Historical Perspective

Transfer of Occupational Health Problems From a Developed to a Developing Country: Lessons From the Japan–South Korea Experience

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Many corporations move their manufacturing facilities or technologies from developed to developing countries. Stringent regulations have made it costly for industries to operate in developed, industrialized countries. In addition, labor costs are high in these countries, and there is increasing awareness among the general public of the health risks associated with industry. The relocation of hazardous industries to developing countries is driven by economic considerations: high unemployment, a cheaper labor force, lack of regulation, and poor enforcement of any existing regulations make certain countries attractive to business. The transfer of certain industries from Japan to Korea has also brought both documented occupational diseases and a new occupational disease caused by chemicals without established toxicities. Typical examples of documented occupational diseases are carbon disulfide poisoning in the rayon manufacturing industry, bladder cancer in the benzidine industry, and mesothelioma in the asbestos industry. A new occupational disease due to a chemical without established toxicities is 2-bromopropane poisoning. These examples suggest that counter-measures are needed to prevent the transfer of occupational health problems from a developed to a developing country. Corporate social responsibility should be emphasized, close inter-governmental collaboration is necessary and cooperation among non-governmental organizations is helpful. Am. J. Ind. Med. 52:625–632, 2009. *© 2009 Wiley-Liss, Inc.*

KEY WORDS: developed country; developing country; transfer; South Korea; Japan; occupational diseases; hazardous industries

INTRODUCTION

Many corporations move their facilities and technologies from developed countries to developing countries. Corporations frequently keep their high-technology facilities within developed countries but move traditional manufacturing facilities to developing countries. These manufacturing facilities include those used in the textile, chemical, metal, and machine manufacturing industries. These industries consume high quantities of natural resources and energy and may cause occupational diseases as well as environmental pollution. In industrialized countries, stringent regulations have made it costly for industries to operate while

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conforming to safety and health standards. In addition, labor costs have increased markedly in developed countries, and there is increasing awareness among the general public of the health risks of industry and its waste products. In contrast, developing countries provided strong economic incentives to attract industries from developed countries. Hazardous industries are attracted to developing countries because of their cheaper labor forces, lack of regulation, and poor enforcement of any existing regulations. In addition, many countries in the developing world have pursued a path of rapid industrialization and have been willing to welcome all industries, however hazardous [Castleman, 1980; Jeyaratnam, 1990, 1994; Johanning et al., 1991].

The transfer of hazardous industries and associated occupational hazards occurs around the world. There is a history with respect to the transfer of industry from Japan to South Korea; we evaluated the effects that the transfer has had on the health of Korean workers.

TYPES OF OCCUPATIONAL HEALTH PROBLEMS TRANSFERRED FROM JAPAN TO KOREA

Two types of occupational health problems have been transferred from Japan to Korea: documented occupational diseases and a new occupational disease caused by chemicals without established toxicities.

Typical Examples of Documented Occupational Diseases

Rayon manufacturing and carbon disulfide poisoning

Historically, South Korea has depended on Japan for economic development. Prior to World War II, Japan occupied Korea and exploited the Korean economy, as well as establishing industrial facilities [Jang et al., 1990]. Although some of these industrial facilities remained after Korea was liberated from Japanese colonial rule in 1945, the 1950–1953 Korean War destroyed what was left of Korea's industry [Jang et al., 1990].

Beginning in the early 1960s, the Korean economy began to develop, relying heavily on government-led economic development plans and export-oriented policies. Although the Korean government promoted the growth of export-led, labor-intensive light industry, it also sought ways to develop heavy industries [Kim, 1991].

In post-war Japan, which experienced severe environmental pollution, as illustrated by outbreaks of Minamata disease, Itai–Itai disease, and Yokka–ichi asthma [Miura, 1996a], a strong nationwide anti-pollution movement and the high cost of reducing pollution encouraged Japanese corporations to transfer their manufacturing facilities and technologies to Korea [Sumiya, 1976; Harada, 1985; Korean Institute of Pollution 1986; Jeyaratnam, 1990]. Furthermore, at the end of the 1950s, the Japanese rayon industry was confronted with increasing competition from rayon industries throughout the world, competition due to the manufacture of other synthetic fibers such as nylon and tetron, and an international economic recession [Editorial Committee of the History of Toray Industries, Inc., 1977]. Under these conditions, a Japanese rayon manufacturer sought to relocate its facilities to developing countries. The Heunghan Synthetic Fiber Co., established in 1959, bought used rayon manufacturing machinery that had been made in 1956 from the Toray Co. (Toyo Rayon) of Japan in 1964, using a loan from the Korean government. The establishment of Heunghan was part of the first 5-Year Economic Development Plan, the main goal of which was to nurture strategic enterprises in Korea [Special Committee for Wonjin Rayon Measures, 1994; Korean Medical Association, 1996]. Heunghan later had financial problems, primarily due to the same situation faced by the Japanese rayon industry, and was reorganized as the Wonjin Rayon Co. in 1976 [Special Committee for Wonjin Rayon Measures, 1994; Korean Medical Association, 1996],

At the time of the transfer to Korea, carbon disulfide poisoning was a documented occupational disease in rayon industry workers throughout Japan. The first case of carbon disulfide poisoning in the Japanese rayon industry was reported in 1929, and psychosis and peripheral neuropathy due to carbon disulfide poisoning were first reported in rayon industry workers in 1932 and 1934, respectively [Miura, 1981]. In the 1930s, carbon disulfide poisoning was the most common occupational disease in Japan [Harada, 2002]. Since 1949, rayon manufacturers and university researchers in Japan have worked together to control carbon disulfide concentrations in the workplace and to monitor the incidence of carbon disulfide poisoning [Harada, 2002]. Atherosclerosis type of carbon disulfide poisoning was reported since 1960s in Japan [Harada, 2002].

In Korea, a massive outbreak of carbon disulfide poisoning was observed in workers at the Wonjin Rayon Co. in the late 1980s. This outbreak was thought to be due to long-term high exposure to carbon disulfide, caused by the lack of enclosure of spinning processes, local ventilation, and provision of adequate protective equipment. The ill-preparedness in workplace environmental control originated from a lack of knowledge of the toxicity of carbon disulfide among professionals and a lack of concern regarding occupational health and safety by employers, governments, and professionals [Choi and Jang, 1991; Special Committee for Wonjin Rayon Measures, 1994; Korean Medical Association, 1996]. In addition, the absence of communication between Korean and Japanese scientists prevented the early detection of carbon disulfide poisoning in Korean workers.

This outbreak of carbon disulfide poisoning at the Wonjin Rayon Co. was the turning point for changes in the field of occupational health in Korea. At one time, more than 1,500 workers were employed at this plant; this had decreased to 811 by the time the plant was closed in 1993.

The first case of carbon disulfide poisoning occurred in July 1981; however, this worker received compensation from industrial accident compensation insurance for sulfur dioxide poisoning rather than carbon disulfide poisoning, because Korean medical doctors had no concept of carbon disulfide poisoning at that time [Korean Medical Association, 1996]. In 1987, four workers who had each previously worked for 10 years in the rayon spinning process, making artificial silk thread from pulp dissolved in a carbon disulfide solution, suffered from paralysis of the extremities and speech disturbance, and were compensated for carbon disulfide poisoning [Park and Kim, 1998]. As Korean society became more democratic, many more victims of carbon disulfide poisoning were identified; the total reached 600 by 1997, including 8 who had died. Through the end of 2004, 910 workers had been compensated for carbon disulfide poisoning [Cho et al., 2005]. More workers will be diagnosed as carbon disulfide poisoning due to the combined effects of aging and carbon disulfide.

Although the Wonjin Rayon Co. went out of business in 1993, its equipment was exported again, this time to China, continuing the trend of the globalization of occupational disease and hazardous industry.

Benzidine industries and bladder cancer

Nishimura [1940] reported the first 4 cases of bladder cancers in dye workers in Japan, and there were more than 30 patients with bladder cancer identified by the end of 1961. Beginning in 1962, the Japanese dyestuff industries, with the cooperation of university researchers, introduced urinary cytology examinations for dye workers to detect bladder cancers [Ishizu, 1975]. By 1972, more than 120 dye workers with bladder cancers were identified, and, that same year, the Industrial Safety and Health Law prohibited the manufacture of benzidine, β-naphthylamine, and their salts [Ishizu, 1975]. This law also required government permission for the production of dichlorobenzidine and its salts. However, the import and use of benzidine dyes was permitted, provided the benzidine content did not exceed 1% [Miura, 1996b]. Replacement dyes that matched the benzidine dyes in both price and technical properties were not available, so there was a continuing, albeit declining, demand for benzidine dyes. This demand was met by manufacturers outside Japan, especially those in Korea. Technology for the manufacture of benzidine dyes was transferred from Japan to Korea around the time of prohibition against benzidine in Japan. The Korean dye manufacturing industry expanded considerably by implementing these Japanese technological methods, exporting benzidine dyes to several countries, mainly to Japan [Korea Development Bank, 1977, 1980; KITA, 1974, 1975, 1972–2000, 2008; Woodward and Clarke, 1997]. As shown in Table I, total exported amount of direct dye containing benzidine dye tended to increase and Japan was the country to import the largest amount of direct dye and then Pakistan. Although certain risks were eliminated in the Japanese dye manufacturing industry, these risks were transferred to Korea.

TABLE I. Exported Amount (kg) of Direct Dye Containing Benzidine Dye and Its Major Imported Countries (Unit: kg)

Year	Total exported amount	Japan	Pakistan
1977	238,555	102,219	51,093
1978	96,222	35,340	25,952
1979	271,302	94,730	44,812
1980	235,500	78,400	54,325
1982	194,125	101,220	64,795
1984	203,280	128,230	21,010
1986	364,348	151,180	63,988

In Korea, the decision in 1980 to suspend the production of benzidine and benzidine-based dyes was deferred, owing to the importance of the dye industry in Korea. In the 1990s, one factory manufactured benzidine and benzidine chlorides, and eight factories throughout Korea used benzidine chlorides. In 2000, however, the manufacture of benzidine-based dyes and benzidine chlorides was legally prohibited in Korea [Kim et al., 2007].

To date, there have been a few cases of benzidine-induced cancers in Korea, whereas 592 workers in Japan have received compensation for benzidine and β-naphthylamine-induced cancers [JOSHRC, 2005].

The authors investigated the incidence of bladder cancer in Korea in 1999 and early 2006, in 650 workers who were employed at representative workplaces that manufactured and handled benzidine-based dyes. Using the Korean national cancer registry database and the compensation claims for occupational diseases, we have identified two individuals with bladder cancer. Their latency periods were estimated to be 30 and 36 years, respectively. The relatively low incidence of bladder cancer among these workers and the relatively longer latency periods for these two patients suggest that the Korean workers were exposed to a relatively low level of benzidine compared with Japanese workers. This may be due to differences in the raw materials used to make for benzidine-based dyes in the two countries. Free benzidine base was used in Japan, but benzidine chloride was used in Korea. Benzidine base crumbles easily and can readily disperse in the air; however, if wet-caked as benzidine chloride, its ability to disperse is markedly decreased. This difference may have reduced workers' exposure levels [Kim et al., 2007]. Benzidine-induced cancer, however, will likely be an important future occupational health issue in Korea, although its incidence may be lower and its latency period longer than in Japan owing to differences in exposure level and pattern in the two countries.

The asbestos industry and asbestos-related cancers

The first asbestos health survey in Japan in 1937–1940 found that, of 1,024 asbestos textile workers, 65 had asbestosis [Ishidate, 1938; Council for Health Insurance, 1940], and the first case of asbestos related lung cancer was reported in 1960 [Sera et al., 1960]. The 1972 Industrial Safety and Health Law mandated tighter controls on asbestos handling [Miura, 1996b]. At that time, however, Korea had no regulations on asbestos [Park and Kim, 1998]. Among the asbestos-goods manufacturers in Korea was the Jeil Asbestos Co., which had been established as a joint venture with Nippon Asbestos Co. (NICHIAS) in 1971 [Minami, 2007]. In addition, a Japanese asbestos textile manufacturer, Union Asbestos Co., operated in Korea. At that time, Nippon Asbestos Co. moved some of its crocidolite and chrysotile processing to Jeil Asbestos Co. [Mainichi Shinbun, 2007], exposing Korean workers to both chrysotile and crocidolite. Jeil Asbestos Co. produced 15 tons of crocidolite products monthly, half of which was exported to Japan, and the other to other foreign countries [Onodera, 1973]. A similar pattern of export-re-import was also observed as in the case of benzidine.

To date, at least nine former Korean workers with mesothelioma who had worked in Jeil Asbestos Co. have received compensation [Ministry of Labor, 2008]. Dozens of resident near the factory recently have claimed their mesothelima was due to environmental exposure to asbestos produced in the factory. More and more workers and non-worker residents will be diagnosed with asbestos-related diseases in future.

In Japan, 354 workers with lung cancer and 502 with malignant mesothelioma were compensated for occupational asbestos-related cancers up to the end of 2004. Following the introduction of a new law (the Asbestos-Related Health Damage Relief Law) in 2006 mandating compensation of individuals with environmental or occupational exposure-related cancers, by the end of 2006 more than 6,500 patients with asbestos-related cancers in Japan have received compensation [JOSHRC, 2008a].

In contrast, there have been no explosive, nationwide outbreaks of asbestos-related cancers in Korea, although localized outbreaks have occurred, such as those in the vicinity of Jeil Asbestos Co, and a sporadic pattern has been reported elsewhere. This may be due to big differences between these two countries in amounts and peak time of asbestos use, as well as to the type of asbestos used predominantly in the two countries: chrysotile in Korea and chrysotile with amosite and crocidolite in Japan. In contrast to Japan, asbestos spraying was rarely used in housing or construction in Korea, and crocidolite was not used to make cement pipe in Korea [Ministry of Health Labour and Welfare, 2009; Kurumatani and Kumagai, 2008], which can be inferred from the article by Choi et al. [1998]. However, despite these differences, asbestos-induced cancers may become an important social issue in Korea owing to their long latency periods.

The Jeil Asbestos Co. moved its asbestos processing facilities to Indonesia in 1992.

New Occupational Disease Due to a Chemical Without Established Toxicities Imported From Japan to Korea

One example of new occupational disease by a chemical without established toxicities introduced into Korea from Japan is 2-bromopropane intoxication. The chemical was used by an electronic parts manufacturing company in southern Korea. In 1995, 23 of the 33 workers involved in the assembly process of tactile switch parts who were exposed to 2-bromopropane developed reproductive and/or hematopoietic disorders. Female workers developed ovarian failure and infertility, and male workers developed testicular insufficiency with azoospermia or oligospermia. Many of these workers also developed anemia, leukopenia and/or thrombocytopenia [Kim et al., 1996; Park et al., 1997]. This is the first report of toxicity due to 2-bromopropane. Histopathological examination of biopsies taken from four of the female workers in the factory showed focal or diffuse fibrosis of the ovarian cortex, disappearance of follicles at various stages of development, and low numbers of primary follicles and corpus albicans [Koh et al., 1998]. After this outbreak, Ichihara et al. [1999] showed a possible association between hematological indices and individual exposure levels of 2-bromopropane in workers in a Chinese factory producing the chemical although they could not find cases with severe toxicity similar to the Korean workers. Subsequently, numerous animal studies have confirmed that the chemical is toxic to reproductive organs and hematopoietic tissue as shown in Korean workers [Ichihara et al., 1996, 1997; Kamijima et al., 1997; Lim et al., 1997; Yu et al., 1997, 1999, 2001; Son et al., 1999; Wu et al., 1999; Sekiguchi et al., 2002].

2-Bromopropane was developed as a non-hazardous substitute for chlorofluorocarbons, which had been found to destroy the stratospheric ozone layer. This chemical, which was more expensive than the chlorofluorocarbons, was imported into Korea from an affiliated Japanese company for use as a cleaning solution in 1994 [Kim et al., 1999]. The

Japanese workers had used 2-bromopropane in a similar process for several years while wearing their usual protective personal devices, and significant health effects had not been reported until the outbreak. Moreover, toxicological data were not yet available for this chemical and no occupational standards had been developed [Kim et al., 1999]. Thus, both management and labor were under the false impression that 2-bromopropane was safe, and neither implemented any safety precautions in Korea. After the outbreak we were able to review the periodic medical examination records of Japanese workers exposed to 2-bromopropane, and found out that mild anemia, which was unnoticed by medical staffs, had already occurred in three workers.

The unexpected toxicities associated with 2-bromopropane exposure shocked Korean society, providing the first example of disease due to 2-bromopropane exposure in the world. If the Korean company had not regarded a new chemical without established toxicities as being non-toxic, they might have prevented serious disorders in many workers. 2-Bromopropane has a chemical structure similar to that of 1,2-dibromo-3-chloropropane (DBCP) which has been reported to cause male infertility [Egnatz et al., 1980; Kluwe, 1981a,b; Kim et al., 1996]. Therefore, the reproductive toxicity of 2-bromopropane might have been anticipated based on the terrible similar experience with DBCP which precipitated the export of this hazard from US to Latin American countries and lawsuits filed in the US against Dow and Shell by workers sterilized by DBCP in Costa Rica and Honduras [LaDou, 1999; Levy et al., 1999; Lowry and Frank, 1999].

DISCUSSION

The above-mentioned examples of occupational health problems resulting from the transfer of hazardous chemicals or manufacturing processes from Japan to Korea highlight several issues: First, when toxic substance controls are imposed in developed countries, industries in these countries transfer certain production facilities or technologies to developing countries. An integral part of these transfers is an international double standard in industrial hygiene and pollution control [Castleman, 1980]. Second, on a global basis, occupational health risk levels are not reduced, but merely transferred from developed to developing countries. Moreover, owing to the inferior levels of occupational health protection in developing countries, the risk levels are magnified [Woodward and Clarke, 1997]. Third, although the health effects of transferred hazardous industries were considered problems restricted to workers and to people in developed countries in the past, these issues have recently received increased attention in developing countries.

The experiences of Japan and South Korea suggest several important counter-measures that can be used to prevent the transfer of occupational health problems from a developed to a developing country, or among developing countries in this era of globalization.

First, corporate social responsibilities should be emphasized. Corporations are responsible not only to their stockholders (in terms of maximizing their market shares and profits), but also to society, including the communities surrounding their factories or businesses and the nations in which they conduct business. Corporate social responsibility involves recognizing the social costs of business. Environmental and occupational health and safety issues are recently becoming concerns in corporate social responsibility [Harrison, 2004; Kawashita et al., 2005]. However, in the present age of globalization when the export of hazards has become more complex than in past decades, what is needed for leading to true corporate social responsibility is much more public disclosure of environmental release of pollutants and workers' exposure or who their major suppliers are around the world [Castleman et al., 2008].

Technology transfer, while contributing to the economic development of many countries, has often introduced many occupational and environmental hazards. One unacceptable practice is the export of processes or technologies no longer permitted in one country to other countries where occupational and environmental regulations are less strict and enforcement is weaker [Milad et al., 1998]. The International Labor Organization (ILO) [1988] has produced a Code of Practice for the transfer of technology to developing countries. Important considerations in exporting and importing equipment and machinery include, for example, (1) ensuring adequate conditions of use, including training of workers in the skills required for safe operation, and (2) consideration of ergonomic and anthropometric suitability of the target work force.

When companies transfer potentially hazardous processes or technology to other countries they should take responsibility for any associated occupational health and environmental effects, and take measures to counteract potential occupational diseases and environmental pollution.

Second, close inter-governmental collaboration is necessary. Such collaboration should include rapid communication of new information on health hazards, identification of occupationally or environmentally hazardous processes or substances transferred between countries, and communication of knowledge regarding health impairment. In addition, inter-governmental collaboration is required in the development of measures to counter occupational diseases or pollution, including the development of less hazardous processes or chemicals, more effective hygienic measures, and effective methods for risk communication and management. Governments and/or public organizations can have important roles in preventing the transfer of occupational health problems and minimizing the occurrence of occupational diseases.

One of the objectives of the United Nations Environmental Program (UNEP) is the establishment of a warning system to provide notice to countries in which the environment and human health may be affected by the export of hazardous substances. The London Guidelines for the Exchange of Information on Chemicals in International Trade [UNEP, 1989] is one example of this activity. One of the general principles of these guidelines is that both exporting and importing countries should protect human health and the environment against potential harm by exchanging information on chemicals in international trade [Jeyaratnam, 1994]. These guidelines include a procedure called Prior Informed Consent (PIC), which outlines the concept that importing countries should be made aware of and officially sanction the import of certain hazardous chemicals that are banned or severely restricted in the country of export. PIC was made mandatory in the Rotterdam Convention on the trade of hazardous chemicals (http://www.pic.int/) [Hough, 2000; Harjula, 2006]. However, the Convention's present requirement for unanimous adoption of new substance in PIC list blocked the addition of chrysotile asbestos and pesticide endosulfan to the PIC list at the fourth meeting of the Conference of the Parties to the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade (PIC COP-4) in 2008.

Another example of collaboration on occupational health standards is cooperation between the governments of Japan and Korea, in determining the work-relatedness of the first Korean patient with malignant mesothelioma and in preventing the expansion of 2-bromopropane poisoning. Inter-governmental collaborative organizations or international organizations consisting of representatives of governments, labor and management should be activated to cope with these issues.

Third, cooperation among non-governmental organizations (NGOs) is helpful. These NGOs, located in both developed and developing countries, should be empowered to monitor the transfer of occupational health problems from a developed to a developing country. NGOs can have a positive role in identifying occupational health problems and pressing governments to solve these problems. Typical examples are the close cooperation between Korean and Japanese NGOs regarding issues related to the massive outbreak of carbon disulfide poisoning in the early 1990s [Harada, 2002] and the recent cooperation regarding issues related to asbestos [JOSHRC, 2008b].

In summary, the experiences of Japan and South Korea suggest several important counter-measures that can be used to prevent the transfer of occupational health problems from a developed to a developing country, or among developing countries in this era of globalization. First, corporate social responsibility should be emphasized. Second, close inter-governmental collaboration is necessary. Third, cooperation among non-governmental organizations is helpful.

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