EAHT
Environmental Analysis Health and Toxicology
eISSN: 2671-9525

OpenAccess
Vol: 35(3), Article ID: e2020017, 10 pages
https://doi.org/10.5620/eaht.2020017

Brief Report

Recommendation for the establishment of a poison control center at the Korea Disease Control and Prevention Agency

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Received: August 24, 2020 **Accepted**: September 10, 2020

Abstract

There is currently no governmental body in South Korea resembling the type of poison center (PC) recommended by the World Health Organization (WHO). All Organization for Economic Cooperation and Development (OECD) member countries except for South Korea maintain such a PC tasked with both preventing poisoning accidents and supporting the prompt treatment of poisoned patients. Such a PC could very possibly have allowed the country to more promptly recognize the widespread wave of humidifier disinfectant (HD) associated health effects, including fatal lung injury and death, that lasted started roughly in 2000 and continued through 2011. Despite this chemical poisoning tragedy, South Korea still lacks a surveillance system to monitor health effects caused by the use and consumption of materials that include products containing chemicals, foodborne pathogens, drugs, pesticides, etc. There have been no legal procedures for examining the potential risk of products or materials manufactured by industry. The reporting of national poisoning data or causes of poisoning, which is near ubiquitous in advanced countries with a PC, has not taken place We recommend that a PC should be established within the Korea Disease Control and Prevention Agency (KDCA). In addition, in order to perform surveillance of poisoning cases across the country, a certain number of regional PCs, including at large hospitals, will also be necessary.

Keywords: Poison control center, Korea Disease Control and Prevention Agency, Chemical poisoning, Health surveillance

Introduction

Poisons are substances that can cause death, injury, or harm to organs, usually by means of chemical reactions or other activity on the molecular scales, when an organism absorbs a sufficient quantity [1]. There are various types of poisoning, such as those due to household products, medicines, pesticides, plants, bites and stings, food, and fumes. Since around the 1950s, poison control centers (PC) have been operated not only to recognize poisoning cases, but also to provide prompt treatment information to hospitals. As of February 2019, forty-seven percent of World Health Organization (WHO) member states maintained at least a single PC [2]. South Korea is the only country without a PC among the 37 Organization for Economic Cooperation and Development (OECD) countries. In the US, there are 56 web-based poison centers established and operated by the American Association of Poison Control Centers (AAPCC) to track cases of poisoning and their sources, including household products, food and beverages, chemicals in the workplace and home, environmental toxins, drugs and medicines, and animal and insect bites and stings [3]. Key regulatory agencies including the Centers for Disease Control (CDC) and the Environmental Protection Agency (EPA) in the US rely on web-based near-real-time information provided by the AAPCC as a core public health surveillance system. Article 45 of the Classification Labelling Packaging (CLP)

Regulation in the EU obliges member states to appoint bodies responsible for receiving information related to emergency health responses [4]. These appointed bodies are often known as a PC [5]. We address key reasons why the establishment of PCs in South Korea is required based on the ongoing humidifier disinfectant (HD) associated health effect tragedy, review the major roles for a PC, and recommend the establishment of a PC to the Korea Disease Control and Prevention Agency (KDCA).

Failure to learn lessons from poisoning cases in South Korea

Humidifier disinfectant (HD) associated health effect disaster

Between 1994 and 2011, several chemicals were widely used as a disinfectant in humidifiers in South Korea without any inhalation toxicological information. In spite of a nationwide wave of health problems involving HD lung disease (HDLI) that occurred every year from around 2000 until 2011, South Korea had no surveillance system in place to recognize the tragedy being caused by HD [6,7]. This HD related health effect tragedy reflects how several governmental bodies, including the KDCA, failed to identify the development of health problems and arrest their spread (Table 1).

Frequent occurrence of hamburger disease

A number of children have been reported to have developed hemolytic-uremic syndrome (HUS) within hours of eating a hamburger in South Korea. They related experiencing stomach pain followed by diarrhea. HUS, also known as "hamburger disease," predominantly affects children [5,8]. Hospitals in South Korea did not carry out culturing and identification of *Escherichia coli O157:H7* for HUS patients and no legal measures have been emplaced in to prevent inadequately prepared food. Five consumers have sued the McDonald's Corporation so far, claiming their children suffered HUS after eating McDonald's hamburgers. Since the 1990s, the infection of children with *E. coli O157:H7*-associated with HUS and diarrhea have been widely reported and traced to contaminated hamburgers at fast-food restaurant chains [5,8]. Such outbreaks of HUS highlight the microbiologic hazards of inadequately prepared food and emphasizes the importance of public health intervention in controlling HUS [9]. Public health surveillance through state-mandated reporting of *E. coli O157:H7* infections as was carried out in Washington State was critical for prompt outbreak recognition and control [10]. Unfortunately, no public health surveillance or related organization is in place in South Korea to collect complaints from citizens who are poisoned by the consumption of consumer products including drugs, household products, and contaminated foods.

Limitations of national surveillance of poisoning

Act on registration, Evaluation, Etc. of Chemical Substances (ARECS) by the Korea Ministry of Environment (MOE)

To best address the effects on human health and the environment of the production and consumption of chemical substances, all processes from the registration and evaluation of a substance's Material Safety and Data Sheet (MSDS or SDS) to the collection of information related to emergency health responses should be legally managed and authorized. It is especially necessary to establish a national surveillance system that monitors acute and chronic health problems occurring due to consumer and industrial products that include chemical substances. The Registration, Evaluation, Authorization, and Restriction of Chemicals (REACH) program of EU requires all companies manufacturing or importing chemical substances in quantities of over a ton per year to register substances with new safety and data information. Such a regulatory framework systematically and comprehensively links the steps from the registration of a chemical substance that has been proven to have toxic effects to the monitoring of incidents of poisoning that could arise from its use. If the risks cannot be managed, authorities can restrict the use of substances in different ways [11].

Act on Registration, Evaluation, Etc. of Chemical Substances (ARECS or commonly called K-REACH) was enacted in South Korea 2015 [12] after the HD associated health effect tragedy. The first step in this regulatory framework requires the registration of information on the toxicity profile of chemicals into a national repository. This is only the beginning of the regulation of chemical substance use. Unfortunately, many experts and the Korea ministry of environment (MOE) tend to focus on enacting legislation that simply addresses this initial stage of chemical management. The MOE and the National Institute of Environmental Research (NIER), which are responsible for protecting human health and the environment from the risks posed by chemicals and chemical products, currently lack a system to evaluate chemical exposure scenarios provided by chemical companies and importers in terms of capacity and/or expertise. They also have no means to monitor an incident or poisoning that has occurred following authorization.

Toxicological information and anticipated exposure scenarios provided by chemical companies can be fundamentally uncertain, and the risks of chemicals in household products are likely to vary according to when, where, how, and by whom the product containing chemicals is used. Thus, even with strict management of both chemicals and chemical products through regulations based on a registration and evaluation process, a wide range of chemical poisonings

or other incidents could inevitably occur. This pitfall highlights the necessity of a surveillance system through which various types of incidents involving poisoning by chemicals and chemical products must be implemented in a post-marketing context after authorization. A national surveillance system is required for the tracking of poisoning and its sources, including household products, chemicals in the workplace and home, environmental toxins, etc. South Korea lacks a monitoring or surveillance system to collect cases of incidents that may arise with the application of toxic chemicals or of chemical products in actual situations. Therefore, it is not surprising that the cases of lung injury caused by HD that occurred continuously every year since 2000 went undetected. Unnoticed chemical risks can increase the number of potential health incidents or outbreaks due to abuse of products or through abnormal exposure or use; for example, people who are biologically susceptible can develop chemical poisoning or incidents even with exposures below the given threshold.

Various types of incidents involving poisoning and its sources should be uploaded to a centralized data system at these poison centers and the data accumulated used to detect outbreaks of poison exposure and clinical trends, allowing for a prompt response based on a nearly real-time system.

Limitations of existing poisoning-related surveillance organizations

Table 1 summarizes key roles of governmental or quasi-governmental organizations in South Korea that are performing surveillance-related work connected to poison. No single organization has been comprehensively responsible for surveillance of poisoning data covering all areas including household products, drugs, pesticides, food, etc. All of these organizations have played a partial role in monitoring poisoning. In addition, no poisoning statistics have been available. This situation hampering the efforts to prevent the spread of health effects is a far cry from other countries where all poisoning statistics are comprehensively collected on a real-time basis and made readily available. (Table 1). The number of poisoned individuals in 2018 within the total Korea population (51,826,059) based on the annual rate from US poisoning statistics (631 per 10,000 as of 2018) [13] would be roughly 326,791.26 (95% confidence interval [CI] = 326,350.94 – 327,232.17).The number of fatal poisonings estimated based on the rate of 4.03 per one million in the US would be 210.73 (95% C I= 199.80 – 222.25). Because of the lack of a PC and related national statistics, a great number of cases of poisoning by the consumption of substances have not been officially reported, properly treated, or could otherwise have been prevented.

Cases of release of chemicals from manufacturing plants

Since around the 1970s, three major chemical industrial complexes have been operating in South Korea. Many industrial complexes in the country, including these, are located near a city or residential area, and accordingly there is a high possibility of exposure of a large population to chemicals in the case of incident involving a chemical release. Thousands of chemicals surround us while we are at home, work, school, and play. However, very little information exists about these chemicals and the potential threat they pose to the public when they are spilled and released [14]. Chemical facilities store or use hazardous substances that could kill or cause serious harm to workers or the nearby public if they were released. South Korea has suffered chemical release accidents both large and small, including the release of hydrogen fluoride (HF) in Gumi in 2012, dichloromethane in Ochang in 2019, and various chemicals at the Daesan chemical industry complex. There is an increased risk among the general public to exposure from spills and releases along corridors used to transport toxic substances. Additionally, changes in zoning requirements and the urban sprawl that has occurred in many cities have left large industries in proximity to residential areas, increasing the potential for exposure of the public when a toxic spill occurs [15,16]. Should chemicals be released from chemical plants, a control tower is required to promptly guide real-time detoxification treatment at hospitals, which varies according to the types of chemicals involved. Large volumes of information on thousands of chemical poisons should be available for provision to the hospital by the PC. The US National Toxic Substance Incidents Program (NTSIP) is aimed at establishing a national surveillance system for the identification of hazardous substance spills and shares hazardous spill data through a variety of sources with other governmental bodies, including the US PC. A total of 14,175 total toxic chemical incidents were reported across the United States in 2013 [17]. Of the total incidents, about 64.3% occurred at fixed facilities such as stationary structures, and most of them was related to single chemical releases [17]. To our knowledge, no national data regarding chemical spill or release accidents in workplaces or poisoning of residents and workers has been reported in South Korea.

No available statistical data for poisoning cases

Unfortunately, there is no available national data on poisoning cases or exposure that occurred from materials and products consumed or used in various situations in South Korea. Statistics Korea used to report the number of poisoning cases, the number hospitalized, and medical expenses involved every five years (Table 2). The most recent statistics were released in 2015. Unfortunately, there are no details about poisoning such as the type or source of poisoning, age group poisoned, or type of reasons for poisoning, etc. Factors for preventing and treating poisoning cannot be identified. National poisoning data reported every five years shows little utility [18]. On the contrary, countries with PCs report statistics on poisoning data categorized according to various factors through the published literature or online [13,19].

Table 1. Governmental and quasi-governmental agencies in charge of surveillance of poisoning and injury in South Korea

Agency	Major surveillance activities	Limits of activities	Organizational Form	Number of personnel involved in the activity
National Medical Center (NMC)	▪ Poisoning Data Management System (recording poisoning cases, provision of antidote information, and toxicity analysis) ▪ Emergency Treatment Monitoring (statistics on emergency department visitors)	▪ No information for laypeople ▪ Only ED visits recorded (partial data on toxic exposure cases)	▪ Ministry of Health and Welfare (MOHW)- affiliated organization ▪ National Emergency Medical Center (NEMC)	▪ MOHW Dept. of Emergency Medical Services (10)
National Institute of Food and Drug Safety Evaluation (NIFDS)	▪ Toxicity Information Service System (toxicity, poisoning, and carcinogenicity information)	▪ Association between toxicity and exposure information unavailable ▪ Poisoning information only provided to physicians with permission	▪ Ministry of Food and Drug Safety (MFDS)-affiliated organization	▪ Dept. of Toxicology (17)
Korea Institute of Drug Safety & Risk Management (KIDS)	▪ The Korea Adverse Event Reporting System (KAERS) (reporting and management of adverse event (AE) reports) ▪ Narcotics Information Management System (drug vigilance)	▪ Low consumer reporting rate ▪ Lack of access to information due to privacy concerns ▪ Unable to monitor prescriptions not covered by national health insurance (NHI) ▪ Real-time surveillance unavailable	▪ MFDS-affiliated institute	▪ Dept. of Drug Safety Information, Office of Drug Safety Information (12) ▪ Department of Narcotics Information Management (40)
Korea Consumer Agency (KCA)	▪ Consumer Injury Surveillance System (CISS) (collection and handling of information on dangers and injuries, recommendation of policy improvements to relevant organizations/interested businesses)	▪ Limited surveillance of poisoning	▪ Korea Fair Trade Commission (KFTC)-affiliated agency (entrusted with execution)	▪ Consumer Safety Center (N/A[1])
National Institute of Chemical Safety (NICS)	▪ Emergency Operation Center (tracking the status of industrial chemical accidents, response, and recovery management) ▪ Integrated Chemical Information System (ICIS)	▪ Personal poisoning cases are not monitored ▪ Chemical information management is scattered over different agencies	▪ Ministry of Environment (MOE)-affiliated institute	▪ Accident Coordination & Training Division (35) ▪ Planning & Management Division (1 of 17)
National Institute of Environmental Research (NIER)	▪ National Chemical Information System (provision of chemical information based on CAS no. and name)	▪ No access to test data	▪ MOE-affiliated institute	▪ Chemicals Register & Evaluation Team (2 of 24)
Korean Environmental Industry & Technology Institute (KEITI)	▪ "Ecolife" (household chemical product information system) (provision of information on chemicals contained in household chemical products, notification of product recalls)	▪ Information on incidents involving chemical products is not up-to-date ▪ No collection of actual status of consumption/exposure	▪ MOE-affiliated institute	▪ ME Chemical Products and Biocides Division (N/A[1]) ▪ KEITI Household Chemical Products & Biocides Safety Center (1 of 38)

Table 2. Governmental and quasi-governmental agencies in charge of surveillance of poisoning and injury in South Korea (Continued)

Agency	Major surveillance activities	Limits of activities	Organizational Form	Number of personnel involved in the activity
Korea Occupational Safety and Health Agency (KOSHA)	▪ Prevention Bureau Accident Investigation Board (control tower for industrial accidents) ▪ Dept. of Accident Statistics Analysis (production of statistics regarding different types of industrial accidents) ▪ Chemicals Safety and Health Research Center (production of hazard information, conducting relevant tests)	▪ Surveillance confined to industrial accidents	▪ Ministry of Employment and Labor (MOEL)-affiliated agency (entrusted with the execution)	▪ Dept. of Accident Statistics Analysis (27) ▪ Chemical Safety and Health Research Center (27)
National Institute of Agricultural Sciences (NAS)	▪ Chemical Safety Division (analysis, monitoring, and reduction of hazardous substances) ▪ Agromaterial Assessment Division (establishment of pesticide safety evaluation system) ▪ Agricultural Health and Safety Team (inquiry into farmers' safety issues, research for prevention) ▪ Center for Farmers' Safety & Health (provision of safety and health information, prevention of pesticide incidents) ▪ Provision of pesticide information on website	▪ Surveillance confined to agricultural accidents ▪ No detailed categories provided in statistics	▪ Ministry of Agriculture, Food and Rural Affairs (MAFRA)-affiliated institute	▪ Chemical Safety Division (18) ▪ Agromaterial Assessment Division (23) ▪ Agricultural Health and Safety Team (12)
Korea Fire Institute (KFI)	▪ "Hazmat" (hazardous substance information system) (provision of information on "hazardous substance" (and "non-hazardous substance") regulated by Act on the Safety Control of Hazardous Substances)	▪ No surveillance on poisoning	▪ National Fire Agency (NFA)-affiliated institute	▪ NFI Fire Response & Investigation Division (14) ▪ KFI Hazmat Technical Standard Dept. (N/A[1])

[1] Not available.

The near real-time nature of the National Poison Data System (NPDS) in the US provides a national public health resource for collecting and monitoring poisoning data [20]. The NPDS collects information from all poison centers and provides early recognition of emerging poison hazards.

Recommendations: Establishment of a poisoning center at the Korea Disease Control and Prevention Agency (KDCA)

We recommend that the surveillance system for public health and safety related incidents involving cases of poisoning be compiled into a centralized system and the resultant data be used to identify potential health risks and their causes. The PC should be a medical facility that is able to provide immediate, free, and expert treatment advice and assistance over the telephone for cases of exposure to poisonous or hazardous substances. This year, the KDCA was upgraded to an independent agency with a larger organization following its successful responses to the COVID-19 pandemic. We recommend that all poisoning-related responsibility and authorization be centralized with the CDC in an effort to mitigate all kinds of poisoning. There are certain key reasons why the KDCA should oversee regional PCs and cooperation among governmental ministries (Figure 1-3).

Table 2. Estimated statistical data for 2015 related to poisoning among all diseases in South Korea [18]

Classification	Poisoning[1]	All diseases	Proportion of poisoning[2]
No. of hospitalized patients	90,786	9,614,693	0.94
Hospitalization days	711,192	74,877,267	0.95
Medical costs (billion won)	127.5	17,128.8	0.74

[1] Poisoning cases by drug and injury, [2] These indicate the proportions of poisoning among all diseases (poisoning/all diseases).

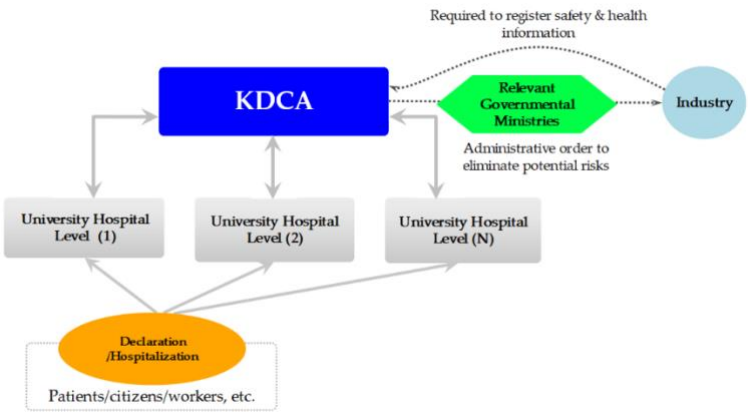

Figure 1. A model for a centralized poison center at the Korea Disease Control and Prevention Agency (KDCA).

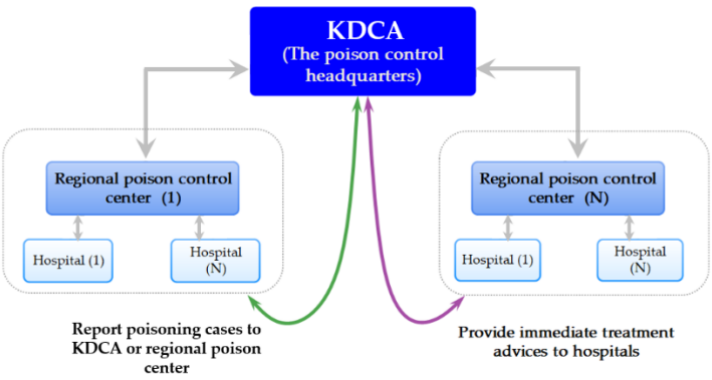

Figure 2. Interaction between the Korea Disease Control and Prevention Agency (KDCA) and regional poison centers.

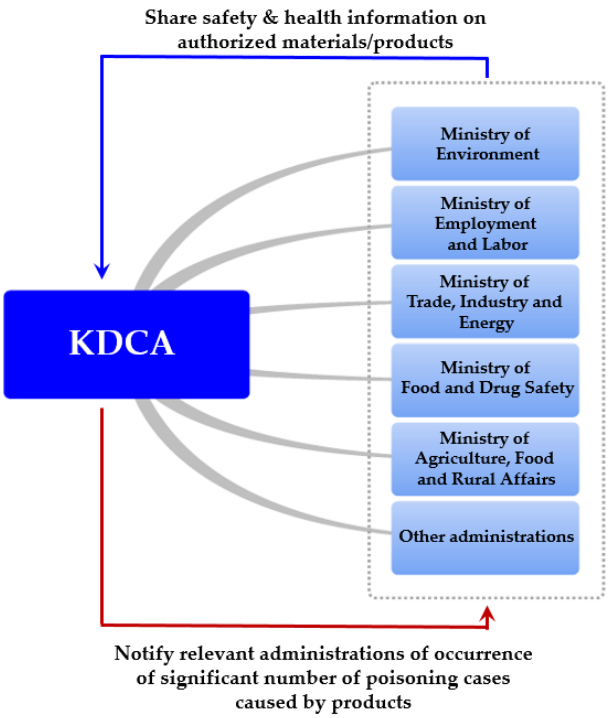

Figure 3. Interaction between the Korea Disease Control and Prevention Agency (KDCA) and relevant administrations.

Firstly, the KDCA would be the most efficient body to lead several hospitals serving as regional PCs. Certain numbers of regional PCs are required to cover particular areas. It is typical to maintain a number of regional PCs closely connected to a central PC (Table 3). As the central PC, the KDCA could register poisoning cases in real-time and manage the tasks required to provide regional PCs with expert advice for treatment and prevent the recurrence of similar poisonings. Regional PCs and hospitals receiving poisoned patients must be required to report to the KDCA and, if necessary, seek immediate expert treatment advice and assistance over the phone (Figure 1). Every PC can provide advice at any time from a certified medical toxicologist. In the US, more than 72% of poison exposure cases are managed simply by phone [21], greatly reducing the need for costly emergency department and doctor visits [22]. PCs reduce the number of poisoning cases that enter the health care system. An independent analysis of costs and benefits associated with poison centers found that PCs effectively reduce health care expenses [20].

Secondly, all SDS information, including toxicological and emergency measures, should be shared among concerned governmental organizations, including PCs. In the EU, manufacturers of hazardous mixtures are required to send the formulations of their products to the European Chemicals Agency (ECHA) and to print a Unique Formula Identifier (UFI) code on their products. This code, along with further available information, enables PCs to identify a mixture based on the exact formulation of a product, which is only shared to the ECHA and appointed PCs in order to protect confidential business information. In South Korea, industry currently reports SDS information only to the MOE and Ministry of Food and Drug Safety (MFDS). Again, in the EU such information can be accessed by PCs and the pertinent administrative body. Such legal measures are required to not only treat poisoned patients, but also to identify the brands causing the poisoning.

The US CDC and state and local health departments with the NPDS access granted by their respective PCs also have the ability to create surveillance definitions for routine surveillance tasks or to respond to emerging public health events. The NPDS serves as a data warehouse for the nation's PCs. The nation's 55 poison centers upload case data automatically to the NPDS [21]. In 2008 in the US, a total of 201 acute selenium poisoning cases were identified across ten states. The source of the outbreak was identified as a liquid dietary supplement that contained 200 times the labeled concentration of selenium. The US Food and Drug Administration (FDA) initiated an independent investigation following similar complaints, at which time other agencies, including PCs and state health departments, cooperated [23]. The CDC reports exposure cases to related administrative bodies so that they can take legal measures to assuage the risk of a product causing poison cases. Poison centers emphasize exposure management, accurate data collection and coding, and responding to the continuing need for poison-related public and professional education.

Table 3. A brief summary of the roles and achievements of poison centers operated in some developed countries

	United States	Netherlands	Germany	Sweden	Japan
Year of Establishment	1953	1949	1964	1960	1986
Structure of Poisoning Surveillance	National surveillance	National surveillance	Partial national surveillance	National surveillance	National surveillance
Operating Body of Surveillance	American Association of Poison Centers (AAPCC)	European Association of Poisons Centres and Clinical Toxicologists (EAPCT)	Federal Institute for Risk Assessment (BfR)	Swedish Poison Information Centre	Japanese Poison Information Centre Foundation
Role in Poisoning (Information) Center	• Collection of chemical information • Hotline • Education • Treatment assistance	▪ Collection of chemical information • Hotline • Testing & analysis • Treatment assistance • Substance analysis	• Collection of chemical information • Hotline • Testing & analysis (BfR) • Treatment assistance • Substance analysis	• Collection of chemical information • Hotline • Treatment assistance • Substance analysis	• Collection of chemical information • Hotline • Education • Treatment assistance • Substance analysis
Availability of Annual Poisoning Statistics	Available	Available	Partially available	Available	Available
Population per Center	5.96 million	17.28 million	10.37 million	10.23 million	126.5 million

Conclusions

Based on South Korea's current level of national economic activity and scope of health surveillance, the establishment of a PC should not be delayed. We recommend that a PC be set up in within the KDCA. The creation of several regional PCs is also highly recommended to serve cities or local provinces across the country. Not only national PCs, but also pertinent government organizations should cooperate to minimize the potential risk posed by products containing chemicals or substances and minimize the spread of poisoning incidents related to consumption of chemicals and chemical products and materials.

Conflict of interest

All authors declare there is no conflict of interest.

CRediT author statement

DUP: Conceptualization, Investigation, Validation, Writing-Original draft preparation, Writing- Reviewing and Editing; JK: Investigation, Data curation, Writing- Original draft preparation; KH: Conceptualization, Investigation, Writing- Reviewing and Editing; SC: Investigation, Writing-Original draft preparation, Writing- Reviewing and Editing; WJC: Investigation, Writing-Original draft preparation, Writing- Reviewing and Editing; JP and HJ: Validation, Visualization, Writing- Reviewing and Editing; SP: Conceptualization, Supervision, Investigation, Validation, Writing- Reviewing and Editing.

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