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Health hazards from fine asbestos dusts

An analysis of 70656 occupational preventive medical investigations from 1973 to the end of 1986

H. J. Raithel, D. Weltle, H. Bohlig, and H. Valentin

Institut für Arbeits- und Sozial-Medizin und Poliklinik für Berufskrankheiten der Universität Erlangen-Nürnberg, Schillerstraße 25/29, D-8520 Erlangen, Federal Republic of Germany

Summary. For the period from 1973 to the end of 1986, 70656 data sets on occupational preventive medical examinations in employees exposed occupationally to asbestos dust (G 1.2) were made available to us by the Central Registry for Employees Exposed to Asbestos Dust (ZAS). On the basis of this data, an analysis of asbestosis risk was to be made in relation to specific areas of work, taking into consideration the beginning and duration of exposure. Proceedings for declaratory appraisal in accordance with occupational disease no. 4103 were instituted in 1760 cases in the report period. In accordance with the character of the available data, the X-ray findings in the lungs were available from the persons investigated as parameters of possible asbestosis risk on the basis of coding consistent with the International Pneumoconiosis Classification (ILO U/C 1971 and/or ILO 1980 West Germany). The major result of the statistical analyses on the mainframe macrocomputer of the University of Erlangen-Nuremberg was that the relatively highest risk of asbestosis was present in persons whose exposure began before 1955. On the other hand, with increasing duration of exposure, an unequivocal rise of the asbestosis risk could not be detected on the basis of the overall population. In relation to the individual fields of work, the relatively highest risk of asbestosis was shown to be in the asbestos textile and paper industry, as well as in the asbestos cement industry. No detectable risk of asbestosis was present in the fields of mining, traffic and health service and for women in the industrial sectors of building material, gas and water, catering trade, building, commerce as well as banking and insurance. Accordingly, it can be assumed that certain fields of work are or were exposed to such a small extent or not at all that a risk of asbestosis which is relevant in terms of occupational medicine is no longer to be assumed or was not to be assumed. This applies above all to certain work in the frictional coating (brake lining) and asbestos paper industry. Furthermore, the analysis of the data material did not provide any unequivocal indications that inhalative smoking habits have a negative effect on the risk of asbestosis. In prinicple, it can be stated that the occupational preventive medical investigations according to G 1.2 are effective. However, irrespective of this, the analysis has shown that a regular exchange of experience on the part of authorized physicians should be institutionalized and the second X-ray appraisal should be retained in order to ensure a high measure of reliability and diagnostic relevance of the available investigation data. Besides this, all expert appraisal results from patients with recognized occupational diseases according to subparagraphs, 4103, 4104 and 4105 BeKV (no. 4103: asbestosis, no. 4104: asbestosis in connection with lung cancer, no. 4105: mesothelioma of the pleura or peritoneum) should be centrally registered and coded in the future. In this way, progress studies, both in persons exposed to asbestos dust and in persons with asbestosis and accompanying malignant diseases, would then be possible.

Key words: Asbestos dust – Asbestosis – Health hazards – Preventive medical investigations

Offprint requests to: H. J. Raithel

Introduction

In the last two decades, asbestos has increasingly been the subject of occupational and social medical as well as of environmental policy discussions. On the one hand, the excellent material properties and the multifarious possible industrial applications resulting from this have been emphasized. On the other hand, attention has been drawn to the various health risks. Good

reviews on this topic have been published by Worth and Worth (1979); Woitowitz (1972); Bohlig and Otto (1975); Bohlig (1976); Woitowitz and Valentin (1977), Selikoff and Hammond (1979); Woitowitz and Rödelsperger (1981) and Becklake (1986).

Whereas health risks from fine asbestos dusts could not be systematically registered previously, it has been possible on the basis of our initiatives since the beginning of the 1970s to investigate all notified occupationally exposed persons in the context of prevention according to professional trade cooperative association principles („Mineral Dust", G 1.2) and to monitor the asbestos-processing enterprises better.

The essential data from the professional preventive medical investigations according to professional trade cooperative association principle G 1.2 (= first examinations and follow-up investigations as well as subsequent supplementary investigations after the end of occupational asbestos exposure) have been collected by the professional trade cooperative association initially on an experimental basis, and from 1971 on a general basis by a „Central Registry of Employees Exposed to Asbestos Dust" (ZAS) in the Textile and Clothing Professional Trade Cooperative Assocation in Augsburg. Since 1973, all information has been stored there on electronic data carriers. Precondition for this was that occupational medical, clinical and radiological findings are documented in a form appropriate for EDP on standardized investigation sheets (VA 2- G 1). The X-ray findings were coded in accordance with the International Pneumoconiosis Classification (ILO U/C 1971 and ILO 1980/West Germany) in set III of the above investigation sheet or on the second appraisal sheet specifically developed for this.

Altogether, 70656 persons exposed to asbestos dust had been investigated in accordance with G 1.2 up to the end of 1986, and the data obtained had been stored. This data material constitutes the basic population of the study and is the basis of all statistical analyses carried out.

Materials and methods

The objectives of this study can be outlined as follows:

1. The fibrogenic risk of exposure to fine asbestos dust of all persons registered by the Central Registry of Employees Exposed to Asbestos Dust (ZAS) was to be investigated.

The "risk" is characterized as a ratio of the number of radiologically abnormal persons (variation 1/0 and more in accordance with ILO Pneumoconiosis classification) and the total number of persons in the population or the respective subpopulation.

2. In the context of the risk appraisal, the beginning and duration of exposure to fine asbestos dust was to be especially considered.

3. The fibrogenic risk from exposure to fine asbestos dust was to be rendered objectively in various fields of work and for particular industrial sectors.

4. It was to be investigated whether the fibrogenic risk entailed in exposure to fine asbestos dust had remained the same for the entire period or whether it could be reduced by successively introduced industrial hygiene and industrial medical measures.

5. Furthermore, it was to be established whether there are fields of work which have or had such a low exposure that no asbestosis cases could be observed.

6. Finally, the extent to which possible inhalative smoking habits influence the fibrogenic risk was also to be examined.

The following factors are to be specified as limiting the information potentially available from this study:

1. The available empirical-casuistic data collection of persons exposed to asbestos dust is not accessible to any of the usual epidemiological methods owing to its unique character. The evaluations we have carried out are hence not to be interpreted as a cross-sectional or a longitudinal study and also not as an intervention study. A reference population was not available.

2. Exact statements on the incidence or prevalence of asbestos-induced fibrosis are not possible on ths basis of the registered data, since neither histological results nor expert appraisals are available. On the contrary, besides some fundamental occupational history data such as occupation, beginning and duration of exposure, only coded X-ray findings are available for appraisal. These are regarded as an indirect indication of asbestosis with a variation of 1/0 and greater.

3. Data on pleural alterations have not been evaluated in this study because of the limited objective character on the one hand and the inadequate possibilities of coding with their unsatisfactory relevance on the other hand especially X-ray examinations of the thorax (Bohlig and Calavrezos 1987).

4. Because of the relatively long time intervals between investigations (three to five years), the data do not allow any reliable appraisals on the frequency of malignant diseases induced by asbestos dust (bronchial carcinoma and pleural mesothelioma).

5. Information on the further fate of the "abnormal" persons detected in the preventive examinations cannot be given, since the data obtained in the context of expert appraisals were not regularly coded on the standardized investigation sheet appropriate for EDP.

6. Reliable and adequate measurement data on the dust exposure at the workplaces are not provided by the available data. A classification in terms of intensity of the exposure to fine asbestos dust in various fields of work can thus be made at best only on an empirical basis.

7. Since it is probable that not all persons exposed to asbestos dust were registered, especially in the earlier years, an estimated proportion of unknown cases is to be expected.

Investigation data and statistical workup. The Central Registry of Employees Exposed to Asbestos Dust in Augsburg provided us with 70656 data sets on occupational preventive medical investigations in employees exposed occupationally to asbestos dust from the period 1973 to the end of 1986. This is based on the standardized investigation sheets "Mineral dust dangerous to health" and the relevant data they contain on

- occupational history (nature of exposure, beginning and duration of exposure, work characteristics),
- results of medical investigations (physical examination, results of standardized tests of lung function, X-ray findings in accordance with ILO Pneumconiosis Classification U/C 1971 and 1980/West Germany and

– occupational medical appraisal by the authorized physicians of the data obtained.

The data sets were checked for completeness and plausibility. In order to be able to make appraisals in terms of the objectives formulated, we have stratified the basic population as follows: according to sex and age of the investigated persons, according to industrial sectors and fields of work, according to the beginning and duration of exposure, and according to smoking habits.

As X-ray finding, the coding of the second appraiser was regarded as authoritative when available. In the absence of a second appraisal, the results of the first appraiser had to be included in the analysis.

The radiological findings of the structure of the small irregular lung radio-opacities (s, t, u) were classified into the categories 0, 1, 2, and 3. We assigned the subcategories of the variation 0/–, 0/0 and 0/1 to the category 0, the last being regarded as the highest subcategory of "normal". The three subcategories 1/0, 1/1 and 1/2 were subsumed in category 1. In agreement with the international scheme, categories 2 and 3 represent the subcategories 2/1, 2/2, 2/3 and 3/2, 3/3, 3/+. In the interest to differentiate an appraisal as far as possible, the subcategories 0/1 and 1/0 are shown separately in Tables 2 and 4 in order to be able to appreciate better the borderline between normal and pathological findings. This differentiated assignment of the results appeared to be especially important, since experience shows that unequivocal appraisals in terms of fibrotic lung changes are frequently not yet possible in these ranges of variation. However, in the following any X-ray finding will be rated as "abnormal" when the variation 1/0 (as a possible indication of an incipient asbestosis) is reached.

The data material was analysed in strict observance of data protection regulations and laws.

Results

The respective last investigation data of 70656 employees exposed to asbestos dust were analysed. This data had been collected in accordance with the professional trade cooperative association principle G 1.2. Of the persons investigated 63445 (= 89.8%) were men, and 7211 (= 10.2%) were women. In 19286 cases, the data derived from first investigations (= 27.3%), from follow-up investigations (= 44.0%) in 31085 cases and from subsequent supplementary investigations (= 20.7%) in 14605 cases. In 5680 persons (= 8%) (!), the data sets did not contain any information on the nature of the investigation. In 1760 cases, the proceedings for declaratory appraisal had been instituted by medical occupational disease notifications in accordance with occupational disease no. 4103. We have no information on the outcome of these notifications.

The radiological data (= coding of the findings in accordance with the ILO Pneumoconiosis Classification) were collected towards the end of the report period by more than 500 authorized physicians (= first appraisers). In some of the cases, a supplementary coding of the lung results was carried out by doctors with special experience in the appraisal of diseases induced by asbestos dust (= "second appraisers"). In this way, a data bank which is as "hard" and reliable as possible was to be attained. However, since about 1980 an increasing reduction in the second appraisals has occurred. In the overall population we analysed statistically, there were only 34212 second appraisals as compared to 62293 first appraisals, and in 6510 cases of the first appraisals (!), no X-ray findings appropriate for EDP were coded at all. In 29934 investigations, only first appraisals were carried out, whereas second appraisals were carried out in merely 1853 cases.

The image quality is of major importance for the establishment of findings in the chest scout-view X-

Table 1. Medians and central 68-percentiles of age, beginning and duration of exposure, VC (actual/predicted value) and relative one-second expiration capacity for male and female patients with normal (category 0) and abnormal X-ray findings (categories 1–3)

X-ray findings		Age (years)	Beginning of exposure	Duration of exposure (years)	VC (act./pred.) in %	FEV_1/FVC in %
	n	49600	46831	38079	48887	48867
No X-ray signs of fibrosis	x_m	41.5	1973	9.0	102.0	81.0
♂	$x_{16/84}$	27.5–54.0	1960.5–1979.5	2.5–21.5	85.0–117.0	71.5–87.5
	n	8167	8031	7667	8002	7997
X-ray signs of fibrosis	x_m	53.0	1964	15.0	93.0	78.0
	$x_{16/84}$	42.5–63.5	1952.5–1974.5	5.5–26.5	73.0–109.0	66.5–84.5
	n	6061	5724	4427	5934	5926
No X-ray signs of fibrosis	x_m	42.0	1973.5	7.0	101.0	81.5
♀	$x_{16/84}$	28.5–55.5	1966–1979.5	2.5–14.5	83.0–117.0	74.5–88.5
	n	729	708	201	707	707
X-ray signs of fibrosis	x_m	58.0	1963.5	11.0	86.0	79.0
	$x_{16/84}$	46.5–68.5	1953.5–1973.5	4.5–18.5	69.0–105.0	69.5–85.5

Table 2. Medians and central 68-percentiles of the vital capacity (actual/predicted value in %) and the one-second expiration capacity (FEV 1 in %) in dependence on the X-ray findings

X-ray findings		Normal		Abnormal			
Category		0		1		2	3
Sub-category		0/−, 0/0	0/1	1/0	1/1, 1/2	2/1, 2/2, 2/3	3/2, 3/3, 3/+
	n	29048	25773	6876	1600	202	31
VC (act./pred.) in %	x_m	103.0	100.0	93.0	87.0	79.0	80.0
	$x_{16/84}$	87.0–119.0	83.0–115.0	75.0–109.0	67.0–104.0	59.0–101.0	46.0–101.0
FEV 1 (%)	x_m	82.0	79.5	78.0	76.0	73.0	77.0
	$x_{16/84}$	72.5–88.5	70.5–86.5	68.5–85.5	64.5–84.5	62.0–81.5	63.5–87.5

ray. For this reason, X-rays (hard radiation technique) were regarded as an adequate radiological procedure in the preventive investigations according to G 1.1 and G 1.2. In the preventive investigations we evaluated, 74.5% of the X-rays were rated as legible without restrictions (+ resp. ±) by the first appraisers, and 79.1% of the X-rays were rated as legible without restrictions by the second appraisers. On the other hand, the classification to the categories "adequate" (±) or "useless" (u) was made relatively more frequently by the second appraisers. In this connection, it is also noteworthy that the first appraisers did not provide any data on the image quality in 9076 cases (= 12.8%!). This must be attributed above all to the fact that the second appraisals have been restricted since 1980 and have been largely omitted completely since 1985. The completeness and "hardness" of the data aimed for automatically suffered from this.

All abnormal X-ray findings (= variation category 1/0 and over) are compared and contrasted with the thorax X-rays (= category 0) classified as normal separately for men and women in Table 1. The median and central 68% regions of age, beginning and duration of exposure as well as vital capacity (actual/theoretical value in %) and one-second expiration capacity (FEV1) in % are reproduced. It is shown that in men and in women the average age in abnormal X-ray findings is 11.5 and 16 years higher in the median respectively than in the subjects of the category 0. The beginning of exposure was on average about ten years earlier than in the "normal" persons both in the abnormal men and the abnormal women (1964 and 1963.5 respectively). The duration of exposure is also 15 and 11 years higher in the median in the cases with abnormal X-ray findings than in those with normal lung X-ray findings (nine and seven years respectively). It appears to be important that evidently lower average duration of exposure was sufficient in women (11 years as compared to 15 years in men) in order to become "abnormal".

The parameters of lung function display a 10 to 15% lower value on average for vital capactiy in the persons with abnormal X-ray findings. On the other hand, on the median basis, there were no fundamental differences between "abnormal" and "normal" subgroups in the relative one-second expiration capacity (FEV 1).

The characteristics of the two major analytical parameters of lung function (vital capacity actual/theoretical as well as FEV 1 in %) are shown in Table 2 in relation to the coded X-ray findings. The vital capacity decreases in terms of a restrictive disorder of ventilation with increasing variation category, whereas the relative one-second capacity does not show any appreciable fluctuations and is within the normal range.

In the context of this evaluation, the frequency of abnormal radiological findings in various fields of work is of particular significance. These categories are shown in Table 3 with inclusion of their subgroups and the pertinent professional trade cooperative association index numbers.

In Table 4, the number and percentage frequencies of X-ray findings are compiled according to variation categories or subcategories for men and women in various fields of work. The listing already shows that radiologically abnormal results were found relatively more frequently in the manufacture and processing of asbestos textiles, asbestos cement products, felts containing asbestos, fleeces, in certain sectors of the asbestos rubber industry and in insulators. This is also confirmed by Table 5. Here, the figures for the radiologically "abnormal" and "normal" results as well as their relative frequencies (in %) are listed separately for different workplaces and in relation to smoking habits.

Table 6 provides a synoptic overview on the relative fibrogenic risk set out in decreasing frequency according to fields of work. Accordingly, the greatest risk of radiologically abnormal alterations in terms of the variation categories defined above was present in the fields of the classical asbestos textile industry (weaving, sorting, packaging, dispatch, carding, spinning, twining division, spooling and braiding) as well as in the asbes-

Table 3. Code numbers together with the work places in the asbestos preparing and processing industry

Code no.	Work places
110	Preparation of asbestos-materials
120	Transportation of raw asbestos (fibres) and asbestos-containing materials (only trade and transportation)
130	Storage and packaging of raw asbestos (fibres) and asbestos-containing materials (only trade and transportation)
	Production and preparation of asbestos-textiles (e.g. yarns, ropes, fabrics)
141	Storage of raw materials
142	Preparation
143	Carding
144	Spinning, twisting, coiling, plaiting
145	Wet-spinning
146	Weaving
147	Cutting and sewing
148	Sorting, packaging, dispatch of the final products
149	Miscellaneous
	Production and processing of asbestos-containing felts, fleeces, papers, cardboards and plates
151	Storage of materials
152	Preparation
153	Wet-processing (beater, pulp, paper machine)
154	Drying
155	Cutting, sawing, punching
158	Sorting, packaging, dispatch of the final products
159	Miscellaneous
	Manufacture and preparation of asbestos cement products (e.g. plates, pipes)
161	Storage of raw materials
162	Preparation
163	Sawing, milling of asbestos sheets
164	Grinding
165	Drilling, punching
166	Processing of molded pieces and pipes like sawing, rotating, milling, grinding
167	Preparation of fibrous fracture
168	Sorting, packaging, dispatch of the final products
169	Miscellaneous
	Production and processing of friction coatings
171	Storage of raw materials
172	Preparation
173	Mixing
174	Pressing, hardening
175	Grinding, sawing, milling
176	Drilling, punching
177	Repair of brakes and clutches
178	Sorting, packaging, dispatch of the final products
179	Miscellaneous
180	Production and processing of rubber products containing asbestos (e.g. tires, washers)
190	Production and processing of asbestos-containing plastics (e.g. synthetic resin molding compounds, thermoplastic, laquer, insulation compound, floor covering)
200	Manufacture of other products containing asbestos
210	Usage of asbestos and materials containing asbestos for insulation (e.g. thermal- and sound insulation, fire protection)
220	Usage of asbestos fabrics and -textiles and asbestos-containing textiles, as far as asbestos dust is emitted (e.g. blankets, awnings, aprons, gloves, tapes and cords)
230	Further usage of asbestos and asbestos-containing products with dust development (e.g. use of asbestos in cooling beds in the glass- and steel-industry)

tos cement and paper industry and the work with raw asbestos.

In the stratification according to industrial sectors, a relatively high incidence of radiologically abnormal results could be demonstrated in the sectors of "paper and printing" and "textiles and leather goods" in men, but also in the industries "building materials", "gas and water", "iron and metals", "chemicals" and "electrical engineering, fine mechanics and optics" as well as finally "commerce, banking and insurance" (Table 7). There were evidently lower risks of acquiring abnormal radiological alterations in terms of asbestosis for women, above all in the industrial sectors "building materials", "iron and metals", "building" as well as "commerce, banking and insurance". In these fields, women are in some cases only now being employed or have been employed in very small numbers. According to our data, there was no risk of asbestosis in men and women in the industrial sectors "mining", "catering trade" and "health service".

In the context of this appraisal, the stratification according to duration and beginning of exposure was of particular interest. Three subgroups were formed. The persons investigated are characterized with regard to the duration of exposure into the groups up to 15, 16 to 25 as well as 26 years and over, and into the subgroups 1955 and earlier, 1956 to 1970 and 1971 to 1986 with regard to the beginning of exposure. This subdivision appeared to be reasonable, since successive improvements in industrial hygiene and medicine had been introduced into the asbestos industry in West Germany in the 1960s and 1970s.

Figures and relative incidences (in %) of the abnormal X-ray results in relation to the beginning and

Table 4. Figures and relative frequencies in per cent of the X-ray findings depending on work places

Code no.	Work place	Total no *n*	♂		♀		X-ray findings available		X-ray findings of the lungs					
			n	%	*n*	%	*n*	%	Normal		Abnormal			
									0		1		2	3
									0/−, 0/0	0/1	1/0	1/1, 1/2	2/1, 2/2, 2/3	3/2, 3/3, 3/+
110	Preparation of asbestos-materials	498	494	99.2	4	0.8	481	96.6	52.0	39.7	5.8	2.1	0.2	0.2
120	Transportation of raw asbestos and asbestos-containing materials	511	509	99.6	2	0.4	495	96.9	38.8	41.8	15.2	4.2	–	–
130	Storage and packaging of raw asbestos and asbestos-containing materials	236	175	74.2	61	25.8	228	96.6	45.2	37.7	14.0	3.1	–	–
140	Production and preparation of asbestos textiles													
141	Storage of raw material	104	98	94.2	6	5.8	95	91.3	38.9	46.3	10.5	3.2	1.1	–
142	Preparation	169	164	97.0	5	3.0	164	97.4	37.8	48.8	11.0	2.4	–	–
143	Carding	417	336	80.6	81	19.4	384	92.1	49.5	31.8	14.3	3.4	0.8	0.3
144	Spinning, twisting, coiling	2068	542	26.2	1527	73.8	1937	93.7	52.9	32.5	11.1	3.0	0.4	0.2
145	Wet-spinning	17	11	64.7	6	35.3	15	88.2	80.0	20.0	–	–	–	–
146	Weaving	612	328	53.6	284	46.4	586	95.8	37.9	35.8	20.5	5.5	0.2	0.2
147	Cutting, sewing	807	309	38.3	498	61.7	769	95.3	54.4	33.3	9.2	2.7	0.3	0.1
148	Sorting, packaging, dispatch	222	162	73.0	60	27.0	214	96.4	38.8	40.7	15.4	4.7	0.5	–
149	Miscellaneous	975	766	78.6	209	21.4	941	96.5	45.4	37.3	12.9	3.6	1.0	–
150	Production and preparation of asbestos-containing felts, fleeces, cardboards and press plates													
151	Storage, raw materials	57	55	96.5	2	3.5	56	98.2	55.4	35.7	5.4	1.8	1.8	–
152	Preparation	80	79	98.8	1	1.2	79	98.8	38.0	50.6	10.1	1.3	–	–
153	Wet-processing	490	474	96.7	16	3.3	477	97.3	46.1	42.1	10.1	1.5	0.2	–
154	Drying	4	4	100	–	–	4	100	–	100	–	–	–	–
155	Cutting, sawing, punching	2925	2589	88.5	336	11.5	2772	94.8	31.6	46.3	17.2	4.5	0.4	0.1
158	Sorting, packaging, dispatch	336	144	42.9	192	57.1	329	97.9	53.2	38.0	7.0	1.5	0.3	–
159	Miscellaneous	5016	4715	94.0	301	6.2	4486	89.4	37.0	46.7	13.3	2.7	0.2	–
160	Manufacture and preparation of asbestos cement products													
161	Storage of raw material	199	197	99.2	2	1.0	187	94.0	36.9	36.9	19.8	5.3	1.1	–

Table 4. Continued

Code no.	Work place	Total no *n*	♂		♀		X-ray findings available		X-ray findings of the lungs					
			n	%	*n*	%	*n*	%	Normal		Abnormal			
									0		1		2	3
									0/−, 0/0	0/1	1/0	1/1, 1/2	2/1, 2/2, 2/3	3/2, 3/3, 3/+
162	Preparation	833	829	99.5	4	0.5	751	90.2	33.6	39.5	18.8	7.3	0.7	0.1
163	Sawing, milling of asbestos sheets	14743	14676	99.5	67	0.5	12734	86.4	46.9	42.2	9.0	1.6	0.3	–
164	Grinding	579	577	99.7	2	0.3	541	93.4	43.3	40.5	13.1	2.8	0.4	–
165	Drilling, punching	1299	1192	91.8	107	8.2	1138	87.6	54.3	35.1	8.1	2.0	0.3	0.2
166	Pipe processing	2149	2049	95.3	100	4.7	1698	79.0	42.1	39.6	13.8	3.8	0.6	–
167	Preparation of fibrous fracture	141	141	100	–	–	139	98.6	31.7	47.5	14.4	4.3	1.4	0.7
168	Sorting, dispatch	259	272	92.2	23	7.8	273	92.5	31.1	39.2	21.2	8.1	0.4	–
169	Miscellaneous	2594	2406	92.8	188	7.2	1846	71.2	38.1	42.5	14.5	4.3	0.5	0.1
170	Production and processing of friction coatings													
171	Storage of raw materials	147	138	93.9	9	6.1	145	98.6	51.7	38.6	8.3	1.4	–	–
172	Treatment	291	270	92.8	21	7.2	270	92.8	61.5	27.8	8.9	1.9	–	–
173	Mixing	1096	1074	98.0	22	2.0	1026	93.6	52.1	37.6	8.3	1.9	0.1	–
174	Pressing, hardening	4756	4447	93.5	309	6.5	4501	94.6	64.2	30.6	4.4	0.7	0.1	–
175	Grinding, sawing, milling	3928	3093	78.7	835	21.3	3740	95.2	59.6	33.0	6.0	1.1	0.2	–
176	Drilling, punching	593	441	74.4	152	25.6	579	97.6	50.6	40.9	6.4	2.1	–	–
177	Repair of brakes and chlutches	2798	2687	96.0	111	4.0	2644	94.5	50.5	39.0	9.0	1.4	0.1	–
178	Sorting, dispatch	866	533	61.5	333	38.5	824	95.1	55.7	37.1	5.0	1.8	0.4	–
179	Miscellaneous	2904	2511	86.5	393	13.5	2812	96.8	43.8	45.9	8.5	1.4	0.3	–
180	Production and processing of rubber products containing asbestos	558	415	74.4	143	25.6	546	97.8	36.8	42.1	15.8	4.4	0.7	0.2
190	Production and processing of asbestos containing plastics	2936	2711	92.3	255	7.7	2830	96.4	46.6	38.4	12.1	2.7	0.2	–
200	Manufacture of other products containing asbestos	2033	1883	92.3	150	7.4	1956	96.2	43.0	39.8	12.8	3.3	0.9	0.2
210	Insulation with asbestos containing materials	6883	6666	96.8	217	3.2	6567	95.4	36.7	44.4	14.3	4.1	0.4	–
220	Use of asbestos textiles	672	649	96.6	23	3.4	594	88.4	36.1	47.6	12.8	2.2	1.0	–
230	Further use of asbestos	1474	1359	92.2	115	7.8	1422	96.5	34.5	50.0	12.4	2.3	0.2	0.1

Table 5. Numbers of persons with normal and abnormal X-ray findings together with the relative frequency in % in dependence on the work places for smokers, ex-smokers and non-smokers

Work places	Code no.	X-ray findings											
		Normal				Abnormal							
		NS	S+Ex	no info	total	NS		S+Ex		No info		Total	
						n	%	*n*	%	*n*	%	*n*	%
Raw asbestos	110	136	302	3	441	12	8.1	28	8.5	–	–	40	8.3
	120	80	315	4	399	12	13.0	83	20.9	1	20.0	96	19.4
	130	63	125	1	189	13	17.1	24	16.1	2	66.6	39	17.1
Asbestos textile	141	20	61	0	81	5	20.0	8	11.6	1	–	14	14.7
	142	40	100	2	142	5	11.1	17	14.5	–	–	22	13.4
	143	79	216	17	312	27	25.5	45	17.2	–	–	72	18.8
	144	793	833	34	1660	152	16.1	122	12.7	10	22.7	284	14.6
	145	2	12	1	15	–	–	–	–	–	–	–	–
	146	193	233	6	432	64	24.9	86	27.0	4	40.0	154	26.3
	147	298	369	7	674	48	13.9	46	11.1	1	12.5	95	12.4
	148	52	113	5	170	11	17.5	30	21.0	3	37.5	44	20.6
	149	282	477	16	775	55	16.3	107	18.3	2	11.1	164	17.5
Asbestos paper	151	13	36	2	51	2	13.3	3	7.7	–	–	5	8.9
	152	18	52	–	70	1	5.3	8	13.3	–	–	9	11.4
	153	122	296	3	421	9	6.9	46	13.5	1	25.0	56	11.7
	154	1	3	–	4	–	–	–	–	–	–	–	–
	155	698	1436	25	2159	157	18.4	450	23.9	6	19.4	613	22.1
	158	106	193	1	300	9	7.8	19	9.0	1	50.0	29	8.8
	159	1045	2689	22	3756	155	12.9	568	17.4	7	24.1	730	16.3
Asbestos cement	161	48	88	2	138	16	25.0	31	26.1	2	50.0	49	26.2
	162	145	391	13	549	47	24.5	149	27.6	6	31.6	202	26.9
	163	3112	8155	74	11341	297	8.7	1082	11.7	14	15.9	1393	10.9
	164	111	340	2	453	23	17.1	65	16.0	–	–	88	16.3
	165	287	728	3	1018	36	11.1	81	10.0	3	50.0	120	10.5
	166	384	995	9	1388	62	13.9	241	19.5	7	43.8	310	18.3
	167	15	95	–	110	4	21.1	25	20.8	–	–	29	20.9
	168	48	141	3	192	19	28.4	61	30.2	1	25.0	81	29.7
	169	386	1090	12	1488	63	14.0	288	20.9	7	36.8	358	19.4
Friction coatings	171	37	91	3	131	2	5.1	11	10.8	1	25.0	14	9.7
	172	67	168	6	241	8	10.7	19	10.2	2	25.0	29	10.7
	173	182	733	6	921	25	12.1	79	9.7	1	14.3	105	10.2
	174	1225	3001	42	4268	56	4.4	173	5.5	4	8.7	233	5.1
	175	1118	2312	36	3466	77	6.4	192	7.7	5	12.2	274	7.3
	176	190	340	0	530	14	6.9	34	9.1	1	–	49	8.5
	177	916	1431	18	2365	79	7.9	198	12.2	2	10.0	279	10.6
	178	255	503	7	765	17	6.3	38	7.0	4	36.4	59	7.1
	179	892	1612	19	2523	71	7.4	214	11.7	4	17.4	289	10.3
Asbestos rubber	180	161	266	4	431	35	17.9	80	23.1	–	–	115	21.1
Asbestos plastic	190	748	1639	17	2404	101	11.9	321	16.4	4	19.0	426	15.1
Further asbestos containing products	200	460	1149	10	1619	71	13.4	261	18.5	5	33.3	337	17.2
Insulation	210	1519	3764	46	5329	247	14.0	980	20.7	11	19.3	1238	18.9
Asbestos textile	220	161	336	2	499	19	10.6	76	18.4	–	–	95	16.0
Asbestos production	230	384	808	17	1209	38	9.0	171	17.5	4	19.0	213	15.0

NS = non-smoker; S = smoker; Ex = ex-smoker

Table 6. Abnormal X-ray findings (in %) depending on work places

Code no.	Work place		Abnormal X-ray findings in %
168	Asbestos cement	Sorting, packaging, dispatch of the final products	29.7
162	Asbestos cement	Preparation	26.9
146	Asbestos textile	Weaving	26.3
161	Asbestos cement	Storage of raw materials	26.2
155	Asbestos paper	Cutting, sawing, punching	22.1
180	Asbestos rubber		21.1
167	Asbestos cement	Preparation of fracture material	20.9
148	Asbestos textile	Sorting, packaging, dispatch of the final products	20.6
169	Asbestos cement	Miscellaneous	19.4
120	Raw asbestos	Transportation of raw asbestos (fibres) and asbestos-containing products (only commerce and transportation trade)	19.4
210		Usage of asbestos and materials containing asbestos for insulation (e.g. thermal- and sound insulation, fire protection)	18.9
143	Asbestos textile	Carding	18.8
166	Asbestos cement	Molded piece and pipe-processing: Sawing, twisting, milling, grinding	18.3
149	Asbestos textile	Miscellaneous	17.5
200		Production of other asbestos-containing products	17.2
130	Raw asbestos	Storage and packaging of raw asbestos (fibres) and asbestos-containing products (only commerce and transportation trade)	17.1
159	Asbestos paper	Miscellaneous	16.3
164	Asbestos cement	Plate processing: grinding	16.3
220		Usage of asbestos fabrics and -textiles and asbestos-containing textiles, as far as asbestos dust is emitted (e.g. blankets, awnings, aprons, gloves, tapes and cords)	16.0
190		Production and processing of asbestos-containing plastics (e.g. synthetic resin molding compounds, thermoplastics, lacquers, insulation material, floor covering)	15.1
230		Further usage of asbestos and asbestos-containing products with dust development (e.g. use of asbestos in cooling beds in the glass- and steel-industry)	15.0
141	Asbestos textile	Storage of raw materials	14.7
144	Asbestos textile	Spinning, twisting, coiling	14.6
142	Asbestos textile	Preparation	13.4
147	Asbestos textile	Cutting and sewing	12.4
153	Asbestos paper	Wet processing (beater, pulp, paper machine)	11.7
152	Asbestos paper	Preparation	11.4
163	Asbestos cement	Plate processing: drilling, punching	10.9
172	Friction coatings	Preparation	10.7
177	Friction coatings	Repair of automobiles, brake and clutch service	10.6
165	Asbestos cement	Plate processing: drilling, punching	10.5
179	Friction coatings	Miscellaneous	10.3
173	Friction coatings	Mixing	10.2
171	Friction coatings	Storage of raw materials	9.7
151	Asbestos paper	Storage of raw materials	8.9
158	Asbestos paper	Sorting, packaging, dispatch of the final products	8.8
176	Friction coatings	Drilling, punching	8.5
110	Raw asbestos	Preparation of asbestos materials	8.3
175	Friction coatings	Grinding, sawing, milling	7.4
178	Friction coatings	Sorting, packaging, dispatch of the final products	7.2
174	Friction coatings	Pressing, curing	5.2
154	Asbestos paper	Drying	–
145	Asbestos textile	Wet-spinning	–

Table 7. Figures and relative frequencies of normal and abnormal X-ray findings in various industrial branches

Industrial branches	X-ray findings of the lungs					
	Men			Women		
	Normal	Abnormal		Normal	Abnormal	
	n	*n*	%	*n*	*n*	%
1. Mining	–	–	–	–	–	–
2. Mineral industry	1489	392	20.8	41	2	4.7
3. Gas and water production	133	25	15.8	–	–	–
4. Iron and metal industry	13252	2645	16.6	1059	67	6.0
5. Electronic, fine mechanics and optics	2390	369	13.4	423	38	8.2
6. Chemical industry	15927	2654	14.3	2244	236	9.5
7. Wood and associated industries	350	47	11.8	4	1	
8. Paper and printing industry	682	213	23.8	262	51	16.3
9. Leather and textile industry	2095	318	13.2	1951	330	14.5
10. Foodstuff industry incl. alcohol and tobacco	17	–	–	–	–	–
11. Construction	11385	1250	9.9	31	1	3.1
12. Trade, banking, insurance	1376	208	13.1	44	3	6.4
13. Transport	502	66	11.6	–	–	–
14. Health service	–	–	–	–	–	–
Total	49598	8187	14.2	6059	729	10.7

duration of exposure are shown for the individual fields of work in Table 8. According to the definition, only those cases whose thorax X-rays displayed the variation categories 1/0 or over according to ILO Pneumoconiosis Classification were rated as "abnormal" here. With regard to the duration of exposure, Table 8 shows that the number of proceedings for declaratory appraisal was greatest amongst the employees whose exposure began before 1955 for all three subgroups.

On the other hand, the duration of exposure in a later beginning of exposure (1956 and later) appears to have less effect on the fibrogenic risk to the extent that the absence of subgroups with a longer duration of exposure permits an appraisal. These results are also confirmed synoptically by a graphic representation of percentage incidences of abnormal X-ray findings in relation to the duration and beginning of exposure (Fig. 1).

However, it must be pointed out that the evaluation of the data available did not consider all those persons exposed to asbestos dust at an earlier time who had died in the period before registration in the context of occupational preventive medical investigations was possible.

With regard to smoking habits, Table 9 shows that smokers and exsmokers displayed radiologically abnormal findings relatively more frequently than nonsmokers. Above all it is shown (in accordance with general clinical experience) that bronchitis had occurred relatively more frequently in smokers and exsmokers (Table 10). In this connection, it must be assumed that incipient and slight reticular-linear structural proliferations in the X-ray (= subcategory 0/1 and 1/0) may be correlates both of asbestotic and chronic bronchitic alterations. It has to be borne in mind that these diseases are also frequently present in combination and cannot be differentiated in radiodiagnostic terms.

Discussion

Occupational diseases induced by asbestos dust constitute a topical theme in all industrialized countries. This applies despite the fact that prevention has been appreciably improved both in the fields of occupational hygiene and occupational medicine in the last 30 years. In West Germany, the financing agencies of the statutory accident insurance have intensified the registration of industries processing asbestos and using asbestos products in the last 20 years. At the same time, compulsory occupational preventive medical examinations have been introduced for employees with exposure to asbestos dust. The data from these preventive examinations according to G 1.2 (= first and follow-up investigations as well as subsequent supplementary investigations) have been collected since 1971 by the "Central Registry of Employees Exposed to Asbestos Dust" (ZAS) in the Textile and Clothing Professional Trade Association in Augsburg. Up to the end of 1986, the results of more than 70000 persons for-

Table 8. Figures and relative frequencies (in %) of cases with abnormal X-ray findings depending on the beginning and duration of exposure

Work place	Code no.	Duration of exposure (years)								
		-15			16–25			26-		
		Beginning of exposure			Beginning of exposure			Beginning of exposure		
		-1955	1956–70	1971–86	-1955	1956–70	1971–86	-1955	1956–70	1971–86
Raw asbestos	110	3 (23.1)	7 (17.5)	15 (5.2)	2 (33.3)	6 (10.0)	–	1 (8.3)	1 (12.5)	–
	120	1 (25.0)	20 (27.4)	42 (14.8)	6 (46.2)	18 (22.2)	–	4 (30.8)	3 (50.0)	–
	130	–	9 (23.1)	23 (15.2)	1 (33.3)	3 (20.0)	–	2 (25.0)	–	–
Asbestos textile	141	–	2 (13.3)	3 (6.0)	2 (66.7)	3 (18.8)	–	2 (40.0)	1 (100)	–
	142	1 (20.0)	11 (30.6)	6 (6.5)	1 (50.0)	1 (4.8)	–	2 (100)	–	–
	143	13 (44.8)	21 (25.6)	22 (9.4)	4 (100)	6 (50.0)	–	4 (100)	1 (100)	–
	144	42 (42.9)	88 (24.6)	81 (6.5)	13 (41.9)	27 (33.3)	–	19 (73.1)	2 (50.0)	–
	146	22 (51.2)	47 (32.2)	42 (15.0)	8 (53.3)	24 (48.0)	–	7 (29.2)	–	–
	147	2 (50.0)	26 (18.4)	36 (6.9)	7 (70.0)	17 (30.9)	–	3 (33.3)	–	–
	148	–	9 (16.1)	9 (9.4)	6 (60.0)	10 (32.3)	–	5 (45.5)	3 (60.0)	–
	149	9 (40.9)	40 (23.8)	37 (7.5)	11 (57.9)	24 (19.8)	–	33 (54.1)	4 (33.3)	–
Asbestos paper	151	–	2 (11.2)	2 (6.9)	–	–	–	1 (50.0)	–	–
	152	1 (100)	2 (14.3)	5 (8.6)	–	1 (20.0)	–	–	–	–
	153	1 (100)	15 (23.8)	24 (7.2)	1 (25.0)	8 (23.5)	–	4 (26.7)	–	–
	155	7 (28.0)	222 (26.0)	87 (7.9)	82 (45.1)	108 (33.0)	–	87 (40.8)	9 (39.1)	–
	158	1 (50.0)	12 (22.6)	4 (1.9)	3 (33.3)	2 (7.7)	–	6 (42.9)	1 (50.0)	–
	159	24 (42.1)	143 (18.1)	234 (10.6)	36 (35.6)	150 (20.6)	–	111 (31.4)	15 (18.5)	–
Asbestos cement	161	–	16 (36.4)	9 (12.7)	3 (75.0)	14 (29.2)	–	4 (50.0)	–	–
	162	24 (70.6)	66 (38.6)	35 (12.2)	10 (55.6)	38 (27.5)	–	19 (45.2)	2 (25.0)	–
	163	19 (32.8)	259 (14.8)	416 (6.1)	36 (18.4)	320 (15.5)	–	246 (19.7)	50 (17.0)	–
	164	–	18 (23.1)	35 (11.0)	1 (12.5)	20 (26.3)	–	6 (24.0)	2 (28.8)	–
	165	4 (44.4)	16 (10.6)	52 (7.2)	8 (53.3)	20 (15.7)	–	14 (23.7)	–	–
	166	26 (56.5)	86 (24.2)	77 (9.4)	26 (54.2)	47 (19.3)	–	29 (34.1)	11 (33.3)	–
	167	–	6 (42.9)	14 (15.1)	2 (100)	4 (40.0)	–	1 (100)	1 (100)	–
	168	6 (66.7)	20 (29.4)	15 (12.4)	11 (78.6)	19 (50.0)	–	9 (69.2)	1 (100)	–
	169	25 (50.0)	70 (25.1)	63 (6.8)	41 (65.1)	79 (26.9)	–	58 (46.4)	13 (30.2)	–
Friction coating	171	–	–	5 (5.5)	–	6 (26.1)	–	2 (20.0)	–	–
	172	–	10 (30.3)	14 (8.3)	2 (33.3)	3 (23.1)	–	–	–	–
	173	1 (33.3)	24 (21.1)	38 (5.8)	6 (50.0)	24 (35.3)	–	5 (35.7)	2 (25.0)	–
	174	3 (100)	38 (14.4)	126 (4.1)	9 (39.1)	33 (19.4)	–	16 (28.1)	4 (50.0)	–
	175	6 (54.5)	58 (18.8)	135 (5.5)	7 (28.0)	40 (17.9)	–	20 (37.7)	3 (13.0)	–
	176	2 (18.2)	9 (13.4)	16 (4.3)	1 (14.3)	12 (20.0)	–	6 (28.6)	2 (14.3)	–

Table 8. Continued

Work place	Code no.	Duration of exposure (years)								
		-15			16–25			26–		
		Beginning of exposure			Beginning of exposure			Beginning of exposure		
		-1955	1956–70	1971–86	-1955	1956–70	1971–86	-1955	1956–70	1971–86
	177	2 (28.6)	32 (12.5)	108 (7.8)	5 (41.7)	83 (13.7)	–	32 (16.2)	11 (13.3)	–
	178	2 (22.2)	16 (18.4)	14 (2.8)	4 (30.8)	6 (6.7)	–	12 (35.3)	4 (26.7)	–
	179	12 (31.6)	50 (16.7)	86 (5.3)	18 (32.1)	61 (16.8)	–	45 (26.9)	10 (19.2)	–
Asbestos rubber	180	4 (100)	29 (26.9)	37 (11.4)	4 (40.0)	26 (43.3)	–	10 (58.8)	3 (75.0)	–
Asbestos plastic	190	4 (50.0)	103 (21.8)	161 (9.2)	30 (46.2)	75 (26.6)	–	40 (39.6)	6 (31.6)	–
Further asbestos-containing products	200	7 (30.4)	89 (22.6)	74 (7.7)	15 (25.9)	76 (27.0)	–	58 (43.3)	9 (26.5)	–
Insulation	210	31 (43.1)	191 (17.9)	237 (9.7)	89 (39.4)	340 (23.8)	–	276 (32.9)	42 (19.8)	–
Asbestos textile	220	1 (10.0)	23 (14.6)	28 (11.3)	4 (19.0)	21 (24.7)	–	15 (35.7)	2 (22.2)	–
Asbestos production	230	7 (28.0)	36 (16.4)	51 (8.1)	15 (27.8)	38 (17.1)	–	50 (28.1)	6 (18.2)	–

merly or currently exposed occupationally to asbestos dust could be registered. The data sets of the last investigation performed were available to answer the questions we formulated above. The present study attempts to detect the consequences of asbestos dust infiltration in empirical-casuistic terms on the basis of occupational preventive medical investigations. It also attempts to appraise the fibrogenic risk in various fields of work with consideration of the beginning and duration of exposure. It is thus not an epidemiological study in the classical sense; on the contrary, the results and data of occupational preventive medical investigations have been analysed statistically. As far as we know, comparable investigations have not been published up to now.

In our analysis, the appraisal of the risk of asbestosis is oriented to the coding of the X-ray findings of the lungs. An X-ray finding was rated as "abnormal" in terms of asbestotic alterations when at least the variation 1/0 of the small irregular lung radio-opacities (s, t, u) or a higher subcategory had been attained in accordance with International Pneumoconiosos Classification (ILO U/C 1971 or ILO 1980 West Germany). On the other hand, the initiation of the proceedings for declaratory appraisal could not be regarded as a reliable criterion for radiological asbestotic lesions, since it is shown in the data analysis that normal lung results of category 0 were recorded in more than 23% of the proceedings for declaratory appraisal instituted, so that according to the definition there were no indications of asbestosis (Otto 1976).This discrepancy will be discussed in more detail elsewhere.

A major result of our evaluation so far is that the intensification both of industrial hygiene and occupational medical measures has led to an appreciable reduction of the risk of asbestosis. The decrease of the risk from 1956 to 1970 and to a greater extent for the period from 1971 to 1986 is shown inter alia in that the relative frequency of the higher variation categories decreases, and the prevalence of normal findings increases. The conditions in the individual industrial sectors and fields of work require a differentiated appraisal. There was thus a relatively high risk of asbestosis inter alia for women in the asbestos textile industry up to the middle of the 1950s; here, relatively short exposure times were sufficient in order to give rise to clinical manifest asbestosis.

In the asbestos cement industry, besides asbestos processing surprisingly the departments involved in sorting, packaging, dispatch of endproducts and the raw materials store were found as industrial sectors or fields of work with a relatively high risk of asbestosis (cf. Table 8). However, it must be borne in mind here that the fields of work specified last are areas of predilection for switching of workplaces within the enter-

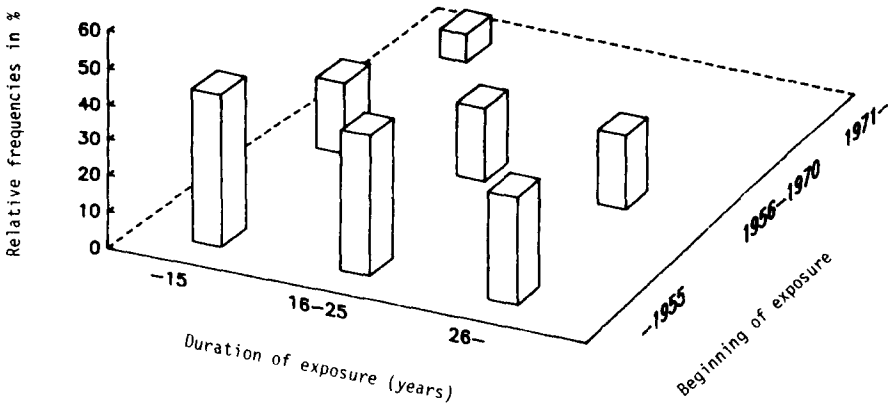

Fig. 1. Relative frequencies (in %) of findings with abnormal X-ray findings (sub-category 1/0 and/or more) in relation to the duration and beginning of exposure

Table 9. Numbers and relative frequencies of normal and abnormal X-ray findings in smokers (including ex-smokers) and non-smokers

X-ray findings	Smoking habits					
	NS		S + Ex		No information	
	n	%	*n*	%	*n*	%
Abnormal	2180	11.4	6603	14.8	133	20.5
Normal	16986	88.6	38159	85.2	516	79.5

Table 10. Numbers and relative frequencies (in %) of patients with chronic bronchitis depending on the smoking habits and the X-ray findings

X-ray findings	Smoking habits				
	NS		S + Ex		No information
	n	%	*n*	%	*n*
Abnormal	259	23.0	1000	28.2	10
Normal	869	77.0	2552	71.8	16

prise when a workplace with lower risk is to be found for employees with abnormal lung findings. It is thus to be assumed that persons with a formerly more intensive exposure have also been registered here. However, the data available to us only show the last field of work.

Less danger with regard to the risk of asbestosis were and are present in the frictional coating (brake lining) industry, especially in car repair, in brakes and clutch service, in certain areas of the asbestos cement industry as well as evidently in areas of drying work in the asbestos paper industry and the wet spinning division in the asbestos textile industry.

The fact that absolute figures for the asbestoses compensated for the first time and malignancies induced by asbestos dust (occupational disease no. 4103–4105) are still rising at present in the "Occupational Disease Documentation" is essentially due to the latency periods of 20 to 30 and more years on the one hand and on the other hand is due to the fact that relatively slight or brief exposures to asbestos dust appear to be relevant, in particular for the induction of malignant mesotheliomas. In this connection, it must also be taken into consideration that the number of persons exposed to asbestos dust increased markedly in the 1960s and 1970s.

The data material available to us does not allow any appraisals of the cancer risk from inhalation of fine asbestos dust (IARC 1977; Becklake 1986). The symbol "ca" (carcinoma) was entered 51 times and the coding "me" (mesothelioma) 12 times in set III of the investigation sheet, i.e. suspicion of a neoplasia of the thorax region. However, it was not possible to verify these diagnoses on the basis of our data from preventive investigations. To what extent a putative cancer diagnosis has been confirmed at all and in particular with regard to asbestos as the cause is not apparent from the investigation data, since these cases could not be followed further either in time or with regard to the outcome of the occupational disease proceedings.

The professional trade cooperative associations are therefore recommended to have all investigation results in the context of occupational disease proceedings and expert reports coded on standardized sheets according to G 1.2, and thus to bring together in the Central Registry of Employees Exposed to Asbestos Dust in Augsburg all data of all exposed persons irrespective of the question of recognition of an occupational disease in accordance with subparagraphs 4103–4105 BeKV.

Finally our evaluations have confirmed once more that relevant investigation results have not been documented or have only been documented incompletely in a substantial percentage by the authorized physicians. Irrespective of the radiological coding accord-

ing to ILO Pneumoconiosis Classification (Bohlig et al. 1981), its application requires that the basic rules of classification must be followed (here in particular comparisons with adequate standard films). Important anamnestic data such as areas of work, beginning and duration of exposure were not specified or only partially specified. These parameters were thus not available in a percentage which varies between ca 10 and 25%! This situation can be improved by regular exchange of experience between authorized physicians and second appraisers at seminars. This has repeatedly been suggested by the doctors concerned. In particular the capacity to code X-ray findings cannot be learned solely from papers and slide presentations, but can be acquired and promoted in seminar work in small groups.

On the part of the professional trade cooperative associations, essential instruments rendering the investigation data more precise would be to monitor more consistently the instrumental and especially the professional prerequisites for authorized physicians, and in particular to keep the number and fluctuation of these doctors as small as possible. In addition, the system of second appraisal by especially experienced physicians which is plausible from a medical point of view and which is also required by the International Labour Organization (ILO) in Geneva should be retained and intensified. Only in this way is the strict observance of the given coding instructions to be ensured. At the same time, however, the reliabilty and information content of the data contained in the investigation sheets "Mineral Dust" could be further improved in this way.

Conclusions and recommendations

In terms of the objectives specified at the beginning, the following conclusions can be drawn:

1. On the basis of the overall population, the highest relative pathogenic risk induced by fine asbestos dust was present in persons whose exposure commenced before or up to 1955. In these cases, a duration of exposure of a few years was often sufficient to result in a clinically manifest asbestosis later. With a later beginning of exposure, the risk of asbestosis must be regarded as considerably lower. This also applies even considering the relative long latency periods of 20 years and over.

2. With increasing duration of exposure, no unequivocal rise of the fibrogenic risk can be detected on the basis of the overall population. This applies even when it is considered that occupationally exposed persons have been repeatedly switched from workplaces with high exposure to areas of less risk.

3. Abnormal radiological findings as indications of asbestosis were found relatively frequently in men and women in the industrial sectors "paper and printing" as well as "textiles and leather". Previously women were at risk above all in the classical fields of the asbestos textile industry (weaving, carding). It is important in this regard that women were frequently employed formerly as unskilled or semiskilled staff under unfavorable conditions of industrial hygiene. For men, there was evidently a relatively high fibrogenic risk in the industrial sectors "building materials", "iron and metal", "gas and water", "chemicals" as well as "electronic engineering, fine mechanical engineering and optics". On the other hand, no appreciable fibrogenic risk was present in the industrial sectors "mining", "catering trade" as well as "health service" and for women in the areas "building materials", "gas and water", "building" as well as "iron and metals". However, it should be considered here that women were practically not employed in certain areas of industry, or that processing of asbestos generally did not occur (Table 7).

4. The fibrogenic risk has decreased appreciably since 1955 with a later beginning of exposure. The consistently performed industrial hygiene cleanup measures and the occupational preventive medical examinations according to G 1.2 are responsible for this. No appraisals can be made about the oncogenic risk on the basis of the data material available.

5. Certain fields of work are or were evidently subject to such low exposure that a fibrogenic risk induced by asbestos dust which is relevant in terms of occupational medicine cannot be assumed. This applies irrespective of the fact that asbestos is increasingly being replaced in production by other materials or fibers for certain work in the brake lining, but also in the asbestos paper industry.

6. The analysis of the data material did not provide any unequivocal indications that inhalative smoking habits affect the fibrogenic risk in principle. A relatively higher number of radiologically abnormal findings were found in the group of smokers and exsmokers only in occasional areas of work. These tendencies which are significant in subpopulations cannnot be extrapolated to the overall population, however (cf. Table 5).

Finally, our evaluation has also shown that preventive investigations according to G 1.2 have proved in principle to be a useful instrument for occupational medical monitoring and prevention in persons exposed to asbestos dust. This does not rule out the possibility that on the basis of experience further improvements should be carried out where necessary. For this reason, the following concluding recommendations are made:

1. In future, all those patients where an occupational disease is recognized and if necessary also com-

pensated in accordance with occupational diseases no. 4103, 4104, or 4105 should be generally registered and coded. Only in this way would a follow-up study of all persons exposed to asbestos dust be possible.

2. In the context of postgraduate training, an exchange of experience at seminars should be organized for authorized doctors in order to restrict appraiser variation and to ensure as high a state of training as possible.

3. Finally, the second appraisal of X-rays by especially experienced doctors should be retained and intensified. The reliability and informative content of the available investigation data could be appreciably improved by this measure.

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