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Asbestos-related findings in chest radiographs of the male population of the county of Telemark, Norway — A cross-sectional study

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HILT B, LIEN JT, LUND-LARSEN PG, LUND K, LANGÅRD S. Asbestos-related findings in chest radiographs of the male population of the county of Telemark, Norway — A cross-sectional study. *Scand J Work Environ Health* 12 (1986) 567—573. In order to investigate the prevalence of asbestos-related diseases, a cross-sectional population study was conducted among 28 216 men aged 40 years in nine municipalities of the county of Telemark, Norway. In a primary radiographic screening 10 × 10-cm chest radiographs were taken of 21 483 persons. In two independent readings of the radiographs, pleural changes were observed in 6.9 and 8.5 % of the study subjects. Radiographic findings in the primary screening led to 1 431 subjects being selected for a reexamination. On the basis of occupational histories and 40 × 40-cm chest radiographs, it was concluded that 470 of these subjects (2.2 % of the screened population) had radiographic changes consistent with an asbestos-related disorder. Among these, 86 had lung fibrosis (82 in combination with pleural plaques) and 384 had pleural plaques only. There were marked differences in the occurrence of asbestos-related disorders between the seven urban and two rural communities studied, and agreement was observed between the occurrence of such disorders and the degree and duration of the reported asbestos exposure. The study presents evidence that asbestos-related disorders may be more prevalent in the general male population than has been recognized earlier.

Key terms: asbestos-related disorders, general population, occupational history, X-ray screening.

In recent years the importance of previous asbestos exposure as a disease determinant in the general population has become more and more obvious. Therefore, different attempts have been made to estimate the number of people with a history of asbestos exposure, and the prevalence of asbestos-related diseases in the general population (13, 16, 19).

In health-survey material from six municipalities in the county of Uppsala, Sweden, Hillerdal (4) observed pleural plaques in 0.5—3.5 % of males above the age of 40 years. Among the 354 subjects with pleural plaques who were questioned, 79.4 % confirmed that they had been exposed to asbestos.

Of the 824 chest radiographs taken on admission to the Pennsylvania University Hospital in the United States (US), 6.2 % showed bilateral pleural thickening (1). There was a marked difference in the occurrence between males and females (16.7 and 0.4 %, respectively). Among 52 patients with pleural thickening, 44 % had had "definite" or "probable" occupational exposure to asbestos, and an additional 23 % had "possible" exposure. Among 17 % of the patients other causes of the pleural thickening, such as chronic renal failure, severe rheumatoid arthritis, previous infections or emboles, chest surgery or injuries, were observed, while no discernible cause was found for the remaining 16 %.

In another US study Anderson & Selikoff (2) observed pleural thickening in 0.9 % of midwest dairy farmers and 1.2 % of New Jersey residents without known asbestos exposure. In routine radiographs taken during one year at the Los Angeles University Hospital, Sargent et al (18) observed 36 cases of pleural thickening and were subsequently able to document previous occupational exposure to asbestos in all of the cases.

In routine chest radiographs of patients at the Telemark County Hospital 69 patients were found with, previously unrecognized, pulmonary fibrosis and/or pleural plaques between 1978 and 1981. In thorough interviews of these patients about their occupational histories, 43 (62.3 %) reported previous occupational exposure to asbestos (7). The main causes of the observed changes among the others were previous tuberculosis or other pulmonary or pleural infections, while no clear explanation was found in 11 cases.

In a questionnaire screening the prevalence of asbestos exposure and smoking habits in the general male population aged 40 years and over from the county of Telemark was recorded (6). The aim of the present study was to investigate the prevalence of asbestos-

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related disorders, in terms of asbestos-related findings in chest radiographs, in the same population. The present paper presents the results of a primary radiographic screening of 28 216 men and a secondary screening, including a clinical examination, of a selected group, the secondary screening hereafter being referred to as the reexamination.

Subjects and methods

Study population

The county of Telemark is located in southeast Norway. There is heavy industry in some parts of the county, and previous investigations have shown that asbestos has been extensively used in many workplaces since the turn of the century (5, 7, 8, 10, 12, 21). The county has 18 municipalities, and on 31 December 1981 there were 80 435 male and 81 612 female inhabitants. Natural fibrous minerals occur sparsely in Telemark. Asbestos fibers can be found in certain rocks, but only in very limited areas.

For economic and practical reasons the survey population could not exceed 30 000 persons, and therefore the study population was restricted to men aged 40 years and over from nine municipalities. Seven of the municipalities are typical industrial communities with a variety of industries, such as electrochemical plants, ferroalloy plants, electrical equipment industries, iron foundries, paper mills, and shipyards. These seven municipalities had an average of 3 816 (range 1 652—9 500) males above 39 years of age. The two rural municipalities, which were included as "reference" communities, had 777 and 724 males above 39 years of age. All in all 28 216 men were eligible for the study, 26 715 from the industrialized communities and 1 501 from the rural ones.

Primary radiographic screening

The Norwegian National Health Screening Service has carried out screening for tuberculosis throughout the country since 1947. In recent years it has also conducted selective pneumoconiosis screening of employees in certain industries where dust exposure occurs. As a tuberculosis screening was planned in the county of Telemark for 1982—1983, it was decided to include a population screening of asbestos exposure and asbestos-related diseases. The screening was conducted by mobile X-ray units in which 10 × 10-cm chest radiographs in frontal and lateral projections were taken. For practical reasons radiographs with an oblique view could not be taken during this screening.

All the radiographs from the screening were examined by the National Health Screening Service in the same manner as in screening for tuberculosis and by help of a magnifier which enlarged the radiographs by 25 %. All the radiographs were first read independently by two experienced radiologists. The findings were noted in radiological terms and coded as indicated in table 1. In the selection of subjects for reexamination all the radiographs with possible abnormal findings, according to at least one reader, were examined again by a third reader, who also had access to previous radiographs of the subject. If the radiographic abnormality observed was considered by the third reader to have immediate health implications, the subject was referred to reexamination by a pneumonologist (JTL) at the out-patient clinic of the county hospital. In addition, all the written descriptions of radiographs with abnormalities were reviewed by one of us (BH) in order to identify findings which could represent an asbestos-related disorder. Such descriptions were "lateral pleural changes," "pleural calcifications," or "basal pulmonary fibrosis." All subjects with findings possibly related to asbestos exposure were selected for a clinical reexamination at the Department of Occupational Medicine. The only criterion for this selection was the radiographic findings from the primary screening.

Reexamination

In an attempt to standardize procedures, the reexamination was conducted in the same way at the Department of Pneumonology and at the Department of Occupational Medicine. A detailed occupational history with special emphasis on previous exposure to asbestos was recorded for all the selected subjects and by the same physician (BH). For those who were examined at the Department of Occupational Medicine 40 × 40-cm chest radiographs were taken at the Department of Radiology in frontal, lateral, and 45° oblique views. For technical reasons, it was not possible to take radiographs with an oblique view of those who were examined at the Department of Pneumonology.

When previous occupational exposure to asbestos was reported in the occupational history at the interview of those who attended the reexamination, the exposure was coded according to the degree, start, and duration of exposure. On the basis of each subject's own opinion of his previous exposure, and of the interviewer's knowledge about the exposure situations at different workplaces, the degree of exposure was categorized into the following groups: (i) *uncertain,* includes subjects who had been employed in typical workplaces with possible asbestos exposures, such as ship machine rooms or ferroalloy industries, but who were not certain themselves whether they had been exposed or not; (ii) *light,* includes subjects with confirmed exposures from, eg, ship machine rooms, automobile workshops, or building trades; (iii) *moderate,* includes industrial employees who worked regularly with asbestos, eg, industrial plumbers or certain maintenance workers in the ferroalloy or electrochemical industries; and (iv) *heavy,* includes, eg, industrial insulators or workers who had regularly used asbestos as a jointing material in acid production or had been engaged in preparing raw asbestos for different purposes such as packing or insulation materials.

The duration of exposure was defined as the time from the start to the end of employment in the job with exposure. For those with intermittent exposure, eg, three months a year, the estimated duration of exposure was adjusted accordingly.

At the reexamination smoking habits were recorded for all the subjects. Those who had smoked regularly for one year or more were regarded as smokers. Those smokers who had stopped smoking more than one year prior to the examination were regarded as exsmokers.

Among those who attended the reexamination, asbestos-related diseases were diagnosed when the following three criteria were met: (i) verified previous occupational exposure to asbestos in the interview; (ii) findings on the 40 × 40-cm chest radiographs consistent with a pulmonary and/or pleural asbestos-related disorder — such findings would be reticular fibrosis with irregular opacities in the lower parts of the lung fields, distinct pleural thickening with or without calcifications located on the chest wall or on the diaphragm, or diffuse pleural fibrosis as found in asbestos pleurisy; and (iii) absence in the medical history of any previous pulmonary or pleural disease or injury which could be regarded as a more probable cause of the findings observed. In a few cases it was concluded that the same subject had findings both related to previous asbestos exposure and as a sequel to a previous disease and/or injury.

Results

There were 21 483 (76.1 %) of the 28 216 men eligible who attended the primary radiographic screening.

The radiographic findings observed by the radiologists who read the 21 483 10 × 10-cm radiographs from the primary screening are presented in table 1. The two independent readers described abnormalities in 4 558 (21.2 %) and 5 009 (23.3 %) subjects, respectively, and pleural changes in 1 835 (8.5 %) and 1 482 (6.9 %), respectively. According to the described criteria, 1 431 subjects were selected for reexamination, 624 (2.9 %) at the Department of Pneumonology and 807 (3.8 %) at the Department of Occupational Medicine. Fifty-nine (4.1 %) did not attend the reexamination. Of these 22 had died between the primary screening and the follow-up, 11 were sick when the reexamination took place, and 7 gave other reasons for not attending. The remaining 22 did not even respond to a second invitation.

Table 2 presents the prevalence of asbestos-related disorders diagnosed in the reexamination in each of the municipalities. In all, 86 subjects showed lung fibrosis, 82 of them in combination with pleural plaques. Other cases of pulmonary diseases were also diagnosed in the clinical reexamination. Table 3 summarizes the most frequent of these diagnoses and the asbestos-related disorders.

Previous occupational exposure to asbestos was verified for 852 subjects at the reexamination. Table 4 presents the type of industries or occupations in which the exposure had taken place, and the number of men with diagnosed asbestos-related disorders from each of the exposure situations. There were 156 subjects who had been exposed at more than one workplace. Therefore, table 4 contains 1 008 different exposure situations.

Eighty-six persons, 34 with lung fibrosis and pleural plaques and 52 with pleural plaques only, who were

Table 1. Findings in 21 483 10 × 10-cm chest radiographs of the primary screening, as described by two independent radiologists.

Grouping of described findings	First reader		Second reader	
	N	%	N	%
Normal	16 925	78.8	16 474	76.7
Lung or hilar calcification	900	4.2	1 120	5.2
Pleural changes	1 393	6.5	1 108	5.2
Lung changes without pleural changes or calcifications	886	4.1	1 263	5.9
Lung infiltration and calcification	221	1.0	416	1.9
Lung infiltration and pleural changes	442	2.1	374	1.7
Changes in heart configuration or big vessels	448	2.1	421	2.0
Anomalies	7	0.0	26	0.1
Other findings	246	1.1	266	1.2
Technically useless radiographs	15	0.1	15	0.1
All	21 483	100.0	21 483	100.0

Table 2. Prevalence of asbestos-related disorders verified in the reexamination.

Municipality	Lung fibrosis ± pleural plaques (1) (N)	Pleural plaques only (2) (N)	Crude prevalence rate (1 + 2) (%)	Age-adjusted prevalence rate (1 + 2) (%)
Industrial				
Porsgrunn	35	136	3.6	3.7
Skien	19	79	1.4	1.5
Notodden	11	55	2.7	2.4
Bamble	3	25	1.7	1.9
Kragerø	4	13	1.0	0.9
Nome	2	8	0.7	0.7
Tinn	10	66	5.4	5.0
Reference				
Seljord	1	1	0.3	0.3
Kviteseid	1	1	0.3	0.3
All	86	384	2.2	

Table 3. Radiographic diagnosis for the 1 371 subjects who attended the reexamination.

Diagnosis	Asbestos disease		
	None	Lung fibrosis ± pleural plaques	Pleural plaques only
1. No other lung disease	195	77	341
2. Probable sequel to pulmonary or pleural tuberculosis	202	3	13
3. Lung cancer or metastasis	24	—	2
4. Other pneumoconiosis	23	1	—
5. Other lung diseases or combinations of 2—4	457	5	28
All	901	86	384

Table 4. Number of reported exposure situations and prevalence of asbestos-related disorders by type of industry or occupation.

Type of industry or occupation	Number of reported exposures	Prevalence of asbestos-related disorders
Electrochemical and chemical	391	222
Building and construction	141	52
Shipyards	85	38
Seaman (machine room)	117	47
Ferroalloy	62	25
Automobile repair work	28	9
Electrical equipment	41	26
Cement (not asbestos)	7	3
Wood processing	21	5
Iron foundries	15	7
Metal work (including welding)	8	2
Refractory material	4	2
Mechanics	12	3
Insulators	5	5
Others	71	24
All	1 008	470

Table 5. Degree of asbestos exposure among 86 subjects with lung fibrosis alone or in combination with pleural plaques and among the 384 with pleural plaques.

Diagnosis	Degree of exposure							
	Uncertain		Light		Moderate		Heavy	
	N	%	N	%	N	%	N	%
Lung fibrosis ± pleural plaques	3	3.5	46	53.4	27	31.4	10	11.6
Pleural plaques only	33	8.6	209	54.4	104	27.1	38	9.9

already registered at the Department of Occupational Medicine prior to the investigation, were among the 21 483 subjects who attended the primary screening. As a result, 50 of these persons were selected for the reexamination, in which 17 with lung fibrosis and 33 with pleural plaques were "rediscovered." This occurrence indicates that the study method, with a primary radiographic screening and reexamination of a selected

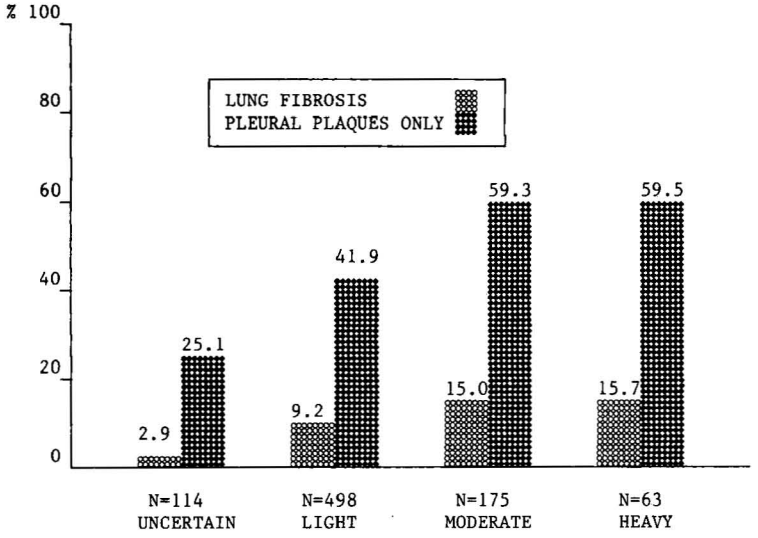

Figure 1. Age-adjusted rate of asbestos-related disorders in relation to the degree of asbestos exposure among 850 of those who, at the reexamination, reported exposure.

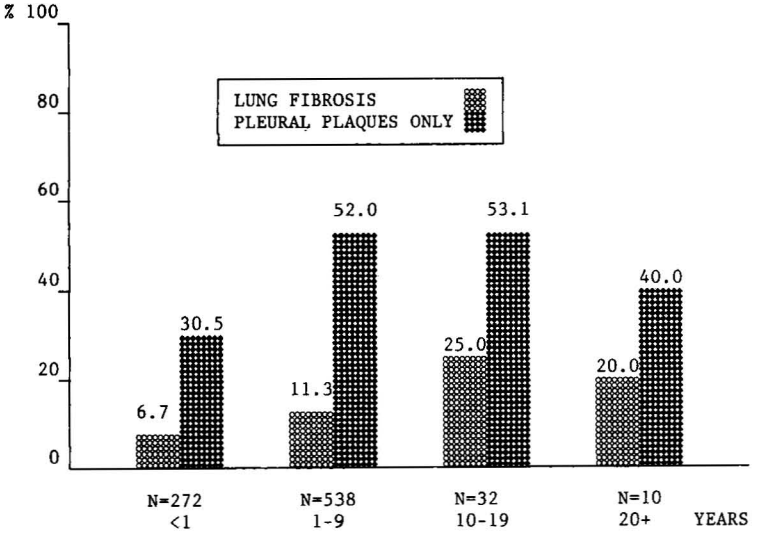

Figure 2. Rate of asbestos-related disorders in relation to the duration of asbestos exposure among 852 of those who, at the reexamination, reported exposure.

group, has a sensitivity for these findings of 50.0 and 63.5 %, respectively.

Figure 1 presents the age-adjusted prevalence rate of asbestos-related disorders in relation to the degree of exposure among 850 of those who reported asbestos exposure in the interview. Table 5 presents the degree of exposure among the 86 subjects with lung fibrosis and the 384 with pleural plaques only.

In figure 2 the prevalence of asbestos-related disorders is presented in relation to the duration of asbestos exposure. The mean duration of the total exposure for those with lung fibrosis was 4.1 (range < 1—24) years, and for those with pleural plaques only it was 3.4 (range < 1—30) years. The 382 subjects who reported asbestos exposure, but in whom no asbestos-related disorders were diagnosed, had a mean duration of exposure of 2.0 (range < 1—31) years.

The prevalence of asbestos-related disorders is presented in relation to the time of first exposure in figure 3. The mean duration from first exposure until diagnosis for those with lung fibrosis was 39.6 years, and for those who had pleural plaques only it was 37.3 years.

Figure 4 presents the age-adjusted prevalence of asbestos-related disorders in relation to smoking habits among 1 367 of those who attended the reexamination. Lung fibrosis was more prevalent among the smokers, 8.0 % for all current smokers compared to 2.8 % for the never smokers. There were no marked differences in the prevalence of pleural plaques between the smoking categories. Among the 86 subjects with lung fibrosis there were 39.5 % exsmokers and 54.7 % current smokers, whereas the corresponding figures for

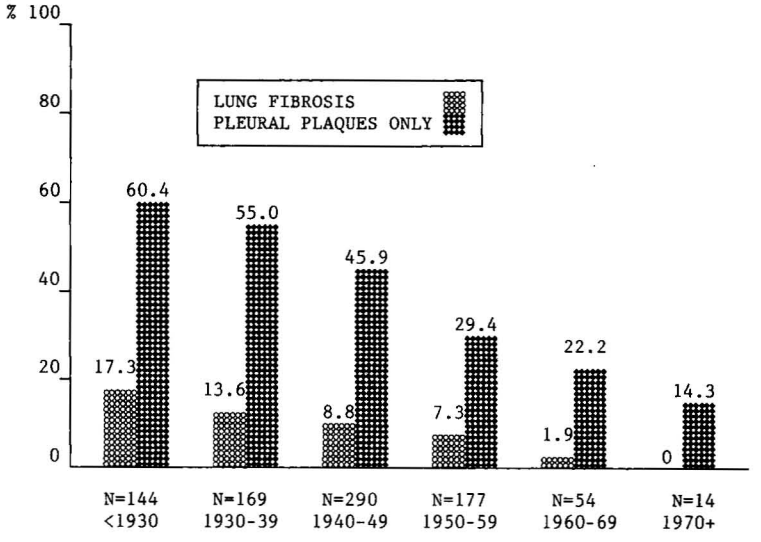

Figure 3. Rate of asbestos-related disorders in relation to the decade of first exposure among 848 of those who, at the reexamination, reported exposure.

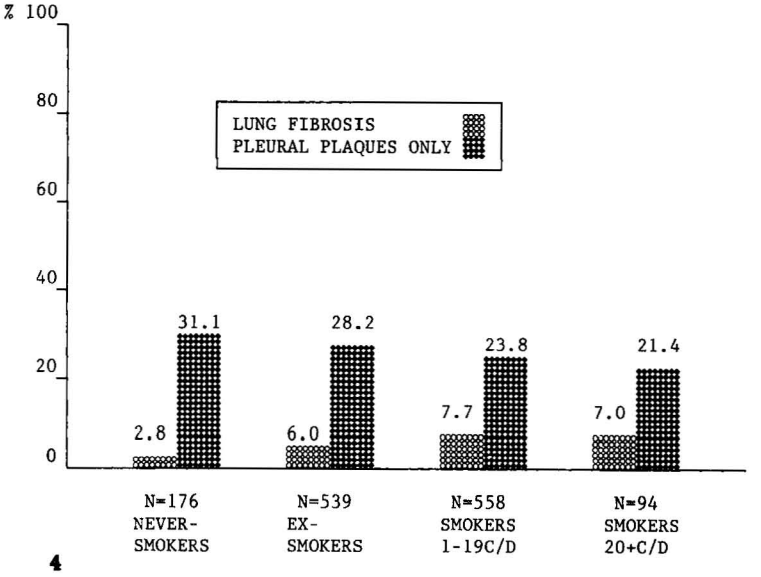

Figure 4. Age-adjusted rate of asbestos-related disorders in relation to smoking habits among 1 367 of those who attended the reexamination. (C/D = cigarettes/day)

the 384 with pleural plaques only were 47.4 and 38.3 %, respectively.

Discussion

In accordance with the results from the county of Uppsala, Sweden (4), the present study provides evidence for a higher prevalence of asbestos-related radiographic changes in the general population than has been suggested earlier. The results of the primary radiographic screening in the present study indicate pleural changes in 6.9—8.5 % of the males of the general population above 40 years of age. These figures correspond well to the 7.2 % with such changes which has been observed in a British study from the Birmingham area (3).

In the present study it was found that 2.2 % of the study population had radiographic changes which were probably caused by previous occupational exposure to asbestos. The present study and that of Hillerdal (4) were restricted to men above the age of 40 years. This restriction might explain some of the observed excess in pleural changes as compared to results of other surveys (2, 9). In the present study 10 × 10-cm radiographs, in both frontal and lateral projections, were used. Probably both the size of the pictures and the reading procedures have improved the sensitivity of the study method as compared to the use of the 7 × 7-cm radiographs, in a frontal projection only, that are more commonly used in mass surveys.

In keeping with the findings of Albelda et al (1), the present study also showed a marked difference in the occurrence of asbestos-related disorders between urban and rural communities. The two municipalities with the highest rates of asbestos-related disorders were Tinn and Porsgrunn with 5.4 and 3.6 %, respectively.

As a result of access to hydroelectric energy a large fertilizer plant was built in Tinn early in this century, and the new town of Rjukan grew up around the plant. Consequently this community has had a large proportion of industrial workers. In the town of Porsgrunn there are two shipyards, ferroalloy industry, and various smaller industries. From 1928 on, a large electrochemical plant was constructed which now produces fertilizers, chlorine, magnesium, and polyvinyl chloride.

The 852 subjects who reported asbestos exposure at the reexamination had been selected as a result of radiographic findings in the primary screening. Therefore, table 4 does not reflect the proportion of subjects with asbestos-related disorders from the industries or workplaces listed.

The primary radiographic screening was attended by 76.1 % of the 28 216 subjects who were invited to participate. A nonrespondent analysis has not been conducted, but in accordance with previous studies (14, 17) there is no reason to assume that the nonrespondents should represent a healthier part of the population than the respondents. Therefore, the number of persons attending was used as a basis for the calculations of the rates of persons with asbestos-related disorders.

As only those whose asbestos exposure was confirmed in the interview were considered to have asbestos-related disorders, there is no zero exposure level in figures 1 and 2. Also, as all 852 subjects had been selected through findings in their radiographs in the primary screening, the observed proportions of asbestos-related disorders in each of the exposure categories in the diagrams are probably higher than could be expected in an unselected group.

In common with previous observations (20), the present results indicate a higher prevalence of pulmonary asbestosis among smokers than never smokers (figure 4), which probably reflects a greater retention of fibers in the lung tissues of smokers. No positive association was observed between smoking habits and the prevalence of pleural plaques. On the other hand, it is probable that, because of ill health, a greater proportion of the subjects with both asbestos exposure and heavy smoking than never smokers without asbestos exposure had been selected out of the study base prior to the investigation.

When the rather low sensitivity of the study method is considered, together with the losses made through the restrictions imposed on the study and the nonrespondents in the primary screening, it can be assumed that the 470 subjects in whom asbestos-related disorders were diagnosed should be regarded as a minimum number. The results in the present study cannot be applied generally to other counties in Norway. On the other hand, it is likely that asbestos has also been extensively used in other parts of the country with similar industrial structures. In a study on the distribution of occupational determinants for lung cancer in Telemark and the neighboring county, Vestfold, Kjuus et al (11) found that previous asbestos exposure was present to the same extent among lung cancer patients in both counties. When studying the occurrence of mesothelioma in Norway, Mowé (15) observed considerable regional variations, but cases of the disease were found in all but one of the 19 counties in the country. If it is assumed that 2—3 % of the men above the age of 40 years who live in urban areas and 0.2—0.3 % of the men of the same age who live in rural areas have radiographic changes consistent with an asbestos-related disorder, it would mean that between 7 800 and 11 700 Norwegian men above the age of 40 years have such disorders.

The present study presents evidence that occupational asbestos exposure and asbestos-related diseases may be more prevalent among the general population than has thus far been recognized. As asbestos-related diseases will be a significant public health problem for many years to come, it is of importance for preventive purposes to identify subjects with a history of asbestos exposure and subjects who have signs of an asbestos-related disorder already today.

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