Review

Railways and Asbestos in Japan (1928–1987)—Epidemiology of Pleural Plaques, Malignancies and Pneumoconioses—

Yutaka Hosoda1, Youmei Hiraga2 and Sumiko Sasagawa3

1Formerly Japan National Railways Central Health Institute, 2Sapporo Hospital, Hokkaido Railway Co. and 3Institute for Environmental Sciences, Japan

Abstract: Railways and Asbestos in Japan (1928–1987)—Epidemiology of Pleural Plaques, Malignancies and Pneumoconioses—Yutaka Hosoda, et al. Formerly Japan National Railways Central Health Institute—Asbestos has been an indispensable insulating material for railway industries, especially steam locomotives (SLs). This review (1928–1987) consists of three parts. 1) Pleural plaques: Since the 1970s, pleural plaques have been regarded as evidence of past asbestos inhalation, and more recently recognized as a risk factor of asbestos-related malignancies. For diagnostic criteria on plain radiographs, the modified ILO 1980 International Classification of Radiographs of Pneumoconioses was used. Most cases had pleural plaques with normal lungs. Large plant workers showed a significantly higher rate of plaques than workers in smaller plants. Bilateral plaques were dominant followed by the left, then the right lung, and chest wall plaques were dominant over the diaphragm. The manifestation of pleural plaques was more correlated to years since the onset of the asbestos exposure than the sum of asbestos work years, although the result was not significant. The boilermen of railway ferry steamers had a significantly higher plaque rate than other seamen. CT studies on plaques started in 1978. 2) Asbestos-related malignancies: Five retrospective cohort studies 1960–1970 were made on primary lung cancer incidence and mortality among 350,000 active railway men with smoking information. The follow-up period was 20 yr at the longest. Almost all plant workers showed a tendency of higher incidence or mortality than the controls. Two cases of mesothelioma were reported in 1980. 3) Pneumoconioses: Most studies (1928–1975) had relatively low prevalence rates among SL-related workers.

Key words: Asbestos, Railways, Workers, Pleural plaques, Epidemiology, Lung cancer, Mesothelioma, Pneumoconioses

Purpose of the review

In Japan train services started in 1872. The government was in charge of almost all railways until 1987 when the Japanese National Railways (JNR) was privatized. For many years, asbestos was universally used for heat and electric insulation, and anti-friction. The words "no asbestos, no vehicles" mirror the reality of the railway industry.

The purpose of the present article is to review epidemiological studies on asbestos-related abnormalities reported by railway physicians. In 1928, two railway physicians, Suzuki and Noda1, 2) reported the first case of asbestosis discovered through an X-ray survey at a railway plant in Japan.

Chronology of asbestos-related diseases

Asbestos has two different biological effects: fibrogenicity and oncogenicity. The efforts of the ILO (International Labour Office), WHO (World Health Organization) and many other organizations have been successful in decreasing occupational asbestos exposure3–15), resulting in improvement of asbestos work circumstances16–18) . Consequently, lung fibrosis has decreased19, 20) and patients are living longer. New reports appeared on primary lung cancer (1955)21), pleural mesothelioma (1960)22), and pleural plaques in the 1970s23). It is noted that railway plant workers were exposed to various carcinogenic dusts other than asbestos in their workplaces.

The IARC (International Agency for Research on Cancer, Lyon) cautiously evaluated asbestos as a group 1 carcinogen (definite) in 1987, though it belonged to group 2 (suspect) in the 1973 and 1977 versions24). Another carcinogenic material prevalent in industry is
crystalline silica\textsuperscript{25–27}). It was evaluated by the IARC as a group 1 carcinogen, as far as occupational exposure was concerned.

\textit{Steam locomotives and asbestos (Fig. 1)}

In the railway industry, asbestos exposure occurred in train repair plants, especially during the dismantling of steam locomotives (SLs). Though many amateurs still love SL’s magnificent features, beneath the outer black iron cylinders lies the asbestos lagging wrapping the boiler\textsuperscript{28}. Lagging at JNR consisted of amosite textile bags stuffed with amosite fibers. These asbestos materials were gradually replaced by man-made mineral fibers, such as long fiber glass bags and rock wool stuff\textsuperscript{29}. Lagging at the South African Rhodesian Railways\textsuperscript{30} was made of crocidolite and that at a US railroad\textsuperscript{31} was made of both amosite and chrysotile.

From 1945 and during the 1950s, about 6,000 JNR...
SLs were in active service. During SL dismantlement, workers had asbestos exposure. From the work system, asbestos exposure was not full-time, but intermittent. Since the enactment of the Japanese Ordinance on Prevention of Hazards due to Specified Chemical Substances in 1971, work environments have further been improved. The dismantlement of JNR SLs terminated in the late 1960s, as they were replaced by Diesel and electrical locomotives.

In the health surveillance system of JNR employees, there were about 40 railway hospitals together with many local clinics, in which a total of about 160 full-time industrial physicians were stationed. Almost all workers were employed immediately after leaving high school (primary school in the past), and they worked until the retirement age. About 98% of the employees complied with annual health check-ups and the health records of all 400,000 employees (97% males) were computerized by 1976.

**Pleural Plaques**

*Diagnostic criteria on plain radiographs*

It is difficult to distinguish pleural plaques on plain chest radiographs from the mimicking shadows, such as rib-companion shadows, M obliques externus abdominis, M serratus anterior, and extra-pleural fat. The JNR Study Team used the ILO International Classification 1980 version of Radiographs of Pneumoconioses which instructs to descriptively record the circumscribed pleural thickening (pleural plaques) by the location, side (right or left), and size (width and length). As the ILO 1980 version did not define the minimum width of in-profile (lateral chest wall) plaques, the JNR Study Team defined chest wall in-profile plaques to be 3 mm or more in width, based on several case-control studies. In the Pennsylvania Railroad studies, Oliver defined 2 mm or more width of the lateral chest wall thickening as positive findings, though Sepulveda reported the prevalence of pleural plaques as 2 and 20%, respectively, in Pennsylvanian railroad workers. According to job category, 33% were boilermakers and 30% were machinists. Some workers had prior job histories of exposure to coal and silica together with asbestos.

**Plain radiographic morphology of pleural plaques (Fig. 2)**

Kikuchi et al. reported that among 70 cases of chest wall pleural plaques (in-profile + face-on) 68.6% were found on both sides of the lung, 25.7% on the left and 5.7% on the right and that among 40 cases with diaphragmatic pleural plaques, 22.5% were found on both sides, 60% on the left and 17.5% on the right. Of the 22 calcified cases, calcification was found in 32 sites, and among these 32 sites 26 sites were located on the diaphragm (13 on the left and 13 on the right), 3 sites on cardiac margins, and 3 sites on the chest wall.

**Growth of calcified pleural plaques (Fig. 3)**

Hosoda and Saitou revealed the progress of pleural plaques as shown in Fig. 3. Hiraga also observed the growth of pleural plaques at the two points of time, 1970 and 1990. Normal diaphragm with short linear calcifications increased from 3 to 21 cases, irregular diaphragm with calcified dots from one to 11 cases, and irregular diaphragm with linear calcification from null to 8 cases. The latent period since the onset of exposure was 21 to 40 yr.

**A surrogate of exposure**

Hosoda et al. examined miniature X-rays of 4,150
workers over the age of 50 yr in 10 SL plants in 1983. Observations were made by dividing workers into two groups: those working in large plants where the annual number of SL dismantlements exceeded 100 or more, and those working in small plants where annual dismantlements were below 99. The prevalence rate of pleural plaques ranged from 2.1% to 16.8%. The average rate in large plants (number of workers=2,126) was 15.5%, while that in small plants (n=2,024) was 4.9% (difference \( p < 0.001 \)). These results suggest that SL-related works were a main source of asbestos exposure, especially in the SL golden era from 1945 and during the 1950s. Furthermore, the results suggest that the prevalence rate of pleural plaques is an important surrogate of asbestos exposure dose.

**Latency of pleural plaque manifestation (Table 1)**

Hiraga\(^44\) observed 96 asbestos workers over the age of 40 in relation to pleural changes and the sum of asbestos work years (work years, non-asbestos work years were excluded) or years since the onset of exposure (onset year). According to work years, pleural plaques, and calcification were found among those who had worked for as little as 1–4 yr. While, according to onset year, no X-ray abnormalities were found at less than 15 yr. Table 1 shows the correlation coefficients between pleural changes and work years and onset year. Both correlation coefficients between calcified pleural plaques and onset year (0.985) and work years (0.740) were significant (\( p < 0.05 \)). While, the correlation coefficient between non-calcified plaques and onset year and work years was 0.284 and –0.511, respectively, neither of which were significant. These data suggest that onset year might be a more important factor than work years in occurrence of calcified pleural plaques.

Oliver's data\(^39\) showed 20–28 yr latency since hire. Oliver's and Hiraga’s data reported a significant association with years since hire and the onset of exposure, respectively. These data suggest that there are dose and time (since the onset of exposure) relationships in pleural plaques, while Mosret of the Rhodesia Railways\(^30\) and others\(^39, 40\) described that there is a possible dose/time relationship in the manifestation of cases of mesothelioma.

**Pioneering CT studies**

The JNR study team commenced a pioneering CT study in 1978 using the second generation EMI scanner CT 5005, which took 20 s to perform a single CT slice\(^49\). First, the study team began experimental CT studies using pieces of animal muscle and fat on a phantom, and found this EMI scanner CT 5005 could distinguish between plaques and fat. Then, the team took CTs of 26 workers with pleural plaque-like shadows on plain radiographs\(^47, 48, 51\). Ten of

---

**Fig. 2. Location and side of pleural plaques on chest X-rays based on the ILO 1980 Classification\(^46, 47\).**

<table>
<thead>
<tr>
<th>Location</th>
<th>Bilateral</th>
<th>Right</th>
<th>Left</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest wall</td>
<td>68.6%</td>
<td>5.7%</td>
<td>25.7%</td>
</tr>
<tr>
<td>Diaphragm</td>
<td>22.5%</td>
<td>17.5%</td>
<td>60.0%</td>
</tr>
<tr>
<td>Calcified</td>
<td>32 sites in 22 cases</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

: Non-calcified plaques
- Calcified plaques
14 asbestos-exposed workers showed muscle density, 3 fat density, and one was normal. While of the 12 non-exposed obese workers (10%+ more than the standard body weight), 9 showed fat density and 3 were normal. Kikuchi et al. CT-examined 50 plant workers with over 15 yr since onset of asbestos exposure. Thirty percent of all pleural plaque shadows were located in the para-vertebral region. Using the pioneering EMI CT apparatus, Katz et al. compared pleural plaques on plain radiographs and on CT images. Of 36 asbestos-exposed cases, 66% had pleural abnormalities on plain radiographs and 75% on CT images. Hiraga reported 88.6% CT-positive out of

![Fig. 3. Development of pleural plaques in 2 cases from a single plant.](image)

**Table 1.** Correlation of lung and pleural plaque findings to years since first exposure to asbestos and sum of asbestos work years.

<table>
<thead>
<tr>
<th>Findings</th>
<th>Workers (n)</th>
<th>Correlation coefficient</th>
<th>Correlation coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Years since first exposure</td>
<td>Sum of asbestos work years</td>
</tr>
<tr>
<td>Lung</td>
<td>15</td>
<td>0.239</td>
<td>0.114</td>
</tr>
<tr>
<td>Plaques non-calcified</td>
<td>59</td>
<td>0.284</td>
<td>-0.511</td>
</tr>
<tr>
<td>Plaques calcified</td>
<td>22</td>
<td>0.905*</td>
<td>0.740*</td>
</tr>
</tbody>
</table>

*p<0.05. Analyzed by Mizuno S based on Hiraga’s Table.*
36 plaque cases on plain radiographs and 50% CT-positive out of 14 plaque cases on plain radiographs. The differences in these data may have resulted from plaque diagnostic criteria, selection bias, too small number of examinees, and the CT apparatus used, etc.

Pleural plaques in railway ferry workers (Fig. 4)

It is well known that steam ships were equipped with asbestos insulating materials before the 1970s. Ushio\(^53\) reported that about 20% had pneumoconioses (profusion-1) among 90 engine room workers in 1931, but the details were not described. In 1978, Hosoda and Hiraga\(^54,55\) examined 287 crew members over the age of 50 of the railway ferry steamers which navigated between Aomori (the main island of Japan) and Hakodate (Hokkaido Island). The prevalence rates of pleural plaques were 10% among 90 engine room seamen, and 1.5% among 197 seamen in other jobs \(p<0.05\). Those with plaques had an average of 35 yr job history.

Cohort Studies on Primary Lung Cancer and Pleural Plaques

Incidence and mortality studies

Five retrospective cohort studies were carried out. Study 1 is an incidence cohort study of all 350,000 workers of JNR. Relative risk was estimated using inner controls. Studies 2, 3, and 4 are mortality studies of the sub-cohorts of all JNR employees. Risk was estimated by O/E (ratio of observed versus expected). Study 5 was focused on the effect of pleural plaques on prognosis quaod vitam and the chi-square test was applied to the null hypothesis test.

1 Incidence study of the cohort of all JNR employees or workers

Hosoda et al.\(^56\) made a cohort study of lung cancer incidence using all 355,145 JNR employees aged 25–49 in 1960 (birth year 1911–1935). The lung cancer information was available from the JNR Cancer Registry which was available in the 1960s–1970s. The observation was carried out until retirement age of 55, with the longest observation of 18 yr. The registry disclosed 259 lung cancer cases, consisting of 26 cases in plant workers, 27 in steam locomotive department workers, and 206 in others. Relative risks were calculated according to the job groups by dividing into the five birth cohort ages. In the plant worker group, relative risks in each five birth cohorts were null, 1.27, 1.32, 1.53, and 1.09, respectively. Likewise, in the steam locomotive department group, the relative risks of each birth cohort were null, 1.42, 1.57, 0.70, and 0.76, respectively. These relative risks were not statistically significant. The dropout rate was about 12% during observation period. The ratio of lung cancer histological types of adenocarcinoma, squamous cell carcinoma, and undifferentiated carcinoma was shown to be 2 : 1 : 1 and this ratio was the same in the three work groups and national statistics. The percentage of smokers among plant workers, steam locomotive department workers and inner controls were 65%, 74%, and 73%, respectively, with Brickman indices of 450 ± 219, 91 ± 404, and 547 ± 1,291, respectively. The proportion of smokers among plant workers was somewhat lower than that of the other two groups. As for yearly changes of smokers, a survey of 6,745 subjects around the Tokyo area revealed percentages of 71.1% in 1986, 72.1% in 1987, and 70.7% in 1988\(^57\).
Yutaka Hosoda, et al.: Railways and Asbestos in Japan

Table 2. Birth cohort study on cancer mortality at 17 main plants

<table>
<thead>
<tr>
<th>Age in Workers</th>
<th>Follow-up</th>
<th>All deaths</th>
<th>All cancers</th>
<th>Lung cancer</th>
<th>Gastric cancer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>O</td>
<td>O/E (95%CI)</td>
<td>O</td>
<td>O/E (95%CI)</td>
</tr>
<tr>
<td>50–54</td>
<td>3,401</td>
<td>From 1970</td>
<td>179</td>
<td>0.54**</td>
<td>77</td>
</tr>
<tr>
<td></td>
<td></td>
<td>till 1970</td>
<td>(0.43–0.64)</td>
<td>(0.47–0.83)</td>
<td>(0.16–1.17)</td>
</tr>
<tr>
<td>45–49</td>
<td>4,835</td>
<td>till 1970</td>
<td>196</td>
<td>0.65**</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td></td>
<td>till 60 yr</td>
<td>(0.53–0.76)</td>
<td>(0.38–0.79)</td>
<td>(0.36–1.62)</td>
</tr>
<tr>
<td>40–44</td>
<td>7,024</td>
<td>of age 182</td>
<td>182</td>
<td>0.57**</td>
<td>54</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.46–0.68)</td>
<td>(0.46–0.90)</td>
<td>(0.18–1.57)</td>
<td>(0.41–1.11)</td>
</tr>
<tr>
<td>Total</td>
<td>15,260</td>
<td></td>
<td>557</td>
<td>184</td>
<td>27</td>
</tr>
</tbody>
</table>

* local sub-population.  O/E=observed number/expected number.  *p<0.05, **p<0.01.

Mortality studies of the 17 plant worker cohorts (follow-up in 1970–1979) (Table 2)

Hosoda et al.\(^{56}\) made a birth cohort study of 15,260 workers aged 45 to 60 in the 17 plants for 10 yr at the longest. They were grouped into the following 3 birth cohorts aged 40, 45, and 50 yr at the start of observation, respectively. Total number of deaths was 557. Lung cancer O/E ranged from 0.7 to 1.0, while stomach cancer O/E ranged from 0.6 to 0.8. These figures were reversed to the national statistics (stomach cancer > lung cancer). The low cancer O/E of this study suggests the existence of a healthy worker effect\(^{58}\) on cancer mortality as well as incidence. The dropout rate was about 12% during the observation period.

Mortality study of the O plant cohort (1967–1985)

Fukushima et al.\(^{32}\) followed up 3,205 workers at the O plant for 18 years from 1967 to 1985 using health examination records. By job group, 654 were SL workers, 2,299 non-SL workers, and 256 clerks. Prevalence rates of pleural plaques on miniature X-rays in 1977 showed the highest (6.2%) in SL workers followed by non-SL workers (3.0%), and clerks (1.4%). Relative risks of all causes of death were 0.58 in SL workers (high level asbestos exposure), 0.59 in non-SL workers (low), and 0.31 clerks, of all cancer deaths 0.93, 0.98, 0.59, respectively, of lung cancer death 1.32, 1.04, null, respectively, and of stomach cancer 0.32, 0.53, 0.22, respectively (no statistical significance). The percentages of smokers in 1975–1979 were 78.3 % for SL workers, 74.6% for non-SL workers, and 69.2% for clerks. The percentage of workers remaining in the same plant until retirement age was 96.8% for SL workers, 95.4% for non-SL workers, and 50.8% for clerks, and the percentage of those missing was 17.3%, 14.6%, and 3.8%, respectively. All SL works in the O plant terminated in 1967 when this follow-up study started.


Hiraga et al.\(^{44}\) followed up a cohort of 1,142 workers who had been exposed to asbestos in the N plant for 21 yr from 1970 to 1990. There were 133 deaths of all causes and 68 of all cancer. O/E by cause of death was 0.72 for all causes and 0.76 for all cancers, 1.45 for lung cancer, 1.34 for esophagus cancer, and 1.26 for stomach cancer. Though the O/Es were not statistically significant, lower O/Es for all causes and all cancers suggest the existence of a healthy worker effect\(^{58}\) in the subject population.

Studies on prognosis quoad vitam with or without pleural plaques of asbestos-exposed subjects (1970–1990)

Hiraga et al.\(^{49, 59}\) followed up the N plant workers: 98 cases with pleural plaques and 1,027 cases without plaques for 21 yr (1970–1990). The number of all causes of death was 9 deaths in the pleural plaque group, and 124 deaths in the no plaque group. Their relative risks compared with inner controls were 1.04 in the pleural plaque group and 0.92 in the no plaque group, the difference being not significant in prognosis quoad vitam between the two groups. When the observation was limited to 30–44 yr at the start of observation, the survival lines of the two groups, the 78 pleural plaque subjects and the 443 no pleural plaque subjects had a similar trend.

Pleural mesothelioma reports by railway companies

Hiraga et al. reported only two mesothelioma cases were included in the JNR cohort study. There have been several papers on mesothelioma of railroad workers including two railroad men out of 33 pleural mesothelioma cases\(^{22}\), and 12 railroad men out of 70 mesothelioma cases at South African Railways Locomotive Workshops\(^{60}\). Mosret et al.\(^{30}\) reported two mesothelioma cases, a locomotive driver and a storeman on the Rhodesian Railways. Mansuco et al.\(^{31}\) reported eight pleural mesothelioma cases among railroad machinists in a cohort study of 197 white males hired before 1935 and still alive in 1954 on a US Railroad Company.
Pneumoconioses Surveys

Osaka steam locomotive department and railway plants (1928, 1929)

Suzuki and Noda of Osaka Railway Hospital demonstrated a case of pneumoconioses with a radiograph at the Meeting of Japanese Railway Doctors’ Association in April 1928 (published in 1929). In the 1920s, because of the unavailability of diagnostic criteria for pneumoconioses, doctors had to refer to autopsy findings of workers who died from other causes of death. In 1922, X-ray films were first imported to Japan as a substitute of glass plate from the UK. One hundred twenty of 504 workers engaged in dust jobs for many years were selected for radiographic examinations. The prevalence rates of pneumoconioses were 32.6% among SL related workers, 26.3% among foundry workers, 52.0% among blacksmiths, 54.5% among lathe workers, and 80.0% among asbestos workers (4 of 5 workers).

It is noted that Suzuki and Noda published the above results around the same period as Cooke published his reports of “Fibrosis of the lungs due to the inhalation of asbestos dust” and “Pulmonary asbestosis.” However, their report was written in Japanese and has never been cited in foreign publications.

Sapporo steam locomotive department and railway plant (1934)

Yamakawa made an X-ray survey of 277 workers: 140 at the steam locomotive department, 109 at the railway plant, and 28 at other sites. The X-rays were used reading the Japanese Arima criteria. The prevalence rates of pneumoconioses were 4.6% among SL workers (SL crew 6.1%, train shed workers 2.3%), 22.0% among workers exposed to coal and metal dusts, 31.0% among foundry workers, 11.0% among lathe workers, and 35.7% among others.

Welders and foundry workers at railway plants (1955)

Matsufuji et al. reported the following three survey results.

1) Pneumoconioses were examined using the ILO International Classification in 371 electric welders and 385 gas welders at 9 plants, with welding work experience of 10–16 yr. The prevalence rates were 36.4% for electric welders and 21.3% for gas welders, respectively. All of their X-rays of pneumoconioses showed profusion-1.

2) Seventy-six foundry workers at the O plant were X-rayed in 1944 and 1955 to examine the progress of pneumoconioses. The prevalence rate in 1944 31.5% gradually increased and reached 44.7% in 1955. The authors’ conclusion was that progress of their disease was slow.

3) One hundred and seventy sand-blasters at 22 railway plants showed a prevalence rate of pneumoconioses (profusion-1) of 8.8% corresponding to the ILO International Classification. The authors noted that the low rate was due to the use of sand protection hoods, the replacement of soil sand with iron particles, and intermittent exposure.

Osaka steam locomotive department (1970)

Zenda made an X-ray survey of 2,450 workers in the Osaka area: 791 at the steam locomotive department, 331 at the railway maintenance department, 324 at the railway plants, and 1,004 clerks in 1955–1956. He reported that the prevalence rate of pneumoconioses with profusion-1 of the ILO International Classification was 21.4% at the steam locomotive department, 24.8% at the railway maintenance department, 8.0% at the railway plants, and 3.6% among clerks. SL crew showed a lower prevalence rate than train shed workers. This report did not mention workers’ dust job history prior to JNR employment. In fact, a large number of former dust workers were re-employed after World War II.

Nationwide railways maintenance department workers (1975)

Kikuchi et al. X-rayed a total of 35,000 nation-wide trackmen for pneumoconioses. The average prevalence rate was 3/10,000, with an increasing tendency by age: null in the younger than 40 age group, 4 in the 40s age group, and 10 in the 50s age group. The prevalence rates among those with and without dust job history before railway employment were 33.6% (51/1,488) and 1.8% (6/33, 220), respectively. As for the prevalence and dust job history: profusion-1/0 (slight) was shown in 6 workers without prior dust job history, and profusion-1/1 or more in 5 workers with prior dust job history. There were no workers aged 39 or younger, 4 aged 40s, and 10 aged between 50–54, showing an increasing trend with advance in age.

After 1987

East Japan Railway company which hired many ex-JNR employees reported only 6 cases of pleural plaques among 2,000 voluntary examinees, probably due to improvement of the work environments and also the retirement of workers with plaques. After the so-called steam engine era, few railroad men with pleural plaques were reported on US railways. On the other hand, 77 ex-JNR men were qualified for asbestos labor compensation by the JNR Settlement Headquarters, as of May 2007. Of them, 42 cases (54.5%) had pleural mesothelioma, 19 (24.7%) lung cancer, and 16 others. As for former work sites, 50 cases (64.9%) were formerly plant workers.

In several countries including Finland and Germany, HRCT (high resolution computed tomography) screening has allowed early detection of malignancies in asbestos-exposed workers. In Japan, the HRCT project headed by
Kusaka Y, Fukui University, has taken an active role in HRCT international study for occupational and environmental respiratory diseases[22].

Acknowledgments: The review is dedicated to Dr Y. Chiba MD who established the health surveillance system of Japan National Railway (JNR) employees. We also express our appreciation to medical and para-medical staff who were involved in the reference studies. We are most grateful to Dr I. Shigematsu MD for his valuable comments and to Drs K. Nobutomo MD, N. Saitou MD, S. Mizuno PhD, and Om P. Sharma MD for their hearty cooperation.

References
28) Tomita M. Personal communication. 2007.
30) Mostert C and Neintjes R: Asbestosis and...
48) Hosoda Y, Saitou N. Unpublished data.