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Cancer incidence of Taiwanese shipbreaking workers who have been potentially exposed to asbestos

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ABSTRACT

Background: Shipbreaking remains one of the most dangerous jobs worldwide. Shipbreaking workers are exposed to many hazardous chemicals, especially asbestos. Unfortunately, long-term follow-up studies of cancer incidence patterns in shipbreaking workers are lacking. This study examines whether there is an increased risk of cancer among male shipbreaking workers over a 24-year follow-up period.
Methods: 4155 male shipbreaking worker's information was retrospectively collected from Kaohsiung's Shipbreaking Workers Union database from 1985. The study cohort was linked to the Taiwan Cancer Registry from 1985 to 2008 for new cancer cases. The expected number of cancers for shipbreaking workers was calculated by using the age (5-year intervals) and calendar time-specific annual rates of cancer incidence with reference to the general population of Taiwan from 1985 to 2008. Standardized incidence ratios (SIRs) were calculated as relative risk estimates. The hazard ratio (HR) for cancer was calculated for the shipbreaking workers with Total Exposure Potential Scores for asbestos.
Results: After consideration of a 5-year latency period, an elevated incidence of overall cancer ($N=368$; SIR = 1.13 (1.01–1.25)), oral cavity cancer ($N=83$; SIR = 1.99 (1.58–2.46)), and trachea, bronchus, and lung cancers ($N=53$; SIR = 1.36 (1.02–1.78)) was found among male shipbreaking employees. Moreover, mesothelioma cases were found in those who had the occupation of flame cutter. The high asbestos exposure group was associated with an increased SIR of developing overall cancer and oral cancer, whether we considered a 5-year or 10-year latency period.
Conclusion: Asbestos-related diseases, including lung cancer and mesothelioma, were seen in excess in these shipbreaking workers and some cases appeared to have a dose-dependent relationship. Preventative measures among male shipbreaking workers should be researched further.

1. Introduction

The global shipping industry relies upon the developing world to dispose of retired deep-sea vessels through the process of shipbreaking. The ship-recycling market hit a 13-year high in 2009 and has attracted many international organizations concerned with environmental and occupational health effects in shipbreaking industry countries (Japan, 2012; Sarraf, 2010). South Asian countries (such as Bangladesh, Pakistan, India and China) are the leaders of the shipbreaking industry (Japan, 2012; Sarraf, 2010). A small percentage of ships are dismantled in facilities located in Europe and USA. These facilities mainly use dry docks or work alongside the piers. The International Labor Organization issued draft guidelines for shipbreaking industries to follow focusing on improvements for occupational safety and creation of healthy working conditions for employees (ILO, 2004). However, many shipbreaking yards located in developing countries do not operate according to laws and do not address work-related environmental hazards. These situations can potentially lead to large quantities of toxic materials escaping into the environment and cause serious health problems for workers, the local population, and wildlife.

Abbreviations: SIRs, age and calendar standardized incidence ratios; PVC, poly-vinyl chloride; ICD-O3, International Classification of Diseases for Oncology issued

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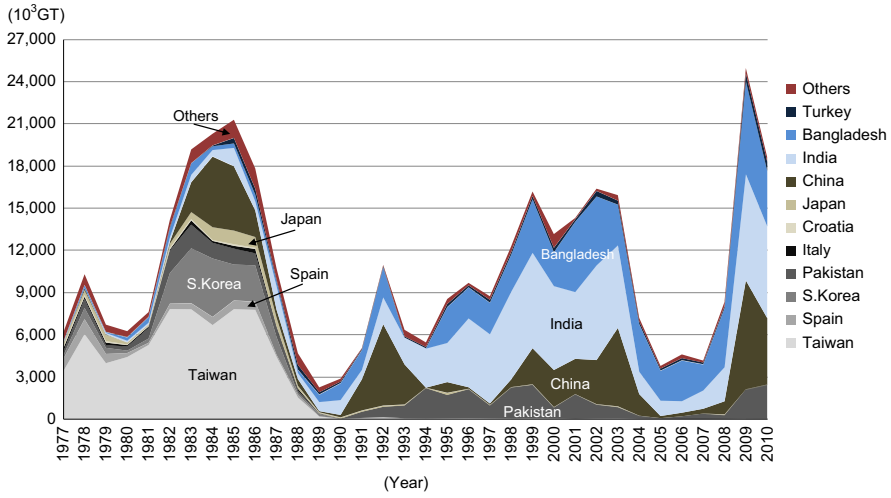

Fig. 1. Trends of GT of ships by major demolition countries in the world from 1977 to 2010.

The occupational environment has been fruitful for studying the etiology of human cancers. Many recognized human carcinogens can be found in the occupational environment. Many vessels that were built in the 1960s–1970s contained many tons of asbestos. The amount of asbestos in a naval vessel exceeded the expected amount in typical merchant ships (Sarraf, 2010). Every year, out of about 1000 ocean-going ships sold for recycling, 80% end up on the beaches of South Asia. There they are disassembled by thousands of poorly trained and poorly equipped workers who use blowtorches to demolish and dismantle the ships (Heidegger and Reuter, 2013). Exposure to asbestos remains a significant long-term problem in the shipbreaking industry. Asbestos can cause a range of diseases, such as lung cancer, mesothelioma, larynx cancer, ovarian cancer and asbestosis (Straif et al., 2009; WHO, 2006). Long-term health effects of cancer among shipbreaking workers have not been adequately documented. In addition to asbestos, shipbreaking workers are exposed daily to other environmental health hazards and toxins such as metals in paint, polychlorinated biphenyls, and metal fumes. Shipbreaking workers also risk falling off the ship and being crushed by falling plates (Mattorano et al., 2001; Rousmaniere and Raj, 2007; Tewari et al., 2001). Chronic illnesses and cancers with long latency periods caused by exposure to toxins are more difficult to track because workers are often not registered and may migrate within or outside their country.

Taiwan was the world's largest shipbreaking nation with approximately 65% of the obsolete ships in the world being crushed there. These vessels accounted for more than 67 million gross tonnage (GT) and were scrapped from 1977 to 1988 in Taiwan (Fig. 1), Taiwan's shipbreaking teams were able to dismantle a 30,000-ton tanker in as little as 6 weeks (Kojima, 2008). These past experiences in Taiwan provided a unique opportunity to study the long-term effects of the shipbreaking workers on the development of cancer.

In the present research, a cohort study was conducted to link male shipbreaking workers with the Taiwan Cancer Registry (TCR). This was done in order to test the hypothesis that shipbreaking workers have experienced an increased risk of neoplasm, particularly for asbestos-related cancers, after a 24-year follow up.

2. Methods

2.1. Study population

A 24-year retrospective study design was adopted for this study. The study's subjects were members of the 1985 Kaohsiung Shipbreaking Workers Union who participated in the state-run Labor Insurance Program. These workers were registered in the Union in order to be covered by insurance. A total of 70% of workers employed in the shipbreaking industry were members of the Union during this period. The Union kept employment records for each worker, including birth date, gender, job title, and employment period. The whole cohort, between 1975 and 1989, comprised 4962 workers. This number included 4157 men and 805 women. Female workers were excluded from this study because of their relatively small sample size and low cancer incidence numbers ($n=69$). The researchers also excluded two male shipbreaking workers who were diagnosed with cancer before employment. A total of 4155 male shipbreaking workers were used in this study. In order to qualify, these participants must have been employed for over a year and the date of their first employment in the shipbreaking industry must have begun in 1975. The Institutional Review Board of National Health Research Institutes, Miaoli County, Taiwan, approved this study.

2.2. Data sources for outcomes

Information on new cases of cancer was obtained from the Taiwan Cancer Registry (TCR), which was established in 1979 to monitor the incidence and the mortality rates of cancer in Taiwan (Bureau of Health Promotion, 2013). All hospitals with more than 50-beds and that provided outpatient and hospitalized cancer care were required to report all newly diagnosed malignant neoplasms to the registry. Under the current system, the TCR captures 97% of cancer cases in Taiwan (Bureau of Health Promotion, 2013). The percentage of Death Certificate Only Cases (DCO%) and the percentage of Morphologically Verified Cases (MV%) help indicate if the cancer registry is of good quality. High data quality represented by a DCO% would be 0% and MV% would be 100% (Bray and Parkin, 2009). The DCO% of the cancer cases in the TCR decreased from 8.78% in 1998 to 0.85% in 2010 (Bureau of Health Promotion, 2013). The MV% ranged from 87.5% in 2002 to 91.11% in 2010 (Bureau of Health Promotion, 2013). These indices show that the quality of the TCR is comparable to other well-established cancer registries in the world (Bray and Parkin, 2009; Shin, 2008). TCR has been frequently used as a quality measure or benchmark in cancer epidemiological studies (Chen et al., 2002; Lee et al., 2010; Tsai et al., 2013). The cancer found in participant records was coded based on the *International Classification of Diseases for Oncology, Third Edition (ICD-O3)*.

In the present study, the deterministic record linkage strategy was used to pick Personal Identification Numbers (PINs) for the study subjects as their unique identifiers. Records that share the same value identified the same person. Using each worker's PIN, researchers were able to link 377 newly diagnosed cancer cases from shipbreaking workers in the last 24 years (1 January 1985 to 31 December 2008) to the TNCR. To account for any latency period reflected in occupation exposure that could have been etiologically responsible for the cancer incidence, this analysis only included cancer incidence that occurred 5 and 10 years after the first day of employment (Silva, 1999).

2.3. Exposure scores for asbestos

The majority of the workforce in the shipbreaking industry consists of flame cutters, odd-jobbers, lifters, supervisors, knockers, sorters, drivers, and administrators. Flame cutters are reported to have the most severe exposure to hazardous substances because many of them perform their tasks in confined spaces or within close proximity to asbestos-related emissions (Krstev et al., 2007). After cutting, flame cutters collect and pack the pieces of the ship that they cut. They pass these pieces to the odd-jobbers who then continue with their respective tasks of