

การเฝ้าระวังทางการแพทย์ตามมาตรฐาน OSHA ประเทศสหรัฐอเมริกา: การศึกษา ในโรงงานการผลิตขนาดใหญ่ เขตระเบียงเศรษฐกิจภาคตะวันออก ประเทศไทย

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บทคัดย่อ

โปรแกรมเฝ้าระวังทางการแพทย์เป็นสิ่งจำเป็นสำหรับการป้องกันโรคที่เกิดจากการทำงานในกลุ่มลูกจ้างกลุ่มเสี่ยงสูง โดยเฉพาะอุตสาหกรรมเคมี โปรแกรมดังกล่าวครอบคลุมทั้งสิ้น 14 ขั้นตอนหลัก โดยแพทย์อาชีวเวชศาสตร์มีบทบาทสำคัญ ในขณะที่แนวปฏิบัติขององค์กร OSHA ของประเทศสหรัฐอเมริกาสามารถสร้างแนวปฏิบัติได้ครบถ้วนทั้งหมด ในขณะที่กฎหมายและแนวปฏิบัติของประเทศไทยนั้นขาดองค์ประกอบที่สำคัญบางประการ ซึ่งอาจส่งผลกระทบต่อสถานประกอบการตามมาได้ การวิจัยนี้จึงมีวัตถุประสงค์ 1) เพื่อหาสัดส่วนของโรงงานอุตสาหกรรมผลิตขนาดใหญ่ที่มีการใช้สารเคมีซึ่งสามารถปฏิบัติตามโปรแกรมเฝ้าระวังทางการแพทย์ได้ตามเกณฑ์มาตรฐานองค์กร U.S. OSHA 2) ศึกษาความแตกต่างระหว่างปัจจัยการมีแพทย์และไม่มีแพทย์อาชีวเวชศาสตร์กับการผ่านมาตรฐาน U.S. OSHA การศึกษาแบบภาคตัดขวางนี้ ศึกษาในโรงงานที่ตั้งในจังหวัดระยอง ชลบุรี และฉะเชิงเทรา (พื้นที่เขตพัฒนาพิเศษภาคตะวันออก) ดำเนินการตั้งแต่เดือนมกราคมถึงเดือนมีนาคม พ.ศ. 2565 ขนาดตัวอย่าง 190 โรงงาน วิธีการวิจัยประกอบด้วย การทบทวนวรรณกรรมเพื่อพัฒนาแบบสอบถามที่มี 38 ข้อ โดยมีการทดสอบความถูกต้องของเนื้อหาและความเชื่อมั่นของเครื่องมือและส่งแบบสอบถามให้โรงงานโดยผู้ตอบที่มีประสบการณ์เกี่ยวกับโปรแกรมเฝ้าระวังทางการแพทย์ ผลการวิจัยพบว่ามีเพียงร้อยละ 3.4 (ความเชื่อมั่นร้อยละ 95 = 1.1-8.9) ของโรงงานปฏิบัติตามอย่างน้อย 8 ขั้นตอนสำคัญจาก 14 ขั้นตอนของโปรแกรมตามมาตรฐาน OSHA โดยสามขั้นตอนที่โรงงานปฏิบัติตามมาตรฐานได้ต่ำสุด ได้แก่ 1) การออกแบบรายการตรวจเพื่อติดตามสุขภาพร้อยละ 12.6 (ความเชื่อมั่นร้อยละ 95 = 6.9-20.8) 2) การเดินสำรวจค้นหาสารเคมีร้อยละ 25.3 (ความเชื่อมั่นร้อยละ 95 = 17.1-35.1) และ 3) การจัดเก็บข้อมูลโดยแยกตามชนิดสิ่งคุกคามร้อยละ 29.9 (ความเชื่อมั่นร้อยละ 95 = 21.0-40.0) โดยการมีแพทย์อาชีวเวชศาสตร์เข้าร่วมสามารถเพิ่มอัตราการปฏิบัติตามมาตรฐาน U.S. OSHA มากขึ้นในบางขั้น เช่น การเดินสำรวจค้นหาสารเคมี (OR = 4.33, ความเชื่อมั่นร้อยละ 95 = 1.56-12.51, $p=0.003$) และการออกแบบรายการตรวจเพื่อติดตามสุขภาพ (OR = 20.71, ความเชื่อมั่นร้อยละ 95 = 4.36-154.7, $p<0.001$) โดยสรุปมีเพียงร้อยละ 3.4 ของโรงงานการผลิตขนาดใหญ่ เขตระเบียงเศรษฐกิจภาคตะวันออกในประเทศไทยปฏิบัติตามมาตรฐานของ OSHA ของประเทศสหรัฐอเมริกา และการมีส่วนร่วมของแพทย์อาชีวเวชศาสตร์ในโปรแกรมเฝ้าระวังทางการแพทย์ โดยเฉพาะการออกแบบรายการตรวจเพื่อติดตามสุขภาพ ผ่านองค์กรที่มีความเชี่ยวชาญและมีการจัดทำแนวปฏิบัติตามมาตรฐานมีส่วนช่วยที่สำคัญต่อการดำเนินการ

คำสำคัญ: โปรแกรมเฝ้าระวังทางการแพทย์; การตรวจสุขภาพตามปัจจัยเสี่ยง; มาตรฐาน U.S. OSHA; แพทย์อาชีวเวชศาสตร์

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Medical surveillance followed the U.S. OSHA standard: A study in large manufacturing factories, the Eastern Economic Corridor of Thailand

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Abstract

Medical surveillance is essential to protect employees at high risk of occupational diseases, particularly in the chemical industry. A comprehensive medical surveillance program has 14 key steps, with occupational health physicians (OHPs) playing a significant role. While the U.S. OSHA guidelines meet all requirements, Thailand's legislation lacks essential elements, leading to potential negative consequences for companies. This study aims to 1) determine the proportion of large chemical manufacturers that follow the U.S. OSHA standard medical surveillance program; and 2) to study the difference between the presence or absence of OHPs and compliance with U.S. OSHA standards. A cross-sectional study involving large chemical-using factories in Rayong, Chonburi, and Chachoengsao provinces (EEC area) was conducted from January to March 2022, with a sample size of 190 factories. The methodological steps included a literature review, the development of a 38-item questionnaire, content validity and test-retest reliability analysis. Finally, the questionnaire was completed by experienced respondents in various factories. The results showed that only 3.4% (95%CI: 1.1-8.9) of the surveyed factories implemented at least eight essential steps of the U.S. OSHA medical surveillance program. The most common three lowest substandard steps identified were designing medical surveillance at 12.6% (95%CI: 6.9-20.8), conducting walk-through surveys 25.3% (95%CI: 17.1-35.1), and medical recordkeeping 29.9% (95%CI: 21.0-40.0). The presence of OHPs significantly improved compliance rates in specific steps, such as conducting walk-through surveys (OR 4.33, 95%CI: 1.56-12.51, $p=0.003$) and design for the components of the medical surveillance program (OR 20.71, 95%CI: 4.36-154.7, $p<0.001$). In conclusion, only 3.4% of large manufacturing factories in the Eastern Economic Corridor of Thailand complied with U.S. OSHA standards. The involvement of OHPs in this program, particularly in terms of the design for the components of the medical surveillance program through specialized organizations and the development of standardized practices is a crucial contribution.

Keywords: medical surveillance; health risk examination; U.S. OSHA standard; occupational health physicians

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Introduction

Medical surveillance is a critical preventive service for protecting employees exposed to various hazards and at increased risk of occupational disease. As a result, these programs should be comprehensive, monitoring individual and group occupational health trends for effective risk reduction^{1,2}. In particular, employees working with chemicals may experience acute and chronic health effects. Previous research has demonstrated that the basic steps of a medical surveillance program include 14 steps^{3,4}. 1) a walk-through survey; 2) identifying known health effects; 3) measurement of the area or personal sampling; 4) action level or health risk assessment; 5) designing medical surveillance programs; 6) medical examinations; 7) access to health database information; 8) interpreting tests and ongoing data analyses; 9) medical removal; 10) written reports; 11) work environment reevaluation; 12) medical recordkeeping; 13) audits; and 14) employer actions.

Occupational health physicians (OHPs) play an important role in suggesting lists and biological monitoring of chemical hazards⁵, conducting risk assessment and communication, providing medical clearance for respirators, maintaining health databases, writing reports, and facilitating return to work⁶⁻¹⁰. The American College of Occupational and Environmental Medicine (ACOEM) recommends these as their core competencies¹¹. Furthermore, standardized tools, such as questionnaires, uniform laboratory testing, and fit-to-work

certificates, help make the program more effective^{12,13}. Many countries have published standard guidelines for medical surveillance programs for chemical hazards through specific agencies such as the U.S. Occupational Safety and Health Administration (OSHA), the Malaysian Department of Occupational Safety and Health (DOSH), the South African Academic Model Providing Access to Healthcare (AMPATH), the Singaporean Workplace Safety and Health Council (WSHC), the Australian Safe Work (WHS), and the German Social Accident Insurance (DGUV1)¹⁴⁻¹⁹. According to Convention 161 of the International Labor Organization (ILO), the goal is to achieve a standard occupational health service²⁰. Comparing these standards highlights differences, and only the U.S. OSHA guideline meets all requirements and serves as a model for easy implementation. A previous study conducted after the establishment of U.S. OSHA found that 52% of industries complied with the standards used²¹.

Although Thailand has published numerous guidelines^{22,23} and regulations²⁴⁻²⁸, including the Ministry of Industry notification: establishment of industrial product standards and health check-up practices based on chemical and physical risk factors in the workplace, B.E. 2555 (2012)²² and ministerial regulations set the standard for employee health checks relating to risk factors B.E.2563 (A.D. 2020)²³, they do not include all the essential elements²⁹ such as the participation of OHPs in all processes. Failure to comply with international standards can lead to

negative consequences, such as the inability to export products, legal liability, and loss of investment opportunities. Therefore, companies must prioritize the health and safety of their employees and ensure compliance with international standards to avoid these impacts³⁰. Thailand's Eastern Economic Corridor (EEC) area is designated for large manufacturing industries, and the Thai government has supported its development to meet international standards in all fields. This is especially true for occupational safety and health management in Thai manufacturing, such as medical emergency preparedness³¹ and medical surveillance programs that should involve OHPs and follow the correct processes.

Objectives

To determine the proportion of large chemical manufacturers in the EEC area that follow the U.S. OSHA-recommended medical surveillance program, and study the difference between the presence or absence of OHPs and compliance with U.S. OSHA standards.

Materials and Methods

A cross-sectional study was conducted from January 15 to March 15, 2022, using a self-administered questionnaire distributed to factories. Responding to the questionnaire was considered informed consent. The Khon Kaen University Ethics Committee for Human Research reviewed and approved the ethical considerations following the Declaration of Helsinki and the ICH Good Clinical Practice Guidelines (approval number HE641358).

Study populations

The population included large factories that used chemicals. These factories were located in the provinces of Rayong, Chonburi, and Chachoengsao. A large-scale industrial factory is defined as a factory with a minimum of 200 employees. The term "use of chemicals" refers to 41 types of chemicals for which experts recommend the implementation of a medical surveillance program⁵. The sample size was determined using the Winpepi program and cluster sampling, which randomly selected 7 sample groups from 10 industrial estates. The acceptable difference (by precision) was $d = 0.05$, resulting in a 10% acceptable difference (50%) and a 95% confidence interval based on 250 factories. This led to a total of 190 factories being included in the sample.

Research tools and measurement

The study used several methodological steps. First, a comprehensive review of existing literature on medical surveillance programs was performed to inform the development of new questionnaire items. Second, the questionnaire was structured into four sections with a total of 38 items, including (a) general information about the industry, (b) the standard/guideline used to establish medical surveillance programs, (c) the purpose of establishing the program, and (d) the 14-step process of preparing the program. Third, to ensure the content validity of the questionnaire, it was sent to three OHPs with at least 3 years of experience who assessed the content

validity using Item Objective Congruence (IOC) with a range of 0.6 to 1, where higher values indicate better congruence with the research objectives. Fourth, the questionnaire was administered to ten stakeholders, including safety officers, occupational health nurses, and OHPs. Finally, test-retest reliability results were interpreted, with a high correlation

coefficient indicating a stable and consistent questionnaire.

The questionnaire consisted of 14 steps as shown in Table 1. Factories capable of complying with the U.S. OSHA standards were required to perform at least eight steps, including the 1st, 2nd, 3rd, 4th, 5th, 6th, 9th, and 10th steps.

Table 1 Details of medical surveillance based on the U.S. OSHA standards

Steps	A description of the steps required to comply with the U.S. OSHA standards.
1*	Walk-through Survey: OHPs walk through to identify workers who may need surveillance or screening for potential exposure to hazardous chemicals. This happens annually or when different chemicals are used.
2*	Known hazards health effect: At least one data source was utilized to retrieve information, including MSDS, regulations, OSHA, NIOSH, and IARC.
3*	Measurement area or personal sampling: Measurement of the chemical levels in the environment and designing medical surveillance accordingly.
4*	Actionable level or health risk assessment: Retrieval of the data from steps 1-3 to evaluate health risk assessment, health risk assessment at an actionable level or at an action level only.
5*	Design for components of medical surveillance program: OHPs use data from various sources such as walk-through surveys, known hazards, and health risk assessments. The goal is to create a medical surveillance program, including questionnaires, physical examinations, and biomarkers.
6*	Medical exams: Regular intervals consist of at least two types: pre-placement or baseline examination before employment and periodic examination at least once a year.
7	Providing information: Informing employees about health hazards and the medical surveillance program, ensuring confidential results.
8	Ongoing data analysis: Evaluating past information for medical surveillance.
9*	Medical Removal: The industry removes employee(s) from work or transfers them to a different job to prevent chemical overexposure.
10*	Medical recordkeeping: Collecting information about the health of an individual in Similar Exposure Groups, including paper documents, X-ray films, microfiche, microfilm, or automated data, for at least two years.
11	Environment Re-evaluation: Using the results of medical surveillance to evaluate and adjust the workplace environment to decrease employee hazards, such as the hierarchy of controls.
12	Written report: A document written by a doctor that summarizes the results of a health examination and includes recommendations about any health problems that may affect work.
13	Audit: An auditor examining and inspecting various processes in the medical surveillance program, such as external or internal audits.
14	Employer Actions: Adjust workplaces to reduce health hazards and risks for employees, participate in an occupational safety committee, allocate budgets, or establish policies.

* An essential step of the medical surveillance program.

Data collection and statistical analysis

The questionnaires were sent by email to the factories with a QR code linking to a Google form. Data were saved in MS Excel format. The qualifications of the respondents included physicians/OHPs, human resource or safety officers, or other individuals who worked in the safety committee team and had at least one year of experience in a medical surveillance program. The data were analyzed using SPSS version 28 with a license. Qualitative data were presented as number and percentages. The Chi-square test was employed to analyze compliance with U.S. OSHA standards between having OHP and non-OHP groups. OpenEpi was used to determine odds ratios and 95% confidence intervals. A p -value < 0.05 was considered significant.

Results

Respondent demographics and factory characteristics

In the study, 190 factories were contacted, of which 87 factories (45.8%) responded, representing various positions in the industry. Most of the respondents, 70/87 (80.5%), were safety officers. A smaller number of respondents, 2/87 (2.3%), consisted of occupational health physicians and nurses who focused on the health and well-being of workers in the occupational setting. The remaining 15/87 respondents (17.2%) represented other roles within the industry. The summary of the study findings on the industrial classification of factories and chemicals used in production processes contributed to the data presented in Table 2. On average, industrial factories have a workforce of 436 employees.

Table 2 The characteristics of a factory in term of industrial classification and the chemicals used in production processes (n=87)

Factory description	n	(%)
Industrial Classification		
- Repair of vehicle equipment and machinery equipment	14	16.1
- Electrical equipment	7	8.1
- Coke, refined petroleum products, basic metals	12	13.8
- Chemical products, rubber, plastics, textiles, wood, paper, pharmaceutical products, computers, electronics and optical products, furniture	14	16.0
- Others; not specified	40	46.0
Groups of chemicals in the production process*		
- Group 1: Organic solvents; Benzene, Styrene, Toluene, Xylene, MEK, Methanol	65	74.7
- Group 2: Gas groups; ETO, Hydrogen cyanide, Fluorine, Carbon disulfide	8	9.2
- Group 3: Metal; Aluminum, Lead, Chromium (vi), Cadmium, Manganese, Mercury, Arsenic, Nickel, Tin, Selenium, Cobalt	23	26.4
- Group 4: Pesticides; organophosphate and carbamate	2	2.3
- Group 5: Other groups include wood dust, glass fiber, silica, asbestos fiber, coal	32	36.8

*A single factory can use more than one type of chemical

Regard to the responses from the 87 participating factories, the reasons for implementing medical surveillance varied, with the most common motivations being as

Table 3. Various standards and regulations the 87 participating factories used for setting up medical surveillance programs in their facilities presented in Table 4.

Table 3 The purpose of setting up medical surveillance in Thai industries (n=87)

Purposes	n	(%)
- Compliance with the law and regulations	49	56.4
- Ensure employee health and safety	32	36.8
- Compliance with customer requirements or affiliated parent companies	3	3.4
- Others	3	3.4

Table 4 Standards used for setting up medical surveillance programs in factories (n=87)

Standards	n	(%)
- U.S. OSHA standard ^(a) and Thai guidelines ^(b) and Thai regulation ^(c)	32	36.8
- U.S. OSHA standard ^(a) and Thai regulations ^(c)	16	18.4
- Thai regulations ^(c) and the standards of other countries ^(d)	16	18.4
- Thai regulations ^(c) and Thai guidelines ^(b) and the standards of other countries ^(d)	16	18.4
- Other country standards only ^(d)	7	8.0

(a) U.S. OSHA: Medical screening and surveillance requirements in OSHA standards¹

(b) Thai guidelines: Notification from the Ministry of Industry: Establish industry product standards and health check-up practices based on chemical and physical risk factors from occupations in the workplace B.E. 2555 (A.D. 2012)²².

(c) Thai regulations: Ministerial Regulations set the standard for employee health checks related to risk factors B.E. 2563 (A.D. 2020)²³.

(d) Others; DOSH, AMPATH, WSHC, WHS, and DGUV¹⁴⁻¹⁹

The proportion of large industries using chemicals complying with U.S. OSHA standards

Based on Figure 1, the percentages represent the number of respondents who reported compliance with the U.S. OSHA standard with each step of the medical surveillance program. The data presented highlight the varying levels of compliance with

different components of a medical surveillance program among a sample of participants. For example, while some components, such as known hazards, health effects, and employer actions, achieved high levels of compliance, others, including design for components of medical surveillance program, walk-through survey and medical recordkeeping, had relatively low levels of compliance.

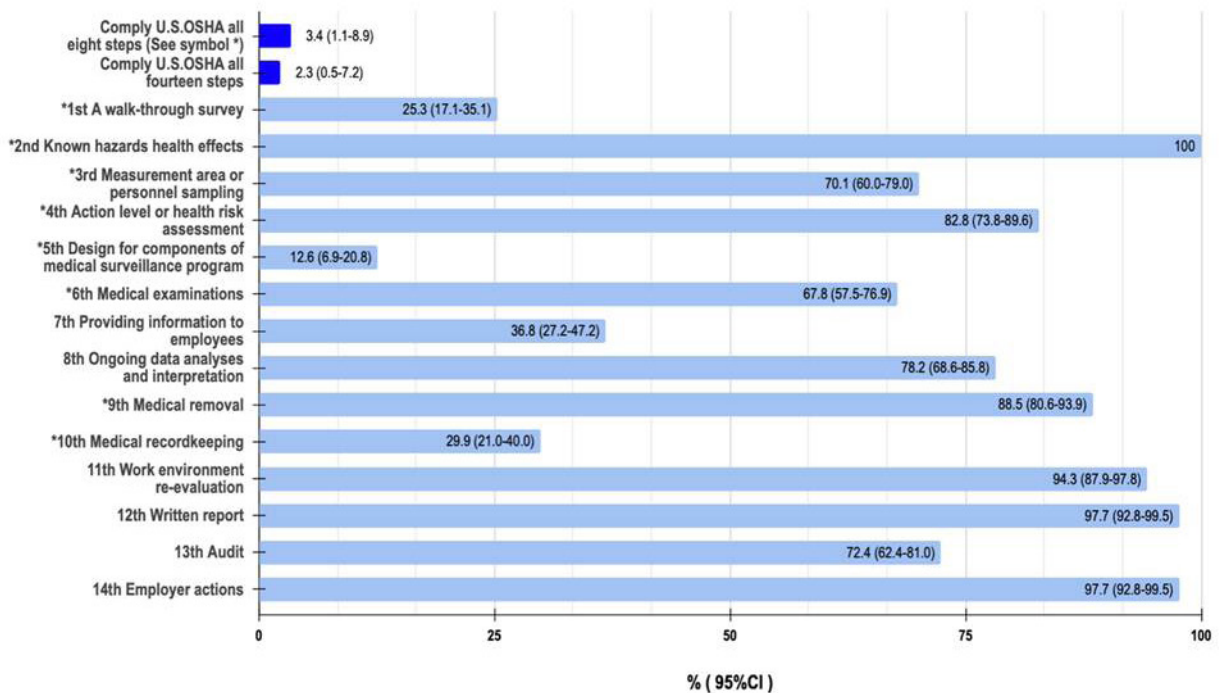


Figure 1 Compliance with medical surveillance program in terms of U.S. OSHA requirements.

Low compliance with the U.S. OSHA: the results show that Step 5 “having a physician with short-course training in occupational medicine” was only (3.4%). In contrast, a high percentage of participants reported having a board-certified occupational health physician (21.8%), while most participants reported that the program design included a safety officer (62.1%). The most commonly reported design component comprised a questionnaire, history-taking and physical examination, biological exposure, and biological effect. However, less than half of the participants (44.8%) reported having this type of program design. Step 1 of the medical surveillance program found that 29.9% of factories identified hazards in the workplace

by relying solely on the factory database. In addition, a walk-through survey was conducted, which indicated that most participants reported having performed a walk-through survey (55.2%). Of those who reported performing a walk-through survey, a high percentage (93.8%) indicated that the survey was performed each time a medical surveillance program or chemical modification occurred in the production process. However, a smaller percentage of participants (52.0%) reported that the walk-through survey was performed by a board-certified occupational health physician or a physician with short-course training in occupational medicine. Step 10 involves medical recordkeeping, and the results show that all participants (100%)

reported storage duration times of at least two years, with a median of 5 years. However, a smaller percentage of participants (29.9%) reported that health data were stored by a similar exposure group (SEG). Regarding source storage data, most participants reported using paper files/X-ray film or electronic systems (74.7% and 83.9%, respectively), while a few participants reported using a continuous processing system, cloud/Google drive (11.5%).

High levels of compliance for Step 2 involves identifying known chemical hazards with health effects, reported using the correct data source, such as Safety Data Sheets (SDS), were the most reported data source (74.7%), followed by regulations (65.5%), OSHA (27.6%), NIOSH (16.1%), and IARC monographs (3.4%) respectively. These findings suggest that the participants were generally well-informed

about the known hazards associated with the chemicals used in their workplaces. Step 14 reported taking employer actions to improve workplace safety. Joining an occupational safety and health committee was the most reported action (85.1%), followed by having a budget for safety initiatives (62.1%). A low percentage of participants (57.5%) reported setting policies in the workplace, indicating that employers may have an opportunity to improve their efforts to promote workplace safety by establishing clear policies.

However, Table 4 shows that the involvement of OHPs in a medical surveillance program may lead to better compliance with specific steps, including conducting a walk-through survey and performing a measurement area or personnel sampling. OHPs were also more likely to have a medical surveillance program design and to keep medical records by type of hazard.

Table 5 The comparison of medical surveillance in compliance with U.S. OSHA in each step between factories with OHP and without OHP support of the program

Steps in a medical surveillance program	OHP Total = 22	Non-OHP Total = 65	Crude OR (95%CI)	p-value
	n (%)	n (%)		
Step 1: A walk-through survey	13 (59.0)	16 (24.6)	4.33 (1.56 - 12.51)	0.003
Step 3: Measurement area or personnel sampling	18 (81.8)	43 (66.2)	4.33 (1.56 - 12.5)	0.165
Step 5: Design for components of a medical surveillance program	9 (40.9)	2 (0.03)	20.71 (4.36 - 154.70)	<0.001
Step 9: Medical removal	20 (90.9)	57 (87.7)	1.39 (0.29 - 10.34)	0.683
Step 10: Medical recordkeeping by type of hazard	10 (45.5)	16 (24.6)	2.52 (0.89 - 7.08)	0.065
Step 13: Audit	18 (81.8)	45 (69.2)	1.98 (0.61 - 7.61)	0.254
Step 14: Employer actions	22 (100.0)	63 (96.9)	1.11 (0.06 - 42.54)	0.405

Discussion

The study was cross-sectional design, with a response rate of 45.8%, which was lower than expected. Possible reasons for this low response include the sensitive nature of the questions, which require technical interpretation or legal release, and the lack of perceived benefit for respondents^{32,33}. Moreover, due to Thai law^{24,25}, most respondents were safety officers (80.5%), and there were limited numbers of OHPs with relevant expertise in the factories. This could potentially affect the accuracy of the information obtained, as medical surveillance is considered a primary role of OHPs^{11,34,35}. According to data collected from the questionnaire, the study factories were large manufacturing plants with more than 200 employees, mainly involved in the repair of vehicle equipment and the production of electrical machines and petroleum products. Solvents were the chemicals most commonly used (65%) among the 41 chemicals recommended by OHPs for medical surveillance programs⁵.

This research study aimed to investigate the proportion of large-scale industrial factories that have implemented a medical surveillance program designed according to the U.S. OSHA standards. It was hypothesized that the industrial factories with OHPs would have a high compliance rate. The research findings showed that at least 8 critical steps in the U.S. OSHA Medical surveillance program were implemented in 3.4% of the surveyed factories. Compared to a similar study

conducted in the United States, the compliance rate was only 52%²⁹. This indicates a significantly low compliance rate among industrial factories in Thailand, which may be attributed to various factors specific to the industrial environment in Thailand. Moreover, a lack of awareness among factory management regarding the U.S. OSHA standards and their importance in ensuring employee health and safety. These may be due to inadequate training or insufficient access to resources that explain the U.S. OSHA standards and their implementation²⁹.

The limited enforcement of U.S. OSHA standards by local regulatory authorities, or a focus on other standards that factories may be more familiar with or prioritize, may lead to partial compliance with the U.S. OSHA standards. This may result in a lack of incentives for factories to comply with U.S. OSHA standards fully. Moreover, there may be differences between local Thai regulations and the U.S. OSHA standards, causing factories to prioritize compliance with local Thai regulations and guidelines²²⁻²⁸. This may result in partial or low compliance with the U.S. OSHA standards. For example, according to the U.S. OSHA standards, Step 1 OHPs must participate in a walk-through with a multidisciplinary team to identify hazards yearly or change chemical process^{1,6,16}. However, this issue is not specified in Thai laws, resulting in a compliance rate of only (25.3%). Then, the study found that only (12.6%) of the factories met the U.S. OSHA standard for Step 5, which emphasizes using

data from previous steps (1 to 4), including sources like NIOSH, IARC, or ACGIH, in addition to legal sources^{3,4}. OHPs should prioritize personal sampling over area sampling in Step 3 of exposure assessment¹, which is emphasized in Thai law. In Step 4, the action level principle should be used to evaluate chemical exposure^{1,4,14,17,18}, while Thai regulation focuses on health risk assessment²². OHPs should evaluate all data to design appropriate employee health examinations, such as medical questionnaires, physical examinations, and biomarker tests¹². However, the regulation and guidelines in Thailand^{23,24} may not be comprehensive enough to comply with U.S. OSHA standards, resulting in many industrial factories failing to meet these standards. This is consistent with previous studies that found that health examination programs in Thai industries were inadequate according to academic or international standards³⁶.

Additionally, only 29.9% of the factories met the U.S. OSHA standard for storing Similar Exposure Group (SEG) health data in Step 10. While Thai law requires data to be stored for at least ten years, it does not require storing data separately, according to SEG. This may not be sufficient for carcinogenic substances³⁷, as OSHA recommends keeping data for at least 30 years^{1,16}. Furthermore, collecting employee health data accurately and appropriately can predict trends in health³⁷.

Finally, some factories may perceive the U.S. OSHA standards as complex and challenging to implement. This perceived complexity could discourage factory

management from fully adopting these standards in their medical surveillance programs^{2,3}. Included resources for implementing a comprehensive medical surveillance program following the U.S. OSHA standards may require significant financial or human resources. Some factories may lack qualified personnel, such as OHPs, to establish and maintain program¹¹. However, involving occupational health professionals such as OHPs in the medical surveillance program can significantly improve the program's effectiveness and enhance workplace safety and health²⁰. This study reveals that an OHP was associated with a significantly high likelihood of conducting a walk-through survey (Step 1) and designing a medical surveillance program (Step 5), respectively. Consistent with the previous study, it was found that OHPs play a vital role in other steps of the process. Besides, in Step 6, having OHPs in the factory can help in the medical removal and return-to-work processes for employees^{7,8}. In Step 11, as PPE respirators can affect health, OHPs should oversee medical clearance for their use^{10,38}. In Step 12, when writing health reports for employees, OHPs should provide only fit notes to the employer that indicate the employee's ability to work without risk^{13,39}. In Step 14, OHPs can provide ethical arguments to employers regarding the return on investment for employee health⁹.

Conclusions and Recommendations

Few industrial factories in Thailand comply with U.S. OSHA standards for medical

surveillance programs, with a low compliance rate of 3.4% (95% CI: 1.1-8.9). The study identified the top three lowest substandard steps were designing medical surveillance (12.6%; 95% CI: 6.9-20.8), conducting walk-through surveys (25.3%; 95% CI: 17.1-35.1), and maintaining medical recordkeeping (29.9%; 95% CI: 21.0-40.0). The low compliance rate included a lack of awareness among factory management, inadequate regulations and/or guidelines, and perceived complexity. However, having OHP doctors is an important factor that contributes to factories complying with standards more effectively.

This study recommends that the industrial factories in Thailand should improve their compliance with the U.S. OSHA standards and implement a comprehensive medical surveillance program. This can be achieved by increasing awareness among factory management, providing adequate training and resources, and involving occupational health professionals such as OHPs by implementing guidelines via specific agency such as U.S. OSHA. Future research can focus on identifying barriers to compliance and developing strategies to overcome them, as well as evaluating the effectiveness of interventions to improve compliance and promote workplace safety and health.

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References

1. Occupational Safety and Health Administration. Medical screening and surveillance requirements in OSHA standards: a guide [Internet]. 2014 [cited 2022 Dec 2]. Available from: <https://kku.world/0yc3f>.
2. Craner J. Medical surveillance. In: LaDou J, Harrison R, editors. Current occupational & environmental medicine. 5th ed. New York: McGraw-Hill; 2014. p. 693-707.
3. Koh D, Aw TC. Surveillance in occupational health. *Occup Environ Med* 2003;60:705-10, 633.
4. Trout DB, Schulte PA. Medical surveillance, exposure registries, and epidemiologic research for workers exposed to nanomaterials. *Toxicology* 2010;269:128-35.
5. Srisook P, Chaiear N, Ekpanyasakul C, et al. A systematic review of chemical inventory required medical surveillance in the context of occupational. *Srinagarind Med J* 2020;35:173-81. (in Thai)
6. Persechino B, Fontana L, Buresti G, et al. Professional activity, information demands, training and updating needs of occupational medicine physicians in Italy: National survey. *Int J Occup Med Environ Health* 2016;29:837-58.
7. Schaafsma F, Hugenholtz N, de Boer A, et al. Enhancing evidence-based advice of occupational health physicians. *Scand J Work Environ Health* 2007;33:368-78.

8. de Boer AGEM, van Beek JC, Durinck J, et al. An occupational health intervention programme for workers at risk for early retirement; a randomised controlled trial. *Occup Environ Med* 2004;61:924-9.
9. Miller P, Haslam C. Why employers spend money on employee health: Interviews with occupational health and safety professionals from British Industry. *Saf Sci* 2009;47:163-9.
10. Martyny J, Glazer CS, Newman LS. Respiratory protection. *N Engl J Med* 2002;347:824-30.
11. Hartenbaum NP, Baker BA, Levin JL, et al. ACOEM OEM Core Competencies: 2021. *J Occup Environ Med* 2021;63:e445-61.
12. Breeher LE, Molella RG, Vaughn AI, et al. Medical surveillance programs for workers exposed to hazardous medications: a survey of current practices in health care institutions. *J Occup Environ Med* 2019;61:120-5.
13. Subsookumnuay P, Chaiear N, Krisorn P. Development of an appropriate medical certificate of employment for administrative purposes. *Chiang Mai Med J* 2021;60:449-62.
14. Department of Occupational Safety and Health, Ministry of Human Resource of Malaysia. Guidelines on medical surveillance. Putrajaya: The Department of Occupational Safety and Health; 2001. (in Thai)
15. Academic Model Providing Access to Healthcare. AMPATH medical surveillance guideline. [n.p.]: AMPATH; 2014.
16. Occupational Safety and Health Administration. OSH act of 1970 [Internet]. 2004 [cited 2021 Feb 6]. Available from: <https://kku.world/66195>.
17. Safe Work Australia. Hazardous chemicals requiring health monitoring [Internet]. n.d. [cited 2021 Feb 22]. Available from: <https://kku.world/1ejka>.
18. Workplace exposure standards and biological exposure indices. Wellington: Worksafe Mahi Haumaru Aotearoa; 2020.
19. Froneberg B, Timm S. Country profile of occupational health system in Germany. Copenhagen: WHO Regional Office for Europe; 2012.
20. Rantanen J, Fedotov IA. Standards, principles and approaches in occupational health services [Internet]. 2002 [cited 2021 Feb 22]. Available from: <https://kku.world/s9j5e>.
21. Conway H, Simmons J, Talbert T. The purposes of occupational medical surveillance in US industry and related health findings. *J Occup Med* 1993;35:670-86.
22. Notification of Ministry of Industry: Thailand industrial standard for chemical health risk assessment for industrial worker B.E. 2555. (A.D. 2012). *Roy Thai Gov Gaz* 2012;129 (Special Pt 146 ng):12, 1-14. (in Thai)
23. Notification of Ministry of Industry: Establish industry product standards, health check-up practices based on chemical and physical risk factors from occupations in the workplace B.E. 2555 (A.D. 2012). *Roy Thai Gov Gaz* 2012;129 (Special Pt 105 ng):6, 1-59. (in Thai)

24. Ministerial Regulations set the standard for employee health checks relating to risk factors B.E. 2563 (A.D. 2020). Roy Thai Gov Gaz 2020;137:30-3. (in Thai)
25. Ministry of Public Health: Occupational health and safety and environment act B.E. 2554 (A.D. 2011). Roy Thai Gov Gaz 2011;128:5-25. (in Thai)
26. Ministerial Regulations on the provision of safety officers for personnel, agencies or personnel to carry out safety operations B.E. 2565 (A.D. 2022). Roy Thai Gov Gaz 2022;139:9-24. (in Thai)
27. Notification of Ministry of Public Health: Isclosure of personal information under the disease control act from occupations and environmental diseases B.E. 2562 (2019) B.E. 2565 (A.D. 2022). Roy Thai Gov Gaz 2022;139:1-4. (in Thai)
28. Personal data protection act B.E. 2562 (A.D. 2019). Roy Thai Gov Gaz 2019;136:52-95.
29. Silverstein M. Analysis of medical screening and surveillance in 21 Occupational Safety and Health Administration standards: support for a generic medical surveillance standard. Am J Ind Med 1994; 26:283-95.
30. Thailand Board of Investment. Thailand's Eastern Economic Corridor (EEC): industrial estate authority of Thailand [online] 2017 [cited 2021 Feb 22]. Available from: <https://www.kku.world/fw43v> [in Thai].
31. Sangphoo T, Chaiear N, Krisorn P. The proportion of medium sized manufacturing factories performing medical emergency preparedness and response according to United States Occupational Safety and Health Administration (U.S. OSHA) standards. J Med Health Sci 2021;28:120-31. (in Thai)
32. Sombutteera K, Thavornpitak Y. Response rate and factors associating mailed questionnaire response rate in nursing sciences and public health research. KKU Res J (Graduate Studies) 2558;15:105-13. (in Thai)
33. Edwards P, Roberts I, Clarke M, et al. Increasing response rates to postal questionnaires: systematic review. BMJ [Internet]. 2002 May 18 [cited 2021 Feb 22]; 324:1183. Available from: <https://kku.world/f389b>.
34. Ishimaru T, Punpeng T, Maiyapakdee C, et al. Survey of the necessary competencies and proficiency of safety officers in Thailand. Ind Health 2020;58:403-13.
35. Yiu NSN, Famakin IO. A review on safety practitioners' competency profiles from the employers' perspective. J Edu Res Rev 2021;9:77-83.
36. Tangyosthakijjakul S, Chernbamrung T. The appropriation of chemical and physical health risk examination of establishment in Rayong province and details of the result reporting to labor inspector. J Safety Health 2018;11:35-46. (in Thai)

37. Choi BCK. The past, present, and future of public health surveillance. *Scientifica (Cairo)* [Internet]. 2012 Oct 23 [cited 2021 Feb 22];2012:875253. Available from: <https://kku.world/76yok>.
38. Szeinuk J, Beckett WS, Clark N, et al. Medical evaluation for respirator use. *Am J Ind Med* 2000;37:142-57.
39. Kaplan B. How should health data be used? *Camb Q Healthc Ethics* 2016;25:312-29.