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Silicosis in a grey iron foundry

The persistence of an ancient disease

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LANDRIGAN PJ, CHERNIACK MG, LEWIS FA, CATLETT LR, HORNUNG RW. Silicosis in a grey iron foundry: The persistence of an ancient disease. *Scand J Work Environ Health* 12 (1986) 32–39. An industrial hygiene and medical survey was conducted in an iron foundry to study the occurrence of silicosis. Breathing zone exposures to respirable crystalline silica had been very high in 1977 [1 045 $\mu\text{g}/\text{m}^3$ (geometric mean) for coremakers and 198 $\mu\text{g}/\text{m}^3$ for fettlers]; exposures in 1980 and 1982 were substantially lower. A radiographic evaluation of 188 workers revealed silicosis in 18 (9.6%). Eight had category 1 profusion of small rounded pulmonary lesions (by the 1980 classification of the International Labour Office); two had category 2; and eight had category 3. Two had progressive massive fibrosis. Four workers without silicosis in 1977 had developed lesions by 1980. The prevalence increased from 1.5% among workers employed less than 20 years to 53% among longer term workers. No association was found between the prevalence of silicosis and cigarette smoking. Chronic cough was more common in workers with heavy current dust exposure than in those with light exposure, more common in smokers than in nonsmokers, and more common in silicotics than in nonsilicotics. A multiplicative interaction existed between dust exposure and smoking in the etiology of cough. Silicosis continues to exist in American foundries. Cigarette smoking does not contribute to the causation of silicosis, but it aggravates the attendant respiratory symptoms.

Key terms: occupational disease, pulmonary function.

Silicosis is a diffuse interstitial pulmonary fibrosis caused by the deposition of fine particles of crystalline silica in the lungs (9, 21, 23, 26). Diagnosis is based on a history of exposure to silica coupled with radiographic demonstration of multiple, small, discrete, rounded opacities, concentrated initially in the upper lung fields. The pathognomonic lesion is a sharply demarcated nodule, 1–3 mm in diameter, characterized histologically by a concentric deposition of collagen fibers on a dust focus (26). Although rapidly progressive silicosis has been described following massive overexposure to silica (3, 23), the typical course is of several decades' duration. Symptoms of dyspnea and cough appear, if at all, only late. Diminution in forced vital capacity (FVC) is the classic functional impairment and may precede the appearance of radiographic lesions (34). Silicosis may be complicated by the development of massive fibrotic pulmonary lesions, consisting of matted, conglomerated nodules. An association between silicosis and tuberculosis is well recognized (26).

Clinical and epidemiologic studies have shown consistently that silicosis is caused by exposure to silica dust in such occupations as mining (2, 13, 27, 30, 33), tunneling (2, 13, 27, 33), quarrying (2, 13, 27, 33), sandblasting (12, 13, 39), foundry work (13, 33, 36), ceramics manufacture (7, 33), sculpting (19, 31), pottery making (13, 33), and granite cutting (34).

A clear dose-response relationship has been demonstrated between cumulative exposure to respirable, crystalline silica and the development of the radiographic and functional abnormalities of silicosis (4, 21, 26, 34). To prevent the development of silicosis, the National Institute for Occupational Safety and Health (NIOSH) recommends that occupational exposure to respirable crystalline silica not exceed an 8-h, time-weighted average (TWA_8) of 50 $\mu\text{g}/\text{m}^3$ of air (21).

Data on the current prevalence of silicosis in the United States (US) are scant (8). Although it is speculated that the disease may be less common now than previously (11), cases continue to be reported in foundrymen (6), sandblasters (39), and packers of silica flour (3).

In this report, we describe a cross-sectional study of silica exposure and silicosis in a grey iron foundry in Pennsylvania. This investigation was intended (i) to determine whether silicosis is present in the examined workforce, (ii) to investigate the relationship between silica exposure and cigarette smoking in the etiology of silicosis, and (iii) to explore interrelations between silica exposure, cigarette smoking, respiratory symptoms, and pulmonary dysfunction.

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Background

Foundry consists of pouring liquid metal into a mold which has been formed in the external shape of the object to be cast (20). In most foundries today, as has been the practice for centuries, molds are made of silica sand bound into shape with clays and resins. Foundry workers are at risk of exposure to silica in the making of molds and cores; in knock-out operations, where castings are separated from molds; in fettling, where surplus metal and adherent silica are stripped from the surfaces of castings with air chisels and grinding wheels; and in sand preparation and reclamation. Foundry workers are also exposed to dusts and fumes produced by the pyrolysis of binding resins (14, 32).

The foundry evaluated in this study produces cast iron pipe and fittings (24). It employs approximately 150 workers. Pipe segments are cast in centrifugal casting machines (coreless casters). Until 1982, the inner surfaces of these machines were dusted before each pouring with a "parting compound" consisting of silica flour. Silica flour is a finely ground form of silica, with a crystalline silica content of greater than 80 % and with mean particle diameters ranging from 2.3 to 5.2 μm (3, 23).

Methods

Industrial hygiene

To evaluate past exposures to silica in the foundry, we reviewed industrial hygiene data from 1977, 1980, and 1982 (24). No data were available for earlier years. We also obtained information on measures taken to reduce exposures.

To evaluate current exposures, we conducted an industrial hygiene evaluation in October 1983 in which we collected personal (breathing zone) air samples for the determination of respirable crystalline silica.

Each air sample was obtained with a sampling pump, a 10-mm nylon cyclone, and a preweighed polyvinyl chloride membrane filter (37-mm, 5-mm pore size) at a flow rate of 1.7 l/min over the entire work-shift. Total weights of dust were determined gravimetrically; all weighings were done in duplicate. Samples were analyzed for two species of silica — quartz and cristobalite — by X-ray diffraction according to NIOSH method P & CAM 259 (23). The lower limit of analytical detection for each species was 0.03 mg in a 2-mg sample.

We classified workers into the following three exposure categories (17, 20) according to their current job assignment: (i) high silica exposure (fettlers and grinders, coremakers and coresettlers, sand preparation and sand reclamation workers, casting and pouring operators, and stripping and knock-out workers), (ii) moderate silica exposure (mold makers and furnace repairers), and (iii) low silica exposure (pattern shop workers, furnace chargers, maintenance workers, ma-

chinists, general laborers, shippers, supervisors, and office workers). Workers with the heaviest exposure to silica also probably had the heaviest exposure to other fumes and dusts (14, 32). Data on workers' tenure in their current jobs were not available; therefore the extent to which current assignment reflects past exposures is not known.

Medical evaluation

Chest radiographs from 1977 and 1980 were available for our review. They had been taken on standard 14 × 17-inch (35 × 43-cm) films.

To assess the prevalence and severity of silicosis, we arranged for each film to be read by a panel of three radiologists, all of whom were certified B readers. Each reader (independent of one another) examined each film for the presence and profusion of pneumoconiotic lesions, utilizing the 1980 revision of the International Labour Office (ILO) classification system (15). To assess progression in the profusion of lesions for those workers who had examinations performed in both years, the readers (independent of one another) read the paired films side-by-side with knowledge of their temporal sequence (18, 28). In cases of disagreement among the readers, a standard procedure was followed to derive a consensus interpretation (10, 24).

Respiratory questionnaires were administered to workers in 1980 and 1982. These questionnaires obtained demographic data and a brief occupational history. They also sought information on whether each worker coughed daily for at least three months per year, on whether the worker produced phlegm each morning, and on whether the worker experienced shortness of breath while either walking on level surfaces or climbing stairs. The questionnaires also sought information on respiratory disease and smoking histories. Lifetime consumption of cigarettes was expressed in pack-years (average number of packs per day × number of years smoked). Chronic bronchitis was defined as the simultaneous presence of cough and phlegm production, lasting at least three months per year.

Pulmonary function testing was conducted in 1980 and 1982 by the American Lung Association of the Lehigh Valley. The testing was performed with a Vitalograph (Buckingham, England) spirometer. The tests performed were FVC and the 1-s forced expiratory volume ($\text{FEV}_{1.0}$). The apparatus was calibrated twice annually and checked in the field on each day of use. The tests were administered by either a registered nurse or a trained technician. The subjects did not wear nose clips. They were instructed to perform forced expiration two times. The mean of these two values was chosen to express the FVC and $\text{FEV}_{1.0}$ so long as results were within 5 % of each other. Additional tests were performed if the variation was wider than 5 %, according to the criteria of the American Thoracic Society (1); in such situations, analysis was based on the mean of the two highest values.

Table 1. Mean^a exposure to respirable crystalline silica ($\mu\text{g}/\text{m}^3$) by job category in a Pennsylvania foundry, 1977–1983.

Job category	1977			1980			1981–1982			1983		
	Number	Mean	Range	Number	Mean	Range	Number	Mean	Range	Number	Mean	Range
Sand preparation	1	74	.	—	.	.	—	.	.	1	61	.
Coremaking	3	1 045	500–1 516	4	112	44–461	9	40	23–77	5	55	< 36–318
Pouring	—	.	.	2	292	185–461	3	22	13–35	1	36	.
Knockout	—	.	.	—	.	.	2	27	22–33	1	49	.
Fettling	2	198	86–454	6	135	13–461	7	47	14–99	2	< 36	all < 36

^a All means are geometric mean values and refer to 8-h time-weighted exposures in personal (breathing zone) air samples.

Figure 1. Chest radiograph of case 9 in appendix 1, a 44-year-old male foundry worker with grade 3/2 profusion of small rounded (q/p) opacities in all lung fields and with superimposed grade C large pulmonary opacities of progressive massive fibrosis.

Statistical methods

To evaluate possible associations between silica exposure and either respiratory symptoms or radiographic findings, logistic regression was used. To assess the effects of silica exposure upon pulmonary function, multiple linear regression was used. Since pulmonary function is sensitive to smoking status, age, and height, these covariates were included in all the analyses of pulmonary function.

Results

Industrial hygiene results

Workers at this foundry have, in the recent past, been exposed to excessively high concentrations of respirable crystalline silica (table 1). In 1977 the geometric mean breathing-zone exposure was 1 045 (range 500–1 516) $\mu\text{g}/\text{m}^3$ for coremakers and 198 (range 86–454) $\mu\text{g}/\text{m}^3$ for fettlers.

Subsequent exposures were found to be generally lower (table 1). These decreases appear to have resulted

from improvements in plant ventilation and work practices. A very important change was the removal of silica flour (23) in 1982 and its replacement with a compound containing less than 1.5 % crystalline silica.

General medical results

We obtained medical and demographic data on 223 workers, all of whom were actively employed at the time of the evaluation. Participation in the medical evaluation was mandatory for hourly workers. However, the sample sizes for individual tests varied because the workforce was not constant and the examinations were administered at different times.

The average age of the workers evaluated was 35.1 (SD 12.6) years on 1 January 1983. The mean duration of employment was 8.6 (SD 7.5) years. Forty-nine workers (22 %) were currently employed in jobs with high exposure to silica, seven (3 %) had moderate exposure, and the remaining 167 (75 %) had low exposure. The mean age of these three groups was 38, 34, and 33 years, respectively, and the corresponding mean duration of employment was 13.3, 7.5, and 7.3 years.

A smoking history was available for 138 workers. Seventy-four (53 %) were current smokers, 30 (22 %) were exsmokers, and 34 (25 %) had never smoked. Fifty percent of the high-exposure group, 57 % of the moderate-exposure group, and 35 % of the low-exposure group were current smokers.

Radiographic results

Chest radiographs were available from 1980 for 153 workers; 134 were readable. Radiographs were available from 1977 for 120 workers; 118 were readable. Altogether, we obtained at least one readable radiograph for 188 (84.3 %) of the 223 workers.

Eighteen workers (9.6 %) had small rounded lesions in their lung fields consistent with a diagnosis of silicosis (appendix 1). Eight had category 1 profusion (grade 1/0 or greater), two had category 2, and eight had category 3. In addition one worker had 0/1 profusion. Four workers also had small, irregular opacities; no worker had irregular opacities alone. Two workers had large opacities (one category A, and one category C) typical of progressive massive fibrosis (PMF); both had underlying category 3 silicosis (figure

1). Two workers had evidence of inactive tuberculosis; neither had silicosis.

Sixty-four workers had readable radiographs obtained in both 1977 and 1980. When these films were examined side-by-side (18, 28), three workers with no detectable disease in 1977 were found to have developed category 1 profusion of small rounded lesions by 1980; two had been employed less than 10 years. Another worker with category 0/1 profusion in 1977 had advanced to category 1 in 1980. No worker with silicosis in 1977 had clear lung fields in 1980. No new cases of progressive massive fibrosis had developed.

The prevalence of silicosis increased from two cases (1.5 %) in 134 workers employed for less than 20 years to eight cases (53 %) in 15 workers employed for 20 or more years (table 2). All the workers with grade 2 or grade 3 silicosis or with progressive massive fibrosis had been employed for more than 20 years. The relationship between disease prevalence and duration of employment was highly significant (chi square = 19.50, $p < 0.001$) and remained so when the data were adjusted for age ($p = 0.0081$). The mean duration of employment for workers with silicosis was 24.9 (range 6 to 33) years. The youngest worker with silicosis was 37 years old, and the oldest was 67 years.

Nine cases of silicosis occurred in workers with current employment in high-exposure jobs (prevalence 18.4 %), one (14.3 % prevalence) in the moderate-exposure group, and three (1.8 % prevalence) in the low-exposure group. The highest prevalence rates were observed in stripping and knockout [two cases in six workers (33 %)] and in casting and pouring [four cases in 12 workers (33 %)].

The prevalence of silicosis was not influenced by cigarette smoking. Four (11.8 %) of 34 workers who had never smoked had small rounded pulmonary lesions; by comparison, three (10.0 %) of 30 exsmokers and five (6.8 %) of 74 current smokers had such lesions. There was no evidence of a dose-response relationship between cumulative cigarette consumption and the prevalence of silicosis (chi square = 0.87, $p = 0.352$) (table 3).

Respiratory questionnaire

One hundred and thirty-eight (61.8 %) of the 223 workers completed a respiratory questionnaire in either 1980 or 1982. Twenty-three (16.7 %) reported daily cough for more than three months, 14 (10.1 %) reported phlegm production, and three (2.2 %) reported shortness of breath. Seven workers (5.1 %) reported both chronic cough and phlegm production and thus fulfilled our definition of chronic bronchitis.

Workers with heavy current exposure to foundry dust had a higher age-adjusted prevalence of cough than workers with moderate or light exposure (table 4). Smokers also had higher age-adjusted prevalences of cough, phlegm production, and chronic bronchitis than nonsmokers (table 5). There appeared to be an

interaction between current dust exposure and current smoking status in the etiology of cough (figure 2).

Workers with silicosis had higher age-adjusted prevalences of cough and shortness of breath than workers without silicosis (table 6).

Pulmonary function

One hundred and thirty-eight (61.8 %) of the 223 workers underwent pulmonary function testing. FVC, adjusted for age and height, was not associated with current dust exposure ($p = 0.81$) or with years of employment at the foundry ($p = 0.71$). It was significantly reduced in current smokers as compared to that of nonsmokers ($p = 0.025$). However, an association of only borderline significance was evident between FVC and pack-years of cigarette consumption ($p = 0.1$).

Three (1.4 %) workers had evidence of restrictive impairment (defined as FVC less than 75 % predicted). One had category 3 silicosis with progressive massive fibrosis; the other two had no silicosis. There was only a weak association between prevalence of restriction and pack-years of cigarettes smoked ($p = 0.09$) and no association with duration of employment ($p = 0.93$).

Table 2. Prevalence of silicosis by duration of employment in a Pennsylvania foundry, 1980.^a

Duration of employment (years)	Number of workers	Workers with silicosis	
		Number	Percent
0-4	37	—	0
5-9	54	2	3.7
10-14	35	—	0
15-19	8	—	0
20-24	4	—	0
≥ 25	11	8	72.7
Incomplete data ^b	74	.	.
Total	223	10	.

^a Test for linear trend between prevalence (%) of silicosis and duration of employment: $\chi^2 = 19.50$, $p < 0.001$.

^b No readable radiographs were available for 33 of these workers, and for the remaining 41 no data were available on duration of employment.

Table 3. Prevalence of silicosis in a Pennsylvania foundry by pack-years^a of cigarettes smoked, 1980.^b

Pack-years	Number of workers	Workers with silicosis	
		Number	Percent
0	34	4	11.8
1-19	70	3	4.3
20-39	19	2	10.5
≤ 40	15	3	20.0
Incomplete data ^c	85	.	.
Total	223	12	.

^a Pack-years = average number of packs smoked per day × number of years smoked.

^b Test for linear trend between pack-years of cigarettes and prevalence (%) of silicosis: $\chi^2 = 0.87$; $p = 0.352$.

^c No readable radiographs were available for 33 of these workers, and for the remainder no data were available on smoking history.

Table 4. Prevalence of respiratory symptoms in a Pennsylvania foundry by current dust exposure,^a 1982.

Dust exposure	Number of workers	Cough		Phlegm		Chronic bronchitis		Shortness of breath	
		Number	Percent	Number	Percent	Number	Percent	Number	Percent
Light or moderate	95	12	12.6	8	8.4	4	4.2	2	2.1
Heavy	43	11	25.6*	6	14.0	3	7.0	1	2.3
Incomplete data ^b	85	.	.	.	.	.	.	.	.
Total	223	.	.	.	.	.	.	.	.

^a Dust exposure defined by current job title.^b Respiratory questionnaire data were not available for 85 workers.* $p < 0.05$.**Table 5.** Prevalence of respiratory symptoms in a Pennsylvania foundry by smoking status of the workers, 1982.

Smoking status	Number of workers	Cough		Phlegm		Chronic bronchitis		Shortness of breath	
		Number	Percent	Number	Percent	Number	Percent	Number	Percent
Never smoked	34	1	2.9	—	0.0	—	0.0	—	0.0
Exsmokers	30	3	10.0	—	0.0	—	0.0	1	3.3
Current smokers	74	19	25.7*	14	18.9*	7	9.5*	2	2.7
Incomplete data ^a	85	.	.	.	.	.	.	.	.
Total	223	.	.	.	.	.	.	.	.

^a Respiratory questionnaire data were not available for 85 workers.* Statistically significant difference ($p < 0.05$) between current smokers and ex- and nonsmokers combined.**Table 6.** Prevalence of respiratory symptoms in a Pennsylvania foundry by presence of silicosis, 1982.

Silicosis	Number of workers	Cough		Phlegm		Chronic bronchitis		Shortness of breath	
		Number	Percent	Number	Percent	Number	Percent	Number	Percent
Absent	126	20	15.7	13	10.2	6	4.7	2	1.6
Present	12	3	25.0*	1	8.3	1	8.3	1	8.3
Incomplete data ^a	85	.	.	.	.	.	.	.	.
Total	223	.	.	.	.	.	.	.	.

^a Respiratory questionnaire data were not available for 85 workers.* $p = 0.08$. **Figure 2.** Effect of silica exposure and current smoking on the prevalence of cough in a Pennsylvania foundry, 1982.

The $FEV_{1.0}$, adjusted for age and height, was associated only weakly with current dust exposure ($p = 0.09$) and not associated with duration of employment ($p = 0.94$). $FEV_{1.0}$ was, however, significantly

reduced in current smokers as compared to that of nonsmokers ($p = 0.0073$), and a significant negative association was found with cumulative cigarette consumption ($p = 0.011$).

Thirteen (9.4 %) workers had evidence of outflow obstruction (defined as an $FEV_{1.0}$:FVC ratio less than 70 % predicted). All 13 were smokers, and a strong association was evident between cumulative smoking history and prevalence of obstruction ($p=0.0007$). No association was apparent between duration of employment and prevalence of obstruction ($p=0.57$).

The annual rate of decline in $FEV_{1.0}$ was examined for 83 workers who participated in both rounds of testing. The mean annual decrement was 78 (SD 153) ml. No association was evident between current level of silica exposure and annual rate of decline.

No associations were found between the presence of silicosis (adjusted for age, height, and smoking status) and either FVC ($p=0.34$) or $FEV_{1.0}$ ($p=0.32$). Furthermore, no association was evident between category of silicosis and degree of functional impairment.

Discussion

The principal finding in this study was that 18 (9.6 %) of 188 workers evaluated in 1977 and 1980 at a foundry in Pennsylvania had radiographic evidence of chronic silicosis. Two also had progressive massive fibrosis. The disease was the most common in workers with the heaviest and longest exposure to silica. These findings are consistent with previous reports of a strongly positive dose-response relation between cumulative exposure to silica and the prevalence and severity of silicosis (4, 11, 19, 26, 34).

The second major finding was that cigarette smoking had no influence on the development of the small, rounded pulmonary opacities of silicosis. A similar lack of association has been reported for sandblasters (12) and granite cutters (34), although for the granite cutters an association was noted between cigarette smoking and the development of irregular opacities (34). Studies of workers exposed to asbestos (8, 29) and to coal dust (16) have also found no association between cigarette smoking and the development of pneumoconiotic lesions.

Past exposures to silica at this foundry have been intense. As recently as 1977, coremakers were exposed to silica in a concentration 30 times the limit value of $50 \mu\text{g}/\text{m}^3$ recommended by NIOSH (21), and fettlers were exposed to nine times that concentration. The finding of new cases of silicosis in this workforce, as recently as 1980, is consistent with the observation that major exposures have only recently been brought under control. A very significant improvement was the replacement in 1982 of silica flour with a parting compound of much lower silica content. Because of its small particle size and high silica content, silica flour is extremely toxic (3, 23, 26). Relatively safe substitutes for silica flour have, however, been known and used in the foundry industry for many years.

The respiratory symptoms of silicosis are cough in the early phases (9, 17, 26, 38) and shortness of breath

later (9, 11, 26). In the present study cough was found to be more common in silicotics than in workers without disease. Cough was also more common in workers with heavy current dust exposure than in those with lighter exposure. There appeared to be a multiplicative interaction between current dust exposure and cigarette smoking in the etiology of cough; this finding is consistent with data from the Finnish foundry study (17). Shortness of breath, in the study by Flinn et al (11) of American hard rock miners, was found to be very strongly associated with silica exposure and silicosis. In the present study, although the number of workers with dyspnea was small, a positive relationship was evident between shortness of breath and silicosis.

In the pulmonary function testing, the most obvious effect was that due to smoking. Neither current dust exposure, as defined by job category, nor duration of employment in the foundry nor radiographic evidence of silicosis was associated with reduction in either $FEV_{1.0}$ or FVC. The Finnish foundry study (17), using a cross-sectional design, also found no decrements in either $FEV_{1.0}$ or in FVC in relation to silica exposure; the authors suggested that selective removal of workers with functional impairment from dusty jobs might have accounted for their negative findings (17). Silica exposures in the Finnish foundries (32) appear to have been comparable to those encountered in our study. On the other hand, a study of workers exposed to silica in the Vermont granite sheds (34) found the prevalence of diminished FVC to increase among workers heavily exposed to silica; the long follow-up and the high cumulative exposure of that workforce may have enhanced the detection of that effect.

Although silicosis is a preventable disease and had been targeted for eradication by the US Public Health Service (37), the findings of the present study appear to be neither isolated nor unusual. They are consistent with other recent reports of silicosis in the United States (3, 5, 6, 12, 39). An estimated 1.2 million American workers are potentially exposed to silica, 260 000 of them in foundries (21). Industrial hygiene surveys conducted from 1976 to 1981 in 205 American foundries showed that silica levels above the NIOSH recommended limit of $50 \mu\text{g}/\text{m}^3$ were present in 1 012 (58.1 %) of 1 743 air samples (25). In 1980 the US Department of Labor estimated that 59 000 of workers exposed to silica would ultimately develop silicosis (36). This information suggests that silicosis is not merely a disease of the past, but that instead it exists widely today among American workers.

A major impediment to the prevention of silicosis in the United States is the lack of accurate information on the incidence and prevalence of the disease (8). In the absence of such data, it is not possible to determine whether the number of cases is increasing or declining, whether there is geographic variation or variation by industrial sector, or whether control strategies are effective. To remedy this situation, the Conference of

State and Territorial Epidemiologists and NIOSH have resolved recently that silicosis be declared a reportable disease. That resolution implements a recommendation made by the US Public Health Service in 1955 (35). Silicosis will become the first noninfectious occupational disease to be reportable in the United States.

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Appendix

Clinical and radiographic features of workers with silicosis in a Pennsylvania foundry, 1982

Case number	Age (years)	Years employed	Radiographic features ^a			Clinical features ^b			Forced vital capacity (% predicted)
			Small opacities		Large opacities	Cough	Phlegm	Dyspnea	
			Shape/size	Profusion					
1	62	38	q/q	1/1	0	—	—	—	99
2	..	..	q/r	3/2	0	—	—	—	..
3	45	6	q/q	1/0	0	—	—	—	117
4	55	33	q/r	2/3	0	+	+	—	108
5	52	27	q/r	3/2	0	—	—	—	102
6	64	28	q/r	3/2	A	—	—	—	96
7	46	24	r/r	1/0	0	—	—	—	106
8	53	25	q/q	3/3	0	—	—	—	119
9	44	..	q/u	3/2	C	+	—	+	73
10	..	..	p/s	1/2	0	—	—	—	..
11	67	..	q/u	1/1	0	—	—	—	117
12	..	..	r/u	1/1	0	—	—	—	..
13	..	..	q/q	1/2	0	—	—	—	..
14	64	..	q/q	3/2	0	—	—	—	84
15	53	31	q/q	3/2	0	—	—	—	84
16	45	25	q/r	3/2	0	+	—	+	94
17	48	30	q/q	2/3	0	—	—	—	105
18	37	7	q/q	1/1	0	—	—	—	100

^a Radiographic features are classified according to the 1980 classification of the International Labour Office (ILO).

^b + = symptom present, — = symptom not present.