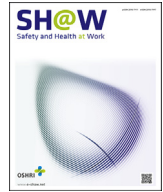




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Original article

Management and Collection of Occupational Data for Health (ODH) in National Public Health Statistics: Evaluation and Recommendations for Korea



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ABSTRACT

Background: The aims of this study are to examine how occupation-related data and information for health (ODH) are collected and managed from census-based surveys and potential occupational illness and injuries (POIs) statistics, and to propose a national strategy for the systematic collection, analysis, and management of ODH by building on the Korean Standard Classification of Occupation (KSCO) and using a job exposure matrix (JEM).

Methods: The status of the collection and management of ODH registered as national statistics, drawn not only from the census-based general population and workforce, but also from POIS statistics was reviewed and evaluated.

Results: ODH from the Republic of Korea's Census of Population and Labor Force are collected and classified according to the KSCO. In contrast, national statistics on POIS are not systematically collected for KSCO coding, reflecting the lack of an KSCO and related guidelines on how to collect ODH. Key frameworks for the construction of both an KSCO and a reference JEM for public health surveillance are proposed.

Conclusions: Further research is needed to develop a national system for collecting and managing ODH, which will ultimately contribute to the use of a national KSCO and the construction of JEM for public health surveillance.

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1. Introduction

Considering that an average worker works eight hours a day for roughly 40 years, exposure to different work environments plays a significant role in health outcomes [1]. Understanding the impact of occupation-related factors on the development of potential occupational illnesses, and injury, including cancers and injuries (POIs), is critical to both occupational health and public health disease surveillance. Socioeconomic status (SES) is strongly correlated with health and nutrition outcomes, with lower SES often associated with higher rates of chronic disease and poorer diet quality due to limited access to nutritious foods and healthcare resources [2,3]. The occupational contribution and effect on cancer risk, including deaths, have been widely estimated using the standardized incidence ratio (SIR), standardized mortality ratio (SMR), and population attributable fraction (PAF). These types of epidemiologic studies require the proportion of POIs in a population due to specific exposures over a period of time, thus quantifying the impact or adjustment of an occupational risk factor on public health, systematically categorized by type of disease and standardized occupation, such as standardized occupational classification (SOC) and the International Standard Classification of Occupations (ISCO) (hereafter referred to as Republic of Korea SCO). The KSCO provides a standardized system for categorizing occupations, facilitating consistent data collection and analysis across regions and countries, identifying and monitoring work-related diseases, and informing targeted health and safety interventions.

To our knowledge, there has been a lack of research and government reporting on how occupation affects POIs incidence and economic burden in the Republic of Korea (Republic of Korea), which is common in several developed countries [4–7]. The objectives of this study are to review the current status of the management and collection of occupation-related data and information for health (ODH) not only from the general population or workforce, but also from patients with POIs, and to propose a national approach to the systematic collection, analysis, and management of ODH, ultimately contributing to the use of a KSCO and construction of a job exposure matrix (JEM) in the national public health surveillance system. JEMs are essential tools that systematically link occupational exposures to specific jobs, facilitating the assessment and surveillance of POIs. Their use allows the identification of exposure-disease relationships, supporting targeted occupational health interventions and policy development [8–10].

2. Methods

2.1. Evaluation and selection of national population surveys and records of patients with POIs

This study summarizes key methods from selected national surveys and POIs databases that focus on collecting and classifying ODH from the general population, cancer patients, and injury victims. A total of six national census survey statistics (Tables 1 and 2) and five POIs databases (Table 3), including those related to cancer and compensated work injuries, were selected based on their relevance to occupational and public health surveillance, such as their ability to estimate the prevalence of work-related symptoms, injuries, and cancers using standardized occupational classifications. The selection process for these surveys and databases was subjective and not based on scientific criteria from the literature review. Key aspects, including the responsible organization, project objectives, occupational data, occupational coding, and strengths and limitations of the integration of KSCO and JEM, were summarized and evaluated. Information on the current status and evaluation of these surveys was obtained from Statistics Republic of

Korea (<https://www.k-stat.go.kr/metasvc/msaa100/search>) by searching the selected national project surveys. For example, national population or labor force surveys are conducted periodically by governments or research organizations to better understand the population, including labor force dynamics and to assess the prevalence of exposure to various public health problems related to occupations, environmental hazards, demographic characteristics, and diet, and to make necessary adjustments (Tables 1 and 2). National statistics on POIs obtained from various public health organizations and surveys, including hospitals, are used to provide data on the association and causality of POIs, including cancer, with occupations classified under the KSCO.

2.2. Recommendations for standardized collection and management of ODH from both the national census and POIs statistics-based on KSCO and JEM

Based on our findings, we proposed several key frameworks for the national management and collection of ODH in public health disease surveillance systems. These frameworks include strategies for the effective collection and analysis of ODH, not only from the general population and the workforce, but also from patients with POIs. This comprehensive approach is intended to support the development of a national KSCO and JEM system so that ODH can be linked to the public health surveillance system.

3. Results

3.1. Current status of collection of ODH from the general population or labor force census survey

Statistics Republic of Korea collects ODH in the census, categorizes them from major groups down to unit groups following the International Labour Organization's ISCO [11], and publishes the results (Table 1). They provide insight into the number of national workers classified by KSCO over time. The Korea Occupational Safety and Health Agency (KOSHA) has conducted a survey of around 50,000 workers in Republic of Korea aged 15 years and older to assess employment and working conditions related to occupational safety and health, classifying ODH up to the KSCO unit group [12]. The national population and labor force census statistics in Republic of Korea can be used to estimate the exposure prevalence rate among occupations classified by the KSCO in principle (Table 2). Work-related information in the Korean National Environmental Health Survey (KoNEHS) and the Republic of Korea National Health and Nutrition Examination Survey was not collected according to the standard codes, resulting in a lack of ODH adjustment for the effects of various dietary, demographic, and chemical exposures. The reliability of these census survey results classified by Republic of Korea Standard Industry Classification (KSIC) and KSCO for the national workforce exposed to various occupational hazards remain unconfirmed.

3.2. Current status of the collection of ODH from patients with POIs and compensated occupational accident cases, including cancers

No case statistics have been established for systematic collection for KSCO coding, showing the lack of a standardized system and guidelines for ODH classification from POIs cases (Table 3). Cancer registry statistics, which combine SES, demographic, and clinical information on POIs collected from hospitals, classify occupations into nine broad categories, including “unclassified,” which is not coded with a KSCO code. The Ministry of Employment and Labor (MOEL) in Republic of Korea annually provides statistics on

Table 1

Overview of the methods used to collect and manage ODH from national population and labor force surveys

Project name ^a	Organizing body	Project goals	Key occupational questions	Year initiated (Survey frequency)	Survey methods	Data collection methods	Published results with the level of the job classification	Occupation coding levels
Population Census	Statistics Republic of Korea	Provide essential data for informed decision-making by governments, businesses and researchers	1) Industry: company name, business type 2) Occupation: department/division, position/role, duties description 3) Years in current occupation 4) Major workplace: various workplace types	1925 (Annual census, sample survey every five years)	Door-to-door interviews, internet and telephone surveys conducted first, followed by in-person interviews using tablets for non-respondents	Jobs briefly described by the enterprise and number of workers, coded with KSCO codes.	Yes: Major one-digit KSCO code	Major groups (10), Sub-major groups (52), Minor groups (156)
KWCS: Korean Working Conditions Survey	OSHRI	Identify health risk factors in the work environment	What were your tasks last week? 1) Description of duties 2) Company name (job position) 3) Workplace (or department name)	2006 (Every three years)	Targets 50,000 households (one person per household), totaling 50,000 employees	Jobs briefly described by subjects and coded by researchers	Yes: Major one-digit KSCO code	Major groups (10), Sub-major groups (52), Minor groups (156), Unit groups (450). Up to four digits (unit group) coded.
KoNEHS	NIER	Provide data for national environmental health policy and contribute to public health	1) Your occupation? 2) Longest-held job?	2005 (Every three years)	426 households nationwide, 6,381 participants/ Questionnaire, clinical tests (21), environmental chemical exposures in biospecimens (33)	Jobs briefly described by subjects, coded by researchers. No short text on occupation or work	Not specified	Not specified.
KNHANES	KDCA	Study population health and nutrition status to plan national health improvement policies	1) Current occupation? 2) Position, shift type, working hours, work type (regular/ irregular) 3) Longest-held occupation?	1998 (Yearly)	Around 14,400 households nationwide	Major two-digit Korean Employment Occupational Classification code selected, describing job and work. No short text on occupation or work	Yes: Major one-digit KSCO code	Major group (10)
Occupational Labor Force Survey	MoEL	Identify employee shortages by industry, and occupation for employment policies	Jobs briefly described by business and number of workers, coded with KECO codes	1976 (Semiannual)	Around 72,000 sampled businesses with one or more employees	Jobs briefly described by enterprise and number of workers employed in the job and coded with KECO code	Yes: Minor groups (three-digit) KECO code	Major groups (10), submajor groups (52), minor groups (156), unit groups (450)

Local Area Labor Force Survey	Statistics Republic of Korea	Provide employment structure data, including industry and occupation, by region	1) What was your job during the surveyed week? 2) What was your job title?	2008 (Semiannual)	Survey unit: household Target population size: Approx. 234 thousand households	Respondents describe their job and work, coded using the KSCO	Yes: Major one-digit KSCO code	Major groups (10), submajor groups (51), minor groups (153)
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Abbreviations: ISCO, International Standard Classification of Occupations; the classification of industries and occupations in Republic of Korea, called KSIC and KSCO, follows the international standard classification; KECO, Republic of Korea Employment Classification of Occupation; KDCA, Republic of Korea Disease Control and Prevention Agency; KNIHANS, Republic of Korea National Health and Nutrition Examination Survey; KoNEHS, Korean National Environmental Health Survey; MoEL, Ministry of Employment and Labor; NIER, National Environmental Science Institute; OSHRI, Research Institute for Occupational Safety and Health (under the Ministry of Labor and Employment).

* Reference sources are obtained from Statistics Republic of Korea (<https://www.k-stat.go.kr/metasvc/msaa100/search>) by searching the selected national project name.

occupational accidents, including occupational diseases, categorized by classified for compensation, but not by KSCO [1].

3.3. Recommendations for standardized collection and management of ODI from both the national census and POIs statistics

One of the most important factors in collecting occupational histories from the national survey for estimating occupational exposure prevalence by KSCO code is to include simple but integrated questions:

- When, where, and for how long were you employed?
- What specific tasks and roles did you perform?

One of the most important factors in collecting occupational histories from national surveys to estimate occupational exposure prevalence using the KSCO code is the inclusion of simple yet integrated questions. It is important to keep the questions as simple and comprehensive as possible to ensure that they can be easily collected and matched to both KSCO and JEMs. The responses from the general population and from patients with POIs to key ODH questions were matched, classified, and incorporated into specific categories of the KSCO (Fig. 1) and referenced JEMs for specific hazardous agents (Fig. 2). Key job histories from individual responses to the ODH questions were matched with similar job exposures from the reference JEMs, which were constructed based on the combination of specific jobs, hazardous agents, and occupational exposures. These matched JEMs can be considered representative of the exposure characteristics of individuals and patients with POIs. This study recommends a key framework for the development of a reference JEM that could be used to assess the exposure characteristics of the general population, including patients with POIs, using key occupational and job histories obtained from national surveys and statistics. The reference JEM for specific hazardous agents can be constructed by incorporating extensive databases from various occupational health activities conducted in Republic of Korea (Table 4 and Fig. 2).

4. Discussion

This study found that there has been a lack of a national ODH database system classified by KSCO among health organizations in Republic of Korea or research on how occupation is associated with POIs, particularly occupational cancer and various accident injuries (Tables 1 and 2). To estimate the association and causation of POIs with jobs or occupations, a national system and related policies should be developed to systematically collect and manage ODH for both the general population, occupational accident injury victims, and cancer patients. This study discusses the framework for building large national systems in Republic of Korea to systematically collect and manage ODH throughout an individual's working life. These systems can be incorporated into KSCO (Table 4 and Fig. 1) and even be aligned with reference JEMs associated with specific jobs (Fig. 2).

Firstly, the MOEL in Republic of Korea needs to develop a customized KSCO that reflects the unique aspects of Korean workplaces and occupations and recommend it to other national health-related organizations and research institutions for use in compiling ODH in a harmonized manner. Unlike in regions such as the United States [13] and the United Kingdom [14], Republic of Korea does not currently have national statistics on cases with POIs, classified by KSCO. Existing data collection and occupational categorization methods in national public health statistics are inadequate for accurately determining the risk and burden of

Table 2
Evaluation of key methods for collecting and managing work-related data from national general population and labor force surveys and statistics, with a focus on estimating the prevalence of occupational exposures

Project name	Data availability for occupational exposure estimation	Strengths of work and job-related data	Limitations of work and job-related data
Population Census	Single-digit major group data are published; for detailed occupational exposure analysis, four-digit coding is needed.	Survey responses allow jobs to be classified into submajor (two digits), minor (three digits), and detailed unit groups (four digits), enhancing the analysis of exposure similarity.	1) Occupations are coded up to four digits, but only nine major groups have been published. 2) KSCO is not used to link these results to specific cases of cancer or other diseases.
Korean Working Conditions Survey	Published single-digit major groups are insufficient for linking occupations to health effects. Detailed four-digit codes are needed for analysis.	1) Identify detailed information on work environment, tasks, duration, shifts, and job satisfaction. 2) Estimate the prevalence rate of work-related injuries and health-related symptoms and diseases across detailed occupation levels.	Occupations are coded up to four digits, but only nine major groups are published. This limits the study of health effects and symptoms associated with occupational exposure, as there is a lack of exposure similarity among the single-digit occupational groups ($n = 10$).
KoNEHS	Currently, there is no standardized data available on job classifications, making it impossible to consider occupational impacts in population nutrition studies.	1) Data on key chemical exposures is available, including results from 21 clinical tests and 33 environmental chemical analyses in biospecimens. 2) With KSCO information, the impacts of occupations on environmental chemical exposures and related health symptoms can be analyzed.	Due to the lack of KSCO coding, there is limited ability to study the effects of occupation on environmental chemical exposures and health symptoms.
KNHANES	There is no current access to a standardized system for occupational survey and coding. This absence means current data cannot be adjusted for occupational impacts in population health and nutrition studies.	Comprehensive nutrition and health status information are provided, collected through face-to-face interviews conducted across 192 regions, with 23 households per region, totalling 4,416 households.	No published KSCO-coded ODH. Limited ability to analyze occupational effects on diet and health symptoms due to KSCO absence.
Occupational Labor Force Survey	Occupations are detailed up to four digits, with 52 submajor groups published, enabling specific occupational exposure estimation.	1) Detailed occupational classification up to submajor (two digits), minor (three digits), and unit groups (four digits) 2) The data allows for studying the impact of occupation on diseases, including cancer and health symptom effects.	The results cannot be linked to specific cases of cancer or other diseases using KECO-coded occupations.
Local Area Labor Force Survey	Occupations are coded in detail up to four digits, and minor groups with three-digit codes (130 categories) have been published, enabling accurate estimation of specific occupational exposures.		KSCO coded occupations cannot be utilized to link these results to specific cases of cancer or other diseases.

Abbreviations: KSCO, follows the international standard classification; KNHANES, Republic of Korea National Health and Nutrition Examination Survey; KoNEHS, Korean National Environmental Health Survey; ODH, Occupational Data for Health.

POIs, including cancer associated with specific occupations (Table 3). The US Bureau of Labor Statistics (BLS) has developed the US SOC and regularly updates changes in the occupational structure of the US [15]. The development and active use of an KSCO system is essential for effectively examining and adjusting the impact of occupation on public health status, including cancer and occupational injury [16].

Secondly, key ODH data from the general population and patients with POIs, including cancer, should be collected and standardized using similar questions in parallel with national census-based surveys and patient ODH records. (Tables 1–3). In particular, hospitals, physician practices, health plans, and local and state governments across Republic of Korea play an important role in recording, collecting, and incorporating employment and workplace information into existing data and actively using KSCO and building JEM to overcome the challenges of broad major classification or no occupational coding. The Cancer Control Act states that “the Minister of Health and Welfare (MOHW) shall collect and analyze ODH for cancer patients [17]. Healthcare entities face challenges in the collection of key job information, including employment history, from patients, enrollees, members, and respondents. In general, many public health organizations, including hospitals, face health information technology limitations and internal resistance [18] due to the volume of information they must collect and handle. US National Institute of Occupational Safety and

Health provides guidance on incorporating occupational data into electronic health record (EHR) systems, addressing key data elements such as employment status, occupation, and workplace hazards [19]. In Republic of Korea, it is particularly difficult to propose an effective solution because there is currently no infrastructure or management system to support the collection of ODH through EHR. The only proposal under consideration at the time of this study is to require healthcare organizations, including hospitals, to collect employment information from patients as part of the national hospital certification program. Further research is needed to establish public health governance and develop a national system for collecting occupational data from hospitals.

Thirdly, national public health statistics in Republic of Korea, including ODH, should be harmonized to establish at least one KSCO to provide a comprehensive framework for examining POIs health risks by occupation (Fig. 1). UK Health and Safety Executive (HSE) uses the SOC system to monitor and analyze work-related health hazards to guide targeted interventions and health and safety policies [20]. The WHO has recommended that the International Classification of Diseases ICD-11 include occupation as an extension code to be used as supplementary or additional codes for providing more detailed information within statistical categories classified elsewhere [21,22]. Numerous studies have compared observed cancer cases with expected numbers categorized by SOC. They have used SIR and SMR to examine established associations

Table 3

Evaluation of the main methods used to collect and manage work-related data from public health-related national statistics, with a focus on cancer, severe injuries, and compensated industrial accident cases

National project or survey [*]	Responsible organization	Project overview and current status	Limitations based on work and job-related information
Cancer Registration Statistics	Ministry of Health and Welfare	Since 1980, Cancer Registration Statistics has gathered, and analyzed data annually on cancer incidence and prevalence within the national population to presents cancer registration statistics, including cancer incidence, survival rates, and prevalence statistics.	1) Cancer patients are not classified according to standardized occupational classifications such as KSCO, despite the Cancer Prevention Law requiring classification by occupation. Occupations are currently categorized into 9 groups, including “unable to classify” and “unknown.” 2) The annual report of the National Cancer Registry does not include cancer statistics classified by KSCO.
Industrial Accident Statistics	Ministry of Employment and Labor	Since 1975, Industrial Accident Characteristics reports have been compiled quarterly.	1) Absence of a standardized system and guidelines for occupational classification. 2) Limited to studying compensated occupational accidents, including occupational diseases classified by job and occupation, due to the lack of standardization of occupation.
Annual Statistics on Workers' Health Examination Report	Ministry of Employment and Labor	Special health examinations of workers exposed to hazardous substances in workplaces are collected and reported annually (as of 2022, n = 2,453,697).	1) KSCOs are currently coded, but statistics classified by KSCO are not published. 2) Limited to examining occupational health effects and symptoms classified by occupation
National Health Screening Statistical yearbook	National Health Insurance Service	Since 2009, annual efforts have been made to gather basic data for formulating healthcare and health insurance policies.	1) No questions are currently asked to collect information on work, job, and occupation. 2) Limited to the examination of severe injury cases classified by occupation, due to the lack of standardization of occupation and industry.
Emergency Medical Statistics Report	National Medical Center	To provide insights for national policies aimed at improving the emergency patient care system and safeguarding public health through the development of an advanced emergency medical system.	

Abbreviations: KSCO, Republic of Korea Standard Classification of Occupation.

* Reference sources are obtained from Statistics Republic of Korea (<https://www.k-stat.go.kr/metascv/msaa100/search>) by searching the selected national project name.

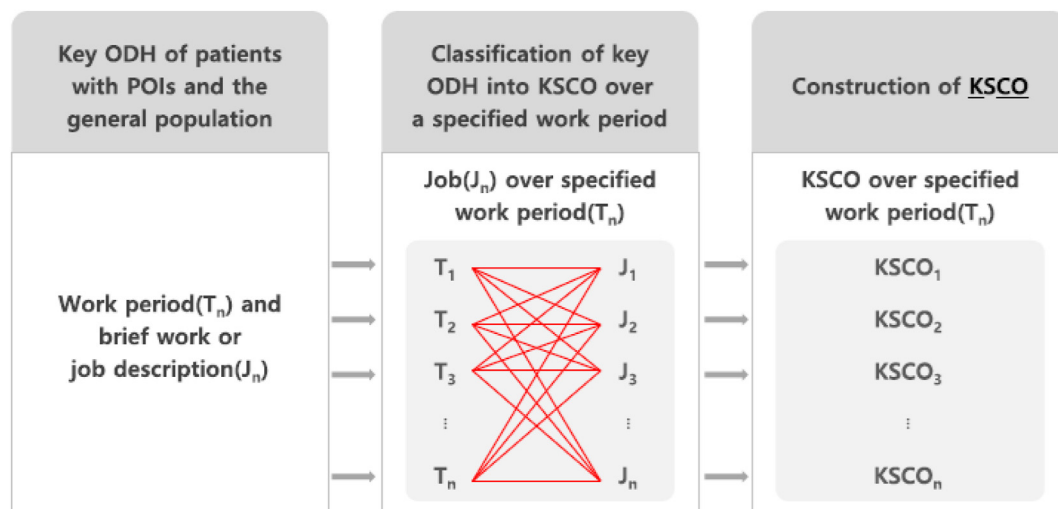


Fig. 1. A schematic diagram for categorizing key occupational data for health (ODH) collected from both the general population and patients with potential occupational illnesses and injury (POIs) into the Republic of Korea Standard Classification of Occupation (KSCO).

between different occupations and cancer risk [23,24]. A 45-year cohort study analyzed occupational cancer incidence in the Nordic countries (Denmark, Finland, Iceland, Norway, Sweden), examining 2.8 million cancer cases classified by country, sex, age,

and occupation, and validated many known occupational-cancer associations using SIR. ODH from the census and cancer patients were obtained through self-administered questionnaires and categorized into 53 standardized occupational groups [6].

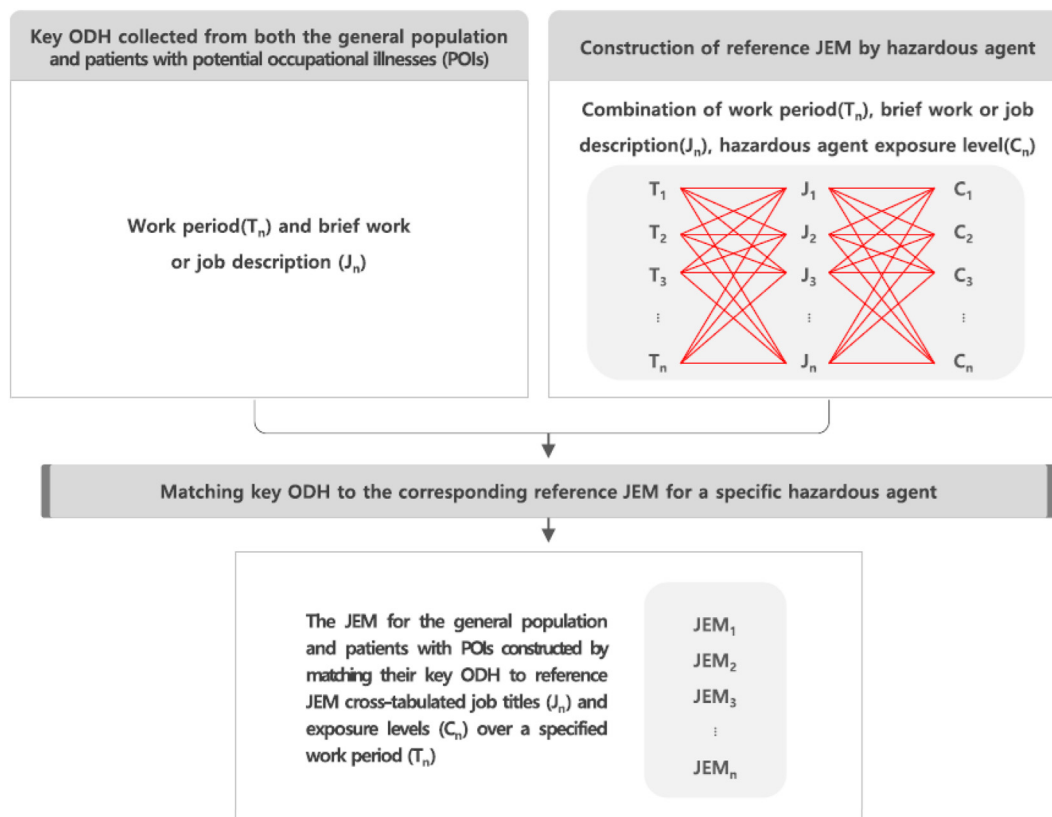


Fig. 2. A schematic diagram matching occupational data for health (ODH) collected from the general population and patients with potential occupational illnesses and injury (POIs) to one of the reference job exposure matrix (JEM) for a specific hazardous agent.

Table 4
Recommendations for the systematic collection, analysis, consolidation, and management of important work-related information from national public health related surveys and statistics

Type of key activities or responsible organization	Specific framework recommended
Collection of occupational and work-related data from victims of occupational injuries, cancer patients, and the general population	Include two key simple questions with free text: 1) When, where, and for how long were you employed? 2) What specific tasks and roles did you perform?
Classification or standardization of occupation and job-related free text information into KSCO	Classification of occupation and job-related free text information into KSCO by either AI or expert input
Statistics Republic of Korea	1) Systematic collection of ODH from the general population and sharing with health-related organizations. 2) Requirement for KSCO-coded occupation groups from major to unit for publication.
Ministry of Employment and Labor	Development of a Standard Occupational Classification tailored to Korean job, occupation, and industry characteristics to adjust occupation as SES and examine its association with disease risk.
Health-related organizations, including the National Cancer Institute	1) Systematic collection of ODH from patients, including cancer and chronic diseases, and coding according to the KSCO standard. 2) Development of guidelines for collecting ODH from cancer patients and disseminating it to hospitals. 3) Standardization of ODH into KSCO by either AI or expert input.
Various national activities, surveys, and health research	Systematic survey, collection, and standardization of ODH in accordance with the KSCO standard.

Abbreviations: KSCO, follows the international standard classification; ODH, Occupational Data for Health; SES, Socioeconomic status.

Assessing association and causality of outcomes based on job title alone, or by using Standard Industrial Classification (SIC) and SOC codes, may be limited due to the heterogeneous nature of occupational exposures. However, SOC may still be useful in identifying and prioritizing key occupations or jobs with specific health risks or higher accident rates, such as welders, cleaners, and firefighters. To improve the accuracy of linking occupational exposures to health outcomes, this study recommends the development and

implementation of a reference JEM for specific hazards in public health surveillance systems.

Finally, further studies to establish a reference JEMs by specific hazardous agent should be conducted to provide the presence and intensity of exposure to hazardous agents that cause potential health risks, including cancer. In Republic of Korea, there is no model, guide, or reference available to show how a government agency, employer, national survey, or health organization can

complete a JEM for their specific SIC, SOC, and ODH. The reference JEM was constructed by cross-tabulation of hazardous agent exposure intensity, industry, and occupation over a specific time period using various occupational health statistics and literature reviews in Republic of Korea can be matched and linked with the same or similar ODH data obtained from the general population and cases with POIs and considered as their exposure characteristics (Fig. 2). This study suggests that a reference JEM can be constructed by using the results of regular work environment measurements, special health examinations, other national occupational health activities, and the results of research of conducted in Republic of Korea since the early 1980s. CANJEM [2], FINJEM [25], and the Nordic Occupational Cancer Study JEM [26] are not only important for occupational health studies in their respective countries, but they also contribute significantly to international research and policy making in this field [27]. The national reconstruction and implementation of a JEM will greatly improve the effectiveness of the national public health surveillance system for understanding and estimating the effect of occupation and exposure to specific hazardous agents on POIs risks, especially cancer.

A major limitation of this study is the inability to assess detailed information on the quantitative reliability, data quality, standardization issues, and population coverage gaps of OHD collected from the national census and cases of POIs for public health surveillance. Specifically, discrepancies in OHD classifications and inconsistencies in data entry between the census and records of patients with POIs in Republic of Korea cannot be verified, which affects the reliability and utility of national public health statistics related to KSCO and JEM. The strength of this study lies in its potential to assist both Republic of Korea and neighboring countries in establishing national statistics on ODH, enabling them to examine the impact of occupation on public health and to create an internationally integrated comparative system. In conclusion, further research is needed to develop a national system for collecting and managing ODH based on harmonized internal approaches. This would ultimately contribute to the establishment of a national SOC and JEM and help to estimate the association and causation of occupation with the risk of POIs, including cancer and occupational accidents.

CRediT authorship contribution statement

Dong-Uk Park: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Kyung Ehi Zoh:** Formal analysis, Data curation. **Yun-Keun Lee:** Project administration, Methodology, Conceptualization. **Hoekyeong Seo:** Resources, Data curation. **Sangjun Choi:** Methodology, Data curation, Conceptualization. **Dong-Hee Koh:** Writing – review & editing, Methodology, Conceptualization. **Jin-Ha Yoon:** Methodology, Investigation, Data curation, Conceptualization. **Kanwoo Yoon:** Writing – review & editing, Methodology, Investigation. **Mo-Yeol Kang:** Writing – review & editing, Validation, Resources, Methodology. **Eun Suk Choi:** Writing – review & editing, Methodology, Investigation. **Jungwon Kim:** Writing – review & editing, Visualization, Investigation, Data curation. **Yangho Kim:** Writing – review & editing, Visualization, Validation, Data curation, Conceptualization. **Domyung Paek:** Writing – review & editing, Supervision, Investigation, Data curation, Conceptualization.

Conflicts of interest

The authors declare no conflict of interest.

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