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Original Article

Asbestos-Related Diseases in a Population Near a Fibrous Cement Factory

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ABSTRACT

Background and Objective The first fibrous cement factory in Spain was set up in Cerdanyola, Barcelona, in 1907 and was a source of pollution there until it was closed in 1997. The aim of this study was to determine the clinical and epidemiologic characteristics of the population with asbestos-related diseases who had worked in the factory and/or lived in the vicinity.
Material and Methods: We retrospectively collected information available on patients with asbestos-related diseases who at the time of diagnosis had resided in the area near the fibrous cement factory. Information was obtained from the medical records of the primary care centers of the 12 surrounding towns and the sole referral hospital in the area for cases diagnosed between January 1, 1970 and December 31, 2006.
Results: In the 559 patients diagnosed, 1107 cases of asbestos-related diseases were identified. Between 2000 and 2006, the average annual incidence was 9.5 cases per 100 000 inhabitants for the entire study area and 35.5 cases per 100 000 for the area nearest the factory. The prevalence of asbestos-related diseases as of December 31, 2006 was 91 cases per 100 000 inhabitants in the entire study area and 353.4 cases per 100 000 in the area nearest the factory. Of the 1107 asbestos-related disease cases identified, 86.5% were benign and 8.4% pleural mesothelioma.
Conclusions: The factory introduced an important area-wide risk factor for asbestos-related diseases for both workers and the nearby population. The number of cases detected annually showed an upward trend and the incidence of asbestos-related diseases was extremely high.

Palabras clave:
Asbesto
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Enfermedad ambiental

Enfermedad por amianto en una población próxima a una fábrica de fibrocemento

RESUMEN

Introducción: En 1907 se instaló en Cerdanyola (Barcelona) la primera fábrica de fibrocemento de España, que actuó como foco contaminante hasta su cierre en 1997. El objetivo del estudio ha sido conocer las características clinicoepidemiológicas de la población afectada por enfermedades relacionadas con el amianto (ERA) que había trabajado o/y vivía en el entorno de esta fábrica.

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Material y métodos: Se trata de un estudio retrospectivo que reúne la información disponible de los pacientes afectados de ERA que residían en el momento del diagnóstico en la zona cercana a la factoría de fibrocemento. La información se obtuvo a partir de la documentación médica de los centros de atención primaria de las 12 poblaciones circundantes y del único hospital de referencia de la zona, para los casos diagnosticados entre el 1 de enero de 1970 y el 31 de diciembre de 2006.
Resultados: En los 559 pacientes diagnosticados se identificaron 1.107 casos de ERA. La incidencia anual media entre 2000 y 2006 fue de 9,5 pacientes por 100.000 habitantes para toda la zona, y de 35,5 para la más próxima a la fábrica. La prevalencia de pacientes con ERA a fecha de 31 de diciembre de 2006 fue de 91 por 100.000 personas en toda la zona y de 353,4 en la más próxima a la fábrica. De los 1.107 casos, el 86,5% correspondía a enfermedad benigna y el 8,4% a mesotelioma pleural.
Conclusiones: En la zona estudiada, la fábrica supuso un factor de riesgo importante de ERA para sus trabajadores y la población cercana. La detección de casos mostró una tendencia ascendente. La incidencia de ERA fue muy elevada.

Introduction

Asbestos is a fibrous mineral whose specific properties have encouraged its use since ancient times, but particularly for industrial applications since the 19th century.[1] Asbestos inhalation can lead to a variety of abnormalities and diseases, embraced under the term asbestos-related diseases.[2] Workers were the first population at risk to be studied, as most patients with asbestos-related diseases have a history of intense exposure in the workplace. At the beginning of the 1960s, it was shown that asbestos-related diseases affected not only directly exposed workers, but also the population residing in the vicinity of a source of pollution.[3]

Although Spain is not an asbestos-producing country, the use of the mineral was especially high in industry between 1960 and 1984,[4] reaching its peak in 1973.[5] The incidence of at least some asbestos-related diseases, in view of their prolonged latency period, is expected to rise in Europe until approximately the second decade of the 21st century.[6,7] In 1907, the first fibrous cement factory in Spain was set up between Cerdanyola and Ripollet, in the province of Barcelona. This factory was a source of pollution until it closed in 1997. Concerned by the high frequency of asbestos-related diseases detected in the primary health care centers of this area, we thought it worthwhile to study these in a population that had lived or worked near a large fibrous cement factory, and for this purpose designed the present study. The aim of the study was to determine the clinical and epidemiologic features of asbestos-related diseases in this exposed population.

Materials and Methods

We carried out a retrospective study of cases found between 2004 and 2007, collecting the available epidemiological and clinical data on patients diagnosed with asbestos-related diseases who at the time of diagnosis had resided in the vicinity of the fibrous cement factory located between Cerdanyola and Ripollet, in the province of Barcelona. Rather than defining a specific radius around the source of pollution, we chose to include all the surrounding towns, in order to avoid omitting any important population nucleus that might lie outside the radius. The study area, which has a single referral hospital (Consorci Sanitari Parc Taulí), included 12 towns in the Vallès Occidental: Badia, Barberà del Vallès, Castellar del Vallès, Cerdanyola del Vallès, Palau de Plegamans-Solità, Polinyà, Ripollet, Sabadell, Sant Quirze del Vallès, Sant Llorenç Savall, Santa Perpètua de la Mogoda, and Sentmenat. The catchment population according to the 2005 census was 417 785 inhabitants, of whom 93 386 resided in the towns nearest the source of pollution (Cerdanyola-Ripollet).

The information was obtained from all available medical records, most specifically from those of the primary care centers of the above-mentioned towns and from those of the referral hospital. Regardless of whether the cases were found through a primary care center or through the referral hospital, a single family doctor, who is also a pulmonologist, was in charge of gathering, reviewing, and validating the data. We analyzed cases diagnosed between January 1, 1970 and December 31, 2006, as adequate information was not available for the period before this interval.

All diseases or disorders caused by the inhalation of asbestos fibers were considered to be asbestos-related diseases.[2,8] Six involve benign processes (pleural plaques, pleural thickening, benign pleural effusion, rounded atelectasis, asbestosis, and chronic airflow obstruction) and four are malignant ones (pleural mesothelioma, peritoneal mesothelioma, bronchopulmonary carcinoma, and other asbestos-related cancers). A disease or disorder was considered to be asbestos related if it met the following criteria: *a)* diagnosis was established using clinical/epidemiological criteria, imaging studies, and/or pathology reports, and *b)* other possible diagnoses were ruled out.[2,8] For a case of bronchopulmonary carcinoma in patients with domestic or environmental asbestos exposure to be included, the presence of other abnormalities indicative of asbestos-related disease was required. Cases were classified according to source of exposure as *a)* occupational (documentation from a reliable source attesting that the worker's occupational activity involved asbestos was required); *b)* domestic (sharing living quarters on a regular basis with a worker exposed to asbestos in the workplace was required), or c*)* environmental (habitual residence in the study area was required). Although several types of exposure could coexist in a single case, each case was classified in the group in which exposure was thought to be highest: occupational, domestic, or environmental, in that order.

Throughout the study, confidentiality and ethical criteria regarding the treatment of personal data were respected.

Statistical Analysis

For the bivariate analyses, the χ^2 and t tests were used, and a P value less than .05 was considered significant. The statistical analysis was carried out using the SPSS statistical package. For the calculation of cumulative incidence, we used the annual mean of data for 2000 through 2006, as the diagnostic techniques and quality of the medical records were more reliable than in previous years. Results were specified for the entire study area (total population: 417 715) and for the population of Cerdanyola-Ripollet (total population: 93 386). The calculation of prevalence, also given for both the entire study area and for the area of Cerdanyola-Ripollet, was based on the number of patients still alive as of December 31, 2006. Information on the population of the towns during the study period was obtained from census records provided by the Catalan Institute of Statistics for 2005 (IDESCAT)[9]

Results

In the 559 patients diagnosed, 1107 asbestos-related diseases were identified, with a mean of 1.98 diseases per patient. A total of 228 patients (40.9%) had a single asbestos-related disease; 204 (36.4%) had 2, and 127 (22.7%) had 3 or more at the time of diagnosis. The mean (SD) age of the 559 patients, of whom 413 (74%) were men, was 63.9 (12.2) years.

Exposure was occupational in 400 patients (71.6%), domestic in 61 (10.9%), and environmental in 98 (17.5%). The source of pollution was the fibrous cement factory in 364 (91%) of the 400 patients with occupational exposure, and other industries (all of them located in the study area) in 36 (9%).

The number of new cases detected annually is shown in the figure. An increase in the total number of cases is apparent from the beginning of the study, period, with 58 new cases recorded in 2006. Two peaks can be seen, one between 1975 and 1978, and the other in the period from 2003 to 2006. Malignant disease also showed an upward trend, but with a much flatter curve, with 6 new cases in 2006.

Table 1 shows the mean cumulative incidence of asbestos-related diseases in the period from 2000 to 2006. An average incidence of 9.5 cases of asbestos-related diseases per 100 000 inhabitants per year (men, 13.2/100 000; women, 5.8/100 000) was detected for the entire study area. The incidence rose to 35.5 cases per 100 000 inhabitants per year (men, 45.5/100 000; women, 25.4/100 000) in Cerdanyola-Ripollet. The mean cumulative incidence of pleural mesothelioma for the same period was 1.5 cases per 100 000 inhabitants per year (men, 2.3/100 000; women, 0.7/100 000) in the entire study area, and 4.7 per 100 000 inhabitants (men, 6.7/100 000; women, 2.8/100 000) in Cerdenyola-Ripollet.

Table 2 shows the prevalence of asbestos-related diseases as of December 31, 2006. The prevalence of all asbestos-related diseases for the entire study area was 91 per 100 000 inhabitants (men, 125.5/100 000; women, 57/100 000), rising to 353.4 per 100 000 inhabitants (men, 457.6/100 000; women, 248.8/100 000) in Cerdanyola-Ripollet.

Table 3 shows the distribution of asbestos-related diseases, time of exposure, and latency period according to source of exposure. Of the 1107 cases, 958 (86.5%) involved a benign disease—737 (66.3%), benign pleural disease and 221 (21%), asbestosis—and 149 (13.4%) were neoplastic disease, of which pleural mesothelioma, with 93 cases (8.4%), was the most common. Occupational exposure accounted for practically all the bronchopulmonary carcinomas and peritoneal mesotheliomas, while pleural mesotheliomas appeared in cases of occupational (62%) as well as of domestic (15%) and environmental (23%) exposure. In other words, 38% of the mesotheliomas were attributable to nonoccupational exposure. There were 34 cases of bronchopulmonary carcinoma of occupational origin, with a mean exposure time of 23.2 (9.9) years.

The mean exposure time was 22.2 (15.3) years overall—18.5 (11) years for occupational exposure; 27.9 (16.3) for domestic exposure; and 37.6 (21.6) for environmental exposure ($P<.001$). Analysis of exposure time for each of the asbestos-related diseases showed significant differences according to source of exposure. The mean overall latency period was 40.9 (15.1) years—37.1 (13.2) years for occupational exposure; 52.5 (10.9) for domestic exposure; and 52.7(16.8) for environmental exposure ($P<.001$). Analysis of the latency period for each of the diseases also showed significant differences according to the source of exposure.

In Table 4, which shows the distribution of cases by sex according to source of exposure, significant differences between the sexes can be seen.

Discussion

Until 1960, studies of asbestos-related diseases had dealt exclusively with the occupationally exposed population. Since then, various observers have seen that these diseases may be caused by exposure outside the workplace.[3] In 1960, Kiviluoto[10] was the first to attribute the presence of pleural calcifications in Finnish farmers to an anthophyllite mine near their homes. Later, however, it was suggested that the high asbestos content of the rocks in the area, as was subsequently seen in other geographic locations,[11-14] might have

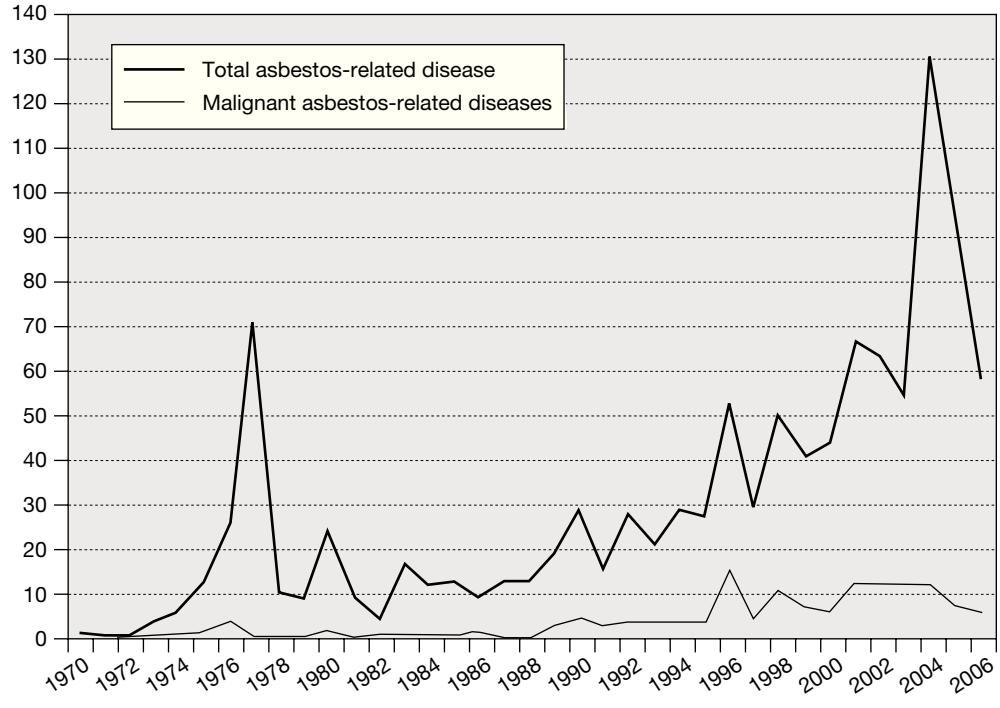

Figure. Number of cases of asbestos-related diseases (total and malignant) diagnosed each year.

Table 1
Incidence of the Various Asbestos-Related Diseases per 100 000 Inhabitants[a]

	Entire Study Area			Cerdanyola-Ripollet		
	Men	Women	Total	Men	Women	Total
Total number of patients with asbestos-related diseases	13.2	5.8	9.5	45.5	25.4	35.5
Pleural plaques	9.4	5.2	7.3	33.0	23.0	28.0
Pleural thickening	5.0	2.2	3.6	17.7	9.5	13.6
Benign pleural effusion	2.0	0.3	1.2	5.8	1.5	3.7
Atelectasis	0.9	0.1	0.5	3.7	0.3	2.0
Asbestosis	3.6	1.4	2.5	13.7	6.4	10.1
Pleural mesothelioma	2.3	0.7	1.5	6.7	2.8	4.7
Peritoneal mesothelioma	0.9	0.0	0.4	2.7	0.0	1.4
Bronchopulmonary carcinoma	0.8	0.0	0.4	3.1	0.0	1.5

[a]Values are expressed as number of cases diagnosed between 2000 and 2006 (annual average) per 100 000 inhabitants (2005 census).

Table 2
Prevalence of the Various Asbestos-Related Diseases per 100 000 Inhabitants[a]

	Entire Study Area			Cerdanyola-Ripollet		
	Men	Women	Total	Men	Women	Total
Total number of patients with asbestos-related diseases	125.5	57.0	91.0	457.6	248.8	353.4
Pleural plaques	107.2	55.1	80.9	399.8	240.3	320.2
Pleural thickening	44.9	15.2	29.9	168.9	66.5	117.8
Benign pleural effusion	12.5	2.8	7.7	40.6	12.9	26.8
Atelectasis	8.2	1.4	4.8	36.3	4.3	20.3
Asbestosis	53.6	15.7	34.5	192.4	68.6	130.6
Pleural mesothelioma	1.4	0.5	1.0	4.3	2.1	
3.2Peritoneal mesothelioma				0.0	0.0	0.0
Bronchopulmonary carcinoma	1.9	0.0	1.0	8.6	0.0	4.3

[a]Values are expressed as number of cases diagnosed between 2000 and 2006 (annual average) per 100 000 inhabitants (2005 census).

been the true source of the farmers' exposure.[15] Also in 1960, Wagner et al[16] reported the appearance of pleural mesothelioma in South Africans who had never worked as miners, and attributed the disease to the considerable mining of asbestos in the area where they lived. Later studies, all dealing with malignant mesothelioma, made it possible to confirm that an environmental source such as a mine, factory, or plant could cause an increase in cases in its vicinity.[17-21] However, in some of these studies it was difficult to determine whether the disease had been produced by environmental exposure alone, as occupational exposure or domestic contact with a directly exposed worker could not be ruled out entirely.[22] We believe that the importance of our study lies, first of all, in the fact that it describes the impact of an important source of asbestos emission on the entire population in its vicinity, distinguishing between occupational, domestic, and environmental exposure. Secondly, we did not focus exclusively on malignant mesothelioma, but included all the malignant and benign diseases associated with asbestos exposure.

While the incidence of mesothelioma and the upward trend it is expected to follow in the coming years has been well documented,[6,7] this is not the case for asbestos-related diseases in general. In our study, the average incidence of these diseases was 9.5 per 100 000 inhabitants per year, and we found an upward trend in the detection of new cases, with 2 peaks in the periods from 1976 to 1977 and from 2004 to 2006. There are 2 specific factors that can probably account, to a large extent, for the increase in new cases of benign asbestos-related diseases. The first is the exhaustive study of the population employed at the fibrous cement factory, undertaken at the request of the workers' committee,[23] and the second is a possible magnet effect on the population as their attention was called to our study.

There were no peaks in the detection of new cases of malignant diseases, as they are unlikely to go unnoticed. The literature reports an annual incidence of mesothelioma in the general population of between 0.1 and 0.3 cases per 100 000 inhabitants.[8,24] In our study, the incidence was 1.5 cases per 100 000 inhabitants per year, rising to 4.7 in Cerdanyola-Ripollet. This cumulative incidence was even higher than the 2.4 per 100 000 inhabitants reported by Agudo[25] for the area nearest the fibrous cement factory. That study, however, was based on information from death records, which do not always reflect the exact cause of death, and this may account for the variation. Another more recent study found a relative risk of death from pleural cancer of 1.5 or higher and confirmed that Cerdanyola was the town with the highest mortality rate from this disease in Spain.[26] In our study, the high prevalence of benign asbestos-related diseases was also noteworthy, especially in Cerdanyola-Ripollet. In contrast, the prevalence of malignant disease was understandably low. This is because prevalence is expressed in terms of the number of patients alive with a disease, and the mortality rate of these diseases is high.

The mean age and general distribution of asbestos-related diseases by sex in our study did not differ from reports in the literature.[27] When cases were analyzed according to the source of exposure, we found a greater proportion of men with diseases due to occupational exposure, in line with the greater proportion of male workers in the fibrous cement factory. It is also interesting to note that diseases related to domestic exposure affected twice as many women as men (64 women vs 34 men), whereas those related to environmental exposure affected more men than women (105 men vs 71 women). This may be related to the fact that women spend more time in the home than men. Our study also showed that 29% of all asbestos-related diseases, almost a third of the cases, were not related to occupational exposure. This fact shows the impact that a source of pollution can have on the general population and demonstrates that the problem of asbestos-related diseases extends beyond the workplace into the realm of public health.[28-30] There may be important implications in this for primary care and general medical practice. For example, medical histories in patients with asbestos-related diseases might have to take into consideration not only aspects related to the patient's occupation, but additional factors such as place of residence.

In our series, exposure time in cases of environmental origin (37.6 years) was greater than in those of domestic origin (27.9 years), and exposure time for the latter was, in turn, greater than in those of occupational origin (18.5 years). These differences can be explained by the fact that diseases develop as a result of the total cumulative dose of asbestos in the tissues. Patients whose exposure was less intense, as in the case of environmental exposure, would require more exposure time to reach the same cumulative dose as those with domestic exposure, who in turn would require more time than those with occupational exposure. The latency period for asbestos-related diseases of environmental origin (52.7 years) and for those of domestic origin (52.5 years) was longer than for those of occupational origin (37.1 years). These differences could be explained, in the first place, by the fact that environmental and domestic exposure are, understandably, less intense than workplace exposure. Moreover, individuals exposed on the job were more likely to be diagnosed because, unlike the general population, they underwent systematic preventive and diagnostic medical examinations for asbestos-related diseases.

Neoplastic diseases due to asbestos exposure accounted for 13% of all the asbestos-related diseases diagnosed, and of these, pleural mesothelioma, with 8% (n=93) of the cases, was the most common. It is noteworthy that 38% of pleural mesotheliomas were not of occupational origin. This is consistent with data from other studies carried out in the same area[25,30,31] as well as in other countries,[16-21,29] and confirms the impact of asbestos on the general population living near a major source of pollution. Our study also showed, as has been mentioned elsewhere,[33] that peritoneal mesothelioma was rare in the nonoccupationally exposed population. It should be noted that this type of mesothelioma is generally associated with extremely

Table 3
Number of Cases, Exposure Time, and Latency Period for Each Type of Exposure[a]

	Total	Occupational	Domestic	Environmental	*P*
Pleural plaque					
Cases	436 (39.4%)	308	49	79	
Exposure time, y	22.5 (16.1)	18.3 (11.7)	27.3 (17.0)	38.3 (21.6)	<.0001
Latency period, y	42.8 (15.2)	38.6 (13.5)	54.1 (10.6)	53.9 (15.9)	<.0001
Pleural thickening					
Cases	218 (19.7%)	155	26	37	
Exposure time, y	22.7 (15.6)	18.8 (11.5)	31.2 (18.8)	34.9 (21.3)	<.0001
Latency period, y	42.0 (14.3)	38.8 (12.4)	51.7 (12.0)	49.8 (18.1)	<.0001
Benign pleural effusion					
Cases	58 (5.2%)	48	3	7	
Exposure time, y	22.9 (15.0)	19.3 (10.8)	40.7 (6.7)	43.0 (24.6)	<.0001
Latency period, y	42.9 (13.0)	40.7 (12.1)	53.1 (7.2)	55.9 (13.8)	<.01
Atelectasis					
Cases	25 (2.2%)	15	4	6	
Exposure time, y	26.8 (19.4)	18.3 (14.4)	43.8 (20.4)	38.9 (19.7)	<.05
Latency period, y	46.8 (15.0)	39.9 (12.4)	60.7 (7.6)	56.5 (14.7)	<.01
Asbestosis					
Cases	221 (20%)	191	10	20	
Exposure time, y	21.5 (12.8)	19.9 (10.5)	30.9 (21.4)	32.8 (20.2)	<.0001
Latency period, y	36.8 (15.8)	34.3(14.2)	55.2 (13.2)	53.3 (17.1)	<.0001
Pleural mesothelioma					
Cases	93 (8.4%)	58	14	21	
Exposure time, y	21.1 (14.0)	17.2 (10.5)	26.7 (14.8)	31.1 (18.6)	<.0001
Latency period, y	42.0 (12.0)	39.3 (9.6)	48.4 (9.3)	46.3 (18.5)	<.05
Peritoneal mesothelioma					
Cases	19 (1.7%)	19			
Exposure time, y	16.9 (8.3)	16.9 (8.3)			
Latency period, y	40.5 (8.3)	40.5 (8.3)			
Bronchopulmonary carcinoma					
Cases	37 (3.3%)	34	2	1	
Exposure time, y	25.3 (13.8)	23.2 (9.9)	31.2 (6.9)	83.2	<.0001
Latency period, y	40.6 (12.9)	38.0 (9.0)	59.6 (3.8)	89.1	<.0001
All asbestos-related diseases					
Cases	1107 (100%)	828 (74.8%)	108 (9.7%)	171 (15.4%)	
Exposure time, y	22.2 (15.3)	18.5 (11.0)	27.9 (16.3)	37.6 (21.6)	<.0001
Latency period, y	40.9 (15.1)	37.1 (13.2)	52.5 (10.9)	52.7 (16.8)	<.0001

[a]Values are expressed as number of cases of each type and, in parentheses, the percentage of the total number of asbestos-related disease cases. Exposure time and latency period are expressed as mean (SD).

Table 4
Asbestos-Related Diseases According to Type of Exposure and Sex[a]

Source of Exposure	Men	Women	Total	*P*
Occupational	691	137	828	<.0001
Nonoccupational				
Domestic	34	69	103	<.05
Environmental	105	71	176	<.05
Total	830	277	1107	

[a]Values are expressed as number of cases.

intense asbestos exposure.[34] The incidence of this disease in men in industrialized countries has been reported to be between 0.05 and 0.3 per 100 000 inhabitants.[35] In our study, however, the incidence in men was 2.7 per 100 000 inhabitants in the area nearest the factory. This leads us to believe that the intensity of asbestos exposure at the fibrous cement factory must have been extremely high, even though we do not have measurements for the period when the factory was active. The large majority of cases of bronchopulmonary carcinoma were of occupational origin. This is not surprising, as this type requires more intense exposure. Of all the asbestos-related diseases of occupational origin, bronchopulmonary carcinoma was the one associated with the longest exposure time (23.2 years), confirming that this type of cancer requires a high cumulative dose of asbestos.

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