

Screening for occupational cancer

by Matti S Huuskonen, MD¹

HUUSKONEN MS. Screening for occupational cancer. *Scand J Work Environ Health* 1992;18 Suppl 1:110—114. The main strategy for preventing occupational cancer is an environmentally based approach or primary prevention. However, it should be combined with screening, early diagnosis, and treatment. This review discusses screening for occupational cancer but not from the point of view of medical screening. Instead it focuses on asbestos exposure and asbestos-related cancer in Finland and the role screening plays in the current Finnish asbestos program. For example it is the feeling in Finland that screening is a very effective way of preventing further occupational exposure to asbestos and of organizing antismoking campaigns. An individually oriented strategy in cancer prevention should include the modification of exposures by behavioral change, the monitoring of early effects of exposures, and health examinations. The termination of exposure, antismoking campaigns, improved diagnostics, and careful attention to compensation issues combined with the study of other opportunities for prevention are seen as the key issues in screening.

Key terms: asbestos, asbestos program in Finland, lung cancer, mesothelioma, prevention.

Control of occupational cancer is attained first and foremost through primary prevention. The efficiency of screening for the early detection of lung cancer, the main type of occupational cancer, is debated. Screening can identify only relatively few individuals when their disease is at a surgically curable stage. This review does not discuss occupational cancer from the point of view of medical screening (1). Screening in itself does not prevent anything; only the appropriate intervention can be preventive. The usefulness of screening should rest on one criterion: whether or not it contributes to the prevention of occupational disease (2). A total of 2—8% of cancers is attributable to the cancer patient's occupation (3). In terms of total numbers, these figures represent a significant burden or morbidity and mortality. Some cancers, however, are eminently preventable (4, 5). The main strategy for preventing occupational cancer is an environmentally based approach or primary prevention. However, it should be combined with screening (a tool for secondary prevention), early diagnosis, and treatment. Secondhand intervention against the causative agent to which people are already exposed and tertiary prevention are focused on individuals within a population (6).

There has been little success in eliminating work-related cancer. Cancer mortality is increasing, and occupational exposures appear to account for at least part of this trend (7). Three-quarters of occupational cancers among men are found in the lungs (3). Between

13 and 27% of lung cancers is attributable to some form of occupational exposure, to asbestos in particular (8). Although asbestos is less frequently used than it used to be, it is still widely dispersed. Approximately 10 000 asbestos-related deaths are expected to occur in the United States each year for the remainder of the century (9). A hospital-based case-referent study of 176 lung cancer patients revealed that 25% of the diseased and 10% of the referents had been moderately to heavily exposed to asbestos at work (10). Information on such exposure was lacking in 90% of the medical records of these patients (10).

The responsibility of health personal in notifying people of their potentially increased risk of lung cancer has been discussed (11). Any undue psychological distress caused by such notification appears to be outweighed by the benefits of notification and screening (12). A person's right to know about exposures to carcinogens at work is a key issue in prevention (6, 13). The shift from environmentally based primary prevention to individually based secondary and tertiary prevention is justified (6, 14). Risks can be minimized by keeping people exposed to carcinogens at work adequately informed about potential hazards (further exposure, smoking). Occupational histories obtained by screening should be added to the medical records of cancer patients. The history of asbestos exposure, tissue fiber burdens, asbestos bodies, and clinical data are useful, if available, when compensation cases for asbestos-related lung cancers are dealt with. Although improvements in diagnostics do not directly contribute to prevention, they give realistic dimensions to the problem and have a positive impact by calling attention to the need for preventing asbestos exposure. Should tertiary prevention (eg, beta carotene) be feasible at some time in the future, a screened and identified group will be instantly available for intervention.

¹ Asbestos Program, Institute of Occupational Health, Helsinki, Finland.

The asbestos program of the Finnish Institute of Occupational Health

The Finnish Institute of Occupational Health set up a program to prevent asbestos-induced hazards in 1987, the starting point being that exposure to any type of asbestos causes asbestos-related diseases, cancer included (15, 16). The program, which stresses primary and secondary prevention of asbestos-related cancer, involves the dissemination of information, training, services, and research. The Institute is carrying out the program together with the authorities, industry, the unions, the health care system, and insurance companies. The program aims to prevent asbestos-related health hazards (by minimizing exposure to asbestos and by educating workers already exposed), to assess the risks caused by exposure to asbestos, and to improve the diagnosis of asbestos-related diseases in Finland.

The main health hazards of asbestos exposure recognized at the individual level used to be parietal pleural changes and asbestosis. Nowadays interest also focuses on visceral pleural diseases (17) and, especially, on the diagnostic criteria of asbestos-related occupational cancer (18). As a result, asbestos workers suffering from mesothelioma and lung cancer receive compensation more often than before, even if clinics still underdiagnose asbestos-related cancer as an occupational disease because of a lack of etiologic evaluations based on chronological occupational histories.

Exposure to asbestos

The 1986 convention of the International Labour Organisation (19), concerning the use of asbestos, has been ratified in Finland. If asbestos inventories are correctly performed in construction work and if individual companies do asbestos work properly using trained workers and special equipment, it will be possible to keep the occupational, and also some of the environmental, exposure to asbestos under control.

In 1990, the State Committee on Asbestos (20) proposed a ban on the manufacture, import, and use of products containing asbestos, such as chemicals, vehicle parts, consumer appliances, and building materials.

At a rough estimate, more than 200 000 currently active or retired workers have been exposed to asbestos (at least 2 fibers per milliliter for a period of at least two months) in Finland. The Finnish population as a whole is about five million. Altogether some 50 000 workers, the majority over 40 years of age, have had more than 10 years of exposure to asbestos (mainly in the construction industry) (21). Today around 10 000 workers employed in house and ship renovating, in the service branch of industry, in garages, and in licensed asbestos removal companies are exposed to asbestos. If these figures are taken into consideration, the incidence of asbestos-related diseases should reach its peak after the year 2000 (20, 21).

Asbestos-related pleural and parenchymal diseases

Data on the screening of 437 Finnish construction workers imply that cases of pleural and parenchymal asbestos-related diseases have still not been diagnosed. The mean age of the workers surveyed was 59 years, and they had been employed in the construction branch of industry already in 1967. One in four of the screened construction workers had positive pleural or parenchymal findings in chest radiographs. Almost all of them were ignorant of their clinical status. When interviewed, they reported an average of 3.7 years of asbestos exposure. Many workers were not aware of exposure, especially indirect exposure to asbestos at work. Half of these individuals were retired (22). Asbestos-related occupational disease was diagnosed for more than half of the subjects screening positive in the clinical studies. Pleural findings were more common than parenchymal ones. It may be inferred that there are still about as many undiagnosed cases of asbestosis in Finland as there are diagnosed ones.

Because the routine health care system has been unable to trace subjects for further clinical evaluations and because there is no form of systematic surveillance of people already exposed, the Institute of Occupational Health started a screening study in April 1990 for people significantly exposed to asbestos. About 6000 persons were screened in 1990, and about 8000 will be screened in 1991 and 1992. It is estimated that about half of the 50 000 people invited to the screening, which consists of an interview about exposure and a chest radiograph, will attend. All of the persons with radiographic findings implying asbestos exposure are suspected of suffering from occupational disease and are legally obliged to be referred for further clinical studies. Points of view of primary and secondary prevention are involved in screening, and it is the feeling in Finland that this is a very effective way of preventing further occupational exposure to asbestos and of organizing antismoking campaigns. Data on exposure to asbestos among the screened individuals will be recorded. This information will be available from the Institute if needed for occupational disease considerations.

Important points in organizing this screening were both the occupational health legislation act from 1978 (23), which stipulates the follow-up of workers with health examinations, and ILO convention 139 from 1974 (concerning the prevention and control of occupational hazards caused by carcinogenic substances and agents) (24), which has been ratified in Finland. Informing workers is a key issue in this regard (eg, workers exposed to carcinogens must be provided with all information available on any dangers involved). Subjects with occupational diseases will be followed later either in occupational medical clinics or in health centers, which will also survey people with a significant level of exposure but negative screening findings. Workers will be followed at occupational health centers, whereas retired people will be tested at municipi-

pal health centers or by their own doctors. People who participate in screening because of exposure to asbestos will be kept informed about further surveillance. This screening study is mainly being financed by the state and has been planned together with the authorities, unions, insurance companies, businesses, companies, and employment pension funds.

Asbestos and cancer

Asbestosis patients

A large proportion of those who develop asbestosis will eventually die of cancer. About 40% of the asbestosis patients diagnosed in Finland have died of lung cancer, 5–10% of mesothelioma, and 10% of other cancers (25).

Paraneoplastic involvement of the nervous system is often encountered in cancer patients, even at very early stages of disease. Asbestosis patients have a high cumulative risk of cancer. In order to assess the importance of this finding, a cohort of 115 asbestosis patients has been followed since 1979. Twenty-one of the asbestosis patients have contracted lung cancer since the observation period began. The estimated annual lung cancer incidence is thus 2.2 per 100 persons. Two mesotheliomas were found in the same follow-up. In addition a study of 144 silicosis patients revealed three lung cancers and no mesotheliomas. The mean age at death was 62 years for the asbestosis patients and 67 years for the silicosis patients. Cancer mortality was higher among the asbestosis patients than among the silicosis patients (17 versus 4%). The asbestosis and silicosis patients showed radiological progression of lung fibrosis in 38 and 48% of the cases, respectively (26). The asbestosis patients with lung fibrosis revealed central nervous system dysfunction, but the individual neurological findings did not correlate with the results of pulmonary function tests, most of the immunologic tests and tumor markers, the radiological findings, or the progression of asbestosis. The mechanism of this central nervous system dysfunction in lung cancer patients may be paraneoplastic. Thus asbestosis patients with unknown central nervous disturbances should be considered potential cancer cases (27).

Lung cancer

The association between exposure to asbestos and an elevated risk of cancer has been well established epidemiologically (15, 16). Because of concurrent exposures and possible interactions between various carcinogens, it is, however, difficult to attribute individual cases unequivocally to specific causative agents (eg, asbestos). Lung cancer is a common disease in the general population and is to a great extent due to smoking. About 2000 cases of lung cancer are diagnosed in Finland annually. The etiologic fraction of occupational exposures ranges between 13 and 35% for lung cancer (28, 29). Asbestos is the most important single occupa-

tional cause of lung cancer. A Norwegian study estimated that 23% of lung cancers could be prevented if exposure to asbestos were eliminated (29).

In the Finnish insurance system, at least one year's heavy exposure to asbestos (eg, spraying, insulating) or at least 10 years' moderate exposure to asbestos (eg, construction work), plus a latency period of at least 10 years, fulfills the criteria of significant exposure when lung cancer is treated as an occupational disease. A detailed occupational history is not the only way to establish significant exposure to asbestos at the individual level; even more effective is knowledge of the number of asbestos bodies or fibers in lung tissue. Among diseased persons the presence of pleural or parenchymal asbestos-related findings confirms the significance of exposure to asbestos in the etiology. Asbestos-related tissue reactions are better seen in tissue samples, and with high-resolution computed-tomography techniques, than in conventional chest radiographs (30, 31). The Finnish legal approach to compensation questions is based on the idea that, if the attributable risk of exposure exceeds 50%, it is likely that the exposure has caused the disease (18). This approach does not recognize the contribution of etiologies. Between 1982 and 1986 nine lung cancers were recorded as occupational disease because of asbestos exposure, none in 1987, and 18 in 1988. The estimated number of annual occupational asbestos-related lung cancers is 100. These figures reflect underdiagnosis.

A small group of new lung cancer patients ($N=35$) has been interviewed, and their exposure to asbestos has also been evaluated from fresh lung tissue samples. One in three of the lung cancer patients was exposed to asbestos at work according to the interviews. Six of these 35 subjects fulfilled the Finnish criteria of significant exposure, entitling the subject to compensation. Five of these six patients had more than three million asbestos fibers per gram of dry lung tissue when examined by transmission electron microscopy. Four of these six patients also had histological asbestosis. Five of the 25 subjects who did not remember being exposed to asbestos showed signs of real exposure in their tissue samples (more than 3 million fibers per gram of dry lung tissue). However, when these five subjects were interviewed again, they recalled occupational exposure to asbestos. The number of subjects studied was so small that it was difficult to interpret the results. A final conclusion cannot be drawn about the role of asbestos in the etiology of lung cancer in Finland without further study. It is already clear, however, that the number of fibers in the lungs of diseased persons is much lower among office workers, who formed the unexposed reference group (32).

Physicians should pay more attention to the etiologies of lung cancer. The Medical Board of Finland (33) recommended in 1990 that the occupational history of every lung cancer patient be recorded and that an etiologic evaluation then be done. All lung cancer patients with significant exposure to asbestos should be re-

ported to insurance companies for compensation considerations. Asbestos workers who smoke are also covered by insurance schemes. Thus, if exposure is significant, smoking habits do not exclude compensation.

Mesothelioma

About 50 pleural mesotheliomas or 10 per million inhabitants are diagnosed in Finland annually. The number of mesotheliomas has tripled since the 1970s. About 80% of the mesothelioma patients have had occupational exposure to asbestos. Nearly all of them have had the number of fibers in their lung tissue analyzed. About 200 000 people have been occupationally exposed to asbestos at some time, and, of them, 50 000 have been highly significantly exposed. The annual risk of mesothelioma is about 400 per million persons for the most highly exposed 50 000 people and 70 per million persons for the 150 000 persons with moderate occupational exposure to asbestos. Forty percent of the Finnish mesothelioma patients revealed significant exposure, and 20% moderate exposure, to asbestos. Nearly all of the remaining subjects revealed minimal occupational or environmental exposure to asbestos (34). Mesotheliomas are not well diagnosed as occupational diseases. For example, 14 were recorded in 1982–1986, 6 in 1987, 13 in 1988, and 22 in 1989. Annually, about 40 people with pleural mesothelioma and with a record of occupational exposure to asbestos would be able to obtain compensation if the insurance authorities were able to get the necessary information from physicians.

In one study the fiber concentrations measured by scanning electron microscopy were 0.5–370 million per gram of dry lung tissue in mesothelioma patients and 0.1–3.2 million per gram of dry lung tissue in the accidental reference group (35). This accidental reference group included many people with occupational exposure to asbestos. Another reference group comprising office workers showed less than 0.1–0.6 million fibers per gram of dry lung tissue. Scanning electron microscopy showed that amphibole was the most dominant asbestos fiber in lung samples of the mesothelioma patients. Further transmission electron microscopy of these mesothelioma patients revealed amosite and crocidolite fibers in 60%, anthophyllite fibers in 50%, chrysotile in 37%, and tremolite fibers in 18% (34–36).

Only some peritoneal mesotheliomas have been found in Finland. It is very probable that the true number is much higher. Current diagnostic procedures do not permit a final diagnosis without clinical suspicion, which should be present in cases of diffuse adenomatous malignomas of the abdominal cavity among people significantly exposed to asbestos.

The asbestos to which people are exposed is very often mixed. Most commercial types of chrysotile also include tremolite fibers as an impurity. Commercial chrysotile fibers are not refined from tremolite. In the Finnish series, chrysotile is seldom seen in scanning

electron microscopy but fairly often in transmission electron microscopy (34–36). Possibly the purest type of chrysotile is mined in Zimbabwe. Even so, cases of mesothelioma and lung cancer have also been found among Zimbabwean miners and millers (37). Anthophyllite fibers have often been found in the lungs of mesothelioma patients. Earlier data have not indicated anthophyllite as a cause of mesothelioma (38–40). The present findings from tissue analyses open the discussion. Anthophyllite has been the main type of fiber in the lungs of many mesothelioma patients (35). Two mesothelioma patients had only anthophyllite fibers in their lung tissue, and six subjects had only anthophyllite and chrysotile fibers (34–36).

Summary

There is no known safe level of exposure to asbestos at work. Primary prevention is the main goal of the asbestos program in Finland. Mining of anthophyllite asbestos was stopped in 1976. The State Committee on Asbestos proposed a ban on asbestos in 1990. Primary prevention carried out today can reduce the incidence of disease in years to come. The current disease panorama is a consequence of past exposures, mainly those before the 1970s. The peak incidence of asbestos-induced disease will be reached 15–20 years from now. The annual number of premature deaths related to asbestos exposure is currently estimated at about 150, which exceeds the annual number of fatal work accidents. The annual number of pleural mesotheliomas has tripled since the 1970s and is now about 50, or 10 per million persons, per year. Only in a very few cases of mesothelioma has no relevant exposure to asbestos been found. This exposure is mainly mixed. Anthophyllite and chrysotile fibers are also found in the lungs of mesothelioma patients.

Physicians have paid little attention to exposure, and therefore asbestos-related cancers are not adequately recorded as occupational diseases. Thus not many claims are filed with insurance companies. Physicians need to be informed and trained if the present situation is to be improved. An individually oriented strategy in cancer prevention includes modification of exposures by behavioral change, monitoring of early effects of exposures, and health examinations. The screening of subjects already significantly exposed to asbestos has been started in Finland. The termination of exposure, antismoking campaigns, improved diagnostics, and careful attention to compensation issues combined with the study of other opportunities for prevention are the key issues in screening and, indeed, in the whole asbestos program of the Finnish Institute of Occupational Health. If tertiary prevention becomes feasible, there is a group of people with a significant level of exposure to asbestos that has been screened and identified, and is readily available for the appropriate intervention.

References

1. Wilson MMG, Junger G, ed. Principles of screening for disease. Geneva: World Health Organization, 1968.
2. Millar JD. Screening and monitoring: tools for prevention. *J Occup Med* 1986;28:544-6.
3. Doll R, Peto R. The causes of cancer: quantitative estimates of avoidable risks of cancer in the United States today. New York, NY: Oxford University Press, 1981.
4. Brandt-Rauf PW, ed. Occupational cancer and carcinogenesis. Philadelphia, PA: Hanley & Belfus Inc, 1987. (Occupational medicine: state of the art reviews 2/1.)
5. Vainio H. Occupational cancer prevention. *J Cancer Res Clin Oncol* 1987;113:403-12.
6. Rantanen J. Preventive strategies for occupational cancer in Finland. In: Eysenbosch LNV, Depoorter AM, ed. Primary prevention of cancer. New York, NY: Raven Press Ltd, 1988:313-35.
7. Bailar IC, Smith EM. Program against cancer. *N Engl J Med* 1986;314:1226-32.
8. Kvale G, Bjelke E, Heuch I. Occupational exposure and lung cancer risk. *Int J Cancer* 1986;37:185-93.
9. Nicholson WJ. Cancer from occupational asbestos exposure: projections 1965-2020. In: Selikoff IJ, ed. Disability compensation for asbestos-related disease in the United States. New York, NY: Mt Sinai School of Medicine, Environmental Science Laboratory, 1985.
10. Kjuus H, Skjærven R, Langård S, Lien JT, Aamodt T. A case-referent study of lung cancer, occupational exposures and smoking: II. role of asbestos exposure. *Scand J Work Environ Health* 1986;12:203-9.
11. Cone JE. Occupational lung cancer. In: Rosenstock L, ed. Occupational pulmonary disease. Philadelphia, PA: Hanley & Belfus Inc, 1987:273-95. (Occupational medicine: state of the art reviews 2/2.)
12. Meyerowitz BE, Sullivan CD, Premeau CL. Reactions of asbestos-exposed workers to notification and screening. *Am J Ind Med* 1989;15:463-75.
13. Millar JD. The right to know in the workplace: the moral dimension. *Ann NY Acad* 1989;572:113-23.
14. Brandt-Rauf PW, Brandt-Rauf SI. The high-risk occupational disease: notification and prevention act: from primary to secondary prevention: from paternalism to autonomy. *Ann NY Acad Sci* 1989;572:151-4.
15. International Agency for Research on Cancer (IARC). IARC monographs on the evaluation of carcinogenic risks to humans: supplement 7. Lyon: IARC, 1987: 106-8.
16. International Programme on Chemical Safety. Asbestos and other mineral fibres. Geneva: World Health Organization, 1986. (Environmental health criteria; 53.)
17. Nordman H, Keskinen H, Alanko K. Keuhkojen ammatissairauksien muuttuva kirjo [The changing picture of occupational lung disease]. *Duodecim* 1988;104: 473-9.
18. Federation of Accident Insurance Institutions. Report of occupational cancer 24. Helsinki: Federation of Accident Insurance Institutions, 1988.
19. International Labour Office (ILO). Conventions 162 and 172 concerning use of asbestos. Geneva: ILO, 1986.
20. State Committee on Asbestos. Final report 66/1989 [in Finnish]. Helsinki: Ministry of Labour, 1990.
21. Huuskonen MS, Koskinen H, Roto P, Tuomi T, Heikkilä P, Rantanen J. Asbestos still significant health hazard after year 2000 in Finland [in Finnish]. *Suomen Lääkäril* 1987;42:1669-72.
22. Oksa P, Koskinen H, Roto P, Rinne J-P, Zitting A, Huuskonen MS. Chest x-rays and questionnaires as indicators of exposure to asbestos among construction workers. *Am J Ind Med* 1990, in press.
23. Act on Occupational Health Services 743/1978. Helsinki: Government Printing Centre, 1978.
24. International Labour Office (ILO). Convention 139 concerning occupational cancer. Geneva: ILO, 1974.
25. Huuskonen MS. Asbestosis in Finland: clinical and immunological findings and mortality among asbestosis patients [dissertation]. Helsinki: University of Helsinki, 1979.
26. Oksa P, Huuskonen MS, Juntunen J, Kivistö H, Klockars M, Korhonen O, et al. Follow up of asbestosis and silicosis patients. Helsinki: Institute of Occupational Health, 1989. (Final report to Finnish Work Environment Fund 87013.)
27. Juntunen J, Oksa P, Koskinen H, Huuskonen MS, Partanen T. Occupational cancer and nervous system: a ten year follow-up of asbestosis patients. In: Abstracts of the 7th international symposium of epidemiology in occupational health. Tokyo: 1989.
28. Pastorini A, Berrino F, Gervasio A. Proportions of lung cancers due to occupational exposures. *Int J Cancer* 1984;33:231-7.
29. Kjuus H, Langård S, Skjærven R. A case-referent study of lung cancer, occupational exposures and smoking: III. etiological fractions of occupational exposures. *Scand J Work Environ Health* 1986;12:210-5.
30. Gamsu G. High-resolution CT in the diagnosis of asbestos-related pleuroparenchymal disease. *Am J Ind Med* 1989;16:115-7.
31. Hillerdal G, Malmberg P, Hemmingsson A. Asbestos-related lesion of the pleura: parietal plaques compared to diffuse thickening studied with chest roentgenography, computed tomography, lung function and gas-exchange. *Am J Ind Med* 1990;18:627-39.
32. Vainio H, Anttila S, Heikkilä L, Hietanen E, Husgavel-Pursiainen K, Kalliomäki P-L, et al. Asbestin osuus keuhkosityövän ja fibroosin synnyssä: altisteen ja kudosreaktion osoittaminen [Role of asbestos in fibrosis and cancer of the lung: study of exposure and tissue reaction]. Helsinki: Institute of Occupational Health, 1990. (Final report to Finnish Work Environment Fund 87143.)
33. Medical Board of Finland. Diagnostics and follow-up of asbestos-related diseases. Helsinki: Medical Board of Finland, 1990. (Publication series 148/89.)
34. Hernberg S, Tuomi T, Tammilehto L, Huuskonen MS, Virtamo M. Mesothelioma and exposure to asbestos. Helsinki: Institute of Occupational Health, 1990. (Final report to Finnish Work Environment Fund 86081.)
35. Tuomi T, Segerberg-Konttinen M, Tammilehto L, Tossavainen A, Vanhala E. Mineral fiber concentration in the lung tissue of mesothelioma patients in Finland. *Am J Ind Med* 1989;16:247-54.
36. Tuomi T, Huuskonen MS, Vanhala E, Virtamo M. Occupational exposure to asbestos as evaluated from work histories and lung tissue analysis of mesothelioma patients. *Br J Ind Med* 1991;48:48-52.
37. Baloyi R. Exposure to asbestos among chrysotile miners, millers and mine residents and asbestosis in Zimbabwe [dissertation]. Kuopio: University of Kuopio, 1989.
38. Nurminen M. The epidemiologic relationship between pleural mesothelioma and asbestos exposure. *Scand J Work Environ Health* 1975;1:128-37.
39. Huuskonen MS, Ahlman K, Mattsson T, Tossavainen A. Asbestos disease in Finland. *J Occup Med* 1980;22: 1261-5.
40. Huuskonen MS. Asbestos and cancer in Finland. *J Toxicol Environ Health* 1980;6/5-6:1261-5.