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BIOLOGICAL EFFECTS OF ASBESTOS

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OCCUPATIONAL AND NONOCCUPATIONAL EXPOSURES TO ASBESTOS

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Numerous reports by many investigators from various countries establish the fact that an occupational or nonoccupational inhalation of dust of different chemical and physical types of asbestos results in the development of asbestosis of the lungs which, depending upon the type of exposure, may be designated as an occupational, neighborhood or household pneumoconiosis. Since 1935 an increasing amount of epidemiologic, clinical and pathologic evidence, moreover, incriminates this health hazard as one of the environmental sources of cancers of the lung (TABLE 1), and more recently also of mesotheliomas of the pleura and peritoneum, although some commercially interested parties and their medical guardians and protectors still prefer for their own reasons and motives, to deny the existence of these dangerous and usually fatal sequelae of a respiratory contact with asbestos dust. The obvious fallacy of such allegations is well demonstrated by the remarkable and progressive rise in the number of cases of asbestosis and of cancers of the lung, pleura, and peritoneum reported from various countries during the past two decades. It is shown also by the increase of publications noting the first observations on the occurrence of asbestosis and asbestos cancers from several countries during the past decade (Denmark, Sweden, Belgium, Finland, Japan).[1-6] Both occupational diseases are definitely not as rare and in fact, have become less so in recent times, as has been claimed by several industrial parties.[7]

There was, for instance, an estimated total of about 700 cases of asbestosis in Germany in 1946 among a total of approximately 8,000 employees of the asbestos industry.[8-11] Wegelius[2] found 125 cases of asbestosis of the lung in a roentgenologic examination of 476 asbestos workers of one company in Finland. Of 132 asbestos workers examined by Böhme,[12-13] 29 per cent showed radiologic evidence of asbestosis. The morbidity rate of asbestosis in members of this worker group rose, moreover, with the duration of employment, being five per cent in workers exposed to asbestos for less than three years; 56 per cent for those employed for five to ten years, and 79 per cent for those with over 10 years' exposure. A similar morbidity rate of 80 per cent among English asbestos workers with over 20 years of employment, was reported by Merewether and Price[14] in 1930. Nöro[4] noted an asbestosis attack rate of 65 per cent in 167 asbestos workers studied roentgenologically. It is remarkable that no large-scale observations on the incidence, morbidity and mortality rates of asbestosis and asbestos cancers have been published from the giant American asbestos industry.

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TABLE 1
CARCINOMAS OF THE LUNG IN ASBESTOTICS: REPORTED CASES

Country	Number	Sex	Age	Exposure time	Latent period	Lag period	Site*	Histological type†
USA	35	M 34 F 1	37-69 Av. 50	5-36 Av. 20	6-36 Av. 23	1-30	LL 26 UL 2	S 16 R 5 A 7
Canada	10	M 10	48-66 Av. 57	2-33 Av. 22.5	14-34 Av. 25	4-16 Av. 11		A 2
England	138	M 106 F 32	32-76 Av. M. 55.2 F. 44.6 Av. 54	1-45 Av. 16	16-45 Av. 23	9-20 Av. 3	LL 4 UL 1	S 16 R 24 A 6
Germany	51	M 44 F 7	35-71 Av. 52	3-34 Av. 15	4-40 Av. 28		LL 22 UL 4	S 12 R 11 A 6
Finland	1							
Italy	3	M 2 F 1	46-54 Av. 49	17-26 Av. 29				S 1
France	1							
Switzerland	1	M 1	62	7	24	17	LL	A 1
Total	240	M 197 F 41	32-76	1-45	4-45	1-30	LL 53 UL 7	S 45 R 40 A 19

*LL-Lower Lobe; UL-Upper Lobe.
†S-Squamous Cell; R-Round Cell; and A-Adenocarcinoma.

It is an axiom of sound public health practice that protective and preventive control measures, to be rational and effective against environmental health hazards, must be based on adequate information on the sources and types of exposure of the causative agent involved and on the population groups affected. For such an assessment of the potential scope of an environmental health hazard of occupational and nonoccupational implications, it is necessary to determine the distribution pattern of the agent from the site of its original occurrence and production through the sites and types of its subsequent industrial and commercial uses to the homes of the ultimate consumers. It is, moreover, essential to ascertain the various types of products into which the causative agent might be incorporated and the purposes for which such products might be used. It is important furthermore to investigate the existence and degree of environmental pollution of the plant area as well as of the plant vicinity and the zones along the routes of transportation of such materials. When some or all of such data have become available, a sound factual basis is provided for a competent epidemiologic investigation of the workers employed in mines and factories producing, using and handling the causative agent, and of the members of various trades and occupations having primary and associated contact with it, as well as of members of the general population sustaining an incidental exposure to it. Past experiences have shown that only through such comprehensive and painstaking epidemiologic procedures are any worthwhile, factual data on the existence and scope of occupational and related environmental health hazards obtained. The continued insistence of some industrial parties that reliable decisions on such aspects can be based on what is called deceptively "sound clinical impression" often merely reflects an objectionable desire to escape from an unpleasant situation into a wishful dreamland in which profits are properly protected against just compensation claims.

A brief presentation of the sources and types of occupational and nonoccupational exposures to asbestos and of the various occupational and nonoccupational population groups having such contacts, therefore, may furnish a proper foundation for the subsequent discussions of the biologic functional and anatomic effects associated with and produced by the inhalation of asbestos dust. The immediate importance of such data is indicated by the fact that the world production of asbestos has increased from 500 tons in 1880, to 330,000 tons in 1925, to 446,000 metric tons in 1938, to over 2,000,000 tons in 1958, and that it is still rising (FIGURE 1). The main producing country is Canada, while the principal consuming country is the United States of America, which consequently should have the largest number of individuals exposed for occupational and nonocuppational reasons to an inhalation of asbestos dust from an increasing number of sources and from a growing number and variety of products.

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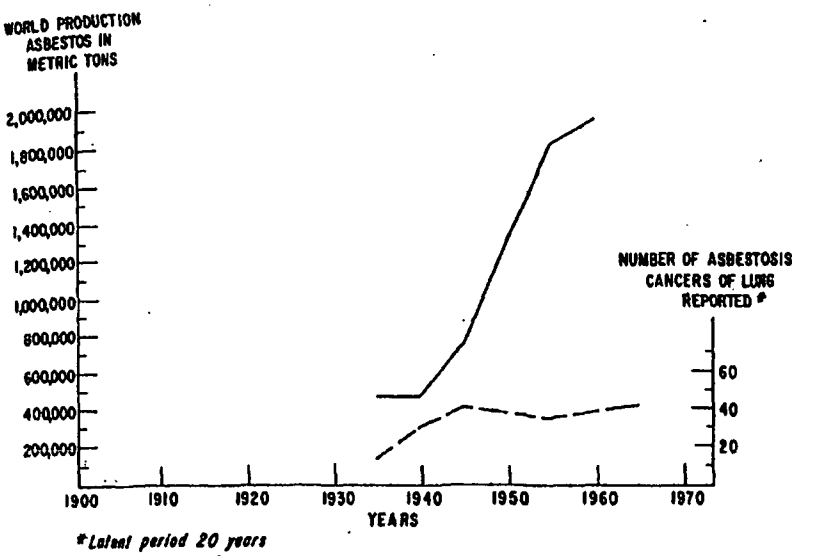

FIGURE 1. World production of asbestos and asbestosis carcinoma of the lung.

Since, of the different types of asbestos, chrysotile represents approximately 95 per cent of the total asbestos produced, contact with this type of asbestos furnishes the chief cause of asbestos pneumoconiosis and cancer in most countries, and especially in the U.S.A. which mainly produces, imports, processes and uses chrysotile.[7-15] Contact with other types of asbestos, particularly amosite and crocidolite, is of comparatively minor and regional importance for occupational reasons because these varieties of asbestos are mainly mined in South Africa and preferably consumed in Great Britain, and represent only a relatively small fraction of the total amount of asbestos produced and used. The exposure data to be given apply, therefore, mainly to chrysotile, although according to Lanza[16,17] all three types of asbestos elicit the same kinds of biologic reactions.

Occupational Activities, Processes and Products with Asbestos Hazards

Asbestosis and asbestos cancer hazards related to an inhalatory exposure to asbestos exist not only for asbestos workers proper engaged in the direct and regular production, processing, handling, and using of asbestos-containing materials, but also for the large number of individuals who may sustain such contacts on an incidental basis. Such persons may be employed permanently or temporarily in or near operations where asbestos and asbestos products are produced or handled and where they inhale,

TABLE 2
ASBESTOS

Sites of asbestos cancers	Exposure stigmata
Recognized—Lung	Chronic fibrosing pneumonia involving first lower lobes (asbestosis), asbestos bodies in sputum, asbestos warts of skin (fingers)

Compounds of economic importance

Chrysotile, amphibole, amosite, crocidolite, tremolite containing magnesium, aluminum, calcium, iron, silica.

Operations and products with contact to asbestos for producers, processers, users, consumers, residents

Asbestos rock mining, loading, shipping, crushing, milling, asbestos spinning, weaving, mixing, cutting, pressing, molding, plastering, cementing, spraying of steel construction, undercoating of automobiles, insulating pipes, etc., clothes, cloths, sheets, blankets, curtains, brake linings, yarns, cords, ropes, twines, ribbons, artificial snow, filler in rubber goods, plastics and roof coatings, filter cloths, filter pads, filter paper, artificial wood, tiles, shingles, cardboards, wall boards, partitions, panels, paper, clutch facings, clapboard, pipe coverings, pipes, insulation blocks, insulation jackets, gaskets, pump packings, electric wire insulation, structural heat insulation, facings of acoustical building materials, catalyst supports in sulfuric acid production, putties

Population groups with occupational and environmental exposure to asbestos

Occupational groups	Nonoccupational groups
Asbestos rock miners, loaders, truckers, crushers, millers, asbestos spinners, weavers, electrical appliance and wire manufacturers, masons, carpenters, heating equipment workers, rubber workers, shingle and tile manufacturers, building material manufacturers, filtering material manufacturers, molders of asbestos products, asbestos-asphalt makers, putty manufacturers, asbestos cement makers, asbestos paper, cardboard and brake-lining producers, asbestos felt insulation workers, asbestos sound insulation workers, asbestos insulators, pipe coverers, asbestos tube wrappers, asbestos cork insulation workers, construction workers, automobile makers, garage attendants	Residents in vicinity of asbestos processing and textile mills inhaling plant effluents polluted with asbestos dust, and individuals living and working along roads on which asbestos is trucked; inhabitants of houses with asbestos insulation.

therefore, air polluted with asbestos dust (repairmen, maintenance men, engineers, mechanics, laboratory technicians, office workers, medical personnel, truckers, railroad workers, yardmen, construction workers, shipyard workers, automobile plant and garage employees, etc.).[18-23]

The total number of individuals in the United States having manifest, suspected and possible, but often unsuspected contact with asbestos, should run between 50,000 and 100,000. The duration and degree of exposure to asbestos in members of this group, however, must vary considerably and their relative liability to asbestosis and asbestos cancer consequently will also show distinct differences. The recent estimate as to the total number of about 50,000 asbestos workers employed in the United States, Canada, England, and several other European countries made by Braun and Truan[24] must be considered an optimistic understatement which tends to minimize the actual scope of the health hazard associated with work in asbestos. The numerous occupations and products associated with the production and utilization of asbestos provide a vivid illustration of the wide scope of the industrial health problem related to this mineral (TABLE 2).

Asbestos Ore Mining and Milling

Miners, sorters or dressers of asbestos ore in open pit mines, but particularly in underground mines, are exposed to the inhalation of rock dust containing asbestos. Similar exposures exist for the loaders of the mined rock and for the truckers and railroad personnel who haul the material and deliver it to the crushing mill.[25] The crushing and screening of asbestos rocks (comminuation), carried out in the mills for separating the asbestos fibers from the adherent rock, is associated with the production of a great deal of dust and thus entails a heavy exposure to asbestos unless stringent technologic precautionary measures are taken for protecting the workers employed in these mills. The amount of dust produced in these operations and escaping from the mill buildings can, moreover, cause a marked pollution of the intraplant and periplant environment with asbestos dust and thereby create not only an intraplant asbestosis hazard for workers employed in the yard and offices located on the premises but also a periplant hazard endangering individual and animals working and living in the vicinity of such plants (industrial neighborhood and household hazard).[26-34] Reports on the occurrence of asbestosis and asbestos cancer among asbestos miners and millers which are on record from Canada, the United States, and South Africa[25-30,34,35,35a] demonstrate the existence of the typical health hazards associated with these occupations in asbestos.

Asbestos Cement Production and Consumption

The greatest quantity of asbestos of all grades is used in the manufacture of a variety of asbestos cement and plaster products, such as asbestos cement proper which may be applied like ordinary mortar or plaster, or

which may be sprayed on walls; insulating material for the covering of pipes, boilers, cables, conduits and ducts; siding shingles, roofing shingles, tiles, flat and corrugated sheets, wallboard, clapboard and automobile undercoating.[26,7] The production, processing and commercial use of these materials often entail for workers engaged in such activities, a distinct exposure to asbestos-containing dust. Reports in the more recent medical literature attest to the existence of distinct occupational health hazards from such exposures by noting the occurrence of asbestosis and asbestos cancers in asbestos cement and plaster makers, mixers, and sprayers, insulators, laggers and pipe coverers, especially those employed in shipyards, and masons.[23,21a,40,41,28,42,3,44-46,22,47,48] The circumstances under which asbestos cement products are used in the human economy make it likely that they may create asbestos health hazards of an associated type for other workers as well as in homes where asbestos insulating is used.[20,30]

Manufacture of Asbestos Textiles

Asbestos alone or in combination with other vegetable or animal fibers and synthetic plastics is employed extensively in the manufacture of threads, yarns, wicks, cords, ropes, tapes, cloths, sheets, blankets, and similar products which in turn are used widely in industry (automobile, aircraft) as friction materials, brake linings, fireproof safety clothing, curtains, life jackets, and similar articles, clutch facings, lagging cloths, and gaskets. During the preparation of the asbestos fibers and in the fabrication process of textiles from asbestos (carding, stripping, mixing, bobbing, spinning, and weaving), the workers become exposed to asbestos dust released into the air, although the absolute amounts of this have greatly been reduced during recent years by proper technologic measures in modern textile plants.[49,50] Whether the introduction of such protective procedures has succeeded in totally eliminating asbestotic hazards for the workers employed in such plants, however, remains to be seen because of the often relatively long latent period which may elapse before asbestosis may become symptomatically manifest even after workers have left such hazardous operations.[51-54,18] Exposure conditions in the asbestos textile industry until rather recent times, definitely demonstrate that asbestos textile workers (spinners, carders, weavers) were subject to a distinct asbestosis and asbestos cancer hazard.[55-58,12,13,53,54,59-72,58,73,74,20,75,76]

Periplant hazards for the population living in the vicinity of such plants may ensue if the effluents of exhaustive ventilation equipment are released into the environmental air without previous removal of their asbestos constituents.

Miscellaneous Asbestos Products

Asbestos is being made into floor tiles by blending it with other materials, such as asphalt, plastics, and similar chemicals. It is used for seals,

packing material for pumps and joints, for making paper, filter material, circuit breakers, molds, and many other articles, whose total number Selikoff *et al.*[23] have estimated to run at about 3,000 different items. While not all contacts with asbestos and asbestos products are associated with exposures to asbestos dust and thus may result in the development of pneumoconiosis and cancers of the lungs, pleura and peritoneum or less often of asbestos warts of the skin,[77-81] there can be little doubt that such health hazards are connected with the production, processing and handling of many of them. Their existence, however, may often not be known, recognized and appreciated by members of the medical profession, not adequately familiar with industrial practices and products.

Protection of Asbestos Workers by Workmen's Compensation Laws

Asbestos workers of several countries, acquiring as the result and in the course of their regular employment asbestosis of the lung with or without a complicating respiratory cancer, are covered by provisions of workmen's compensation laws. These occupational diseases must moreover, in some countries be reported to governmental agencies (Germany, Great Britain).[82,83,66,87,20] It seems, however, that this type of protection applies in Great Britain to only some types of occupations but not to others. The conditions on this matter differ distinctly in the different states of the United States, where each state has its own compensation acts differing from each other to a considerable degree concerning the type of coverage and the length of the mandatory time-clause. Compensability of asbestosis was denied, for instance, in North Carolina in 1937 in a suit against the Carolina Asbestos Company by the Industrial Commission. In an appeal, this decision was confirmed by the Supreme Court of North Carolina. Legal provisions furnishing presumably adequate protection of asbestos workers against the health hazards peculiar to their occupation at the present time still leave much to be desired in many states.

Conclusions

(1) The enormous rise in the production and industrial use of asbestos during the past 50 years has resulted in markedly widened exposure to asbestos dust for a greatly increased number and variety of workers. Some of them, moreover, sustain such contacts incidentally either when being employed in various capacities in operations where asbestos products are processed, used, or handled or when working in plant areas in which an environmental pollution of the air with asbestos exists.[84-89]

(2) The harmful effects of such growing exposures to asbestos during the past two decades are reflected not only in a growing number of reports on the occurrence of asbestosis and asbestos cancer in a variety of asbestos workers but also in the fact that such reports originate from a rising

number of countries in some of which such observations were made only recently for the first time.

(3) Information on the number and variety of exposed workers and on the occurrence and incidence of asbestosis and of asbestos cancers among them is most fragmentary in all countries, especially in the United States and Canada, one being the principal consumer of asbestos and the other the chief producer of this mineral. It is for this reason regrettable that the original plan of having a recent epidemiologic survey on these aspects of asbestos production in Canadian mines and mills to be undertaken under the aegis of the National Cancer Institute of Canada was not adhered to and that this study was carried out as an industry-dominated venture which yielded highly controversial negative results.[90,84-89,65,91]

(4) The principal worker groups exposed to respiratory contact with asbestos are employed in the asbestos mining and milling industries, in the production and commercial use of asbestos cement and plaster and their numerous secondary products, in the production and application of asbestos for insulating purposes, and in the processing of asbestos and its manufacture into textiles.

(5) Because in many countries and states the workmen's compensation laws are defective, the protection of asbestos workers against occupational health hazards related to respiratory and cutaneous contact with asbestos is inadequate.

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