Science of the Total Environment 542 (2016) 1–11

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Predicting the mortality from asbestos-related diseases based on the amount of asbestos used and the effects of slate buildings in Korea

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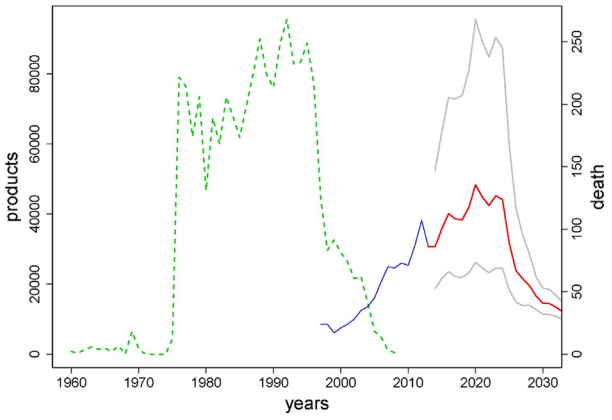
HIGHLIGHT

- There is no previous study on the mortality of asbestos-related diseases in Korea.
- Thus, we aimed to predict the future mortality from asbestos-related diseases.
- In particular, this study also investigated the effects of asbestos-containing slate.
- The results showed that the mortality is expected to peak in 2020.
- The databases created are expected to contribute to policies regarding compensation.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 2 June 2015
Received in revised form 13 October 2015
Accepted 23 October 2015
Available online xxxx

Editor: D. Barcelo

Keywords:
Asbestos
Asbestos-related diseases
Mortality
Slate building

ABSTRACT

Asbestos has been used since ancient times, owing to its heat-resistant, rot-proof, and insulating qualities, and its usage rapidly increased after the industrial revolution. In Korea, all slates were previously manufactured in a mixture of about 90% cement and 10% chrysotile (white asbestos). This study used a Generalized Poisson regression (GPR) model after creating databases of the mortality from asbestos-related diseases and of the amount of asbestos used in Korea as a means to predict the future mortality of asbestos-related diseases and mesothelioma in Korea. Moreover, to predict the future mortality according to the effects of slate buildings, a comparative analysis based on the result of the GPR model was conducted after creating databases of the amount of asbestos used in Korea and of the amount of asbestos used in making slates. We predicted the mortality from asbestos-related diseases by year, from 2014 to 2036, according to the amount of asbestos used. As a result, it was predicted that a total of 1942 people (maximum, 3476) will die by 2036. Moreover, based on the comparative analysis according to the influence index, it was predicted that a maximum of 555 people will die from asbestos-related diseases by 2031 as a result of the effects of asbestos-containing slate buildings, and the mortality was predicted to peak in 2021, with 53 cases. Although mesothelioma and pulmonary asbestosis were considered as asbestos-related diseases, these are not the only two diseases caused by asbestos. However the results of this study are highly important and relevant, as, for the first time in Korea, the future mortality from asbestos-related diseases was predicted.

Abbreviations: AIC, Akaike information criterion; BIC, Bayesian information criterion; GPR, generalized Poisson regression; KCD, Korean Standard Classification of Diseases.

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http://dx.doi.org/10.1016/j.scitotenv.2015.10.115

These findings are expected to contribute greatly to the Korean government's policies related to the compensation for asbestos victims.

1. Introduction

Asbestos has been used since ancient times, owing to its heat-resistant, rot-proof, and insulating qualities, and its usage rapidly increased after the industrial revolution, as a result of the introduction of the steam engine (Becklake, 1976). In the 1940s, the global consumption of asbestos significantly increased, peaking in the 1980s (Virta, 2006). However, the risks associated with asbestos and the related diseases have been known since the 1960s (Selikoff et al., 1964), and as it became established that asbestos causes incurable illnesses such as pulmonary asbestosis, mesothelioma, and poor-prognosis lung cancer after a latent period of 20–50 years, the International Agency for Research on Cancer classified asbestosis as a class 1 carcinogen (Doll et al., 1985). Due to its harmfulness, many countries, including the United States and Japan, have prohibited its use since the 1990s, and its consumption has steeply decreased worldwide (Bahk et al., 2013). In Korea, asbestos has been imported since the 1960s, with the highest record of import, at 95,000 metric tons, in 1992; however, since then, its use has been continuously declining (Kim et al., 2009). In addition, after the amendment of the Industrial Safety and Health Act in 1990, which classified asbestos as a harmful substance, its use needed to be approved by the government. Finally, in 2009, the use of asbestos was completely prohibited, owing to the amendment of the Enforcement Decree Act (The Ministry of Environment of Korea government, 2009). Since the establishment of the Asbestos Injury Relief Act, the South Korean government has been providing medical and living expenses to asbestos-related patients. Moreover, the Asbestos Safety Management Act, which legislates the safety management of asbestos that has already been used, has been recently established (Kim et al., 2014).

In Korea, approximately 96% and 82% of the asbestos imported in the 1970s and 1990s, respectively, was used for making slates (Paek et al., 1998). All slates made in Korea during this time period comprised approximately 90% cement and 10% chrysotile (white asbestos) (Kim et al., 2010). From the 1970s to 1990s, these slates were widely used in the construction sector; over time, their surfaces have become damaged by climate-related changes (Bornemann and Hildebrandt, 1986). These fibers are also released into the air when buildings containing asbestos are damaged due to an impact (Kim et al., 2015), and this can cause serious problems to people who live in or close to them (Pastuszka, 2009). In fact, in Korea, the people who did not have jobs related to handling asbestos but who live or lived in buildings made of slates have been diagnosed with mesothelioma and lung cancer due to releasable asbestos content in the slates (Jung et al., 2006). Accordingly, in Korea, old slates are being removed; however, residual slates are still a serious social problem.

In the United States, where the amount of asbestos used is the largest in the world, and where it has been used for a long time, serious damages and aftermath from asbestos use have been reported, and these effects were recognized as a health crisis in the 1970s (Carroll et al., 2005). Asbestos has also been forecasted to become a serious social and public health issue in Asian countries, including China, and, in particular, health problems due to asbestos exposure are on the rise in Japan (Harris and Kahwa, 2003). In this way, the mortality from asbestos is predicted to increase worldwide. At present, developed countries, including the U.K. and Italy, are actively conducting studies related to the prediction of the mortality from asbestos-related diseases, and are proactively addressing the need for compensation for these patients (Girardi et al., 2014; Health and Safety Laboratory, 2009). However, few studies on forecasting the mortality from asbestos-related diseases have been performed in Asian countries. Moreover, except for Japan, Singapore, Korea, and Sri Lanka, no Asian countries have identified the current status of asbestos-related diseases in the respective country (Korea Occupational Safety and Health Agency, 2008). In particular, no study has been performed on the mortality from asbestos-related diseases in Korea.

In Korea, observation on the mortality from asbestos-related diseases started in 1997, and the number has been continuously rising. Therefore, to address the damages caused by asbestos-related diseases, this study aimed to predict the future mortality from asbestos-related diseases in Korea based on the amount of asbestos used and the overall reported mortality, for the purpose of asbestos-induced injury compensation. Moreover, the future mortality was predicted according to the amount of asbestos contained in slates, which, as mentioned above, were known to release large amounts of asbestos fibers. To achieve these aims, first, this study analyzed data on the causes of death, provided by Statistics Korea, and identified the asbestos-related deaths between 1997 and 2013. In the second phase, the total amount of the asbestos used was identified by adding the import and production output of asbestos provided by the Korea Customs Service. In the third phase, based on the previous mortality from asbestos-related diseases and the total amount of asbestos used, this study predicted the future mortality from asbestos-related diseases and mesothelioma in Korea through a generalized Poisson regression (GPR) model using "R" software. Lastly, by analyzing these data according to the amount of asbestos contained in slate buildings, it forecasted the future mortality from asbestos-related diseases due to the effects of slate buildings. This study is particularly meaningful as it is the first study forecasting the future mortality from asbestos-related diseases in Korea, and since no study related to this topic has been performed in this country. The result of this study is thought to contribute greatly to the Korean government's policies related to compensation for asbestos victims in the future. Furthermore, it is expected to contribute substantially to the methodologies for forecasting the mortality from asbestos-related diseases due to the effects of slate buildings in many countries. Fig. 1 shows a diagram of the study flow.

2. Theoretical consideration and application

In order to achieve the purpose of this study, this section provides an overview of asbestos and slate, an asbestos-containing material, through an extensive literature review. Subsequently, it reviews the import and export statistical data provided by the Korea Customs Service and the data on the causes of death from Statistics Korea to organize the mortality from asbestos-related diseases and the total amount of asbestos used up until now into a database. Further, the feasibility of the building register, which summarizes the information of all structures in Korea, as a means to organize information on slate buildings into a database, is considered. Lastly, it explains the GPR model used in this study to predict the mortality from asbestos-related diseases.

2.1. Overview of slate and asbestos-containing materials

Asbestos, which is a kind of igneous rock, is a silicate mineral classified into two groups: serpentine and amphibole (Becklake, 1976). Asbestos was extensively used as a building material after the 20th century owing to its chemical stability and nonflammable, fire-resistant, heat-resistant, preservative, and insulating qualities and high tensile strength (Kim, 1991). More than 90% of the asbestos used worldwide was used in the making of asbestos cement sheets and pipes (Ramazzini, 2010). In Korea, approximately 80% of the imported