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Radiographic abnormalities among Finnish construction, shipyard and asbestos industry workers

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Objectives The prevalence of asbestos-related radiographic abnormalities was surveyed among Finnish construction, shipyard, and asbestos industry workers.

Methods The radiographic screening focused on active and retired workers who were under the age of 70 years and had been employed for at least 10 years in construction or for at least 1 year in shipyards or in the asbestos industry. In 1990—1992, 18 943 people participated in an X-ray examination of the lungs and an interview on work history and exposure. The criteria for a positive radiological finding were (i) small irregular lung opacities clearly consistent with interstitial pulmonary fibrosis (ILO 1/1 or higher), (ii) lung opacities indicating mild pulmonary fibrosis (ILO 1/0) with unilateral or bilateral pleural plaques, (iii) marked adhesions with or without thickening of the visceral pleura, or (iv) findings consistent with bilateral pleural plaques.

Results Fulfilling the criteria were 4133 workers (22%) (22% from construction, 16% from shipyards, and 24% from the asbestos industry). The radiological findings included signs of pulmonary fibrosis (3%), changes in the visceral pleura (7%), bilateral plaques (17%), and unilateral plaques (10%). Occupational disease was diagnosed according to the Finnish insurance regulations for three-fourths of those referred for further examinations, 96% being abnormalities in the pleura and 4% being asbestosis.

Conclusions Exposure to asbestos dust has been common in ordinary construction work, and, consequently, radiographic abnormalities (mostly pleural) occur frequently among active and retired construction workers.

Key terms anthophyllite, asbestosis, chrysotile, fibrosis, pleural abnormalities, screening.

Altogether 300 000 t of asbestos were used in Finland between 1918 and 1988 for buildings, ships, construction materials, machines, transport vehicles, and various consumer products. The total volume consisted of 175 000 t of chrysotile, 120 000 t of anthophyllite, and 5000 t of crocidolite and amosite. More than a third of the 1 million buildings in Finland still contain over 200 000 t of asbestos. These figures emphasize the need to control exposure to asbestos in rebuilding and construction situations as a means of primary prevention. The manufacture of new asbestos products practically ceased in 1988. Moreover, the decision of the Council of State has prohibited the manufacture and import of asbestos-containing products since the beginning of 1993. The highest peak in the use of asbestos occurred in the late 1960s and early 1970s. In the past few decades over 200 000 workers have been exposed to asbestos in Finland (1). In the Finnish adult population, bilateral plaques were present in 7.7% of the 2384 urban men and in 4.2% of the 890 rural men included in a representative national sample (2). Earlier exposure to asbestos may cause about 150 premature deaths from lung cancer and mesothelioma annually (3).

In 1988, altogether 453 construction workers were examined by the Finnish Institute of Occupational Health in a pilot study that showed that 116 (25%) had distinct signs of lung fibrosis or pleural plaques. Most of these cases had not been identified by the occupational health care system (4). This finding led to a large-scale prevention and screening study on asbestos-induced diseases, which was a crucial part of the asbestos program of the Finnish Institute of Occupational Health. The objectives were to find X-ray abnormalities caused by asbestos exposure, to carry out the clinical examinations of the workers who screened positive, to organ-

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ize the follow-up, to stop further exposure to asbestos, to influence smoking habits, and to establish a register of heavily exposed and diseased workers, as well as to evaluate the possibilities of preventing asbestos-related cancer (3, 5).

In several studies of plumbers, pipefitters, boilermakers, carpenters, and other workers employed in building construction, parenchymal findings [International Labour Office (ILO) 1/0 or higher] have ranged from 6.8% to 19.4% and pleural abnormalities from 16.8% to 29.4% (6—11). In the screening of 631 construction carpenters in the United States, pleural fibrosis was detected in 106 workers (16.8%) and radiographic small irregular opacities consistent with interstitial lung fibrosis were noted in 6.8% (ILO 1/1 or higher in 2.8%) of the workers (9). Among 9605 sheet metal workers 31.1% had asbestos-related radiographic changes, 18.8% had pleural abnormalities alone, and 4.5% had parenchymal abnormalities (ILO 1/1 or higher). The participants had worked for an average of 32.8 years in the construction industry, and their median age was 57 years (11). In the screening of 1295 sheet metal workers and 2611 insulators, the prevalence of parenchymal fibrosis (ILO 1/1 or higher) was 10.1% and 42.2%, respectively. The profusion score and pleural findings were related to spirometric lung function in both work forces (12—14). The prevalence of pleural plaques was 13.2% in 6183 North American shipyard workers (15). In Sweden, 4.3% of 5898 construction workers and 9.9% of 203 asbestos cement workers had small opacities (ILO 1/1 or higher). In these 2 cohorts pleural thickening of the chest wall (diffuse or circumscribed) was present in about 45% of the examined persons (10, 16).

Subjects and methods

A preliminary questionnaire was sent to 54 409 workers, of whom 36 308 responded. Altogether 24 589 of them were invited to the screening and 18 943 (77%) participated. Of them 17 937 were from the construction industry, 456 from shipyards, and 550 from the asbestos industry. The coverage for the construction sector was rather good because all current and retired workers employed in that sector for more than 10 years according to the register of the LEL Employment Pensions Fund were invited to participate. The study included a detailed questionnaire, an interview, and an X-ray examination comprising full-size anteroposterior and lateral chest radiographs (5).

The workers who participated in the study were (i) persons who were under 70 years of age and had worked for at least 10 years in construction and had commenced work before 1980, (ii) persons who had worked for at least 1 year in shipyards and had commenced work before 1980, (iii) persons who had worked for at least 1 year in an asbestos quarry or in the asbestos product industry and had commenced work before 1976.

The mean age of the screened persons was 53.2 years in construction, 49.8 years in shipyards and 52.5 years in the asbestos industry. Altogether, 18 237 were men (mean age 52.9 years) and 706 were women (mean age 59.9 years). Of all those screened, 66% were still working at the time of the study in 1990—1992.

Those who had smoked at least 1 cigarette per day for a period of at least 12 months were classified as smokers. Those who had not smoked for the past 6 months were considered ex-smokers. The smoking habits of all the screened persons from the 3 sectors are presented in table 1. About 28% of the men were smokers and 41% were ex-smokers. For the women, the corresponding figures were 23% and 15% respectively.

"Onset of exposure" was recorded as the year in which the subject had started to work in construction, shipbuilding, an asbestos quarry, the manufacture of asbestos products, or in brake and clutch maintenance in car repair shops. Accordingly, all known exposure situations were taken into account in addition to the inclusion criteria. "Years worked" refers to the duration of employment in these selected risk sectors. "Duration of exposure" equals the total number of years that the worker had been exposed to asbestos in various jobs specified separately in the interview forms (eg, asbestos spraying, pipe insulation, installation and use of asbestos-containing materials, handling of asbestos cement products, cleaning work at building sites, asbestos removal).

The criteria for a positive radiological finding were (i) small irregular lung opacities clearly consistent with interstitial fibrosis (ILO profusion at least 1/1), (ii) small irregular lung opacities indicating mild interstitial fibrosis (profusion 1/0) and findings consistent with unilateral or bilateral pleural plaques, (iii) findings indicating marked abnormalities of the visceral pleura (obliterated costophrenic angle or other evident pleural adherences with or without pleural thickening) not known to be caused by infection, (iv) findings consistent with bilateral pleural plaques.

For the classification of radiographs, a system suitable for the screening was developed, with the aim of achieving maximal simplicity yet leaving out nothing essential. It was intermediate between the complete and short ILO classification (17) with some simplifications and the following additions: (i) a subcategory of the ILO profusion category 0/0 was

Table 1. Smoking habits of the screened workers (%).

Group of workers	Industry			
	Construction	Shipyard	Asbestos	All combined
Nonsmokers	30.4	34.6	40.2	30.7
Ex-smokers	41.4	35.1	33.9	41.0
Smokers	28.3	30.3	25.9	28.2
Workers without data on smoking	0.1	0.0	0.4	0.1

added to the 12-point scale for recording minute lung abnormalities, (ii) the concept of uncertain, suspected abnormality was added for the pleural abnormalities, (iii) pleural adherences other than costophrenic angle obliteration were separately recorded, (v) the concept of "diffuse pleural thickening" of the ILO classification was substituted with "thickening of the visceral pleura", denoting pleural thickening in connection with adherences.

The ILO reference films were used for comparison with every posteroanterior radiograph. The profusion of small lung opacities was classified in accordance with the complete ILO system using a 12-point scale with the aforementioned addition. Their distribution in the 6 ILO lung zones was not recorded. The size and shape of small opacities were categorized in a simplified manner as irregular, consistent with asbestos exposure, or mainly or partly rounded. Right-sided and left-sided pleural abnormalities were recorded separately, but a complete recording of their site (diaphragm, chest wall, other) was not made. Local pleural thickening of the lateral chest wall with a width of at least 5 mm seen only in profile was treated as circumscribed thickening if no adherences were present. To avoid false-positive findings, slight lateral shadows less than 5 mm wide were not recorded, and irregularities in the diaphragmatic outline were registered as plaques with caution; calcification was considered to be a definite sign of plaques.

Results

The findings were positive for 22% of all the subjects (22% in construction, 16% in shipyards, and 24% in the asbestos industry). The mean age of those with positive findings was 59 years, and for those who were negative it was 51 years. The prevalence of radiological findings increased with age as reported earlier (5, 18). Of all the 18 983 persons screened, 66% were still working. The persons who screened positive were older, and, consequently, the corresponding figure was lower (45%) for them. A total of 706 women, most of whom were employed as cleaners, took part in the screening study. Although their mean age was higher than that of the men, they had fewer positive findings (18.7% versus 22.1%). The women had typically started their work in construction at an older age than the men, and their average duration of employment (19 years) was also shorter than the men's (26 years).

The findings were positive for 20% of the smokers, 26% of the ex-smokers, and 19% of the nonsmokers. Pleural plaques, both unilateral and bilateral, were found in 22% of the smokers, 31% of the ex-smokers, and 26% of the nonsmokers. X-ray findings indicating pulmonary fibrosis (at least ILO 1/0) were diagnosed for 4.5% of the smokers, 4.0% of the ex-smokers, and 1.6% of the nonsmokers. Eight percent of the smokers gave up smoking after being screened, as confirmed after a 12-month monitoring. At the time of the study, 28% of the men and 23% of the women smoked (19).

The most common radiographic findings were bilateral pleural plaques alone (12.5%) or together with other findings (17.0%). These are the most typical of the changes caused by asbestos exposure. The lower prevalence of plaques among the shipyard workers was partly explained by the fact that the majority (more than 80%) was still working and their mean age was lower. The prevalence of positive findings indicative of pulmonary fibrosis was almost equal in all the sectors: 2.9% in construction, 3.1% in shipyards, and 3.1% in the asbestos industry (table 2). Small irregular lung opacities indicating interstitial pulmonary fibrosis (at least ILO 1/0) was found in 3.4% of the subjects, including 2.5% with associated pleural plaques. Changes in the visceral pleura were found in 7.0% of the subjects, most of whom also had pleural plaques. Small rounded opacities consistent with silicosis (at least ILO 1/0) were found in 55 workers from construction (0.3%), 4 from shipyards (0.1%) and 3 from the asbestos industry (0.1%). Unilateral pleural plaques only were diagnosed for 10.3% of the subjects, and small opacities of profusion 1/0 suggesting incipient pulmonary fibrosis were found in 0.5%. Neither were counted as positive findings, and the subjects were not referred for follow-up examinations.

There was marked variation in the geographic distribution of the positive findings (figure 1). The prevalence was highest in the province of Uusimaa (29%), including the Helsinki area. Increased findings were also the case for coastal towns such as Turku, Pori and Kemi, probably because of heavier industrial use of asbestos in these regions.

Positive findings grew with the time that had elapsed since the commencement of employment in the asbestos-related occupations. The mean year of onset of exposure for the entire study group was 1960. If the exposure predated 1955,

Table 2. Radiological findings by industry (% of the screened).

Radiological finding[a]	Industry			
	Construction	Shipyard	Asbestos	All combined
Small irregular lung opacities (ILO 1/1 or higher)[b]	1.6	2.2	2.6	1.7
Small irregular lung opacities (ILO 1/0) and plaques[b]	1.2	0.9	0.6	1.2
Bilateral plaques[b]	12.5	7.9	15.1	12.5
Thickening of visceral pleura[b]	3.0	2.2	2.0	2.9
Thickening of visceral pleura and plaques[b]	4.1	2.2	4.4	4.1
Small irregular lung opacities only (ILO 1/0)	0.5	0.9	0.9	0.5
Unilateral plaques only	10.3	9.0	10.2	10.3
No findings	66.7	74.8	64.4	66.8

[a] The ILO classifications in parentheses are based on reference 17.
[b] Screened positive.

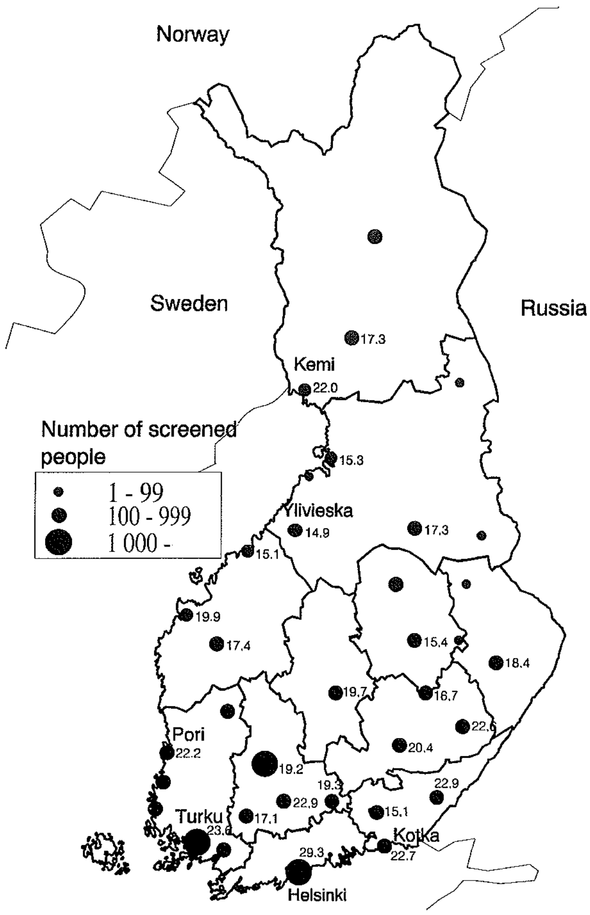

Figure 1. Positive findings by locality (%).

more than one-third of the subjects screened positive. If it was after 1970, only 2% screened positive. The earlier the onset of exposure, the higher the incidence of small opacities and pleural plaques (table 3).

The mean duration of employment in the risk sectors was 26 years (table 4). The percentage of positive findings increased with the number of years worked, one exception being a special group of several hundred workers who had been subjected to brief (fewer than 5 years), but heavy asbestos exposure in insulation work or in the asbestos industry. No separate analysis was made of the compounded effect of age and duration of exposure. Of the subjects diagnosed with small irregular lung opacities (at least ILO 1/0), 52% were found to have bilateral pleural plaques, 20% unilateral plaques, and 28% no plaque change. When the duration of employment was 15 years or less, more than half of the lung opacities occurred without pleural plaques, whereas associated plaque changes were detected in 79% of those employed in risk sectors for 30 years or more. Bilateral pleural plaques were found in 17% of the subjects, three-quarters of whom presented no other radiological findings. Associated findings suggesting pulmonary fibrosis (at least ILO 1/0) were found in 11% of these subjects (ie, 5 times more frequently than in plaque-free cases).

The duration of asbestos exposure was calculated also from reported occupational contact with asbestos spraying, pipe insulation, installation; the use of asbestos-containing materials; the handling of asbestos cement products; cleaning work; or asbestos removal. The interviews revealed that the average duration of such exposure was 9.0 years in construction, 7.8 years in shipyards, and 9.7 years in the asbestos industry. The average for all sectors combined was 9.0 years. Jobs and tasks involving direct exposure to asbestos thus accounted for about one-third of the total time worked in risk occupations, which averaged 26 years. The prevalence of positive findings rose with the duration of exposure. This percentage was 18% among those who had been exposed to asbestos for less than 10 years (12 507 persons), 27% among those exposed for 10—30 years (5542 persons), and 43% among those exposed for over 30 years (914 persons).

The prevalence of positive findings ranged from 11% to 32% when the subjects were grouped on the basis of their last occupation as reported during the interviews. This variation was largely due to the age differences between the occupational groups (table 5). Only 10% of the subjects had left their previous occupation in favor of an entirely different branch of industry.

Table 3. Radiological findings (% of the screened workers) according to the year asbestos exposure commenced.

First year of employment in the risk sectors	Number of screened workers	Radiological finding			
		Screened positive (%)	Small irregular opacities ILO 1/0 or higher[a] (%)	Bilateral pleural plaques (%)	Unilateral pleural plaques (%)
1940 and before	206	53.4	11.7	32.2	18.5
1941–1945	973	45.1	8.0	30.5	18.0
1946–1950	2588	40.0	7.0	27.1	18.2
1951–1955	2760	32.1	4.8	22.0	17.0
1956–1960	3658	23.1	3.6	15.8	13.3
1961–1965	3987	15.3	1.9	10.6	10.9
1966–1970	2110	8.4	0.6	5.6	6.8
1971–1975	1524	2.2	0.3	1.1	2.0
1976–	1108	2.0	0.2	1.2	1.6

[a] According to reference 17.

Table 4. Radiological findings (% of the screened workers) according to the workyears in the risk sectors.

Duration of employment in the risk sectors (years)	Number of screened workers	Radiological finding			
		Screened positive (%)	Small irregular opacities ILO 1/0 or higher[a] (%)	Bilateral pleural plaques (%)	Unilateral pleural plaques (%)
≤ 4	640	18.8	3.6	13.8	7.5
5—10	580	14.5	2.8	9.7	7.8
11—15	1777	9.6	1.0	6.2	4.5
16—20	2337	10.4	1.8	6.8	7.1
21—25	2971	16.7	2.5	10.7	10.4
26—30	4073	20.9	3.2	14.2	12.3
31—35	3329	28.5	4.1	19.7	15.8
36—40	2293	37.5	6.5	25.7	18.5
> 40	943	41.3	6.2	28.7	17.8

[a] According to reference 17.

Construction

Altogether 17 937 construction workers were examined; 22% had a positive chest X-ray finding. The differences in positive findings between 46 occupational titles were small (18). The prevalences were about the same if only the workers who had worked in only 1 occupation in construction were included. Such people accounted for 47% of all workers in the sector. Standardization by age revealed that the below-average positive findings for electricians (11%) were due to their lower mean age. There were fewer positive findings (11—15%) for workers in typical women's occupations (cleaners and building assistants) than in other occupations. There were likewise fewer positive findings in ancillary occupations such as machine or tractor driving (14—17%). Blasters (36%) and pipe insulators (31%) had the most positive findings. The occupation of a blaster is not typical of building construction, but the study included 39 people who had worked in this occupation at some stage, usually for a short period (1—2 years). Only 4 people had worked as a blaster for more than 10 years, and of these only 1 exclusively as a blaster. Four of the X-ray findings among the blasters were suspected pneumoconiosis (1 of these nodular), 10 were bilateral plaques, and 1 was a change in the visceral pleura.

Table 5. Positive screening findings grouped by the last occupation.

Occupation	Number	Screened positive (%)	Standardized by age (%)
Engineers, foremen and architects	1 528	22.6	23.3
Sales, research, administrative and office employees	376	23.9	26.9
Farmers and forestry workers	109	18.8	17.2
Land and water construction workers and vehicle operators	277	24.2	23.2
Carpenters	4 664	25.0	20.3
Bricklayers	1 296	31.6	24.6
Steel fixers and concrete workers	839	29.7	22.5
Insulators	431	22.7	26.1
Sheet metal workers	241	21.6	31.7
Plumbers	2 258	17.3	24.7
Welders	105	13.3	16.8
Electricians	2 337	10.6	29.0
Painters	1 332	26.4	25.2
Other occupations in construction	1 896	21.3	18.3
Other industrial occupations	762	20.5	21.4
Cleaners and caretakers	419	21.0	16.7
Other service workers	73	20.6	17.9
Total	18 943	22.0	22.0

Table 6. Positive screening findings, smoking habits, fibrosis (ILO 1/0 or higher[a]), and age of the carpenters, insulators, construction engineers and the entire group of construction workers.

Group	Number of workers	Age (years) of all screened (mean)	Age (years) of workers screening positive (mean)	Duration (years) of employment (mean)	Nonsmokers (%)	Ex-smokers (%)	Smokers (%)	Screening positive (%)	Fibrosis (ILO 1/0 or higher[a]) (%)	Bilateral plaques (%)	Unilateral plaques (%)
Carpenters	4 513	56.9	61.6	29.0	27.9	46.7	25.3	25.5	4.1	19.2	14.6
Insulators	418	51.5	57.4	25.1	26.6	40.8	32.6	23.8	8.5	16.0	11.6
Engineers	1 063	52.6	59.3	24.7	41.0	40.7	18.3	22.3	1.4	16.5	13.2
All construction workers	17 937	53.2	59.5	26.5	30.4	41.4	28.3	22.1	3.4	16.7	12.8

[a] According to reference 17.

Construction workers had been employed, on the average, in 2.4 sectors, 1.8 occupations, and 3.4 jobs. The worktime in sectors other than construction was 19%, of which 3% were risk sectors (shipyards, asbestos industry, car repair shops). About 75% of the construction work had been done on new buildings and 25% in renovation work. Positive findings were above the average when the persons had worked in the asbestos industry or in asbestos spraying or insulation in shipyards in addition to the minimum 10-year period in construction. The number of positive findings was below the average among the past garage workers.

According to the interview and questionnaire, 45% of the construction workers had installed asbestos-containing wall panels, 31% had installed asbestos-containing ceiling panels, 36% had used asbestos paints, putties and fillers, 21% had installed heat and fire insulation, 39% had dismantled asbestos-containing materials, and 27% had cleaned areas where asbestos was present. Over 90% of the workers reported that the tasks involving exposure to asbestos dust were done near them or in the same workplace.

Table 6 presents the data on the typical occupations of the construction industry. The findings were positive for 24% of the insulators, 26% of the carpenters, and 22% of the engineers. Bilateral pleural plaques were found in 16%, 19% and 17%, respectively. The mean age and duration of exposure were nearly equal in these occupations. Pulmonary fibrosis (ILO 1/0 or higher) was more common among the insulators (8.5%) than among the carpenters (4.1%), and the engineers (1.4%). Fibrosis was also more frequent among the carpenters than among the workers in the construction branch as a whole. The insulators were presumably exposed to asbestos the most intensively, while the engineers had short-term exposures from other previous construction jobs or indirectly during worksite visits.

Shipbuilding

Radiological findings were positive for 16% of the 456 subjects representing shipbuilding. There were too few workers in each of the 31 occupational categories to draw reliable conclusions on possible differences between them (18). On the average, the workers in shipbuilding were employed in 2.5 sectors, 1.4 occupations, and 2.8 jobs. Occupations other than those directly related to shipbuilding accounted for 20% of the total period of workyears. Of the subjects who were screened, 39% had handled asbestos-based insulation materials, 34% had touched asbestos sprayings, 28% had cut or installed asbestos gaskets, 22% had handled or installed asbestos wall units, and 20% had been exposed to asbestos in engine rooms. Some 85% reported that jobs involving exposure to asbestos dust had been carried out near them or in the same work space.

Asbestos industry

Radiological findings were positive for 24% of the 550 subjects screened from the asbestos industry. On the average, they had been employed in 2.3 sectors, 1.4 occupations, and 2.0 jobs. Sectors other than the asbestos industry accounted for 73% of the total number of workyears. Exposure to asbestos dust was typical in the following jobs: repair (26%), cleaning (22%), handling of raw asbestos (13%), grinding and mixing of asbestos cement (13%), cutting of asbestos panels (13%), and other jobs in the asbestos industry (81%). There were no marked differences between 45 separate occupational categories. A small number of the subjects (29 persons) had been reportedly exposed to asbestos in the general environment only and thus did not fulfill the formal inclusion criteria. (See the Subjects and Methods section.) They were elderly residents of the district of Paakkila, the site of an anthophyllite mine, and pleural plaques were common among them.

Discussion

The present study showed that, in the chest X-ray examinations, 1 out of 5 (22%) of all the screened 18 943 workers had abnormalities commensurate with exposure to asbestos. Altogether 4708 people (25%) were referred for clinical examination (anamnesis, lung function, laboratory tests). An occupational disease according to the Finnish insurance regulations was diagnosed and registered for three-fourths of the 4133 persons who screened positive (96% with abnormalities in the pleura and 4% with asbestosis). Regular health checks were recommended for 97% of those screened but not referred for follow up. The fact that only 3% of the subjects had not been exposed to asbestos to a degree warranting follow-up shows that the target group was well-chosen a priori in this respect. There were no remarkable differences regarding the prevalence or type of radiographic findings between the 3 sectors (construction, shipyards, and asbestos industry). There was a clear correlation between a positive finding and age because the mean exposure to asbestos was longer or heavier for older workers; in addition to which there had been more time for the gradual change caused by asbestos to become apparent. Women accounted for a smaller proportion of positive cases than the men. They had entered construction jobs later than the men and therefore had been exposed for a shorter time. The prevalence of small irregular opacities and pleural changes depended much also on the onset and duration of exposure.

Findings suggestive of pulmonary fibrosis (ILO 1/0 or higher) were almost equally present among the workers in construction, shipyards and the asbestos industry (3.4—4.0%). All told, 6.2% workers with more than 40 years at risk had interstitial fibrosis (at least ILO 1/0), and the corresponding figure was 1.5% for the workers with 10—20 years at risk. Pulmonary fibrosis was more common among the insulators than among the carpenters or construction engineers, while pleural changes were equally prevalent in these

3 occupations; this finding suggests that heavy exposure had occurred the most frequently among the insulators. The present study indicates that radiological signs of parenchymal fibrosis are generally associated with reasonably high exposure levels (13, 20).

Asbestos-associated pleural abnormalities are divided into pleural plaques mainly involving the parietal pleura sometimes with calcification and diffuse pleural thickening, which is a collective name for pleural reactions involving mainly the visceral pleura. The latter includes asbestos-related pleural effusion, blunted costophrenic angle, crow's feet, or pleuroparenchymal strands and rounded atelectasis (21, 22). For the screened persons the prevalence of bilateral plaques (17%) was about 4 times as high as among unlikely exposed men in Finland (2, 23). The comparison with the population sample can be assumed to be valid because the studies were made with a corresponding methodology and one of the authors (AZ) participated in each study. Pleural plaques were diagnosed for two-thirds of the workers with parenchymal fibrosis. They were observed in less than half of workers with small irregular opacities and less than 15 years of exposure, but after a long period of exposure (more than 30 years) pleural plaques were present in 80% of such cases. This finding indicates that parenchymal fibrosis may have developed after shorter and possibly more massive asbestos exposure, whereas pleural plaques require a longer period to become detectable by chest radiography. The prevalence of positive findings increased with both the onset and duration of asbestos exposure (tables 3 and 4). A positive X-ray finding was assessed for 20% of the smokers, 26% of the ex-smokers, and 19% of the nonsmokers. Smoking was, then, a relatively insignificant factor for the positive findings (mostly pleural). Unilateral or bilateral pleural plaques were not associated with smoking. Pulmonary fibrosis, in contrast, was more common among regular or former smokers. Smoking effects and lung diseases (bronchitis, emphysema) may influence the radiological interpretation of pulmonary fibrosis (2, 20, 24).

The majority of the findings in the construction sector were pleural plaques, and the percentage of screening-positive cases did not materially differ from each other in the 46 different occupational groups. Virtually all pleural plaques are caused by asbestos, and their occurrence illustrates the frequency of exposure to asbestos in the groups of workers. As individual differences have a significant effect on the incidence, site, and size of plaques, they may not be useful for evaluating individual exposure levels, particularly in this target group, in which nearly everybody had been exposed to asbestos dust to some extent. When age was accounted for, positive findings were observed the most often for pipe insulators, ventilation technicians, sheetmetal workers, masons, and plasterers. These are all occupations in which exposure to asbestos is common. Such comparisons could not be made for shipyards or asbestos-products factories owing to the small number of subjects.

Unilateral pleural plaques are generally caused by asbestos; in all likelihood, they later develop into the bilateral form. Plaque diagnosed as unilateral in a normal lung X-ray often turns out to be bilateral in a more-detailed examination. Exclusively unilateral plaques were not considered positive, however, because they are not necessarily caused by exposure to asbestos. Asbestos is clearly more often the cause of bilateral plaques. It was further assumed that impaired lung function may not be associated with unilateral plaques. Only some of the plaques are seen in normal X-rays; in other words, there was in fact a considerably higher number of them among the subjects examined. The visceral pleural lesions indicate heavier exposure than plaques alone, and they are often concurrent with parenchymal asbestosis (13, 21). An unknown percentage of the changes in the visceral pleura were probably caused by some other illness (eg, an infection). To some extent, pleural abnormalities reflect the type of asbestos exposure. The Paakkila anthophyllite mine was in operation between 1918 and 1976, and thus about 40% of all asbestos used in Finland has been amphibole. The high prevalence of pleural abnormalities in Finland and in the present survey is not surprising (2, 3, 23), because anthophyllite is one of the most aggressive asbestos fibers to induce pleural plaques (25). In terms of use and exposure, chrysotile was the most widespread type in the construction and asbestos cement industry.

Cancer was diagnosed only in a few individual cases, even though the risk of lung cancer or mesothelioma was highly probably elevated owing to the exposure to asbestos. Pleural changes or pulmonary fibrosis are considered an indication of asbestos exposure but the cancer risk may be significantly elevated in exposed people without such changes. The early detection of asbestos-related diseases primarily attempts to support other preventive actions, but the screening for lung cancer in high-risk groups has also been proposed (26, 27). There is evidence that such programs may improve the outcome (28, 29). Lung cancer can often be found in active surveillance by comparing consecutive chest X-rays or by using computed tomography to detect small malignant changes. In normal X-ray examinations, pleural changes may occasionally cover an incipient cancer. Since local and, above all, nonsmall cell lung cancers can often be cured with radical surgery, the prognosis for a cancer diagnosed at an early stage is better than that for a cancer diagnosed later (30).

Concluding remarks

As a summary of this screening study, it is concluded that:

1. Direct and indirect exposure to asbestos has been common in construction work, and, consequently, radiographic lung abnormalities occur frequently among active and retired workers.

2. Pleural plaques indicate the probability of any asbestos exposure, whereas parenchymal fibrosis is more closely related to higher levels of exposure.
3. Screening has a notable effect on the registration of asbestos-induced diseases.

Exposure to asbestos dust in ordinary construction work and its significance for the onset of lung diseases had not previously been surveyed in Finland. The bulk of the exposure is indirect. Asbestos work is done in the same workplace or nearby, and asbestos-containing dust remains in the work environment for a long time. Thus all occupational groups in the construction sector have probably been exposed to asbestos at some of the numerous sites where they have worked during the past. Most of the diseases diagnosed were changes in the pleural membrane; changes suggestive of asbestosis or cancer were rare.

Only 1 in 4 of the people examined had been covered by the mandatory medical examinations despite their considerable occupational exposure to asbestos. It was clear from the screening that, without specific joint efforts at the national level, the follow-up of asbestos diseases and people exposed to asbestos will not function properly. Such health problems will be important for many years to come, even if current asbestos exposure can be prevented.

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