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Original Article

Estimates of the Number of Workers Exposed to Diesel Engine Exhaust in South Korea from 1993 to 2013

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ABSTRACT

Background: The aim of this study was to estimate the number of workers exposed to diesel engine exhaust (DEE) by industry and year in the Republic of Korea.
Method: The estimates of workers potentially exposed to DEE in the Republic of Korea were calculated by industry on the basis of the carcinogen exposure (CAREX) surveillance system. The data on the labor force employed in DEE exposure industries were obtained from the Census on Establishments conducted by the Korea National Statistical Office from 1993 to 2013. The mean values of prevalence rates adopted by EU15 countries were used as the primary exposure prevalence rates. We also investigated the exposure prevalence rates and exposure characteristics of DEE in 359 workplaces representing 11 industries.
Results: The total number of workers exposed to DEE were estimated as 270,014 in 1993 and 417,034 in 2013 (2.2% of the total labor force). As of 2013, the industry categorized as “Land transport” showed the highest number of workers exposed to DEE with 174,359, followed by “Personal and household services” with 70,298, “Construction” with 45,555, “Wholesale and retail trade and restaurants and hotels” with 44,005, and “Sanitation and similar services” with 12,584. These five industries, with more than 10,000 workers exposed to DEE, accounted for 83% of the total DEE-exposed workers. Comparing primary prevalence rates used for preliminary estimation among 49 industries, “Metal ore mining” had the highest rate at 52.6%, followed by “Other mining” with 50.0%, and “Land transport” with 23.6%.
Conclusion: The DEE prevalence rates we surveyed (1.3–19.8%) were higher than the primary prevalence rates. The most common emission sources of DEE were diesel engine vehicles such as forklifts, trucks, and vans. Our estimated numbers of workers exposed to DEE can be used to identify industries with workers requiring protection from potential exposure to DEE in the Republic of Korea.

1. Introduction

Diesel engines power a large portion of land and sea transport and generate the electricity required in numerous farming, construction, and industrial activities [1]. Exposure to diesel engine exhaust (DEE) is currently widespread due to the increasing volume of motor vehicles and machinery using diesel fuel. DEE consists of hundreds of gas-phase, semivolatile, and particle-phase organic compounds that are produced through the combustion of this fossil fuel [1].

In 2012, based on sufficient available evidence that exposure to it is associated with an increased risk for lung cancer, DEE was

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reclassified by the International Agency for Research on Cancer (IARC) from probably carcinogenic to humans (Group 2A) to carcinogenic to humans (Group 1) [2]. IARC also noted that DEE has a positive association (based on limited evidence) with an increased risk of bladder cancer.

One of the major challenges in occupational cancer prevention is a lack of knowledge regarding precisely where carcinogenic exposures are occurring and the number of workers affected. To create an exposure surveillance system supporting the effective prevention of occupational cancer, it is necessary for a country to build a basic database to perform surveillance on the number of workers exposed to carcinogens and their distribution according to type of industry, occupation, and other exposure variables. The carcinogen exposure (CAREX) system is an international information system for estimating the numbers of workers exposed to known (Group 1) and suspected (Group 2A) carcinogens as classified by the IARC. Estimates on occupational exposure to carcinogens in the European Union (EU) in the 1990s, including DEE, have been published [3,4]. CAREX was subsequently adapted to serve as a carcinogen exposure surveillance system in several countries [5–7]. No estimates have as yet been produced for Asia, including for the Republic of Korea.

The aims of this study were to estimate the number of workers exposed to DEE by industry and by year in the Republic of Korea using the CAREX method, to compare our estimates with results from other countries in which the CAREX method has been applied, and to investigate the DEE prevalence rate for several industries.

2. Materials and methods

The CAREX surveillance system has already been fully explained elsewhere [3–6]. A brief description of the assessment procedures used to estimate the number of workers exposed to DEE in this study is presented here as Fig. 1.

Firstly, all industries projected by the CAREX results from the 15 EU countries were listed. The 49 industries with an exposure prevalence rate were first referred to as “industries with the possibility of DEE exposure” (hereafter referred to as DEE exposure industry). Industries with an International Standard Industrial Code (ISIC) revision 2 were reclassified according to the three-digit level of the Korea Standard Industrial Classification (KSIC) revisions 8 and 9. Some nonmanufacturing sectors were classified at the one- or two-digit levels.

Secondly, data on the labor force employed in DEE exposure industries were obtained from the “Census on Establishments” (a nationwide annual census on the characteristics of enterprises with one or more employees doing business in Korea) conducted by the Korea National Statistical Office from 1993 to 2013 [8]. The industrial classes of the labor force from 1993 to 2005 and from 2006 to 2013 were coded at the three-digit level of KSIC revisions 8 and 9, respectively. These labor force figures cover all workers, including self-employed workers, working family members, and part-time workers.

Thirdly, the estimates of workers potentially exposed to DEE were calculated on the basis of the CAREX system, multiplying the labor force by the primary prevalence rate of the industry concerned. In this study, we used the mean value of prevalence rates adopted by the EU15 countries as the primary prevalence rate for estimation of DEE exposure.

Finally, our field investigation of DEE exposure rates from 11 DEE exposure industries were compared with those estimated for EU countries. We investigated 359 workplaces where workers were exposed DEE in order to obtain DEE exposure prevalence rates. Because of the lack of airborne DEE levels or industrial hygiene data to assess DEE exposure, we qualitatively assessed DEE exposure among the overall workforce in terms of the workers involved, how, and what type of job. Workers who drive diesel vehicles or work near the operation of such vehicles or who work in a space where diesel fuel is used by vehicles or mechanical instruments were considered workers exposed to DEE. Exposure to DEE over more than 75% of the working hours was regarded as the minimum DEE exposure duration guideline as indicated by the CAREX system. The surveyed prevalence rates were compared with the primary prevalence rates.

3. Results

3.1. Number of workers exposed to DEE by industry and year

The number of workers exposed to DEE from among the total labor force and in DEE exposure industries has been on the rise from 1993 until 2013 (Fig. 2). The total number of workers exposed

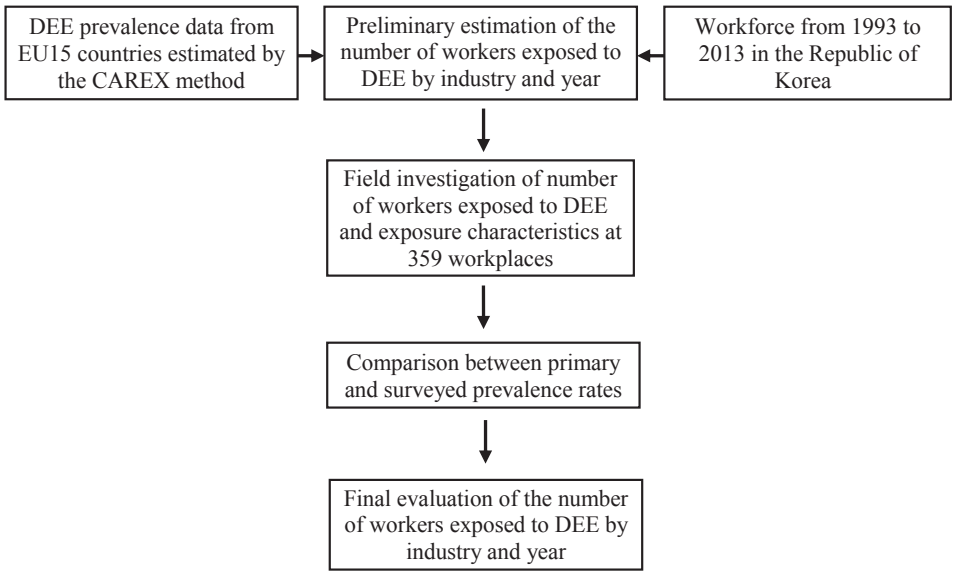

Fig. 1. Procedure for estimating the numbers of workers exposed to diesel engine exhaust (DEE) in the Republic of Korea. CAREX, carcinogen exposure system; EU, European Union.

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