EFFECT OF DUST SUPPRESSION MEASURES ON THE PREVALENCE OF COAL-WORKERS' PNEUMOCONIOSIS IN THE DUTCH COAL-MINES

BY

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The underground workers in the Dutch coal-mines have been radiographed (70 mm.) seven times since 1949. The prevalence of coal-miners' pneumoconiosis shows a continuous decrease in all age groups. To evaluate the effect of the intensive system of dust suppression over this period a cohort analysis was made of the proportion of men with pneumoconiosis with the same number of years of exposure underground but who started work in different years. The results show that the number of men with pneumoconiosis decreases the longer they have worked in the period since dust suppression measures were applied intensively. The differences are significant at the 5% level.

In 1936 the Medical Department of the Dutch Coal-mines introduced chest radiographs for mining entrants and periodic radiographs for stone-workers. Mey (1947) described the results of these surveys during the period 1936 to 1946. It soon became clear that serious pulmonary lesions could occur amongst other underground workers as well. The Boards of the Dutch Coal-mines therefore decided on periodic radiographic examinations of all underground workers, the first survey being carried out in 1949 to 1950 by the Instituut voor Longonderzoek*. At the same time an intensive dust suppression programme was introduced in all working places (Matla, 1959). Since then, several other radiographic surveys have been completed. This paper is concerned with the results of the first seven surveys.

Methods

The periodic radiographic examinations have been carried out with a Philips Odelca camera (70 × 70 mm.). Radiophotography is suitable for this purpose provided that the technique is of a high standard and the readers are experienced (Aupetit and Flouquet, 1956; Balgairies, Foubert, and Aupetit, 1957). The new radiophotograph was compared with the previous ones (Gernez-Rieux and Gervois, 1956) and if

there was any difficulty in reading, or if any change was suspected, a 35 × 35 cm. radiograph was taken. We are conscious of the possible errors introduced by differences in radiographic technique and the lack of dual readings, but we believe that the risk of a case of pneumoconiosis being missed in the course of several surveys is small.

The radiographs in the surveys so far have been classified using the method introduced by Eck and Hanaut (1944-1945), and later modified by the Belgians in 1948 (Van Mechelen and McLaughlin, 1962). In future, the new 1958 I.L.O. Classification (International Labour Office, 1959) will be used. The lowest category of our present classification is intermediary between categories 1 and 2 of the I.L.O. Classification. The sub-divisions of the Eck and Hanaut classification have not been used. A study of the prevalence of simple pneumoconiosis and progressive massive fibrosis in Dutch coal-mines has been published elsewhere (Hendriks, 1961).

Populations

All miners working underground at the time of the survey were radiographed. In addition, those working on the surface, who had previously worked more than one year underground, were included. This for the sake of brevity is referred to as the underground population. Very nearly the whole (over 98%) of the

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TABLE 1
POPULATIONS AVAILABLE AND ACTUALLY
RADIOGRAPHED AT THE TIME OF EACH RADIOLOGICAL
SURVEY

Radiological Survey	Population Available	Population Actually Radiographed	
		No.	%
1	28,697	28,273	98.5
2	30,550	30,039	98.3
3	33,996	33,626	98.9
4	33,985	33,649	99.0
5	33,464	33,170	99.1
6	33,172	32,961	99.4
7	33,709	33,495	99.4

populations available at the time of each survey were radiographed (Table 1). Starting from the time of the fifth survey, we have information on the number of men who left the pits between surveys and of those who started working underground (new entrants). Table 2 shows the changes in populations which occurred, sub-divided according to radiological category. Tables 3 and 4 show the populations shown in columns "P₁" and "P₂" of Table 2, respectively, analysed according to years of exposure.

Results

Figure 1 summarizes the prevalence of pneumoconiosis, divided into pneumoconiosis with small and with large opacities, found at the periodic surveys. In 1950, 27% of the population had pneumoconiosis; in 1960, only 15.9%. The prevalence of pneumoconiosis with large opacities has decreased more

FIG. 1.—Prevalence of coal-workers' pneumoconiosis in the underground population, i.e. miners underground and surface workers formerly employed underground for more than one year. Top section of column indicates pneumoconiosis with large opacities; bottom section, pneumoconiosis with small opacities.

rapidly, from 5.3 to 2.4 (55%), than that of pneumoconiosis with small opacities, from 21.7 to 13.5 (38%).

Figure 2 shows that the difference between the 1950 and 1960 surveys is apparent in all years of exposure. This makes it improbable that the change in prevalence is due only to the pensioning off of old

TABLE 2
CHANGE IN POPULATION AVAILABLE BETWEEN 5th AND 7th RADIOLOGICAL SURVEYS DUE TO DISCHARGES AND NEW ENTRANTS, ACCORDING TO RADIOLOGICAL CATEGORIES

Population	No Pneumoconiosis (PO)	Pneumoconiosis		Total
		P ₁	P ₂	
5th Survey Radiographed	27,165	5,195	1,104	33,464
Not radiographed*	222	47	25	294
Discharges, etc.	-5,653	-437	-215	-6,305
PO → P ₁ and P ₂	-326	+324	+2	
P ₁ → P ₂		-102	+102	
New entrants	6,013			+6,013
6th Survey Radiographed	27,199	4,980	993	33,172
Not radiographed*	151	36	24	211
Discharges, etc.	-3,994	-510	-226	-4,730
PO → P ₁ and P ₂	-115	+114	+1	
P ₁ → P ₂		-36	+36	
New entrants	5,258	9		5,267
7th Survey Radiographed	28,348	4,557	804	33,709
Not radiographed*	171	33	10	214

PO = No pneumoconiosis.

P₁ = Pneumoconiosis with small opacities.

P₂ = Pneumoconiosis with large opacities.

*X-ray category of those not radiographed assumed to be that of last available film.

TABLE 3
CHANGE IN POPULATION BETWEEN 5th AND 7th SURVEYS ACCORDING TO YEARS OF EXPOSURE IN THE GROUP WITH CATEGORY P₁ AT THE TIME OF 5th SURVEY

Population	Exposure (years)									Total
	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40+	
5th Survey										
Radiographed	22	162	471	1488	926	991	794	291	50	5195
Not radiographed	—	1	1	4	5	7	13	11	5	47
Discharges	—	6	14	29	31	80	121	127	29	437
6th Survey										
Radiographed	20	118	374	1315	1147	908	756	297	45	4980
Not radiographed	—	—	1	5	5	5	8	6	6	36
Discharges	2	5	14	29	35	79	138	167	41	510
7th Survey										
Radiographed	17	88	327	1024	1261	873	674	260	33	4557
Not radiographed	—	2	2	3	12	6	2	6	—	33

TABLE 4
CHANGE IN POPULATION BETWEEN 5th AND 7th SURVEYS ACCORDING TO YEARS OF EXPOSURE IN THE GROUP WITH CATEGORY P₂ AT THE TIME OF 5th SURVEY

Population	Exposure (years)									Total
	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40+	
5th Survey										
Radiographed	1	10	44	154	202	317	245	120	11	1104
Not radiographed	—	—	1	—	1	5	7	8	3	25
Discharges	—	—	2	13	21	52	59	65	3	215
6th Survey										
Radiographed	1	8	41	123	202	270	236	98	14	993
Not radiographed	—	—	1	4	2	5	8	4	—	24
Discharges	—	—	7	16	23	49	60	58	13	226
7th Survey										
Radiographed	2	8	35	79	183	227	190	72	8	804
Not radiographed	—	—	2	1	1	—	5	1	—	10

FIG. 2.—Relation between prevalence of pneumoconiosis and years of exposure.

miners. The material can also be examined from the point of view of new cases of pneumoconiosis discovered at each survey. In Fig. 3 these new cases have been expressed as a proportion of those who previously had normal radiographs. This shows rather unexpectedly a rise at the time of the fifth survey which is probably an artefact since a new reader of the radiographs was introduced at this time.

FIG. 3.—Radiological attack rate of coal-workers' pneumoconiosis in the underground population.

Another approach is through the number of cases awarded compensation (Fig. 4). As is usual with such statistics, the pattern is rather irregular because of changes in the means of assessing the degree of disablement and the alteration of legal regulations.

As we are chiefly interested in the effect of the intensive system of dust suppression introduced in 1951 on the development of pneumoconiosis, none

FIG. 4.—Number of men receiving compensation and average percentage of disablement.

FIG. 5.—Coal-workers' pneumoconiosis in men with less than 15 years of service underground.

of these types of analysis, although promising, is altogether satisfactory. The material includes many men exposed during the period before 1951, during which the basis for the onset and the development of pneumoconiosis may have been laid. For the next analysis, men who have worked for more than 15 years underground have been excluded as well as those who have worked a similar time on the surface after having worked underground. The material then has been grouped according to the number of years spent underground. The results shown in Fig. 5 are more definite, with a striking and regular fall in the

proportion of men with pneumoconiosis of all types, at each survey.

We are not yet, however, in a position to test the hypothesis that the intensive dust suppression programme has led to a continuously decreasing risk of developing pneumoconiosis. The best we can do is to apply a "cohort" analysis, *i.e.* analyse the fate of each cohort of new entrants separately. Thus groups are compared that differ with regard to the number of years worked in the period of intensive dust suppression. Figure 6 shows a comparison of the cumulative percentage of new cases found in groups of

INITIAL YEAR OF EMPLOY- MENT	YEARS BETWEEN INITIAL YEAR OF EMPLOYMENT AND RADIOLOGICAL SURVEY																											
	1/2	1	1 1/2	2	2 1/2	3	3 1/2	4	4 1/2	5	5 1/2	6	6 1/2	7	7 1/2	8	8 1/2	9	9 1/2	10	10 1/2	11	11 1/2	12	12 1/2	13	13 1/2	
1946																												
1947												0.32				0.89			1.73		3.81				4.89			6.21
1948																												
1949																												
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FIG. 6.—Cumulative number of new cases of coal-workers' pneumoconiosis, in per cent, found during the second to the seventh radiological surveys among those first employed underground in the Dutch mining industry after 1945, divided according to number of years elapsed since initial employment.

miners entering the industry each year, analysed according to the number of years spent underground. From this figure it is clear that the probability of having pneumoconiosis becomes smaller, at the same number of years of exposure underground, as the men examined have worked for a longer time in a period of intensive dust suppression. The differences are significant at the 5% level. The same results are shown graphically in Fig. 7.

FIG. 7.—Graphical representation of data in Fig. 6. Year indicates initial year of employment; 1952 and later is O-line.

Even this type of analysis is open to certain theoretical criticisms. It could be argued that the differences might be due to changes in the pattern of work underground and not to changes in dust concentration. This, however, is very unlikely as in Holland the pattern of work has changed little. No

analyses have been done of the relation of the attack of pneumoconiosis to the particular occupation of the miner. It appeared to be impossible to find out whether certain underground occupations involve greater risks than others (Hendriks, 1961). However, there are a few groups of underground workers in which hardly any pneumoconiosis has ever been found, *e.g.* signalmen, engine-drivers, and electricians. It also could be argued that the reduction was due to a change in the level of reading pneumoconiosis due to changes in the radiographic technique or to observer bias. It is difficult to exclude this possibility altogether without reclassifying a very large number of films, with their dates concealed, both for pneumoconiosis and technique. This has not proved possible, but there is some evidence (Fig. 4) that the new reader reads more rather than less pneumoconiosis than the old one. Furthermore, the gradual improvement in radiographic technique with time makes it easier rather than more difficult to diagnose the early stages of pneumoconiosis. We therefore think it reasonable to conclude that the risk of developing coal-workers' pneumoconiosis has been greatly reduced since 1950 and that this is probably related to the measures taken to reduce dust.

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