

Potential years of life lost and work tenure lost when silicosis is compared with other pneumoconioses

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Potential years of life lost (PYLL) and potential years of work lost (PYWL) because of pneumoconiosis were studied using the data from the Nationwide Epidemiological Study on Pneumoconioses in China. The cases were patients diagnosed with pneumoconiosis between 1949 and 1986. The subjects studied for PYLL included 74 741 cases ranging in age from 15 to 75 years, while for PYWL there were 74 224 cases with 1 to 35 years of remaining employment experience. Overall there were 1 489 692 potential years of life lost, and there was an average of 19.9 years for all pneumoconioses. Silicosis had the greatest mean PYLL with an average of 22.1 years. Coal workers' pneumoconiosis was the second leading cause of PYLL with an average of 17.0 years. The mean PYWL for all pneumoconioses was 19.7 years, and the mean PYWL from silicosis was 21.5 years. The conclusion was reached that silicosis is the most serious pneumoconiosis in China with regard to years of life lost, and chronic respiratory diseases such as chronic pulmonary disease and tuberculosis are the main causes of death for patients with pneumoconiosis.

Key terms China, cohort follow-up, potential years of life lost, potential years of work lost, pneumoconioses, silicosis.

Pneumoconiosis is one of the most serious occupational diseases in China. Every year since 1980 there have been about 20 000 workers diagnosed and more than 5000 workers have died annually from pneumoconioses throughout the country. It is a great economic loss, producing a severe toll on workers' health and productive capacity. Many mortality studies of pneumoconiosis have been carried out using different methods, but none have been done using the potential years of life lost (PYLL) and potential years of work tenure lost (PYWL) approach. The objective of this study was to apply PYLL and PYWL and to evaluate the impact of pneumoconioses on the workers who suffer from them.

The concept of PYLL was based on the following hypothesis: the average life-span of a healthy worker is expected to be 75 years. As an example, if a worker dies at 50 years of age, he or she is considered to have lost 25 years of life, or PYLL of 25 years. PYWL is derived from PYLL, with the hypothesis that a healthy worker would be able to work for at least 35 years (1, 2).

Subjects and methods

The information used in the study was drawn from a data base created for the Nationwide Epidemiological Study of 393 797 pneumoconiosis patients in China in 1986 (3). The cases were 79 636 pneumoconiosis patients who died from 1949 to 1986. Of this group, 74 741 cases with various pneumoconioses were selected as the subjects to be studied for PYLL. All of them died between 15 and 75 years of age. There were 74 224 cases with various pneumoconioses who died with a residual work tenure of 1 to 35 years and were subjects for calculating the PYWL.

A reference group of 141 484 cases with pneumoconioses was selected to standardize the constitution of work tenure. We developed a "measurement index" of PYWL (abbreviated IPYWL) based on the principle of proportionate mortality ratio using an indirect method of age standardization.

The formulas for calculating PYLL and PYWL are as follows:

$$PYLL = \sum_{i=15}^{75} N_{ai} Y_{ai} = \sum_{i=15}^{75} N_{ai} (75 - M_{ai}),$$

$$\text{mean PYLL} = \frac{\sum PYLL}{\sum N_{ai}},$$

$$PYWL = \sum_{i=1}^{35} N_{bi} Y_{bi} = \sum_{i=1}^{35} N_{bi} (35 - M_{bi}),$$

$$\text{mean PYWL} = \frac{\sum PYWL}{\sum N_{bi}},$$

$$IPYWL = \frac{\sum PYWL}{\sum Ex.} = \frac{\sum PYWL}{\sum (\sum N_{bi}) W_i Y_{bi}}.$$

The 95% confidence interval could be estimated as follows:

$$IPYWL \pm 1.96SE = IPYWL \pm 1.96 \sqrt{IPYWL / \sum Ex.},$$

where, N_{ai} = number of deaths in age i group, Y_{ai} = remaining years to live in age i group, N_{bi} = number of deaths in i years group of employment, Y_{bi} = remaining years to work in i years group of employment, M_{ai} = midvalue of age i group of death, M_{bi} = midvalue of employed work tenure group, Ex = expected PYWL, W_i = the standard proportion calculated by numbers of death in i year

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group of employment divided by all workers with 1–35 years of employment.

Results

The total PYLL was 1 489 692 years and the mean PYLL was 19.9 years for deaths from all pneumoconioses. Silicosis had a mean PYLL of 22.1 years and coal workers' pneumoconiosis

Table 1. Potential years of life lost (PYLL) by type of pneumoconiosis in China, 1949 to 1986.

Type of pneumoconiosis	Deaths (N)	PYLL	Mean PYLL
Silicosis	44 108	976 244	22.1
Coal workers' pneumoconiosis	26 356	447 480	17.0
Asbestosis	557	8 542	15.3
Cement worker's pneumoconiosis	408	6 035	14.8
Pottery worker's pneumoconiosis	1 439	21 758	15.1
Foundry worker's pneumoconiosis	1 873	29 633	15.8
Total	74 741	1 489 692	19.9

ranked second with a mean PYLL of 17.0 years (table 1). Thus, on the average, the persons with pneumoconioses died at 55 years of age and those with silicosis died at 53 years of age.

Table 2 shows the mean PYLL for various causes of death among persons with silicosis, asbestosis, and coal workers' pneumoconiosis. For those with silicosis, the leading causes of death included pneumothorax (PYLL = 26.6), pulmonary tuberculosis (PYLL = 24.5), and emphysema (PYLL = 24.2). For asbestosis patients the leading causes of death were emphysema (PYLL = 30.0), pulmonary tuberculosis (PYLL = 18.5), and liver cancer (PYLL = 16.5). The leading causes of death for patients with coal workers' pneumoconiosis included emphysema (PYLL = 19.5), cancer of the lung (PYLL = 19.0), and tuberculosis (PYLL = 18.9). Age-specific mortality showed the maximum PYLL for silicosis at 45 years; for CWP and asbestosis the peak was 50 years of age (figures not shown).

Table 3 describes the PYWL, the mean PYWL, and the IPYWL (and the 95% confidence intervals) for different pneumoconioses. The total PYWL for all pneumoconioses was 1 458 436 years, and the mean PYWL was 19.7 years. The mean PYWL was 21.5 for silicosis and 19.8 years for asbestosis; the IPYWL for silicosis and asbestosis was 1.1525 and 1.0649, respectively, both being significantly elevated. Figure 1 illustrates the distribution of PYWL by six types of pneumoconioses. It shows that the highest

Table 2. Potential years of life lost (PYLL) by the causes of death for different types of pneumoconiosis.

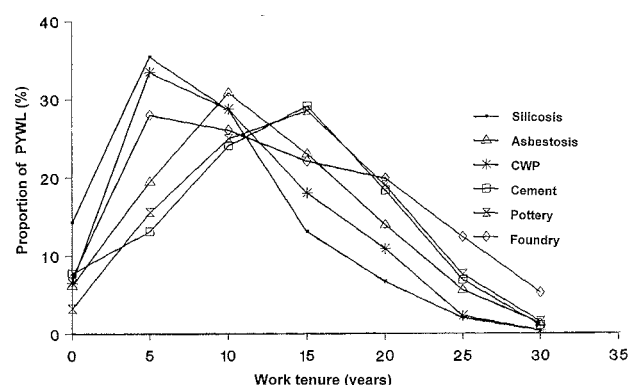
Cause	Silicosis			Asbestosis			Coal workers' pneumoconiosis		
	N	PYLL	Mean PYLL	N	PYLL	Mean PYLL	N	PYLL	Mean PYLL
All causes	41 738	913 651	21.9	466	6 659	14.3	20 785	347 880	15.1
Pulmonary tuberculosis	15 300	374 455	24.5	78	1 440	18.5	4 832	91 495	18.9
All cancers	3 593	65 443	18.2	129	1 843	14.3	2 948	48 268	16.3
Esophagus	444	7 495	16.9	12	145	12.1	622	9 325	16.4
Stomach	129	2 383	18.5	7	78	11.1	84	1 388	16.0
Liver	726	15 085	20.8	19	313	16.5	586	11 155	15.5
Lung	1 758	30 860	17.6	79	1 158	14.7	1 130	18 000	19.0
Circulatory diseases	7 117	141 022	19.8	148	1 980	13.4	6 335	96 218	15.9
Hypertension	558	8 515	15.3	16	200	12.5	504	6 705	15.2
Hypertensive heart diseases	324	4 915	15.2	11	138	12.5	274	3 875	13.3
Arterial heart disease	303	5 568	18.4	16	245	15.3	275	4 448	14.1
Cor pulmonale	5 932	122 025	20.6	105	1 398	13.3	5 282	81 190	16.2
Respiratory disease	19 321	332 728	17.2	91	1 393	15.3	6 670	111 900	15.4
Pneumonia	844	18 485	21.9	17	243	14.3	412	6 690	16.8
Asthma	366	7 610	20.8	—	—	—	379	6 203	16.2
Pneumoconioses	15 029	232 208	15.5	66	1 010	15.3	5 138	86 300	16.4
Pneumothorax	1 036	27 600	26.6	—	—	—	322	6 280	16.8
Emphysema	1 599	38 648	24.2	2	60	30.0	66	1 115	19.5
Others	447	8 178	18.3	6	80	13.3	353	5 313	16.9

Table 3. Potential years of worklife lost (PYWL) for different types of pneumoconiosis in China. (IPYWL = measurement index for PYWL, 95% CI = 95% confidence interval)

Type of pneumoconiosis	Number	PYWL	Mean PYWL	Expected PYWL	IPYWL	95% CI
All pneumoconioses	74 224	1 458 436	19.7	—	—	—
Silicosis	43 720	938 185	21.5	814 066	1.1525	1.1501–1.1548
Coal workers' pneumoconiosis	25 168	423 088	16.8	468 628	0.9028	0.9001–0.9055
Asbestosis	610	12 095	19.8	11 358	1.0649	1.0459–1.0839
Cement pneumoconiosis	421	6 753	16.0	7 839	0.8614	0.8409–0.8819
Pottery pneumoconiosis	1 277	19 553	15.3	23 778	0.8223	0.8108–0.8338
Foundry pneumoconiosis	1 801	31 323	17.4	33 534	0.9340	0.9237–0.9444

Table 4. Potential years of work lost (PYWL) for the different stages of pneumoconiosis. (IPYWL = measurement index for PYWL, 95% CI = 95% confidence interval)

Stage	Deaths (N)	PYWL	Mean PYWL	Expected PYWL	IPYWL	95% CI
I	29 449	530 218	18.0	54 834	0.9670	0.9696—0.9644
II	27 544	554 036	20.1	51 286	1.0803	1.0831—1.0774
III	17 231	374 183	21.7	320 841	1.1663	1.1700—1.1625
Total	74 224	1 458 436	19.7	1 382 051		

**Figure 1.** Proportion of potential years of life lost (PYWL) by type of pneumoconiosis. (CWP = coal workers' pneumoconiosis)

proportion of PYWL was found within five years of work tenure for silicosis, coal workers' pneumoconiosis, and foundry workers' pneumoconiosis and was at 10 years of work tenure for asbestosis and at 15 years for pottery and cement workers' pneumoconiosis.

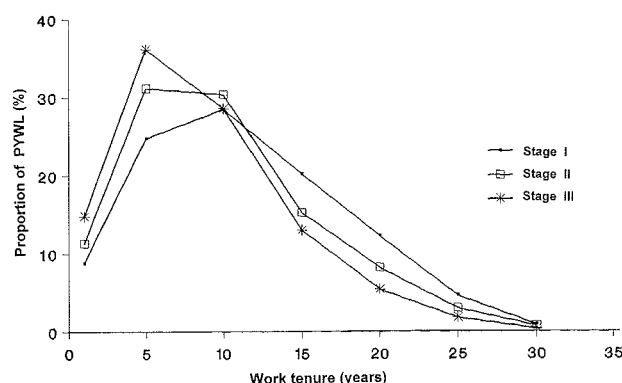
Table 4 indicates the status of work tenure lost in different stages of pneumoconiosis. The mean PYWL for stages I, II, and III were 18.0, 20.1, and 21.7 years, respectively. The proportional IPYWL was 0.9670, 1.0803, and 1.1663, respectively, and the latter two indices were statistically significant. Figure 2 shows that the highest proportion of PYWL for stages II and III was at 5 years of work tenure; for stage I it was 10 years.

The mean PYWL values were compared by different causes of death from all pneumoconiosis, and the results were similar to that in table 2, but are not shown. Specifically, the greatest risk for the mean PYWL included pneumothorax, pulmonary tuberculosis, and emphysema. Furthermore the proportional IPYWL values for pneumothorax, tuberculosis, and emphysema were significantly elevated.

Discussion

From 1949 to 1986 there were 79 636 deaths among 393 797 patients with pneumoconiosis in China. In this study, there were 74 741 subjects for the PYLL analysis (ie, 93.8%) between the ages of 15 and 75 years and 74 224 cases (ie, 93.2%) with 1–35 years of work tenure for PYWL. Therefore, the studied subjects were clearly representative of the total pneumoconiotic patient population in China.

PYLL is a function of mean age at death (4). It is based on the concept that a healthy person will live for 75 years. Subjects not reaching this age, and who die from causes of interest (cancers and respiratory diseases), would be considered as having years of life lost. The life lost corresponds to the extent of hazard from special causes of death. Therefore, studying special causes would

**Figure 2.** Proportion of potential years of life lost (PYWL) for different stages of pneumoconiosis.

help to define and prevent the main causes of premature death in this cohort.

The mean PYLL of all pneumoconiosis was 19.7 years, but the mean PYLL of silicosis was 22.1 years and was more than that for all pneumoconiosis. Thus silicosis could be considered the most serious pneumoconiosis, having caused more years of life lost than other occupational lung diseases. The greatest proportion of PYLL for silicosis was at 45 years of age, while it was at 50 years of age for asbestosis and coal workers' pneumoconiosis. Therefore, silicosis during these years was more dangerous to workers at younger ages than the other pneumoconiosis were.

The mean PYLL was the greatest for emphysema, pneumothorax (except among those with asbestosis), and pulmonary tuberculosis among the workers with silicosis, asbestosis and coal workers' pneumoconiosis. Those with coal workers' pneumoconiosis had an elevated risk of PYLL for lung cancer as well. Therefore, chronic respiratory diseases such as chronic lung diseases and pulmonary tuberculosis caused more years of life lost and were the main causes of premature death among patients with pneumoconiosis.

The total PYWL was 1 458 436 years, of which 938 185 years (64.3%) were due to silicosis and 423 088 years (29.0%) to coal workers' pneumoconiosis. From these data it is clear that silicosis and coal workers' pneumoconiosis were the leading pneumoconiosis in China from 1949 to 1968 and caused the greatest loss of work tenure. In a comparison of the mean PYWL between different pneumoconiosis, it was found that the mean PYWL of silicosis and asbestosis was 21.5 and 19.8 years, respectively. There is a legal stipulation in China that a worker should stop working when he or she is diagnosed with pneumoconiosis. Our results suggest that the average length of dust exposure was only 15.3 years for the workers before they were diagnosed with pneumoconiosis and lost 19.7 years of employment. Silicosis and asbestosis were the

leading causes of work tenure lost for all pneumoconioses, and this finding was confirmed by the elevated proportional IPYWL for silicosis and asbestosis as well. The highest proportion of PYWL was in the five-year interval of work tenure for both silicosis and asbestosis.

In a comparison of the different stages of pneumoconiosis, the mean PYWL for stage II or stage III of pneumoconioses was significantly more than that of stage I and that of all pneumoconioses. The result shows that stage II and III caused greater loss of work years than stage I. Since work tenure is defined from the date of first employment to the date of pneumoconiosis diagnosis, regardless of stage the patients having developed stage II or III had a shorter duration and a higher intensity of dust exposure.

It was seen from the mean PYWL that pneumoconiosis complicated by chronic respiratory diseases and pulmonary tuberculosis were the leading causes of death from 1949 to 1986. Although work environments may not have changed much, we believe the risk has declined over the last 30 years, and the rate of pneumoconiosis needs to be examined by decade-specific comparisons. In order to measure that change, field investigations are necessary to monitor silica dust levels and to reduce the risk of pneumoconiosis.

Concluding remarks

Silicosis is the most serious type of pneumoconiosis in China. The leading causes of death among patients with pneumoconioses are emphysema, pneumothorax, and pulmonary tuberculosis. Controlling silica and other workplace dust exposures will prevent pneumoconiosis, including complications such as chronic lung disease and tuberculosis. Pneumoconiosis stages II and III represent significantly higher mortality risks, as measured by the PYWL, than stage I does. The PYLL and PYWL can be used as indices to evaluate the risks of occupational exposures to workers.

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