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Identification and Priority Setting for Occupational Carcinogens (OCs) in Industries in Thailand

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Abstract

Several chemicals, including occupational carcinogens (OCs), have been used in Thailand. Apart from asbestos and silica, other OCs need to be identified for further monitoring and management. The study aimed to identify and conduct priority setting of these carcinogens in Thailand. The methods of the study were applied from Hanlon's method for priority setting. The first step was to identify OCs from the lists of the National Hazardous Substance Registry by using the criteria as follows: 1) being classified as OCs by Loomis et al., and 2) having high amount of import/export in the country during 2018–2020. After that, the identified agents were ranked according to three criteria: 1) size of the problem, 2) severity of the problem, and 3) feasibility of interventions. The results found that 18 occupational carcinogens were identified and 12 of them were still allowed to be used in the country. According to available information, seven agents were matched for priority setting, and the top three scored OCs included 1) arsenic and inorganic arsenic compounds, 2) trichloroethylene, and 3) formaldehyde. Further action plan includes health risk assessment, setting up of health surveillance, and implementation of preventive and control measures in the target workplaces.

Keywords: occupational carcinogen, priority setting, arsenic, industry, Thailand

Introduction

Occupational cancer is one of the serious occupational health problems worldwide. The International Labour Organization (ILO) estimated that each year, at least 666,000 persons died from occupational cancer.[1] From recent estimation, occupational cancer accounted for 26% of the 2.4 million deaths due to work-related diseases globally every year.[2] The Global Burden of Disease 2016 estimated that 349,000 deaths and 7.2 million disability-adjusted life years (DALYs) in 2016 were due to exposure to occupational carcinogens (OC).[3] Out of the 349,000 deaths, lung cancer accounted for 86% of the deaths, mesothelioma for 7.9% and laryngeal cancer for 2.1%. Of more than 1,000 substances classified by the International Agency Research on Cancer (IARC) to date, 122 agents are classified as group 1 (carcinogenic to humans).[4] According to Loomis et al., at least 47 agents listed in group 1 were identified as OCs.[5] Moreover, other studies have been conducted to identify the priority of OCs. For example, the Global Burden of Disease 2016 showed that asbestos caused the highest number of deaths; the others included secondhand smoke (14%), silica (14%) and diesel engine exhaust (5%).[3]

In Thailand, cancer is the first leading cause of death with 19% of total deaths.[6] The data from the Global Cancer Observatory showed 190,636 newly diagnosed cancers with 124,866 deaths in the country in 2020.[7] However, the number of reported cases with occupational cancer has been very few. According to the report from the Thai Workmen's Compensation Fund, only six cases of occupational cancer were claimed during 2016–2020.[8] The problems of under-reported cases may be due to several reasons, such as lack of awareness among workers, employers, and medical doctors, long latency period of exposure, and no information of carcinogens' exposure in workplaces.

Nowadays, several types of chemicals are used and produced with high amounts in industries in Thailand. According to the report under the Department of Industrial Work (DIW), Ministry of Industry showed that nearly 4 million tons of toxic chemicals were imported for industrial use and approximately 2.5 million tons were exported to other countries annually during 2018–2020.[9] Some of these chemicals are carcinogens. Relevant international agencies, such as World Health Organization, ILO, and the International Commission on Occupational Health urged every country to set up policy and measures to protect workers from occupational cancer by focusing on primary prevention, e.g., eliminating or reducing exposure to known and probable carcinogens.[10–12] Until now, asbestos and silica are the only two OCs which have been selected for the national occupational disease prevention and control program.[13] Moreover, all forms of asbestos have already been selected to be the first priority for banning by the Thai Government since 2011 following the third National Health Assembly.[14] Therefore, identifying other important OCs is necessary for further health surveillance and management. This study aimed to identify OCs in industries and to conduct priority setting of these carcinogens.

Methods

The design of the study was adapted from Hanlon's methods for priority setting.[15] The methods of this study included two steps, consisting of identification of OCs and ranking of the identified OCs (Figure 1). The first step was to review literature and information regarding OCs from IARC monographs and relevant publications. Data and information of hazardous substances used in Thailand were collected from the hazardous substances database under the DIW.[9] According to the Thailand Hazardous Substances Act B.E. 2535 (1992), hazardous substances are classified into four categories, 1–4.[16] All hazardous substances in category 4 are prohibited for production, import, export, or possession in the country. All controlled chemical substances with clear identifiers are listed in annex 5 (5.1). Information regarding each substance in annex 5.1 includes name of chemical (or mixtures), CAS number, coding number, and amount of import and export annually.

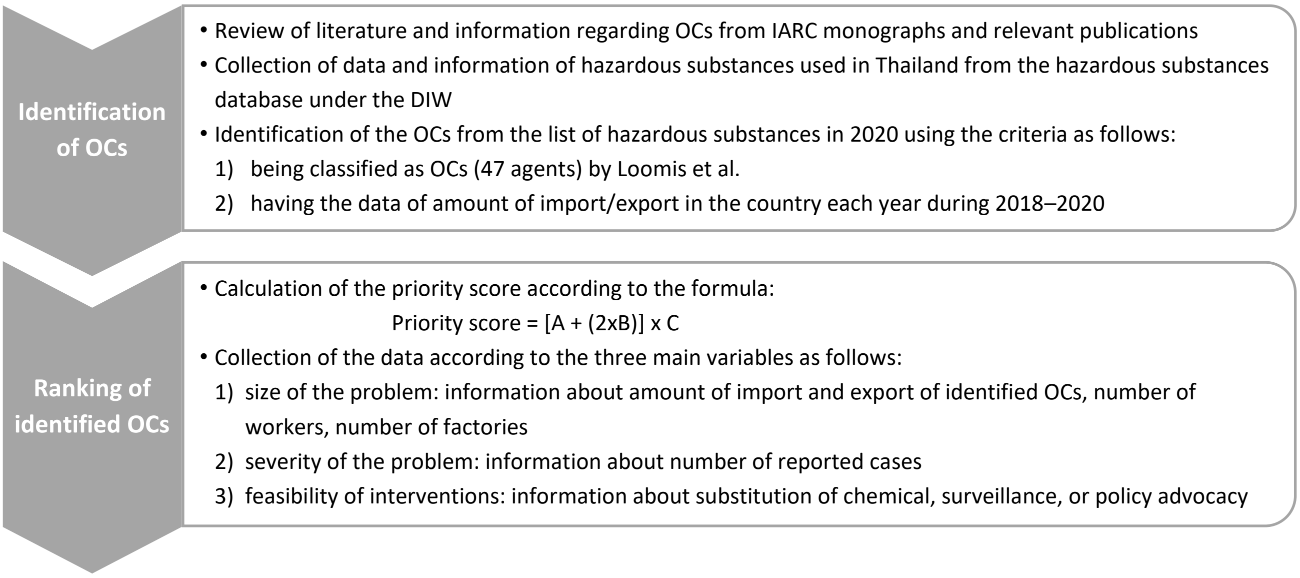

Figure 1. Two main steps of the Hanlon's method for priority setting

The next step was to identify OCs from the list of hazardous substances in 2020 using the criteria as follows: 1) being classified as OCs (47 agents) by Loomis et al., and 2) quantifying data concerning the amount of import/export in the country each year during 2018–2020.[5] However, all forms of asbestos (including chrysotile) and all acids were excluded from the study. The ranking of identified OCs was performed by calculating priority score using the formula below:

$$\text{Priority score} = [A + (2xB)] \times C$$

where A was size of the problem: [(RIEx3) + (RWx2) + (RFx1)] / 6.

RIE (ranking score for sum of amount of import and export of identified OCs) was quartile of sum of amount of import and export.

RW (ranking score of number of workers) was quartile of number of workers.

RF (ranking score of number of factories) was quartile of number of factories.

B was severity of the problem (4=having some reported cases of CA, 3=having some reported cases of severe poisoning, 2=public concern, and 1=none).

C was feasibility of interventions (4=substitution of chemical + surveillance + policy advocacy (e.g., international/national policy agenda recommended by World Health Organization/ILO), 3=surveillance + policy advocacy, 2=policy advocacy only, and 1=none).

In the study, number of factories and number of workers were collected from the lists of industries registered with DIW.[17] The information under the industry registry includes registration number, name of enterprise, address, type of industry, and number of workers, et cetera. However, this database has no information about chemicals used or produced (types and amount of chemicals) in each enterprise. Therefore, types of enterprises possibly using each target carcinogen were identified by seeking information from literature review for each chemical. For example, benzene may be produced from petrochemical manufacturing. Then petrochemical companies were sorted out and data about number of enterprises and number of workers were collected and summarized. After finishing collection of information for all selected carcinogens, the data of three factors were distributed from minimum number to the highest number. Then we divided into four quartiles and gave score 1 for the lowest quartile, score 2 for higher one, until score 4 for the highest numbers. To calculate the final step for the size of the problem (A), we weighed the ranking scores of three factors according to the formula.

The severity of the problem was scored by using information about availability of reported cases of cancer or other severe systemic poisoning caused by each carcinogen (see formula). The data were mainly reviewed and collected from annual reports under the Division of Occupational and Environmental Diseases, Department of Disease Control, during 2015–2020. The annual reports carried out regularly by the division summarize the disease situation based on three data sources—1) outbreak investigation, 2) ICD-10 related to environmental and occupational diseases, and 3) other related reports from stakeholders such as office of disease prevention and control or hospitals. Besides health data, the contents on the annual reports also include environmental monitoring data and control and prevention measures. The other sources of data to identify reported cancer cases were from published paper of case reports or research studies. Moreover, the feasibility of interventions was scored by reviewing whether each carcinogen has other chemical substitution available or available technique for health surveillance (see formula). After complete collection of information, the process of selected carcinogens' prioritization was arranged in a consensus meeting among experts and stakeholders.

Results

Totally 864 chemicals were listed as hazardous substances according to Thailand Hazardous Substances Act B.E. 2535 (1992) annex 5 (5.1) in 2020. According to the lists of 47 OCs by Loomis et al., 18 OCs (total 41 items of agents, e.g., asbestos has 5 items of agents) were identified in the report of hazardous substances lists (Table 1). Of these 18 OCs, 9 OCs were classified as category 4; 11 OCs were classified as category 3; and 1 OC was classified as category 2. Therefore, only 12 OCs were allowed to be used in the country, i.e., all OCs in category 4 were not allowed. However, three OCs (arsenic and inorganic arsenic compounds, asbestos, and chromium (VI) compounds) were classified as both categories 3 and 4. All acid chemicals which were classified as an OC (acid mist) by Loomis et al., were excluded in the study. Chrysotile was the only single type of asbestos, classified as category 3, which was still allowed to be used in the country.

Table 1. Occupational carcinogens classified within each category

Category	Name of chemicals	Number
1	-	-
2	formaldehyde	1
3	1,3-butadiene, 2-naphthylamine, 4-aminobiphenyl, arsenic and inorganic arsenic compounds, asbestos (chrysotile), benzene, benzidine, cadmium and cadmium compounds, chromium (VI) compounds, trichloroethylene, vinyl chloride	11
4	arsenic and inorganic arsenic compounds (copper arsenate hydroxide, lead arsenate, calcium arsenate), asbestos (except chrysotile), beryllium and beryllium compounds, bis (chloromethyl) ether, chromium (VI) compounds (sodium chromate), nickel compounds, pentachlorophenol, polychlorinated biphenyls, sulfur mustard (also mustard gas)	9
Total		**18†**

Notes: All acids were excluded. †Three agents (arsenic and inorganic arsenic compounds, asbestos, and chromium (VI)) are classified in both categories 3 and 4.

After identifying amount of chemicals, seven chemicals from categories 2 and 3 were selected for further priority ranking. The rest of the OCs from category 3 in Table 1 had no information about amount of import/export during 2018–2020. Only 2-naphthylamine had data about very few amounts of import in 2018 and 2019, but no data of import in 2020 and no data of export at all. The seven OCs include benzene, vinyl chloride, 1,3-butadiene, formaldehyde, trichloroethylene, chromium (VI) compounds, and arsenic and inorganic arsenic compounds. Amount of import and export of these agents are shown in Table 2. Approximately 20,000 tons of all seven OCs were imported to be used in the country each year. Nevertheless, nearly one million tons of the seven OCs were exported to other countries. The highest amount of import and export of listed carcinogens was benzene, probably due to very high manufacturing of petrochemicals in eastern industrial estates in the country. Similarly, the production of vinyl chloride and 1,3-butadiene was also high because of the same reason. However, arsenic and inorganic arsenic compounds were imported to be used in the country only, but not enough production for export.

Regarding number of factories and exposed workers, over 200,000 workers from 1,411 enterprises may be exposed to these seven OCs (Table 2). Trichloroethylene was the top of the agents with the highest number of factories and exposed workers. More than 70% of all workers (157,187) were exposed to trichloroethylene in their working environment; while, nearly half of all target factories (657) used this chemical in the process of their manufacturing. Formaldehyde was the second highest number of both factories and exposed workers. Although benzene was the agent with the highest production, only 2.8% of all target workers were exposed to this chemical.

Table 2. Average amount of import and export of seven chemicals during 2018–2020, and distribution of seven carcinogens by number of factories and number of exposed workers

Name of carcinogens	Number of import (tons/year)	Number of export (tons/year)	Number of factories (%)	Number of exposed workers (%)
Benzene	2,914.67	755,245.00	78 (5.5%)	6,068 (2.8%)
Vinyl chloride	0.05	106,397.67	9 (0.7%)	1,000 (0.5%)
1,3-Butadiene	10,943.56	62,176.67	23 (1.6%)	1,355 (0.6%)
Formaldehyde	2,801.41	505.66	367 (26.0%)	34,897 (15.9%)
Trichloroethylene	1,939.83	7.96	657 (46.6%)	157,187 (71.9%)
Chromium (VI) compounds	1,399.11	54.80	230 (16.3%)	8,349 (3.8%)
Arsenic and inorganic arsenic compounds	318.10	-	47 (3.3%)	9,894 (4.5%)
Total	**20,316.73**	**924,387.76**	**1,411 (100%)**	**218,750 (100%)**

Notes: 1) Chrysotile, acids, and 2-naphthylamine were excluded.
2) RIE scores: 1=318.1–1,700, 2=1,701–3,307, 3=3,308–89,758, and 4=89,759–758,159.67
3) RF scores: 1=9–35, 2=36–78, 3=79–298, and 4=299–657
4) RW scores: 1=1,000–3,711, 2=3,712–8,349, 3=8,350–22,395, and 4=22,396–157,187

After reviewing reported cases caused by these seven carcinogens from the Health Data Center (HDC) and other published reports, only skin cancer cases caused by arsenic were identified.[18,19] An outbreak of 1,500 cases with arsenic poisoning and 1,231 cases with skin cancer caused by arsenic have been found since 1987. Most cases were exposed to drinking water with arsenic contamination from old tin-mines in the south of the country. Furthermore, some cases of acute trichloroethylene poisoning were diagnosed from an institute of occupational medicine hospital (unpublished information). Other carcinogens, e.g., benzene, 1,3-butadiene, and vinyl chloride, raise health concerns among workers and the public in the area of large petrochemical industries.[20–22] These studies also showed that levels of exposure from these carcinogens were very high. However, there have been no report of confirmed cancer cases caused by those chemicals until now.

Regarding the feasibility of intervention, arsenic, trichloroethylene, formaldehyde, and chromium (VI) compounds may have other alternatives for substitution in manufacturing. The laboratory analysis of biomarkers for all these chemicals are also available. Health surveillance and control of arsenic poisoning is one of the major public health issues in terms of occupational and environmental health in the country. Based on the ranking using the formula, (Table 3), arsenic and inorganic arsenic compounds were the top priority with the highest scores, followed by trichloroethylene and formaldehyde, respectively; while, chromium (VI) compounds were the last with the lowest scores.

Table 3. Ranking of scores for selected occupational carcinogens

Name of carcinogens	Size of problems	Severity (scorex2)	Feasibility	Total score
1. Arsenic and inorganic arsenic compounds	1.83	8	4	39.32
2. Trichloroethylene	3	6	4	36
3. Formaldehyde	3	4	4	28
4. Benzene	3	4	3	21
5. Vinyl chloride	2.5	4	3	19.5
6. 1,3-Butadiene	2	4	3	18
7. Chromium (VI) compounds	1.67	2	4	14.68

Discussion

From this study, at least 18 OCs were identified using the existing data from national registration for hazardous substances. However, all acids were excluded from the study because there are several kinds of acid and all acids are generally used in most types of factories. It is so difficult for policy makers, especially relevant government agencies, such as public health sectors, to set up a policy for their management. Agents, which were produced or by-produced during the process of manufacturing, were not listed in the study, including diesel engine exhaust, leather dust, silica dust, welding fumes, and wood dust. Other carcinogens, such as, outdoor air pollution including particulate matter, solar radiation, and secondhand tobacco smoke, were also excluded because they are not classified as registered chemicals to be used for manufacturing. All radionuclides are registered to another national authority, the Office of Atoms for Peace.[23] Therefore, the group of those carcinogens were not included in the results.

Until now, several countries, especially the developed countries, have made efforts to study about OCs in terms of identification of new agents/risk factors, the burden of disease from occupational exposure, priority setting of these agents and development of effective control measures.[24–28] A good example of a project on the estimation of the burden of occupational cancer was conducted by an international group of experts, called the carcinogen exposure (CAREX) network.[29] An interesting finding showed that 32 million workers in the European Union were exposed to agents covered by CAREX. The most common exposures were solar radiation, environmental tobacco smoke, crystalline silica, diesel exhaust, and wood dust. Another example was a project of occupational cancer burden in Great Britain, demonstrating that asbestos, mineral oils, solar radiation, silica, and diesel engine exhaust were the top five of priority carcinogens.[30]

The study of priority setting for occupational cancer was performed by CAREX Canada in 2015 using four criteria, including 1) the likelihood of presence and /or use in Canadian workplaces; 2) toxicity of the substances; 3) feasibility of producing a carcinogen profile; and 4) special interest from the public and scientific communities.[31] The results showed that 103 agents were prioritized as high (n=11), medium (n=33) and low (n=59). The industrial chemicals classified as high priority exposure included 1-bromopropane, 1,2-dichloropropanem acrolein, dimethylformamide, and furan. Another study in Australia, called "the Australian Work Exposures Study" was conducted which aimed to investigate the current prevalence of occupational exposure to carcinogens.[32] The study showed similar finding as the most common carcinogens of exposure were solar radiation, diesel engine exhaust, environmental tobacco smoke, benzene, and silica. Up to now, all studies have been conducted in developed countries. The findings might not be able to compare with the situation in Thailand.

For this study, the method for priority setting of OCs was used by applying the Hanlon technique. Currently, there are several methods for prioritization in public health.[15] The Hanlon's method was developed by J.J. Hanlon. Researchers, public health professionals, and health policy makers use or apply this method in their works.[33,34] The method is simple and inexpensive. The method in this study should be recommended to use for priority setting of OCs in other countries, especially in developing countries. The data of the study were collected and analyzed by the existing information and registry from relevant governmental agencies. Additionally, representatives from those relevant agencies and stakeholders were invited to give some feedback and suggestions in the workshop at the end of the study. This process could support to give consensus of the results and may lead to further policy development.

Although the results of the study are very useful as a starting point for policy development and implementation of preventive and control measures, some limitations of the study have to be concerned. For example, the exact amount of target chemical used in each factory was not available. Furthermore, numbers of workers working in the small-scale enterprises or in the informal sectors may not be included in the study. The reason was that the regulations under the DIW require enterprises with some particular size and machines to report to the department. In addition, number of workers were not the same as number of exposed workers. The exact number of exposed workers were not compulsory to be reported according to the Thailand Hazardous Substances Act B.E. 2535 (1992). If we need to tackle these problems in the future, we need to use other different methods by conducting walk-through surveys in enterprises. Another major limitation was that data of exposure levels were not available. Moreover, there was considerable debate on feasibility's score among participants during the workshop.

Conclusions

Eighteen OCs were identified from this study. Among these, 12 agents were still allowed to be used or produced in industries in the country. Apart from asbestos, at least seven other OCs have to be considered for further policy development. Arsenic and inorganic arsenic compounds was the top priority. Meanwhile, improvement of chemical information database is very important. Further action plans should include health risk assessment, setting up of health surveillance, and implementation of preventive and control measures in target workplaces.

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Conflicts of Interest

There are no conflicts of interest.

Suggested Citation

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