

PULMONARY CHANGES IN WORKERS EXPOSED TO ASBESTOS DUST IN AN ASBESTOS-CEMENT FACTORY

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ABSTRACT

In an asbestos-cement factory an epidemiologic investigation designed to determine the biological effects of asbestos on the lungs of exposed workers was carried out at two plants: an asbestos-cement plant and a cement works. The authors analysed the state, trends and correlation of three principal diagnostic criteria: radiographs, lung-function tests and dyspnea. Subtle roentgenological changes and slightly impaired lung-function tests were found. In workers from the asbestos-cement plant who were more excessively exposed to asbestos a significant correlation among the three observed diagnostic criteria could not be established. The majority of the observed persons showed no pathological changes during the observed period, despite a long period of exposure to asbestos (mean exposure 18 years). The authors could make the conclusion that in the asbestos-cement factory asbestosis occurs more rarely than in certain other asbestos consuming industries and that its progress is slow and without severe repercussions on the workers' lung function and working ability.

The annual output of asbestos-cement products in an asbestos-cement factory in Slovenia amounts to 220 000 tons, for which are needed 20 000 tons of asbestos fibres composed of chrysotile (94%) and amphiboles (6%). The health state of the 400 most exposed workers from the asbestos-cement works at the factory has been more or less regularly controlled by the health service for about 20 years. During all these years various classifications have been applied for the evaluation of X-ray pictures, with only individual cases of slight fibrotic changes being discovered. The present longitudinal retrospective analysis was intended to reassess the influence of exposure to asbestos dust on the lungs and lung functions of exposed workers in the asbestos cement industry on the basis of the new International Classification ILO U/C 1971, lung function tests, and clinical examinations.

EXPOSED WORKERS AND METHODS

In 1966, 113 out of 400 persons exposed to asbestos dust in the asbestos-cement plant of an asbestos-cement factory were chosen on the basis of suspect X-ray pictures according to previous evaluations. The health state of these persons was reevaluated after an interval of 9 years. In this study, the state,

trends and correlation of three principal diagnostic criteria (radiographs, lung-function and dyspnea) were analysed and statistically evaluated.

Radiological examination and subsequent evaluation of X-ray pictures were made in accordance with the instructions of the ILO U/C 1971 International Classification under equal conditions for the observed persons and the comparative group of persons.

Measurements of the lung functions included ventilatory lung functions (static and dynamic lung volumes) and diffusion capacity. For the evaluation of dyspnea a special questionnaire was used.

For the comparative group, the authors chose 94 persons from the cement works of the same factory with equal average age, time of exposure (51 years for age, and 18 years for exposure) and similar smoking habits as were those of the observed group to carry out a cross-sectional epidemiological investigation of the same extent.

On the basis of qualitative measurements of dust in both works a ranged attributive estimation of exposure for both the observed group from the asbestos-cement plant and for the comparative group from the cement works was obtained.

TABLE 1
Ranged attributive estimation of exposure in asbestos-cement and cement works.

Type of dust	Asbestos-cement works	Cement works
Asbestos	+++ (fibres)	+(dust)
SiO ₂	+	+
Cement	++	+++

The health state of both groups was compared on the basis of the fact that the comparative group was exposed to negligible amounts of asbestos dust (contamination of the whole atmosphere from the asbestos-cement plant), which was also qualitatively different (fibres-dust).

RESULTS

The results obtained in the observed group after the reassessment of diagnoses after an interval of 9 years were as follows: radiographic changes did not show any marked progress during the observed period. The occurrence of diffuse fibrotic radiographic changes was established but these were mostly slight and in some cases only more expressive and did not show any tendency of progression. In 9 out of 113 persons suspected fibrotic changes (type s,t 0/1), and in 17 persons diffuse fibrotic changes were found, while 70 persons had no fibrosis. The diffuse fibrotic changes were mainly of the types s and t. Maximal density of opacities was estimated as being of the category 2/2 in 4 cases,

TABLE 2

The results of lung function tests according to the type of impairment and the connection with pulmonary radiographic changes.

Lung function	Radiographic changes						
	Asbestos-cement works			Cement works			
	Normal	Suspected or diffuse fibrotic changes	Total	Normal	Suspected or diffuse fibrotic changes	Total	
Restrictive insufficiency	11	2	13	2	1	3	
Restrictive insufficiency and reduction of diffusion capacity	4	5	9	4	—	4	
Obstructive insufficiency	7	2	9	8	2	10	
Obstructive insufficiency and reduction of diffusion capacity	—	—	—	1	—	1	
Mixed ventilatory insufficiency	2	1	3	3	—	3	
Mixed ventilatory insufficiency and reduction of diffusion capacity	1	1	2	2	—	2	
Reduction of diffusion capacity	1	—	1	2	1	3	
Reduction of distribution	—	—	—	2	—	2	
Other types of respiratory insufficiency	2	3	5	2	2	4	
Total	N %	28 66	14 34	42 100	26 81	6 19	32 100

followed by the category 1/2 in 2 cases, 1/1 in 6 cases and 1/0 in 5 cases. A high percent (35) of pleural thickening and a widening of interlobar fissure (51%) was found. Abnormal values from one or more functional pulmonary tests were found in 43% of the workers. Among the pathological results of the lung function tests restrictive insufficiency was most commonly found (in 23 cases, in comparison with obstructive insufficiency which was established in 9 cases). In the observed sample it was not possible to establish a significant correlation between radiographic changes, positive lung function tests and dyspnea, the last being the most frequently found diagnostic sign (63%) but, in most cases, not confirmed by the positive results of the lung function tests.

In the comparative group, a significantly lower number of diffuse fibrotic radiographic changes and cases with dyspnea were found. In 9 out of 94 persons suspected X-ray changes (type s,t 0/1) and in 3 persons diffuse fibrotic changes, were found, while 82 persons had no fibrosis.

All the established radiologic changes were minimal – not exceeding small opacities – the type 1/1 of the Classification. Thirty-five persons complained of dyspnea.

TABLE 3
Survey of observed diagnostic criteria in asbestos-cement and cement works.

Observed diagnostic criteria	Asbestos-cement works			Cement works			Statistical significance of differences between groups
	Normal	Pathological	Total	Normal	Pathological	Total	
Radiographic changes	70	17 ^a + 9 ^b	96	82	3 ^a + 9 ^b	94	P < 0.05
Results of lung function	56	42	98	62	32	94	N.S.
Dyspnea	35	59	94	59	35	94	P < 0.001

a = diffuse fibrotic; b = suspected fibrotic

The difference in persons with dyspnea between the observed and the comparative group was not statistically significant, both as regards age (under and above 45 years) and as regards length of exposure (under and above 20 years). Besides, in workers aged under and above 45 years from both groups differences in the incidence of dyspnea regarding exposure were studied separately but could not be statistically established.

The number of persons in the comparative group with impaired lung function was 32; it was thus significantly lower as regards ventilatory insufficiency of the restrictive type, while obstructive ventilatory insufficiency was found in 10 cases. Only slightly impaired lung function tests correlated well with dyspnea, but no correlation with X-ray changes could be established.

A high proportion of pleural thickening (29%) and of a widening of interlobar fissure (44%) was also found in the comparative group, the number of cases being only slightly though not significantly, lower than in the asbestos-cement works.

All the other observed pathologic symptoms were otherwise more discrete in the comparative group.

DISCUSSION

The present study deals with the direct biologic effects of asbestos dust on the health state of 113 exposed asbestos-cement workers which was reassessed after an interval of 9 years and compared with the established health state of a comparative group from the cement works at the same factory. The comparison was made on the basis of dust measurements data according to which the comparative group from the cement works was exposed to minimal quantities of asbestos dust (contamination of the entire atmosphere from the asbestos-cement plant), which was also qualitatively different.

The established occupational pathology was higher in the asbestos-cement plant than in the cement works. The difference may no doubt be attributed to the

more excessive exposure to asbestos dust in the asbestos-cement plant and perhaps also to the different qualities of the asbestos (fibres-dust) used. All other factors – connected with the working environment or outside it which could affect the workers' health condition – were equal or similar in both observed groups.

Among the pathological findings of lung functions, restrictive ventilatory disorders, isolated or in combination with a reduction of diffusion capacity, prevailed. According to Becklake² and Fournier-Massey and Becklake⁵ a general restriction of the lung volume is the most characteristic disorder of lung function in asbestosis. The ratio among established obstructive, restrictive and mixed ventilatory disorders was 1:4:2. Considering the findings of our investigation, obstructive ventilatory disorders were most probably the consequence of an unspecific combined effect of dust environment and cigarette smoke.

According to Becklake², Weill⁸, Duwoos and co-workers⁴, lung function represents a more sensitive indicator for establishing early pathological changes due to the inhalation of asbestos dust than do radiological changes. In our study, radiological changes also were the least frequent but they were early indicator of biological effects of asbestos dust. The connection of lung function and radiological changes with length of exposure could not be established statistically. The same was reported by Bader and co-workers¹.

Studies of the health conditions in asbestos-cement industries, in comparison with other asbestos consuming industries, show distinctively fewer cases of asbestosis which manifest themselves only after longer exposure^{3,6,7,8}. This is in agreement with our statement that the majority of the observed persons from both works did not show any objective pathological changes despite long periods of exposure to asbestos. Thus we may conclude that asbestosis occurs more rarely in the cement-asbestos industry than in certain other asbestos consuming industries and that its progress is slow and without severe repercussions on lung function and working ability. The results of the survey point to the fact, that consideration of only individual criteria for the diagnosis of asbestosis would be unreliable since these can be strongly influenced by objective and subjective factors (quality of X-ray pictures, evaluation method, classification used, age and health condition of the examined persons, etc). The expected greater reliability, however, is not achieved by considering and evaluating several pathognomonic signs simultaneously, the connection among them being rather weak and unreliable. This statement is valid at least in our case, which involved discrete and non-progressive diffuse fibrotic pulmonary changes. In such cases especially, assessment and evaluation are greatly helped by the period of observation as a further criterion (indicator) which makes possible a comparison of the results obtained within the observed group with these of the control group. The high correlation of the original assessment of the individual diagnostic criteria with the reassessment after a longer period of observation confirms the reliability of the observed diagnostic criteria giving them certain diagnostic value in epidemiologic research.

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