1996	Mortality 1981-1996
Number ♂ / ♀	1,333/53	114/2
Ratio ♂: ♀	25:1	57:1
Age-adjusted average annual rate / 100,000 ♂ ♀	 4.41 0.13	 0.26 -
S.s.* annual trend and sex	Decrease among ♂	-
Average annual increased rate	-3.7%	-
Region with a s.s.* excess and rate / 100,000	Chaudière-Appalaches ♂ 23.73 Estrie ♂ 16.00	Chaudière-Appalaches ♂ 1.50 Estrie ♂ 0.95

*s.s. = statistically significant

The *Fichier des décès* data show 114 men and 2 women died from asbestosis between 1981 and 1996. The male to female ratio was 57:1 and the deaths were observed in the 50 and over age group. The average annual death rate for all of Quebec was 0.26/100,000 person-years among men and there was no statistically significant annual variation in these rates[2] (Table 9).

The distribution of cases by geographic region showed a statistically significant excess of asbestosis **hospitalizations** and **deaths** only among men and this, in the Estrie and Chaudière-Appalaches regions[2] (Table 9). These are the two regions in Quebec with asbestos mines. Chaudière-Appalaches region also has a shipyard.

3.3. PULMONARY CANCER

Pulmonary cancer is a tumour that occurs frequently in the population (more than 3,500 cases per year among Quebecers).[58] The principal risk factor is cigarette smoking, but some cases may be due to asbestos exposure. According to studies, the lung cancer risk attributable to asbestos exposure varies from approximately 0.5% to 15%.[6]

Consequently, we did not look for information on pulmonary cancer statistics in general. Data on the cases of asbestos-related pulmonary cancer determined to be of occupational origin by the *Comité spécial des présidents* for the CSST are presented in section 5 of this report.

3.4. PLEURAL ABNORMALITIES

We did not find a study that would allow us to establish the frequency of asbestos-related pleural abnormalities in the Quebec population. These abnormalities are generally considered to be indicators of asbestos exposure with no clinical effect. However, some grow to a considerable size, affecting workers' respiratory function and lead to compensation by the CSST. The only findings we have come from various screening campaigns carried out among workers exposed to asbestos. These findings will be presented in section 5 of this report. Studies published elsewhere in the world provide an idea of the prevalence of pleural abnormalities in the general population, usually less than 10%.[59,60]

4. ASBESTOS-RELATED DISEASES IN THE GENERAL POPULATION OF THE MINING REGION

Information on the state of health of Quebec's mining region population comes from two sources: first, from studies published on this subject during the 1970s and 1980s and second, from a series of more recent projects whose objective was to study mesotheliomas occurring among women residing in this region.

4.1. THE GENERAL POPULATION

All of the studies published on the population of this region between the end of the 1970s and the beginning of the 1980s do not have the same scientific value. Nevertheless, they are presented in order to preserve the "memory" or "trace" of what has been done in Quebec in this area.

We found six studies, published during this period of time, whose aim was to assess the cancer risk of the population in the asbestos region.[61-66]

The first of these studies compared cancer incidence in the population of counties where asbestos mines were located with that of other counties in Quebec (counties peripheral to mining regions, other rural counties, Montréal, and Quebec City), between 1969 and 1973. The relative risk of cancer of the pleura was 8.1 for men and 3.4 for women in the asbestos region. For cancer of the peritoneum, relative risk reached 2.0 among men, but no cases were reported among women.[61] This study did not include any statistical analysis; after verification, no result was statistically significant.[67]

The second study compared the mortality of residents of the mining region (the towns of Thetford Mines and Asbestos) to the mortality observed in 19 other urban areas in Quebec between 1966 and 1977. No significant excess was noted among women, but men showed a higher and statistically significant comparative mortality figure: 1) for all causes of deaths combined in the two mining towns; 2) for all cancers combined and for respiratory cancers in Thetford Mines only; and 3) for deaths from respiratory diseases in Asbestos only. The authors estimated that among men and women in mining region towns, slightly less than two deaths per year might be associated with asbestos pollution.[62]

The aim of the third study was to assess the cancer mortality, between 1964 and 1973, of residents of 32 Quebec municipalities grouped according to their level of asbestos exposure in drinking water (high, possibly high, and probably low). The purpose of the project was to verify if there was a link between the ingestion of asbestos fibres and cancer of the digestive system. Men in Thetford Mines and Asbestos, towns where exposure was considered high, presented statistically significant excesses of deaths from stomach cancer and lung cancer, which the author attributed to work in the mines.[63]

The fourth study was conducted in 85 mining towns in Canada (including Thetford Mines and Asbestos) where at least 20% of the male workforce were employed in the mining industry. Mortality from benign respiratory disorders and from lung cancer among men in these towns was calculated for the period from 1966 to 1976. Men from Thetford Mines and Asbestos showed significantly higher mortality rates for these two causes after standardization for age.[64]

In a similar study, another author described the mortality of Thetford Mines and Asbestos residents, but this time, during the years from 1975 to 1977. Among men, there was a statistically significant excess of mortality from lung cancer, malignant tumours of the digestive system and the peritoneum, and from all malignant tumours combined, while among women this was not the case.[65]

The sixth study consisted in drawing a parallel between ambient air concentrations of asbestos fibres measured during the summer of 1980 in the municipalities of Danville, Asbestos, and Wottonville, and the cancer mortality data for men and women 20 years of age and over, residing in these towns, who died between 1965 and 1974. Asbestos concentrations were higher in Asbestos than in Danville. The situation was less clear for Wottonville (concentrations sometimes higher, sometimes lower than in Danville). The area of the town of Asbestos was then divided into three zones based on total dust levels. Mortality rates for men in Asbestos were higher in the zones presenting the highest exposures, and the lowest rates were observed in the zones where exposure was lowest. Among women, rates were higher in zones where concentrations were highest, but were lowest in zones with medium exposure.[66]

To sum up, these six studies would suggest that, at the time they were published, there might have been an increased incidence of or increased mortality from respiratory cancers, cancers of the peritoneum, and respiratory diseases, especially among men in the mining region. While it may be correct to estimate that 70% of men in the region worked in the asbestos industry[7], it is difficult to estimate the contribution of environmental exposure to the development of these cancers. In the case of women, it is not easy to determine the contribution of environmental exposure due to the small number of studies and the limited data on the subject. It must be remembered that these studies lacked statistical power, did not control for risk factors related to these cancers or diseases, or did not perform statistical analyses. Finally, it must be noted that filing a declaration in the *Fichier des tumeurs du Québec* was not a requirement when the first study was conducted, thus rendering the data on incidence very unreliable.

4.2. MESOTHELIOMA AND LUNG CANCER AMONG WOMEN IN THE MINING REGION

Some recent studies and analyses were carried out as part of the epidemiology subcommittee's work[8-11,13,68] as well as outside this context[12], to get a better idea of the situation with respect to mesothelioma of the pleura and lung cancer among women in Quebec's mining region.

The women in this region suffering from mesothelioma of the pleura were traced. To do this, the authors first identified the mesotheliomas occurring in an area that includes approximately 78% of the population of Quebec.

From this, we learned that between 1970 and 1989 ten women suffering from mesothelioma of the pleura resided in the mining region at the time they were diagnosed while 108 others lived elsewhere in Quebec at the time of diagnosis. Of the 10 women in the mining region, 6 had a "definite" diagnosis of mesothelioma and 4 had a "possible" diagnosis, according to the study's two expert pathologists. The annual mesothelioma incidence rate for women in the mining region (10 cases or 22.7 per million) was then compared with the incidence rate estimated for women in the rest of Quebec (108 cases or 2.1 per million). Women in the mining region thus had 10.8 times more mesotheliomas than women elsewhere in Quebec. If we added to the 10 women, 7 other women who no longer resided in the mining region at the time they were diagnosed, but who had lived there in the past, the risk then became 20.3 times higher.[68]

In a previous study by this group of researchers[12], asbestos exposures of occupational, domestic (cohabitation with one or more asbestos workers), and residential origin had already been estimated separately for women residing in the mining region. The control women in the present study would have been exposed to concentrations varying between 0.2 and 1.5 fibre/ml during their lifetime, a mean cumulative exposure of approximately 25 fibres/ml-years.[8]

Data from this study were then used to validate the US Environmental Protection Agency's (EPA) risk assessment model for mesothelioma. The number of cases predicted by the EPA model (traditional linearized multistage model of carcinogenesis) was then compared with the number of cases observed among women in the mining region, on the basis of their town of residence.

We found that 10 women who had died of mesothelioma of the pleura had been traced in the aforementioned case-control study. The study focusing on mesothelioma of the pleura had excluded one case of mesothelioma of the peritoneum. However, for the purpose of validating the EPA model, the 11 cases were taken into consideration, since the EPA model does not differentiate by site of the mesothelioma. The EPA model predicted a mesothelioma incidence 59 times (650/11) higher than the observed incidence. To be extremely conservative, were we to add 7 other women who had resided in the mining region but were no longer living there when they were diagnosed with mesothelioma, the model would nevertheless overestimate mesothelioma risk by a factor of 36 (650/18)[10,11] (Table 10).

Table 10: Comparison between observed number of mesothelioma cases from 1970 to 1989 and expected number according to the Environmental Protection Agency model

	Observed cases	Expected cases (plausible range)
Asbestos*	1	150 (30-750)
Thetford Mines*	10	500 (100-2500)
Total	11	650 (130-3250)

* 1 mesothelioma of the peritoneum in Asbestos and 10 mesotheliomas of the pleura in Thetford Mines.

The same approach was applied to lung cancer deaths. Between 1970 and 1989, 71 lung cancer deaths occurred among women in the two mining communities while expected numbers, using two possible calculation methods, were between 64.5 and 71.4 cases (Table 11). The Environmental Protection Agency predicted between 132 and 146 cases based on the method for calculating expected numbers. The ratio between the excess of predicted deaths and the excess of observed deaths varied between 10.4 and infinity depending on the method chosen for calculating expected numbers[12] (Table 11).

Table 11: Observed excess of deaths from pulmonary cancer compared with predicted excess of deaths following the Environmental Protection Agency model based on the two calculation methods used

	Standardized mortality (SMR)	Proportional mortality (PMR)
Observed deaths	71	71
Expected deaths	71.4	64.5
Excess of observed deaths	- 0.4	6.5
Predicted deaths	146.4	132.2
Excess of predicted deaths	75.0	67.7
Ratio of predicted : observed excesses	∞	10.4

Between 1970 and 1989, a case-control study was also conducted among the 10 women in Thetford Mines suffering from mesothelioma of the pleura (the cases) and among 74 women residing in the same town, but free from mesothelioma (the controls). Researchers compared asbestos exposures of the cases with those of the controls for each source of exposure separately and for all asbestos exposures together. The three previously described sources of exposure (professional, domestic, and residential) were identified. However, we utilized a simplified exposure metric: total cumulative exposure to asbestos in fibre/ml-year.

Table 12 shows that significantly more of the mesothelioma cases than controls had worked in the asbestos industry and for a longer time. Relative risk was greater than 30 for a woman who had worked with asbestos. Cohabitation with an asbestos worker increased by a factor of five the risk of mesothelioma of the pleura, though the risk did not reach the statistically significant level. Mesothelioma risk also increased with the number of asbestos workers with whom study subjects had cohabited and with the length of cohabitation time with these workers, yet was not statistically significant.

Table 12: Relative risk of mesothelioma of the pleura associated with domestic and occupational exposures, based on certain categorical exposure variables*

	Number of cases	Number of controls	OR**	95% CI ***
Occupational exposure				
Had worked in the asbestos industry				
No	5	72	1.0	-
Yes	5	2	31.4	3.5 – 277.4
Number of years of work in the asbestos industry (years)				
0	5	72	1.0	-
1-5	2	1	25.3	1.5 – 435.2
> 5	3	1	36.0	2.9 – 449.1
Number of years of work in the asbestos industry: risk per year	10	74	1.23	1.04 – 1.46
Domestic exposure				
Had cohabited with an asbestos industry worker				
No	1	26	1.0	-
Yes	9	48	5.1	0.6 – 44.6
Number of asbestos industry workers with whom the subject cohabited ↓				
0	1	26	1.0	-
1-2	5	37	3.5	0.4 – 32.7
≥3	4	11	11.6	1.0 – 140.6
Number of years of cohabitation with an asbestos industry worker (years) ↕				
0	1	26	1.0	-
1-40	5	32	4.3	0.4 – 41.5
>40	4	16	6.7	0.6 – 72.5

* Each result presented here is based on a model incorporating a single exposure variable.

** OR = odds ratio

*** 95 % CI = 95% confidence interval

↓ In some cases, the participant had cohabited with several workers at the same time.

↕ The number of years of cohabitation is calculated by totaling the number of years of cohabitation with each worker.

The level of cumulative asbestos exposure, whether the source of this exposure was residential, occupational, domestic, or all origins combined, was always higher among cases than among controls. The only exception was domestic exposure of cases and controls. For all sources of asbestos exposure combined, cases were exposed on average to 226 fibres/ml-years and controls to 96 fibres/ml-years (Table 13).

Table 13: Cumulative asbestos exposure (fibre/ml-year) of cases of mesothelioma of the pleura and of controls over the 10 to 50 previous years, by source

	CUMULATIVE ASBESTOS EXPOSURE (fibre/ml-year)					
	Cases (n=10)			Controls (n=74)		
Source of asbestos exposure	Mean	Standard Deviation	Range	Mean	Standard Deviation	Range
Residential	102.0	10.1	82.1-115.0	74.3	39.1	0.4 – 121.4
Occupational	94.5	140.0	0.0-390.0	0.8	4.9	0.0 – 34.0
Among those exposed (n)*	236.3 (4)	118.8	100.0-390.0	29.5 (2)	6.4	25.0 – 34.0
Domestic	29.6	20.3	0.0-55.2	21.0	20.5	0.0 – 63.6
Among those exposed (n)	32.9 (9)	18.5	2.4-55.2	33.0 (47)	16.2	8.4 – 63.6
All sources	226.1	146.7	84.5-525.6	96.1	51.3	0.4 – 182.7

* Excluding one case in which exposure occurred 50 years before the diagnosis of cancer

Mesothelioma risk associated with occupational exposure increased by 3% for each additional fibre/ml-year of asbestos exposure. Mesothelioma risk increased by 2% for domestic exposures, by 5% for residential exposures, and by 2% for all sources combined. This last increase almost attained the statistically significant level. Since the three sources of asbestos exposure were correlated, they were then simultaneously incorporated into the analytic model. Mesothelioma risk then increased by 4% for residential and occupational exposures, but it did not increase with domestic exposure (Table 14).

Table 14: Relative risk of mesothelioma of the pleura associated with a progressive increase of one fibre/ml-year for residential, domestic, and occupational cumulative exposures, expressed on a continuous scale*

Source of exposure	Number of cases	Number of controls	OR**	95 % CI***
Models with one variable at a time				
Residential	10	74	1.05	0.99 – 1.11
Occupational	10	74	1.03	0.99 – 1.08
Domestic	10	74	1.02	0.99-1.06
All sources	10	74	1.02	1.00-1.04
Model with the 3 variables				
Residential	10	74	1.04	0.98 – 1.10
Occupational	10	74	1.04	0.96 – 1.12
Domestic	10	74	1.00	0.96 – 1.04

* The relative risk presented here indicates the increased risk for each increase of one fibre/ml-year of cumulative exposure.

** OR = odds ratio

*** 95% CI = 95% confidence interval.

This study confirmed the known link between occupational asbestos exposure and the development of mesothelioma, but it also shows, for the first time, an exposure-risk relationship ("dose-response") between mesothelioma of the pleura and cumulative exposure to asbestos from all sources combined in a population of women. In fact, the study suggests that it is cumulative exposure or dose that determines risk, independent of source (residential, occupational, or domestic).[13] However, the low statistical power and the methodological limitations of the study do not allow us to conclude that there was no difference based on source of exposure. Finally, this case-control analysis does not examine the effect of different types of fibres (amphiboles vs. chrysotile).

5. ASBESTOS-RELATED DISEASES AMONG QUEBEC'S WORKERS

Quebec's workers have been the subjects of various studies. These studies focused on both the health of workers in general and the health of specific groups of workers, such as workers in asbestos mines and mills, processing plants, or construction.

5.1. WORKERS IN GENERAL

First, studies on the health of workers in general will be reviewed. The information on this subject comes partly from studies documenting the state of health of workers during the 1960s, 1970s, and 1980s and partly from an analysis of the profile of workers suffering from an asbestos-related disease whose occupational origin was recognized by the committee (*Comité spécial des présidents*) set up by the CSST for this purpose.

5.1.1. Published studies

From the end of the 1960s to the mid 1980s, several studies were published with the aim of documenting the link between mesothelioma and lung cancer and work with asbestos.

The first publication we surveyed was a case-control study conducted among 344 men suffering from mesothelioma in the United States and Canada (including cases in Quebec) and deceased between 1960 and 1975. The relative risk associated with work in the insulation sector reached 46.0; in asbestos production and manufacture: 6.1; in work related to heating but excluding insulation: 4.4; in shipyards: 2.8; and in the construction industry: 2.6. In nearly half of the mesothelioma cases among men and approximately 5% of these cases among women, it was possible to attribute the tumour to occupational exposure to asbestos.[69]

The second study, also a case-control, had been conducted among 32 Quebecers who had died from mesothelioma between 1969 and 1972 and two groups of 32 controls. The proportion of persons who had been exposed to asbestos in a mine or a plant was 34.4% among the cases and 1.6% among the controls. Relative risk was 33.[70]

In the third study we examined, Ruffie reviewed 332 cases of pleural mesothelioma hospitalized between 1965 and 1984 in the university hospitals of Toronto and Quebec City. The author was able to trace a prior exposure to asbestos in 44% of these people.[71]

The fourth study, a case-control, focused on the link between cancer and work and was conducted in the Montréal area between 1979 and 1985. Eight hundred fifty-seven lung cancer cases and 12 mesothelioma cases along with their respective control groups (1,360 and 2,862 people) were interviewed, in order to document their exposure on the basis of their occupational history. The results were presented first on the basis of the extent of the subjects' exposure to asbestos (any exposure versus a heavy exposure) and then on the basis of type of asbestos fibre (chrysotile asbestos with or without exposure to amphiboles versus amphiboles with exposure to chrysotile).

The mesothelioma risks were increased and statistically significant for any type of asbestos exposure (chrysotile with or without amphiboles: any exposure: odds ratio (OR) = 4.4; 95% CI = 1.6-11.9 and heavy exposure: OR = 14.6; 95% CI = 3.5-60.5; amphibole with chrysotile: any exposure: OR = 7.2; 95% CI = 2.6-19.9 and heavy exposure: OR = 14.6; 95% CI = 3.5-60.5). Lung cancer risks were higher when subjects had been exposed to chrysotile asbestos with or without amphiboles (any exposure: OR = 1.2; 95% CI = 1.0-1.5; heavy exposure: OR = 1.9; 95% CI = 1.1-3.2), but they were not when subjects had been exposed to amphiboles with chrysotile.[17]

A new analysis of these data was published in 2002. The relative risk of mesothelioma was very high and statistically significant following substantial exposure to amphiboles. However, due to the small number of mesothelioma cases, the risk among workers exposed to chrysotile without amphiboles (i.e. with an unreported exposure to amphiboles) was not measured. Heavy exposure also led to an increased risk of lung cancer, but without reaching the statistically significant level. The highest risk was observed with chrysotile exposure with no mention of amphiboles (OR = 3.1; 95% CI = 1.0 – 9.8). This risk was at the limit of statistical significance, which suggests that lung cancer risk from chrysotile exposure is not lower than the risk from exposure to amphiboles. Mesothelioma and pulmonary cancer risks were not as high following very low exposure to the two types of asbestos fibres and did not reach the statistically significant level. This may be interpreted in two ways: either at a low exposure there is no detectable risk, or, at a low exposure the risk is slight and real, but the statistical power of the study does not confirm it. In the latter case, the large proportion of cases of the two cancers in which asbestos exposure was low, rather than high, could make this a non-trivial risk.[18]

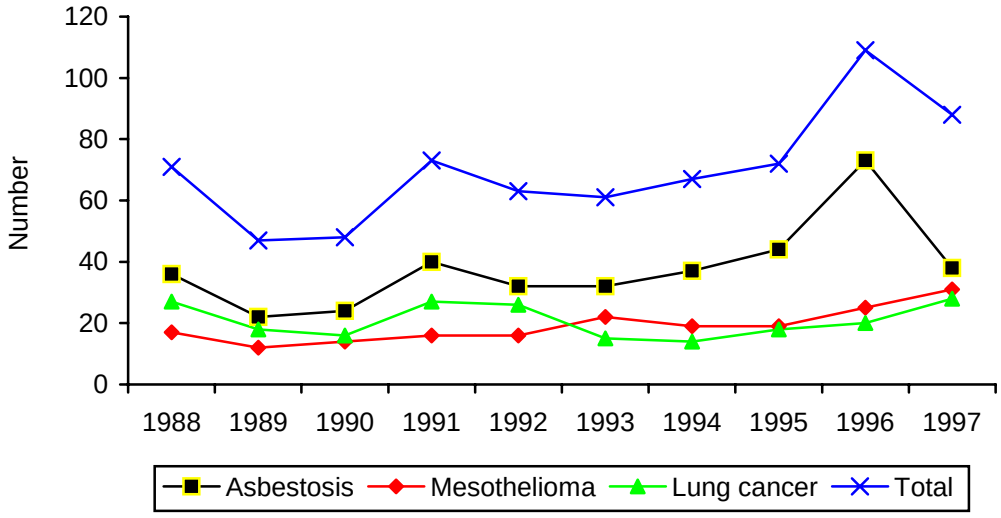
5.1.2. Data on occupational pulmonary diseases

In 1992, the authors of a study that looked at the files of 120 Quebec workers suffering from work-related mesothelioma between 1967 and 1990 published their findings. The workers had been separated based on the origin of their asbestos exposure-asbestos mines and mills (group 1) (41% of cases); asbestos processing and insulation (including insulators, pipe fitters and shipyard workers) (group 2) (42% of cases); and incidental exposure (including general construction workers, plumbers and electricians, and workers subject to bystander exposure) (group 3) (17% of cases). This study showed an increase in the number of cases between 1967 and 1990, with a more pronounced increase in group 3 than in the first two groups.[72]

The 691 files of workers suffering from asbestos-related diseases whose occupational origin had been recognized by the *Comité spécial des présidents* between 1988 and 1997 were subsequently analyzed. Among these persons, 378 suffered from asbestosis, 191 from mesothelioma, and 209 from lung cancer.[24]

During the 10 years of the study, the number of workers suffering from any of the asbestos-related diseases, from asbestosis, and from mesothelioma appeared to increase while the number of workers with lung cancer appeared stable (Figure 6).

Figure 6: Asbestos-related diseases by year. Comité spécial des présidents 1988-1997



Based on their occupational history, these workers were divided according to the source of their asbestos exposure, namely mines, asbestos processing industry, construction industry, maintenance and repair of asbestos-containing products or structures, or other sources combined. The majority of workers with asbestos-related diseases came from mines (35%). Second were the maintenance and repair workers (25.5%), and third, construction workers (17%). The latter two industries together generated 42% of all cases, thus surpassing the mines. Then followed processing workers (13.5%) and "other" workers (4.9%) (Table 15).

Table 15: Asbestos-related diseases based on sector of economic activity and occupation. Comité spécial des présidents 1988-1997

Sector/ Occupation	Asbestosis		Mesothelioma		Pulmonary cancer		Total workers*	
	n	%	n	%	n	%	n	%
Mines	120	31.7	34	17.8	130	62.2	240	34.7
Processing	50	13.2	27	14.1	25	12.0	93	13.5
Construction	73	19.3	35	18.3	15	7.2	115	16.6
Maintenance and repair	101	26.7	67	35.1	27	12.9	176	25.5
Other	15	4.0	17	8.9	4	1.9	34	4.9
Mixed	11	2.9	4	2.1	3	1.4	17	2.5
Unknown	8	2.1	7	3.7	5	2.4	16	2.3
TOTAL	**378**	**100.0**	**191**	**100.0**	**209**	**100.0**	**691**	**100.0**

* A worker may have more than one disease.

The workers suffering from mesothelioma were then divided into the 3 groups defined in the preceding study based on origin of asbestos exposure.[72] The upward trend observed between 1967 and 1990 persisted until 1997, particularly in groups 2 and 3, but the trend seemed on the decline in group 1.[24]

5.2. ASBESTOS MINE AND MILL WORKERS (INCLUDING ONE ASBESTOS PRODUCTS FABRICATION FACTORY)

The information on the health of mine and mill workers comes from three sources: 1) published studies on this population in the scientific literature; 2) screenings carried out among these workers; and 3) of these workers suffering from asbestos-related diseases recognized to be of occupational origin by the *Comité spécial des présidents*.

5.2.1. Published studies

The first study we traced on Quebec's asbestos miners dates back to 1958. This was a study conducted among 5,958 workers in Thetford Mines and Asbestos, employed in mines in 1950 and exposed to asbestos for at least 5 years. The workers' vital status was determined in order to find out if lung cancer deaths were related to work with this fibre. After determining vital status between 1952 and 1955, that is after a short elapse of time, the authors concluded at the time that the miners did not have more lung cancer deaths than the population of various areas in Quebec chosen for comparison.[73]

Subsequently, a study was set up involving a large cohort of 10,918 workers from asbestos mines, mills, and one products fabrication factory in Thetford Mines and Asbestos, born between 1891 and 1920, and followed from hiring date (beginning in 1904) to May 31, 1992. It was used to describe the mortality of this group of workers. Among the 9,780 workers traced, 8,009 were deceased.

Researchers counted 38 deaths from mesothelioma, 657 from pulmonary cancer, and 108 from pneumoconiosis.[74]

While the number of mesothelioma deaths observed among the workers was in excess compared with Quebec's male population, the number of pulmonary cancer deaths was not. However, pulmonary cancer deaths in a sub-group of workers exposed to relatively high levels for a long time (which represents approximately one quarter of the cohort), allowed researchers to determine that the relative risk reached two in this sub-group of workers (compared with the Quebec population). Approximately one hundred pulmonary cancer deaths would thus be work-related. Finally, among the 108 pneumoconiosis deaths, 46 cases of asbestosis were found.[7]

Thirty-three of the 38 mesotheliomas had occurred among miners and 5 among plant workers, the latter having all been exposed to crocidolite or to amosite. The mesothelioma rate per 100,000 person-years was 33.7 among miners in Thetford Mines, 13.2 among miners in Asbestos, and 46.2 among employees in the Asbestos plant. The difference between the observed mortality rates in the two towns could be explained by the presence of tremolite in the chrysotile asbestos deposits mined in Thetford Mines.[75]

The studies conducted on this population of workers have generated a great deal of information on the relation between asbestos exposure and the diseases studied (lung burden, link with type of fibre, mineralogy, etc.).[7] The findings of these studies will not be described here, but much of the knowledge from these studies is included in section 2 of this report.

At the same time as the studies described in the preceding paragraph were being conducted, a group of American researchers was performing similar studies, by union request, among the same workers. We traced the results of a study on the mortality of 544 workers employed in the asbestos mines of four companies in Thetford Mines in 1961. These workers had 20 years seniority at the time of the study and their mortality between 1961 and 1977 was studied. The standardized mortality ratio or SMR for all causes of deaths was 1.11 and for pulmonary cancer it was 2.52 (n=28). A single case of mesothelioma of the pleura and 26 deaths from asbestosis were documented.[76]

5.2.2. Screenings

Quebec statutes require workers in Quebec's mines, quarries, and sand pits to undergo regular lung x-ray screenings for asbestosis.[77] The lung x-rays of asbestos mine workers are stored in the Chaudière-Appalaches and Estrie regions. Due to a lack of resources, we did not look at this database in the framework of our studies, but it would be interesting to combine the radiography results with the data on asbestos exposure to describe how the situation has evolved in this sector in more recent years.

The aim of a study currently under way is to compare, at the time of diagnosis, the results of various clinical indicators among workers compensated for asbestosis by the CSST who have never been included in a screening program to those who have been included in a screening program. The study covers cases seen at the CSST between 1938 and 1997. Its aim is to study the influence of asbestosis screening on severity of disease at time of diagnosis. It was undertaken to respond to questions from doctors in the public health network on the pertinence of current Quebec regulations prescribing

regular screening for asbestosis among workers in mines, quarries, and sand pits. The findings should be available sometime in 2003.[78]

5.2.3. Data on occupational pulmonary diseases

We saw above that among the 691 cases of asbestos-related diseases whose occupational origin had been recognized by the *Comité spécial des présidents* between 1988 and 1997, 240 (35%) came from the mining industry. This is also the industry that generates the most cases of asbestosis (32%) and pulmonary cancer (62%). For mesothelioma, the situation is different. Most cases are found among workers doing maintenance and repair of asbestos-containing products or structures (35%). The mining industry is in second place, tied with the construction sector (18% of cases)[24] (Table 15).

Between 1988 and 1997, in this industry, the number of asbestosis cases appeared to increase, the number of pulmonary cancer cases appeared stable, and the number of mesothelioma cases appeared to decrease.[24]

There is a surprisingly high proportion of lung cancer cases (62 %) from mines compared with the other industries. Since doctors are well aware of the link between lung cancer and asbestos exposure and are equally aware of asbestos exposure in the mining industry, we may expect that nearly all cases from this industry will be presented to the CSST for compensation. However, it is possible that cases from other industries are under-estimated because workers are less aware of their exposure to asbestos and doctors are not sufficiently aware of the potential sources of asbestos exposure outside the mining industry. Moreover, among smokers, it is easier for doctors to identify cigarette smoking as the causal factor for lung cancer than to identify an often unapparent asbestos exposure.

5.3. WORKERS IN ASBESTOS PROCESSING PLANTS

5.3.1. Studies published in the 1970s and 1980s

We traced three studies, published between the end of the 1970s and the beginning of the 1980s, which dealt with work involving asbestos processing.

The first of these studies was carried out among workers in a factory in Asbestos that manufactured gas masks during World War II. Chrysotile had been in use since World War I, but production in the textile department was redirected between 1939 and 1941 toward gas masks filters manufactured with crocidolite. A second factory of this type, located in Montréal, had opened its doors in 1928 and manufactured brakes before the war. Between November 1940 and June 1941, this factory also diverted its production toward gas masks filters manufactured with crocidolite. From 1939 to 1942, in a third factory, located in Ottawa, workers assembled the filters in a canister containing crocidolite. Of the 199 male and female workers employed in the three factories, 174 were followed from 1939 to 1975. The death certificates of 53 of the 56 deceased were located. Twenty-three of the deaths were due to cancers. These included 9 cases of mesothelioma (including 6 peritoneal) and 8 cases of pulmonary cancer. Four workers had died from pneumoconiosis: two from asbestosis at the Montréal factory and two from silicosis (one silicosis and one silico-tuberculosis) at the Asbestos factory. Duration of asbestos exposure for mesothelioma cases was between 4 months and 6 years.[14]

In 1977 and 1980, two studies seem to focus on workers from one textile plant in Valleyfield that used only chrysotile to produce belt conveyors for paper mills.[15,16] The aim of the first study was to document the mortality of 413 workers (326 men and 87 women) employed by the company between 1935 and 1961.[15] The aim of the second was to describe, among employees of the company in 1975, the prevalence of respiratory symptoms with relation to the level of asbestos exposure.[16] The authors of the latter study had also included workers from another Montréal area plant that manufactured insulation products and cement containing chrysotile, amosite, and crocidolite.

In the first of these studies, the vital status of workers was determined in 1975, that is, after a follow-up for a minimum of 14 years. In 1975, 78 workers (including 3 women) were deceased and the death certificates of 68 people were traced. The author established that lung cancer mortality (n=8) of the textile plant workers was 9 times higher than that of the regional population and 5 times higher than that of the population of the province of Quebec. In addition, seven people had died from asbestosis.[15]

The findings of the second study showed that workers in the Valleyfield plants (n=272) and the Montréal plants (n=8) presented more respiratory symptoms than asbestos miners (n=1,015), even though the Montréal workers were exposed to lower levels of asbestos and for a shorter time than miners.[16]

5.3.2. Studies published from 1990 to 2000

A more contemporary study conducted on the Island of Montréal identified 27 plants where workers had been exposed to asbestos between 1992 and 1997. Twenty-three of these plants used asbestos during processing, but in the four remaining plants, exposure resulted from the maintenance of pipes or mechanical equipment. Problems with regard to exceeding standards were confirmed in 7 of the 23 establishments (30%). These seven plants manufactured brake pads (n=3), asphalt products (n=1), joint sealants (n=1), asbestos products (n=1), and adhesives and caulking products (n=1).[19]

In July 2000, the situation in the seven companies was followed up in two ways: by consulting the files of these establishments in the CLSCs (local community health centres) and by consulting the health teams responsible for these companies (doctors and industrial hygienists).

The results for the year 2000 show that two of the seven companies merged and another closed its doors, leaving a total of five establishments to be checked (one asphalt production plant, three brake factories, and one caulking and insulation products plant). All these plants used chrysotile asbestos. Three of the five companies were subjects of an asbestos environmental assessment. Of the three, one exceeded standards at 13 of the 14 work areas sampled.

Medical surveillance activities were carried out in 4 of the 5 companies among 304 workers. Two workers showed abnormalities compatible with a diagnosis of asbestosis, one of which was confirmed. A third worker, not included in the screening, was already known to have had asbestosis since 1990.[20]

The latter two studies give us a contemporary portrait of asbestos exposure and a general idea of compensable cases, among workers still employed with these Montréal-based companies. We know there are other asbestos processing plants in Quebec, but we do not know their number and their situation with regard to asbestos exposure.

5.3.3. Data on occupational pulmonary diseases

The data on the 691 workers suffering from asbestos-related diseases whose occupational origin had been recognized by the *Comité spécial des présidents* between 1988 and 1997 show that 93 persons (13.5%) were exposed to asbestos in the processing industry. An almost equal proportion of cases of asbestosis (13%), mesothelioma (14%), and pulmonary cancer (12%) were from this industry (Table 15). The 93 workers differ from the total 691 cases in that they were exposed to asbestos for a shorter time on average (16 years) than the total number of cases (27 years) before being seen by the *Comité*. During the 10 years of the study, the number of mesothelioma cases increased, but cases of asbestosis and pulmonary cancer decreased.[24]

5.4. CONSTRUCTION WORKERS

The data we have on the respiratory health of construction workers comes from three sources: 1) studies published in the scientific literature on insulators and sheet metal workers exposed to asbestos, which probably included workers from Quebec; 2) screenings begun in 1995 of workers in targeted construction trades in Quebec; and 3) data from the CSST on the cases of asbestos-related occupational pulmonary diseases between 1988 and 1997.

5.4.1. Published studies

Selikoff's studies documented the presence of asbestos-related diseases among large populations of insulators and sheet metal workers recruited through American and Canadian trade unions. However, it is not possible to separate the findings of the follow-up of Canadian workers from those of American workers. Moreover, it is not evident from reading the articles that the Canadian workers included workers from Quebec.[79,80]

The only indication we have of some representation from Quebec comes from a 1981 study. The author reviewed the files of 36 insulators from Quebec deceased between 1967 and 1977 whose death certificates had been sent to Selikoff. The author also identified four other insulators who had a file with the *Commission des Accidents du travail du Québec*, a compensation board that preceded the CSST. Among these 40 individuals, 5 died from asbestosis, 1 from mesothelioma, and 9 from pulmonary cancer.[21]

Among the 17,800 insulators Selikoff studied, 4,951 were deceased in 1986. There were 1,168 lung cancer deaths (SMR = 435), 173 pleural mesothelioma deaths, and 285 peritoneal mesothelioma deaths.[79] In Selikoff's second study that dealt with 1,330 sheet metal workers, 33% of the workers had parenchymal opacities.[80]

In 1994, a new study by Selikoff focusing this time on 9,605 American sheet metal workers (including the 1,330 sheet metal workers in the aforementioned study) showed 12% of sheet metal workers had parenchymal opacities on pulmonary radiography. The study also included Canadian subjects, but we found only the results for Americans, even though future publication of the Canadian population data was announced in the article.[81]

Toward the end of the 1980s and at the beginning of the 1990s, the results of different studies conducted among a group of 644 Quebec insulators were published.[82-86] One of the studies documented the prevalence of radiographic abnormalities, including asbestosis, in a sub-group composed of 110 of the 644 insulators. Ten percent of these insulators suffered from asbestosis[86] (Table 16).

5.4.2. Screenings

Starting in 1995, three different screenings were carried out among workers in various construction trades who had been exposed to asbestos in the past. The first looked at 972 workers in the Montréal area;[22] the second looked at 492 other workers present during construction of two major industrial sites in Quebec,[23] and the third looked at a small group of 83 maintenance workers in one of the school boards on the Island of Montréal.[87]

The screening in Montréal showed 2.1% of workers presented abnormalities compatible with a diagnosis of asbestosis and 23.1% had pleural abnormalities. The screening of construction site workers revealed two cases of abnormalities compatible with a diagnosis of asbestosis and 12.8% pleural abnormalities. No case of asbestosis was detected among the school board employees, but four of them exhibited pleural abnormalities on radiography (Table 16).

Table 16: Asbestosis screening among construction workers and school board maintenance workers

Occupation	Number of workers screened	% of pleural abnormalities	% of asbestosis	Reference
Plumbers/pipe fitters	464	26.9	2.6	22
	291	14.8	0.3	23
Sheet metal workers/ tinsmiths	86	23.3	2.3	22
	42	7.1	-	23
Elevator mechanics	196	10.2	-	22
Fire protection mechanics	65	16.9	1.5	22
	7	-	-	23
Insulators	111	58.2	10.0	86
	161	31.1	3.1	22
	45	17.8	-	23
Boilermakers	88	9.1	-	23
Asbestos removal workers	14	7.1	7.1	23
Asbestos demolition workers	5	-	-	23
School maintenance workers	83	3.6	-	87

Taking into consideration workers' occupations, we observe, in Table 16, that the prevalence of abnormalities compatible with a diagnosis of asbestosis and the prevalence of pleural abnormalities varies respectively between 0.3% and 3.1% and between 7.1% and 31.1%.

Among insulators, the prevalence of various abnormalities found on radiographies decreases as the research projects and screenings become more recent. Differences with regard to duration of asbestos exposure, period when workers were exposed to this fibre, workers' age, provenance of the persons screened, and so on, may explain the disparity of the results (Table 16).

The prevalence of pleural abnormalities in the sampling of school maintenance workers from one school board was lower, at 3.6%, than in all the other groups (Table 16). It is close to the expected frequency in the general population as we saw in section 3 of the report.

The screening data presented here should be interpreted with caution, their disadvantage being that they deal with a poorly identified proportion of the target population, given that participation in these activities is optional. There may be bias due to this fact.

5.4.3. Data on occupational pulmonary diseases

The CSST data are the third source of information on the construction milieu. Among the 691 workers with an asbestos-related disease whose occupational origin had been recognized by the *Comité spécial des présidents* between 1988 and 1997, 115 (17%) had been exposed to asbestos while working for construction contractors. In terms of frequency of cases generated, this industry was third on the list, after mining and maintenance and repair of asbestos-containing products or structures. Seventy-three of the 115 construction workers had been diagnosed with asbestosis, 35 with mesothelioma, and 15 with pulmonary cancer (Table 15). Construction workers differed from other workers in that they developed their disease a little younger (60 years of age) than the group of 691 cases taken as a whole (65 years of age).

When the construction workers suffering from mesothelioma were divided according to their respective trades (electricians, plumbers-pipe fitters-welders, insulators, and others), we observed that insulators had developed their cancer after a shorter mean exposure (15 years) than that of the total number of mesothelioma cases among workers in the construction industry (22 years). All the diseases among construction industry workers were on the rise during the period of the study.[24]

Workers involved in the maintenance and repair of asbestos-containing products or structures may practise trades matching those in construction, but in enterprises whose main economic activity is other than construction. This is the group of workers that generates the highest number of cases of mesothelioma (35%) and the second highest number of asbestoses (27%) and pulmonary cancers (13%) (Table 15). In this group, the number of asbestosis and mesothelioma cases increased between 1988 and 1997, while there seems to be a slight reduction in pulmonary cancers. It is in this industry that the increase of cases appears the most striking.[24]

5.5. OTHER WORKERS

Among the 691 workers with an asbestos-related disease whose occupational origin had been recognized by the *Comité spécial des présidents* between 1988 and 1997, 34 or 5% had an indirect ambient exposure to asbestos or an exposure secondary to colleagues' work with asbestos. These 34 people generated 9% of all mesothelioma cases in the study. The workers with this cancer had been exposed to asbestos for a shorter time on average (15 years) than the total number of mesothelioma cases (22 years). If this observation holds true in the future, it will be interesting to follow up, since some of the workers and some of the population in Quebec could be exposed in this manner.[24]

6. COSTS

The CSST set up a computerized databank that included incurred costs in 8 different expense categories, for the 691 workers suffering from an asbestos-related pulmonary disease whose occupational origin had been recognized by the *Comité spécial des présidents* between 1988 and 1997. These costs include: medical assistance payments, rehabilitation benefits, income replacement indemnity, temporary indemnity, death benefits, compensation for bodily injury, social and economic stabilization, and compensation for permanent disability.

The amounts were disbursed starting in 1984 and up to 30 September 2000, in undiscounted dollars.

The files of 688 of the 691 cases of asbestos-related diseases were traced. Disbursements for these persons total $66,214,105.00. Fifty-six percent of expenses are in the category of compensation for permanent disability.[24] The total of expenditures underestimates incurred costs because it is in undiscounted dollars, calculations ended in 2000, and this total does not include costs not charged to the CSST, as for example, unclaimed care or hospitalization costs.

We did not document incurred costs for the cases identified in the *Fichier des tumeurs du Québec* (tumour registry), the *Fichier des décès* (death registry), and the MED-ECHO database (hospitalization data file). We would have had to set up a separate project on this aspect of the issue, and this exceeded the mandate the group had specified for itself. Neither did we quantify the direct and indirect costs associated with these diseases.

7. MATCHING AND COMPARISON OF DATA FROM VARIOUS SOURCES

In order to investigate which would be the most appropriate source for monitoring asbestos-related pulmonary diseases, the cases of mesothelioma, lung cancer, and asbestosis from various information sources were matched or compared.

7.1. MESOTHELIOMA

A search was performed among all cancer cases registered in the *Fichier des tumeurs du Québec* between 1975 and 1996 for the 261 mesothelioma cases recognized as occupational pulmonary disease by the CSST *Comités* set up for this purpose between 1967 and 1997 (for simplicity, we will call them the "CSST cases") and the 126 cases of mesothelioma of the pleura and peritoneum diagnosed between 1975 and 1990 among women in one part of Quebec as part of an epidemiological study conducted by researchers from the Institut Armand-Frappier.[4]

7.1.1. Matched data from the CSST and the Fichier des tumeurs du Québec

Of the 261 CSST mesothelioma cases, 226 or 86.6% were found in the *Fichier des tumeurs du Québec* and 35 (13.4%) were absent. Of the 226 cases identified in the *Fichier des tumeurs du Québec*, 188 or 83.2% had the same diagnosis in both databanks.

If we limit the period of observation from 1982 to 1996, i.e. to a time when the data of the *Fichier des tumeurs de Québec* begins to improve and when the tumour morphology code is present, 91.1% of CSST cases (184/202) have the same diagnosis as in the *Fichier des tumeurs de Québec* (Table 17).

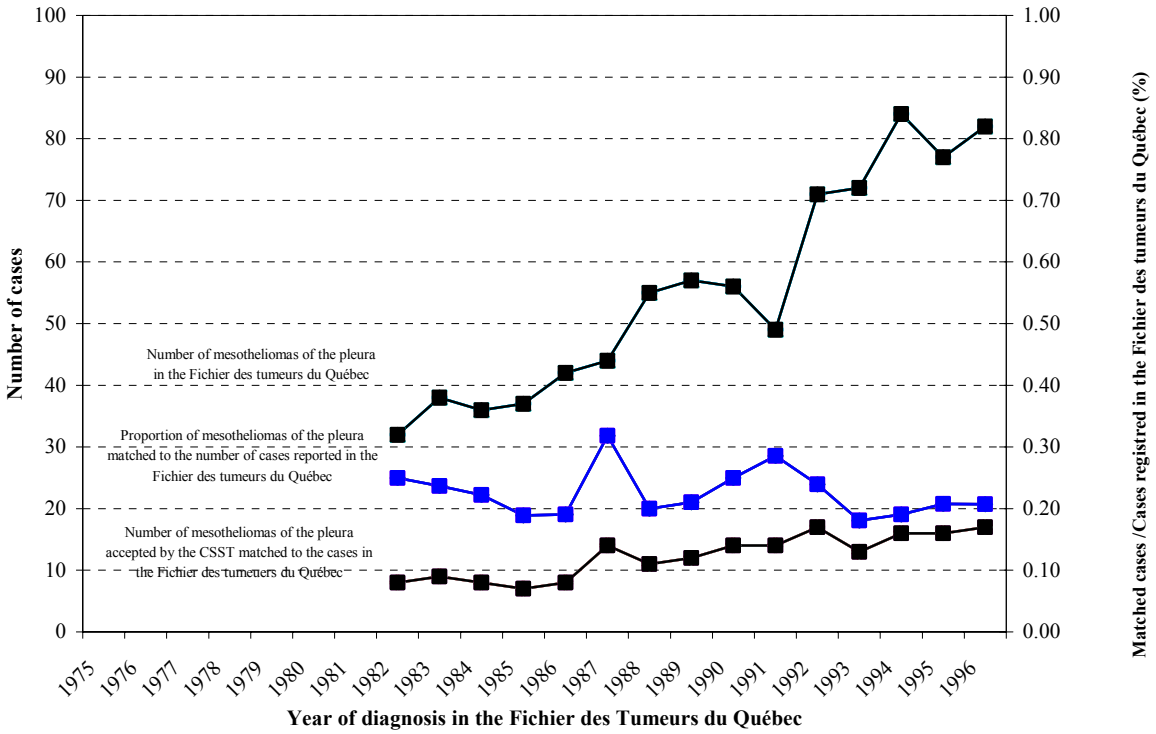
Table 17: Number of mesothelioma cases diagnosed by the CSST according to the diagnosis found in the Fichier des tumeurs du Québec. 1982-1996

		FTQ*					
		Mesothelioma of the pleura	**Mesothelioma other sites**	**Other diagnoses**	**Total**	**Not found in the FTQ**	**Total**
CSST	**Present**	184	6	12	202	29	231
	Absent	648	-	-	-	-	-
	Total	832	-	-	-	-	-

* FTQ=Fichier des tumeurs du Québec (Quebec's tumour registry)

During this same period, the CSST mesothelioma cases represent 22.1% (184/832) of the mesotheliomas recorded in the *Fichier des tumeurs du Québec* (Table 17). However, this percentage varies in different regions of Quebec. It is higher in the Chaudière-Appalaches, Lanaudière and Montérégie regions. It also varies between 18.1% and 31.8% depending on the year of diagnosis, though we could not establish a significant upward or downward trend (Figure 7).

Figure 7: Number and proportion of mesothelioma of the pleura cases diagnosed by the CSST and matched in the Fichier des tumeurs du Québec according to year of diagnosis in the Fichier des tumeurs du Québec. 1982-1996



The numbers of cases of mesothelioma of the pleura in the *Fichier des tumeurs du Québec* and at the CSST increased from 1982 to 1996. However, the increase is more striking in the *Fichier des tumeurs du Québec* data than in the CSST data (Figure 7). This difference leads us to suspect an increasing trend to under-identify mesothelioma cases related to occupational exposure.[4]

7.1.2. Matched data from the Institut Armand-Frappier and the Fichier des tumeurs du Québec

Among the 126 mesothelioma cases occurring among women and traced by the Institut Armand-Frappier between 1975 and 1990, 109 (86.5%) were found in the *Fichier des tumeurs du Québec* and 17 (13.5%) were absent. Among the 109 women traced and found in both databanks, 71 (65.1%) have the same diagnosis.

Restricting the observation period from 1982 to 1990, 78.3% (65/83) of mesothelioma cases have the same diagnosis in the data of the Institut Armand-Frappier and in the *Fichier des tumeurs du Québec*. During this period, the mesothelioma cases of the Institut Armand-Frappier represent 54.2% (65/120) of cases in the *Fichier des tumeurs du Québec* (Table 18). This is due in part to the fact that the study by the Institut Armand-Frappier did not cover the whole of Quebec.[4]

Table 18: Number of mesothelioma cases diagnosed among women in a study conducted by the Institut Armand-Frappier, according to the diagnosis found in the Fichier des tumeurs du Québec. 1982-1996

		FTQ*					
		Mesothelioma of the pleura and peritoneum	**Mesothelioma other sites**	**Other diagnoses**	**Total**	**Not found in the FTQ**	**Total**
IAF*	**Present**	65	3	15	83	1	84
	Absent	55	-	-	-	-	-
	Total	120	-	-	-	-	-

* FTQ= Fichier des tumeurs du Québec (Quebec's tumour registry), IAF= Institut Armand-Frappier

7.2. LUNG CANCER

A search was performed among all cancer cases recorded in the *Fichier des tumeurs du Québec* between 1975 and 1996[4] for the 210 CSST pulmonary cancer cases recognized between 1988 and 1997.[1]

One hundred eighty-seven CSST cases or 89.0% were found in the *Fichier des tumeurs du Québec*. Of these 187 individuals, 168 or 89.8% had the same diagnosis in both databanks. We also note that 23 of the 210 CSST cases or 11.0% were absent from the *Fichier des tumeurs du Québec*.

This proportion does not change if we restrict the observation period to the years from 1982 to 1996. However, the 186 CSST cases represent only 0.26% of lung cancer cases recorded in the *Fichier des tumeurs du Québec* (Table 19). Given the impact of tobacco use on lung cancer, it is probable that workers with this cancer (that might be caused by their work) who are also smokers are not referred to the CSST. Many cases recorded in the *Fichier des tumeurs du Québec* have no connection to work and are exclusively caused by tobacco use.

[1] Note that at the time of the study, one person was registered twice in our CSST databank. This explains why in Chapter 5 of the report, the analysis of workers suffering from pulmonary cancer discusses 209 individuals.

Table 19: Number of pulmonary cancer cases diagnosed by the CSST according to the diagnosis found in the Fichier des tumeurs du Québec. 1982-1996

		FTQ*				
		Lung cancer	**Other cancers**	**Total**	**Not found in the FTQ**	**Total**
CSST	**Present**	167	19	186	23	209
	Absent	63 076	-	-	-	-
	Total	63 243	-	-	-	-

* FTQ=Fichier des tumeurs du Québec (Quebec's tumour registry)

The 187 CSST lung cancer cases found in the *Fichier des tumeurs du Québec* between 1975 and 1996 are mostly from the Chaudière-Appalaches region (45%). This is followed by Estrie (22%), Montréal-Centre area (10%) and Montérégie (8%).[4]

7.3. ASBESTOSIS

A different procedure was used to match asbestosis cases. The available data were the 340 CSST asbestosis cases recognized between 1988 and 1996[24] and the 1,234 persons hospitalized in Quebec during these years with this diagnosis and recorded in the MED-ECHO database (hospitalization data file). It was not possible to perform a nominal matching with the MED-ECHO data at the time the project was under way. The comparison performed shows that hospitalized cases are 3.6 times more numerous than CSST cases, but it is not possible to determine if they involve the same persons.[2]

Three hypotheses may be advanced to explain this disparity, but have yet to be confirmed.

The first assumes that the workers suffering from asbestosis were hospitalized after they had received compensation, that is, at a time when, as they aged, they developed chronic diseases that required hospitalization. During this hospitalization, a pulmonary radiography or a review of medical history would reveal the presence of an asbestosis previously recognized by the CSST. The fact that the hospitalized cases between 1987 and 1996 are on average older (69.9 years for women and 68.1 years for men)[2] than the CSST cases (64.7 years between 1988 and 1997)[24] supports this hypothesis.

The second hypothesis concerns the method of recording cases in the MED-ECHO database. It is only since 1987 that this database has distinguished between incident cases and prevalent cases. Consequently, it is possible that some asbestosis cases from the years just prior to 1987 were hospitalized before 1987, thus overestimating the real number of incident cases.

The third hypothesis is that a considerable number of workers with asbestosis do not request CSST compensation.

7.4. CONCLUSION ON MATCHINGS AND COMPARISONS

We learn from these matchings that mesothelioma cases identified by the CSST and by the Institut Armand-Frappier represent only a small proportion of new cases recorded in the *Fichier des tumeurs du Québec* (respectively 22.1% and 54.2%). Consequently, the data from the CSST and the Institut Armand-Frappier are less exhaustive and less useful than those from the *Fichier des tumeurs du Québec* for monitoring annual trends of this disease, but they are the only ones containing information on asbestos exposure. Thus, no databank allows optimal pathology surveillance.

For lung cancer, the cases identified by the CSST represent only 0.26% of new cases declared in the *Fichier des tumeurs du Québec*. Even though there are more cases registered in the *Fichier des tumeurs du Québec*, the risk attributable to asbestos is too low in relation to that associated with tobacco use for it to be worthwhile to monitor annual trends of this cancer from data in the *Fichier des tumeurs du Québec*.

For asbestosis, only the CSST data contain information on work and on occupational asbestos exposure. The number of hospitalizations for asbestosis is much higher (close to 4 times higher) than the number of cases compensated for the same disease, and justifies a more in-depth study.

8. CONCLUSION

The findings that have been summarized here show a statistically significant increase in the incidence of mesothelioma of the pleura among Quebec men between 1982 and 1996. Statistical projection suggests that this increase might level off in a few years, but this is not certain. Quebec men and women also show significantly higher rates of mesothelioma of the pleura than men and women in the rest of Canada and in several other countries. This clearly points to the necessity of monitoring the evolution of this cancer in Quebec in the coming years, especially to see whether or not the increase levels off and to describe the geographical distribution of cases. Moreover, these findings show the relevance of continuing international comparisons.

Matching cases of asbestos-related diseases of recognized occupational origin to cases observed in the general Quebec population reveals two principal findings: cases of occupational origin may be far underestimated, and Quebec does not have an adequate surveillance system for asbestos-related diseases that includes information on the diseases, on exposure to this fibre, and on the populations at risk.

In terms of the relation to work, the number of workers with an asbestos-related disease of recognized occupational origin also increased over the last decade. These claims are mainly from workers in the construction industry and that of the repair and maintenance of asbestos-containing products or structures. The increased number of demands was also more striking in these two industries. The number of claims from mine workers appeared stable. However, it might decrease in coming years following the lowering of the exposure standard to 1 fibre/ml in 1990. These data showed processing workers also made claims. The overexposure to asbestos documented in that industry as well as in construction[88] and the reported incidences of standards being exceeded in mines[89] demonstrate the importance of properly monitoring the exposure and state of health of workers in future.

The under-estimation of lung cancer and the poor recognition of the link between asbestos work and this tumour indicate a need to continue and to strengthen prevention, health promotion, and education among doctors, workers, and employers on this matter. The same holds true for other asbestos-related diseases.

In terms of the relation with the environment, information is more scarce. The study of women diagnosed with mesothelioma in the town of Thetford Mines showed an increased risk of this cancer with an increase in their occupational and domestic exposure. It also suggested a possible impact from environmental exposures to asbestos.

Some analyses that were not performed in the framework of the studies conducted by the sub-committee on the epidemiology of asbestos-related diseases in Quebec would be worth undertaking.

All these findings lead the sub-committee to make the following recommendations.

9. RECOMMENDATIONS

Surveillance of mesotheliomas

In order to monitor the temporal and geographic trends of mesothelioma in Quebec and its risk factors, and this with the aim of guiding preventive actions, we recommend:

1. That the *ministère de la Santé and des Services sociaux* (department of health and social services) set up in Quebec a prospective surveillance system for mesothelioma of the pleura and peritoneum, ensuring compliance with good surveillance system criteria (accuracy and quality of diagnoses, completeness of ascertainment of cases (i.e. different sources for collecting all the cases), speed of reporting of cases, presence of additional information such as asbestos exposure, etc.).
2. That a feasibility study be undertaken to determine both the kind of additional information to collect in order to set up a good surveillance system and the method for collecting this information as efficiently as possible for each new case diagnosed.
3. That the data collected on mesotheliomas be analyzed on a regular basis and include national and international comparisons.

With the aim of being able to study mesothelioma trends in Quebec since 1990, we recommend:

1. That the data from the *Fichier des tumeurs du Québec* (tumour registry) on mesotheliomas of the pleura and peritoneum registered since 1990 be validated and harmonized with the prospective surveillance system, particularly in regard to the completeness of ascertainment of cases collected and the accuracy of diagnosis.
2. That the *ministère de la Santé et des Services sociaux* consider recognizing mesotheliomas of the pleura and peritoneum notifiable diseases,[2] thereby permitting epidemiological investigations to be conducted on the exposure characteristics of the cases.

Surveillance of asbestosis

In order to set up a surveillance system for asbestosis in Quebec, we recommend carrying out the following preliminary work:

1. That the *ministère de la Santé et des Services sociaux*, in consultation with the CSST, oversee the matching of cases of asbestosis registered in the MED-ECHO hospitalization database and cases of asbestosis recognized by the *Comité spécial des présidents* to be of occupational origin.
2. On the basis of the findings of the preceding proposal, that the *ministère de la Santé et des Services sociaux* oversee a study of hospitalization records in Quebec in which asbestosis is mentioned to determine the criteria on which this diagnosis is based; this study should distinguish cases in which asbestosis is a principal diagnosis from cases in which it is a secondary diagnosis.

[2] This has already been accomplished with the addition of mesothelioma, asbestosis, and lung cancer related to asbestos exposure to the list of notifiable diseases in Quebec in the *Gazette officielle* of November 20, 2003.

3. That the *ministère de la Santé et des Services sociaux* consider asbestosis a notifiable disease,[2] thereby permitting epidemiological investigations to be conducted on the exposure characteristics of the cases.

Surveillance of pulmonary cancers

1. That the *ministère de la Santé et des Services sociaux* consider lung cancer associated with asbestos exposure a notifiable disease,[2] thereby permitting epidemiological investigations to be conducted on the exposure characteristics of the cases.
2. See the following paragraph.

Surveillance of the three diseases

1. With a goal of knowing more about the links between workplaces in Quebec where there has been asbestos exposure and the asbestos diseases recognized to be of occupational origin by the CSST and about the course of these diseases, that the *ministère de la Santé et des Services sociaux*, in consultation with the CSST, ensure regular statistical analysis of cases of asbestos-related diseases (mesothelioma, asbestosis, pulmonary cancer) whose occupational origin has been recognized by the *Comité spécial des présidents* for the CSST.

Training and prevention

1. That the *ministère de la Santé et des Services sociaux* urge the faculties of medicine of Quebec universities to further emphasize, both at the continuing medical education level and in the training of new doctors, the importance of fully documenting occupational history in a medical history.
2. That the *ministère de la Santé et des Services sociaux*, with the continuing medical education organizations, use continuing medical education sessions or any other mechanism deemed appropriate to further enable doctors to recognize the occupations and the workplaces in Quebec where there may be asbestos exposure.
3. That the same procedure be undertaken, with continuing professional development organizations, among other health professionals likely to have a part in recognizing a link between asbestos exposure and the development of asbestos-related diseases.
4. That the *ministère de la Santé et des Services sociaux*, in concert with partners such as the CSST, the *associations sectorielles paritaires* (joint sector-based associations), etc., take measures to empower workers and employers to recognize workplaces where there may be asbestos exposure, to know the risks associated with asbestos exposure, and to know how to handle asbestos safely.

[2] This has already been accomplished with the addition of mesothelioma, asbestosis, and lung cancer related to asbestos exposure to the list of notifiable diseases in Quebec in the *Gazette officielle* of November 20, 2003.

Research

1. That the *ministère de la Santé et des Services sociaux* oversee the evaluation of methods of relaying information to doctors and other concerned health professionals about the importance of gathering information on occupation and occupational exposures in the medical history. In addition, that this research also document the most appropriate tools and mechanisms for gathering such information.
2. Although asbestos exposure is not directly within the jurisdiction of our sub-committee, we recommend that the *ministère de la Santé et des Services sociaux* oversee the implementation of studies aimed at better documenting asbestos exposure in construction industries and industries involving the maintenance and repair of asbestos-containing products or structures.
3. That the *ministère de la Santé et des Services sociaux* oversee a study on the prevalence of asbestosis among workers in Quebec.
4. That the *ministère de la Santé et des Services sociaux* evaluate the potential benefits that might be obtained by pooling the results of asbestosis screening activities among mine workers with the documented levels of asbestos exposure in these environments.
5. That a study be undertaken of the mesothelioma files submitted to the *Comité spécial des présidents* and not recognized as occupational pulmonary diseases, in order to describe the characteristics of these cases and to provide guidelines for prevention measures.

BIBLIOGRAPHY

1. Camus M. Document synthèse sur l'amiante préparé pour le Comité aviseur sur l'amiante du ministère de la Santé et des Services sociaux du Québec; October 2001.
2. Lebel G, Gingras S, Lévesque B. Épidémiologie descriptive des principaux problèmes de santé reliés à l'exposition à l'amiante au Québec. Beauport: Unité de recherche en santé publique, Centre de recherche du CHUL; October 2001.
3. Camus M. Comparaisons et tendances de l'incidence des mésothéliomes de la plèvre et du péritoine au Québec et au Canada; December 2001.
4. Lebel G, Gingras S, Lévesque B. Analyse de l'appariement des cas de mésothéliome de la plèvre et de cancer du poumon diagnostiqués par la CSST et par l'Institut Armand-Frappier avec le Fichier des tumeurs du Québec, MSSS. Beauport: Unité de recherche en santé publique, Centre de recherche du CHUL; October 2001.
5. Health Effects Institute-Asbestos Research. Asbestos in Public and Commercial Buildings: A Literature Review and Synthesis of Current Knowledge - Final Report. Cambridge: Health Effects Institute-Asbestos Research; 1991.
6. INSERM. Effets sur la santé des principaux types d'exposition à l'amiante. Paris: Les Éditions INSERM; 1997.
7. Siemiatycki J, Campbell S, Richardson L. Projets de recherche épidémiologique réalisés au Québec dans le domaine de l'amiante. Laval: Institut Armand-Frappier, Université du Québec; October 2001.
8. Siemiatycki J, Camus M, Case B, Richardson L. Collecte de données pour les études de l'équipe de l'Institut Armand-Frappier sur l'Épidémiologie du mésothéliome chez les femmes au Québec, 1970-1989. Laval: Institut Armand-Frappier, Université du Québec; October 2001.
9. Camus M. Évaluation des expositions à l'amiante des résidantes des agglomérations d'Asbestos et de Thetford Mines en fonction des besoins du modèle de prévision de risque du mésothéliome. Laval: Institut Armand-Frappier, Université du Québec; October 2001.
10. Camus M, Siemiatycki J. Évaluation des modèles de risque de l'EPA pour le mésothéliome suite aux expositions à l'amiante. Laval: Institut Armand-Frappier, Université du Québec; October 2001.
11. Camus M. Évaluation du modèle exposition risque de l'EPA prédisant le risque de mésothéliome résultant d'expositions à l'amiante. Laval: Institut Armand-Frappier, Université du Québec; October 2001.
12. Camus M, Siemiatycki J, Meek B. Nonoccupational exposure to chrysotile asbestos and the risk of lung cancer. New Engl J Med 1998; 338: 1565-71.
13. Siemiatycki J, Camus M, Parent ME, Désy M, Case B. Étude cas-témoins sur le mésothéliome chez les femmes de la région de l'amiante. Laval: Institut Armand-Frappier, Université du Québec; October 2001.
14. McDonald AD, McDonald JC. Mesothelioma after crocidolite exposure during gas mask manufacture. Environmental Research 1978; 17: 340-6.

15. Pouliot B. La mortalité associée à l'exposition à la chrysotile dans une usine de textile du Québec (thèse). Montréal: McGill University; March 1977.

16. Becklake MR, Arhirii MI, Gibbs GW, Hurwitz S. Exposure to asbestos and respiratory abnormality: The influence of fibre type and nature of exposure. IARC Scientific Publications. 1980: 763-8.

17. Siemiatycki J, ed. Risk Factors for Cancer in the Workplace. Boca Raton: CRC Press; 1991.

18. Laplante O, Parent ME, Siemiatycki J. Risk de mésothéliome et de cancer du poumon associés à l'exposition professionnelle à l'amiante selon le type de fibres (Montréal, 1979-85). Laval: Institut Armand-Frappier, Université du Québec; March 2002.

19. Simard R. Bilan de situation concernant l'exposition à l'amiante dans l'industrie de la transformation à Montréal-Centre. Montréal: Régie régionale de la santé et des services sociaux de Montréal-Centre, Direction de la santé publique; September 1998.

20. Auger N, Simard R. Industrie de la transformation de l'amiante dans l'île de Montréal: proposition d'un programme de contrôle de l'exposition à l'amiante. Montréal: Régie régionale de la santé et des services sociaux de Montréal-Centre, Direction de la santé publique; November 2001. Rapport interne.

21. Myre M. Les calorifugeurs de la province de Québec: causes de mortalité. Union médicale du Canada 1981; 110: 362-7.

22. De Guire L, Binet J, Boucher S, Rossignol M, Bonvalot Y. Prévalence des anomalies pulmonaires consécutives à l'exposition à l'amiante parmi un groupe de: tuyauteurs-plombiers, tôliers-ferblantiers, mécaniciens d'ascenseur, mécaniciens en protection des incendies et calorifugeurs. Montréal: Régie régionale de la santé et des services sociaux de Montréal-Centre, Direction de la santé publique; February 2000.

23. De Guire L, Binet J, Nadeau D. Programme intégré d'intervention sur l'amiante dans la construction: prévalence des anomalies pulmonaires dépistées lors des travaux de construction des entreprises Magnola et Alcan. Montréal: Régie régionale de la santé et des services sociaux de Montréal-Centre, Direction de la santé publique; September 2000.

24. Provencher S, De Guire L. Étude des nouveaux cas de maladies professionnelles pulmonaires reliées à l'exposition à l'amiante au Québec de 1988 à 1997. Montréal: Régie régionale de la santé et des services sociaux de Montréal-Centre, Direction de la santé publique; May 2001.

25. Ministère de la Santé et des Services sociaux. Groupe de travail sur l'Épidémiologie et l'amiante. La recherche épidémiologique québécoise concernant l'amiante et la santé: rapport d'étape au Comité aviseur sur asbestos; September 1998.

26. World Health Organization. Asbestos and other natural mineral fibres. International Programme on Chemical Safety (IPCS). Geneva: World Health Organization; 1986.

27. World Health Organization. Chrysotile asbestos. Environmental Health Criteria 203. Geneva: World Health Organization; 1998

28. United Kingdom Health and Safety Executive. Asbestos: The Control Limit for Asbestos. London, England: Her Majesty's Stationery Office; 1983.

29. Becklake MR. The epidemiology of asbestosis. In: Liddell D, Miller K, eds. Mineral fibers and health. Boca Raton; CRC Press; 1991. P 104-19.

30. Case BW, Dufresne A. Asbestos, asbestosis, and lung cancer: Observations in Quebec chrysotile workers. Environ Health Perspect 1997; 105: 1113-9.

31. Mossman BT, Churg A. Mechanisms in the pathogenesis of asbestosis and silicosis. Am J Resp Crit Care Med 1998; 157: 1666-80.

32. Banks DE, Wang M, Parker JE. Asbestos exposure, asbestosis, and lung cancer. Chest 1999; 115: 320-2.

33. Becklake MR. Symptoms and pulmonary functions as measures of morbidity. Ann Occup Hyg 1994; 38: 569-80.

34. National Industrial Chemicals Notification and Assessment Scheme. Chrysotile asbestos. Priority Existing Chemical Report No. 9. Australia: National Industrial Chemicals Notification and Assessment Scheme (NICNAS); 1999.

35. Becklake MR. The mineral dust diseases. Tuber Lung Dis 1992; 73: 13-20.

36. Becklake MR, Case BW. Fiber burden and asbestos-related lung disease determinants of dose-response relationships. Am J Respir Crit Care Med 1994; 150: 1488-92.

37. McDonald JC, McDonald AD, Hugues JM. Chrysotile, tremolite and fibrogenicity. Ann Occup Hyg 1999; 43: 439-42.

38. Meldrum M. Review of Fibre Toxicology. HSE Books. Sudbury Suffolk, England, UK Health and Safety Executive; 1996.

39. Dupré J, Mustard J, Uffen R. Report of the Royal Commission on Matters of Health and Safety Arising from the Use of Asbestos in Ontario. Vol 1-3, Toronto: Ontario Ministry of the Attorney General; 1984.

40. Stayner L, Smith R, Bailer J, Gilbert S, Steenland K, Dement J, Brown D, Lemen R. Exposure-response analysis of risk of respiratory disease associated with occupational exposure to chrysotile asbestos. Occup Env Med 1997; 54: 646-52.

41. Hodgson JT, Darnton A. The quantitative risks of mesothelioma and lung cancer in relation to asbestos exposure. Ann Occup Hyg 2000; 44: 565-601.

42. Hughes JM. Epidemiology of lung cancer in relation to asbestos exposure. In: Liddell D, Miller K, eds. Mineral Fibers and Health. Boca Raton: CRC Press; 1991. P. 135-46.

43. Lash TL, Crouch EA, Green LC. A meta-analysis of the relation between cumulative exposure to asbestos and relative risk of lung cancer. Occup Environ Med 1997; 54 (4): 254-63.

44. Camus M. Le risque d'évaluer les risques de l'amiante. Trav Santé 1997, 13: S16-7.

45. Camus M. Why experts disagree about risks of cancer due to exposure to environmental asbestos. In: Herzberg AM, Krupka I, eds. Statistics, science and public policy: hazards and risks. Kingston: McGill-Queen's University Press; 1997. P. 9-25.

46. Wilkinson P, Hansell DM, Janssens J, Rubens M, Rudd RM, Taylor AN, McDonald C. Is lung cancer associated with asbestos exposure when there are no small opacities on the chest radiograph? Lancet 1995; 345 (8957): 1074-8.

47. Nicholson WJ and U.S. EPA. Airborne Asbestos Health Assessment Update. Research Triangle Park N.C., Environmental Criteria and Assessment Office, Office of Health and Environmental Assessment, Office of Research and Development, U.S. Environmental Protection Agency; 1986.

48. McDonald JC, McDonald AD, Armstrong B, Sébastien P. Cohort study of mortality of vermiculite miners exposed to tremolite. Br J Ind Med 1986; 43: 436-44.

49. Hansen J, de Klerk NH, Musk AW, Hobbs MS. Environmental exposure to crocidolite and mesothelioma: exposure-response relationships. Am J Respir Crit Care Med 1998; 157: 69-75.

50. Wagner JC, Sleggs CA, Marchand P. Diffuse pleural mesothelioma and asbestos exposure in the northwestern Cape Province. Br J Ind Med 1960;17: 260-71.

51. Goldberg P, Luce D, Billon-Galland MA, Quénel P, Salomon-Nekiriai C, Nicolau J, Brochard P., Goldberg M. Rôle potentiel de l'exposition environnementale et domestique à la trémolite dans le cancer de la plèvre en Nouvelle Calédonie. Rev Épidém et Santé Publ 1995; 43: 444-50.

52. Constantopoulos SH, Saratzis NA, Kontogiannis D, Karantanas A, Goudevenos JA, Katsiotis P. Tremolite whitewashing and pleural calcifications. Chest 1987; 92: 709-12.

53. Gardner MJ, Saracci R. Effects on health of non-occupational exposure to airborne mineral fibres. In: Bignon J, Peto J, Saracci R, eds. Non-occupational exposure to mineral fibres. Lyon: International Agency for Research on Cancer; 1989. P. 375-97.

54. Marchand JL, Luce D, Leclerc A, Goldberg P, Orlowski E, Bugel I, Brugère J. Laryngeal and hypopharyngeal cancer and occupational exposure to asbestos and man-made vitreous fibers: results of a case-control study. Am J Ind Med 2000; 37: 581-9.

55. Doll R, Peto J. Other asbestos-related neoplasms. In: Antman K, Aisner J, eds. Asbestos-related malignancy. Orlando: Grune & Stratton Inc; 1987. P. 81-98.

56. Doll R. Mineral fibres in the non-occupational environment: Concluding remarks. In: Bignon J, Peto J, Saracci R, eds. Non-occupational exposure to mineral fibres. 90. Lyon: International Agency for Research on Cancer; 1989. P. 511-8.

57. Camus M. Trends in the incidence of mesothelioma in Quebec, British-Columbia and Canada. Ottawa: Health Canada; October 1997. Contract no: 97-CH017.

58. Ministère de la Santé et des Services sociaux. Incidence du cancer au Québec, 1998. Québec: Ministère de la Santé et des Services sociaux; 2001.

59. Hillerdal G. Pleural plaques: Incidence and epidemiology, exposed workers and the general population. Indoor Built Environ 1997; 6: 86-95.

60. Schwartz DA. New developments in asbestos-induced pleural disease. Chest 1991; 99: 191-8.

61. Graham S, Blanchet M, Rohrer T. Cancer in asbestos-mining and other areas of Quebec. J Natl Cancer Inst 1977; 59: 1139-45.

62. Pampalon R, Siemiatycki J, Blanchet M. Pollution environnementale par l'amiante et santé publique au Québec. Union médicale du Canada 1982; 111: 475-89.

63. Wigle DT. Cancer mortality in relation to asbestos in municipal water supplies. Arch Environ Health 1977; July/August: 185-90.

64. Morrison HI. Maladies chroniques au Canada. 1981; 2: 27-31.

65. Loslier L. Environnement et surmortalité à Asbestos et Thetford Mines. Le Médecin du Québec 1983; January; 97-9.

66. Singh B, Thouez JP. Ambient air concentration of asbestos fibres, dust content and mortality: the case of Asbestos, Quebec. Ecology of Disease 1983; 2: 343-51.

67. Camus M. Personal communication. June 2002.

68. Siemiatycki J, Camus M, Désy M. Comparaison du risque de mésoth.éliome de la plèvre entre les régions minières et les autres régions de la province. Laval: Institut Armand-Frappier, Université du Québec; October 2001.

69. McDonald AD, McDonald JC. Malignant mesothelioma in North America. Cancer 1980; 46: 1650-6.

70. Thériault GP, Grand-Bois L. Mesothelioma and asbestos in the province of Québec, 1969-1972. Arch Environ Health 1978; January/February 15-9.

71. Ruffie P, Feld R, Minkin S, Cormier Y, Boutan-Laroze A, Ginsberg R, Ayoub J, Shepherd FA, Evans WK, Figueredo A, Pater JL, Pringle JF, Kreisman H. Diffuse malignant mesothelioma of the pleura in Ontario and Quebec: A retrospective study of 332 patients. J Clinical Oncology 1989; 7: 1157-68.

72. Bégin R, Gauthier JJ, Desmeules M, Ostiguy G. Work-related mesothelioma in Québec, 1967-1990. Am J Ind Med 1992; 22: 531-42.

73. Braun DC, Truan TD. An epidemiological study of lung cancer in asbestos miners. A.M.A. Arch Ind Health 1958; 17: 634-53.

74. Liddell FDK, McDonald AD, McDonald JC. The 1891-1920 birth cohort of Quebec chrysotile miners and millers: Development from 1904 and mortality to 1992. Ann Occup Hyg 1997; 41: 13-35.

75. McDonald AD, Case BW, Churg A, Dufresne A, Gibbs GW, Sébastien P, McDonald JC. Mesothelioma in Quebec chrysotile miners and millers: Epidemiology and aetiology. Ann Occup Hyg 1997; 41: 707-19.

76. Nicholson WJ, Selikoff IJ, Seidman H, Lilis R, Formby P. Long-term mortality experience of chrysotile miners and millers in Thetford Mines, Quebec. Annals of the New York Acad of Sciences 1979: 11-21.

77. Règlement sur les examens de santé pulmonaire des travailleurs des mines. Décret 1325-95, Gazette Officielle. 18 October 1995, p. 4444 and amended by Erratum, Gazette Officielle. 29 November 1995, p. 4999.

78. Infante-Rivard C, Dufresne A, Ernst P. Protocole de recherche pour évaluer la surveillance chez les travailleurs des mines, carrières et sablières. September 1998

79. Selikoff IJ, Seidman H. Asbestos-associated deaths among insulation workers in the United States and Canada, 1967-1987. Ann NY Acad Sci 1991; 643: 1-14.

80. Selikoff IJ, Lilis R. Radiological abnormalities among sheet-metal workers in the construction industry in the United States and Canada: relationship to asbestos exposure. Arch Environ Health 1991; 46: 30-6.

81. Welch LS, Michaels D, Zoloth SR and The National Sheet Metal Examination Group. The national sheet metal workers asbestos disease screening program: Radiologic findings. Am J Ind Med 1994; 25: 635-48.

82. Ernst P, Shapiro S, Dales RE, Becklake MR. Determinants of respiratory symptoms in insulation workers exposed to asbestos and synthetic mineral fibres. Br J Ind Med 1987; 44: 90-5.

83. Delfino R, Ernst P, Bourbeau J. Relationship of lung geometry to the development of pleural abnormalities in insulation workers exposed to asbestos. Am J Ind Med 1989; 15: 417-25.

84. Ernst P, Bourbeau J, Becklake MR. Pleural abnormality as a cause of impairment and disability. Ann NY Acad Sci 1991; 643: 157-61.

85. Bourbeau J, Ernst P. Between- and within-reader variability in the assessment of pleural abnormality using the ILO 1980 international classification of pneumonconiosis. Am J Ind Med 1988; 14: 537-543.

86. Bourbeau J, Ernst P, Chrome J, Armstrong B, Becklake MR. The relationship between respiratory impairment and asbestos-related pleural abnormality in an active work force. Am Rev Respir Dis 1990; 142: 837-42.

87. Binet J, Savard M, De Guire L. Dépistage des lésions pulmonaires reliées à l'exposition à l'amiante dans les écoles de la Commission scolaire de Montréal. Montréal: CLSC des Faubourgs; September 2000.

88. Auger A. État de la situation de l'amiante dans le secteur de la construction. Symposium sur l'exposition à l'amiante et son impact sur la santé au Québec. 3 December 2001; Montréal, Québec, Canada. Québec: Institut national de santé publique du Québec; 2001.

89. Collectif d'auteurs sous la direction de Pierre Lajoie. Fibres d'amiante dans l'air intérieur et extérieur. État de situation au Québec. Québec: Comité aviseur sur l'amiante, ministère de la Santé et des Services sociaux; June 2001.

APPENDIX

Highlights of the report
"The Epidemiology of Asbestos-related Diseases in Quebec"

HIGHLIGHTS

1. General remarks

- Asbestos has three main effects on health: asbestosis, mesothelioma of the pleura and peritoneum, and lung cancer. Asbestos also causes diffuse pleural effusion and pleural plaques, but generally their clinical significance is minor. Asbestos may also cause other types of cancer, but the relation between exposure and disease is more tenuous or uncertain. Asbestosis, mesothelioma, and lung cancers secondary to asbestos exposure usually appear after a latency period of 20 to 40 years.[1]
- Mesothelioma of the pleura and peritoneum are two rare cancers and are rapidly fatal.[1]
- Occupational exposure to chrysotile and amphibole types of asbestos increases lung cancer risk. Whether or not there is a risk differential for this cancer based on asbestos type is a subject of controversy in the scientific community.[1]
- Mesotheliomas have been observed following an occupational exposure to amphiboles and to chrysotile asbestos. However, the risk of developing a pleural mesothelioma is higher with exposure to amphibole asbestos than with exposure to chrysotile asbestos. Mesothelioma of the peritoneum is mainly associated with exposure to amphiboles.[1]

2. Mesothelioma

2.1. Incidence of mesothelioma of the pleura

- The only data available to describe the incidence of mesothelioma of the pleura is from the *Fichier des tumeurs du Québec*. This tumour database has become more exhaustive over the years, and since the 1990s the use of immunohistochemistry has made pathological diagnosis easier.
- In Quebec, from 1982 to 1996, 832 persons (655 men and 177 women) were newly diagnosed with mesothelioma of the pleura. During this period, the age-adjusted incidence rate of this cancer was 1.49 per 100,000 person-years among Quebec men and 0.32 per 100,000 among Quebec women.[2]
- Between 1984 and 1996, the age-adjusted incidence rate of mesothelioma of the pleura among Canadian women was 0.16 per 100,000 person-years. This rate comes close to what most experts estimate to be the expected background concentration in a population not exposed to asbestos (an incidence rate of 0.1 to 0.2 per 100,000 persons per year). Thus, Quebec men and women have rates 9.5 and 2 times higher than the expected background concentration.[3]
- Despite the interpretation difficulties mentioned in the report, data from the World Health Organization's International Agency for Research on Cancer show a statistically significant excess of mesothelioma of the pleura and peritoneum among men in several counties in the United Kingdom, several states in Australia, and several regions in the Netherlands in comparison to Quebec. However, in Quebec, the rate of mesothelioma of the pleura and peritoneum among men is similar to the rate among American men and is significantly

higher than in the rest of Canada and in several European countries. Among women, no country shows an excess of mesothelioma of the pleura and peritoneum in comparison with Quebec, but several have significantly lower incidence rates.[2]

- We observed a statistically significant increase in the incidence rate of mesothelioma of the pleura among Quebec men between 1982 and 1996, corresponding to a 5% average annual rate of increase. Among women, the average annual rate of increase was 3% and is not statistically significant.[2]
- Between 1984 and 1996, incidence rates of pleural mesothelioma appeared stable among the Quebec population under 60 years of age, while it increased among persons aged 60 and older, especially among men.[3] This might presage a leveling off of pleural mesothelioma incidence among Quebec men.
- The study of different male birth cohorts in Quebec suggests that the population born between 1930 and 1939, who started to work after World War II, that is at a time when there was a marked increase in the use of asbestos, had higher incidence rates of mesothelioma of the pleura than preceding or subsequent cohorts. For cohorts born after 1940, the data suggest a lower risk, but it is still too soon to conclude that this is a true decrease because the persons in these cohorts are still too young.[3]
- Standardized incidence rates of mesothelioma of the pleura are significantly higher among men and women in the Chaudière-Appalaches region and among men in Montérégie. Chaudière-Appalaches has a shipyard and working asbestos mines, and Montérégie had a shipyard in the past.[2]

2.2. Incidence of mesothelioma of the peritoneum

- In Quebec, between 1984 and 1996, 63 men and 45 women were newly diagnosed with mesothelioma of the peritoneum. This corresponded to annual age-adjusted rates of 0.14 per 100,000 person-years among men and 0.08 per 100,000 person-years among women. During this period, annual cancer rates appeared stable and no region in Quebec showed a statistically significant excess but the rarity of this cancer prevents us from making statistical inferences.[2]

2.3. Matching of mesothelioma cases from the Fichier des tumeurs du Québec and mesothelioma cases of recognized occupational origin

- By matching the 261 mesothelioma cases whose occupational origin had been recognized between 1967 and 1997 by the special *Comités* set up by the CSST and the *ministère du Travail* (ministry of labour) to cases from the *Fichier des tumeurs du Québec*, we observe the following:
  - 87% of the CSST cases were found in the *Fichier des tumeurs du Québec*;
  - 83% of the CSST cases found in the *Fichier des tumeurs du Québec* had the same diagnosis in both databases; and

- CSST mesothelioma cases represent only 22% of mesothelioma cases recorded in the *Fichier des tumeurs du Québec*.[4] This proportion is surprising since data in the literature show that asbestos exposure can be documented in between 70% and 90% of mesothelioma cases among men.[5]

3. Pulmonary cancer

- Pulmonary cancer is frequent in the general population (more than 3,500 cases per year among men in Quebec).[58] The principal risk factor is tobacco use. According to studies, lung cancer risk attributable to occupational asbestos exposure varies between 0.5% and 15% among men.[6]
- The matching of lung cancer cases whose occupational origin had been determined by the *Comité spécial des présidents* between 1988 and 1997 with the cases in the *Fichier des tumeurs du Québec* shows that :
  - 89% of CSST cases were found in the *Fichier des tumeurs du Québec*;
  - 90% of CSST cases found in the *Fichier des tumeurs du Québec* had the same diagnosis in both databases; and
  - CSST cases represent only 0.3% of pulmonary cancer cases recorded in the *Fichier des tumeurs du Québec*.[4]

4. Asbestosis

- The sources of available information on asbestosis are incomplete and the findings that follow must be interpreted with caution.
- In Quebec, between 1987 and 1996, 1,333 men and 53 women were hospitalized for a first time with a primary or secondary diagnosis of asbestosis. However, it is impossible to know if this was a first diagnosis of the disease or if it was an existing disease, but declared for the first time in a hospital record. During this period, we observe a statistically significant decrease in hospitalization rates for this disease among men only.[2]
- In Quebec, between 1988 and 1996, there were 3.6 times as many persons hospitalized with a primary or secondary diagnosis of asbestosis than there were cases determined to be of occupational origin by the *Comité spécial des présidents*.[4,24] However, the reliability of this observation is limited by uncertainty with regard to the identification of incident cases from the MED-ECHO hospitalization database.
- Between 1981 and 1996, asbestosis was identified as the principal cause of death in 114 Quebec men and 2 Quebec women.[2]
- Two regions in Quebec show a statistically significant excess of hospitalizations and deaths due to asbestosis among men, and not among women: Estrie and Chaudière-Appalaches.[2] These are both mining regions. In addition, we note the presence of a shipyard in Chaudière-Appalaches.

5. Asbestos-related diseases in the general population of the asbestos region

- Mortality and incidence data used to conduct studies in the general population of Quebec's asbestos region during the 1960s and 1970s all pointed to higher frequencies of diseases related to this fibre, particularly among men.[61-66] Since approximately 70% of these men worked in the asbestos industry, it was difficult to separate the effect of occupational exposure from that of environmental exposure. Moreover, these correlation (or ecological) studies, did not take into account the impact of asbestos fibre type on the disease.
- A study of new mesothelioma cases diagnosed between 1970 and 1989 in women residing in the towns of Thetford Mines and Asbestos and born between 1906 and 1940 estimated the past lifetime asbestos exposure of these women at 0.2 to 1.5 fibre/ml, for all sources of exposure together (occupational, domestic (i.e. cohabitation with one or more asbestos workers), or residential). Their average cumulative exposure was approximately 25 fibres/ml-years.[8,9]
- Based on this assessment of exposures, lung cancer risk attributable to asbestos is overestimated by a factor of 10 or more by the Environmental Protection Agency risk assessment model.[12]
- Furthermore, the Environmental Protection Agency mesothelioma risk assessment model overestimates by a factor of approximately 60 the real incidence risk of this cancer.[10,11]
- Ten new cases of mesothelioma of the pleura occurred among women in the region between 1970 and 1989, all residents of Thetford Mines. The only case of mesothelioma of the peritoneum occurred in a resident in the Asbestos area. Among the 10 cases, six were "definite" and four "possible." Six other women suffering from mesothelioma had lived in the Thetford Mines area in the past, but no longer resided there at the time of their diagnosis.
- The risk associated with occupational asbestos exposure among these women, compared with the control group, is particularly high (approximately 30 times higher) and statistically significant but there is a considerable margin of uncertainty.
- Mesothelioma risk would increase from 2% to 5% per fibre/ml-year with any source of asbestos exposure: occupational, domestic, or residential. It was not possible to dissociate the respective contributions to mesothelioma risk of these three sources of exposure, due to the small number of mesotheliomas in this population and to errors of estimation of exposures.[13]

6. Asbestos-related diseases among workers in general

- In three studies that focused on mesothelioma cases diagnosed in Canada and in Quebec during the 1960s, 1970s, and 1980s an occupational exposure to asbestos was found in from 34% to nearly 50 % of the subjects.[69-71]
- A fourth case-control study conducted among Montrealers, had to do with both lung cancer and mesothelioma. It allowed researchers to document the exposure of study subjects on the basis of their occupational history. The relative risk of mesothelioma was very high, and statistically significant, following heavy exposure to amphiboles. However, the small number of mesothelioma cases did not allow researchers to measure the risk among workers exposed to chrysotile without amphiboles (i.e. with an unreported exposure to amphiboles).

A heavy exposure also led to an increased risk of lung cancer, but without reaching the statistically significant level. The highest risk was observed with an exposure to chrysotile without mention of amphiboles (OR = 3.1; 95% IC = 1.0 – 9.8). This risk was at the limit of statistical significance, which suggests that lung cancer risk from exposure to chrysotile asbestos would not be lower than the risk from exposure to amphiboles. Mesothelioma and pulmonary cancer risks were not as high following a low exposure to the two types of asbestos fibres and did not reach the statistically significant level. This may be interpreted in two ways: either at a low exposure, there is no detectable risk, or at a low exposure, the risk is slight and real. In the latter case, the large proportion of cases of the two cancers among whom asbestos exposure was low, rather than high, could make this a non-trivial risk.[17,18]

- Between 1988 and 1997, the *Comité spécial des présidents* recognized an occupational origin to an asbestos-related pulmonary disease among 691 male and female workers. Among these persons, 378 were suffering from asbestosis, 191 from mesothelioma, and 209 from lung cancer, several persons having more than one disease. During the period of the study, the number of workers suffering from all the diseases combined, and the numbers suffering from asbestosis and from mesothelioma appeared to increase while the number of workers suffering from lung cancer appeared stable.[24]

7. Asbestos-related diseases among workers in the asbestos region (asbestos mines and mills, and one asbestos products fabrication factory)

- Asbestos mine, mill, and products fabrication factory workers in this region are the only asbestos workers in Quebec to have been the subjects of extensive studies.
- Several studies have documented asbestos diseases among these workers since the first study was published in 1958. The most extensive was based on a cohort of close to 11,000 workers from Thetford Mines and Asbestos of whom 9,780 were followed until 1992. The cohort included workers from mines, mills, and one products fabrication factory, born between 1891 and 1920. Among the 8,009 deceased workers, there were 38 deaths from mesothelioma, 657 from lung cancer (of which approximately one hundred were asbestos-related), and 108 from pneumoconiosis (of which 46 were asbestoses). The number of mesothelioma deaths represented a significant excess compared with Quebec's male population. Risk of death from pulmonary cancer was two times higher among workers exposed to greater amounts of asbestos and for a longer time, these workers representing approximately one quarter of the cohort.[7]
- Mandatory screenings currently under way among workers still employed in these mines were not analyzed in the framework of the projects carried out by the sub-committee.
- The activity sector that generated the largest number of cases of asbestos-related diseases at the CSST between 1988 and 1997 was mining (35%). When the various asbestos diseases are considered separately, work in the mines also explains the largest number of asbestosis cases (32%) and lung cancer cases (62%), and, tied with construction work, the second largest number of mesotheliomas (18%). The high percentage of pulmonary cancer cases among mine workers suggests that poor recognition of asbestos exposure in the other industries by workers and by doctors, may be due to the fact that it is easier to attribute a lung cancer to tobacco use, in a smoker, than to suspect an exposure to asbestos. In mining,

during the 10 years of the study, the number of pulmonary cancer cases was stable, the number of asbestoses increased, and the number of mesotheliomas decreased.[24]

8. Asbestos-related diseases among asbestos processing workers

- We found three studies that had looked at the health problems of workers in Quebec's asbestos processing plants in the past. Two plants (one located in Montréal and the other in Asbestos) manufactured asbestos-containing filters for gas masks during the Second World War, a third plant, in Valleyfield, produced chrysotile asbestos-based textile (belt conveyors for paper mills), and a fourth business manufactured insulation and cement products in the Montréal area. These studies showed deaths from asbestosis, from pulmonary cancer,[14,15] and from mesothelioma[14] or respiratory symptoms among the workers.[16]
- Between 1992 and 1997, a study of 23 asbestos processing plants in the Montréal area showed problems in 7 of these enterprises (30%) related to exceeding asbestos exposure standards.[19] A follow-up carried out in the year 2000 in 5 of the 7 plants showed that environmental measurements had been taken in 3 workplaces. Standards were still being exceeded in 1 of the 3 plants. The asbestosis screening carried out among 304 workers in 4 of the 5 plants revealed one confirmed and one possible case of asbestosis. A third worker had been diagnosed with this disease in 1990.[20]
- Data on the 691 cases of diseases whose occupational origin had been recognized by the Comité spécial des présidents between 1988 and 1997 show that 93 of these cases were workers from the processing industry (50 asbestoses, 27 mesotheliomas, and 25 pulmonary cancers). These 93 workers had been exposed to asbestos on average for a shorter period of time (16 years) than all cases combined (27 years) before developing their disease. During the period of the study, the number of cases of asbestosis and of lung cancer attributed to exposure in this industry decreased while the number of mesothelioma cases increased.[24] The upward trend among mesotheliomas has been observed since 1967.[24,72]

9. Asbestos-related diseases among construction workers

- Insulators were the first construction industry workers in Quebec in whom asbestosis, mesothelioma, and lung cancers were documented, as far back as 1981.[21] Later, toward the end of the 1980s and the beginning of the 1990s, insulators,[79,86] sheet-metal workers, and tinsmiths[80] became the subjects of other studies.
- In 1995, a screening of 972 workers from the same trade groups to which were added plumbers-pipe fitters-welders, boilermakers, fire protection mechanics, and elevator mechanics also showed the presence of radiological abnormalities compatible with a diagnosis of asbestosis (n=20) among these persons and a 23.2% frequency of pleural abnormalities.[22] Then, screenings carried out as part of an integrated intervention program among the same groups of construction workers, to which were added asbestos removal workers and asbestos demolition workers, brought to light 2 cases of lesions compatible with a diagnosis of asbestosis and 12.8% pleural abnormalities among the 492 workers screened.[23]

- A screening carried out among a group of 83 asbestos-exposed maintenance workers (from one school board on the Island of Montréal) showed no abnormalities compatible with asbestosis and only 3.6% of workers presented pleural abnormalities.[87]
- The analysis of 691 cases of asbestos-related diseases whose occupational origin had been recognized by the *Comité spécial des présidents* between 1988 and 1997 showed that construction industry workers (17% of cases) were in third place (after workers from the mining industry and the repair and maintenance of asbestos-containing products and structures) in generating cases of asbestos-related diseases. These workers were younger (60 years old) than all cases combined (65 years old) at the time their disease was diagnosed. Furthermore, insulators suffering from mesothelioma were exposed to asbestos for a shorter time before their diagnosis (15 years) than other workers suffering from this cancer (22 years). If we add maintenance and repair workers to construction workers, due to the possible similarities between the two industries, the two groups together give rise to the greatest number of cases of asbestos-related diseases, asbestosis, and mesothelioma. During the 10 years of the study, the number of cases of all asbestos-related diseases among construction industry workers was on the rise.[24]

10. Costs of asbestos-related diseases

- Cases of asbestos-related pulmonary diseases whose occupational origin had been recognized by the *Comité spécial des présidents* between 1988 and 1997 generated direct costs totalling 66.2 million dollars (undiscounted) in compensation costs to the CSST.[24] Other costs are also associated with these diseases and should be evaluated in a more in-depth study.