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For Scott Dawkins

Cancer in relation to environmental exposure

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There are a number of difficulties involved in making a report on environmental asbestos-induced malignant tumours:

(1) Firstly, the term "environmental cancers" has not yet been clearly defined. With regard to asbestos, the literature lists as "environmental cancers" those which occurred in a number of widely differing situations, e.g., endemic, family, domiciliary, neighbourhood, as a result of spare-time work, etc. An environmental tumour can, in the first place, be defined as a non-occupational tumour; on the other hand, the exposure itself is in many cases the same as under occupational conditions, and although it may be less intensive, it is sometimes even longer lasting. Thus one can consider environmental exposure to be simply a slighter form of occupational exposure, but with ill-defined borderlines (Langer & Selikoff, 1971).

(2) Since the cause of cancer development is still unknown, and since a great many individual factors in our environment are considered to be conjunctly responsible for the complex cancerisation process, it is difficult to single out one group of possible agents, namely the fibriform silicates.

While environmental asbestosis of the lungs was found to exist in animals as early as 1930 (Stewart, 1930; Schuster, 1931), pleural plaques and other pleural manifestations due to asbestos dust inhalation in man have been recorded in the literature only during the past 30 years (Meurman, 1966). There are some regions in which there is a high number of plaque-bearing subjects whose asbestos dust exposure is not of an occupational nature but is due to neighbourhood exposure, for example, in the vicinity of asbestos mines or factories, or of ship-building centres (Kiviluoto, 1960; Anspach, 1962; Rubino *et al.*, 1968; Dalquen *et al.*, 1970).

In addition, there are regions in which the soil contains weatherworn asbestos (Burilkov & Michailova, 1970; Ginzburg *et al.*, 1970) where inhabitants or workers evince in their pleura, both radiologically and autoptically, the consequences of asbestos dust inhalation. Cases have also been observed in which subjects acquired plaques through contamination from occupationally exposed members of the family (Hinz, 1968). It also seems likely that plaques may be the result of spare-time work with asbestos-containing products. Pleural plaques must hence be looked upon as important indications in the detection of environmentally jeopardised population groups (see below).

Information concerning environmentally induced cancers is not entirely reliable; yet there is a series of reports which prompts us to consider that many tumours may be asbestos-induced, despite the absence of an occupational exposure, hence that the underlying cause must be an environmental one (Oels *et al.*, 1971).

In addition to mesothelioma of the pleura and/or peritoneum the literature also mentions bronchial carcinoma (Wagner *et al.*, 1971), some of the carcinomas of the gastro-intestinal tract (Merliss, 1971) and tumours of the haemopoietic system as asbestos-induced malignant diseases; however, so far, studies published in connection with environmental hazards have nearly always been limited to a consideration of mesotheliomas as sequels of asbestos dust inhalation (Lieben & Pistawka, 1967).

Since the ubiquitous bronchial carcinoma is more frequently seen than is mesothelioma, evidence of its asbestos-induced nature in individual cases would be considerably more difficult to obtain. These carcinomas are frequently encountered concomitantly

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with asbestosis of the lung in asbestos workers (Demy & Adler, 1967; Newhouse & Wagner, 1969), but this is far less often the case as regards mesothelioma (Elmes & Simpson, 1971). This rare tumour is found *post mortem* in from 0.018 to 0.07% of all autopsies; however, following asbestos exposure, they are observed more frequently. Unlike the dose-response relationship for bronchial cancers, a considerably reduced lower limit for asbestos dust inhalation must be assumed for mesothelioma, the magnitude of which is still open to speculation.

Our information concerning the development of mesothelioma as a result of exposure to all kinds of asbestos dust is still so meagre that we can speak of causality only with reservations. However, the correlation between asbestos exposure and consequent mesothelioma is at times so striking that there can be no doubt as to their relationship. This opens a wide field for future investigations.

A noteworthy fact in connection with the occurrence of pleural plaques is that all regions which have a known increased incidence rate of mesothelioma have at the same time a greater incidence of pleural plaques. On the other hand, there are areas where an increased presence of plaques has been noted where so far mesotheliomas are absent (Kiviluoto, 1972 [1]) or have been found only sporadically (Cartier, 1972 [2]).

In South Africa, the frequency of environmental mesothelioma cases is highest in the neighbourhood of the crocidolite mines of the North-West Cape Province. In this connection, a remarkable fact is that similar observations could not be made in the vicinity of the crocidolite mines of the Transvaal and Australia. Some cases have occasionally been found in the vicinities of asbestos processing factories in England (Newhouse & Thompson, 1965) and Germany (Bohlig *et al.*, 1970). In the past, these factories processed several kinds of asbestos among which, doubtless, was crocidolite.

Noteworthy numbers of cases have not so far been reported in the neighbourhoods of chrysotile, anthophyllite, or amosite mines; although occupationally induced mesotheliomas were described by Selikoff (1973) in a factory processing pure amosite.

A particularly striking piece of evidence is that in the neighbourhoods of shipyards in France (Tayot *et al.*, 1966), Germany (Bohlig *et al.*, 1970; Stössel *et al.*, 1972), The Netherlands (Stumphius, 1969), the United Kingdom (Wagner *et al.*, 1971), and the USA (Tabershaw *et al.*, 1970) environmental mesotheliomas have been observed, in addition to occupationally induced ones; thus, an increased incidence of mesotheliomas within the range of large shipbuilding areas has been reported, the sole cause of which has up to now been considered to be pollution of the air by asbestos dust, the high concentrations of which have been demonstrated by Harries (1971). In this connection, it is important to note that since about 1900 it is precisely crocidolite that has been used for insulation purposes in ships, particularly in war-ships (Wagner, 1968).

The exact number of asbestos-induced tumours due to environmental hazards cannot be deduced from the literature, inasmuch as occupational and extra-occupational exposure can often not be separated with certainty on the basis of the published reports. However, we must reckon with a magnitude of several hundred cases, which is a sufficiently alarming number to put us on the alert for the future.

An important possible cause of asbestos-induced cancers may be found in connection with asbestos spraying as used for fire, heat, or sound insulation in ships, skyscrapers, apartment houses and car bodies

Table 1. Criteria for asbestos induced environmental cancers

1. Histology:	proved by: biopsy / necropsy	malignant mesothelioma? bronchial carcinoma? carcinoma of the GI-tract?
2. History:	occasions for asbestos contacts: (*a*) endemic: asbestos mining? soil? (*b*) neighbourhood: factories? shipyards? asbestos spraying? (*c*) domiciliary: family members / inmates of the house } occupationally exposed? (*d*) due to spare-time work: handling asbestos-containing products? (*e*) other sources?	
3. Time:	Onset of exposure at least 15 years prior to tumour manifestations (normal latent period = 20–40 years)	
4. Frequency:	Analogous cancers following a similar exposure should be more frequent in the respective regions than in the rest of the population.	
5. Evidence of asbestos:	Asbestos in tumoral tissue can but seldom be demonstrated. Its presence in lung tissue ought to be recorded quantitatively (for instance following incineration)	

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(Lumley *et al.*, 1971). While the asbestos sprayers themselves are nowadays completely protected by fresh air supplies, others working nearby or persons living in the neighbourhood may possibly be exposed to severe air pollution resulting from the sprayed asbestos dust. This possibility has recently led to the partial prohibition of asbestos spraying in some states of the USA, and in Denmark.

Since negative results are not considered as evidence in medical diagnoses, the question arises as to how an environmental tumour may be diagnosed with certainty as being induced by asbestos dust. In Table I an attempt is made to compile the criteria required to warrant the assumption of an environmental tumour. These data must, however, be taken merely as a basis for discussion; point 5, in particular, indicates how much precise knowledge is still lacking for the establishment of a causal relationship.

The number of questions still open can be demonstrated by a discussion of the occurrence of mesotheliomas in Hamburg. Hamburg is a harbour town with an important ship-building industry and a number of asbestos processing enterprises, the most important of which is indicated on the map in Figure 1.

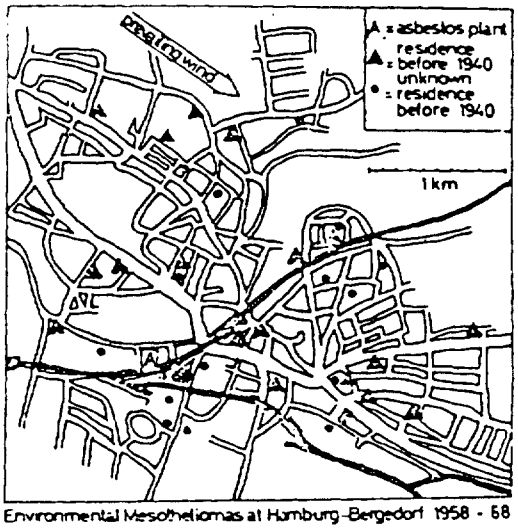


Fig. 1. Residence of 38 patients suffering from non-occupational mesothelioma due to a severe, snowfall-like asbestos air pollution in the environment of a factory which used to blow dust into the atmosphere during the years before World War II.

While the incidence rate of mesothelioma among the general population of the town of Hamburg was found in 1969 to be 0.056‰ for the past decade, the incidence rate in the residential area in the neighbourhood of that factory was 0.96‰! The patients, who lived within the vicinity of the plant before the Second World War, reported that a severe, visible, snowfall-like air pollution was emitted from this factory, which blew dust-laden air into the atmosphere (Dalquen *et al.*, 1969).

Those cases considered to be occupational tumours, found in former asbestos workers, were not used; thus, the map shows only the 38 non-occupational mesotheliomas. Their distribution in the neighbourhood of the factory evidently seems to depend on the prevailing direction of the wind (Fig. 1). In reference to the criteria proposed in Table 1, most of the cases shown in the figure meet at any rate conditions 1–4. Latency times range from 20 to 48 years, and medium latent periods from 30 to 40 years.

Besides the cases mentioned in our preliminary report (Bohlig *et al.*, 1970) an additional 251 proved mesotheliomas were collected from the pathology departments of the large city hospitals, histories of which could be found in 150 cases. Of these tumours, those due to occupational and those to environmental causes are being mapped, and these results will be published as soon as possible.

We feel sure that should such retrospective investigations be made in other cities similar results would be found. We consider that investigations of this sort are necessary and should be made as soon as possible, since prospective studies in regard to this problem would come too late wherever successful dust control of the exhausted air will have rendered the neighbourhoods of the factories relatively free of asbestos dust pollution (Rickards & Badami, 1971).

Since, however, asbestos dust can also get into the atmosphere from asbestos-containing products such as brake-linings and friction materials as well as from asbestos cement products, it is our duty to investigate further the possibility that this indestructible material may accumulate in our environment, and the possible health hazards that this might imply.

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SUMMARY

Several occurrences of cancer development following non-occupational exposure to asbestos dust are reviewed. Some discrepancies are pointed out in reports of the appearance of pleural plaques and of malignant mesothelioma. As the fibrous silicates form only a small fraction of environmental pollution, in which many other potential carcinogens are found, it has been difficult to establish that these fibres can be a direct causative agent of any specific neoplastic disease.

A proposal is made for discriminating between asbestos-induced cancers and those due to other causes. A survey of 38 mesothelioma cases from the neighbourhood of a single asbestos plant in Hamburg during the period 1958 to 1958 is given.

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