Indicators in Health

Indicators in Occupational Health

Occupational risks due to asbestos

FRENCH INSTITUTE
FOR PUBLIC HEALTH
SURVEILLANCE

Sommaire

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Abreviations

CépiDc	Centre d'épidémiologie des causes de décès
CIM	Classification internationale des maladies
Circ	Centre international de recherche sur le cancer
CnamTS	Caisse nationale d'assurance maladie des travailleurs salariés
CPAM	Caisse primaire d'assurance maladie
DMP	Demande de reconnaissance en maladie professionnelle
DST	Department of Occupational Health - Département santé travail
ESPrI	Épidémiologie et surveillance des professions indépendantes
Fiva	Fund for Indemnification of Victims of Asbestos - Fonds d'indemnisation des victimes de l'amiante
FMA	Fibre minérale artificielle
FPE	Fonction publique de l'État
HAS	Haute autorité de santé
IC	Intervalle de confiance
Inserm	Institut national de la santé et de la recherche médicale
InVS	French Institute for Public Health Surveillance - Institut de veille sanitaire
MSA	Mutualité sociale agricole
PNSM	National Mesotheliome surveillance Program - Programme national de surveillance du mésothéliome
OR	Odds-ratio
RGSS	Régime général de la Sécurité sociale
SPP	Suivi médical postprofessionnel

Workplace health indicators: why?

Since the enactment of the Public Health Policy Act of 9 August 2004 and the formulation of thematic action plans in the domains of the environment, cancer, and workplace health, France has sought to develop sets of indicators intended to monitor health trends at the national level. Nonetheless, for these occupational risks, the information required to develop useful and reliable indicators — about working conditions and their health effects at the population scale — has not yet been assembled. The limitations of each of the principal data sources available in terms of populations covered, exhaustiveness, representativeness of the data collected, regularity of production, etc. explain this delay, even though the Department of Occupational Health (DST) of the French Institute for Public Health Surveillance (InVS) has worked since its creation in 1998 to develop monitoring programs in diverse domains to produce such data regularly and improve our knowledge of occupational health risks.

Today, the data sources have been fleshed out substantially in some areas of occupational risks. This greater detail makes more feasible producing indicators from diverse sources. In 2009, therefore, the DST established a program for the regular production of indicators intended to provide a national snapshot of health problems related to the workplace environment and working conditions and exposures, as well as of their trends over time. These indicators are established from different sources and will be published regularly on the InVS website (www.invs.sante.fr), where they will document the situation and changes in occupational risks and thus contribute both to the determination of priorities for action and to the assessment of the results of the actions conducted.

The principal relevant indicators

The principal indicators useful for studying occupational risks report: *(i)* exposure to established risk factors of occupational disease; *(ii)* population health impact indicators, especially diseases risk fractions and number of cases attributable to occupational factors; *(iii)* indicators about compensation of occupational diseases. Indicators of occupational demography (workers and companies), of employment, and of occupational health services will not be covered for they are already produced regularly by other agencies, including Dares (Direction de l'animation de la recherche, des études et des statistiques, i.e., the Direction of research, studies and statistics), the DGT (la Direction générale du travail, i.e., the Directorate-General of Labor), Insee (Institut national de la statistique et des études économiques, i.e., the national institute for statistics and economic studies), and the health insurance funds.

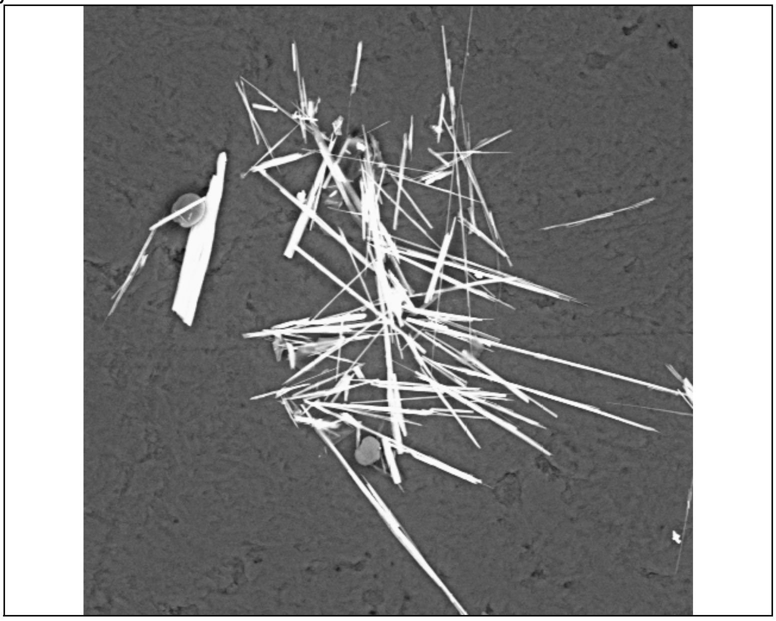
We selected domains of major interest for public health in terms of disease and risk factors when the data necessary to establish national indicators could be brought together from sources available at the DST and in other accessible information systems (including, for example, health and health-related administrative databases and ad hoc surveys).

1. Introduction: Asbestos, exposure, health effects

1.1. Asbestos: nature and uses

Asbestos comes in two principal varieties: chrysotile and amphibole fibers. The production and use of both increased substantially over the course of the 20th century. Asbestos was widely used in **the construction industry**, for various purposes, most especially asbestos-cement, but also floor tiles, cardboard coating, insulation products and fireproofing for insulation, sealers, felt squares, bituminous roofing felt, cardboard for ceiling filling, partitions and fire doors, some coatings and glue, and diverse insulation products. It was also widely used in the form of sprayed coating intended to increase the fire resistance of buildings or improve either sound or heat insulation.

Image 1: Chrysotile crystals



Source: InVS.

A wide range of other industries also used asbestos. In decreasing order of asbestos mass, we find cardboard and paper, textiles, gaskets and friction linings, catalytic screens and insulation devices for heaters, liquid filters; road surfacing products, air filters and filters for the transportation, distribution and use of gases, filters for medical uses, electrolytic cell membranes, as well as some household articles, such as ironing boards and their covers, toasters, insulation panels for do-it-yourself household work, and portable heaters. This list is not exhaustive, for a wide variety of products contained asbestos, including toys and finished products sold at the retail level to the public (such articles for smokers as pipes and cigarette-holders).
Table 1 shows the trends in asbestos consumption in France according to the principal types of use from 1951 through 1975.

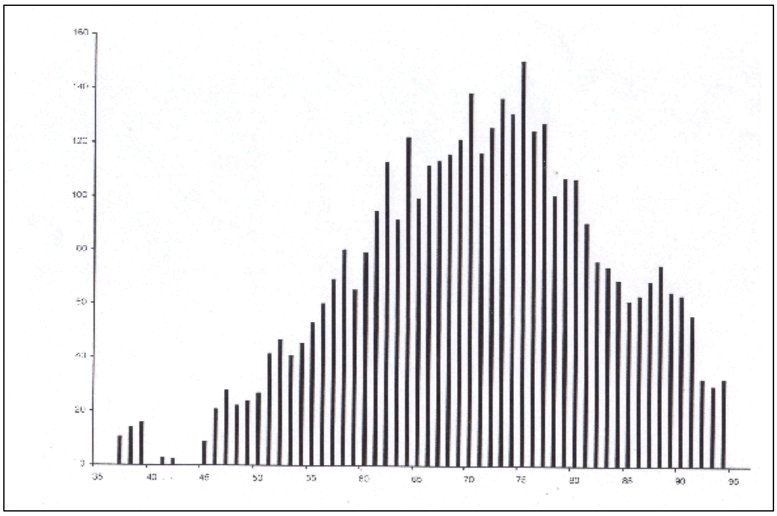
Table 1: Crude asbestos consumption in France by industry: 5-year means in tons (1951-1975)

	1951-55	1956-60	1961-65	1966-70	1971-75
Asbestos-cement	38,450	59,320	78,030	93,600	103,900
Floor covering	1,830	5,060	8,060	9,190	12,140
Spinning	1,970	3,440	3,060	3,670	4,160
Cardboard/paper	2,360	3,485	6,265	7,560	10,103
Gaskets	790	995	1,160	1,560	1,935
Friction linings	645	1,175	2,055	2,970	4,180
Molded insulation objects	2,260	2,180	2,730	2,790	2,715
Other	1,150	1,680	1,915	2,450	3,600

Source: Association française de l'amiante, 1996.

Figure 1 shows the trends in asbestos imports into France. These imports stopped in 1997, when asbestos was banned. We estimate that overall approximately 80 kg per inhabitant was imported into France from 1937 through 1995.

Figure 1: Asbestos imports into France, in thousands of tons (1937-1995)



Source: Association française de l'amiante, 1996.

1.2. Main circumstances of asbestos exposure

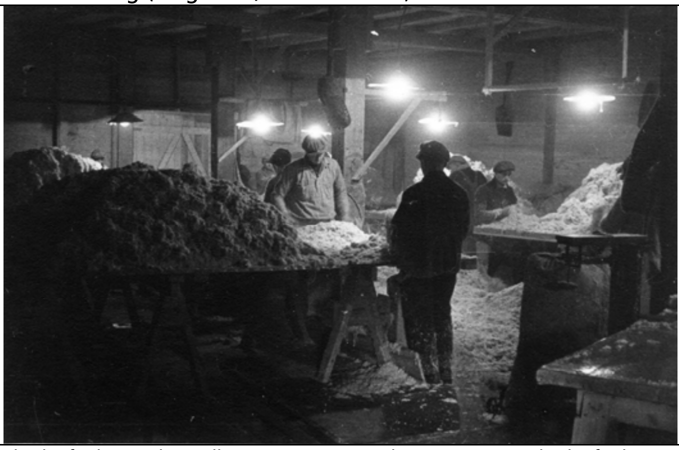
The diversity of its sources and the multiplicity of its uses make asbestos almost ubiquitous in the industrialized countries, and the circumstances of population exposure are quite varied.
By far the most important source of exposure in these countries is the workplace. Occupational exposure occurs to people who as part of their job produce or process asbestos or use it directly to produce different materials or products or for thermal or sound insulation or who work with asbestos-containing materials.
"Paraoccupational" exposure affects people in contact with workers in the first group, especially at their home. Wives or children, for example, may be exposed to asbestos dust, transported especially by work clothes.
We use the term "residential exposure" to designate other sources of pollution due to household objects containing asbestos (e.g., ironing boards, insulation panels, toasters, or portable heaters). Also in this category is exposure by individual do-it-yourself work (changing brake linings, building a garden shed of fiber cement, or changing asbestos-containing gaskets in, for example, kitchen stoves, gas cookers, or fireplaces).

Environmental exposures can be classified in three categories: pollution emitted by natural sources (geological sites), pollution emitted by an industrial point source (asbestos mine, asbestos-processing plant), and pollution emitted by asbestos installed in various buildings and other structures, the fibers of which can be released into the air due either to the deterioration or the operation of these installations.

1.2.1. Exposed occupations and industries

Because of the very widespread use of asbestos over time, the occupations concerned by exposures to it have changed across the decades. In the 1960s, the principal occupations affected were those involving the production and use of asbestos, and they led to massive exposure. Since the 1980s and 1990s, on the other hand, the jobs most often exposed to asbestos have been those that involve working on asbestos-containing materials; these result in discontinuous or occasional exposures. The multiplicity of uses for asbestos explains the large number of people exposed in the workplace. Two independent studies have estimated that approximately one quarter of all currently retired male wage-earners were exposed to asbestos at least once during their working life [1,2].

Image 2: Asbestos workers - Fiber cleaning (King Shed, October 1935)



Source: Centre d'archives de la région de Thetford, Canada – collection Musée minéralogique et minier de Thetford Mines (donateur : Alfred Lloyd Penhale).

Image 3: Asbestos - Worker on a rooftop

Source: Fotokris©: www.dreamstime.com.

1.3 Principal health effects

Asbestos induces mainly diseases of the respiratory system.

1.3.3 Asbestosis and pleural disease

The risks of pulmonary fibrosis, called asbestosis, are associated with especially high levels of asbestos exposure. Diverse forms of benign pleural damage are also associated with asbestos exposure. The most common of these is pleural plaques, calcified or not. Pleural thickening can also occur.

1.3.2 Mesothelioma

The pleura are the principal site of mesothelioma: pleural mesothelioma is five times more frequent than peritoneal mesothelioma, and all other sites are quite rare. The latency period between exposure and disease onset ranges on average from 30 to 40 years. No risk factor except asbestos exposure is currently known to be associated with mesothelioma.

1.3.3 Lung cancer

The latency period between exposure and disease onset ranges on average from 10 to 20 years. It has been clearly established that a causal association between asbestos exposure and lung cancer also exists among nonsmokers.

1.3.4 Other cancers

In 2009, the International Agency for Research on Cancer (IARC) also concluded that both **laryngeal** and **ovarian cancer** may be caused by exposure to asbestos fibers. A causal association with **colorectal cancer** is also strongly suspected [3]

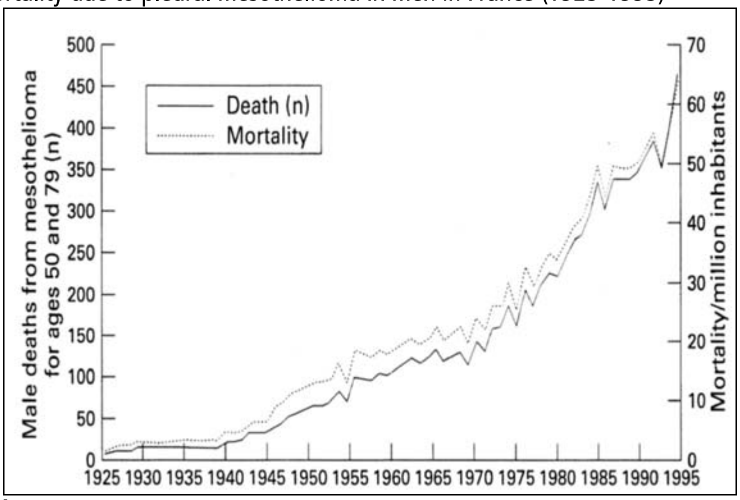
1.4 Trends in the incidence of pleural mesothelioma

Studies of the time trends of health problems induced by asbestos exposure are usually based on pleural mesothelioma. Because of the monofactorial nature of its etiology, pleural mesothelioma can be considered a specific marker of asbestos exposure at the population level. Moreover, an excess of mesothelioma in a population is always accompanied by an excess of lung cancers associated with asbestos exposure.

When cases with known exposure to sources of asbestos, occupational or not, are excluded, the baseline incidence of mesothelioma is very low (less than 1 case per million per year) and similar in men and women. Trends in the incidence of mesothelioma in men in industrialized countries show that a pandemic first appeared in the 1950s, with an increase of approximately 5 to 10% per year since then. This pandemic and its growth are closely linked to the introduction and development of massive asbestos use in industrialized countries. Because the proportion of women exposed occupationally in industrialized countries is much lower than that of men, the incidence rates of mesothelioma are clearly lower in populations of women.

Mortality from pleural mesothelioma increased in France at a constant rate from the 1950s through the end of the 1990s (Figure 2).

Figure 2: Trends in mortality due to pleural mesothelioma in men in France (1925-1995)



Source: Banaei et al, *2000 [4].*

Because asbestos exposure is very largely occupational, the rate of increase of mesothelioma incidence and mortality started to slow in the first decade of this century in several countries, such as the United States and the Scandinavian countries, where strict worker protection measures were implemented early. These trends are not homogeneous in all industrialized countries, however.

1.5 Prevention and management of people exposed to asbestos

France banned the import and use of asbestos in all its forms in 1997. This ban has applied to the entire European Union since 1st January 2005. This measure, as well as the strengthening of worker protection regulations, will have positive effects, but the long latency periods between asbestos exposure and the diseases it induces means that these effects will not be seen immediately. Past exposure will continue to cause disease for a long time to come. Moreover, although the use of asbestos is now forbidden, asbestos materials remain in a very diverse range of settings, and exposure continues.

1.5.1. Compensation for occupational diseases

The system of compensation for occupational diseases created in France in 1919 was designed to complete the workplace accident system set up in 1898. Since 1946, the national social insurance funds have been responsible for this insurance system, paid by employers. Currently, only employees (people who earn a salary, hourly, monthly, or otherwise) and farmers have this kind of insurance. The insurance funds for self-employed workers offer no coverage for occupational risks.

Two items of the French occupational diseases system govern the compensation of diseases due to occupational asbestos exposure. The first covers "Occupational diseases following inhalation of asbestos dust" (Table 30 of the general employees social insurance system, the RGSS, and Table 47 of the farmer and agricultural worker fund, the MSA), the second, "Bronchopulmonary cancer induced by the inhalation of asbestos dust" (Table 30bis of the RGSS and 47bis of the MSA).

Additionally, any person harmed by the effects of asbestos can obtain indemnification for this damage from a specially created fund, the Fund for indemnification of victims of asbestos (Fiva), established in 2002 by decree dated 23 October 2001.

1.5.2. Post-retirement follow-up

Although France has a system for dealing with the occupational health problems of current employees, based mainly on monitoring by occupational physicians, no institution is responsible for monitoring work-related health problems in retirees. The only existing regulatory scheme is the post-retirement medical follow-up for former workers exposed to carcinogenic substances or processes during their working life (article D. 461-25 of the Social Security Code). The post-retirement follow-up is financed by the National Health and Social Action Fund of the RGSS, after approval by the occupational accident and disease department (AT-MP) of the primary health insurance fund (CPAM) This system covers only retirees covered by this general fund for employees, although the proportion of self-employed workers exposed to asbestos is particularly high.

Recently, the National Authority for Health (HAS) has developed guidelines intended to update this regulation. After public hearings, HAS published guidelines in April 2010 (www.has-santé.fr). The first recommendation (R1) specified that "Persons occupationally exposed to asbestos must be able to receive post-retirement follow-up regardless of the social insurance fund that covers them (employees, self-employed, government workers, etc.)" [14].

2. Principal indicators of occupational risks due to asbestos

Data sources used to establish these indicators[1]

Occupational history samples and job-exposure matrices - DST*.

National Mesothelioma Surveillance Program (PNSM): General Presentation and Assessment of Its Early Years of Operation (1998-2004). InVS, 2006*.

Francim network of cancer registries: estimation of incidence of and mortality from cancer in France from 1980 through 2005.
(http://www.invs.sante.fr/surveillance/cancers/estimations_cancers/default.htm)

Centre d'épidémiologie des causes de décès (CépiDC-Inserm).
(http://www.cepidc.vesinet.inserm.fr/)

ESPrI Program* (http://www.invs.sanre.fr/surveillance/espri/) and Spirale Program.
(http://www.spirale.rppc.fr/amiante/html)

National Health Insurance Fund (Occupational risk department) (http://www.risquesprofessionnels.ameli.fr/)

Fund for indemnification of victims of asbestos (Fiva) (http://www.fiva.fr/)

[1] The sources from the DST marked with an asterisk are described below.

2.1. Exposure indicators

The indicators of exposure prevalence distinguish between **point prevalence**, that is, the proportion of people exposed in the population at a given moment, and **lifetime prevalence,** that is, the proportion of persons exposed to asbestos at least once during their working life. These two indicators are complementary:

- point prevalence is especially useful for estimating the extent of the problem at a given moment, and analysis of its trends over time make it possible to guide and assess prevention;
- lifetime prevalence is more appropriate for studying health risks, because it has been clearly established that the cumulative lifetime asbestos dose is linearly associated with the cancer risk.

Because of the very long latency periods between asbestos exposure and the cancer risk, the exposure values reported here cover the 1990s, since current health problems are due to exposures from that period.

The data used come from linking a sample of job histories to a job-exposure matrix specific for asbestos, developed at the DST (see the Matgéné program).

Representative sample of the French population

To describe the prevalence of occupational exposure in the French population as well as its course over time and to assess lifetime exposure, a sample was set up and then linked to the Asbestos job-exposure matrix of the Matgéné program. This sample is representative of the French population aged 25 to 74 years in 2007. Sex, region of residence, age and socio-occupational category were taken into account in setting it up. This sample therefore includes simultaneously people currently working, people who are retired, and others who are not in the labor force.
Each subject's complete job history was reconstructed (including periods of unemployment or out of the labor force). The following information was provided for each job: job title, industry, year job began and ended, and if it was a full-time or part-time job. Other data were collected for farmers (agricultural area, type of crops, number of employees) and the self-employed (number of employees).
This sample contained **10,010 subjects** including 4,758 men (47.5%) and 5,252 women (52.5%). On average, each individual had 2.8 jobs — 3.1 for the men and 2.6 for the women.

Exposure levels were established with a composite index, the product of the mean of the intensity and the frequency of exposure. Two sets of indicators were computed: first, all exposure levels were considered; next, only substantial levels (intermediate and high, that is, >0.1 f/L) were considered, with low exposure levels considered equivalent to no exposure.

2.1.1. Point prevalence by sex and age group

Table 2: Trends in the point prevalence of exposure, 1950-2007

	All exposure levels combined	
	Men	Women
1950	24.1%	37%
1960	17.2%	1.9%
1970	15.7%	2.1%
1980	14.4%	1.4%
1990	12.5%	1.0%
2000	6.2%	0.4%
2007	1.4%	0.1%

Source: DST-InVS.

Comments

These data, because they are calculated from people alive at the time of the survey (2007), do not really allow to describe the trends in exposure prevalence. They nonetheless show that on the whole the proportion of asbestos-exposed workers has dropped substantially over time, falling from 24.1% of men in 1950 (3.7% of women) to 1.1% of men (0.1%) in 2007.

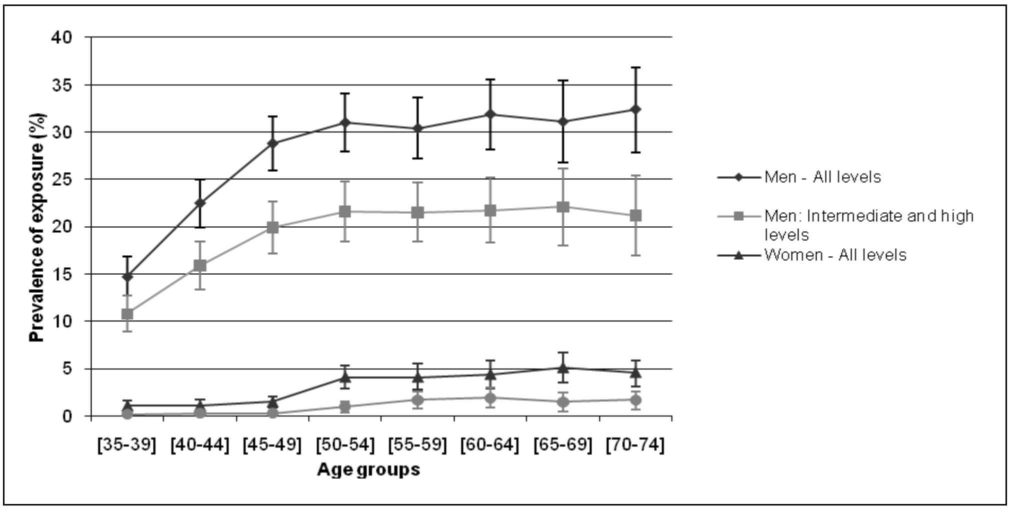
2.1.2. Prevalence for entire working life by sex and age group

Table 3: Prevalence of cumulative occupational exposure through 1995 in men and women

	Men		Women	
	All levels % exposed [95% CI]	Intermediate and high levels % exposed	All levels % exposed [95% CI]	Intermediate and high levels % exposed
All ages	22.6% [21.6-23.6]	15.8% [14.9-16.7]	2.4% [2.1-2.7]	0.78% [0.6-0.9]

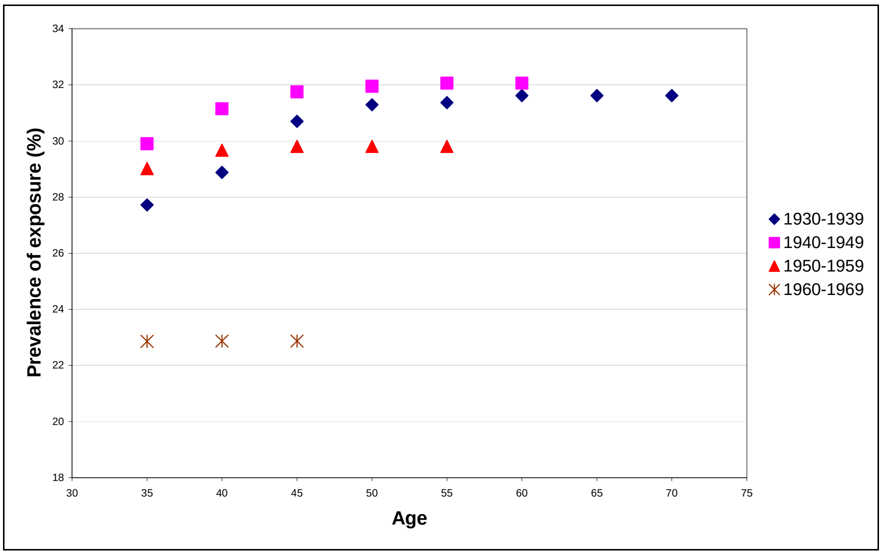
Source: DST-InVS/Essat Université Bordeaux 2- InVS.

Figure 3: Prevalence of cumulative occupational exposure through 1995 in men and women by age group (2007)



Source: DST-InVS.

Figure 4: Prevalence of cumulative occupational exposure through 1995 in men (all exposure levels combined), by age (2007) and 10-year birth cohort



Source: DST-InVS.

Table 4: Population of retired men (2005-2007): Career cumulative occupational exposure according to principal industries for employees and self-employed tradesmen

Industries (ISIC Revision 2)		Wage-earners (N=12 002[1])		Self-employed tradesmen(N=1371[2])	
		Subjects (%)	Exposed (%)	Subjects (%)	Exposed (%)
331	Manufacture of wood and wood products, including furniture	9.8	23.5	4.7	50.8
37	Basic metal industries	9.2	58.9	*	/
3381	Manufacture of fabricated metal products, machinery and equipment	12.1	55.4	7.4	67.3
3841	Shipbuilding and repairing	8.1	69.2	*	/
5000	Construction	30.8	50.3	63.4	97.9
9513	Vehicle repair	8.4	73.3	12.7	92.0

Sources: Spirale - Inserm U 1018 CESP and ESPrI – DST-InVS programs.

[1] Participants in Spirale pilot program (2006-2007).

[2] Participants in the "ESPrI" pilot program (2005-2007).

* Fewer than 10 subjects.

Image 4: Shipyard

Source: Caramaria© : www.dreamstime.com.

Comments

Even when considering only intermediate and high exposures, a substantial number of men — more than 10% for most age groups — were exposed during their working life. The prevalence of lifetime exposure nonetheless varied substantially according to age group and birth cohort, reflecting the history of the introduction and distribution of asbestos in France. When we consider birth cohorts, we observe that the cohorts of men born between 1940 and 1950 were exposed most frequently. Because the health effects occur so long after exposure, the long-term consequences of these exposures are worrisome. The cohort of men born in the 1960s, the most recent, is clearly less exposed than the others.

Self-employed tradesmen are more frequently exposed to asbestos than wage-earners in the principal industries, due to the greater diversity of occupations of employees and their higher proportion of non-manual jobs. When all lifetime exposure is considered, regardless of level, we estimate that approximately one quarter of the population of retired men employees were exposed, and the double of this proportion for self-employed tradesmen. The construction industry accounts for by far the largest number of current retirees exposed to asbestos.

2.2. Population health impact indicators

We present two categories of impact indicators:

- health indicators of the frequency of diseases due to asbestos exposure;
- indicators of the distribution of these diseases within the French population.

2.2.1. Health indicators

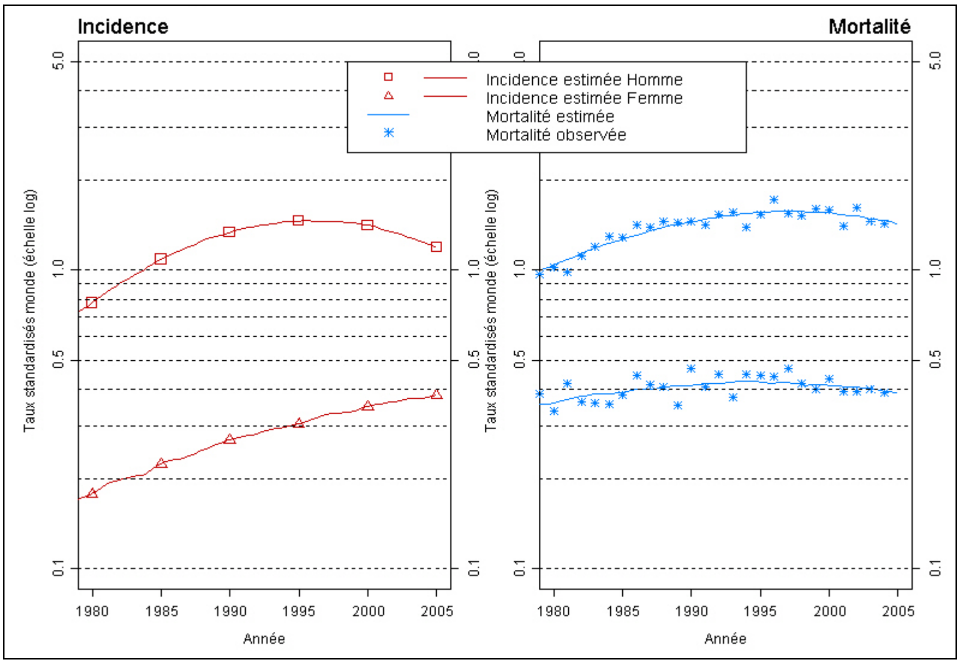
The primary indicator of the health impact of asbestos is pleural mesothelioma (with other primary pleural cancers). Only a very few sufficiently reliable indicators exist to describe the frequency of other health problems induced by asbestos exposure. Nonetheless, the monofactorial character of its etiology makes pleural mesothelioma a specific marker of past asbestos exposure at the population level, and it is closely associated with other diseases due to asbestos

2.2.2. Pleural mesothelioma

2.2.2.1. Incidence (Sources: Francim and PNSM)

The Francim network of cancer registries has estimated trends in the incidence of pleural cancer and mortality from it for France as a whole from 1980 through 2005. Note that until 2000, the International Classification of Diseases did not distinguish pleural mesotheliomas from other malignant neoplasms of the pleura. Nonetheless these tumors are quite rare, and the frequency of pleural cancer is an accurate reflection of that of mesothelioma.

Figure 5: Pleural cancer: chronological trends of incidence and mortality - France, 1980-2005, in men and women.

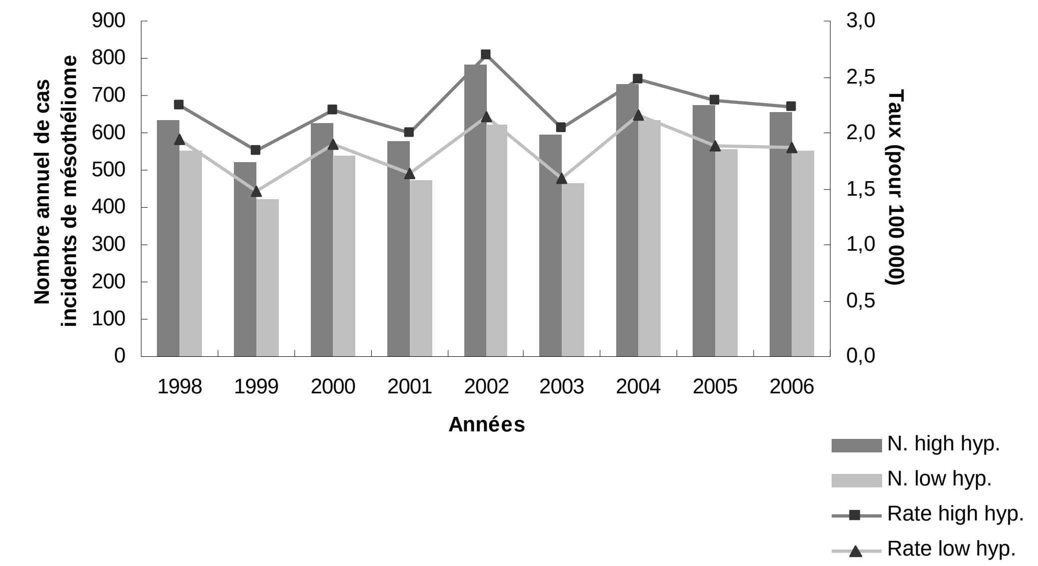


Sources: Francim and InVS.
Note: taux standardisé monde (échelle log): world standardized rates (log scale); année: year; incidence estimée homme: estimated incidence men; incidence estimée femme: estimated incidence women; mortalité estimée: estimated mortality; mortalité observée: observed mortality.

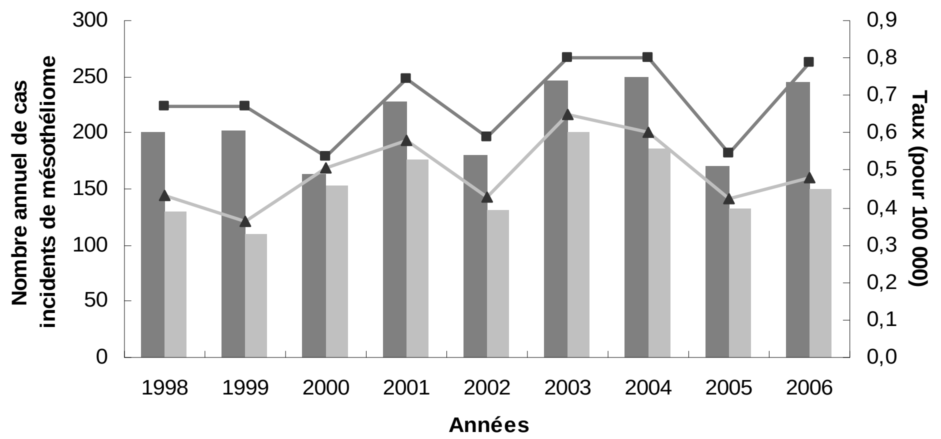
The PNSM, coordinated by the InVS DST, began operations in 1998. This program records all cases of pleural mesothelioma diagnosed in 22 districts of France. It has furnished estimates of the consolidated national incidence through 2006. Figure 6 presents the minimum and maximum estimates of the annual number of incident cases of mesothelioma, in men and in women, based respectively on a low hypothesis that includes only cases certified by an expert group assessment (pathology or clinical) and a high hypothesis that does not exclude any cases.

Figure 6: Estimated annual number of certified incident cases of pleural mesothelioma and their crude rate (per 100,000) in France, in men and in women, 1998-2006.

Men



Women



Source: PNSM (DST-InVS).
Note: nombre annuel de cas incidents de mésothéliome: annual number of incident cases of pleural mesothelioma ; années: years.

Comments

The projections by Francim from the registry data show a strong and regular increase in both incidence and mortality in men from the end of the 1970s through 2000, followed by a decrease through 2005. This increase is still more marked among women.
The PNSM data appear to show that the trend has been stabilizing since around 2000, among both men and women. That is, globally, for the entire 1998-2006 period, no particular trend has been observed, and the annual number of incident mesothelioma cases may be estimated at 535-645 among men and 152-210 among women. The crude incidence rates range from 1.85 to 2.23 per 100,000 in men and 0.5 to 0.68 in women. Nonetheless, because of the relatively short period of this monitoring, confirmation is required over a longer period.
The two sources (Francim registries and PNSM) are not strictly comparable for the period considered. Specifically, the geographic area covered by these two systems overlaps only partially, and the PNSM diagnoses are more reliable because of the systematic clinical and pathological review of all cases.

2.2.2.2. Mortality (Source: CépiDc-Inserm)

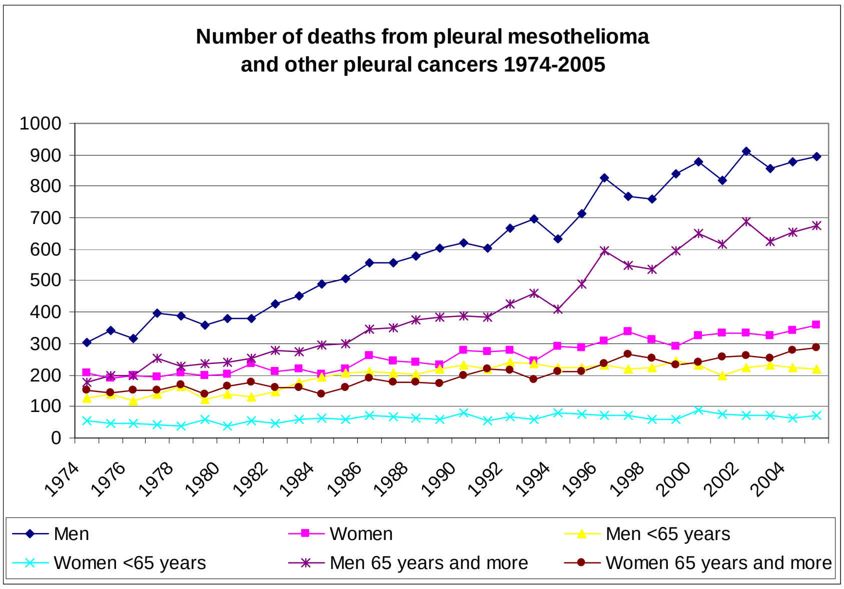
The diagnoses of pleural mesothelioma on death certificates are not completely reliable, and both under- and over-registration exist. Nonetheless, from the perspective of a study of time trends, this problem is relatively minor. The mortality data remain very useful, especially to the extent that mesothelioma is still a highly lethal disease and France has collected exhaustive mortality data according to cause since 1968.
We present here the number of deaths from and mortality rates for pleural mesothelioma from 1975 through 2005. The International Classification of Diseases has undergone three revisions during this period, with different coding for pleural mesothelioma in ICD-8 (1974-1978), ICD-9 (1979-1999), and ICD-10 (2000-2005). We cannot rule out the possibility that changes in nomenclature, especially the move to ICD-10, which for the first time differentiated mesothelioma from other malignant pleural neoplasms, influenced the trends observed, but if this effect exists, it is likely to be marginal.

Table 5: Number, rate, and trends in deaths from pleural cancer*, by sex and age – 1975-2005

	All ages			<65 years			65 years and older		
	n	Rate[a]	% change	n	Rate[a]	% change	n	Rate[a]	% change
Men									
1975	340	1.7		140	0.7		200	7.9	
1985	507	2.4	41%	208	0.9	29%	299	11.7	48%
1995	714	2.9	21%	223	0.9	0%	491	15.2	30%
2005	893	3.0	3%	218	0.8	-11%	675	16.5	9%
Women									
1975	189	0.7		47	0.2		142	3.5	
1985	221	0.7	0%	59	0.2	0%	162	3.7	6%
1995	286	0.8	14%	76	0.3	50%	210	4.1	11%
2005	358	0.9	13%	71	0.3	0%	287	4.6	12%

Source: CépiDc-Inserm.
* Deaths from pleural cancer:ICD-8 =163.0 (1974-1978); ICD-9=163 (1979-1999); ICD10=C45.0, C45.9, C38.4 (2000-2005).
[a] Age-standardized rates (reference population: France 1990).

Figure 7: Trends in the number of deaths from pleural cancer by sex and age – 1974-2005



Source: CépiDc-Inserm.
NB: change of ICD version in 1979 and 2000.

Comments

Trends in mortality, like those for incidence, show a substantial overall increase for the period 1975-2006 for both sexes, a rise that appears to have stabilized over the most recent period. This stabilization involved the youngest cases, while the trend to increased mortality continued in those 65 years or older. This phenomenon may correspond to a diminution in asbestos exposure that began around the end of the 1970s, when the first asbestos-related worker-protection regulations were implemented. Because of the very long latency periods, the oldest generation, which was exposed earliest, would have benefited least from this reduction in exposure. Although the mortality rate has appeared to be stabilizing or even falling in recent years, the absolute number of death continues to increase. This apparent contradiction simultaneously reflects the increased size and the aging of the population. The age-standardized rates smooth out these phenomena.

2.2.2.3 Occupational exposure-attributable fractions for mesothelioma (Source: PNSM)

Globally, the occupational exposure-attributable fraction of the risk of pleural cancer and mesothelioma in the French population (that is, the theoretical proportion of cases that would be avoided if this exposure did not exist) is 83.2% (95% CI: 76.8-89.6) in men and 38.3% (95% CI 26.6-50.0) in women.

Comments

The large male predominance in the manual jobs causing exposure explains the substantial difference in the attributable fraction for occupational exposure according to sex. The fraction not attributable to occupational exposure is probably due to domestic, paraoccupational, and environmental asbestos exposure, especially that due to residence near large industrial polluters

2.2.3. Other respiratory diseases

2.2.3.1. Lung cancer

Table 6: Fraction and number of cases of lung cancer attributable to occupational asbestos exposure (intermediate and high levels) in men and women aged 25-75 years in 2007. (Exposure prevalence data for 1995)

	Men		Women		All
	L[c]	H[c]	L[c]	H[c]	
Fractions of lung cancers attributable to occupational asbestos exposure[a]	8.2%	13%	0.4%	1%	
Number of cases of lung cancer attributable to occupational asbestos exposure between the age of 25 and 75 years[b]	1,488	2,359	20	50	1,508-2,409

Source: DST-InVS.

[a] *Attributable fractions calculated taking population age into account, low hypothesis: only exposures>0.1 f/mL were included, high hypothesis: all exposures.*

[b] *Calculated from data published by InVS: Lung cancer, estimates 2005: www.invs.sante.fr, age groups 25-74 years.*

[c] *Low (L) and high (H) estimates.*

Comments

Contrary to mesothelioma, there is no, studies for lung cancer from which the number of cases attributable to occupational asbestos exposure in France can be directly estimated. We therefore used assessments of the fractions of cancer attributable to occupational asbestos exposure. These assessments are based on solid epidemiologic data published in the international literature. For the risk of lung cancer associated with occupational asbestos exposure, the global relative risks calculated by Goodman et al.[6] in a meta-analysis of 69 occupational cohorts were used. These relative risks were applied to the cumulative prevalent exposure rates in the French population for those aged 25-75 years in 2007, asbestos exposure 10 years earlier not being taken into account. Two levels of exposure were considered: only exposure greater than 0.1 f/mL/year and all exposure levels. The number of annual cases of lung cancer due to occupational asbestos exposure ranged from 1,508 to 2,409 depending on the hypothesis applied. This is a relatively wide interval, and the real number is probably somewhere within this range.

2.2.3.2. Non-cancer respiratory disease

There are no large national studies that provide prevalence or incidence data for non-cancer respiratory disease due to asbestos. Here we used data collected from a large sample of self-employed tradesmen included in the ESPrI Program of post-retirement asbestos follow-up. They all underwent computed tomography of the chest to look for radiologic abnormalities. Although not representative of the population of asbestos-exposed workers, this sample allows us to estimate the order of magnitude of the frequency of pleural and pulmonary abnormalities in subjects occupationally exposed to asbestos dust.

Table 7: Population of retired self-employed tradesmen: disorders identified in subjects who underwent a chest CT scan as part of a medical work-up.

	Subjects who had a medical work-up (N=1350[a])	
	N	%
At least one non-normal pathology finding	220[b]	16.3
Benign pleural disease	183	13.6
Pulmonary fibrosis	43	3.2
Suspected cancer (lung/pleura)	12	0.9
No abnormal findings	1,090[c]	80.7
Inconclusive medical work-up	40	3.0

Source: ESPrI Program, 2005-2008 – DST-InVS.
[a] *Subjects in the ESPrI program (2005-2008).*
[b, c] *Isolated pulmonary nodule found for 36 of 220 subjects and 143 of 1090 subjects.*

Comments

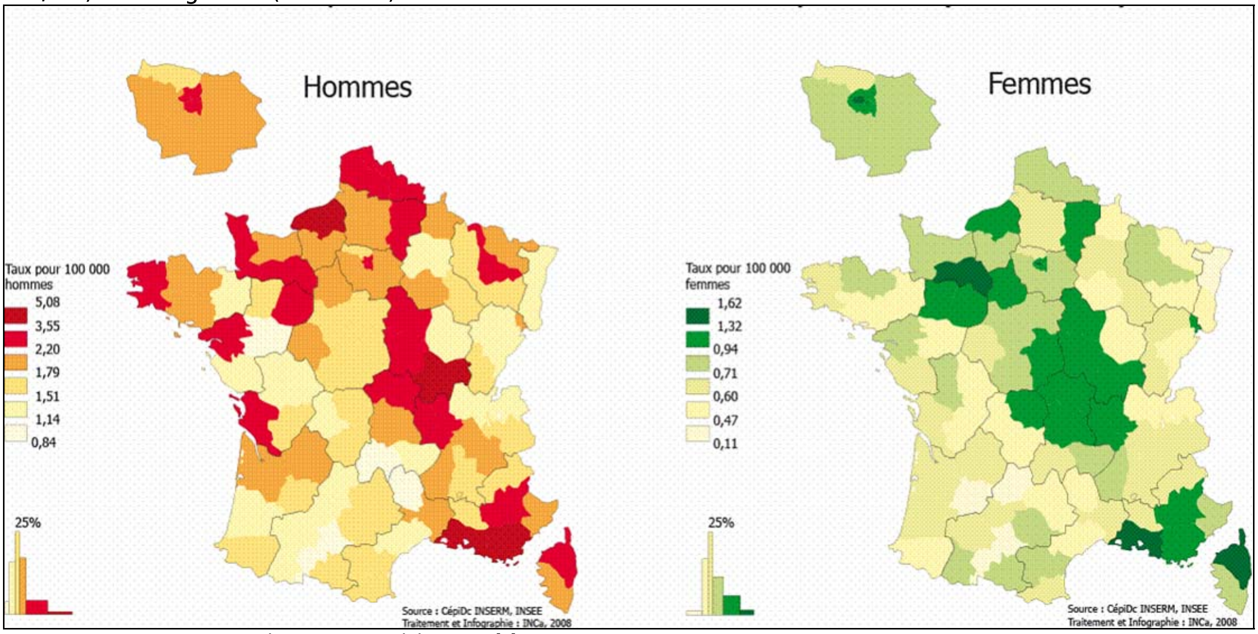
Among retirees exposed to asbestos and benefiting from post-retirement follow-up, more than 15% had a radiologic thoracic abnormality, mainly benign pleural diseases. These findings about self-employed tradesmen are similar to observations in a population of asbestos-exposed retired wage-earners.

2.3. Indicators of population distribution of pleural mesothelioma

2.3.1. Geographic distribution of mortality

The only data source available is CépiDc, which is in charge of coding the medical cause of deaths in France.

Figure 8: Disparities between districts in metropolitan France for mortality from pleural cancer (standardized rate per 100,000) according to sex (1974-2005)



Source: CépiDc-Inserm, InVS and Institut national du cancer [8].
Note: hommes: men; femmes: women; taux pour 100 000: rate per 100,000.

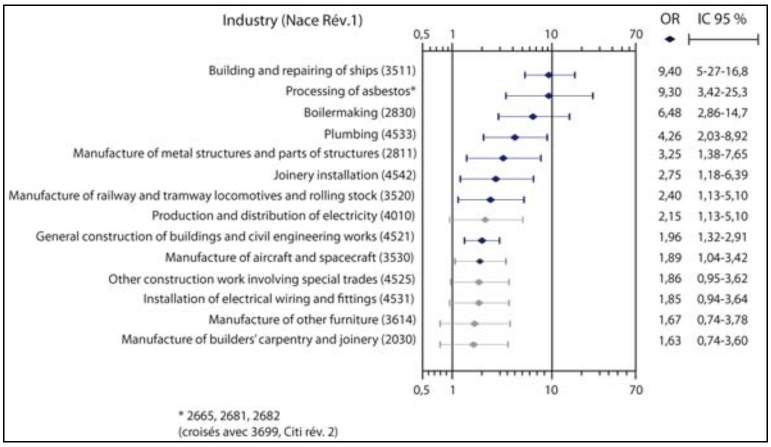
Comments

Very clear-cut geographic disparities were observed. They were strongest among men, but their distribution among men and women was related. These differences do not show regular spatial structures and correspond to variable levels of industrialization. The ship-building industry in some coastal regions (Paca, Haute-Normandie, and Nord-Pas-de-Calais), with its high historical exposure levels, probably explains the high levels of mortality there.

2.3.2. Distribution by industry and occupation

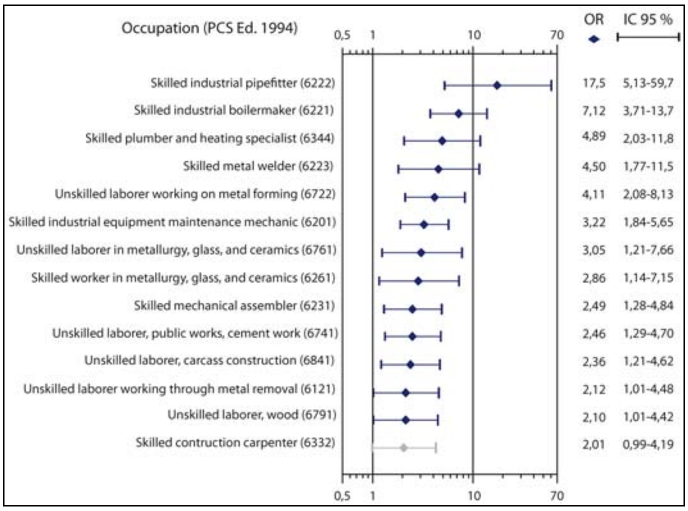
Figures 9 and 10 present, for each occupation and each industry, the risk of mesothelioma, estimated by an odds-ratio (OR) that corresponds to the risk among subjects who worked for at least one year in the occupation or industry, compared with subjects who never did.

Figure 9: Risk of pleural mesothelioma by industry in men (incident cases, 1998-2002)



Source: PNSM [9] DST-InVS.

Figure 10: Risk of pleural mesothelioma by occupation in men (incident cases, 1998-2002)



Source: PNSM [9] DST-InVS.

Comments

High risks were found not only in the industries involving the processing of asbestos and manufacture of asbestos products, but also in industries where large quantities of asbestos were used: ship construction and repair, insulation and maintenance of installations and machines, metalwork, construction, and manufacture of railroad equipment. The occupations at the highest risk are industrial pipefitters, boilermakers, industrial sheet metal workers, plumbers, heating engineers, and metal welders.

The industries at highest risk of developing pleural mesothelioma are not those with the highest number of exposed workers (see Exposure indicators, Table 3). The risk of mesothelioma according to industry is determined by the exposure levels prevalent there, independently of the number of employees. The number of persons exposed, on the other hand, is essentially explained by the number of workers in the industry.

Image 5: Foundry

Source: Dragan Trifunovic©: www.dreamstime.com.

Image 6: Lagging

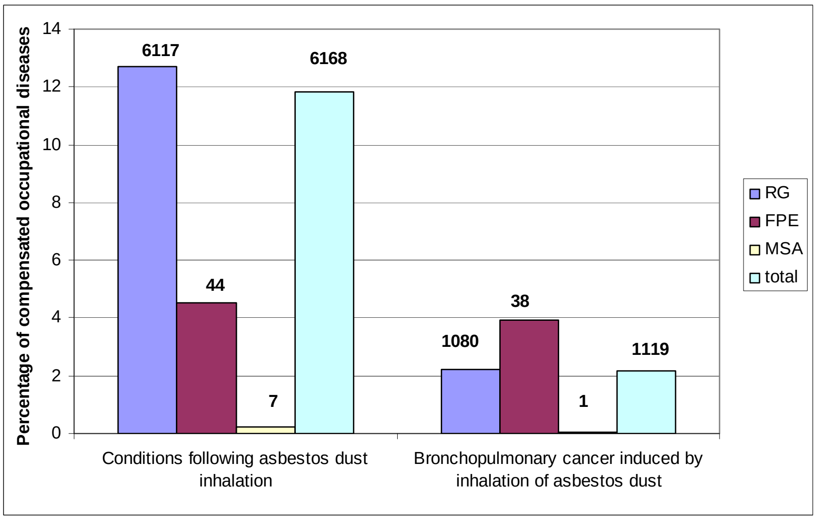
Source: Bernau©: www.dreamstime.com.

2.4. Indicators of compensation

2.4.1. Distribution of compensated asbestos-related diseases according to insurance fund

In 2004, workers covered by three separate social insurance systems (national government civil servants in FPE, wage-earners under the RGSS, and those covered by the Agricultural fund or MSA), had 6,168 occupational diseases reported that were officially recognized as such according to the list of "Occupational diseases following inhalation of asbestos dust" and 1,119 according to the list of "Bronchopulmonary cancers induced by the inhalation of asbestos dust." Figure 11 shows the distribution of diseases associated with asbestos exposure according to insurance fund and for all employees of all three funds.

Figure 11: Proportion and number of occupational diseases associated with inhalation of asbestos dust compensated in 2004 in current or former employees covered by the social insurance funds for employees in general, agricultural workers, and civil servants



Source: CnamTS [10], MSA [11], and FPE [12].

Comments

Overall, occupational diseases associated with asbestos exposure in 2004 accounted for nearly 14% of all the occupational diseases compensated in these three working populations. They ranked second, after musculoskeletal disorders, which were by far the most common occupational disease (approximately 70%). They occurred among employees and civil servants, but not agricultural workers. Pleural plaques accounted for 70% of the compensated asbestos-related occupational diseases among wage-earners. The prevalence rate of these conditions is very low before retirement: 0.62 per 100,000 employees (Table 30) and 1.2 per 100,000 employees (for Table 30bis) in 2004. The diseases had not yet had the time to develop symptoms and be diagnosed.

2.4.2. Trends in the compensation of asbestos-related occupational diseases in the general employees social insurance fund (Source: CnamTS [13])

Due to the lack of centralization of the different health insurance funds data, the data reported below concern only the RGSS.

From 2004 to 2007, the number of cases of compensated occupational diseases as covered by Table 30 fell, dropping from 6,117 cases in 2004 to 5,161 in 2007. This reduction is due principally to the fall in the number of compensated cases of pleural plaques, by far the most common disease listed in Table 30. This number dropped from 4,272 in 2004 to 3,633 in 2007. On the other hand, the number of compensated cases of pleural mesothelioma varied little during this period: there were 416 in 2004, and 355, 403 and 379 in the years that followed. The same is true for the number of cases of lung cancers compensated under Tables 30B and 30A (1,214 in 2004, 1,193 in 2005, 1,161 in 2006, and 1,240 in 2007).

The number of lung cancers attributable to occupational asbestos exposure was estimated in 2007 (see section 2.2.4.1); it ranged among men aged 25-75 years from 1,488 to 2,359, and among women of the same age from 20 to 50. The estimated total number of incident cases of lung cancer attributable to occupational asbestos exposure therefore ranged from 1,508 to 2,409 for those aged 25-75 years.

The number of patients with pleural mesothelioma due to occupational asbestos exposure ranged from 503 to 617 in both sexes, all age groups combined, according to the PNSM data. Applying a reduction of 20% to this estimate to take into account that it includes cases from other health insurance funds, one would expect to observe 430 to 494 cases receiving compensation as an occupational disease. Roughly, then, 18 to 28% of the occupational cases of pleural mesothelioma receive no compensation. The comparison is less precise for lung cancer, the estimates being limited to the 25-75 year-old age group, while the compensation data are not reported by age, so that the number of cancers for which compensation is provided in persons aged over 75 years is unknown. We note nonetheless that in 1999, only 458 lung cancers received compensation as an occupational disease, a figure corresponding to 27% of the expected number, while in 2007 this proportion was around 60% (Table 8).

Table 8: Estimated number of cases of lung cancer and of pleural mesothelioma attributable to occupational asbestos exposure and the number of cases compensated by the RGSS*.*

	Men and Women
Number of cases of lung cancer attributable to occupational asbestos exposure in persons aged 25 to 75 years in 2007 (reduction of 20% for the RGSS alone)	1,206-1,927
Number of cases of pleural mesothelioma attributable to occupational asbestos exposure, all ages combined – 2005 (source PNSM)	430-494
Lung cancers awarded compensation in 2007 – RGSS all ages combined[a]	1,240
Pleural mesotheliomas awarded compensation in 2005 – RGSS all ages combined[a]	355

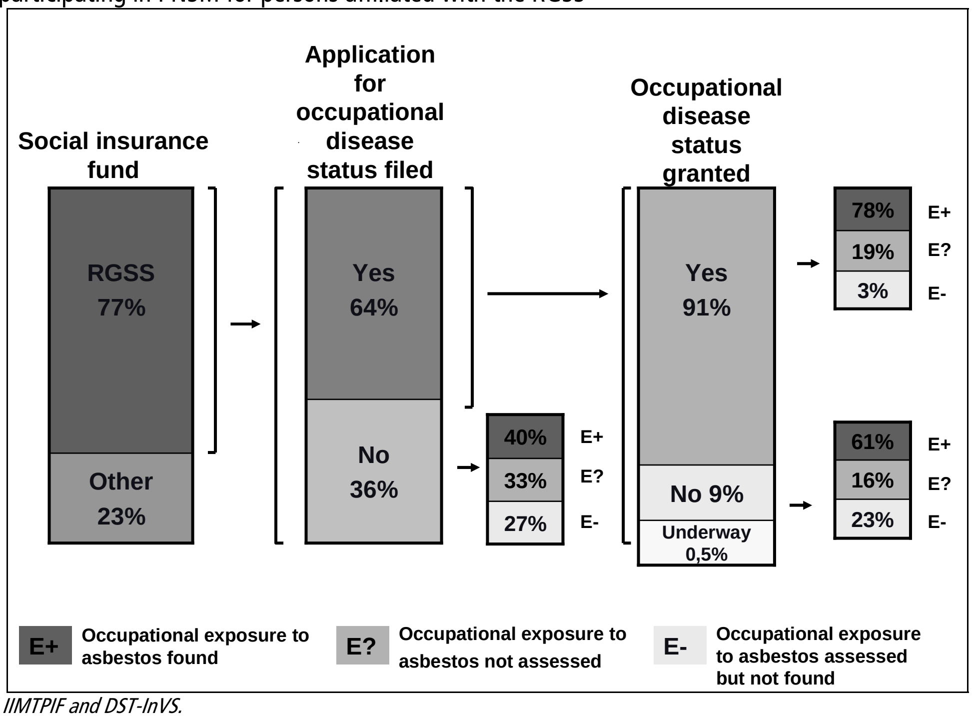
Source: DST-InVS.

[a] *Source CnamTS-Occupational risk branch. Enumeration of occupational diseases reported and recognized as such by the RGSS 2004-2007. Study 2009-0051v1; March 2009.*

2.4.3. Applications for compensation as an occupational disease for persons with mesothelioma covered by the general employees health insurance fund (Source: PNSM)

Here are only reported the cases with a full exposure assessment diagnosed in the districts participating in PNSM, and who were covered by the RGSS, which provides insurance for more than 80% of the French population.

Figure 12: Compensation as an occupational disease of cases of mesothelioma diagnosed between 2005 and 2007 in all districts participating in PNSM for persons affiliated with the RGSS



Source: PNSM IIMTPIF and DST-InVS.
NB: Individual occupational exposure was assessed as part of PNSM.

Comments

Of those with mesothelioma and covered by the RGSS, which provides occupational disease compensation, only 64% applied for compensation as an occupational disease (71% of the men and only 32% of the women). A more detailed analysis of the PNSM data shows that the proportion of cases seeking compensation increased with the strength of the probability of high asbestos exposure: 81% of the men (and 71% of the women) with probable or very probable asbestos exposure applied, compared with 30% of those who were not exposed (17% of the women). Among the patients not making such an application, a substantial proportion (40%) were nonetheless exposed and could have received compensation. Finally, the denials of compensation (9%) were mainly for administrative reasons.

2.4.4. Compensation fund for asbestos victims (Fiva)

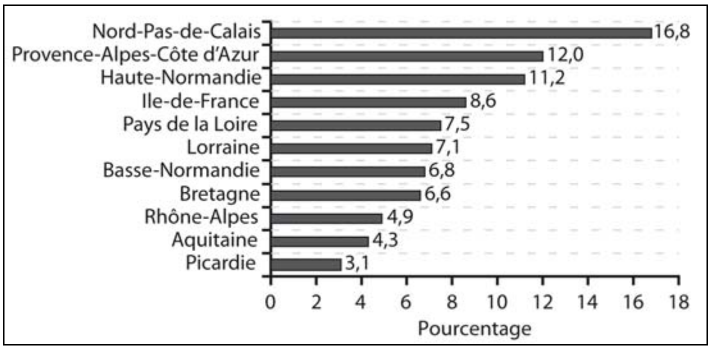
FIVA, established in 2002, now rounds out the compensation procedures for all the health insurance funds, and any person with a disease due to asbestos exposure in France can receive compensation, regardless of the source (occupational or not) of exposure and regardless of insurance status.

Table 9: Annual number of compensation applications to Fiva (2002-2008)

Year	Annual total	Monthly mean	Trends
2002	3,229	538	
2003	7,774	648	20.4%
2004	8,040	670	3.4%
2005	8,467	706	5.3%
2006	8,929	744	5.5%
2007	10,771	898	20.6%
2008	6,563	547	-39.1%

Source: Fiva.

Figure 13: Geographic distribution of applications for compensation in 2008 (percentage of total requests)



Source: Fiva.

Comments

Since FIVA was set up in 2002, it has identified 53,773 victims through 2008, 6,553 of them in 2008. The number of new claims increased regularly each year through 2007, when the annual augmentation was highest (+ 20.6%) since the fund's creation. Except for the very first years of its implementation, when a catch-up phenomenon was likely, the causes of the regular increase in the number of new requests are difficult to explain. A notable decrease was seen in 2008 and has to be confirmed in the years to come.
From a geographic perspective, 82% of the victims seeking compensation from Fiva come from seven regions, and nearly half from the first four of these. The geographic origin of the claims is consistent with the distribution of the disease (See, Maps of mesothelioma mortality, page 20).

2.4.5. Post-retirement follow-up

No national data are available about the number of people followed in this program, but it appears quite low: an (unpublished) survey by CnamTS of its local offices reports 3300 people receiving post-retirement follow-up from 1995, when the program began, to 2002.
No more recent data are currently available at the national level, but the Spirale program actively searched for eligible retirees in 14 districts (14, 22, 30, 31, 33, 34, 44, 45, 59, 73, 75, 76, 86, and 90), and its results make it possible to observe trends from 2002 to 2008 (Table 10).

Table 10: Trends in the number of workers receiving regulatory post-retirement follow-up from the RGSS in 14 districts (2002-2008)

	Cases receiving regulatory post-retirement follow-up			
	Applications		Acceptances	
Year	N[a] including (via Spirale)	Impact of "Spirale"[c]	N[a] including (via Spirale)	Impact of "Spirale"[c]
2002	592 (0)	/	544 (0)	/
2003	724 (0)	/	600 (0)	/
2004	1,636 (0)	/	1,361 (0)	/
2005	1,692 (0)	/	1,430 (0)	/
2006[b]	1,217 (133)	+ 12.3%	1,043 (119)	+ 12.9%
2007	1,508 (489)	+ 47.9%	1,300 (399)	+ 44.3%
2008[d]	1,198 (227)	+ 23.4%	998 (194)	+ 11.7%

Source: Spirale - Inserm U 1018 CESP.
[a] *Number of requests (Information collected retrospectively from 14 CPAM in the "Spirale" program (2006-2007)).*
[b] *2006: year of implementation of pilot "Spirale" program.*
[c] *Impact of "Spirale": proportion of additional people receiving follow-up due to the Spirale program= number of cases via Spirale/ number of total cases - number of cases via Spirale.*
[d] *Provisional data.*
[e] *Number of follow-ups accepted.*

Comments

Only former workers covered by the RGSS can currently receive post-retirement medical follow-up under current regulations. The application of this program appears to remain very limited, although national data about the number of recipients are not available. The experience of the Spirale project, as well as that of the ESPrI project, shows that an active search directed at the entire population of retirees can substantially increase the number of recipients (Table 10).
It is important to note that in April 2010 [14] the National Authority for Health (HAS) issued guidelines for the post-retirement follow-up of retired workers who were exposed to asbestos, including procedures for their identification and medical follow-up. The first guideline (R1) states: "People occupationally exposed to asbestos must be able to receive post-retirement follow-up regardless of their social insurance system (employees, the self-employed, government workers, etc.)".

3. Activities of the InVS Department of Occupational Health for surveillance of asbestos-related occupational risks

Since its creation in 1998, the DST of InVS has developed epidemiologic surveillance programs specifically directed at the occupational risks associated with asbestos. These programs are described below.

3.1. Ev@lutil

The Ev@lutil program is built on a set of databases about occupational exposure assessment for asbestos fibers and man-made mineral fibers (MMMF) and accessible by Internet. MMMF are defined as mineral wools (glass, rock, and slag), refractory ceramic fibers (RCF), continuous glass filaments, and glass fibers for special usage (e.g., microfibers).
The Ev@lutil databases provide assistance in occupational exposure assessment, in order to: (i) to guide preventive industrial hygiene measures and the implementation of medical monitoring of exposed workers; and (ii) to improve knowledge of the health effects associated with the inhalation of these different types of fibers as part of epidemiologic studies.
The InVS DST serves as the general coordinator of the Ev@lutil program. Scientific responsibility for it is shared with the Laboratory for the Occupational Health Environment (LSTE) of the Institute for Public Health, Epidemiology and Development (ISPED) at Victor Segalen Bordeaux 2 University.
To learn more: http://etudes.isped.u-bordeaux2.fr/evalutil003/

3.2. Matgéné

Around 2000, in collaboration with academic researchers, InVS began the Matgéné program, intended to develop a set of job-exposure matrices applicable to the general population, by covering all the occupations that have existed since the post-World War II period. The linkage of these matrices with representative samples of the population (See sidebar page 10) makes it possible to assess the prevalence of occupational exposure to some hazards, while taking individuals' entire careers into account. Among the hazards already studied are petroleum-based solvents, chlorinated solvents, mineral wool fibers, cement dust, leather and flour dust, silica, and asbestos. These job-exposure matrices allowed DST to assess the prevalence of asbestos exposure in the population and to estimate the proportion of diseases attributable to these exposures.
To learn more: http://www.invs.sante.fr/surveillance/matgene/default.htm

3.3. PNSM

Established in 1998 by InVS, the PNSM exhaustively records all cases of suspected primary tumors of the pleura, and especially mesotheliomas, in several French districts. In 2009, 22 districts participated in this program, covering approximately 18 million people, that is, 30% of the French population.
As of 1 December 2008, 1,947 incident cases (1,538 men and 209 women) had been recorded between 1998 and 2006 and not been excluded by the systematic diagnostic certification procedure. Career-long exposure had been assessed for 1,127 of them (58%) (894 men, 58%, and 233 women, 57%).
Based on these expert assessments, 811 men (91%) were considered to have been occupationally exposed to asbestos. Asbestos exposure was found during the career of only 41% of the women (n=95). There were therefore 83 men (9%) and 138 women (59%) for whom no occupational asbestos exposure was identified.
The MESONAT registry (multicenter mesothelioma registry was established in 2006 to complement the PNSM surveillance system. This registry is intended to provide a permanent and exhaustive recording of cases that have been strictly validated by pathology examinations. It is directed by Pr. F. Galateau-Sallé at the University Hospital in Caen. (http://www.registrescancers-bn.org/meso/activitemeso.php)

3.4. ESPrI

The objective of this program, launched in September 2005 and currently operating in seven regions, is to identify the self-employed trades people exposed to asbestos during their working life, in order to offer them an exposure assessment and medical follow-up. Developed in partnership with RSI, the social insurance fund for self-employed workers, this program provides previously unavailable descriptive data about the circumstances of occupational asbestos exposure of these self-employed trades people (industries, occupations) and its health impact.

As described above, a similar program took place as a pilot study in 14 districts for retired employees covered by the RGSS: the Spirale program. It is under the scientific and operational supervision of INSERM U 1018 CESP.
To learn more: http://www.invs.sante.fr; http://www.spirale.rppc.fr/amiante.html.

3.5. Follow-up of asbestos victims receiving FIVA compensation

The epidemiologic follow-up of people who have applied to FIVA for compensation is currently being set up. This cohort of victims recorded since 2004, with future prospective inclusions, will have as its principal objective the monitoring of the mortality of asbestos-exposed people with benign diseases, who account for the majority of asbestos victims.

4. Open questions

4.1. Are any mesotheliomas due to environmental exposure?

It has long been known that mesothelioma can be induced by environmental exposure to natural geology (asbestos outcrops in inhabited areas), and cases have been reported in French territories (Corsica and New Caledonia). Environmental cases may currently account for 15 to 20% of all pleural mesotheliomas in industrialized countries [15,16]. More and more frequently, cases induced by environmental exposure of anthropogenic origin (living near industrial facilities that released asbestos fibers into the atmosphere for long periods, time spent in premises containing asbestos) are reported. This may be explained in part by better identification of cases associated to such exposures from nearby industrial sources and in part because of the onset of cases due to exposure to the asbestos-containing premises constructed on a wide scale in the 1960s-1970s. Because of the very long latency periods of pleural mesothelioma, these cases have begun to appear only recently. We can therefore expect, if this phenomenon is confirmed, an increased frequency of mesothelioma cases in young subjects. That is, these exposures can concern people from birth or early childhood, and cases are likely to appear in people at the age of 30-50 years, although such cases are currently extremely rare in metropolitan France.

4.2. Why is occupational asbestos exposure found among so few of the women with pleural mesothelioma?

The essential characteristics of pleural mesothelioma in women are their continually rising incidence, although since approximately 2000 at a rate lower than before, and a lower fraction of cases attributable to occupational asbestos exposure (less than 40%) compared with men. Several hypotheses, not mutually exclusive, may explain this profile.
A partial explanation of continued increase in mesothelioma incidence may be the greater propensity of physicians to look for it in women since the public health problems caused by asbestos have become better known to the medical profession; it is better diagnosed today. Another explanation may be an increase in the number of cases induced by environmental exposure: in men this increase is masked by the overwhelming dominance of mesotheliomas induced by occupational exposure. It is thus easier to observe the environmental component in women because occupational exposure is much less common.

4.3. When will mesothelioma prevalence peak in France?

The most recent prediction of trends in pleural mesothelioma incidence and mortality in France date from the end of the 1990s, that is, approximately a decade ago [17,18]. These studies forecasted a peak in both incidence and mortality around 2020-2030. The data observed since then does not appear to confirm these forecasts and may lead to less pessimistic conclusions.
The data from the Francim cancer registries show a strong and regular increase in both incidence and mortality in men from the end of the 1970s that appears to have stabilized or even dropped between 2000 and 2005 [19]. The increase from 1970 through 2000 is still more marked in women and continued from 2000 through 2005. The PNSM data show that the trend has been stabilizing since around 2000, among both men and women. Nonetheless, this trend must be confirmed over a longer period. We note that the two sources (Francim and PNSM) are not strictly comparable for the periods considered.
The mortality trends (source: CépiDc) show, as does the incidence, a globally large increase for the period 1975-2006

for both sexes, which appears to have stabilized for the most recent period. This stabilization involved the youngest age groups, while mortality continued to increase for those 65 years or older. This phenomenon may correspond to a reduction in occupational exposure to asbestos, beginning around the end of the 1970s, when the first occupational safety regulations were enacted to protect workers from asbestos. Because of the very long latency periods, we still observe mesotheliomas in the oldest generation, which was exposed earlier and protected less.
Finally, we cannot rule out the possibility that the epidemic of mesotheliomas has already peaked, even though the rate continues to rise in those older than 65 years and in women. The Department of Occupational Health at InVS is currently conducting studies to confirm these trends.

4.4. What cancers are related to asbestos exposure?

For decades now, it has been clear that asbestos can induce lung cancer and mesotheliomas in diverse sites (the pleura, peritoneum, pericardium, and *tunica vaginalis of the testis*). For a long time, the role of asbestos in the induction of other types of cancer was suspected. Recently (2009), the International Agency for Research on Cancer (IARC) concluded, after an examination of all the data available today, that **laryngeal cancer** and **ovarian cancer** can be induced by exposure to asbestos fibers (and it is very strongly suspected that **colorectal cancer** is as well) [3]. These advances in knowledge will make it possible to estimate the frequency of cases induced by asbestos among all of these cancers.

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Indicators in Occupational Health

Occupational risks due to asbestos

The French government decided to develop a battery of indicators in order to monitor at a national scale the state of health of the population. Since its creation in 1998, the Department of Occupational Health (DST) of the French Institute for Public Health Surveillance (InVS) has developed several health surveillance programs aimed at producing regularly data about occupational risks in the French population. During the last years, different data sources have been established, and in 2009 the DST set up an occupational health indicators program. These indicators are established using several different data sources, and will be regularly available on the InVS' website (www.invs.sante.fr).This is the first report of this series. It is devoted to the risks induced by the occupational exposure to asbestos fibres. In this document, we report data on exposure to asbestos and its evolution over time in different populations (men, women, employed and retirees). Data on the impact of asbestos exposure on the population's health are also gathered according to age, occupation and economic sectors: pleural mesothelioma incidence and mortality, attributable fractions of mesothelioma and lung cancer, respiratory diseases. Some indicators of post-retirement surveillance of workers exposed to asbestos and of compensation are also presented. Finally, important aspects deserving more in depth studies are listed.

Keywords: asbestos, occupational exposure, cancer, health indicators, epidemiological surveillance

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