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Asbestos-related Occupational Cancers Compensated under the Industrial Accident Compensation Insurance in Korea

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Abstract: Compensation for asbestos-related cancers occurring in occupationally-exposed workers is a global issue; this is also an issue in Korea. To provide basic information regarding compensation for workers exposed to asbestos, 60 cases of asbestos-related occupational lung cancer and mesothelioma that were compensated during 15 yr; from 1993 (the year the first case was compensated) to 2007 by the Korea Labor Welfare Corporation (KLWC) are described. The characteristics of the cases were analyzed using the KLWC electronic data and the epidemiologic investigation data conducted by the Occupational Safety and Health Research Institute (OSHRI) of the Korea Occupational Safety and Health Agency (KOSHA). The KLWC approved compensation for 41 cases of lung cancer and 19 cases of mesothelioma. Males accounted for 91.7% (55 cases) of the approved cases. The most common age group was 50–59 yr (45.0%). The mean duration of asbestos exposure for lung cancer and mesothelioma cases was 19.2 and 16.0 yr, respectively. The mean latency period for lung cancer and mesothelioma cases was 22.1 and 22.6 yr, respectively. The major industries associated with mesothelioma cases were shipbuilding and maintenance (4 cases) and manufacture of asbestos textiles (3 cases). The major industries associated with lung cancer cases were shipbuilding and maintenance (7 cases), construction (6 cases), and manufacture of basic metals (4 cases). The statistics pertaining to asbestos-related occupational cancers in Korea differ from other developed countries in that more cases of mesothelioma were compensated than lung cancer cases. Also, the mean latency period for disease onset was shorter than reported by existing epidemiologic studies; this discrepancy may be related to the short history of occupational asbestos use in Korea. Considering the current Korean use of asbestos, the number of compensated cases in Korea is expected to increase in the future but not as much as developed countires.

Key words: Asbestos, Lung cancer, Mesothelioma, Worker's compensation

Introduction

In Korea, 63,000 tons of raw materials were imported for the manufacture of asbestos each year between 1976 and 1990, reaching a peak of 95,000 tons in 1992. After then, the import of asbestos-related raw materials illustrated a decreasing trend where in 2007, it dropped to 1,094 tons[1]. Total amount of imported asbestos can be estimated to be 2,026,963 tons[2]. Meanwhile, the import of asbestos-containing products [Trade item 6803 and 6811 (asbestos-containing construction materials), 6812 (asbestos-containing textiles), 6813 (asbestos-containing friction materials)] increased from 10,000 tons in 1999 to 48,000 tons in 2005[3]. It may look like the import of products known to contain asbestos has increased while imported asbestos has decreased. However, all imported

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friction materials known to contain asbestos were not necessarily all asbestos containing materials, because these included non-asbestos products according to the classification system. Asbestos was found in only 8% of the imported friction materials known to contain asbestos, when the new classification system was applied to the imported friction materials in 2007[2)].

Korea has statistics describing morbidity and mortality associated with malignant mesothelioma (MM). According to the Korea Central Cancer Registry (KCCR), there were 40–50 new cases of MM annually, and these figures have shown a steady trend in the last 10 yr (1993–2002)[4)]. However, the mortality rate of Korean men increased from 0.65 per million persons in 1996 to 1.57 per million persons in 2006, as published by the Korea National Statistical Office (KNSO)[5)]. Also, the number of MM cases in Korean men detected by a nationwide MM surveillance system also increased from 0.42 per million persons in 2000 to 1.15 per million persons in 2006[5)]. Thus, the Korean society anticipates a surge in cases of MM will begin soon.

The link between MM and asbestos exposure was first suggested by studying the case reports in the 1940s[6)]. The studies show approximately 60 to 88% of individuals with MM have a history of occupational asbestos exposure[7–9)]. The earliest recognition of asbestos as a possible lung carcinogen is attributed to a case report by Lynch and Smith in 1935. A proven or highly probable causal relationship between asbestos and lung cancer was agreed upon in 1953 at the International Symposium on the Epidemiology of Lung Cancer. Numerous epidemiologic studies have since confirmed the carcinogenic potential of asbestos on the lung[10)]. Thus, many countries have approved lung cancer as well as MM as asbestos-related occupational cancers.

The first case of occupational MM involved a textile industry worker who had worked for 18 yr, and was approved by the Korea Labor Welfare Corporation (KLWC) in 1993[11)]. The first case of occupational lung cancer related to asbestos exposure involved a textile industry worker who had worked for 25 yr, and was compensated in 1998[12)]. Thereafter, 19 cases of MM and 41 cases of lung cancer were approved as asbestos-related occupational cancers[5)].

Considering the history of asbestos use in Korea, asbestos-related occupational cancer may increase in the near future, but not as much as European countries because Korea has not officially used spray-on asbestos in construction and limited use of asbestos insulation.

Understanding the characteristics of asbestos-related occupational cancer is important so as to institute policies for prevention and compensation for workers exposed to asbestos. Therefore, this study analyzed the characteristics of asbestos-related occupational cancers compensated under the Industrial Accident Compensation Insurance Law (IACIL), which is operated by the KLWC.

Materials and Methods

Materials and methods

Using the database of the KLWC, which is affiliated with the Korea Occupational Safety and Health Agency (KOSHA) electronic data system by the electronic network between the KLWC and KOSHA, 60 cases of compensated asbestos-related cancers that occurred between 1 January 1993 and 31 December 2007 were collected. The diagnosis of the 60 cases was reviewed and confirmed, then the characteristics of the asbestos-related lung cancer and mesothelioma were analyzed.

Also, to obtain more information pertaining to the cases, two additional kinds of data were used: 1) raw data of the Survey of Occupational Accidents and Diseases, which investigated occupation-related cancers by direct interview, and telephone and mail surveys with the compensated workers classified into occupational diseases since 1999 by the KOSHA and 2) Epidemiologic Investigation Data, which was assembled by the Occupational Safety and Health Research Institute (OSHRI) of KOSHA. The OSHRI has been investigating the workers and the workplaces of the claimed cases to decide the work-relatedness of each claimed case since 1992. The cases with more than 50% probability based on the result of the epidemiologic investigation were accepted. Probability was decided by a panel of occupational physicians. It is sometimes difficult to keep the consistency because there is not a quantified method for deciding 50% probability.

Among 60 cases of the study subjects, 47 cases (78.3%) were epidemiologically-investigated by the OSHRI. The other 13 cases were recognized as asbestos-related cancers by the doctors' advisory committee of the KLWC, which was adopted as the diagnostic criteria in the Enforcement Ordinance (an annexed list 3) of Industrial Accident Compensation Insurance Act (IACIA). For example, lung cancer of female worker who worked more than 10 yr at an asbestos textile factory and non-smoker was decided as asbestos-related lung cancer without detailed epidemiologic survey of OSHRI.

Thus, this study basically used the electronic data for the compensated workers by the KLWC and added the information using the two kinds of data (Survey of Occupational Accidents and Diseases by the KOSHA and Epidemiologic Investigation Data by the OSHRI of KOSHA), which provided more detailed information about the compensated workers and their workplaces.

For each case, basic information on the workers and the workplaces and the occupational history (type of industry, specific job, duration of asbestos exposure, and disease latency) were reviewed. The time of first exposure to asbestos was considered to have coincided with the start of employment in the job during which the initial asbestos exposure occurred. The duration of asbestos exposure was estimated by the duration of employment with a probable or definite duration of exposure. In some cases of lung cancers, workers had been exposed to several kinds of lung carcinogens other than asbestos, such as silica, hexavalent chromium, and polycyclic aromatic hydrocarbons (PAHs). In these cases, the duration of exposure was limited to the duration of asbestos exposure. Latency was defined as the duration between the first exposure to asbestos and the diagnostic date of MM or lung cancer.

Industries were classified into the following four types: 1) manufacture of asbestos-containing products, 2) use of asbestos-containing products in the manufacturing process, 3) handling of asbestos-containing products during work, and 4) miscellaneous; each type of industry was classified by the Korea Standard Industrial Classification Code (KSICC).

The compensation criteria for asbestos-related occupational diseases in Korea

Diagnostic criteria of asbestos related diseases was established in 1994, which is now described in the Enforcement Ordinance (an annexed list 3) of IACIA. The Enforcement Ordinance describes three main conditions of asbestos-related diseases as follows; diseases of workers who have been engaged in jobs related to asbestos exposure are recognized as occupational diseases. 1) Asbestosis, 2) primary lung cancer or mesothelioma, which are accompanied by one among these three conditions (1) asbestosis, (2) pleural thickening, pleural plaques, asbestos body or asbestos fiber, (3) workers, even though they don't have (1) or (2), exposed to asbestos more than 10 yr. Also workers exposed to asbestos less than 10 yr may be recognized as occupational diseases, considering the history of smoking, asbestos exposure, and latency. This ambiguity makes a judgment for acceptance be difficult.

Results

The general characteristics of workers and workplaces

1. Asbestos-related occupational mesothelioma

The KLWC approved 19 cases of asbestos-related MM in 15 yr. Males accounted for 84.2% (16 cases) of the approved cases. The absolute number of compensated cases showed a 2.8-fold increase, from 5 cases between 1993 and 1999 to 14 cases between 2000 and 2007. The mean age at the time of diagnosis of MM was 53.1 years. The most common age group was 50–59 yr (10 cases), followed by the groups 40–49 and 60–69 (Table 1).

Among 19 cases of MM, 15 cases (78.9%) occurred in the pleura, 3 cases in the peritoneum, and 1 case in the pericardium (Table 1).

The Kyeongnam area, including Pusan and Ulsan (8 cases), followed by Daejeon · Chungcheong (3 cases) and Daegu · Kyeongbuk (3 cases; Table 1) were the most common geographic areas where compensated workers' companies were located.

2. Asbestos-related occupational lung cancer

The KLWC approved 41 lung cancer cases in the 15 yr between 1993 and 2007. Men accounted for 95.1% (39 cases) of the approved cases. The absolute number of compensated cases increased 7.2-fold, from 5 cases between 1993 and 1999 to 36 cases between 2000 and 2007 (Table 1).

The mean age at the time of diagnosis of lung cancer was 50.6 yr of age. The most common age group was 40–49 yr of age (18 cases), followed by the group 50–59 yr of age (17 cases; Table 1).

Among 34 lung cancer cases, 20 cases (58.8%) were current smokers and 7 cases (20.6%) were ex-smokers (Table 1). The amount of smoking for the current- and ex-smokers was 20.2 pack-years (data not shown).

Simple chest radiographs of the 16 cases were re-read by the radiologists, and just 2 cases had fibrosis that appeared to be asbestos-related (data not shown).

Among 41 cases, the pathologic findings of 32 cases were reviewed. Twenty cases (62.5%) were adenocarcinomas, 6 cases were small cell carcinomas, 5 cases were squamous cell carcinomas, and 1 case was a large cell carcinoma (Table 1).

The Kyeongnam area, including Pusan and Ulsan (12 cases), followed by the Kyeonggi area, including Incheon (9 cases) and Seoul (8 cases) were the most common geographic regions where compensated workers' companies were located (Table 1).

The occupational characteristics of the workers and workplaces

1. Asbestos-related occupational mesothelioma

The mean duration of asbestos exposure for the compensated workers was 16.0 yr. The most common duration of exposure involved the group exposed to asbestos for 10–20 yr (8 cases). The mean duration of the latency period was 22.6 yr. The most common duration of the latency period was 20–30 yr (7 cases; Table 2).

The types of industries involved in asbestos-related occupational mesothelioma were manufacturers of asbestos-containing products (6 cases), use of asbestos-

Table 1. General characteristics of the study subjects

Unit: No. of workers (%)

Variables		Mesothelioma (19 cases)	Lung cancer (41 cases)
Diagnostic year	1993–1999	5 (26.3)	5 (12.2)
	2000–2007	14 (73.7)	36 (87.8)
Gender	Men	16 (84.2)	39 (95.1)
	Women	3 (15.8)	2 (4.9)
Age at diagnosis(years)	30–39	1 (5.3)	2 (4.9)
	40–49	4 (21.1)	18 (43.9)
	50–59	10 (52.6)	17 (41.4)
	60–69	4 (21.0)	4 (9.8)
	Mean	53.1 ± 8.5*	50.6 ± 7.2*
Smoking status (lung ca)	Smoker		20 (58.8)
	Ex-smoker		7 (20.6)
	Non-smoker		7 (20.6)
Primary site (mesothelioma)	Pleura	15 (78.9)	
	Peritoneum	3 (15.8)	
	Pericardium	1 (5.3)	
Pathologic findings (lung ca)	Adenocarcinoma		20 (62.5)
	Squamous cell ca		5 (15.6)
	Small cell ca		6 (18.8)
	Large cell ca		1 (3.1)
Location of enterprises	Seoul	2 (10.5)	8 (18.4)
	Incheon, Kyeonggi	2 (10.5)	9 (22.0)
	Daejeon, Chungcheong	3 (15.8)	2 (4.9)
	Gangwon	0 (0.0)	2 (4.9)
	Kwangju, Honam	1 (5.3)	4 (9.8)
	Daegu, Kyeongbuk	3 (15.8)	4 (9.8)
	Pusan, Ulsan, Kyeongnam	8 (42.1)	12 (29.2)

*Values are given as mean ± SD.

Table 2. Exposure characteristics of the study subjects

Unit: No. of workers (%)

Variables		Mesothelioma	Lung cancer
Year at first exposure*	1960–1969	2 (10.5)	3 (7.3)
	1970–1979	10 (52.6)	18 (43.9)
	1980–1989	3 (15.8)	16 (39.0)
	1990–1999	2 (10.5)	4 (9.8)
	Unknown	2 (10.5)	—
Exposure duration (year)*	< 5	2 (10.5)	1 (2.4)
	≥ 5 and < 10	3 (15.8)	6 (14.7)
	≥ 10 and < 20	8 (42.1)	10 (24.4)
	≥ 20 and < 30	3 (15.8)	21 (51.2)
	≥ 30	2 (10.5)	3 (7.3)
	Unknown	1 (5.3)	—
		16.0 ± 9.9†	19.2 ± 8.2†
Latent duration (year)*	≥ 5 and < 10	1 (5.3)	1 (2.4)
	≥ 10 and < 20	6 (31.6)	8 (19.5)
	≥ 20 and < 30	7 (36.8)	29 (70.8)
	≥ 30	3 (15.8)	3 (7.3)
	Unknown	2 (10.5)	—
		22.6 ± 8.1†	22.1 ± 6.4†

*This means that exposure is just to limit the asbestos. Exposure with other lung carcinogen (Cr^{6+}, PAHs, radon progeny, diesel engine exhausts, and etc.) except asbestos is not included.
†Values are given as mean ± SD.

Table 3. The distribution of industry and job of workers with mesothelioma

Type of exposure	Industrial classification	Job classification	The number of workers
Manufacture of asbestos containing products (6)	Manufacture of asbestos textiles (3)	Textile production and processing machine operators	3
	Manufacture of stone products (1)	Stone splitters	1
	Manufacture of cement (1)	Supervisor of stone quarry	1
	Manufacture of parts and accessories for motor vehicles (1)	Manufacturer of brake lining and pad for motor vehicles	1
Use of asbestos containing products in manufacturing process (1)	Aluminum door & window manufacture and installation (1)	Installer of aluminum door and window	1
Handling of asbestos containing products during their work (12)	Manufacture of pulp and paper (1)	engineering work	1
	Manufacture of basic iron and steel (2)	Health & safety manager Operator of electric furnace	1 1
	Manufacture of electrical equipment (1)	Unknown	1
	Ship building and repairs (4)	Plumber Ship carpenter Arrangement and cleaning Assistant for panel work	1 1 1 1
	Taxi services and repairing (1)	Maintenance and repairman for taxi	1
	Construction (2)	Plumber Bricklayers	1 1
	Fire power generation (1)	Operator for differentiator, boiler and turbine	1

containing products in the manufacturing process (1 case), and handling of asbestos-containing products in the course of work (12 cases). According to the KSICC, the most common industries associated with occupational-related MM were shipbuilding and repair (4 cases), followed by manufacturers of asbestos textiles (3 cases; Table 3).

2. Asbestos-related occupational lung cancer

The mean duration of asbestos exposure for lung cancer cases was 19.2 yr. The most common duration of exposure group was the group with 20–30 yr of exposure (21 cases), followed by the group with 10–20 yr of exposure (10 cases). The mean duration of the latency period was 22.1 yr. The most common duration of the latency period was 20–30 yr (29 cases; Table 2).

The types of industries associated with occupational-related lung cancer were manufacturers of asbestos-containing products (4 cases), use of asbestos-containing products in the manufacturing process (3 cases), handling of asbestos-containing products in the course of work (26 cases), and miscellaneous (8 cases). According to the KSICC, the most common industries associated with occupational-related lung cancer were shipbuilding and repair (7 cases), followed by construction (6 cases), and manufacture of basic iron and steel (4 cases; Table 4).

The most common types of jobs at risk for lung cancer were maintenance and repair (mechanics; 12 cases), followed by boiler-related jobs (installers and operators; 4 cases; Table 4).

Discussion

In Korea, the Industrial Accident Compensation Insurance (IACI) operated by the KLWC covered 11,688,797 all employed workers in 2006, which accounted for approximately 49% of the economically-active population (23,978,000 persons)[13, 14]. The IACI does not cover self-employed workers and some atypical workers. Approximately 1,422,000 government employees, teachers in private schools, and military officers (soldiers and other military staff) are covered their own insurance system. Thus, this study only included the cases compensated by the IACI.

Korea has two representative nationwide statistics for occupational diseases[15]. First statistic is the number of suspected occupational diseases as identified by the Periodic Health Examination Surveillance Program since 1972. Second is the statistics for the compensated workers by IACI since 1964. Also, to analyze the causes of occupational diseases in detail, KOSHA has indepen-

Table 4. The distribution of industry and job of workers with lung cancer

Type of exposure	Industrial classification	Job classification	The number of workers
Manufacture of asbestos containing products (4)	Manufacture of asbestos textiles (1)	Spinner	1
	Manufacture of parts and accessories for motor vehicles (2)	Manufacturing brake lining and pad for motor vehicles Wrapper	1 1
	Manufacture of slate (1)	Mixing work	1
Use of asbestos containing products in manufacturing process (3)	Manufacture of boiler (1)	Boiler maker and installer	1
	Manufacture of fluid power equipment (1)	Repairman for ship engine	1
	Manufacture of motor vehicles (1)	Brake lining assembler	1
Handling of asbestos containing products during their work (26)	Manufacture of basic iron and steel (4)	Maintenance and repairman Crane operator	3 1
	Manufacture of transportation equipment (1)	Maintenance and repairman	1
	Ship building and repairs (7)	Welder Plumber Insulation workers Electricity and cable setting man Ship demolition worker	3 1 1 1 1
	Construction (6)	Plumbing and insulation worker Boiler installer Welder Bridge construction and repairman Interior carpenter	2 1 1 1 1
	Transportation services (2)	Maintenance and repairman	2
	Manufacture of parts and accessories for motor vehicles (1)	Maintenance and repairman	1
	Repair services of motor vehicles (1)	Maintenance and repairman	1
	Transit and ground passenger rail transportation services (3)	Electricity repairman Train operator Installer	1 1 1
	Construction and demolition waste collection and transportation (1)	Truck driver for construction demolition waste	1
Miscellaneous (8)	Mining (1)	Mineral ore and stone products processing machine operators	1
	Manufacture of food (1)	Boiler operator	1
	Manufacture of textiles (2)	Power operator Maintenance and repairman	1 1
	Manufacture of aluminum wrapping paper (1)	Maintenance and repairman	1
	Real estate property management (1)	Maintenance and repairman	1
	Police station (1)	Boiler operator	1
	Operation of highways and related facilities (1)	Highway maintenance and fee cashier	1

dently investigated the compensated occupational disease cases by direct interview, and telephone and mailing surveys for compensated workers since 1999. The KLWC requested an epidemiologic investigation to be conducted by the OSHRI of the KOSHA to determine the work-relatedness of claimed cases. As a resut, the data collected from the investigation contained a significant amount of information about the workers and workplaces of the claimed cases.

This study basically used the electronic data for compensated workers produced by the KLWC and added the statistics for causes of occupational diseases investigated by the KOSHA and the epidemiologic investigation data (47 cases among 60 study subjects) conducted by the OSHRI of KOSHA. The additional statistics included more detailed information about the causes of disease occurrence (i.e., who, when, where, what, why, and how). However, medical information of the cases, such as radiologic findings and pathology, was not sufficient. Therefore in this study, all cases were analyzed utilizing only the available information.

The current rates of MM worldwide mirror the past raw asbestos consumption and there is general agreement that occupational asbestos exposure accounts for the majority of MM cases (60–88%)[7–9]. In this study, the absolute number of compensated cases of MM was just 19 since 1993. Considering asbestos consumption, the number of compensated cases is too small. For the last 30 yr, Korea has used about 2 million tons of asbestos, which is one-fourth the Japanese consumption during the same time period[4]. In contrast with the 223 deaths due to MM that occurred in the Korean general population from 2001 to 2006, only 5 deaths were covered by the IACI during the same period. The proportion of compensated cases among MM is too small compared to Canada, which showed one-third[16]. It could be caused by the coverage of IACI, which was extended to all enterprises employed at least one worker from enterprises employed more than 5 employees in 2000. It also can be explained that latency period caused by occupationally asbestos-related MM has not been reached.

It has been estimated that the number of asbestos-related lung cancer cases is about the same as the number of MM cases[18]. Considering the background incidence of lung cancer in the general population, occupational asbestos-related lung cancer, especially compensated cases, was very small. Germany reported that the number of compensated asbestos-related occupational lung cancer cases (2,885) was similar to that of mesothelomia cases (2,858) between 2000 and 2003[19]. However, most countries compensate a smaller number of lung cancer cases than MM. For example, Italy compensated 1,277 MM and 491 lung cancer between 2000 and 2003[19] and Japan compensated 205 MM and 98 lung cancer cases during the same period[20]. Unlike MM, lung cancer is caused predominantly by smoking and occupational carcinogens other than asbestos. Thus, it is difficult to decide whether the lung cancer is asbestos-related or not. Therefore, many European countries (Germany, Austria, Belgium, Finland, Norway, Sweden, and Switzerland) have two alternative criteria for the recognition of asbestos exposure: either intense exposure is proved (Helsinki criteria or threshold of 25 fibers/ml/yr) or lung cancer is associated with asbestosis or extensive modification of the pleura[21]. This is the reason why the compensated lung cancer cases result in a smaller number than the MM cases in spite of the larger incidence of lung cancer development.

Korea compensated a higher number of lung cancer cases than MM. This was caused by co-exposure of other carcinogens and ambiguous diagnostic criteria. Among 41 lung cancer cases, 16 cases were exposed to the other lung carcinogens such as crystalline silica, hexavalent chromium, diesel engine exhausts (DEE), PAHs, and radon progeny other than asbestos (data not shown). The diagnostic criteria for asbestos related diseases do not contain a quantifying method of asbestos fibers in lung tissue, which was not available when it was established. Thus it is sometimes difficult to apply the criteria when claimed cases are reviewed for decision.

About 80% of compensated lung cancer patients were current- or ex-smokers. Due to the small number of claimed cases and unpredictable past exposure, the current criteria didn't include asbestos exposure level and smoking status. It is necessary to amend the criteria for compensating asbestos-related lung cancer because it is anticipated that claims for asbestos-related lung cancer will be increases.

Increase in the sex ratio (men/women) of MM is more related to the occupational and environmental asbestos exposure. The sex ratio of MM deaths of the general Korean population was about[25]. However, in this study, the sex ratio was 5.3.

Pleural MMs are more common than peritoneal MMs, where pleural MMs accounted for nearly 90% of the cases[6]. In 2002, out of 46 MM cases reported to the KCCR, 26 cases (56.5%) occurred in the pleura and 13 cases (28.3%) occurred in the peritoneum[22]. A Japanese study showed that pleural and peritoneal MM deaths between 1995 and 2003 were 63.3% and 8.7%, respectively[20]. In this study, pleural MM accounted for 78.9% of deaths, which is a higher proportion than the Korean general population reported by the KCCR.

Some studies have shown that asbestos-related lung cancer may increase the frequency of adenocarcinoma[23]. However, another study did not show a pathologic difference between asbestos-related and non-related lung cancer[24]. In this study, among 31 cases investigated, the pathologic type of lung cancers, adenocarcinomas and squamous cell carcinomas, were 20 (62.5%) and 5 cases (15.6%), respectively. This pathologic proportion of lung cancer was different from that of the Korean general population, which involved 3,870 adenoncarinomas (25.7% of 11,741 cases) and 3,870 squamous cell carcinomas (33.0% of 11,741 cases) in 2002[25]. This pathologic difference was based on two reasons: first, adenocarcinoma is really a more frequent pathologic type of asbestos-related lung cancer and 2) lung cancer with adenocarcinoma is easily approved as an occupational asbestos-relatedness disease than other pathologic types of lung cancer. Thus, it caused a discussion on whether the asbestos-related lung cancer increases the frequency of adenocarcinomas.

The risk of MM is very low in the first 10–15 yr after the exposure and the risk as a function of dose and time since first exposure[26]. The mean latency period has been repeatedly found to be 30–40 yr and > 90% of MM were diagnosed more than 15 yr after the first asbestos exposure[27, 28]. However, MM cases were reported with a very brief latency period[29, 30] and epidemiologic studies support the hypothesis that heavy asbestos exposure may result in a shorter induction period[31]. Bianchi *et al.* (2001) investigated 325 mesothelioma cases that occurred in the shipbuilding industry; 15.7% (50 cases) had a latency < 10 yr[32]. The consensus of international experts is that a minimum of 10 yr from the first exposure is required to attribute MM to asbestos exposure[33]. In this study, the mean latency period of 19 MM cases was 22.6 yr (median, 22.0 yr; minimum, 8 yr), which was shorter than the MM latency period identified in the previous epidemiologic studies. It was caused by a short history of occupational asbestos use and relatively younger compensated workers compared to other countries. In accordance with increasing time, the latency period will also increase in Korea, as other countries that used asbestos much earlier than Korea have. For example, reviewing the series of 557 MM of the pleura in Italy, latency period ranged from 14 to 75 yr (mean, 48.8 yr; median, 51.0 yr)[32]. However, there were MM case reports with shorter latency period, which were about 5[34], 6[29], and 8 yr[30].

In this study, the mean duration of asbestos exposure was just 16 yr (range, 2–36 yr) which was shorter than MM latency period identified in the previous epidemiologic studies. However, there were MM cases with shorter duration of asbestos exposure, which were about 5 yr[35] and just three days[34]. In this study, 2 cases had asbestos exposure for less than 5 yr, which are presumed to be high dose exposures. These cases involved a worker from the textile and shipbuilding industries. According to the record of working environment measurement of textile industry in 1990, the concentration of asbestos was 17 fiber/cm[36].

In the case of asbestos-related lung cancer, the latency period was known to be about 25 yr from first exposure[37]. Analyzing 120 asbestos-related lung cancers in Japan, the latency period was found to be between 15 and 69 yr with a median of 43 yr[24]. In this study, the mean latency period was 22.1 yr (range, 9–38 yr), which was shorter than the lung cancer latency period identified in the previous epidemiologic studies. The cause was the same as the short MM latency period.

Duration of asbestos exposure for lung cancer had a mean of 19.2 yr in this study. There were 7 cases of lung cancer with <10 yr duration of exposure. Among 7 cases, 4 cases were exposed to other lung carcinogens (hexavalent chromium, diesel engine exhaust, and radon progeny). Thus, theses cases were approved as occupational lung cancer in spite of a short duration of exposure and latency periods.

The bulk of epidemiologic evidence implicates asbestos as a carcinogen, the effect of which is augmented by cigarette smoking. A synergistic relationship between the two carcinogens is commonly accepted, and a review of 23 studies addressing smoking and asbestos exposure lends support to a multiplicative interaction[38]. Among 34 cases with lung cancer in this study, 79.4% (27 cases) were current- or ex-smokers. The latency and exposure durations were the same in all three categorized groups (current-, ex-, and non-smokers) (data not shown).

The question of whether asbestos itself or asbestosis is the true risk factor for lung cancer has implications for present surveillance practices, as well as compensation issues. The correlation between asbestosis and lung cancer has been shown to be stronger than those between cumulative asbestos exposure and lung cancer[39]. But, lung cancers do appear in heavily exposed individuals without clinical, radiologic, or pathologic evidence of asbestosis[40–42]. In this study, simple chest x-ray or CT findings of 16 cases with lung cancer were re-read through the KOSHA epidemiologic survey. Just 2 cases of pulmonary fibrosis seemed to be due to asbestosis (no asbestosis among 19 mesothelioma cases) and there were no pleural plaques. Also, two lung cancer and mesothelioma with pleural thickening were confirmed. More cases of asbestos-related lung cancer should be reviewed to conclude the role of asbestosis in asbestos-related lung cancer.

Asbestos have been used in a large variety of industrial activities and jobs, which was changed according to the time and the countries. In the early 1970s, many industrialized countries began to legislate for the restricted production and use of asbestos. Thus, the only relevant occupational exposure occurred in maintenance, and removal and disposal of asbestos-containing materials, especially railway carriages, building materials, and heating/ventilating systems; the so called in-place asbestos materials may also be a source of exposure, in selected circumstances[31]. That is, construction workers have the potential for continued exposure during the maintenance, renovation, and demolition of buildings that contain asbestos in countries already banning asbestos. These situations are not the case for countries in transition, where significant production and uses still occur.

In Korea, the raw materials of asbestos were imported from the early 1970 and reached a peak at 95,000 tons in 1992. The asbestos consumption has rapidly decreases since late 1990s when the government enforced regulations for asbestos use. Most imported asbestos, 80%–95% was used in making construction materials such as roofing slate and remains were used in making friction materials and textile materials[2]. All asbestos in use, production, import, and export are planned to ban totally in 2009.

Asbestos-related cancers occurred commonly in the shipbuilding industry (4 MM and 7 lung cancer cases), followed by manufacturers of basic iron and steel (2 MM and 4 lung cancer cases). Construction workers accounted for just 2 cases of MM and 6 cases of lung cancer even though they may be exposed to asbestos more. In the future, asbestos exposure will occur in the workplace of demolishing and remodeling buildings. In Japan, among asbestos-related compensated cases in 2005–2006, the construction workers accounted for 42.0% (872 workers) of 2,078 MM cases and 40.0% (515 workers) of 1,287 lung cancer cases[43].

Through this study, the characteristics of compensated asbestos-related lung cancer and MM cases have been described, which gives some useful information, such as latency period, duration of exposure, kinds of industries involved, and jobs affected. Such information will be helpful to make policy to protect workers exposed to asbestos and to prevent future occurrences of asbestos-related occupational cancers. However, detailed exposure information, such as cumulative exposure dose and the lung burden (asbestos fiber or asbestos body in dried lung tissues, in this study we confirmed just one case of mesothelioma with asbestos body), were not accessed because secondary data was used. Analyzing compensated cases through direct interviews and gathering data from radiologic and pathologic findings is required in the future.

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