


Asbestos: Current Knowledge on the Exposure and Diseases of Workers and the General Population in Québec from 2003 to 2009

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Synthesis Report

Asbestos: Current Knowledge on the Exposure and Diseases of Workers and the General Population in Québec from 2003 to 2009

Direction des risques biologiques
et de la santé au travail

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This document is the result of the synthesis of the studies generated by the surveillance program for asbestos exposures and their related diseases, overseen by the Institut national de santé publique du Québec (INSPQ), and of independent studies, published between 2003 and 2009, that dealt with the subject of asbestos in Québec.

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SUMMARY

This document reports on the Québec data acquired since 2003 on asbestos exposure and asbestos-related diseases, both among workers and in the general population. However, the aim is not to update the knowledge on asbestos as such. This report also summarizes the status of the Québec surveillance system for asbestos exposures and asbestos-related diseases, which will be introduced by the Institut national de santé publique du Québec (INSPQ), as a result of the adoption of the Policy concerning the increased and safe use of chrysotile asbestos in Québec.

The most recent data (2004) on environmental exposure to asbestos in outdoor air identified no asbestos fibres in Montréal and in the city of Québec. However, in Thetford Mines, the average airborne asbestos concentration was 0.0043 fibre/ml (f/ml) by transmission electron microscopy (TEM). This concentration was 215 times higher than that obtained in the air outside buildings involved in litigation regarding the removal of asbestos-containing materials (ACM) in the United States. Between 1998 and 2005, in the city of Asbestos, average concentrations ranged from 0.003 to 0.007 f/ml, although we do not know if these were of asbestos fibres, since the analytic method was not specified.

No publication later than the year 2000 has been found on the exposure levels of asbestos miners in the areas of Thetford Mines and Asbestos.

With respect to the industrial sector, at the end of 2009, nine Québec factories were identified in which asbestos was used in the manufacturing process or in which workers handled asbestos-containing products. None of the factories used asbestos safely in accordance with one or more criteria defined *a priori*. These findings show the importance of exposure surveillance among workers in these workplaces.

Material characterization data obtained in 2009 were collected at high-risk construction sites. Of the 2,475 samples that contained asbestos, 75% contained chrysotile only, 15% chrysotile in the presence of other types of asbestos fibre and 10% amphiboles only (i.e. the asbestos family that excludes chrysotile). In another study, 1,251 material samples contained amphiboles only and 10,538 other samples chrysotile alone (95%) or a mix of chrysotile and amphiboles (5%). Therefore, we find chiefly chrysotile in the on-site materials in the buildings studied.

Of the 3,000 air samples collected during work on high-risk construction sites, 43% had concentrations higher than or equal to 1 f/ml, which is the occupational exposure limit value for chrysotile asbestos in Québec. These results show the importance of enforcing the exposure control measures prescribed in the regulations. Of the 2,626 air samples collected in changing rooms on construction sites, during asbestos removal work, 77% had fibre concentrations equal to or higher than 0.01 f/ml compared to 14% in adjacent areas (0.01 f/ml is the threshold level required by regulation before dismantling the sealed enclosures within which demolition work takes place).

With respect to asbestos-related diseases, from 1982 to 2002, 1,530 people (1,210 men and 320 women) received a new diagnosis of pleural mesothelioma in Québec. During that study period, the annual age-adjusted incidence rates increased significantly among Québec men,

with an average annual growth rate of 3.6%. At the regional level, the standardized incidence rates for pleural mesothelioma were significantly higher among men and women in the Chaudière-Appalaches region, and among men in the Montérégie and Lanaudière regions. Between 1982 and 2002, 170 Quebeckers were diagnosed with a peritoneal mesothelioma (98 men and 72 women).

Between 1992 and 2004, 2,072 people (1,993 men and 79 women) were hospitalized with first mention of asbestosis as the primary or secondary diagnosis. Significant excess hospitalizations for asbestosis were observed among men and women in the Chaudière-Appalaches region and among men in the Estrie and Lanaudière regions.

An estimation of lung cancer and mesothelioma risk among residents in the city of Thetford Mines was carried out using two approaches, one based on the Berman and Crump model and the other on the guidelines of the Ministère de la Santé et des Services sociaux. Depending on the approach used, the lifetime excess mortality for these two cancers ranged from 8.2 to 125 per 100,000 persons residing in Thetford Mines with a continuous lifetime exposure to asbestos.

Few studies have documented asbestos-related diseases among Québec workers. A 2009 publication described all new cases of asbestos-related diseases recognized as occupational lung diseases by the Comité spécial des maladies professionnelles pulmonaires (CSMPP-special committee on occupational lung diseases) between 1988 and 2003. During this period, 1,348 workers had 1,512 diseases. The workers were chiefly exposed in the construction industry and in the maintenance and repair of asbestos-containing products or structures (49.4%), thereby surpassing the number of workers exposed in mines (29.1%).

Mesothelioma and asbestosis cases recognized as occupational diseases by the CSMPP represent respectively 21.4% of pleural mesothelioma cases registered in the *Fichier des Tumeurs du Québec* (tumour registry) and 35% of persons hospitalized with mention of asbestosis registered in the MED-ÉCHO system (*Maintenance et exploitation des données pour l'étude de la clientèle hospitalière* - maintenance and use of data for the study of the hospital clientele).

With respect to asbestos exposure, the surveillance system to be introduced by the INSPQ will prioritize exposure surveillance of miners, workers who transform and process asbestos and construction workers, and the surveillance of environmental exposure to asbestos in the cities of Thetford Mines and Asbestos.

With respect to disease surveillance, the system will prioritize the surveillance of asbestosis, pleural and peritoneal mesothelioma and asbestos-related lung cancer, which are notifiable diseases since 2003. As these diseases are under-reported, a pilot study with the aim to facilitate the reporting of these notifiable diseases by physicians will be introduced in two Québec hospitals. If the pilot study proves effective in identifying and reporting cases, this approach, which requires the collaboration of medical archives departments, would be proposed in all Québec hospitals.

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LIST OF ABBREVIATIONS

95% CI	95% confidence interval
ACGIH	American Conference of Governmental Industrial Hygienists
ACM	Asbestos-containing material
AFSSET	Agence française de sécurité sanitaire de l'environnement et du travail (France environmental and occupational health safety agency)
AHERA	*Asbestos Hazard Emergency Response Act*
ANDEVA	Association nationale de défense des victimes de l'amiante (France national association for the defence of asbestos victims)
ANOVA	Analysis of variance
AVAQ	Association des victimes de l'amiante du Québec (asbestos victims association)
CCQ	Commission de la construction du Québec (construction commission)
CRIQ	Centre de recherche industrielle du Québec (industrial research centre)
CSMPP	Comité spécial des maladies professionnelles pulmonaires (special committee on occupational lung diseases)
CSP	Comité spécial des présidents
CSSS	Centre de santé et de services sociaux (health and social service centre)
CSST	Commission de la santé et de la sécurité du travail (Québec Workers' Compensation Board)
DCGI	Direction de la comptabilité et de la gestion de l'information (accounting and information management department)
FiTQ	*Fichier des tumeurs du Québec* (Québec tumour registry)
HEI-AR	Health Effects Institute-Asbestos Research
IARC	International Agency for Research on Cancer
INSPQ	Institut national de santé publique du Québec (Québec public health institute)
IRSST	Institut de recherche Robert-Sauvé en santé et en sécurité du travail (occupational health and safety research institute)
JEM	Job-exposure matrix
MDDEP	Ministère du Développement durable, de l'Environnement et des Parcs (Québec minister of sustainable development, the environment and parks)
MED-ÉCHO	*Maintenance et exploitation des données pour l'étude de la clientèle hospitalière* (maintenance and use of data for the study of the hospital clientele)
MSSS	Ministère de la Santé et des Services sociaux (Québec minister of health and social services)
MTQ	Ministère des Transports du Québec (Québec minister of transport)

ND	Notifiable disease
OSHA	Occupational Safety and Health Administration
PCMe	Phase contrast microscopy equivalent
PCOM	Phase contrast optical microscopy
PSSE	*Programme de santé spécifique à l'établissement* (specific health program for an establishment)
RSST	Regulation respecting occupational health and safety
SIR	Standardized incidence ratio
SISAT	*Système d'information en santé au travail* (occupational health information system)
SMEST	*Surveillance Médico-environnementale de la Santé des travailleurs* (workers' health medical-environmental surveillance system)
STEL	Short term exposure limit
TEM	Transmission electron microscopy
TWA	Time-weighted average
US EPA	United States Environmental Protection Agency
WTC	World Trade Center

1 INTRODUCTION

1.1 MANDATE

Following the adoption of the Policy concerning the increased and safe use of chrysotile asbestos in Québec in 2002 (Gouvernement du Québec, 2002), the Ministère de la Santé et des Services sociaux (MSSS) mandate the Institut national de santé publique du Québec (INSPQ) to develop a surveillance system for asbestos exposures and asbestos-related diseases, both among workers and in the general population.

1.2 OBJECTIVES

This report is a follow-up to documents published in 2003 by the INSPQ that described the state of knowledge on asbestos exposure and asbestos-related diseases in the Québec population (De Guire et al., 2003a; Lajoie et al., 2003).

The report's objective is to present a concise overview of the studies carried out under the abovementioned system, as well as those conducted independently, between 2003 and 2009, by the INSPQ and by other working groups. It aims to update the portrait of asbestos exposure and its related diseases in Québec while awaiting the completion of the development and implementation of the surveillance system. It is not intended to update the knowledge on asbestos as such. The studies summarized herein are the following:

A. Descriptive Epidemiology of the Principal Asbestos-Related Diseases in Québec, 1981-2004 (Lebel & Gingras, 2007).

B. *Jumelage des cas de mésothéliome et amiantose reconnus comme maladies professionnelles pulmonaires aux nouveaux cas de cancer et aux hospitalisations avec amiantose* (Lebel et al., 2009).

C. *Étude des nouveaux cas de maladies professionnelles pulmonaires reliées à l'exposition à l'amiante au Québec : 1988-2003* (De Guire & Provencher, 2009).

D. *Relation entre la teneur en amiante dans les matériaux et la concentration de fibres dans l'air ambiant lors de travaux de démantèlement* (Dufresne et al., 2009a).

E. *Surveillance de l'exposition à l'amiante dans les métiers de la construction* (Beaudry et al., 2008).

F. Presence of asbestos fibres in indoor and outdoor air in the city of Thetford Mines: Estimation of lung cancer and mesothelioma risks (Bourgault & Belleville, 2009).

G. *Projet Provincial – Amiante/Secteurs industriels* (Huneault, 2008).

H. *Évaluation des effets du programme de dépistage de l'amiantose chez les travailleurs de la construction en Montérégie* (Cambron-Goulet, 2008).

I. *Rapports sur l'échantillonnage des fibres d'amiante dans l'air extérieur de la ville de Thetford Mines à proximité de terrains contenant des remblais d'amiante* (Couture & Bisson, 2006; Ministère de l'Environnement du Québec, 2001; Gauthier & Nantel, 2005).

J. Reports by the Service de la statistique of the Direction de la comptabilité et de la gestion de l'information (DCGI) and the Commission de la santé et de la sécurité du travail (CSST) dated February 22, 2010 (L'Épicier, 2010a).

The first three studies (A, B, C) are updates of prior studies carried out by the INSPQ. The next two (D, E) are research studies carried out at the request of the INSPQ by other research teams to document asbestos exposure in the construction industry. Reports F through J, which were conducted by the INSPQ or by other research teams, do not ensue from the abovementioned mandate, but they contain findings that help provide a portrait of the asbestos situation in Québec.

This document also aims to present the status of the surveillance system for asbestos exposures and their related diseases that will be introduced by the INSPQ under its mandate. Most of the studies listed above have contributed new information necessary to set up this system. The highlights of this report are presented in Appendix A.

Finally, a progress report on the implementation of the recommendations made by the Comité aviseur sur l'amiante in 2003 (De Guire & Lajoie, 2003b) and those made by the INSPQ in 2005 (De Guire et al., 2005) will be the topic of a separate publication. That publication will also include new recommendations.

2 ASBESTOS

2.1 ASBESTOS FIBRES

Asbestos is the name given to a group of natural fibrous silicate minerals that are divided into two mineralogical classes: amphiboles and serpentines. There are five types of amphiboles: crocidolite, amosite, anthophyllite, tremolite and actinolite. Chrysotile is the only serpentine and currently represents 95% of the world production of asbestos. Asbestos fibres are used commercially for their high tensile, thermal and even chemical strength, and for their flexibility (Lajoie et al., 2003).

2.2 HISTORY OF ASBESTOS IN CANADA

In 2007, Canada was the world’s fifth largest producer of chrysotile asbestos (Natural Resources Canada, 2007) and this production was concentrated in the cities of Thetford Mines, in the Chaudière-Appalaches region, and Asbestos, in the Estrie region. In Thetford Mines, the Lac d’amiante du Canada open-pit mine in the Black Lake area is still in operation. The underground Bell Mine, active for 130 years, was definitively closed on March 28, 2008 (Bourgault & Belleville, 2009). In Asbestos, the open-pit Jeffrey Mine has operated sporadically in recent years (Dumas, 2010).

Canada has always exported more than 90% of its production abroad. Until 1985, the United States was the largest export market, and then Japan took the lead for the next 10 years. More recently, Southeast Asia and India are the main importers. The annual chrysotile production used in the manufacture of asbestos-containing materials (ACM) in Canada reached its peak between 1955 and 1977 (approximately 50,000 metric tonnes per year). During the same period, Canada annually imported on average 5,000 tonnes of amosite and crocidolite (Beaudry et al., 2008). This explains why the ACM manufactured prior to the 1980s may have contained crocidolite and amosite in addition to chrysotile. Canada also may have imported ACM containing amphiboles.

Since the beginning of the 2000s, Québec reportedly uses 5,000 tonnes of its asbestos production annually. Most of this local consumption is earmarked for the industrial sector, but one-third is used in the production of asbestos-containing asphalt that is spread on the province’s road surfaces (Adib & Perrault, 2009). This represents an increase over past years. In fact, between 1994 and 1997, the Ministère des Transports du Québec (MTQ) used asphalt containing on average 358 tonnes of chrysotile asbestos per year (Ministère des transports du Québec, 1997).

2.3 MEASUREMENT TECHNIQUES FOR AIRBORNE ASBESTOS FIBRES

The methods most used to measure ambient air asbestos concentrations are phase contrast optical microscopy (PCOM) and transmission electron microscopy (TEM).

PCOM analysis counts the total number of fibres, but does not determine their nature, that is to say it does not distinguish an asbestos fibre from a cellulose fibre, for example. This method is recommended to measure asbestos concentrations in the workplace because the nature of the predominant fibres found there is known *a priori* (Bourgault & Belleville, 2009). Since the magnification obtained by this technique is low (400 to 500 times), fibres of a diameter less than 0.25 µm are not detected. The fibre counting protocol used in Québec counts fibres longer than 5 µm, with a diameter less than 3 µm and with a length: diameter ratio greater than 3:1 (IRSST, 1995). Since all types of fibres are counted, the actual asbestos fibre concentration may be overestimated, particularly in settings where fibres other than asbestos are found.

TEM analysis distinguishes asbestos fibres from other types of fibres and asbestos fibres from one another. It is therefore the preferred method to measure asbestos concentrations in outdoor air and in indoor air in non-occupational settings. As well, its high magnification (10,000 times) displays fibres with a very small diameter (up to 0.2 nm) (Bourgault & Belleville, 2009).

Concentrations are expressed in fibre per millilitre (f/ml; equivalent to f/cm^3) for PCOM. For TEM, they are expressed either in f/ml or electron fibre per millilitre (ef/ml), or in optical equivalent (or phase contrast microscopy equivalent (PCMe)), which is to say by counting the fibre concentrations according to the PCOM counting criteria (Bourgault & Belleville, 2009).

2.4 Asbestos exposure limits and criteria in Québec

The time-weighted average (TWA) corresponds to the average concentration permissible in the workplace, weighted on the basis of 8 hours per day, 40 hours per workweek. The short-term exposure limit (STEL) is a 15-minute time-weighted average concentration that should not be exceeded during a workday. Since 1990, in Québec, the TWA and the STEL are respectively 1 f/ml and 5 f/ml for chrysotile, tremolite, anthophyllite and actinolite. For crocidolite and amosite, the TWA and the STEL are respectively 0.2 f/ml and 1 f/ml (Gouvernement du Québec, 2009a). These values are based on a PCOM count.

The Québec exposure limit for chrysotile of 1 f/ml is relatively high compared to exposure limits elsewhere, notably in Ontario (Ontario, 1990), the United States (ACGIH, 2009) and France (INRS, 2007) where it is 0.1 f/ml. Moreover, the Agence française de sécurité sanitaire de l'environnement et du travail (AFSSET) published an advisory on August 7, 2009 that recommended lowering the French exposure limit to 0.01 f/ml, as the Netherlands and Switzerland had already done (AFSSET, 2009).

With respect to asbestos fibre concentrations in ambient air, the Ministère du Développement durable, de l'Environnement et des Parcs (MDDEP) retained a provisional air quality criterion in Québec of 0.04 f/ml. This matches the air quality criterion for asbestos established in Ontario in 1976. It is based on a 95% probability of a less than 1% risk of developing clinical evidence of asbestosis. The analysis method on which this provisional criterion is based is not specified (TEM or PCOM). The city of Montréal adopted an ambient air quality standard for asbestos set at 0.05 f/ml, under Règlement 90 of the Communauté urbaine de Montréal. However, the bases for this standard are not specified. Finally, the MSSS defined a criterion for the management of ACM in public buildings of 0.01 f/ml, to identify situations that require immediate preventive measures. This criterion is not based on health effects (Bourgault & Belleville, 2009).

3 ASBESTOS EXPOSURE IN THE GENERAL POPULATION OF QUÉBEC

3.1 EXPOSURE SOURCES IN THE MINING REGIONS

The main possible sources of airborne asbestos fibres in mining towns are ore extraction and mine tailings. Mine tailings are sent to accumulation sites and can be used as landfill (Lajoie et al., 2003; Ministère de l'Environnement du Québec, 2001) or as road abrasives (Veillette, 2010).

In Thetford Mines and in Asbestos, several tailings dumps are present close to inhabited, commercial and industrial areas. In Asbestos, the tailings dumps are concentrated around the mine. Reportedly, 10% of the tailings dumps in this city are covered by vegetation (Gagnon, 2010), while this is apparently not the case in Thetford Mines (Veillette, 2010). In Thetford Mines, certain of these accumulation areas are still active. Mine tailings are used as landfill on public and private land in this city. In addition, they are used as road abrasives, but the extent of these practices is not known. Municipal authorities have indicated that the use of asbestos-containing abrasives would be reduced (Veillette, 2010). It has not been possible to learn if accumulation areas are still active in Asbestos, but mine tailings are apparently not used as landfill or as abrasives (Gagnon, 2010). Finally, in Thetford Mines, all-terrain vehicle use on tailings dumps is not completely controlled (Veillette, 2010). In Asbestos, all-terrain vehicle use is restricted to marked sand-covered trails (Gagnon, 2010). To our knowledge, the contribution of this practice to ambient concentrations of asbestos fibres has not been documented.

3.2 ASBESTOS CONCENTRATIONS IN OUTDOOR AIR

3.2.1 City of Asbestos

The Jeffrey Mine took air samples at nine stations in the city of Asbestos between 1998 and 2005. The reported average annual fibre concentrations ranged from 0.003 to 0.007 f/ml depending on the sampling site (range: 0.001 to 0.011 f/ml). However, the analytic method used (TEM or PCOM) was not stated (Deacon, 2005).

3.2.2 Cities of Thetford Mines, Tring-Jonction, Montréal and Québec

In 2004, the MDDEP measured ambient levels of asbestos fibres at six stations located in the following four municipalities: Thetford Mines (two sites), Tring-Jonction, Montréal (two sites) and Québec (Bourgault & Belleville, 2009). These data were collected in connection with the Policy concerning the increased and safe use of chrysotile asbestos in Québec.

The two stations in Thetford Mines were located under the prevailing winds, one near the mine and mill and the other a bit further downwind. The station in Tring-Jonction, a community close to Thetford Mines, served to characterize a setting located near an inactive tailings dump. The stations in Montréal and the city of Québec represented either a downtown urban setting or a neighbourhood with heavy road traffic. The samplings, carried out over 24 hours, were collected in samplers placed on the roofs of public buildings (Bisson & Couture, 2007).

The 125 samples obtained at the two stations in Thetford Mines were analyzed by PCOM. The fibre concentrations ranged from < 0.0015 to 0.056 f/ml. Seven samples with the highest values were also analyzed by TEM. The asbestos fibre concentrations obtained by this method ranged from < 0.0006 to 0.0082 f/ml with an average of 0.0043 f/ml (Bourgault & Belleville, 2009).

The 58 samples from the Tring-Jonction station measured by PCOM had fibre concentrations that ranged from < 0.0015 to 0.0078 f/ml, while the two samples analyzed by TEM were all below the detection limit of the method (< 0.0006 f/ml) (Bourgault & Belleville, 2009). According to the authors, this suggests that the inactive tailings dumps are not a significant source of asbestos fibres in the ambient air in the area (Bisson & Couture, 2007).

The situation was similar for the stations in Montréal and the city of Québec because the fibre concentrations obtained by PCOM analysis (n = 116) were very low (< 0.0015 to 0.0054 f/ml), while TEM analyses (n = 5) did not permit the identification of asbestos fibres (Bourgault & Belleville, 2009).

3.2.3 Comparison of concentrations measured in Thetford Mines with those obtained in other cities

In a study published in 2009 by the INSPQ, the average asbestos fibre concentration obtained by the MDDEP following TEM analysis, in Thetford Mines, in 2004 (0.0043 f/ml) was compared to concentrations obtained in 1997 in the cities of Thetford Mines, Black Lake and Asbestos at seven sampling stations. The levels measured in 1997 were relatively comparable to those measured in 2004 in Thetford Mines. Subsequently, the same average concentration obtained by the MDDEP in Thetford Mines in 2004 was compared to the results of outdoor air samplings from around buildings involved in litigation regarding ACM abatement in the United States. The average concentration obtained in Thetford Mines, like that measured in Asbestos in 1997 (0.004 f/ml), was 215 times higher than that obtained outside buildings across the United States (Bourgault & Belleville, 2009) (Table 1).

Table 1 Comparison of asbestos fibre concentrations (f/ml) measured by transmission electron microscopy in the outdoor air of Thetford Mines with other settings

Year	**2004**			**1997**			**Approximately 1980 to 2000**
Place	Thetford Mines	Urban setting (Montréal and city of Québec)	Tring-Jonction	Asbestos	Thetford Mines	Black Lake	Outside buildings across the U.S.
Detection limit (f/ml)	0.0006	0.0006	0.0006	NA[1]	NA	NA	NA
Number of samples (n)	7	5	2	NA	NA	NA	1,678
Arithmetic mean (f/ml)	0.0043	—[2]	—[2]	0.004	0.004	0.007	0.00002

[1] NA: Information not available.
[2] All the results obtained are below the detection limit.
Source: Bourgault and Belleville, 2009.

3.2.4 Asbestos concentrations in outdoor air in the city of Thetford Mines close to yards and alleys filled with asbestos tailings

In 1999, a working group comprising representatives of the Ministère de l'Environnement du Québec, the MSSS, the INSPQ and the Direction de santé publique de Chaudière-Appalaches was created in order to assess whether there is a potential risk associated with yards and alleys filled with asbestos tailings. To support this risk assessment, an air quality measurement campaign was organized in the city of Thetford Mines in the summer of 2000. Samples were taken close to a schoolyard and a community centre, one metre above the ground, in order to assess the exposure of the most sensitive population: the children. These stations were selected to represent settings affected chiefly by asbestos landfill rather than by the tailings dumps located on the city outskirts. The asbestos fibre sampling was carried out only once at each station at a time when mining activity was minimal and when there was no schoolyard activity. The results obtained by TEM were compared to those of the two control stations located in a more rural area of the Thetford Mines municipality and in a parking lot in the city of Laval. No chrysotile asbestos fibres were detected in the two control samples. However, concentrations of 0.0004 f/ml and 0.0008 f/ml were measured at the school and the community centre respectively (Ministère de l'Environnement et de la Faune, 2000). Since this exposure is higher than that observed in the ambient air of large North American cities, it was then recommended to limit exposure by covering the fill with a non-contaminated material (Ministère de l'Environnement du Québec, 2001; Gauthier & Nantel, 2005).

In 2005, the working group replicated the ambient air sampling that had been carried out in Thetford Mines in the summer of 2000. Air samples were taken at a height ranging from one to two metres above the ground at the same sampling sites used in 2000 except for the Laval test site. As in 2000, samplings were done when mining activity was minimal and the analyses were performed by TEM. However, contrary to the first sampling campaign, the samples were taken during normal school activities and under more frequent wet weather conditions. No asbestos fibres were identified in the samples taken at the three different stations in 2005 (Couture & Bisson, 2006). The rainy conditions might have downwardly influenced exposure levels, which makes comparison with the 2000 sampling difficult. Were it not for these wet conditions and the limited number of samples, fibre concentrations above the detection limit might have been observed. Thus, the recommendation was upheld to exercise the precautionary principle by covering the fill with a non-contaminated material (Gauthier & Nantel, 2005).

3.3 Asbestos concentrations in indoor air

3.3.1 City of Thetford Mines

In 2003 and in 2004, the Association des victimes de l'amiante du Québec (AVAQ) assessed indoor air asbestos concentrations in 26 residences in the city of Thetford Mines. Dwellings were selected based on their location with respect to tailings dumps. Most of them (24/26) were located within a radius less than or equal to two kilometres from the tailings dumps (Bourgault & Belleville, 2009).

The analyses carried out by TEM identified the presence of asbestos fibres in 15 of the 26 houses sampled. Most of these were chrysotile fibres, but one actinolite fibre was identified in two residences and one tremolite fibre in three residences. The concentrations measured ranged from < 0.000553 to 0.010 PCMe fibre/ml (n = 26). The arithmetic mean calculated from these results, but replacing the values smaller than not detected by zero, is 0.0018 PCMe fibre/ml. The results were also presented in structures/ml (s/ml). According to the protocol established in the *Asbestos Hazard Emergency Response Act* (AHERA), each single asbestos fibre that conforms to the counting criteria is counted as a structure, just as is any bundle, cluster or matrix that has at least one asbestos fibre meeting the criteria. The concentrations measured using this protocol (n = 28) ranged from < 0.004 to 0.311 s/ml with an arithmetic mean of 0.051 s/ml (Bourgault & Belleville, 2009) (Table 2).

3.3.2 Comparison of concentrations measured in Thetford Mines with those measured in other settings

In a study published in 2009 by the INSPQ, asbestos concentrations measured in indoor air in residences in the city of Thetford Mines were compared to those obtained by TEM in four studies having comparable sampling protocols and analytic methods (Bourgault & Belleville, 2009).

The first of the four studies, conducted at the end of the 1990s, aimed to measure asbestos fibre concentrations inside 17 Québec schools containing ACM. These schools were selected based on the presence of ACM with a high percentage of asbestos, an average to high asbestos friability and a significant level of degradation of sprayed asbestos (Bourgault & Belleville, 2009).

In the second study that was carried out in the week following the events at the World Trade Center (WTC) in 2001, the authors sampled air inside two apartments affected by the dust cloud from the destruction of the two towers and thereby determined their degree of asbestos contamination (Bourgault & Belleville, 2009).

The third study carried out by the United States Environmental Protection Agency (US EPA) in 2002 aimed to characterize the urban background level of asbestos in Upper Manhattan in New York City by sampling airborne asbestos inside 62 apartments and common areas of 14 residential buildings (Bourgault & Belleville, 2009).

Finally, researchers in the fourth study measured airborne asbestos present in buildings across the United States involved in litigation regarding ACM abatement. During the period of their study (more than 20 years), these researchers took air samples in 317 schools, 234 public and commercial buildings and 5 residences (Bourgault & Belleville, 2009).

The average asbestos fibre concentration measured in residences in the city of Thetford Mines (0.0018 PCMe fibre/ml) is 1.7 and 1.4 times lower than that observed respectively in 17 Québec schools (0.0031 PCMe fibre/ml) and in two apartments affected by dust from the collapse of the WTC towers (0.0026 PCMe fibre/ml). However, it is 16 to 45 times higher than the concentrations reported in schools (0.00011 PCMe fibre/ml), residences (0.00005 PCMe fibre/ml), public buildings (0.00004 PCMe fibre/ml) and commercial buildings (0.00005 PCMe fibre/ml) across the United States (Bourgault & Belleville, 2009).

When expressed in structures/ml, the average concentration obtained by the AVAQ (0.051 s/ml) is 4 to 232 times higher than the concentrations observed in the buildings sampled across the United States and in the apartments of Upper Manhattan in New York City (Bourgault & Belleville, 2009) (Table 2).

Table 2 Comparison of concentrations in PCMe fibres/ml and in structures/ml reported in residences in the city of Thetford Mines with those reported in indoor air in four other studies

Sampling sites	Residences in the city of Thetford Mines	Québec schools with presence of degraded ACM[1]	Apartments four streets north of the WTC[1] in New York	Residential apartment buildings in Upper Manhattan, New York	Buildings across the United States
Number of sites	26	17	2	14	S[1]: 317 R[1]: 5 PCB[1]: 234
Number of samples	26 or 28[2]	77	6	48	S: 1615 R: 39 PB[1]: 590 CB[1]: 746
Arithmetic mean (PCMe fibres/ml)	0.0018	0.0031	0.0026	—	S: 0.00011 R: 0.00005 PB: 0.00004 CB: 0.00005
Comparison with the average concentration in PCMe fibres/ml by AVAQ	—	1.7 times lower	1.4 times lower	—	Respectively 16, 36, 45, 36 times higher
Arithmetic mean (structures/ml)	0.051	—	—	0.00022	S: 0.013 R: 0.0018 PB: 0.0014 CB: 0.0011
Comparison with the average concentration in structures/ml by the AVAQ	—	—	—	232 times higher	Respectively 4, 28, 36, 46 times higher

1 ACM: asbestos-containing materials; WTC: World Trade Center; S: schools; R: residences; PCB: public and commercial buildings; PB: public buildings; CB: commercial buildings.

2 26 samples counted in PCMe fibres/ml or 28 samples counted in s/ml.

Source: Bourgault and Belleville, 2009.

4 ASBESTOS EXPOSURE IN THE QUÉBEC WORKPLACE

4.1 MINING SECTOR

No publication later than the year 2000 has been found on the exposure levels of asbestos miners in the areas of Thetford Mines and Asbestos.

4.2 INDUSTRIAL SECTOR

As part of the Policy concerning the increased and safe use of chrysotile asbestos in Québec, a provincial project called *Amiante/Secteurs industriels* was initiated in 2005. The objective was to ensure a safe use of asbestos in factories that use or process asbestos in their manufacturing operations (Huneault, 2008).

4.2.1 Criteria that define a safe use of asbestos in the *Amiante/Secteurs industriels* project

The committee responsible for the project began by establishing the criteria that define a safe use of asbestos. These criteria, all drawn from the Regulation respecting occupational health and safety of Québec (RSST), are the following:

a) Presence of double changing room (RSST Section 67).
b) Use of protective suit (RSST Section 63).
c) Local ventilation at stationary work stations (RSST Section 107).
d) Annual measurements of work environment by the employer (RSST Section 43).
e) Compliance with the values in Appendix I Part 1 of the RSST (TLV and STEL).
f) To comply with the provisions of RSST Section 42: “substance [to which] exposure shall be reduced to a minimum,” the committee responsible for the project proposes abiding by the recommendation of the American Conference of Governmental Industrial Hygienists (ACGIH) and the Occupational Safety and Health Administration (OSHA) which is a time-weighted average concentration of 0.1 f/ml and an excursion limit of 1 f/ml (Huneault, 2008) based on PCOM analyses.

4.2.2 Industrial sectors and factories that use or process asbestos in Québec

The team responsible for the project targeted eight activity sectors as being the most likely to include factories that use or process asbestos. These sectors are the following:

1) Glove manufacturing
2) Machine shops
3) Transportation equipment industries
4) Shipbuilding and repair
5) Non-metallic minerals: asbestos products
6) Insulation products manufacturing
7) Other petroleum and coal products industries
8) Adhesives industry (Huneault, 2008).

Each region in Québec established its own list of targeted factories in these activity sectors using the CSST lists. Factories outside these sectors could be added, provided they use or process asbestos in their manufacturing operations. As of December 31, 2007, 968 factories had been retained in the project of which 959 (99%) were visited by the public occupational health network. The use of chrysotile asbestos was identified in the processes of less than 1% of the 959 workplaces visited, or eight factories (Huneault, 2008).

A subsequent Internet search identified a ninth factory that processes asbestos-cement (chrysotile) products. The findings from the nine factories are summarized in the following paragraphs.

The team was unable to assess asbestos exposure in five factories because the work with asbestos or asbestos products occurred only occasionally or was of too short duration. Three of these factories were in the machine shop sector and the two others were asphalt manufacturers (which is in the petroleum and coal products industry). Exposure was assessed in the four other factories: a brake pad manufacturer, a joint gaskets manufacturer, an adhesives manufacturer and an asbestos-cement products processing plant.

None of the nine factories used asbestos in a safe manner in compliance with one or more of the criteria established for the project. Twenty-two workers from the four factories in which exposure was assessed were exposed to levels $\geq$ 0.1 f/ml. Two of them, who work at the same factory, were exposed to levels higher than the TWA of 1 f/ml for chrysotile, despite the presence of control measures during sample collection. Moreover, other exceedences of the Québec exposure limit were observed in this factory in three sampling sessions spread out over two years. This suggests that the preventive measures used in the factory to reduce workers' exposure are not effective.

In addition, the *Amiante/Secteurs industriels* project identified 60 factories of the 959 visited that had asbestos-containing equipment (gloves, mittens and covers) (Huneault, 2008).

Finally, in 2010, the MTQ identified 28 plants equipped for the production of asbestos-containing asphalt (Robidas, 2010). For the moment, we have no information on the availability of measurements of workers' exposure in these plants. Two of them might have been included in the *Amiante/Secteurs industriels* project because that study had identified two asphalt producers. However, we cannot confirm that these two asphalt plants are among the 28 plants, due to lack of access to the nominative data of the *Amiante/Secteurs industriels* project. The distribution of the 28 plants in Québec's health and social service regions is presented in Table 3.

Table 3 Distribution of Québec plants possibly producing asbestos-containing asphalt by different health and social service regions

Health and social service region	Number of plants that can produce asbestos-containing asphalt
Bas-St-Laurent (01)	3
Saguenay–Lac-Saint-Jean (02)	0
Capitale-Nationale (03)	2
Mauricie and Centre-du-Québec (04)	2
Estrie (05)	1
Montréal (06)	1
Outaouais (07)	1
Abitibi-Témiscamingue (08)	3
Côte-Nord (09)	0
Nord du Québec (10)	0
Gaspésie–Îles-de-la-Madeleine (11)	0
Chaudière-Appalaches (12)	5
Laval (13)	1
Lanaudière (14)	0
Laurentides (15)	1
Montérégie (16)	4
Nunavik (17)	0
Terre-Cries-de-la-Baie-James (18)	1
Unknown	3
Total	28

Source: Robidas, 2010.

4.3 CONSTRUCTION INDUSTRY

4.3.1 Exposure data sources at high-risk construction sites

Before beginning construction work that is liable to release asbestos dust, an employer must identify the types of asbestos present in the materials. At high-risk construction sites,[a] work is carried out within an airtight enclosure. The employer must collect an air sample at least once per work shift during execution of the work and on completion of the work, but before dismantling the enclosure (Gouvernement du Québec, 2009b). Except as authorized, these samples must be collected in the workers' breathing zone (Gouvernement du Québec, 2009a). Other air samples may be collected in the areas adjacent to the construction site or in the clean changing rooms, to assess the dust caused by workers moving toward the clean area or to ensure the airtightness of the enclosure.

[a] In the Safety Code for the construction industry, a high-risk construction site is a site where high emitting asbestos tasks are performed.

In a study published in 2009, a team from McGill University and the Institut de recherche Robert-Sauvé en santé et en sécurité du travail (IRSST) wanted to better document workers' exposure to asbestos fibres at high-risk construction sites. The researchers used data that had been collected for the purposes of characterizing materials that might contain asbestos and assessing airborne asbestos fibre concentrations at high-risk construction sites. These data came from the IRSST, from some CSST inspectors, from representatives of the Université de Montréal and McGill University and from some consultants specializing in the management and removal of materials liable to release asbestos dust. The study identified 1,182 buildings of which 1,100 were schools. A total of 5,383 material samples from 1,126 of these buildings were characterized and 6,690 air samples from 106 buildings were analyzed by PCOM (Dufresne et al., 2009a) (Table 4).

Table 4 Materials and air sample distribution by category of buildings

Category of buildings	Material samples		Air samples	
	Number of buildings	Number of samples	Number of buildings	Number of samples
Machine shops	1	19	2	52
Others[1]	2	142	4	804
Hospitals and CHSLD[2]	14	466	20	728
Office buildings	12	997	24	2,957
Residential buildings	2	15	4	214
School buildings	1,085	3,263	28	579
Refineries	2	219	5	931
Community halls	6	232	11	205
Plants	2	30		220
Total	1,126	5,383	106	6,690

1 Others = transportation, food warehouses and power station.
2 CHSLD: long term care centre.
Source: Dufresne et al., 2009a.

4.3.2 Exposure determinants in buildings involving high-risk work

4.3.2.1 Asbestos-containing materials

Among the 5,383 material samples, 54% contained no asbestos fibres. For the 2,475 other samples, 75% contained only chrysotile, 15% contained chrysotile in the presence of another type of fibre (amosite, tremolite, actinolite or crocidolite) and 10% contained only amphiboles (amosite, tremolite or actinolite). In total, 90% of the samples contained chrysotile alone or mixed with amphiboles. Finally, a single sample contained a mix of three types of asbestos fibres, these being chrysotile, amosite and crocidolite (Dufresne et al., 2009a).

Among the samples for which a description of the materials was available (3,456/5,383), 53% were identified as plaster and 25% as a spraying. In addition, the type of the structure of 48% (n = 2,525) of asbestos-containing samples was identified as wall, floor, pipe, etc. Floors, ceilings, walls and dropped ceilings constitute the structures with the smallest asbestos load (approximately 7% and less). Pipes, reservoirs, beams, exchangers, pipe elbows and ducts contained more than 40% (Figure 1). The samples with chrysotile generally came from ceilings, walls, pipe elbows and floors while amosite was found mainly in pipes and pipe elbows (Dufresne et al., 2009a) (Figure 2).

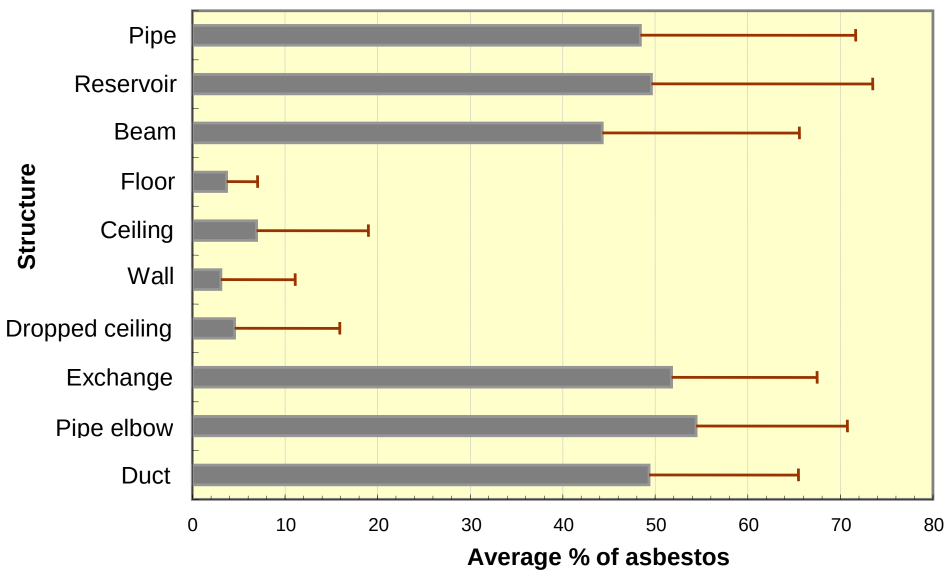

Figure 1 Average percentage of asbestos by structure

Source: Dufresne et al., 2009a.

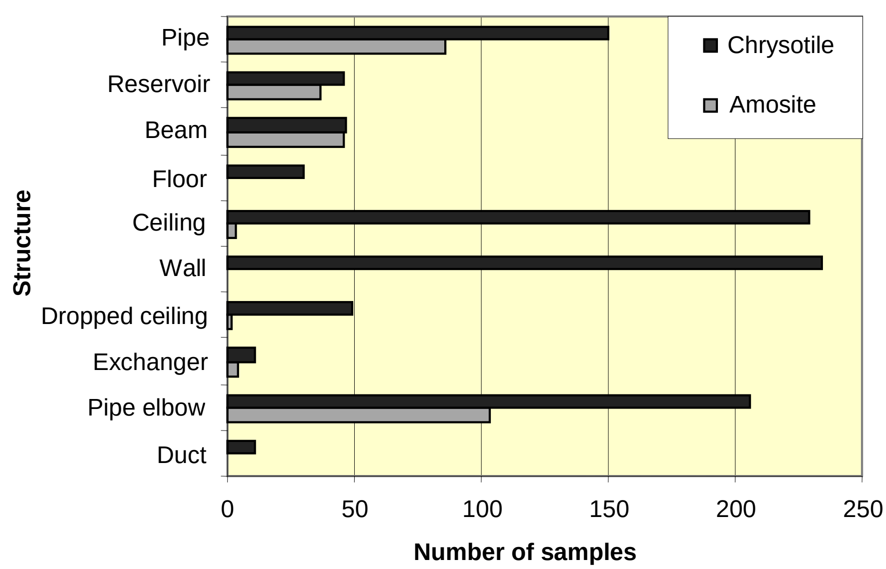

Figure 2 Distribution of samples containing chrysotile or amosite by structures

Source: Dufresne et al., 2009a.

4.3.2.2 Airborne fibre concentrations and exceedence of exposure limits

Of the 6,690 air samples taken in 106 buildings, 45% were collected during work in the asbestos removal area (n = 3,000), 39% in changing rooms (n = 2,623), 9% in adjacent areas (n = 587) and 7% on construction sites after work completion (n = 471). The samples were taken mainly in office buildings and refineries. Since the samples were analyzed by PCOM (Dufresne et al., 2009a), the nature of the fibres they contained is not known.

Construction sites during abatement work

Of the 3,000 air samples collected during abatement work and analyzed by PCOM, 43% (n = 1,294) had concentrations ≥ 1 f/ml which is the exposure limit for chrysotile. Five percent (n = 163) had concentrations higher than 10 f/ml. This concentration is the threshold level in the Safety Code for the construction industry before maximum respiratory protection is required when work is carried out in the presence of crocidolite or amosite. In addition, 14% (n = 404) had concentrations higher than 5 f/ml, the permissible exposure level with a protective factor of 50 for a standardized airborne concentration of 0.1 f/ml according to the ACGIH exposure limit. Only three samples taken in a hospital, a school building and a refinery exceeded 50 f/ml, the maximum value being 96 f/ml (Dufresne et al., 2009a) (Figure 3).

Contrary to the provisions in the Safety Code for the construction industry and the Regulation respecting occupational health and safety, only 3.3% of the samples taken during abatement work were obtained in the workers' breathing zone. The other samples were taken mainly in an observer's breathing zone (that is to say, of the technician performing the sampling) (52%) and at stationary work stations (42%). According to the authors, the number of exceedences of the reference values would be larger if more samples had been taken in the workers' breathing zone (Dufresne et al., 2009a). In fact, other studies have shown that concentrations measured in the workers' breathing zone were 5 to 10 times higher than those obtained at stationary work stations during dismantling of amosite-containing materials (Dufresne et al., 2009b).

Furthermore, more than half (55%) of the 3,000 samples had a fibre density that did not comply with the optimum densities of 100 to 1,300 f/mm^2 recommended by the analytic method utilized (IRSST 243-1) (Figure 4). Fibre densities of 25 to 100 f/mm^2 can be taken into consideration in assessing a worker's exposure, but the method's coefficient of variation is not known at these densities. Thus, 72% of the densities obtained were between 25 and 1,300 f/mm^2, which is an excellent valid sample production rate according to the study's authors. Although these air samples represent only exposure levels observed at specific times, the number of exceedences observed suggests a potential health risk for workers who work in asbestos removal areas during high-risk work if they do not wear or improperly wear protective gear (Dufresne et al., 2009a). As well, samples collected without complying with the prescribed methods could result in the choice of inadequate respiratory protection to effectively protect workers against asbestos fibre inhalation.

Finally, the variability of the fibre concentrations measured during asbestos removal work was assessed by calculating the geometric standard deviation of the concentration distribution profiles in the rooms for which results were available for at least five samples (n = 175). More than 52% of the geometric standard deviations calculated were higher than three. This suggests that the fibre concentrations measured vary significantly, thus indicating situations that are out of control (Dufresne et al., 2009a).

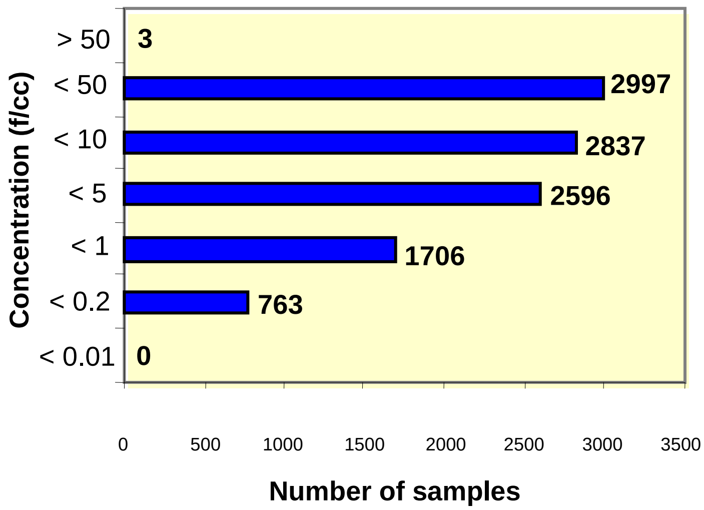

Figure 3 **Frequency of airborne fibre concentrations (n = 3,000)**

Source: Dufresne et al., 2009a.

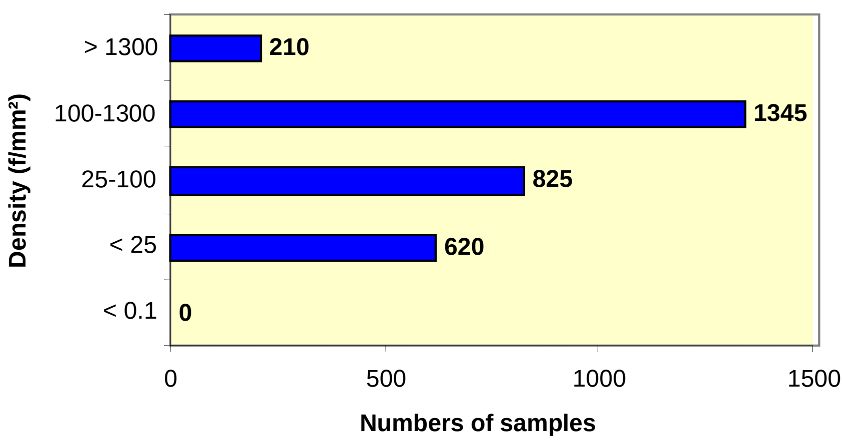

Figure 4 **Distribution of fibre densities on membranes (n = 3,000)**

Source: Dufresne et al., 2009a.

Construction sites after completion of abatement work

Of the 471 samples collected at construction sites after completion of asbestos abatement and before dismantling of the enclosure, 94% had fibre concentrations below 0.01 f/ml by PCOM. This value corresponds to the threshold level required in the Safety Code for the construction industry before dismantling of the airtight enclosure. However, 73% of the results had a density less than 25 f/mm^2, the majority of which had an insufficient sampling volume, which limits the reliability of the results (Dufresne et al., 2009a).

Changing rooms and adjacent areas

Among the air samples taken in changing rooms during asbestos removal work and analyzed by PCOM, 77% (2,013/2,616) had fibre concentrations equal to or higher than 0.01 f/ml. This indicates a certain contamination of the rooms that could have been caused by the movements of workers with soiled clothing or by a leak in the enclosure. However, since several types of fibres other than asbestos can coexist in this kind of environment, the use of PCOM could have overestimated the real asbestos fibre concentrations. Furthermore, 46% of the samples had densities less than 25 f/mm^2 and 98% of the volumes were less than 1,000 litres, which was not in compliance with the requirements of the IRSST method. This may have resulted in a less reliable assessment of the airborne fibre concentration (Dufresne et al., 2009a).

In the areas adjacent to construction sites involving asbestos removal work, 86% (506/587) of the samples had fibre concentrations below the reference value of 0.01 f/ml. However, since 74% of the samples had sampling densities and volumes below the method's applicability requirements, data interpretation is thereby limited (Dufresne et al., 2009a).

4.3.3 Exposure intensity by tasks performed at high-risk construction sites

Despite the little data available on the nature of the work being performed when air samples were taken at an asbestos removal site, a variance analysis (ANOVA) allowed for a comparison of the fibre concentration averages for each of the tasks for which information was available (n = 597). Asbestos dust emissions seemed more intense during waste recovery, material removal and demolition tasks than during cleaning, sealing, inspection and multiple tasks (Dufresne et al., 2009a).

4.3.4 Non-compliance notices issued by the CSST between 2004 and 2008 concerning asbestos construction sites

Non-compliance notices are issued by the CSST for construction sites involving asbestos removal or demolition work, when the methods and procedures utilized do not comply with the provisions of the Safety Code for the construction industry.

CSST inspectors issued non-compliance notices in 21 to 37% of the visits they made, between 2004 and 2008, to construction sites involving work with asbestos (L'Épicier, 2010b) (Table 5). Given the existence of an intervention program in the construction industry since 1998 (CSST, 1998), we might expect a reduction in the percentage of notices issued, but this does not seem to be the case.

Table 5 Non-compliance notices issued by the CSST between 2004 and 2008 involving construction sites with asbestos

Year	Non-compliance notice n	Visits to construction sites n	% of non-compliance notices/visits to construction sites
2004	304	1,453	21
2005	429	1,458	29
2006	432	1,678	26
2007	539	1,467	37
2008	414	1,553	27
Total	2,118	7,609	28

Source: L'Épicier, 2010.

4.3.5 Exposure during repair and removal of asbestos-containing asphalt

Roadwork that involves the repair and removal of asbestos-containing asphalt is considered a construction site in the *Act respecting occupational health and safety* (Gouvernement du Québec, 2009c). For that reason, exposure incurred during this work is discussed in this section on the construction industry.

The MTQ uses part of Québec's asbestos production in the preparation of asbestos-containing asphalt that is laid on some of its road network. According to a study published in 2008 by the Université de Montréal, 145 road stretches in Québec contained asbestos (Beaudry et al., 2008). Cities such as Montréal and Québec have also used asbestos-containing asphalt, but we have no information about the extent.

The only Québec data available on occupational exposure caused by asbestos-containing asphalt come from a 2004 study by the MTQ, the main findings of which are summarized in a literature review published in 2009 by the INSPQ. In the MTQ study, asbestos fibre concentrations in ambient air along a road with asbestos-containing asphalt in the Chaudière-Appalaches region were measured before and during removal of the asphalt (Adib & Perreault, 2009).

The samples taken from along the stretch of road before asphalt removal and analyzed by PCOM ranged from < 0.001 to < 0.004 f/ml (sic). Of the samples taken during removal operations, 20 were collected at stationary stations along the road and 17 at mobile stations, either in the workers' breathing zone or at stationary stations on the equipment. Half of the air samples at the stationary stations were obtained under relatively high dust conditions due to equipment breakage that affected the wetting system. The arithmetic means of the samples taken during the incident and analyzed by PCOM (0.013 f/ml) were three times higher than those of the samples obtained in the presence of wetting (0.0034 f/ml). The samples collected at the mobile stations in the breathing zone of the various workers (n = 11) and analyzed by PCOM had concentrations ranging from < 0.09 to < 0.49 f/ml (sic), while at stationary stations on the equipment (n = 6), the concentrations ranged from < 0.09 to

< 0.90 f/ml (sic). Actinolite was present in three of the five samples collected at mobile stations and analyzed by TEM (Adib & Perreault, 2009).

4.3.6 Tools to document asbestos exposure in the construction industry

A research team from the Université de Montréal has developed new tools to contribute to knowledge on the exposure of Québec construction workers (Beaudry et al., 2008). These tools are described in this section.

4.3.6.1 Inventory of ACM and their suppliers

The team produced an inventory of the commercial names of ACM and the business names of their suppliers, using various sources of information, including a systematic documentation search on asbestos-containing products. In addition, the team examined the current list of products made and distributed in Québec, prepared by the Centre de recherche industrielle du Québec (CRIQ), and its prior hard copy versions. This inventory identified 1,461 ACM that were classified and matched to their 576 suppliers. Most of the suppliers were located in Canada (48%), the United States (30%) and France (16%). The ACM of the three main supplier countries are divided into 11 classes (10 classes based on those of the Association nationale de défense des victimes de l'amiante (ANDEVA) in France and one undetermined class) (Beaudry et al., 2008) (Table 6).

The type of asbestos was not specified for 87% of the ACM. The concentration was available for only 27 of the ACM listed, all classified in the "Asbestos, woven or braided" class and composed of chrysotile (Beaudry et al., 2008).

According to the researchers, this inventory could be the largest ever made, but it is not exhaustive. As well, the ACM listed in it have not necessarily all been used in Québec (Beaudry et al., 2008).

This inventory was compiled in the form of a relational database that the INSPQ plans to put online to make it accessible to stakeholders.

Table 6 Distribution of asbestos-containing materials (ACM) in the ACM-supplier database by class of ACM in the three main supplier countries

Class of asbestos-containing materials	Canada	United States	France
Asbestos, raw in bulk	1	61	7
Asbestos in powders, mineral products (except asbestos-cement)	1	36	11
Asbestos in liquids or pastes	0	427	69
Asbestos in sheets or plates	9	91	11
Asbestos, woven or braided	48	75	18
Asbestos in a resin or plastic	7	62	94
Asbestos-cement	21	51	36
Asbestos in black products	0	3	18
Asbestos in materials and equipment	1	35	0
Non-categorized products	3	15	19
Undetermined class	0	143	80

Source: Beaudry et al., 2008.

4.3.6.2 Registry of ACM in buildings

With the intention to produce a registry of ACM in Québec buildings, researchers contacted 31 public and parapublic organizations and private enterprises chosen for the size of their building inventory. Among these organizations, 18 confirmed that they had information regarding ACM in their buildings, and nine agreed to share the information concerning their ACM inventory, these being three cities, one public service company, one provincial ministry, one federal ministry and three post-secondary educational institutions. As well, the researchers consulted 557 reports by CSST inspectors containing the terms actinolite, tremolite, crocidolite and amosite, to produce the registry (Beaudry et al., 2008).

The registry contains 23,099 ACM reported in 1,550 buildings located across Québec. Pipe insulation, floor coverings, plates and sprayings represent 75% of these ACM. More than 75% of the ACM reported came from nine organizations located in the Montérégie, Montréal, city of Québec, Mauricie and Centre-du-Québec regions. Also, 87% of the ACM came from three types of buildings, namely industrial, administrative and educational buildings (*cégeps* and universities) (Beaudry et al., 2008).

By eliminating all the ACM in which the presence of asbestos had been assessed solely on a qualitative basis, all those in which the result of the quantitative analysis did not specify the type of asbestos and all those in which the results indicated “traces,” there remained only 10,538 ACM containing chrysotile alone or mixed with one or more amphiboles and 1,251 ACM containing only amphiboles. Among the 10,538 ACM containing chrysotile, 95.3% contained only chrysotile, 4.3% contained a mix of chrysotile, crocidolite and amosite and 0.4% contained a mix of chrysotile and amosite (Beaudry et al., 2008). This distribution differs slightly from that observed in the study presented in section 4.3.2.1. Among the 2,475 samples containing asbestos, 75% contained chrysotile alone (Dufresne et al., 2009a).

The materials containing chrysotile were mainly distributed in the following categories: pipe insulation (elbows, valves, straight sections, etc.) (33%), sprayed asbestos (17%), tile or roll flooring (13%) and asbestos-cement plates (8%). The materials containing amosite and crocidolite were mainly pipe insulation (Beaudry et al., 2008).

It is impossible to state the representativeness of this registry with respect to all Québec buildings. Moreover, this tool does not supply any nominative information on the buildings because of confidentiality agreements. It is therefore impossible to use this registry to identify buildings liable to expose construction industry workers to asbestos. However, the systematic inventories that are the sources used to build this registry make it possible for the various owners to inform any construction worker involved in work with these materials.

5 ASBESTOS HEALTH EFFECTS ON THE GENERAL POPULATION OF QUÉBEC

The main diseases associated with asbestos exposure are pleural and peritoneal mesothelioma, asbestosis and lung cancer (WHO, 1998; OMS, 2006). Other health problems such as pachypleuritis, pleurisies and pleural plaques can also be associated with asbestos exposure, but their severity is not as great (Lebel & Gingras, 2007). Finally, the International Agency for Research and Cancer (IARC) has recently added laryngeal and ovarian cancers to the tumours related to asbestos exposure (Straif et al., 2009).

This section of the report presents the results of the analysis of the available epidemiological data on mesothelioma and asbestosis in the general population of Québec. It also includes results on mortality from cancers of the pleura and peritoneum because, up until 1999, mesothelioma mortality was not available and the majority of pleural and peritoneal cancers are mesotheliomas. The results presented below come from a study published in 2007 by the INSPQ (Lebel & Gingras, 2007). Lung cancer epidemiology has not been studied since the publication of studies carried out by the asbestos advisory committee in 2003 (De Guire et al., 2003a), owing to the difficulty of isolating cases attributable to asbestos exposure from among all the cases of this cancer in the general population. In addition, no data on less severe health decrements have been traced. Finally, since the relationship with ovarian and laryngeal cancers had not been established at the time the studies presented in this report were conducted, none of them examined this issue.

5.1 MESOTHELIOMA

5.1.1 Data sources

The incidence of pleural and peritoneal mesothelioma and pleural cancer in the general population was documented using data from the *Fichier des tumeurs du Québec* (FiTQ) for the period from January 1982 to December 2002.

Pleural cancer mortality was described using the *Fichier des décès* for the period from 1981 to 2003.

National and international comparisons were made for mesotheliomas of the pleura, peritoneum and pericardium taken together using the electronic databases of the IARC and the International Association of Cancer Registries because these databases present only the aggregated results for these three cancers (Lebel & Gingras, 2007).

5.1.2 Incidence between 1982 and 2002

5.1.2.1 Number, men/women ratio

In Québec as a whole, 1,832 new cases of pleural cancer of which 1,530 are pleural mesotheliomas, as well as 170 new cases of peritoneal mesothelioma were recorded in the FiTQ between 1982 and 2002. The pleural mesothelioma cases represent 86% of the pleural cancers among men and 74% of the pleural cancers among women. From 1992 on, these proportions are even higher, probably due to the improvements made to the FiTQ beginning in that year and to the improved diagnostic techniques for pleural mesothelioma (Lebel & Gingras, 2007).

The ratios of the number of new cases among men compared to the number of new cases among women were 3.25/1 for pleural cancer, 3.78/1 for pleural mesothelioma and 1.36/1 for peritoneal mesothelioma (Lebel & Gingras, 2007) (Table 7).

Table 7 Incidence of pleural cancer, pleural mesothelioma and peritoneal mesothelioma (1982-2002) and hospitalizations with first mention of asbestosis (1992-2004) in Québec

	Pleural cancer 1982-2002	Pleural mesothelioma 1982-2002	Peritoneal mesothelioma 1982-2002	Asbestosis 1992-2004
Number M[1]/W[1]	1,401/431	1,210/320	98/72	1,993/79
Ratio M/W	3.25/1	3.78/1	1.36/1	25.2/1
Average annual age-adjusted rate/ 100,000 person-years	M: 2.31 W: 0.55	M: 1.98 W: 0.41	M: 0.15 W: 0.09	M: 4.80 W: 0.14
S.s.[1] annual trend by gender	M: increase	M: increase	No trend	No trend
S.s average annual growth rate by gender	M: +2.0%	M: +3.6%	-	-
Regions with a statistically significant excess at the level of 1% and rate/100,000 person-years	Chaudière-Appalaches: M: 3.85 W: 0.97 Montérégie: M: 2.86 Lanaudière: M: 3.32	Chaudière-Appalaches: M: 3.38 W: 0.83 Montérégie: M: 2.53 Lanaudière: M: 2.77	No significant excess	Chaudière-Appalaches: M: 16.48 W: 0.38 Estrie: M: 11.10 Lanaudière: M: 6.22

[1] M = men; W = women; s.s. = statistically significant at the level of 5%.
Source: Lebel and Gingras, 2007.

5.1.2.2 Rates

In general, the age-adjusted incidence rates from 1982 to 2002 were higher among men than among women. In fact, among men, the incidence rates for pleural cancer, pleural mesothelioma and peritoneal mesothelioma were respectively 2.31, 1.98 and 0.15/100,000 person-years for this period, while they were 0.55, 0.41 and 0.09/100,000 person-years among women (Table 7). The most plausible explanation for this preponderance of cases among men is their prior occupational exposure to asbestos (Lebel & Gingras, 2007).

Analysis of the specific incidence rates by five-year age group reveals that pleural cancer and pleural mesothelioma as well as peritoneal mesothelioma are more frequent among persons age 50 and over (Figures 5 and 6).

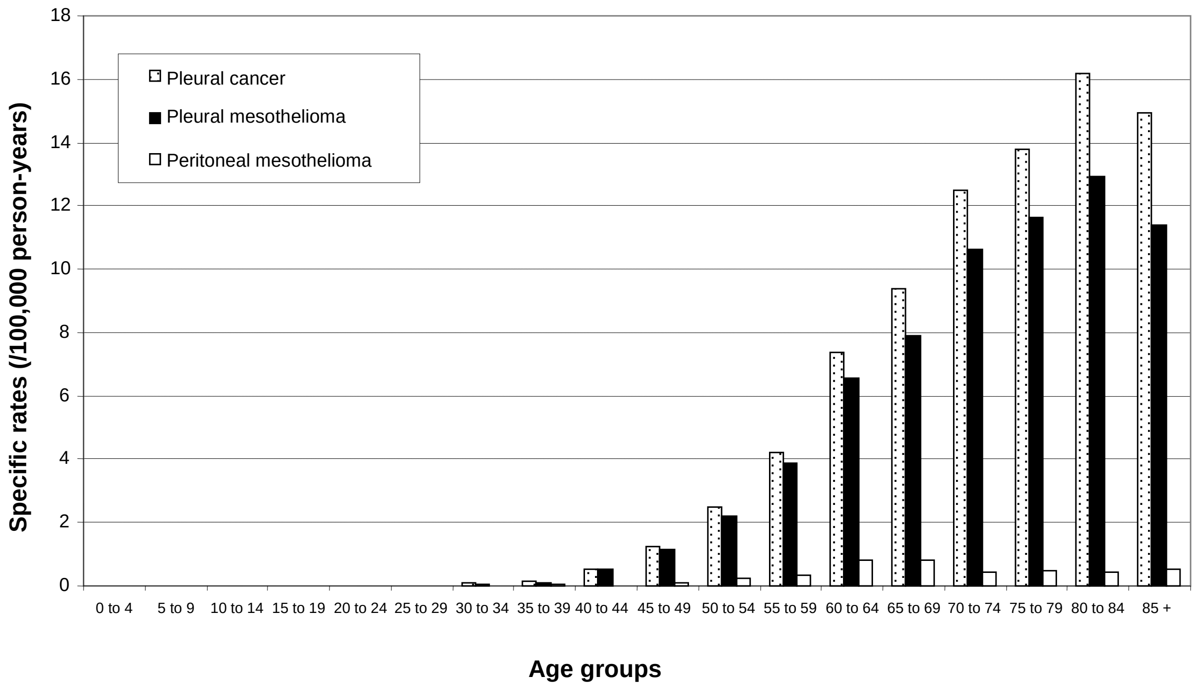

Figure 5 Specific incidence rates by five-year age group (/100,000 person-years) of pleural cancer, pleural mesothelioma and peritoneal mesothelioma among men, Québec, 1982-2002

Source: Lebel and Gingras, 2007.

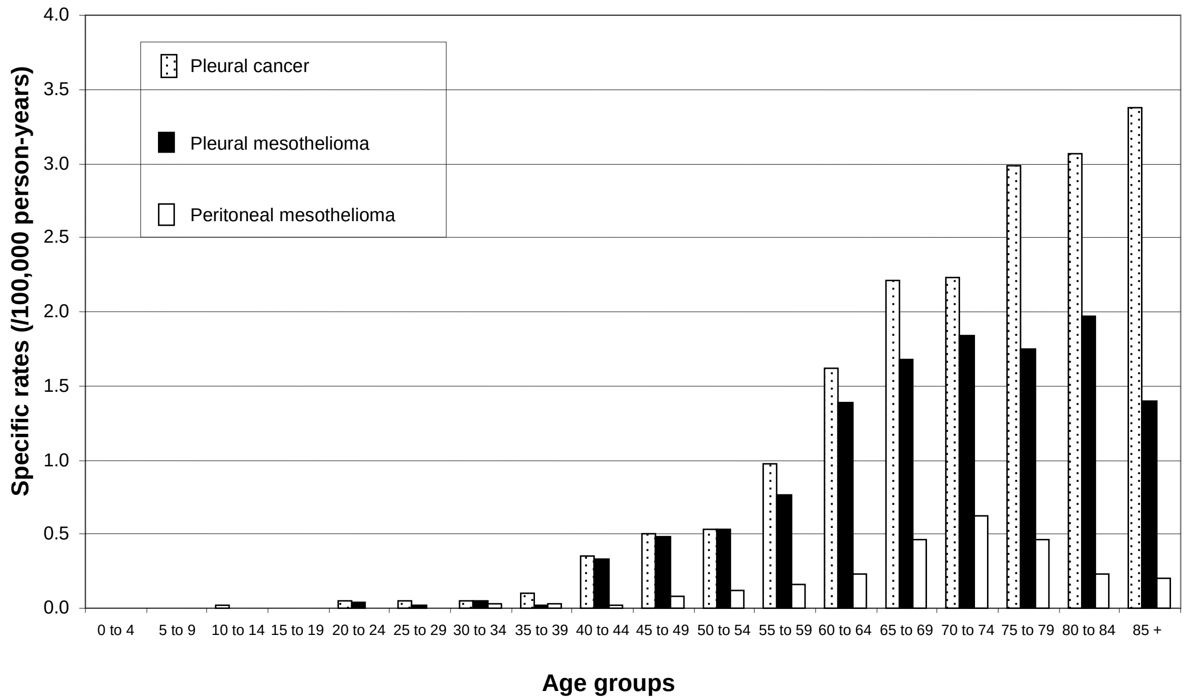

Figure 6 **Specific incidence rates by five-year age group (/100,000 person-years) of pleural cancer, pleural mesothelioma and peritoneal mesothelioma among women, Québec, 1982-2002**

Source: Lebel and Gingras, 2007.

5.1.2.3 Annual trends

Among men, age-adjusted annual incidence rates for pleural cancer and pleural mesothelioma showed a statistically significant increase between 1982 and 2002, while incidence rates for peritoneal mesothelioma remained stable for the same period. Average annual growth rates were 2.0% for pleural cancer and 3.6% for pleural mesothelioma (Lebel & Gingras, 2007), which represents levels below those that were calculated for the period from 1982 to 1996 (3.3% and 5.5% respectively). This decrease in annual growth rates perhaps announces that we have reached the peak of annual incidence rates for pleural mesothelioma forecast for 2010 (De Guire et al., 2003a). Among women, annual incidence rates for each of the diseases showed no significant time trend (Lebel & Gingras, 2007) (Table 7, Figure 7).

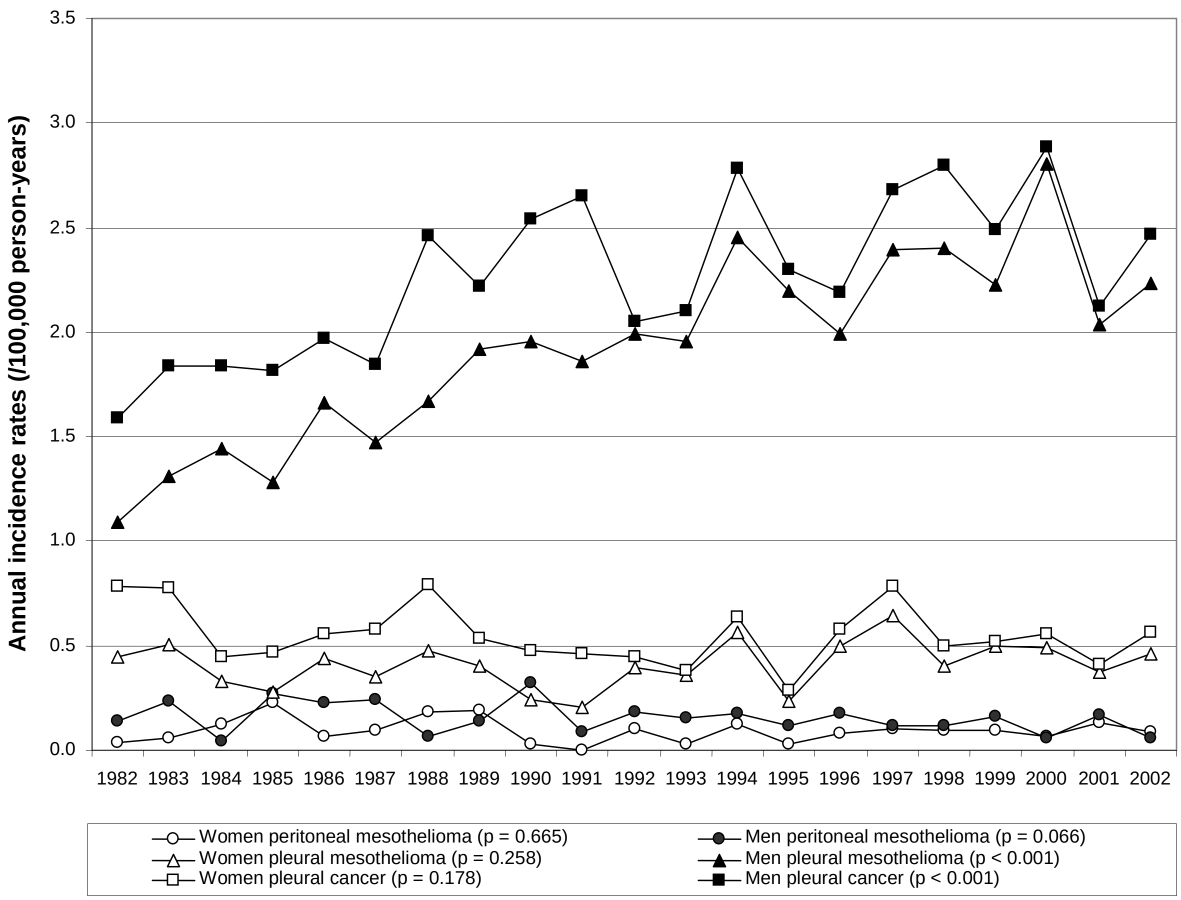

Figure 7 Annual incidence rates (age-standardized/100,000 person-years) of pleural cancer, pleural mesothelioma and peritoneal mesothelioma, Québec, 1982-2002

Source: Lebel and Gingras, 2007.

5.1.2.4 Geographic distributions

Comparing with the rest of the province, we observe that the incidence of pleural cancer and pleural mesothelioma is significantly higher among men and women in the Chaudière-Appalaches region. Among men, these results could be explained by an occupational exposure to asbestos in this region's mines or at the shipyards in Lévis-Lauzon. Among women, these excesses could result from occupational or para-occupational exposures to asbestos. The excesses observed both among men and among women could also be explained by a greater degree of clinical suspicion on the part of health professionals in this region and by the medical surveillance programs set up in the mining industry in the 1980s (Lebel & Gingras, 2007).

As well, significant excess incidence rates for pleural cancer and pleural mesothelioma in the Montérégie and Lanaudière regions were observed among men only. For the previous study period (1981 to 1996), the Lanaudière region showed no excess in relation to provincial incidence rates. Men suffering from pleural cancer and pleural mesothelioma in this region could have been exposed to asbestos at the naval shipyards in Montréal, which are now closed, and in the refineries in Montréal East. The excesses observed in the Montérégie, could be explained by an occupational exposure to asbestos at the naval shipyards in Sorel (Lebel & Gingras, 2007).

We also observe significantly lower incidence rates for pleural mesothelioma and pleural cancer among men in the Bas-Saint-Laurent and Outaouais regions. For the Outaouais, this situation can be explained by the fact that the FiTQ data underestimate the actual regional situation, since part of this region's population obtains its health care in Ontario (Lebel & Gingras, 2007).

Finally, no health and social service region shows a significant excess or deficit in peritoneal mesothelioma incidence either among men, or among women (Lebel & Gingras, 2007) (Table 7).

5.1.2.5 National and international comparisons

For the period from 1993 to 1997, Québec was the province with the highest mesothelioma incidence rates among men and among women in Canada (Lebel & Gingras, 2007) (Table 8). The same was true for 1988 to 1992 study period (De Guire et al., 2003a). This situation is likely attributable to a greater exposure to asbestos in the Québec population through mining, industrial and construction activities (Lebel & Gingras, 2007).

The provinces that presented a standardized incidence ratio (SIR) significantly lower than that in Québec, in any study period, were Alberta, Ontario, New Brunswick, Saskatchewan and Newfoundland among men and Ontario, British Columbia and New Brunswick among women. Furthermore, for the period from 1993 to 1997 only, the SIR among men and women in Nova Scotia and among women in Saskatchewan and Newfoundland were significantly lower than the SIR in Québec (Lebel & Gingras, 2007).

At the international level, the comparisons made among men for the period from 1993 to 1997 reveal that the mesothelioma SIR for New Zealand, the Netherlands and for several regions in the United Kingdom and Australia were significantly higher than those in Québec. The higher SIR observed in Australia could be explained by that country's mining of crocidolite, which carries a higher pleural mesothelioma risk than does chrysotile. The mesothelioma SIR among men in Denmark was not significantly different from that measured in Québec. Finally, the SIR among men in Norway, Sweden, Finland, the United States, all of Canada, Slovenia, Israel, the Czech Republic, Slovakia and Estonia were significantly lower than that of men in Québec (Lebel & Gingras, 2007) (Table 9). For the period from 1988 to 1992, the data produced the same portrait (De Guire et al., 2003a).

Among women, we observe that for the period from 1993 to 1997, Western Australia and Scotland showed significant mesothelioma excesses compared to Québec. Among women in Canada, the United States, Australia (Queensland), New Zealand, the Scandinavian countries, the Netherlands, Northern Ireland, England, Israel and several countries in Eastern Europe, the mesothelioma SIR were significantly lower than that of Québec (Lebel & Gingras, 2007) (Table 10). For the period from 1988 to 1992, the portrait was slightly different because no country presented a SIR statistically higher than that of Québec (De Guire et al., 2003a).

These comparisons must be interpreted with caution, due to the inherent limitations of using IARC databases. Indeed, cancer registries do not exist in every country, the data utilized sometimes provide a fragmentary image of a country and there are differences in diagnostic methods that could bias the results (Lebel & Gingras, 2007).

Table 8 Standardized rates and standardized incidence ratios (SIR) of mesotheliomas (pleura, peritoneum and pericardium), by province and territory (Canada 1993-1997) compared to Québec

Province/Territory	Number of cases observed	Number of cases expected	SR[1]	SIR	95% CI[2] of SIR
Women					
Québec	115	115.0	0.4	100	
Manitoba	13	18.1	0.3	72	(38-123)
Alberta	23	34.7	0.2	66	(42-100)
Ontario	83	169.8	0.2	49	(39-61)
Prince Edward Island	1	2.1	0.1	47	(1-264)
Saskatchewan	7	16.3	0.1	43	(17-88)
British Columbia	23	58.9	0.2	39	(25-59)
New Brunswick	4	11.7	0.1	34	(9-88)
Nova Scotia	4	14.9	0.1	27	(7-69)
Newfoundland	1	7.7	0.0	13	(0-72)
Northwest Territories[3]	0	0.9	--	--	--
Men					
Québec	378	378.0	1.6	100	
British Columbia	189	213.2	1.4	89	(76-102)
Manitoba	50	63.5	1.2	79	(58-104)
Alberta	93	125.1	1.3	74	(60-91)
Prince Edward Island	5	7.5	1.2	67	(22-156)
Ontario	387	587.4	1.1	66	(59-73)
Nova Scotia	30	51.3	0.9	59	(39-84)
New Brunswick	21	40.8	0.8	52	(32-79)
Saskatchewan	29	61.1	0.9	47	(32-68)
Northwest Territories[3]	1	3.8	0.3	26	(1-147)
Newfoundland	7	28.2	0.4	25	(10-51)

1 Age-standardized rate (per 100,000 person-years) on the standard world population.
2 95% CI = 95% confidence interval.
3 Data for the period from 1983 to 1997.
Source: Lebel and Gingras, 2007.

Table 9 Standardized rates and standardized incidence ratios (SIR) of mesotheliomas (pleura, peritoneum and pericardium), among men by country (1993-1997) compared to Québec

Country	Number of cases observed	Number of cases expected	SR[1]	SIR	95% CI[2] of SIR
Western Australia	274	85.1	2.6	322	(285-363)
United Kingdom, Scotland	652	315.7	3.4	207	(191-223)
Australia, New South Wales	645	341.1	3.0	189	(175-204)
Netherlands	1,451	877.8	2.8	165	(157-174)
United Kingdom, England[3]	5,041	3,154.5	2.7	160	(155-164)
South Australia	139	87.4	2.6	159	(134-188)
Australia, Victoria	378	246.7	2.5	153	(138-169)
Australia, Queensland	258	174.6	2.7	148	(130-167)
United Kingdom, Northern Ireland	112	87.6	2.1	128	(105-154)
New Zealand	217	187.8	1.9	116	(101-132)
Canada, Québec	**378**	**378.0**	**1.6**	**100**	**-**
Denmark	322	336.9	1.6	96	(85-107)
Norway	220	278.6	1.3	79	(69-90)
Sweden	497	630.5	1.3	79	(72-86)
United States, SEER	998	1,262.4	1.2	79	(74-84)
Canada[4]	1,190	1,558.7	1.3	76	(72-81)
Finland	196	293.3	1.1	67	(58-77)
Slovenia	47	105.4	0.8	45	(33-59)
Israel[5]	71	227.2	0.6	31	(24-39)
Czech Republic	150	563.4	0.5	27	(23-31)
Slovakia	64	250.1	0.4	26	(20-33)
Estonia	13	72.8	0.3	18	(10-31)

1 Age-standardized rate (par 100,000 person-years) on the standard world population.

2 95% CI = 95% confidence interval.

3 Includes the regional registries of: South and Western, South Thames, Oxford, East Anglia, Trent, West Midlands, Mersey, North Western, Yorkshire.

4 Includes Québec.

5 Disparities in the number of cases observed were remarked between the published tables and the results obtained from the electronic database.

Source: Lebel and Gingras, 2007.

Table 10 Standardized rates and standardized incidence ratios (SIR) of mesotheliomas (pleura, peritoneum and pericardium), among women by country (1993-1997) compared to Québec

Country	Number of cases observed	Number of cases expected	SR[1]	SIR	95% CI[2] of SIR
Western Australia	36	23.2	0.6	155	(109-215)
United Kingdom, Scotland	120	96.3	0.5	125	(103-149)
Australia, Victoria	83	69.1	0.5	120	(96-149)
South Australia	25	24.3	0.5	103	(67-152)
Canada, Québec	**115**	**115.0**	**0.4**	**100**	**-**
Australia, New South Wales	95	94.6	0.4	100	(81-123)
United Kingdom, England[3]	846	934.2	0.4	91	(85-97)
Netherlands	222	261.1	0.3	85	(74-97)
Denmark	71	96.4	0.3	74	(58-93)
Sweden	127	173.2	0.3	73	(61-87)
United States, SEER	272	379.9	0.3	72	(63-81)
Australia, Queensland	33	47.0	0.3	70	(48-99)
Finland	62	97.0	0.2	64	(49-82)
Canada[4]	274	449.7	0.2	61	(54-69)
Czech Republic	112	189.3	0.3	59	(49-71)
Norway	45	79.2	0.2	57	(41-76)
New Zealand	29	52.7	0.2	55	(37-79)
Slovakia	45	83.6	0.2	54	(39-72)
Estonia[5]	14	29.4	0.2	48	(26-80)
Israel[5]	30	67.4	0.2	45	(30-64)
United Kingdom, Northern Ireland	12	26.6	0.2	45	(23-79)
Slovenia[5]	16	37.1	0.2	43	(25-70)

1 Age-standardized rate (par 100,000 person-years) on the standard world population.
2 IC 95% = 95% confidence interval.
3 Includes the regional registries of: South and Western, South Thames, Oxford, East Anglia, Trent, West Midlands, Mersey, North Western, Yorkshire.
4 Includes Québec.
5 Disparities in the number of cases observed were remarked between the published tables and the results obtained from the electronic database.

Source: Lebel and Gingras, 2007.

5.1.3 Pleural cancer mortality between 1981 and 2003

5.1.3.1 Number, ratio men/women

Between 1981 and 2003, 1,059 pleural cancer deaths were recorded in the *Fichier des décès* (Table 11).

The ratio of the number of deaths among men compared to the number of deaths among women was 2.65/1 for pleural cancer and the deaths affected mainly men and women age 50 and over (Lebel & Gingras, 2007). This ratio is similar to the ratio of 2.60/1 calculated for the period from 1981 to 1996 (De Guire et al., 2003a).

Table 11 Pleural cancer and asbestosis mortality for the period from 1981 to 2003 in Québec

	MORTALITY	
	Pleural cancer 1981-2003	**Asbestosis 1981-2003**
Number M[1]/W[1]	769/290	191/4
Ratio M/W	2.65/1	47.75/1
Average annual age-adjusted rate/100,000 person-years	M: 1.16 W: 0.34	M: 0.30
S.s.[1] annual trend by gender	No trend	No trend
Region with a statistically significant excess at the level of 1% and rate/100,000 person-years	Chaudière-Appalaches: M: 2.25 W: 0.78 Montérégie: M: 1.47 Lanaudière: M: 1.71	Chaudière-Appalaches: M: 1.56 Estrie: M: 1.12

[1] M = men; W = women; s.s. = statistically significant at the level of 5%.

Source: Lebel and Gingras, 2007.

5.1.3.2 Rates

During the period of the study, the provincial mortality rate for pleural cancer was 1.16/100,000 person-years among men and 0.34/100,000 person-years among women (Lebel & Gingras, 2007) (Table 11).

5.1.3.3 Annual trends

For the period from 1981 to 2003, there was no significant trend in the pleural cancer mortality rate (standardized for age), either among men, or among women (Lebel & Gingras, 2007) (Table 11 and Figure 8). However, a statistically significant upward trend was observed among men for the previous period from 1981 to 1996 (De Guire et al., 2003a). As with the incidence data for pleural mesothelioma and pleural cancer, the analysis of mortality from 1981 to 2003 shows higher rates among men and among the older population (Lebel & Gingras, 2007).

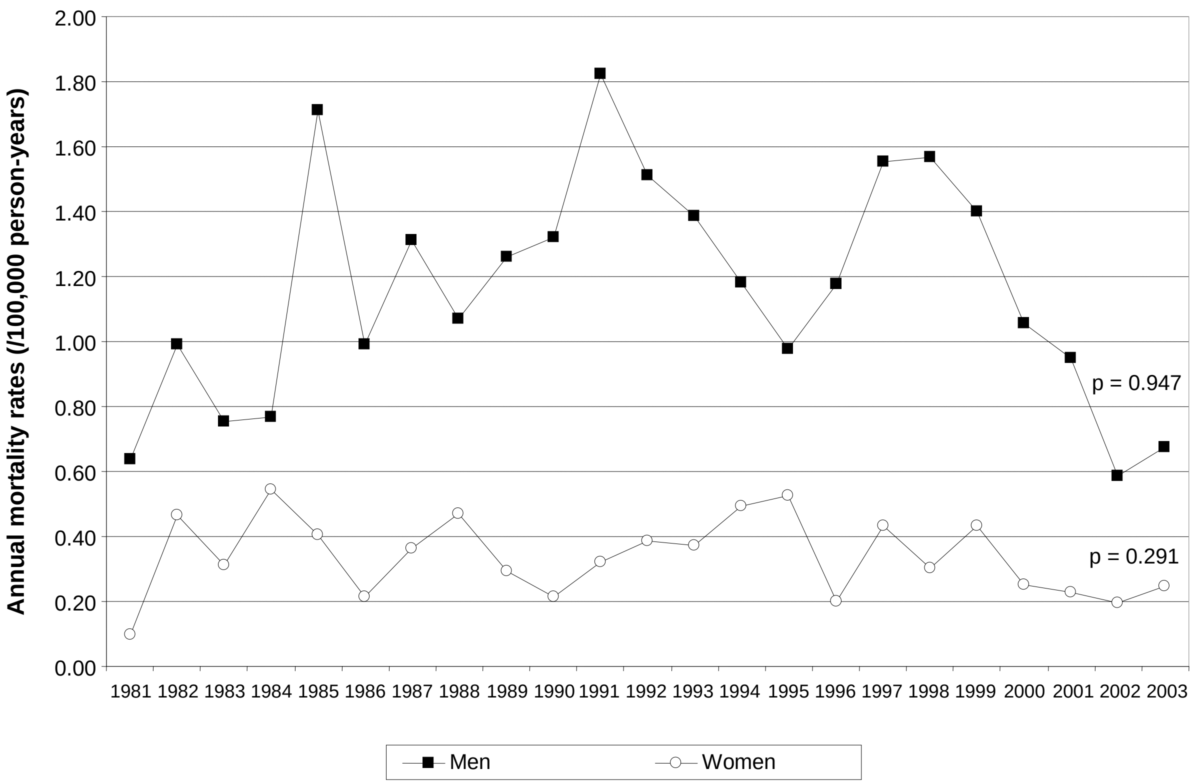

Figure 8 **Annual mortality rates (age-standardized/100,000 person-years) for pleural cancer, Québec, 1981-2003**

Source: Lebel and Gingras, 2007.

5.1.3.4 Geographic distributions

For pleural cancer, the Chaudière-Appalaches region shows significant excesses of adjusted mortality rates both among men and among women. Mortality rates are also higher from a statistical point of view among men in the Lanaudière and Montérégie regions (Table 11). This distribution of pleural cancer mortality rates coincides with that of incidence rates for pleural mesothelioma and pleural cancer (Lebel & Gingras, 2007).

5.2 ASBESTOSIS

5.2.1 Data sources

Asbestosis incidence in Québec was estimated for the years 1992 to 2004 using data on the cases hospitalized with first mention of asbestosis in Québec's *Maintenance et exploitation des données pour l'étude de la clientèle hospitalière* (MED-ÉCHO) system. In this system, an asbestosis diagnosis can be present in the medical file, even if it is just a medical antecedent. As well, it is possible that the date of the initial asbestosis diagnosis is prior to 1992, the date the study began. These two situations could therefore result in an overestimation of incidence for the study period. To assess asbestosis mortality, the *Fichier des décès* was used for the period from 1981 to 2003 (Lebel & Gingras, 2007).

5.2.2 Incidence of hospitalizations with first mention of asbestosis between 1992 and 2004

5.2.2.1 Number, ratio men/women

For the period from 1992 to 2004, 2,072 new hospitalizations were recorded in the MED-ÉCHO system with first mention of asbestosis as the primary or the secondary diagnosis. The ratio of the number of new cases among men (n = 1,993) compared to the number of new cases among women (n = 79) was 25.2/1 and hospitalizations were more frequent among people age 50 and over (Lebel & Gingras, 2007) (Table 7). These results are essentially the same for the previous study period from 1987 to 1996 (De Guire et al., 2003a).

5.2.2.2 Annual rates and trends

Average annual hospitalization rates for the period from 1992 to 2004 were 4.80/100,000 person-years among men and 0.14/100,000 person-years among women. Analysis of the annual hospitalization rates indicates no significant linear time trend either among men, or among women (Lebel & Gingras, 2007) (Table 7), contrary to what was observed between 1987 and 1996, which was a significant decrease of rates among men (De Guire et al., 2003a).

5.2.2.3 Geographic distributions

For the study period from 1992 to 2004, men showed excess hospitalization with first mention of asbestosis in the Chaudière-Appalaches, Estrie and Lanaudière regions. Among women, excess was observed only in the Chaudière-Appalaches region (Lebel & Gingras, 2007) (Table 7). This distribution of cases by geographic region was slightly different for the study period from 1987 to 1996. At that time, men showed significant excess hospitalizations only in the Chaudière-Appalaches and Estrie regions while among women, no region differed significantly from the provincial rate (De Guire et al., 2003a). Since the development of asbestosis requires heavy cumulative asbestos exposure and this is usually encountered only in the context of occupational exposure, the excess of cases observed among women in the Chaudière-Appalaches region is presumably due to this kind of exposure. Also presumably, it is related to an elevated paraprofessional or environmental exposure (Lebel & Gingras, 2007). But this result is based on a small number of cases (n = 12), which means that it must be interpreted with caution.

5.2.3 Asbestosis mortality between 1981 and 2003

5.2.3.1 Number, ratio men/women

From 1981 to 2003, 195 asbestosis deaths were recorded in the *Fichier des décès*. The ratio of the number of deaths among men compared to the number of deaths among women was 47.75/1 and the deaths affected mainly people age 50 and over (Lebel & Gingras, 2007) (Table 11).

5.2.3.2 Annual rates and trends

The annual average death rate for asbestosis for all of Québec was 0.30/100,000 person-years among men, and no statistically significant annual variation in annual rates was observed (Lebel & Gingras, 2007) (Table 11). These results are compatible with those observed for the previous study period from 1981 to 1996 (De Guire et al., 2003a).

5.2.3.3 Geographic distributions

Significant excess asbestosis deaths were observed among men in the Chaudière-Appalaches and Estrie regions (Table 11). This distribution of excess mortality from asbestosis matches that of the hospitalization rates with first mention of asbestosis, except for the Lanaudière and Chaudière-Appalaches regions where significant excesses had been observed respectively among men and among women (Lebel & Gingras, 2007) (Table 7).

6 ESTIMATION OF HEALTH RISKS FROM ENVIRONMENTAL EXPOSURE TO ASBESTOS IN QUÉBEC

6.1 APPROACHES USED TO ASSESS RISK

In a study published in 2009 by the INSPQ, researchers carried out a mesothelioma and lung cancer risk assessment among residents in the city of Thetford Mines using two different approaches. The first approach comes from the methodology proposed in the MSSS *Lignes directrices pour la réalisation des évaluations du risque toxicologique pour la santé humaine* (guidelines to conduct assessments of toxicological risk for human health). This approach is based on the hypothesis that the risk is the same for exposure to amphiboles or to chrysotile. The second approach is based on the recent model by Berman and Crump, according to which the risk associated with amphiboles differs from that associated with chrysotile. In both methods, the risk assessment estimates a lifetime excess mortality from lung cancer and from pleural and peritoneal mesothelioma following a continuous lifetime exposure to asbestos (more simply called lifetime risk in rest of the document) (Bourgault & Belleville, 2009).

Both procedures estimate lifetime risk (R) as the product of the average lifetime exposure dose (D_{avg}) times a lifetime unit risk specific to asbestos (UR). Thus, both use the following equation: $R = D_{avg} \times UR$ (Bourgault & Belleville, 2009).

The average lifetime exposure dose is estimated by weighting the average exposure dose of each age group relative to its duration. For each age group, the average exposure dose is the sum of the average exposure dose by inhalation of indoor air plus the average exposure dose by inhalation of outdoor air. It is therefore based on asbestos concentrations in indoor and outdoor air and on the proportion of time spent indoors and outdoors, which is 0.94 and 0.06 respectively for the age group over 19, and 0.88 and 0.12 for the age group 19 years and under (Bourgault & Belleville, 2009).

In this risk assessment, the age-specific average exposure doses were obtained from concentrations measured in indoor and outdoor air in the city of Thetford Mines as part of the AVAQ and MDDEP studies published in 2007. The asbestos fibre concentrations present in the outdoor environment, estimated from the results of the MDDEP sampling, ranged from 0.00038 to 0.028 f/ml. The average was 0.0029 f/ml with an upper limit of the 95% confidence interval (95% CI) of 0.0035. This latter value of 0.0035 f/ml was retained as outdoor air exposure datum in the calculation of average exposure doses by age group. It is important to note that the sampling in Thetford Mines was conducted while mining activities were in a period of slowdown, which may have contributed to an underestimation of exposure levels. For indoor air, the value of 0.0031 f/ml was retained in the calculation of age group average exposure doses. It corresponds to the upper limit of the 95% CI of the average of 0.0020 f/ml calculated using the results of sampling done by the AVAQ (as presented in Section 3.3.1). The average lifetime exposure dose obtained is 0.0031 f/ml, of which 91.7% is attributable to indoor air inhalation and 8.3% to outdoor air inhalation (Bourgault & Belleville, 2009).

The unit risk represents the excess risk attributable to continuous lifetime exposure to one asbestos fibre/ml. It is determined using dose-response relationships observed in several epidemiological studies conducted among workers, and it differs by type of cancer. For lung cancer, this unit risk is the result of the difference between the lifetime lung cancer mortality risk in the exposed population and the lifetime lung cancer mortality risk expected in a non-exposed control population. The unit risk specific to mesothelioma is obtained using an absolute risk model and is not contingent on mesothelioma incidence in a control population (Bourgault & Belleville, 2009).

6.2 DETERMINATION OF LIFETIME EXCESS RISK

6.2.1 Using the methodology proposed in the MSSS guidelines

For the risk assessment that used the methodological approach proposed in the MSSS guidelines, three unit risks presented by various health organizations were selected. These unit risks derive from Nicholson's works published in 1986 which are highly reputed in the scientific community, and from the works of organizations that use Nicholson's procedure, namely the US EPA and the Health Effects Institute-Asbestos Research (HEI-AR). These average unit risks are combined for the two cancers and for men, women, smokers and non-smokers (Bourgault & Belleville, 2009).

Depending on the average unit risk utilized, lifetime excess mortality from lung cancer and mesothelioma was 72, 110 and 125 per 100,000 persons in the city of Thetford Mines who were continuously exposed to asbestos during their lifetime (Bourgault & Belleville, 2009) (Table 12).

Table 12 Estimated lifetime mortality risk based on unit risks per 100,000 persons in the city of Thetford Mines with a continuous lifetime exposure to asbestos fibres

	Nicholson	US EPA	HEI-AR
Lifetime unit risk UR $(f/ml)^{-1}$	0.35	0.23	0.40
Average lifetime exposure dose D_{avg} (f/ml)	0.0031	0.0031	0.0031
Lifetime mortality risk R	110	72	125

Source: Bourgault and Belleville, 2009.

6.2.2 Using the Berman and Crump model

The approach proposed by Berman and Crump integrates the dose-response relationships defined by Nicholson's works as well as more recent epidemiological data collected among different groups of workers. In addition, in determining the lung cancer unit risk, the authors recommend using the mortality rate of the reference population for the following sub-groups: male smokers, male non-smokers, female smokers and female non-smokers. Next, they suggest combining the estimated risks for these sub-groups and applying them to the general population. However, such data for the Québec population was not available at the time of the analysis. Consequently the average lung cancer mortality rates among men and among women in the Chaudière-Appalaches health and social service region were retained (Bourgault & Belleville, 2009).

The estimated lifetime mortality risk for lung cancer and mesothelioma using the Berman and Crump model was 11.5 per 100,000 men and 4.88 per 100,000 women in the city of Thetford Mines with a continuous lifetime exposure to chrysotile fibres. The excess risk for both sexes combined amounted to 8.2 per 100,000 persons exposed, which represents an approximate value from 9 to 15 times lower than that obtained using the first approach (Bourgault & Belleville, 2009).

6.2.3 Comparison with the estimated risk in other settings

In order to have a point of comparison with the observations in Thetford Mines, mesothelioma and lung cancer risks were re-estimated, but this time based on asbestos fibre concentrations generally found in the indoor and outdoor air of environments where asbestos exposure sources are limited (in other words, the background concentrations). Since background concentration data were scarce, the asbestos fibre concentrations observed inside and outside buildings containing ACM were utilized (Bourgault & Belleville, 2009).

The average outdoor air concentration of 0.00002 PCMe fibre/ml calculated for samples taken across the United States (final column, Table 1) and the average indoor air concentration of 0.00019 f/ml reported by the HEI-AR were used to calculate an average lifetime exposure dose equal to 0.00018 f/ml. The latter dose was 17 times lower than the dose calculated for the city of Thetford Mines, as were the risks obtained. In fact, the risks range from 0.46 to 7.1 per 100,000 persons using the Berman and Crump approach and the MSSS guidelines respectively. Although approximative, this estimation gives a general idea of the gap that exists between the risks calculated for the Thetford Mines population in comparison with those incurred in a population where asbestos exposure sources are limited (Bourgault & Belleville, 2009).

6.2.4 Cautious interpretation of the results

This cancer risk assessment must be interpreted with caution due to the uncertainties it contains. These uncertainties are related on one hand to the determination of unit risks and on the other hand to the determination of the average lifetime exposure dose (Bourgault & Belleville, 2009).

First, the determination of unit risks is based on epidemiological studies conducted in the workplace. These studies differ in the methods used to sample and analyze asbestos exposure. They also present limitations related to the difficulty of characterizing past exposure and to an inadequate description of confounding variables such as tobacco use. The reference population selected to determine the unit risk may have different smoking habits than those of the exposed population. Finally, the risk of developing a lung cancer or a mesothelioma as a result of exposure to low doses may be less than the estimated risk. In fact, the use of linear models to extrapolate the results obtained from worker cohorts exposed to high doses may have overestimated the dose-response relationships used to determine the unit risks. Moreover, the model proposed by Berman and Crump takes into account exposure to chrysotile asbestos only. Yet the AVAQ and MDDEP studies identified the presence of amphibole fibres in indoor and outdoor air in the city of Thetford Mines. All these uncertainties can result in an overestimation or underestimation of the risks calculated that is difficult to quantify (Bourgault & Belleville, 2009).

Second, the average exposure dose through indoor air inhalation is based on measurements that did not always comply with the required sampling conditions. As well, the residences where air samples were collected were not selected randomly so as to represent all Thetford Mines residences. Furthermore, the measurements utilized to determine the average exposure dose through outdoor air inhalation were obtained on building roofs, which does not optimally reflect an individual’s real exposure. Moreover, these measurements represented estimated values, not measured values (Bourgault & Belleville, 2009).

Despite the methodological limitations referred to above, the results of the risk assessment in Thetford Mines (Sections 6.2.1 and 6.2.2), the comparative risk analysis (Section 6.2.3) and the comparisons of exposure levels (Sections 3.2.3 and 3.3.2) suggest a health risk attributable to the presence of airborne asbestos in that city (Bourgault & Belleville, 2009).

7 ASBESTOS HEALTH EFFECTS ON QUÉBEC WORKERS

7.1 NEW CASES OF OCCUPATIONAL LUNG DISEASES: 1988-2003

7.1.1 Study population

In Québec, workers who file a claim with the CSST alleging they are suffering from an occupational lung disease are referred to a committee of physicians whose duties include determining if the worker is actually suffering from such a disease. The report emanating from this committee is then sent to a second committee, the Comité spécial des maladies professionnelles pulmonaires (CSMPP), also called the Comité spécial des présidents (CSP). The CSMPP confirms or quashes the diagnosis and the other findings of the first committee. The files of workers who submit these claims are kept at the CSST Direction des services médicaux (medical services department). They include information on the disease from which the worker is suffering and on the asbestos exposure. In 2009, the INSPQ published a study on all new cases of asbestos-related diseases recognized as occupational lung diseases by the CSMPP between 1988 and 2003 inclusively (De Guire & Provencher, 2009). Following publication of that study, a follow-up analysis of the data was conducted. It is available for consultation in Appendix B.

7.1.2 General description

All new cases of asbestos-related diseases recognized as occupational lung diseases by the CSMPP between 1988 and 2003 were studied. During those years, 1,348 workers had 1,512 diseases, since a worker may have more than one asbestos-related disease. Of these workers, 57.3% (n = 772) presented with asbestosis, 27.9% (n = 376) with mesothelioma and 27.0% (n = 364) with lung cancer (De Guire & Provencher, 2009).

The number of diseases recognized annually doubled during this period, increasing from 71 to 143 cases per year. This increase was chiefly observed for asbestosis. Mesothelioma numbers increased slightly over the years and lung cancer numbers remained relatively stable (De Guire & Provencher, 2009) (Figure 9).

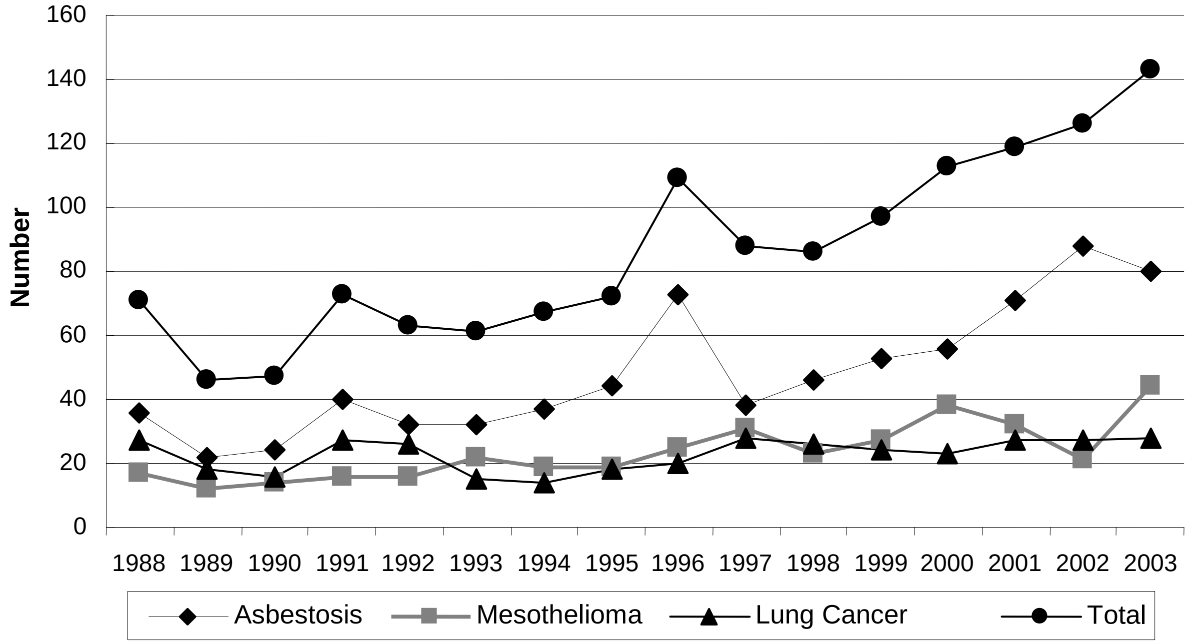

Figure 9 Asbestos-related diseases by year of decision by the Comité spécial des maladies professionnelles pulmonaires, 1988-2003

Source: De Guire and Provencher, 2009.

7.1.3 Distribution of workers by sectors/occupations

7.1.3.1 Distribution and evolution over time

Workers suffering from asbestos-related occupational lung diseases were divided by occupational exposure category, using the following groups of activity sectors and occupations, here called sector/occupation:

- Ore extraction or work in asbestos mines
- Asbestos processing
- Construction
- Maintenance or repair of asbestos-containing products or structures (maintenance and repair category)
- Ambient exposure from the work of colleagues or other sources (Other category)

The results show that 29.1% of workers were exposed in the mines, 28.4% in maintenance and repair work, 21.0% in construction, 11.3% in asbestos processing plants and finally 10.2% in other circumstances or workplaces. The number of workers from the combined construction and maintenance and repair sectors/occupations exceeds the number of miners exposed in mines (49.4% vs. 29.1%). More specifically, the workers suffering from asbestosis were mainly exposed in maintenance and repair work (28.7%), in mines (26.1%) and in the construction industry (24.9%). The workers suffering from mesothelioma came mainly from the maintenance and repair sector (40.2%) while those with an asbestos-related lung cancer came chiefly from the mines (56.5%) (De Guire & Provencher, 2009) (Table 13).

Table 13 Asbestos-related diseases by sector/occupation. Comité spécial des maladies professionnelles pulmonaires, 1988-2003

Sector/occupation	Asbestosis		Mesothelioma		Lung Cancer		Total of workers[1]	
	n	%	n	%	n	%	n	%
Mines	198	26.1	59	16.0	203	56.5	387	29.1
Processing	81	10.7	37	10.1	43	12.0	150	11.3
Construction	189	24.9	71	19.3	38	10.6	279	21.0
Maintenance and repair	218	28.7	148	40.2	52	14.5	377	28.4
Others	48	6.3	39	10.6	12	3.3	91	6.9
Mixed	26	3.4	14	3.8	11	3.1	44	3.3
Unknown	12	-	8	-	5	-	20	-
TOTAL	772	100.0	376	100.0	364	100.0	1348	100.0

[1] 1,348 workers had 1,512 diseases.
Source: De Guire and Provencher, 2009.

During the 16 years of the study, an increase in the number of workers with an asbestos-related disease was observed in the construction and the maintenance and repair industries and in the Others category, while the number of cases reported in the mining and processing industries remained relatively stable. The increase in cases from the construction industry could result from the asbestosis screening activities conducted among workers in this industry that began in Montréal in 1995, and that continued across the province in 1998 (De Guire & Provencher, 2009).

The increasing provenance of claims from construction and maintenance and repair workers compared to those from miners might be due to the fact that the pool of construction workers has been ten times higher than that of miners over the last 20 years. It might also be explained by the fact that exposure control is probably more difficult to achieve on construction sites than in mines. In addition, workers in the construction and maintenance and repair industries probably were informed more belatedly of the asbestos exposure in their workplace than were miners. As a result, they might not have had access to protective measures. Finally, the workers in the first two sectors might have been exposed to more amphiboles than were miners (De Guire & Provencher, 2009).

7.1.3.2 Exposure duration

Workers were exposed to asbestos on average 25.8 years for all sectors/occupations combined. However, when considered separately, miners had a longer average exposure duration (31.4 years) and workers in processing had a shorter duration (16.7 years). The possibility that asbestos exposure was less well controlled in the asbestos processing plants than in the mines could explain this observation. It is also possible that plant workers were exposed to more amphiboles than were miners (De Guire & Provencher, 2009).

7.1.3.3 Regional distribution of compensated workers

At the time of their claim, 55.0% of the workers resided in the following three regions: Montréal (20.3%), Chaudière-Appalaches (19.2%) and Montérégie (15.5%). More specifically, we note that a little more than 80% of workers in the mining sector/occupation resided in regions that had mining towns: Chaudière-Appalaches (50.8%) and Estrie (30.6%). Workers exposed in the combined construction and maintenance and repair industries resided mainly in Montréal (23.8%), Montérégie (22.4%), the Capitale-Nationale (11.6%) and Lanaudière (10.4%). These results demonstrate that the diseases related to asbestos exposure in the workplace do not involve just people who reside in the mining regions (De Guire & Provencher, 2009).

It is interesting to note that some of the regions in Québec that showed excess pleural mesothelioma and asbestosis in Section 5: Asbestos Health Effects on the General Population of Québec, also present high percentages of claims to the CSST for asbestos-related diseases.

7.1.4 Distribution of workers by occupation categories

Between 1988 and 2003, nearly half of the workers with an occupational lung disease related to asbestos exposure worked in skilled trades (49.1%), 17.2% were labourers from various sectors, 11.4% were operators and finally 5.2% were managers or other related workers. When the diseases are considered separately, the distribution of workers by occupation categories is similar to that of all the diseases combined (De Guire & Provencher, 2009).

If we examine in greater detail the 643 workers who engaged in skilled trades, we see that 53.2% of them worked in the following trades: pipe fitters-plumbers-welders (24.1%), insulators (19.1%) and electricians (10.0%). The insulators with an asbestos-related occupational lung disease were exposed for a shorter time to the contaminant than were workers in all the skilled trades taken together (21.3 vs. 26.6 years). This was particularly true for insulators with a mesothelioma for whom the exposure duration was 14.6 years as opposed to 24.6 years for all skilled trades combined. Their work probably involved a more frequent and more intense exposure to asbestos than that of the other workers (De Guire & Provencher, 2009).

7.2 ASBESTOS-RELATED DEATHS ACCEPTED BY THE CSST FROM 2005 TO 2008

Every year, the CSST analyses all deaths caused by work accidents or occupational diseases that were submitted to the CSST Board of Directors and for which the decision was made to compensate. For the years 2005 to 2008, asbestos is responsible for the majority of occupational disease deaths (respectively 89%, 87%, 77% and 83%) and for a little less than half of all deaths combined (respectively 47% (105/223), 39% (81/206), 46% (96/207) and 44% (85/195) (L'Épicier, 2010a) (Table 14).

Among the deaths caused by asbestos exposure, the majority are related to mesothelioma (57% or 208/367), followed by those related to asbestosis (22% or 82/367) and then by those related to lung cancer (21% or 76/367) (L'Épicier, 2010a) (Table 14).

The sectors chiefly affected by asbestos-related deaths for the years 2005 to 2008 are the building and public works sector and the mining, quarrying and oil well sectors (L'Épicier, 2010a) (Table 15). This preponderance of deaths among building and public works workers corresponds to the preponderance that was reported among the cases recognized as occupational lung diseases by the CSMPP (construction and maintenance and repair sectors combined) (De Guire & Provencher, 2009).

Workers' average age is essentially the same over the years, 71.5, 72.2, 71.7 and 71.4 years respectively for the years 2005 to 2008 (Table 16). Although 77.0% of deaths occur from age 65 on, 2.0% are reported among workers under age 55 (L'Épicier, 2010a).

Table 14 Deaths accepted by the CSST by cause of death and year

Cause of death	**Year of acceptance**									
	2005		2006		2007		2008		2005-2008	
	n	%	n	%	n	%	n	%	n	%
Work accidents	105	47	113	55	82	40	92	47	392	47
Occupational diseases	118	53	93	45	125	60	103	53	439	53
• *Asbestos diseases:*	*105*	*89*	*81*	*87*	*96*	*77*	*85*	*83*	*367*	*84*
Mesothelioma	*50*	-	*47*	-	*61*	-	*50*	-	*208*	-
Asbestosis	*33*	-	*19*	-	*13*	-	*17*	-	*82*	-
Lung cancer	*22*	-	*14*	-	*22*	-	*18*	-	*76*	-
Other types	*0*	-	*1*	-	*0*	-	*0*	-	*1*	-
• *Other diseases*	*13*	*11*	*12*	*13*	*29*	*23*	*18*	*17*	*72*	*16*
Total causes of death	223	100	206	100	207	100	195	100	831	100

The text in italics presents causes of death by occupational diseases. The percentages in italics are calculated on the total of occupational diseases.
Source: L'Épicier, 2010a.

Table 15 Deaths caused by asbestos by economic activity sector

Activity sector	**Year of acceptance**									
	2005		2006		2007		2008		2005-2008	
	n	%	n	%	n	%	n	%	n	%
Building and public works	28	27	18	22	35	37	23	27	104	28
Mines, quarries and oil wells	23	22	21	26	21	22	14	17	79	22
Transportation and storage	5	5	3	4	6	6	7	8	21	6
Other business and personal services	10	9	3	4	6	6	7	8	26	7
Other sectors	39	37	36	44	28	29	34	40	137	37
Total	**105**	**100**	**81**	**100**	**96**	**100**	**85**	**100**	**367**	**100**

Source: L'Épicier, 2010a.

Table 16 Deaths caused by asbestos by worker's age at time of death

Worker's age at time of death (years)	Year of acceptance									
	2005		2006		2007		2008		2005-2008	
	n	%	n	%	n	%	n	%	n	%
< 55	1	1	1	1	1	1	3	4	6	2
55 to 64	24	23	18	22	18	19	18	21	78	21
65 to 74	39	37	33	41	42	44	31	36	145	39
≥ 75	41	39	29	36	35	36	33	39	138	38
Total	**105**	**100**	**81**	**100**	**96**	**100**	**85**	**100**	**367**	**100**
Mean age	71.5		72.2		71.7		71.4		-	

Source: L'Épicier, 2010a.

7.3 EVALUATION OF THE EFFECTS OF THE ASBESTOSIS SCREENING PROGRAM AMONG CONSTRUCTION WORKERS IN THE MONTÉRÉGIE

Section 4.3.4 mentioned a program for the prevention of asbestos-related diseases among construction workers that was launched in 1998 in all regions of Québec. It consisted in inviting the workers from seven construction trades most at risk of developing asbestosis to have a chest X-ray (CSST, 1998). Between 2006 and 2009, screening activities were resumed across Québec. The seven trades targeted by the program were: 1) insulators, 2) pipe fitters-plumbers-welders, 3) fire-protection mechanics, 4) tinsmiths and sheet metal workers, 5) boilermakers and boiler attendants, 6) specialized demolition workers and 7) asbestos removal workers. To be admissible, the workers had to have practiced one of these trades for the first time at least 15 years prior to the screening and have a cumulative asbestos exposure of at least 1,000 hours.

The Direction de santé publique de la Montérégie included an important information component when screening recommenced between 2006 and 2009. In one study, the effects of this information component on workers' adoption of preventive behaviours were evaluated by comparing them to workers of the Laval and Lanaudière regions. First, the screening results in these three regions will be presented for the study period from 2006 to 2007. Then, those of the evaluative study will be described (Cambron-Goulet, 2008).

7.3.1 Asbestosis screening

The number of workers who met the inclusion criteria of the asbestosis screening program in 2006 was 1,447 in the Montérégie region, 1,210 in the Lanaudière region and 445 in the Laval region. Among these workers, 925 had a chest X-ray: 38% (557/1,447) in the Montérégie, 17% (204/1,210) in the Lanaudière region and 37% (164/445) in the Laval region. The higher participation in the screening X-ray of workers in the Montérégie and Laval regions compared to workers in the Lanaudière region is probably due to a telephone follow-up to contact workers who did not spontaneously respond to the invitation letter (see following section) (Cambron-Goulet, 2008).

Among the 772 workers who had an X-ray and for whom the results of the screening were available at the time the study ended, six (0.8%) presented abnormalities compatible with asbestosis on radiography. They all came from the Montérégie. Furthermore, 18.4% of the workers screened showed pleural plaques and pleural thickening on radiography (n = 142) that can be associated with asbestos exposure (Cambron-Goulet, 2008) (Table 17).

Table 17 Results of available asbestosis screening chest X-rays by region

Result[1]	Montérégie	Lanaudière	Laval
Normal X-ray	381	93	103
Pleural plaques or pleural thickening	68	40	34
Visceral parietal abnormality	0	4	NA[2]
Suspected asbestosis or opacities	6	0	0
Suspicious mass or nodule	3	7	NA
Other abnormality	23	7	NA
X-ray to be repeated	3	NAp[2]	NA

1 Some workers have two abnormalities.
2 NA: not available; NAp: not applicable.
Source: Cambron-Goulet, 2008.

7.3.2 Evaluation of the screening program's information component

7.3.2.1 Design and study population

A quasi-experimental post-test study with non equivalent control groups was conducted in order to evaluate the effects of the information component of the asbestosis screening program. For the exposed group, samples were collected from among the Montérégie workers invited to the screening (n = 637). The control groups were composed in part of workers in the Lanaudière region (n = 332) and in part of workers in the Laval region (n = 314) where the program had not yet begun at the time of the study (Cambron-Goulet, 2008).

7.3.2.2 How the program's information component worked

Table 18 shows how the program was carried out in the three regions. In November 2006, the 1,447 Montérégie workers first received a letter accompanied by a leaflet about the screening, produced by the MSSS, and a 20-page booklet produced by the CSST that explained the risks associated with asbestos exposure, the main exposure sources and the proper means to protect oneself when working in a hazardous area. In addition, a follow-up phone call was made in December 2006 to contact the workers to whom a letter had been sent, but who had not yet manifested their interest in participating in the program. Finally, in February and March 2007, nurses contacted the workers who volunteered to participate in order to confirm their eligibility, make an appointment for the X-ray and give the workers additional information on asbestos diseases and preventive measures. In the Montérégie, the X-rays were taken in the weeks of May 13 and 20, 2007, and in the fall of 2007 for one of the health and social service centres (CSSS) (Cambron-Goulet, 2008).

In the Laval region, an invitation letter was sent to 445 workers at the end of September 2007 and a follow-up phone call was made. The X-rays were taken at the end of the fall of 2007 (Cambron-Goulet, 2008).

In the Lanaudière region, 1,210 personalized letters were sent in March 2007 to eligible workers, accompanied by the MSSS leaflet. No follow-up phone call system was set up. The X-rays were taken in June 2007 for the workers living in the south of the region and in October 2007 for those living in the north of the region (Cambron-Goulet, 2008).

No information component by a telephone interview was added to the asbestosis screening program in the Laval and Lanaudière regions (Cambron-Goulet, 2008).

Table 18 Participation in the components of the asbestosis screening program among construction workers in the Montérégie, Laval and Lanaudière regions carried out in 2006 and 2007

Region	Invitation letter	Follow-up phone call	Informative component in interview form
Montérégie	x	x	x
Laval	x	x	
Lanaudière	x		

Source: Cambron-Goulet, 2008.

7.3.2.3 Variables measured

To measure the adoption of behaviours to minimize asbestos exposure and the risk of developing one of the related diseases, the different groups were compared on the following variables:

- Workers' perception of the severity of asbestos-related diseases;
- Their perception of their susceptibility to contract these diseases;
- Their perception of the effectiveness of the available protective measures (respiratory protective equipment, work clothes, questioning the construction site manager, requiring protective equipment, identifying asbestos-containing materials);
- Their perception of their ability to implement these measures;
- Their attitude about preventive and protective behaviours;
- Their intent to adopt such behaviours;
- Their knowledge about asbestos (asbestosis latency period, useful ways to prevent exposure and asbestos-containing materials) (Cambron-Goulet, 2008).

The data were collected in a telephone questionnaire containing 72 validated questions administered between September 5 and October 20, 2007 to 421 workers in the three study regions: 219 workers in Montérégie, 132 workers in Lanaudière and 71 workers in the Laval region. The overall participation rate for the questionnaire was 53% (Cambron-Goulet, 2008).

Three sources were used to develop the questionnaire: 1) the *Risk Behavior Diagnosis Scale*, 2) questions inspired by the models of Ajzen and Fishbein and 3) other questions formulated for the study (Cambron-Goulet, 2008).

7.3.2.4 Results

In general, the asbestosis screening program among construction workers seems to have had few beneficial effects on the adoption of preventive behaviours. As a matter of fact, among all the comparisons made, only one significant difference was observed between the Montérégie workers exposed to the information component in an interview and the Lanaudière workers who did not have that information component. According to the results of the study, the informed workers were more aware of the effectiveness of requiring protective equipment to prevent the development of asbestos-related diseases than were the non-informed workers. With regard to the effects of the invitation letter, only the variable concerning knowledge of the asbestosis latency period was significantly different among the groups compared. The Montérégie workers who received an invitation letter were more likely to know the answer to the question about this variable than were the Laval workers, who received and who did not an invitation letter, since it was the Montérégie workers who in general were compared to those in Laval, but without specifically verifying whether the Laval workers had each received the letter (Cambron-Goulet, 2008).

In addition, in all the groups compared, the workers had a good perception of the severity of asbestos-related diseases, of their ability to adopt preventive behaviours and of the effectiveness of preventive measures. Consequently, the possibility of improving behaviours relative to these variables is limited. However, the workers had a poor perception of their susceptibility to developing asbestos-related diseases. They also had a poor perception of the effectiveness of identifying asbestos-containing materials and of the prudence of this identification for disease prevention. Finally, the workers also had a poor perception of their ability to identify asbestos-containing materials in the workplace, and a poor intent to carry out this identification. Therefore, actions to improve these behaviours should be strengthened (Cambron-Goulet, 2008).

The existence of an opposite effect of the program, meaning that workers with a negative screening result would protect themselves less, cannot be rejected. In fact, compared to Montérégie workers with a negative screening result, Montérégie workers with a positive screening result seemed to have a better perception of their susceptibility to asbestos-related diseases, a better perception of their ability to wear work clothes and a greater intent to inquire about the presence of asbestos on construction sites. On the other hand, in reference to the variables studied, the Montérégie workers with a negative screening result do not seem significantly different from all the other workers, including those who did not have an X-ray and those who were not yet invited to have an X-ray. It is important to interpret these results with caution, since to ensure the presence or absence of this kind of opposite effect, it would have been necessary to compare the workers to themselves before and after exposure to the program (Cambron-Goulet, 2008).

Finally, the main sources of information reported by the workers with regard to asbestos and its related diseases were: a training session on construction sites or by the employer, information relayed by the boss, the foreman, a work colleague and the media (Table 19). Workers seldom mentioned the information sources connected with the screening program (invitation letter, nurse, physician) (Cambron-Goulet, 2008).

Table 19 Workers' information source on asbestos and asbestos-related diseases

Information source	Number[1]
Training on construction sites or by employer	161
Boss, work colleague, foreman	99
Media (newspapers, television, radio, Internet)	97
Information leaflet	53
Booklet written by CSST	50
Training given by union	46
Personal experience	45
Workplace safety courses (private firm)	28
Family, friend	26
Letter of invitation to screening	14
CLSC nurse (CSSS)	10
Commission de la construction du Québec	7
Information leaflet from union	4
Physician	4
Union	3
Medical training	1
No information source	1

[1] 421 respondents. Each respondent could mention more than one source of information.
Source: Cambron-Goulet, 2008.

8 MATCHING AND COMPARISON OF DATA FROM VARIOUS SOURCES

The new cases of pleural mesothelioma and asbestosis diagnosed in the general population (Table 6) are more numerous than the cases recognized as occupational diseases (Table 13). Given this observation, the INSPQ carried out a study to match the cases of pleural mesothelioma and asbestosis recognized as occupational lung diseases by the CSMPP to the new cases of pleural mesothelioma recorded in the FiTQ and to asbestosis hospitalizations recorded in the MED-ÉCHO system. The goal of this study, published in 2009, was to evaluate the exhaustiveness and the utility of various data sources for the purpose of asbestos-related diseases surveillance (Lebel et al., 2009).

8.1 MESOTHELIOMA

From 1975 to 2003, 444 cases of pleural mesothelioma were recognized as occupational lung diseases by the CSMPP while 1,604 cases of this same cancer were recorded in the FiTQ for the period from 1975 to 2002. Of the 444 pleural mesothelioma cases recognized by the CSMPP, 89.0% were present in the FiTQ (395/444) and 11.0% (49/444) were absent. Among the 395 cases identified in both registries, 344 had the same diagnosis, that of pleural mesothelioma. The 51 other cases had a non-concordant diagnosis, namely 15 other-site mesotheliomas and 36 other cancer sites. The 344 cases with a concordant diagnosis in both registries represent 21.4% (344/1,604) of all the cases of pleural mesothelioma recorded in the FiTQ (Lebel et al., 2009). This finding has not changed since the previous study that looked at the period from 1967 to 1997 (De Guire et al., 2003a). In addition, these cases with a concordant diagnosis in both registries represent 77.5% (344/444) of the mesotheliomas recognized by the CSMPP (Lebel et al., 2009).

8.2 ASBESTOSIS

From 1967 to 2003, 1,863 asbestosis cases were recognized as occupational lung diseases by the CSMPP, while 2,391 persons hospitalized with mention of asbestosis during the years 1988 to 2003 were registered in the MED-ÉCHO system. The cases recognized by the CSMPP that are also present in the MED-ÉCHO system represent 35.0% of the individuals hospitalized with mention of asbestosis (838/2,391) (Lebel et al., 2009).

9 SURVEILLANCE SYSTEM FOR ASBESTOS EXPOSURE AND ASBESTOS-RELATED DISEASES

In 2008, The INSPQ developed terms of reference with the aim to establish the guidelines for a surveillance system for asbestos exposure and asbestos-related diseases (Labrèche et al., 2008). It defined the objectives of the system and explored all the possible objects of surveillance and data sources.

Since the publication of that document, the objects of surveillance to be targeted by the surveillance system have been defined, the data sources to be used have been selected, steps have been undertaken to gain continuing access to data, and the indicators that could be developed with the help of the system are being identified. This section of the document presents the status of the surveillance system for asbestos exposure and asbestos-related diseases.

9.1 EXPOSURE COMPONENT

The system that will be set up by the INSPQ will prioritize exposure surveillance of miners, workers who transform or process asbestos and construction workers, as well as surveillance of environmental exposure in the cities of Thetford Mines and Asbestos. The surveillance could subsequently extend to other industrial sectors.

Since the Québec government is promoting the increased use of chrysotile asbestos in Québec (Gouvernement du Québec, 2002), it is obvious that exposure surveillance in the mines must be carried out. Data from this exposure assessment, conducted mainly by the mines themselves, can be used for the surveillance, insofar as they are accessible.

The Policy concerning the increased and safe use of chrysotile asbestos also aims to promote asbestos use for the manufacture of asbestos-cement products and asbestos-containing asphalt in Québec (Gouvernement du Québec, 2002). The industrial sector is thus directly affected by this policy, since it includes manufacturing and processing plants that handle asbestos-cement products and manufacturing plants that handle asbestos-containing asphalt. This industry was therefore also selected for the surveillance system.

The third setting was the construction industry. The little data available on exposure in this industry suggests that asbestos exposure is not well controlled in the sector, hence the importance of surveillance. As well, since removal of asbestos-containing asphalt is considered high-risk work according to the Safety Code for the construction industry (Gouvernement du Québec, 2009b), the exposure created by these activities will also be considered in the surveillance system.

A worthwhile data source to exploit for the surveillance is the *système d'information en santé au travail* (SISAT – an occupational health information system) in which are recorded the results of occupational asbestos exposure measurements taken by the *réseau public de santé au travail* (a public network for occupational health). Analysis of these data will allow “routine” monitoring of all the settings in which public health teams become involved because of occupational asbestos exposure.

Finally, with respect to environmental exposure to asbestos in the general population, only the surveillance of asbestos in the outdoor air of mining towns was retained. Other objects of surveillance, as for example exposure related to the use of abrasives, could be integrated into the system by taking into account resources available to elaborate on this subject.

9.1.1 Mining industry

9.1.1.1 Objects of surveillance and data sources

The aim of the system is to monitor the exposure of miners at Lac d’Amiante in the Thetford Mines area and at the Jeffrey mine in the Asbestos area, which are the only two mines still in operation in Québec. Sampling surveys are organized by the occupational health departments of these mines in order to meet the requirements of the *programme de santé spécifique aux establissements* (PSSE – a specific health program for an establishment), which developed from the *Act respecting occupational health and safety* (Gouvernement du Québec, 2009c). Steps are underway to explore the possibility of obtaining access to the data from these sampling surveys.

9.1.1.2 Indicators

Here are some examples of indicators that might be developed using these data:

- Averages and ranges of exposure levels
- Proportion of exposed workers above the 1 f/ml occupational exposure limit
- Proportion of exposed workers above the criterion of 0.1 f/ml used by the *Amiante/Secteurs industriels* project
- Proportion of workers sampled compared to the total number of exposed workers

These indicators could be distributed down by year, health and social service region or trade.

9.1.2 Industrial sector

9.1.2.1 Objects of surveillance and data sources

The surveillance system will take into account the asbestos fibre exposure of Québec workers who work in industries that use asbestos in their processing or in industries where workers handle asbestos products (currently nine factories and 28 mixing plants capable of producing asbestos-containing asphalt). As well, any new factory using asbestos will be added to the list of establishments monitored as they are identified.

To ensure this surveillance, the INSPQ plans to make use of the exposure data collected in the SISAT “hygiene” module. Access to the SISAT provincial data was granted to the INSPQ in 2009, but the mechanisms to extract and exploit the data are not yet established.

To provide for the surveillance of asbestos exposure in industrial settings, the INSPQ must be able to target all the industries that are likely to use asbestos in their processing. To do so, the INSPQ intends to verify with the CSST if it is possible to annually report new workplaces using asbestos (that were not already recorded in the SISAT by technicians working for the *réseau public de santé au travail*), as well as all workplaces visited by inspectors in which the term "asbestos" is mentioned in the inspection reports.

In addition, steps will be taken to have technicians from the *réseau public de santé au travail* visit the workplaces identified by the INSPQ that use asbestos in their processing and those in which workers handle asbestos products. To this end, the staff of the occupational health teams of the various regions in Québec will be made aware of the importance of recording in the SISAT the asbestos exposure data obtained in the workplaces visited. To encourage and harmonize this process, a data-entry protocol specific to asbestos will be developed.

9.1.2.2 Indicators

Here are some examples of indicators that could be developed to describe workers' exposure in workplaces that use or process asbestos and in those where workers handle asbestos products:

- Number of factories that use or process asbestos
- Number of factories where workers handle asbestos products
- Number of new factories using asbestos
- Averages and ranges of exposure levels
- Proportion of workers exposed above the 1 f/ml occupational exposure limit
- Proportion of workers exposed above the criterion of 0.1 f/ml used by the *Amiante/Secteurs industriels* project

These indicators could be distributed by year, health and social service region or trade.

9.1.3 Construction industry

There is little data on asbestos exposure at construction sites. This is due in part to the fact that the construction sites are not permanent and are of different types. We must therefore find new ways to monitor this industry. For this reason, the section on the construction industry begins with the presentation of what the authors of the study summarized in Section 4.3.6 identified as existing tools, in Québec and elsewhere in the world, that may be useful for asbestos exposure surveillance in Québec's construction industry. These tools are summarized in the following paragraphs and their utility for surveillance is discussed. The tools are job-exposure matrices (JEM), national registries of workers exposed to asbestos and exposure databanks (Beaudry et al., 2008).

Job-exposure matrices

Job-exposure matrices, which were originally developed to meet the needs of epidemiological studies, usually contain expert opinions to help assess occupational exposure to substances associated with various trades, using exposure indicators such as probability, intensity and frequency of exposure.

Some JEM focusing specifically on asbestos were found in the literature. One of them, the Ev@lutil, is available on-line in French (Beaudry et al., 2008). These JEM represent a useful source of information when there are worker claims where the prior asbestos exposure source is not obvious. The Ev@lutil asbestos JEM could also be used as a surveillance tool for workers' exposure if it were updated and adapted to the Québec reality. But since the *réseau public de santé au travail* has the SISAT, the Québec data will be entered in the latter system.

National registries of workers exposed to asbestos

National registries of workers exposed to one or more substances on a given territory are tools created by legislation that requires employers to report certain data about these workers to a public organization responsible for compiling the data. Two registries dealing with occupational asbestos exposure were found, one in Finland and one in Ontario. The Finnish registry includes more than 75 carcinogenic substances including asbestos and contains nominative data, but not data on exposure level or duration. According to some authors, it is not exhaustive and the construction industry is under-represented in it (Beaudry et al., 2008).

The Ontario register was created in 1986 following the adoption of a regulation requiring employers in building construction, maintenance and demolition to report annually to the Ontario Minister of Labour the list of employees exposed to asbestos and silica (Beaudry et al., 2008). The data from these registries can be used for surveillance. This type of registry is not available in Québec.

Exposure databanks

Computer systems that record the results of workplace air pollutant measurements collected by government prevention or inspection organizations exist in most industrialized countries. In Québec, the SISAT "hygiene" component, deployed in 2007 and replacing the *Système de Surveillance Médico-environnementale de la Santé des travailleurs* (SMEST – workers' health medical-environmental surveillance system), can be considered as such system. However, the industrial hygiene technicians working for *the réseau public québécois de santé au travail* teams only rarely measure asbestos exposure on construction sites. Thus, unless the *réseau public de santé au travail* procedures are modified, the SISAT cannot be used as a data supply source for the asbestos exposure surveillance system in the construction industry.

9.1.3.1 Objects of surveillance and data sources

Characterization data on asbestos-containing materials and measurement data on airborne fibres at high-risk construction sites

According to the Safety Code for the construction industry, employers must determine the type or types of asbestos present in the materials before undertaking work that might release asbestos dust. The construction site is then categorized as low, moderate or high-risk (Gouvernement du Québec, 2009b).

When a construction site is defined as high-risk, the employer must take measurements of airborne fibres in the work area, during and after abatement work. These data must be recorded in a register, and they must be available on site for the CSST inspectors for the duration of the work (Gouvernement du Québec, 2009b). They could be exploited for surveillance purposes, as was demonstrated in the study conducted by McGill University and the IRSST (Dufresne et al., 2009a). Given this fact, the INSPQ has undertaken steps with the CSST to gain access to these data.

Non-compliance notices

The surveillance system also aims to document the proportion of construction sites that do not comply with the Safety Code for the construction industry (Gouvernement du Québec, 2009b). To do this, the INSPQ should annually obtain the CSST data on non-compliance notices and work cessation on construction sites with asbestos.

Construction workers exposed to asbestos

Following the example of Ontario's register of construction workers exposed to asbestos, a registry of Québec workers exposed to asbestos could be developed with the collaboration of the Commission de la construction du Québec (CCQ). Steps will be undertaken with this Commission to see if it would be possible to invite construction workers to answer some questions concerning their asbestos exposure during the previous year, at the time of the annual renewal of their competency certificate. This information would be recorded in the CCQ registries and it would make it possible to describe the situation regarding workers' exposure in this activity sector.

Registry of road stretches paved with asbestos-containing asphalt

Maintenance and removal of asbestos-containing asphalt are among the activities governed by the Safety Code for the construction industry (Gouvernement du Québec, 2009b). However, occupational exposure to asbestos fibres is not assessed on a regular basis at these construction sites in Québec (Adib & Perrault, 2009).

As part of its surveillance mandate, the INSPQ has undertaken steps with the MTQ to identify road stretches that represent sources of asbestos fibres emissions for the workers involved in these operations, and for the population residing close to these construction sites. The MTQ intends to publish on its Internet site the information it has (Villeneuve, 2010). These steps should also be undertaken in cities such as Montréal and Québec, which maintain their own roadways having asbestos-containing asphalt.

9.1.3.2 Indicators

Here are some examples of indicators that could be developed on workers' exposure in the construction industry:

- Number of high-risk construction sites
- Proportion of high-risk construction sites visited by CSST inspectors that received a non-compliance notice

- Averages and ranges of fibre concentrations at high-risk construction sites during and after abatement work before dismantling the enclosure
- Proportion of construction workers registered in the CCQ exposed to asbestos

These indicators could be distributed by year, health and social service region, trade or type of building.

9.1.4 Other workplaces

As mentioned in the terms of reference for the surveillance system published in 2008, some workers who work in places other than those described above are probably exposed to asbestos fibres without any exposure data being available (Labrèche et al., 2008). For example, workers at landfill sites that receive asbestos waste, those who spread abrasives containing chrysotile asbestos or those who distribute and maintain ballast composed of asbestos waste on certain railway lines. Due to the absence of data sources, the system that will be put in place by the INSPQ will not permit monitoring the exposure of these workers. However, the addition of other sectors to the surveillance system is feasible if and when new data sources become accessible.

9.1.5 Outdoor environment

9.1.5.1 Objects of surveillance and data sources

Most of the data available on asbestos concentrations in outdoor air in Québec come from measurements taken by the MDDEP. In addition, the Jeffrey mine takes measurements in the municipality of Asbestos. Steps will be undertaken with the MDDEP, public health directors in the Chaudière-Appalaches and Estrie regions and the mines to obtain the data on environmental exposure to asbestos.

For the time being, the surveillance system will not consider environmental exposure in cities outside the mining regions.

However, as described in Section 9.1.3.1 (registry of road stretches paved with asbestos-containing asphalt), the INSPQ has undertaken steps with the MTQ to identify road stretches that represent possible sources of asbestos fibre emission for the public. According to the MTQ, the information will be placed on that ministry’s Internet site. Steps should also be undertaken with cities.

9.1.5.2 Indicator

Here is an example of an indicator that could be developed using these environmental data:

- Averages and ranges of ambient asbestos fibre concentrations

This indicator could be distributed by year.

9.1.6 Other living environments

Several other living environments could be exposure sources for the general population. This is true of public buildings or private residences that contain ACM, such as sprayed asbestos or vermiculite contaminated with amphiboles. Since to our knowledge, no exhaustive and nominative inventory of these buildings or residences exists in Québec, and because no exposure data is available in these environments, they will not be monitored under the surveillance system to be set up by the INSPQ.

9.2 ASBESTOS-RELATED DISEASES COMPONENT

9.2.1 Objects of surveillance and data sources selected

The diseases that have been identified as objects of surveillance for the system to be set up are asbestosis, pleural and peritoneal mesothelioma and lung cancer recognized as being related to occupational asbestos exposure. Cancer of the larynx and the ovary, recognized as being related to asbestos exposure by the IARC in 2009 (Straif et al., 2009), will be discussed before they are included or not in the surveillance system. Until now, different data sources have been used to ensure the surveillance of asbestos-related diseases: the FiTQ, the *Fichier des décès du Québec*, the MED-ÉCHO system and claims for asbestos-related diseases recognized as occupational lung diseases by the CSMPP. The matching of data from diverse sources presented in Section 8 of this document provided information on the strengths and limitations of these data sources.

Fichier des tumeurs du Québec

The mesothelioma cases recognized by the CSMPP represent only a small proportion of the cases recorded in the FiTQ (21.4%). The FiTQ is therefore more exhaustive than the CSMPP data and consequently more suitable to provide for monitoring of the annual trends for this disease. However, this registry contains no information on occupational or environmental exposure to asbestos, which limits the production of surveillance indicators for asbestos-related diseases from this data source (Lebel et al., 2009).

MED-ÉCHO

The asbestosis cases recognized by the CSMPP represent only 35% of the cases recorded with this diagnosis in the MED-ÉCHO system. The MED-ÉCHO system seems to be more exhaustive, but it is not necessarily a worthwhile data source for the surveillance of this disease. In fact, it is possible that several asbestosis cases are not recorded in the system owing to the clinical evolution of the disease that does not always result in a hospitalization. Moreover, it is possible that the asbestosis cases recorded in this registry correspond to other abnormalities such as pleural abnormalities (Lebel et al., 2009).

Comité spécial des maladies professionnelles pulmonaires

The information from the CSMPP is one of the rare data sources that include details on the occupational asbestos exposure. Its analysis therefore makes it possible to document the distribution of the diseases targeted by the surveillance system by different job sectors and occupations. However, this data source is not exhaustive, since not all individuals suffering from asbestos-related diseases file a claim with the CSST. It also excludes cases of environmental origin (Lebel et al., 2009).

MADO-Chimique System

Québec's physicians must report to the public health director of their region all suspected cases of asbestosis and mesothelioma as notifiable diseases (MADO in French). For asbestos-related lung cancer, only the cases for which an occupational origin has been confirmed by the CSMPP must be reported. These obligations are set out in the *Public Health Act* (chapter VIII, sections 80 to 82) (Gouvernement du Québec, 2001) and in the corresponding regulations adopted in 2003, these being the Regulation under the *Public Health Act* (Gouvernement du Québec, 2003a) and the Minister's Regulation under the *Public Health Act* (Gouvernement du Québec, 2003b). Notification of these diseases usually leads to a verification of the nosological definition of the disease and it can result in an inquiry by the public health director. The information from these steps is kept in the MADO regional registries of each public health department in Québec.

The MADO-Chimique system therefore represents a new and worthwhile data source to explore for the surveillance of asbestosis, mesothelioma and asbestos-related lung cancer. However, as with all notifiable diseases of chemical origin, these diseases are under-reported. The proportion of cases reported by physicians other than those working for the CSMPP and recorded in the MADO regional registries is actually very low (Lebel et al., 2009).

9.2.2 Use of the MADO-Chimique system for future surveillance

The INSPQ recommends using the MADO-Chimique system as the main data supply source for its surveillance system for asbestos-related diseases. To that end, the INSPQ is developing a two-part approach.

The first part involves **asbestos-related lung cancer** cases. CSMPP physicians already report these cancer cases to the public health directors in each region in Québec. Public health teams verify the nosological definition of the disease and conduct epidemiological surveys if appropriate. The reported cases are recorded in the MADO-Chimique system of the region concerned. To monitor the cases of asbestos-related lung cancer province-wide, the INSPQ intends to develop mechanisms to aggregate the cases from all regions in Québec in order to analyze them for the entire province, but without personal information.

The second part of the approach recommended by the INSPQ concerns **mesothelioma and asbestosis** cases. Considering the documented under-reporting of these diseases in the MADO-Chimique system, the INSPQ aims to boost the reporting of these two diseases by hospital physicians by calling on the assistance of medical archives departments. It is the archivists who will identify the cases of these two diseases, when coding the medical record, and who will send the information, for the physicians, to the public health directors of their region.

To test the feasibility of such an undertaking, the INSPQ proposes to introduce a pilot study in two Québec hospitals. This pilot study will require the agreement of public health directors and the directors of the Professional and Hospital Services, and of physicians and archivists in the hospitals in which the pilot study will take place. It will also require that resources be granted to support the different stages of the study and the additional workload on the staff of hospitals and public health branches. It will also require, as for lung cancer, the development of mechanisms with which to aggregate the mesothelioma and asbestosis cases from all regions. Finally, this project will require adapting the MADO-Chimique system to chronic diseases. To that end, the INSPQ will participate in the activities of the work groups set up by the MSSS to modify the MADO survey questionnaires and the data entry form in the MADO-Chimique system in order to meet the surveillance needs of long-latency diseases.

At the end of the pilot study, if the project proves effective in identifying and reporting mesothelioma and asbestosis cases, this approach would be proposed to all hospitals in Québec.

Finally, the INSPQ should study the relevance of supplementing incidence data on asbestos-related diseases with mortality data.

9.2.3 Indicators

Here are some examples of indicators that could be produced using data contained in the MADO-Chimique system:

- Number of incident cases of mesothelioma (pleural or peritoneal), asbestosis and asbestos-related lung cancer
- Incidence rates for mesothelioma (pleural or peritoneal), asbestosis and asbestos-related lung cancer

Depending on the case, these indicators could be distributed by year, gender, region, job sector and trade.

9.3 EVALUATION COMPONENT

The introduction of a surveillance system requires planning of its evaluation (Labrèche et al., 2008). The INSPQ should define how it intends to carry this out.

10 CONCLUSION

The findings published in Québec over the past few years show that asbestos exposure is still poorly controlled in several workplaces (asbestos products factories, construction, maintenance and repair and to a lesser degree, asbestos mines). Asbestos exposure in the general population is less well documented. Exposure levels are low and stable in mining towns, but they are higher than those documented in other settings. With respect to asbestos-related diseases, there is no notable change compared to the results published in 2003. Pleural mesothelioma is increasing significantly among Quebeckers and the percentage of cases of occupational origin among the cases diagnosed in the general population remains at 22%. The majority of occupational lung diseases are found among construction workers and maintenance and repair workers. Two of the new findings are worthy of attention. First, the lifetime mortality risk for lung cancer and mesothelioma estimated among residents of Thetford Mines suggests a risk attributable to airborne asbestos in this city. Second, the cases of asbestosis recognized as occupational lung diseases by the CSMPP represent 35% of Quebeckers hospitalized with mention of asbestosis. All these results show the importance of setting up a surveillance system for asbestos exposures and asbestos-related diseases in Québec.

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APPENDIX A

HIGHLIGHTS

HIGHLIGHTS

ASBESTOS EXPOSURE LIMITS IN QUÉBEC

- The occupational asbestos exposure limits in Québec have been the same since 1990. The time-weighted average (TWA) and the short-term exposure limit (STEL) for chrysotile, tremolite, anthophyllite and actinolite are respectively 1 f/ml and 5 f/ml. The TWA and the STEL for crocidolite and amosite are respectively 0.2 f/ml and 1 f/ml.
- The 1 f/ml exposure limit is ten times higher than the limit in Ontario, the United States and France, where it is 0.1 f/ml.
- The 1 f/ml exposure limit is 100 times higher than the limit in the Netherlands and Switzerland.
- There is no environmental exposure limit for asbestos, apart from the provisional criterion of 0.04 f/ml in force in Ontario and referenced by the MDDEP.

ASBESTOS EXPOSURE IN THE GENERAL POPULATION OF QUÉBEC

- In 2004, in Montréal and the city of Québec, total fibre concentrations measured in outdoor air by the MDDEP and derived from 116 samples analyzed by PCOM ranged from < 0.0015 to 0.0054 f/ml, while TEM analyses of five samples did not identify any asbestos fibres.
- In the city of Asbestos, the average annual fibre concentrations in ambient air, reported between 1998 and 2005 by the Jeffrey mine, ranged from 0.003 to 0.007 f/ml, depending on the sampling site (analytic method not specified).
- In the city of Thetford Mines, in 2004, the total fibre concentrations measured in outdoor air by the MDDEP from 125 samples analyzed by PCOM ranged from < 0.0015 to 0.056 f/ml. Asbestos fibre concentrations measured in seven samples analyzed by TEM ranged from < 0.0006 f/ml to 0.0082 f/ml with an average of 0.0043 f/ml.
  - The average asbestos fibre concentration measured in outdoor air in the city of Thetford Mines in 2004 by the MDDEP (0.0043 f/ml) was 215 times higher than that obtained in the outdoor air around buildings involved in litigation regarding the removal of asbestos-containing materials in the United States. The same is true for the average concentration of 0.004 f/ml measured by TEM in 1997 by the Association des mines d'amiante du Québec (Québec asbestos mining association) in Asbestos.
- Contrary to the sampling conducted in 2000 by the Ministère de l'Environnement du Québec, no asbestos fibre was detected in 2005 in the ambient air of Thetford Mines close to yards and alleys containing asbestos tailings.
- Asbestos fibre concentrations measured in the indoor air of 26 residences in the city of Thetford Mines in 2003 and 2004 by the Association des victimes de l'amiante du Québec ranged from < 0.000553 to 0.010 PCMe fibre/ml with an average of 0.0018 PCMe fibre/ml.

  - This average concentration is 1.7 to 1.4 times lower than that observed at the end of the 1990s in 17 Québec schools (0.0031 PCMe fibre/ml) and in two apartments affected by dust from the collapse of the World Trade Center towers in 2001 (0.0026 PCMe fibre/ml).
  - It is 16 to 45 times higher than concentrations observed in the indoor air of buildings involved in litigation regarding the removal of asbestos-containing materials in the Unites States from the 1980s to the early 2000s (0.00004 to 0.00011 PCMe fibre/ml).
- No data is available on exposure in the general population to asbestos fibres from asbestos-containing asphalt present on Québec roadways.

ASBESTOS EXPOSURE IN THE QUÉBEC WORKPLACE

Mining

- No publication later than the year 2000 has been found on the exposure levels of miners in the areas of Thetford Mines and Asbestos.

Industrial sector

- Between 2005 and 2009, among nine Québec factories that use chrysotile asbestos in their manufacturing process or in which workers handle asbestos products, none do so in a safe manner.
- In four of the nine factories where asbestos exposure was evaluated, 22 workers were exposed to levels ≥ 0.1 f/ml. Of these, two workers from the same factory were exposed above the time-weighted average of 1 f/ml, and this, despite wetting the materials during sampling.
- In 2010, the MTQ identified 28 mixing plants equipped to make asbestos-containing asphalt in Québec, but at the moment we have no information on these plants.

Construction industry

- Among the 2,475 samples of asbestos-containing materials collected at high-risk construction sites, 75% contained chrysotile only, 15% chrysotile in the presence of other types of fibre and 10% only amphiboles.
  - The samples with chrysotile mainly came from ceilings, walls, pipe elbows and floors.
  - The samples with amosite were chiefly found around pipes and elbows.
- Among 3,000 air samples collected at high-risk construction sites, 43% had concentrations ≥ 1 f/ml (the occupational exposure limit for chrysotile asbestos), 13% had concentrations higher than 5 f/ml and 5% had concentrations above 10 f/ml with a maximum value of 96 f/ml. However, only 3% of the samples were taken in the workers' breathing zone, 52% in the breathing zone of bystanders and 42% at stationary stations. These conditions may have the effect of underestimating the number of exceedences of the reference values.

- Among 2,616 air samples collected in workers' changing rooms on asbestos removal worksites, 77% had fibre concentrations ≥ 0.01 f/ml (the enclosure dismantling criterion on high-risk construction sites) compared to 14% in adjacent areas. However, 46% of the changing room samples and 74% of the samples in adjacent areas did not comply with the prescribed optimal sampling conditions.
- During asbestos removal work, asbestos fibre emissions seem more intense during waste recovery, material removal and demolition tasks compared to during cleaning, sealing and inspection tasks.
- Of the 23,099 samples of asbestos-containing materials indexed in 1,550 buildings located across Québec, 10,538 contained chrysotile. Of these 10,538 samples, 95% contained chrysotile alone and 5% contained a mix of chrysotile and amphiboles (amosite and crocidolite).
  - The materials containing chrysotile were mainly pipe insulation, sprayed asbestos, flooring and asbestos-cement plates.
  - The materials containing amosite and crocidolite were mainly pipe insulation.
- In 2004, according to the MTQ, total fibre concentrations in ambient air along a roadway comprising asbestos-containing asphalt in the Chaudière-Appalaches region prior to removal of this material ranged from < 0.001 to < 0.004 f/ml (sic) by PCOM. Measurements taken at mobile stations (n = 17) during operations to remove the asphalt, revealed concentrations that ranged from 0.09 to < 0.90 f/ml by PCOM analysis. Actinolite was present in three of the five samples analyzed by TEM.

ASBESTOS HEALTH EFFECTS ON THE GENERAL POPULATION OF QUÉBEC

Pleural mesothelioma

- In Québec, 1,530 new pleural mesothelioma cases (1,210 men and 320 women) were recorded in the *Fichier des tumeurs du Québec* between 1982 and 2002. The average age-adjusted incidence rates were 1.98 per 100,000 person-years among men and 0.41 per 100,000 person-years among women.
- From 1982 to 2002, a significant increase in the annual age-adjusted incidence rates for pleural mesothelioma was observed among men. This increase corresponds to an average annual growth rate of 3.6%, which is lower than the value calculated for the period from 1982 to 1996. No significant time trend was observed among women.
- From 1981 to 2003, 1,059 pleural cancer deaths were recorded in the *Fichier des décès*, of which 769 were men and 290 were women.
- At the regional level, the standardized incidence rates for pleural mesothelioma are significantly higher among men and women in the Chaudière-Appalaches region, and among men in the Montérégie and Lanaudière regions. But they are significantly lower among men in the Bas-Saint-Laurent and Outaouais regions. The geographic distribution of the significant excesses of incidence rates coincides with that of the excess mortality from pleural cancer.

- Nationally, mesothelioma incidence rates among men and women in Québec were the highest in Canada for the period from 1993 to 1997.
- Internationally, comparisons made for the period from 1993 to 1997 reveal that only the standardized incidence ratios for pleural, peritoneal and pericardial mesotheliomas taken together among men in New Zealand, the Netherlands, several regions in the United Kingdom, and Australia were higher than the Québec rate. Among women, significant mesothelioma excesses compared to Québec were observed only in Western Australia and Scotland.

Peritoneal mesothelioma

- In Québec, 170 new cases of peritoneal mesothelioma (98 men and 72 women) were recorded in the *Fichier des tumeurs du Québec* from 1982 to 2002. The average annual age-adjusted incidence rates were 0.15 per 100,000 person-years among men and 0.09 per 100,000 person-years among women. Annual incidence rates showed no significant trend and no region in Québec showed a significant excess or deficit for this mesothelioma.

Asbestosis

- From 1992 to 2004, 2,072 persons (1,993 men and 79 women) were recorded in the MED-ÉCHO system with first mention of asbestosis as primary or secondary diagnosis.
- The average annual hospitalization rates with first mention of asbestosis were 4.80 per 100,000 person-years among men and 0.14 per 100,000 person-years among women. No significant time trend of annual rates was observed either among men or among women.
- From 1981 to 2003, 195 asbestosis deaths were recorded in the *Fichier des décès*, 191 men and 4 women.
- Significant excess hospitalizations for asbestosis were observed among men and women in the Chaudière-Appalaches region and among men in the Estrie and Lanaudière regions. With respect to asbestosis mortality, significant excesses were observed only among men in the Chaudière-Appalaches and Estrie regions.

Lung cancer and mesothelioma risk assessment in the general population of Thetford Mines

- A lung cancer and mesothelioma risk assessment in residents of the city of Thetford Mines was conducted using two approaches. The lifetime mortality risk from these two cancers estimated using the approach based on the MSSS guidelines was 72, 110 or 125 per 100,000 persons residing in Thetford Mines and with continuous lifetime exposure to asbestos.
- The lifetime mortality risk for these same cancers estimated using the approach based on the Berman and Crump model was 8.2 per 100,000 persons exposed.

- By way of comparison, the risks associated with asbestos fibre concentrations in the indoor and outdoor air of buildings in the Unites States comprising asbestos-containing materials were calculated. They ranged from 0.46 to 7.1 per 100,000 persons depending on the approach used.
- This risk assessment contains uncertainties related to the determination of unit risks and to the concentrations used to determine the average lifetime exposure dose. It must therefore be interpreted with caution.

ASBESTOS HEALTH EFFECTS ON QUÉBEC WORKERS

New cases of asbestos-related diseases among workers

- From 1988 to 2003, 1,348 workers had 1,512 asbestos-related diseases recognized as occupational lung diseases by the CSMPP following a claim filed with the Commission de la santé et de la sécurité du travail. Of these workers, 57.3% presented with asbestosis, 27.9% with mesothelioma and 27.0% with lung cancer.
- The workers suffering from these diseases were distributed in the following occupational exposure settings:
  - 29.1% in mines
  - 28.4% during maintenance and repair work involving asbestos-containing products or structures
  - 21.0% in construction
  - 11.3% in processing plants
  - 10.2% in other workplaces
- Since construction workers and maintenance and repair workers generally perform the same jobs, the two sectors were combined. The percentage of workers suffering from an asbestos-related disease coming from these two sectors combined (49.4%) surpasses the percentage of mine workers.
- Most of the workers with mesothelioma came from the combined sectors of construction and maintenance and repair (59.5%) while the workers with lung cancer came mainly from the mines (56.5%).
- During the period of the study, there was an increase in the number of workers affected by an asbestos-related disease in the construction and maintenance and repair sectors and in the Others category. The number of cases reported in the mining and processing sectors remained relatively stable.

Asbestos-related deaths among workers

- Between 2005 and 2008, asbestos was responsible for 77 to 89% of all deaths caused by occupational diseases that were submitted to the CSST Board of Directors and for which the decision to compensate was made.

Asbestosis screening in the construction industry

- In 2006, 925 workers from seven construction trades in three regions in Québec (Montérégie, Laval, Lanaudière) had a screening X-ray for asbestosis. Of the 772 X-rays available at the time of the study, six (0.8%) presented abnormalities compatible with asbestosis. As well, 142 (18.4%) showed pleural plaques and pleural thickenings.

MESOTHELIOMA AND ASBESTOSIS OF OCCUPATIONAL ORIGIN IN THE GENERAL POPULATION OF QUÉBEC

- The mesothelioma cases recognized as occupational diseases by the CSMPP between 1975 and 2003, following a claim filed with the CSST, represent 21.4% of all the pleural mesothelioma cases recorded in the *Fichier des tumeurs du Québec* between 1975 and 2002.
- The asbestosis cases recognized by the CSMPP between 1967 and 2003 represent 35.0% of the individuals hospitalized with first mention of asbestosis recorded in the MED-ÉCHO system between 1988 and 2003.

APPENDIX B

ADDITIONAL RESULTS. STUDY OF NEW CASES OF ASBESTOS-RELATED OCCUPATIONAL LUNG DISEASES IN QUÉBEC: 1988-2003

ADDITIONAL RESULTS. STUDY OF NEW CASES OF ASBESTOS-RELATED OCCUPATIONAL LUNG DISEASES IN QUÉBEC: 1988-2003

CONTEXT

Following publication of the report on the aforementioned study (De Guire & Provencher, 2009), a commentary on the 59 mesothelioma cases among Québec's asbestos miners and millers led to an additional analysis of the data. This commentary concerned the study's possible contribution to the data already published on the cohort of Québec asbestos miners and millers (Liddell et al., 1997; McDonald et al., 1997).

COHORT OF QUÉBEC ASBESTOS MINERS AND MILLERS

The mortality of 10,918 Québec asbestos miners, millers and workers in an asbestos products factory born between 1891 and 1920 was described. The cohort under study was followed up to 1992. Of the 9,780 workers traced, 8,009 were deceased: 38 from mesothelioma, 657 from lung cancer and 108 from pneumoconiosis. Of the 38 mesothelioma deaths, 28 occurred among miners and millers in Thetford Mines, 8 among miners and millers in the city of Asbestos and 5 among workers in an asbestos products factory located in Asbestos (Liddell et al., 1997; McDonald et al., 1997).

STUDY OF MESOTHELIOMAS RECOGNIZED AS OCCUPATIONAL LUNG DISEASES IN QUÉBEC ASBESTOS MINERS AND MILLERS

The 59 mesotheliomas recognized as occupational lung diseases by the CSMPP between 1988 and 2003 (De Guire & Provencher, 2009) were reviewed and their year of birth identified in order to determine whether or not they might belong to the cohort of 10,918 workers.

- Sixteen of the 59 mesotheliomas were born between 1891 and 1920. One of them had been exposed to asbestos in a mine located outside of Thetford Mines and Asbestos. The 15 other workers could therefore have belonged to the cohort.
    - Seven of these 15 mesotheliomas had been recognized as having an occupational lung disease between 1988 and 1992 and therefore, they might already be included among the 38 mesotheliomas in the cohort.
    - The eight other workers were alive in 1992. Consequently, although they meet one of the criteria for inclusion in the cohort, namely date of birth, they might not be counted among the 38 workers deceased from mesothelioma in the cohort.
- The 43 other mesotheliomas were born after 1920.

According to the data available in the CSMPP files, 30 of the 59 mesotheliomas had been exposed in Thetford Mines asbestos mines and mills, 20 in Asbestos mines and mills, 2 in Asbestos mines and mills but perhaps also in the asbestos products factory, another in a mine in neither of the two cities mentioned, and for the final six workers the location was unknown.

In another study of mesothelioma cases of recognized occupational origin between 1967 and 1990 (Bégin et al., 1992.), 49 workers presented with this cancer, 29 having been exposed in Thetford Mines asbestos mines and mills and 20 in those in Asbestos.

Conclusion

Although the studies dealing with the cases recognized as being of occupational origin and the study of the mortality of a cohort of workers are different and the data cannot be compared directly, some information can be extrapolated from them. The gross analysis of the 59 mesotheliomas recognized as being of occupational origin between 1988 and 2003 shows that the number of mesotheliomas among Québec asbestos miners and millers has doubled since the end of the mortality study follow-up in 1992 among the Québec cohort of asbestos miners and millers. The gross analysis also shows that these mesothelioma cases come from Québec's two mining towns.

It might be instructive to match the 15 mesothelioma cases recognized as being of occupational origin between 1988 and 2003, born before 1921 and having worked in the asbestos mines and mills in Thetford Mines and Asbestos in order to complete the follow-up of this cohort.

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