Occupational Characteristics of Cases with Asbestos-related Diseases in The Netherlands

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Objective: To describe the occupational background of cases with an asbestos-related disease and to present overall mesothelioma risks across industries with historical exposure to asbestos.

Methods: For the period 1990–2000, cases were collected from records held by two law firms. Information on jobs held, previous employers, activities performed and specific products used were obtained from patients themselves or next of kin. Branches of industry and occupations were coded and the likelihood of asbestos exposure was assessed. For each branch of industry, the overall risk of mesothelioma was calculated from the ratio of the observed number of mesothelioma cases and the cumulative population-at-risk in the period 1947–1960. In order to compare mesothelioma risks across different industries, risk ratios were calculated for the primary asbestos industry and asbestos user industries relative to all other branches of industry.

Results: In total, 710 mesotheliomas and 86 asbestosis cases were available. The average latency period was ~40 yr and the average duration of exposure was 22 yr. Ship building and maintenance contributed the largest number of cases (27%), followed by the construction industry (14%), the insulation industry (12%), and the navy and army, primarily related to ship building and maintenance (5%). In the insulation industry, the overall risk of mesothelioma was 5 out of 100 workers, and in the ship building industry, 1 out of 100 workers. The construction industry had an overall risk comparable with many other asbestos-using industries (7 per 10 000 workers), but due to its size claimed many mesothelioma cases.

Conclusion: The majority of cases with asbestos-related diseases had experienced their first asbestos exposure prior to 1960. For cases with first asbestos exposure after 1960, a shift was observed from the primary asbestos industry towards asbestos-using industries, such as construction, petroleum refining, and train building and maintenance. Due to the long latency period, asbestos exposure from 1960 to 1980 will cause a considerable number of mesothelioma cases in the next two decades.

Keywords: mesothelioma; asbestosis; asbestos

INTRODUCTION

Asbestos is a well-recognized occupational hazard, affecting primarily the lungs, the pleura and the peritoneum. Numerous epidemiological studies have shown that exposure to asbestos may cause asbestosis, bronchogenic cancer and mesothelioma of the pleura or the peritoneum (Mossman and Gee, 1989).

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Since asbestos use in Western Europe remained high until 1980, it is expected that the number of men dying from mesothelioma in Western Europe each year will reach a peak of ~9000 around 2018, and then decline rapidly (Peto *et al.*, 1999). In The Netherlands, a country with one of the highest incidences of mesothelioma, the most plausible scenario predicts an increase in pleural mesothelioma mortality among men from nearly 300 cases in 2000 to ~490 cases in 2017 and a total death toll close to 12400 cases during 2000–2028. During the same period, mortality among women will most likely remain low, with 30 cases annually and a total death toll of ~800 (Segura *et al.*, 2003).

Although the dramatic burden of disease due to occupational exposure to asbestos has long been recognized, there is often debate over whether an individual case with an asbestos-related disease can be attributed to a specific source of previous exposure to asbestos. Hence, asbestos exposure during the work history of an individual worker has to be assessed. While the clinical characteristics of asbestos-related diseases are well described in medical textbooks, there is little information on the quantitative criteria for asbestos exposure in the diagnosis of these diseases. Yet, exposure criteria are important to ensure that asbestos-related diseases are correctly diagnosed and justly compensated (Burdorf and Swuste, 1999).

Characteristics of asbestos exposure among individuals with asbestos-related diseases have been described in a few publications (Yeung *et al.*, 1999; Bianchi *et al.*, 2001; Neumann *et al.*, 2001; Yeung and Rogers *et al.*, 2001; Leigh *et al.*, 2002). Important issues that remain largely unknown include duration of asbestos exposure in relation to disease type, duration of latency period, distribution of asbestos-related diseases over asbestos industries and other branches of industry, and the impact of relatively mild exposure to asbestos. The aim of this paper is to describe the occupational background among cases with asbestos-related diseases in The Netherlands and present information on mesothelioma risks across industries with exposure to asbestos.

MATERIALS AND METHODS

Cases of asbestos-related diseases were collected from the records held by two Dutch law firms that have handled almost all legal suits filed by subjects with asbestos-related diseases against their employers. As standard procedure in these applications, information on the lifetime occupational history was collected by interview from patients themselves or from their next of kin. During these interviews, information about previous jobs held, activities performed, previous employers and specific products used was collected. The diagnosis of an asbestos-related disease by a qualified physician was often based on necropsy, since most patients died during the legal procedures. Not all applications were eventually submitted to court due to lack of written documentation on previous employment status, employers no longer existing and legal limitations such as a 30 yr period of prescription.

For the period 1990–2000, all application files were scrutinized for available information. This period was chosen since in 2000 the Compensation for Asbestos Victims Regulation came into effect in The Netherlands. According to this law, subjects suffering from mesothelioma and satisfying certain conditions may ask for mediation of their claim and can obtain an advance payment for compensation of immaterial damage of up to 15882 euro. Hence, during 2000 the number of asbestos victims seeking legal support through both law firms dropped significantly. The first inclusion criterion was a certified diagnosis from a qualified physician, in order to distinguish two asbestos-related diseases: asbestosis and mesothelioma. The second inclusion criterion was to retain only cases that were still alive after 1 January 1985. Hence, 64 records were not taken into account because the death of the patient preceded the start of the registration by >5 yr. The quality and completeness of the occupational histories were considered too low in cases where next of kin had to provide written and oral documentation on the full employment history >5 yr after the patient had died.

The generalizability of the results was addressed by estimating the fraction of potential claimants with mesothelioma relative to the annual morbidity of mesothelioma made available by The Netherlands Cancer Registry (NCR) for the period 1990–1998 (NRC, 2000). A similar estimation was not possible for asbestosis due to lack of appropriate morbidity statistics.

For each case, the occupational history was reviewed and each period of employment was separately coded by two authors (A.B., M.D.) according to the classifications for branch of industry and occupation that were used by Netherlands Statistics in the period 1945–1971. Based on the occupational history (companies, jobs, activities, products) and a previously designed expert system for the evaluation of historical asbestos exposure (Burdorf and Swuste, 1999), for each subject the primary source of asbestos exposure held responsible for the disease was assessed by the authors and characterized as originating in occupation, household, environment or unknown. For large companies, subjects who had worked at the same workplace as the claimant were interviewed by one of the authors for additional evidence of past asbestos exposure. With regard to occupational exposure, a distinction was made between the primary asbestos industry (with definite exposure), industries well known for using asbestos-containing products (with definite or probable exposure) and all other industries (with probable, possible or no apparent exposure).

The time of first exposure to asbestos was considered to have coincided with the start of employment in the job during which the initial asbestos exposure had occurred. Similarly, duration of asbestos exposure was approximated by duration of employment in the job with probable or definite asbestos exposure. The latency period was defined as the period between the first exposure to asbestos and the certified diagnosis of the asbestos-related disease. Based on information on workforce composition by branch of industry from the national census in 1947 and 1960, the cumu-

lative population-at-risk in men over the period 1947–1960 was estimated for each relevant branch of industry. The estimation was restricted to men since in The Netherlands the mortality of mesothelioma among women is very small compared with that in men (Segura *et al.*, 2003). The population-at-risk was held constant after 1960 because only a small part of all subjects in the study population was not exposed prior to 1960. The initial size of the population-at-risk for a specific branch of industry was determined from the distribution of the male workforce in the national census in 1947. The difference in size of the branch-specific populations between 1947 and 1960 was used to calculate the annual change in absolute numbers. For branches of industry with an increase in the workforce, this annual change was added yearly to the initial population-at-risk. In addition, it was assumed that during each consecutive year ~5% of the workforce had changed job and were replaced by newly hired workers. This assumption of a 5% annual replacement was derived from labour market studies available from 1971 onwards. For branches of industry with a decrease in the workforce, an annual replacement of 2.5% was chosen, assuming that shrinking industries hired considerably fewer new workers. A similar procedure was adopted to estimate the total population-at-risk in all other branches of industries, excluding the primary asbestos industry and asbestos-using industries.

The overall risk of mesothelioma among men in a particular industry in the period 1990–2000 was calculated as the ratio of the expected number of mesotheliomas in a given industry over the estimated population-at-risk during the period 1947–1960. The expected number of mesotheliomas was derived from the observed cases in the study population multiplied by a factor of 5 in order to account for the fact that ~20% of all incident cases of mesothelioma in the period 1990–1998 were present in the study population. In order to compare mesothelioma risks across industries, risk ratios were calculated for the primary asbestos industry and asbestos-using industries relative to all other branches of industries.

RESULTS

A total of 796 asbestos-related diseases was collected by the two law firms: 710 cases with mesothelioma and 86 with asbestosis. This study population included 771 (96.9%) men and 25 (3.1%) women. For the period 1990–1998 the proportion of prospective claimants with mesothelioma relative to the cumulative morbidity of mesothelioma was 0.19. Overall, this proportion rose from 0.09 in 1990 to 0.29 in 1998, illustrating an increasing tendency to file a law suit.

Table 1 describes the age distribution of the patients at time of death, showing few cases below the age of 50 yr. The mean age at death among asbestosis cases (59.4 yr) was significantly lower than in cases with mesothelioma (62.9 yr). The mean latency between initial asbestos exposure and diagnosis of disease was lower for asbestosis (37.0 yr) than for mesothelioma (40.5 yr). Latency periods <20 yr were observed infrequently with three cases (3%) of asbestosis and 13 (2%) cases of mesothelioma.

Table 1. Age at death of 796 patients with asbestos-related diseases in The Netherlands

Age group (yr)	Mesothelioma (710 cases)		Asbestosis (86 cases)	
	n	%	*n*	%
40 or younger	6	1	2	2
41–45	8	1	0	0
46–50	36	5	9	13
51–55	72	10	11	13
56–60	99	14	16	19
61–65	122	17	14	16
66–70	116	16	15	17
71–75	78	11	5	6
76–80	29	4	1	1
Older than 80	9	1	0	0
Unknown/still alive	135	19	15	17

For 94% of all cases, information on the first year of occupational exposure to asbestos was available. About 11% were already exposed before 1940, 24% had experienced their first exposure during the 1940s, 38% during the 1950s, 20% during the 1960s, and 6% were first exposed in 1970 or later. The estimated total duration of asbestos exposure varied between <1 and 51 yr with a mean duration of 21.4 yr. About 10% had experienced <1 yr exposure, 25% between 1 and 10 yr, 20% between 11 and 20 yr, 37% between 21 and 40 yr, and 9% >40 yr. These distributions of duration of asbestos exposure were quite similar with mesothelioma cases not reporting shorter durations of exposure than cases with asbestosis.

Among the 710 cases with mesothelioma, five cases with household exposure and three with environmental exposure were identified. The household cases comprised four wives and one son of men who had held jobs with definite exposure to asbestos. Three women with pleural mesothelioma (age at death 38, 46 and 62) had lived during their childhood along contaminated roads close to an asbestos cement factory in a rural area in the north-east of The Netherlands. For many years this factory made waste material freely available to local residents who used this material to pave dirt tracks.

For all cases except those of household and environmental origin, the distribution over branch of industry is given in Table 2. In 36 (5%) cases, sufficient information on occupation or former employer was lacking to identify branch of industry and estimate the

Table 2. Distribution of 788 patients with asbestos-related diseases over branch of industry

Branch of industry (status of former employer)	Mesothelioma (702 cases)		Asbestosis (86 cases)	
	n	%	*n*	%
Primary asbestos industry				
Insulation industry	59	8	32	37
Asbestos cement industry	23	3	1	2
Asbestos-using industry				
Ship building and maintenance	196	28	15	17
Construction industry	102	15	6	7
Navy and army	37	5	6	7
Mining	26	4	2	2
Fabricated metal products manufacturing	20	3	2	2
Public administration	17	2	3	3
Electronic/electrical equipment manufacturing	16	2	2	2
Chemical industry	13	2	1	1
Power plants	12	2	2	2
Industrial machinery manufacturing	13	2	0	
Petroleum refining and related industries	12	2	0	
Shipping	12	2	0	
Train building and maintenance	10	1	1	1
Primary metal industry	9	1	1	1
Railroad transportation	9	1	0	
Food products manufacturing	8	1	1	1
Miscellaneous industries	75	11	6	7
Unknown	33	5	5	6

likelihood of asbestos exposure. About 15% of all cases had worked in the primary asbestos industry and 71% had experienced definite or probable asbestos exposure due to working with asbestos-containing products. Another 10% of cases had held a wide variety of occupations where specific activities and circumstances may have caused exposure to asbestos. Ship building and maintenance contributed the largest number of cases (27%), followed by the construction industry (14%), the insulation industry (12%), and the navy and army, primarily related to ship maintenance (5%). The insulation industry comprised both asbestos spraying in ships and buildings as well as the production of asbestos-containing insulation products. A work history in ship building and maintenance, the insulation industry, or the navy was more prominent among asbestosis cases (65%) than in mesothelioma cases (44%). Other industries with notable numbers of cases were mining (primarily coal mining), asbestos cement industry, metal products manufacturing, electronic equipment manufacturing, coal-fired power plants and industrial machinery manufacturing.

A significant trend over time was observed, with the traditional primary asbestos industry and ship building and maintance accounting for 49% of all cases with first exposure before 1960 and only 24% among cases who had experienced their first exposure in 1960 or later. After 1960, relatively more cases were observed in the asbestos-using industries, most notably the construction industry, whose contribution rose from 11 to 21%.

Table 3 shows the occupations held by cases in the primary asbestos industry. In the insulation industry, most subjects had worked as laggers/insulators in two companies that held a concession for spraying asbestos insulation in ships, large buildings and industrial facilities. In this occupation, the number of cases with asbestosis was 50% of the number of cases with mesothelioma. Most other jobs in this industry comprised manufacturing of asbestos insulation products or installing insulation products. In the asbestos cement industry, subjects were involved in a wide variety of blue-collar jobs. The only case of asbestosis had worked as a cleaner on the shop floor. Two cases of mesothelioma appeared among former office workers.

Table 4 presents an overview of occupations in asbestos-using industries. In the ship building industry, repair and maintenance fitters, metalworkers, shipwrights, welders, painters and electricians were exposed to asbestos while carrying out installation, repair or renovation tasks. Many subjects interviewed mentioned activities that involved spraying of asbestos on board. Only a few subjects listed their occupation as lagger/insulator, illustrating

Table 3. Occupational distribution of 115 cases with asbestos-related diseases and definite asbestos exposure in the primary asbestos industry

Type of industry	Mesothelioma (n = 82)	Asbestosis (n = 33)
Insulation industry		
Lagger/insulator	30	15
Sheet metal worker	3	2
Fitter/turner	2	
Driver	2	3
Foreman	2	4
Mechanical engineer	3	
Carpenter		2
Plasterer	1	
Storeman	1	1
Timekeeper	1	
Labourer	3	2
Office worker	5	
Unknown	6	3
Asbestos cement industry		
Machine operator	4	
Mechanical (maintenance) engineer	3	
Carpenter	2	
Crane operator/driver	3	
Waste material worker	2	
Storeman	1	
Cleaner		1
Labourer	4	
Office worker	2	
Unknown	2	0

Table 4. Occupational distribution of 556 cases with asbestos-related diseases and definite/probable asbestos exposure in asbestos-using industries

Branch of industry	Mesothelioma (n = 512)	Asbestosis (n = 42)
Ship building and maintenance		
Fitter/turner	40	3
Sheet metal worker	27	
Shipwright/carpenter	30	1
Mechanical (maintenance) engineer	12	
Welder	11	5
Painter	9	
Electrician	7	
Boilermaker	4	
Lagger/insulator	3	
Foreman	5	
Timekeeper	2	
Labourer/miscellaneous	7	3
Office worker	10	1
Unknown	19	2
Construction industry		
Carpenter	32	2
Electrician	19	1
Mechanical (maintenance) engineer	7	
Crane operator/driver	4	
Fitter/turner	3	
Plumber	2	1
Painter	3	
Plasterer	2	
Bricklayer	3	1
Labourer/miscellaneous	13	1
Office worker	4	
Unknown	10	0
Other asbestos-using industries		
Fitter/turner	35	2
Mechanical (maintenance) engineer	22	5
Electrician	14	2
Boilerman	11	
Marine engineer	8	2
Coal miners	7	
Carpenter	4	
Welder	7	1
Car mechanic	5	1
Foreman	10	
Crane operator/driver	5	
Labourer/miscellaneous	60	2
Office worker	17	1
Unknown	19	5

that these activities were usually done by specialized companies. A number of cases had worked predominantly in engine rooms, disturbing asbestos lagging during boiler and engine repairs. In the navy and army a considerable number of mesothelioma cases had a job history of activities in the engine rooms of battleships.

In the construction industry, many carpenters and labourers had worked with asbestos cement products, which were commonly used between 1950 and 1978. Craftsmen such as electricians and mechanical engineers were most likely to be primarily exposed to asbestos during handling, removal and repair of asbestos lagging and other asbestos products. Most cases in other asbestos-using industries had probable exposure during handling of a variety of asbestos products, most notably insulation, asbestos cement and asbestos friction material.

Table 5 shows the estimated population-at-risk and the overall risk of mesothelioma for specific branches of industry. The risks were highest in the insulation industry with an overall risk of mesothelioma for 5 out of 100 workers and in the ship building industry for 1 out of 100 workers. In the reference group of all other industries, the overall risk of mesothelioma was 14 cases out of 100000 workers. The highest risk

Table 5. Estimated overall risk on mesothelioma among men across branches of industry during the period 1990–2000, based on the population-at-risk during the period 1947–1960 in The Netherlands

Branch of industry	No. of workers in 1947 census	No. of workers in 1960 census	Population at risk in industry 1947–1960 (total workforce)	Overall risk of mesothelioma (per 100 000 persons)	Risk ratio
Insulation industry	1689	3982	6309	4676	328.4
Ship building and maintenance	35534	47584	83423	1175	82.5
Petroleum refining	2943	11580	17317	347	24.3
Train/tram building and maintenance	16586	14612	22863	219	15.4
Navy and army	18807	64491	97709	189	13.3
Stone, glass and cement	39699	52702	92575	124	8.7
Mining (coal)	50844	59536	107717	121	8.5
Railroad transportation	32361	26333	44610	101	7.1
Power plants (coal, gas)	28881	38391	67417	89	6.3
Primary metal	18434	33224	54911	82	5.8
Construction	293508	399868	698372	73	5.1
Electronic equipment	34970	77760	124244	64	4.5
Chemical industry	33811	65642	107126	61	4.2
Fabricated metal products	67887	100356	172251	58	4.1
Industrial machinery	45673	80238	133219	49	3.4
Shipping	57173	73660	130272	46	3.2
Public administration	151050	174303	316510	27	1.9
All other industries	1910477	1748769	2633614	14	1.0
Food products	152515	167480	307980	13	0.9

ratios were found for the insulation industry (328), the ship building industry (83), petroleum refining (24), train building and maintenance (15), the navy and army (13), and the stone, glass and cement industry (9). The mesothelioma cases in the latter branch of industry originated from a few asbestos cement factories. The construction industry had a risk comparable with many other branches of the asbestos-using industry, but due to its size claimed many mesothelioma cases. The lowest risk ratios were observed for public administration (1.9) and food products manufacturing (0.9).

DISCUSSION

In this study, the rather unusual source of information was legal records held by two law firms. Most information on characteristics of occupational histories with asbestos exposure has been drawn from national mesothelioma registers (Neumann *et al.*, 2001; Yeung and Rogers, 2001; Leigh *et al.*, 2002) or large patient series from hospitals (Bianchi *et al.*, 2001). Unfortunately, these sources were not available since a mesothelioma register does not exist in The Netherlands, and hospital records or death certificates contain very limited or no information on the patient's occupational history. Although the Dutch national register for occupational diseases is based on mandatory notification by the occupational physician, asbestos-related diseases have been severely underreported. In the period 1990–2000, only a few cases of mesothelioma each year were reported to this register.

The comparison with the morbidity figures of mesothelioma from the NRC (2000) demonstrated that ~20% of all mesothelioma cases had sought legal advice from both law firms. The use of lawyers' records may have resulted in selection bias since it is expected that subjects with asbestos-related diseases before the retirement age of 65 yr and male workers are more likely to file a law suit. Indeed, 60% of the mesothelioma cases in our study population were 65 yr or younger, whereas based on the Cancer Registry a proportion of 40% was expected. This shift towards younger cases may have resulted in a larger contribution from the asbestos-using industries. However, this potential selection bias may have been counteracted by a shift in the occupational distribution towards the classic occupations with definite exposure to asbestos, since an occupational history in these jobs will increase the likelihood of a successful claim. This selection may also have resulted in an underestimation of the proportion of household and environmental cases.

Not surprisingly, mesothelioma cases comprised 89% of the study population. The number of asbestosis cases was almost 9-fold lower than mesothelioma cases. Most cases with asbestosis had an occupational history in the ship building or insulation industries, which are well known for high exposure to

asbestos. Hence, these findings concur with the findings in cohort studies that asbestosis is primarily associated with a high cumulative exposure (Mossman and Gee, 1989).

In our study population the mean age at death among mesothelioma cases (62.9 yr) was >4 yr lower than among cases in the Australian mesothelioma register (Yeung *et al.*, 1999), but slightly higher than in cases of the German mesothelioma register (Neumann *et al.*, 2001). The mean age at death was significantly lower for the eight cases with household or environmental exposure to asbestos, with the most extreme case being a son of an asbestos cement worker who died at the age of 34 yr.

Although the start of asbestos exposure is difficult to assess accurately, the mean latency period was ~40 yr. This is very similar to reports from the Australian and German mesothelioma registers (Yeung *et al.*, 1999; Neumann *et al.*, 2001), but 9 yr less than in Italy (Bianchi *et al.*, 2001). This latency period is considerably longer than the often-quoted latency periods of 20–40 yr (Mossman and Gee, 1989), derived from the earliest cohort studies on mesothelioma among insulation workers (Selikoff *et al.*, 1979). Our study population comprised subjects with asbestos-related diseases in the period 1990–2000 and, hence, the estimated latency periods may be overestimated since subjects with exposure before 1960 and shorter latency periods will have died well before the start of our inclusion period. On the other hand, in the study population younger subjects were overrepresented and this will have resulted in shorter latency periods. It has been reported that latency periods have increased over time due to less heavy exposure conditions (Yeung *et al.*, 1999; Bianchi *et al.*, 2001), but this could not be corroborated in this study. The long latency period also illustrates that most subjects with asbestos-related diseases experienced their first asbestos exposure before 1960. Given the fact that the import of raw asbestos steadily increased from 1945 to 1974, and only decreased sharply after 1978, for most workers with first asbestos exposure after 1960, it is still unclear whether they will contract an asbestos-related disease during their life.

The distribution of mesothelioma cases over branches of industry mirrors the findings in the Australian mesothelioma register (Yeung *et al.*, 1999; Leigh *et al.*, 2002). Ship building and maintenance and the construction industry contributed the largest number of cases. In order to compare mesothelioma risks across different branches of industry, the cumulative population-at-risk was assessed for each industry. It has to be acknowledged that the assessment procedure is very sensitive to the assumptions made to calculate the numerator and the denominator and, as a consequence, the overall risk estimates have limited precision. The numerator was based on the observed number of mesotheliomas, adjusted for the fact that ~80% of cases did not file a claim. The numerator may have been affected by selection bias, although the direction of potential biases is difficult to predict. In addition, in some branches of industry the numerator may have been underestimated due to the fact that the shift from the primary asbestos industry to asbestos-using industries seems to have started only in the period after 1960. The denominator may be too small due to limiting the population-at-risk to the period 1947–1960, based upon the years of first exposure among most subjects with asbestos-related diseases. When including those workers first entering the industry between 1961 and the census of 1971, the population-at-risk increased, on average, by ~65%, and, as a consequence, the overall mesothelioma risks would have been lower. A similar effect will occur if the annual change in the workforce was higher than the expected 5%. On the contrary, the denominator may have been overestimated due to a more stable workforce with fewer job changes than assumed. Given the limited information available on size of industry in the past, it is difficult to evaluate the precision of the estimated population-at-risk.

The presented overall mesothelioma risks, therefore, only approximate to some extent the risks in particular industries and are certainly not an expression of the lifetime risk among exposed workers. It would have been preferable to limit the population-at-risk to those workers exposed to asbestos in each branch of industry. Unfortunately, this information is unavailable for almost every type of industry. Hence, the estimated overall mesothelioma risk in a particular industry will depend greatly on the proportion of workers in the workforce who have been exposed to asbestos. It is safe to assume that all workers in the insulation industry, and all those involved in ship building and maintenance, have been exposed to asbestos. The mesothelioma risk in the stone, glass and cement industry is entirely due to mesothelioma cases from three asbestos cement factories, but the available data do not allow separate calculations for the population-at-risk in asbestos cement plants. As a consequence, the overall mesothelioma risk in this industry is diluted by the fact that many workers in stone and glass factories have most probably not been exposed to asbestos. The effect of the proportion of exposed workers on the overall risk per industry is best illustrated by the construction industry. Since the proportion of exposed workers in this industry will be considerably <100%, and maybe even as low as 15%-40% (Nicholson *et al.*, 1982), the risk ratio is much lower than in industries with a higher proportion of exposed workers. Thus, the presented overall mesothelioma risk does not reflect the risk of mesothelioma among exposed workers in a given industry but expresses the overall risk on mesothe-

lioma in industry as a result of the combined effects of the exposure pattern in this industry, the type of asbestos fibre used and the proportion of exposed workers in this industry.

The estimated risk of mesothelioma across the branches of industry is caused by a situation where at least 90% of the asbestos was chrysotile. The insulation industry and ship building and maintenance were the primary users of crocidolite and amosite. Hence, for most branches of industry, chrysotile will have constituted >95% of all exposure to asbestos fibres (Burdorf *et al.*, 1991). This difference in type of asbestos may partly explain the large differences in risk ratios between insulation and ship building and other branches of industry.

The majority (74%) of all cases had experienced their first asbestos exposure before 1960. In The Netherlands the first regulations on asbestos were introduced in 1971 and the first threshold limit value of 2 fibres/ml was not introduced until 1978. The number of cases with first exposure after 1970 was very low (6%) and, thus, most workers who have only worked under improved conditions have not yet reached a sufficient latency period for mesotheliomas to have developed. Hence, the first indications of whether the asbestos regulations had any effect on the risk on mesothelioma among exposed workers will probably not be drawn until another 5–10 yr have elapsed. The asbestos use in the past will certainly claim many more asbestos-related diseases in the next few decades.

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