Lead Poisoning among Communication radio-repair Workers in Signal Department Royal Thai Army Samutsakhon Province, Thailand

Capt. Manasawee Thongsringklee

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พิษของสารตะกั่วต่อพนักงานซ่อมวิทยุสื่อสาร กรมการทหารสื่อสารกองทัพบก จังหวัดสมุทรสาคร ประเทศไทย

ร.อ.มนัสวี ทองศฤงคลี

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By	Capt. Manasawee Thongsringklee
Field of Study	Public Health
Thesis Advisor	Associate Professor WATTASIT SIRIWONG, Ph.D.
Thesis Co Advisor	Professor Mark G. Robson, Ph.D.

Accepted by the College of Public Health Sciences, Chulalongkorn University in Partial Fulfillment of the Requirement for the Doctor of Philosophy

.... Dean of the College of Public Health Sciences

(Professor SATHIRAKORN PONGPANICH, Ph.D.)

DISSERTATION COMMITTEE

.... Chairman

(Professor SURASAK TANEEPANICHSKUL, M.D.)

.... Thesis Advisor

(Associate Professor WATTASIT SIRIWONG, Ph.D.)

.... Thesis Co-Advisor

(Professor Mark G. Robson, Ph.D.)

.... Examiner

(Associate Professor Ratana Somrongthong, Ph.D.)

.... Examiner

(Assistant Professor NUTTA TANEEPANICHSKUL, Ph.D.)

.... External Examiner

(Apaporn Siripornprasarn, Ph.D.)

มนัสวี ทองศฤงคลี : พิษของสารตะกั่วต่อพนักงานซ่อมวิทยุสื่อสาร กรมการทหารสื่อสารกองทัพบก จังหวัดสมุทรสาคร ประเทศไทย. (Lead Poisoning among Communication radio-repair Workers in Signal Department Royal Thai Army Samutsakhon Province, Thailand) อ.ที่ปรึกษาหลัก : รศ. ดร.วัฒน์สิทธิ์ ศิริวงศ์, อ.ที่ปรึกษาร่วม : ศ. ดร.Mark G. Robson

การรับสัมผัสสารตะกั่วในปริมาณต่ำเป็นเวลานานสามารถส่งผลกระทบต่อทุกระบบและอวัยวะของร่างกาย พิษสารตะกั่วถูกพบในพนักงานซ่อมวิทยุสื่อสารเนื่องจากใช้ตะกั่วเพื่อบัดกรี การศึกษาตามยาวใช้เพื่อตรวจสอบระดับสารตะกั่วในเลือดและในเส้นผม เพื่อตรวจสอบความสัมพันธ์ของระดับสารตะกั่วในเลือดและในเส้นผมกับอาการและอาการพิษตะกั่ว และเพื่อประเมินความเสี่ยงด้านสุขภาพจากการได้รับสารตะกั่วในพนักงาน กลุ่มประชากรมีพนักงานซ่อม 66 คนในกลุ่มรับสัมผัสและพนักงานออฟฟิศ 54 คนในกลุ่มรับสัมผัสต่ำในการเก็บข้อมูลพื้นฐาน และมีพนักงานซ่อม 54 คนในกลุ่มรับสัมผัสและมีพนักงานออฟฟิศ 48 คนในกลุ่มรับสัมผัสต่ำในการเก็บข้อมูลตอนท้าย การเก็บข้อมูลลักษณะทั่วไปของกลุ่มประชากร ความรู้ ความตระหนัก การใช้อุปกรณ์ป้องกันส่วนบุคคลต่อการสัมผัสสารตะกั่ว และอาการพิษสารตะกั่วใช้แบบสอบถาม เก็บเส้นผมเพื่อวัดระดับสารตะกั่วที่ถูกขับออกมา เก็บตัวอย่างเลือดเพื่อวัดระดับตะกั่วในร่างกาย และเพื่อวินิจฉัยโรคโลหิตจาง การทำงานของตับและไต ความดันโลหิตสูงถูกประเมินเช่นกัน ผลการศึกษาพบว่าอายุเฉลี่ย ระดับการศึกษา และการเรียนที่โรงเรียนทหารสื่อสารของกลุ่มที่ได้รับสารสัมผัสต่ำมีค่าสูงกว่ากลุ่มที่ได้รับสัมผัสยกเว้นการดื่มนม คะแนนเฉลี่ยของทั้งความรู้และการใช้อุปกรณ์ป้องกันส่วนบุคคลต่อการรับสัมผัสสารตะกั่วมีระดับต่ำทั้งสองกลุ่ม งานวิจัยแสดงให้เห็นว่า ค่าเฉลี่ยมัธยฐานสูงสุดของปริมาณสารตะกั่วในเลือดและในเส้นผมถูกพบในกลุ่มรับสัมผัส คือ 5.5 ไมโครกรัมต่อเดซิลิตร และ 2.9 ไมโครกรัมต่อกรัม ตามลำดับ นอกจากนี้ยังพบความสัมพันธ์ในเชิงบวกระดับต่ำอย่างมีนัยสำคัญทางสถิติ ที่ระดับความเชื่อมั่น 0.05 ระหว่างปริมาณสารตะกั่วในเลือดและในเส้นผม ผลการวิจัยพบความสัมพันธ์ระหว่างปริมาณสารตะกั่วในเลือดกับอาการพิษจากสารตะกั่ว ได้แก่ เบื่ออาหาร คลื่นไส้อาเจียน อ่อนเพลีย ปวดศีรษะหรือเวียนศีรษะ หงุดหงิด ปวดกล้ามเนื้อและข้อ นอนไม่หลับ และความดันโลหิตสูง อย่างมีนัยสำคัญทางสถิติ ที่ระดับความเชื่อมั่น 0.05 และพบความสัมพันธ์ของ ความหงุดหงิดและปวดเมื่อยกล้ามเนื้อและข้อ กับปริมาณสารตะกั่วในเส้นผมอย่างมีนัยสำคัญทางสถิติ ที่ระดับความเชื่อมั่น 0.05 เช่นกัน นอกจากนี้ผลกระทบต่อสุขภาพจากการได้รับสารตะกั่วมีโอกาสเกิดขึ้น 2.4 เท่าในกลุ่มที่ได้รับสัมผัสในเดือนแรก และผลกระทบต่อสุขภาพจากการได้รับสารตะกั่วมีโอกาสเกิดขึ้น 2.5 เท่าในกลุ่มรับสัมผัสน้อยและ 3.5 เท่าในกลุ่มที่ได้รับสัมผัสในเดือนที่ 6 จากผลการวิจัยสามารถสรุปได้ว่าปริมาณสารตะกั่วระดับต่ำสามารถส่งผลกระทบต่อสุขภาพของพนักงานได้ และเนื่องจากความรู้และการใช้อุปกรณ์ป้องกันส่วนบุคคลต่อการรับสัมผัสสารตะกั่วมีระดับต่ำ จึงควรใช้โปรแกรมการป้องกันพิษจากสารตะกั่วซึ่งประกอบด้วยการเพิ่มขึ้นของความรู้ ความตระหนักและการใช้อุปกรณ์ป้องกันส่วนบุคคลของการสัมผัสกับสารตะกั่ว

สาขาวิชา	สาธารณสุขศาสตร์	ลายมือชื่อนิสิต	....
ปีการศึกษา	2562	ลายมือชื่อ อ.ที่ปรึกษาหลัก	....
		ลายมือชื่อ อ.ที่ปรึกษาร่วม	....

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Chronic exposure to low dose of lead can affect to every systems and organs of the human body. Lead poisoning have been found among communication radio-repair workers because lead is routinely used for soldering. The longitudinal study design was used to investigate blood lead level (BLL) and hair lead level (HLL), to determine the association of BLL and HLL with signs and symptoms of lead poisoning among workers and to determine the health risk assessment of lead exposure among workers. There were 66 repair workers in exposed group and 54 office workers in low exposed group at baseline. And, there were 54 workers in exposed group and there were 48 workers in low exposed group at endpoint. General characteristics, Knowledge, Awareness, and PPE used (KAP) of lead exposure, and signs and symptoms were investigated by using a questionnaire. Hair samples were collected to measure excreted lead level. Blood samples were collected to measure lead level and to diagnose anemia, hepatic and kidney functions. Hypertension was also assessed. Descriptive statistic was used to describe all variables. Chi-square test, Independent T-test, and Mann–Whitney U test were used to compare the variables between both groups. Spearman's correlation was used to determine the correlation between BLL and HLL. Binary logistic regression was used to determine the association of BLL and HLL with signs and symptoms. The results showed the average age, education levels, and study at Signal school of low exposed group were higher than exposed group except for milk drinking (*P-value* < 0.05). The low median scores of knowledge and PPE used among workers were shown. The highest median BLL and HLL of exposed group were 5.5 μg/dL and 2.9 μg/g, respectively. Low positive correlation between BLL and HLL was also found (*P-value* < 0.05). The associations between BLL and signs and symptoms including loss of appetite, nausea and vomiting, excessive tiredness or weakness, headache or dizziness, nervous irritability, muscle and joint pain, insomnia, and hypertension were shown (*P-value* < 0.05). And, there were the associations of nervous irritability and muscle and joint pain with HLL (*P-value* < 0.05). The adverse health effects for lead exposure can be occurred with a chance of 2.4 time in expose group at baseline and can be occurred with a chance of 2.5 and 3.5 times in low exposed and exposed groups, respectively at endpoint. The findings can be summarized that there were existing adverse effects of low lead levels on the workers. Because of low knowledge and used of PPE among workers, lead poisoning protection program that consists of increasing in KAP of lead exposure should be applied as a guideline.

Field of Study: Public Health		Student's Signature ....
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		Co-advisor's Signature ....

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Manasawee Thongsringklee

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CHAPTER I

INTRODUCTION

1.1 Background and Rationale

Occupational health and safety (OHS) is an awareness of workers' health safety and workers' welfare and also might protect co-workers, family members, customers, and others who might be affected by the workplace environment. The goals of OHS include to promote a safe and healthy workplace environment and has a strong focus on primary prevention of hazards. Occupational and work-related diseases are important public health problems, including diseases from toxic substances used in industrial sector. Insufficient prevention and control over these problems in plants always put workers to be at risk of exposure and poisoning.

Lead can enter into human body through various ways, such as eating, inhalation and skin contact (Patrick, 2006b; Pourmand, Khedir Al-Tiae, & Mazer-Amirshahi, 2012). People who are exposed at work are usually exposed by breathing the contained lead particles in air. Between 0.5 and 1.5 million workers are exposed to lead in the workplace. Lead poisoning may vary according to type and dose of lead exposures. When lead gets into the lungs, it goes quickly to other parts of the body via your blood. Level of blood lead depends on type of work and age. In normal adult blood lead level (BLL) should be less than 40 μg/dl and less than 10 μg/dl in children. For those who work with lead, the BLL should be less than 60 μg/dl. Many research studies have showed that human hair mineral analysis is a marker of environmental pollution. Therefore, using hair as an indicator of the environmental exposure to lead (Hair lead level; HLL) has become a common practice (Mehra & Juneja, 2004; Ozden et al., 2007; Strumylaite, Ryselis, & Kregzdyte, 2004). Time of lead exposure can affect all organ systems, such as blood, nervous and renal system. It is accumulated in bones and teeth. If exposure to low dose of lead continues it can gradually build up in the body to cause of the health problems as chronic symptoms such as loss of appetite, headache, heart rate variability, fatigue, anxiety, anorexia, nausea, numbness of the limbs, memory loss, poor concentration, lead line on the gum, and colic pain. Exposure to low lead levels for long term can be the cause of elevation in blood pressure. Moreover, BLL lower than 10 µg/dL caused of tremor (Kosnett et al., 2007). Some patients with high BLL may have seizures, depression and unconsciousness.

In communication radio-repair plant, Signal Department Royal Thai Army (RTA), lead poisoning have been found among workers since lead is used for soldering in their job. Although the plants have working-station exhaust ventilators at the soldering spots, BLL of some workers is still high. They may lack knowledge and understanding about the lead toxicity and the protection against it. As many workers do not use personal protective equipment (PPE) in this plant are risks to lead exposure during their work. In addition, building of the plants is the closed system. Therefore, it is interesting to study because there is no study the effects of lead exposure in the RTA's workers before. This research aims to investigate the occupational exposure to lead from BLL and HLL and to determine the association between the occupational exposures to lead and Signs and symptoms of lead poisoning among the communication radio-repair workers in Signal department RTA at Samutsakhon province. This research will bring about early detection for those with lead poisoning and precaution for those at risk. Moreover, this study hopes to see the workers can work happily and have better life.

1.2 Research Question

1. Are there high lead levels among communication radio-repair workers in the Signal department RTA at Samutsakhon province?

2. Are there the correlation between BLL and HLL among communication radio-repair workers in the Signal department RTA at Samutsakhon province?

3. What are the effects of lead exposure on signs and symptoms of lead poisoning among communication radio-repair workers in the Signal department RTA at Samutsakhon province?

4. Are communication radio-repair workers in the Signal department RTA at Samutsakhon province at risk from occupational exposure to lead?

1.3 Research Hypotheses

1. There are high lead levels among communication radio-repair workers in the Signal department RTA at Samutsakhon province.

2. There is the correlation between BLL and HLL among communication radio-repair workers in the Signal department RTA at Samutsakhon province.

3. The occupational exposure to lead has the effect on signs and symptoms among communication radio-repair workers in the Signal department RTA at Samutsakhon province.

4. Communication radio-repair workers in the Signal department RTA at Samutsakhon province are at risk from occupational lead exposure.

1.4 Research Objectives

General Objectives

1. To investigate the occupational lead exposure from BLL and HLL among communication radio-repair workers in the Signal department RTA at Samutsakhon province within 6 months.

2. To determine the association between the occupational lead exposure (BLL and HLL) and signs and symptoms among communication radio-repair workers in the Signal department RTA at Samutsakhon province within 6 months.

Specific Objectives

1. To describe demographic characteristics, health behaviors, working conditions, KAP of lead exposure, airborne lead concentrations, BLL, HLL, and Signs and symptoms of lead poisoning among RTA communication radio-repair workers at baseline and endpoint.

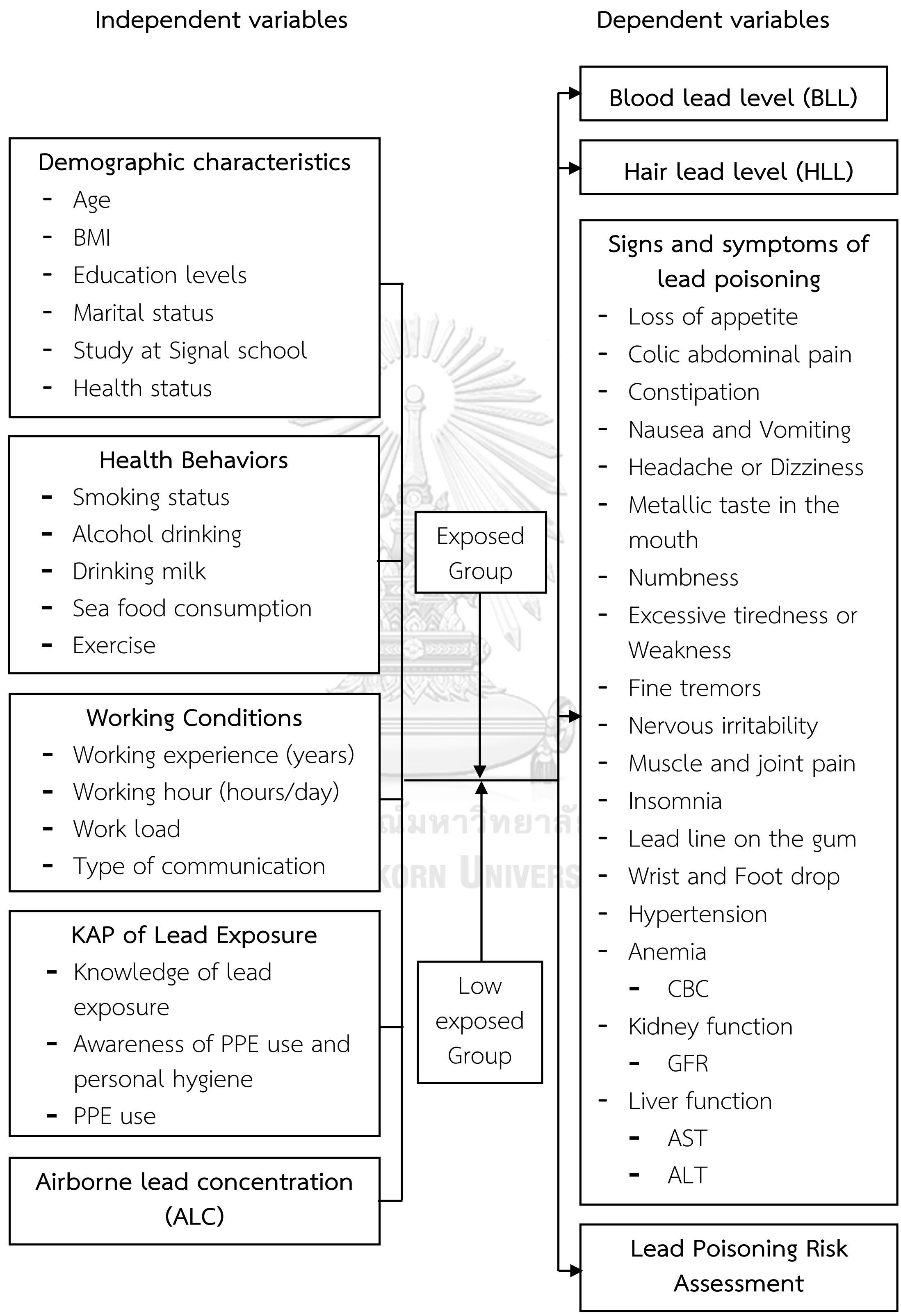
2. To compare AP of lead exposure, airborne lead concentrations, BLL, HLL, and Signs and symptoms of lead poisoning within and between exposed and low exposed group at baseline and endpoint.

3. To assess the association among health risk factors including demographic characteristics, health behaviors, working conditions, KAP of lead exposure, and airborne lead concentrations with lead levels (BLL and HLL) and signs and symptoms of lead poisoning among RTA communication radio-repair workers at baseline and endpoint.

4. To determine the correlation between BLL and HLL among RTA communication radio-repair workers.

5. To determine the health risk assessment of lead exposure among RTA communication radio-repair workers.

1.5 Research conceptual framework



1.6 Definition of Terms

1. Workers in communication radio-repair plant mean commissioned officers, non-commissioned officers and civilian employees who work inside the communication radio-repair plant of the Signal department Royal Thai Army at Samutsakhon province. They will be separated into 2 group as follow:

- **Exposed group** means the workers who are the communication radio repair workers. They use lead for soldering while working.
- **Low exposed group** means the workers who do not repair communication radio. However, they work together in the same plant building with the communication radio repair workers.

2. Communication radio-repair plant: There are 5 sections inside the plant which are separated by the type of work or type of the communication radio that they repair including clerical officer (CO), high frequency radio-repair (HF), very high frequency radio-repair (VHF), field telephone repair (FT), and carrier wave radio-repair (CW) sections. The clerical officer section is low exposed group. The others section are exposed group.

3. Demographic characteristics: All demographic characteristics of the workers including age, BMI, education levels, marital status, study at signal school, and health status are the factors that have the effects on lead levels change in the body.

4. Health Behaviors: These Health Behaviors including smoking status, alcohol drinking status, drinking milk, sea food consumption, and exercise are the factors that have the effects on changing lead levels in the body. For example, there is significant data indicates that alcohol may also increase the susceptibility of some organs, to lead toxicity, by depleting calcium, zinc and magnesium levels (Bechetoille, Allain, Ebran, & Mauras, 1983; Flora, Kumar, Sachan, & Das Gupta, 1991; Gupta & Gill, 2000) and smoking on site was significantly associated with higher BLLs among Bridge Painters (Rodrigues et al., 2010). On the other hand, drinking of milk resulted in decreased content of lead in hair (Michalak, Wołowiec, & Chojnacka, 2014).

5. Working Conditions includes working experience (years), work days/week, working hour (hours/day), work load (communication radios/month), type of communication radio, and job description. All of these are the routine of the workers which are exposure factors to lead into the body.

6. Knowledge, Awareness, and Practice (KAP) of lead poisoning composes of knowledge of lead poisoning**,** awareness of PPE use, and how to use the appropriate PPE, awareness of personal hygiene during working, and use of PPE which including goggles, work uniform, dust respirator and gloves (Lead MSDS). It is likely that KAP are the factors that have the effect on lead levels change in the body.

7. The Airborne Lead Concentrations refer to the lead levels that are measured in the air from representative workers of each section during working periods. The National Institute for Occupational Safety and Health (NIOSH) Recommended Exposure Limit (REL) for lead is a Time Weighted Average (TWA) of 50 $\mu g/m^3$ over 8-hours. And, the required Permissible Exposure Limit (PEL) of the Occupational Safety and Health Administration (OSHA) for lead is not more than 50 $\mu g/m^3$ averaged over an 8-hour period. The PEL is reduced for shifts longer than 8 hours by the equation PEL = 400/hours worked. For Action levels, OSHA required the unprotected workers' exposure to an airborne concentration of lead of 30 $\mu g/m^3$ of air calculated as an 8-hour time-weighted average. However, the standard lead level of the Ministry of Labor and Social Welfare in the air of Thailand is 200 $\mu g/m^3$.

8. Lead Poisoning Risk Assessment: Quantitative health risk assessment refers to a process which consists of hazard identification, dose response assessment, exposure assessment, and risk characterization to evaluate the magnitude of health risk for lead exposure.

9. Blood Lead Level (BLL) refers to a measurement of lead in the blood. The U.S. Centers for Disease Control and Prevention (CDC) recommends the standard BLL that in normal adult BLL should be less than 40 µg/dl. For the workers who work with lead, the BLL must be less than 60 µg/dl. However, if a worker has a BLL equal or higher than 50 µg/dl, then OSHA requires that the worker be removed from the workplace where lead exposure is occurring. By the way, when we focus on health effect for lead exposure, in 2009-2015, CDC designated 10 µg/dL of BLL for adults as a level of concern. Higher than 10 µg/dL are considered elevated BLL. Later in 2015, NIOSH designated 5 µg/dL of whole blood as the reference BLL for adults.

10.Hair Lead Level (HLL) refers to a measurement of lead in hair. Many research studies have showed that human hair mineral analysis is a good biomarker of environmental pollution. Therefore, using hair as an indicator of the environmental exposure to several trace elements has become a common practice (Mehra & Juneja, 2004; Ozden et al., 2007; Strumylaite et al., 2004). One study suggested that level of lead in hair was the mostly meaningful environmental marker of exposure to lead in the human organism (Nowak & Chmielnicka, 2000).

11.Signs and symptoms of lead poisoning: refer to the metal poisoning in humans that caused by increased levels of lead in the body. Occupational exposure is the main cause of lead poisoning. The workers who work in the places that produce a variety of lead containing can be exposed. Lead is toxic to many organs and systems in the body including the cardiovascular, renal, hepatic, nervous, and hematopoietic systems. The United States Environmental Protection Agency (U.S.EPA) indicates that there are many signs and symptoms of lead poisoning for example headache, colic pain, numbness of the limbs, hypertension, lead line on the gum, metallic taste in the mouth and anemia. In severe cases are seizures, coma, and death.

CHAPTER II
LITERATURE REVIEW

2.1 Lead

There is no standard definition assigning metals as heavy metals. Most heavy metals have a high atomic number, atomic weight and a specific gravity greater than 5.0 and a specific density more than 5 g/cm^3. Heavy metals include some metalloids, transition metals, basic metals, lanthanides, and actinides. Heavy metals that main threats to human health are associated with exposure to mercury, arsenic, cadmium, and lead. Less commonly, metals including iron, copper, zinc, aluminum, chromium, beryllium, cobalt, and manganese are considered heavy metals. Some lighter metals and metalloids are toxic and thus are termed heavy metals, which some heavy metals, such as gold, typically are not toxic. In addition, some of these metals are essential to human biochemical processes. For example, zinc is an important cofactor for several enzymatic reactions in the human body and hemoglobin contains iron.

Lead (Pb) exists in three oxidation states including Pb (0), the metal; Pb (II) and Pb (IV). In a vast majority of compounds lead forms, it occurs in oxidation states +2 and +4. Metallic lead, Pb (0) exists in nature, but its occurrence is rare. Lead is common toxic heavy metals in the environment and occupational health (Ahmad et al., 2014; Kevin & Victor., 1998; Pourmand et al., 2012) . It can be found everywhere in the environment (in the air, the soil, and the water) even within the houses. Earlier, lead originated from pots that used for cooking and storage. During the last century, more than 50% of lead emissions to ambient air have further polluted our environment from petrol. However, lead emissions in developed countries have decreased clearly due to the introduction of unleaded petrol over the last few decades. Likewise, Thailand has use unleaded petrol since 1996. As nonperishable nature of lead it can persist for long time in the atmosphere. It can enter into human body through various ways, such as eating, inhalation and skin contact (Kevin &

Victor., 1998; Patrick, 2006b; Pourmand et al., 2012). Adults might be exposed to lead by eating and breathing lead dust or fume from the working areas or in the older houses and buildings. One of the major sources of lead exposure comes from inhalation. Industries, vehicles exhausts, and even dust in the air that people breathe all have the potential of containing lead. Occupational exposure to inorganic lead occurs in mines and smelters as well as welding of lead painted metal, and in battery plants. Airborne lead can be deposited on soil and water, thus reaching humans via the food chain. Another main source of exposure to lead is took place throughout the metabolic process and gastrointestinal tracts. As for workers with active exposure, the most statistically significant route for absorption is through the metabolic track (Papanikolaou, Hatzidaki, Belivanis, Tzanakakis, & Tsatsakis, 2005). The general population is exposed to lead from air and food in roughly equal proportions. Although lead causes of the adverse effects on human it has the benefits for using. Lead's extensive use is largely due to its low melting point and excellent corrosion resistance in the environment. It is used in building construction, lead-acid batteries, bullets and shot, weights, as part of solders and as a radiation shield. Lead and its compounds have been used in a variety of products that were found easily, including ceramics, paint, solders, batteries and cosmetics. This research study interested in harmful effects of lead exposure to among workers in the communication radio-repair plants because they use lead for soldering in their job.

2.1.1 Physical and Chemical properties

Chemical formula	Pb
CAS Number	7439-92-1
Atomic number	82
Atomic mass	207.2 $g.mol^{-1}$
Density	11.34 g/cm^3 at 20°C
Melting point	327°C
Boiling point	1755°C
Isotopes	13
Color	Bluish-white
Physical state	Very soft, highly malleable and ductile
Tensile	It can be stretched without breaking
Luster	A shine or glow
Crystalline structure	Face-centered cubic crystalline structure
Reactivity with water	Dissolves slowly in water
Oxidation	Does not readily react with O_2 in the air
Conductivity	Poor transmission of heat or electricity
Flammability	Does not burn
Reactivity with acids	Reacts quickly with hot acids but slowly to cold acids
Corrosion	Very resistant to corrosion but tarnishes upon exposure to air
Toxicity	Toxic

2.1.2 Toxicokinetics of Lead

Potentially high levels of lead may occur in the industries requiring flame soldering of lead solder. Approximately 95% of deposited inorganic lead is absorbed by inhalation route which is the primary route for occupational exposure. Larger particles of lead (bigger than 2.5 μm) that are deposited in the ciliated airways can be transferred by mucociliary transport into the esophagus and swallowed into the gastrointestinal tract. The extent and rate of gastrointestinal absorption of inorganic lead are influenced by the physiological state of the exposed individual and the species of the lead compound. Adults take up 10-15% of inorganic lead in food, whereas children may absorb up to 50% via the gastrointestinal tract (GI tract). Inorganic lead is low absorbed rate via dermal route but organic lead compounds penetrate the skin easily. Inorganic lead does not penetrate the blood brain barrier (BBB) in adults, whereas this barrier is less developed in children. Therefore, the high GI uptake and the permeable BBB make children especially susceptible to lead exposure. Children are at the highest risk of lead exposure including the developing fetus and the impoverished. Lead in blood is bound to erythrocytes and is distributed throughout the body. In the body, about 94% of the total amount of lead is accumulated in the bones and teeth. The elimination half-lives for inorganic lead in blood is approximately 30 days and in bone is around 20-30 years. Independent of the route of exposure, absorbed lead is slowly released from body compartment and slowly excreted from the body (Mushak, 2011). The most significant excretion route for lead is Urinary tract (Zhang et al., 2013). In addition, alternative pathways of lead excretion may include secretion into the sweat, bile, gastric fluid, saliva, and hair (Rabinowitz, Wetherill, & Kopple, 1976).

2.2 Lead Poisoning

Lead is a highly poisonous metal. Exposure at workplace is a common cause of lead poisoning in adults with certain occupations at particular risk. In 2013 lead is believed to have resulted in 853,000 deaths. It occurs most commonly in the developing world. Those who are poor are at greater risk (WHO, 2016). Exposure to lead can cause a variety of health problems. Lead poisoning may be acute or chronic, but the latter is much more common. Chronic effects are significantly because of lead accumulation within the human body. Chronic lead exposure is related to many health diseases in humans. It is reported to be a toxic substance to several organs and systems such as renal, hepatic, hematopoietic, skeletal, cardiac, reproductive systems, and central and peripheral nervous system (CNS and PNS). It can result in behavioral problems. Some of the effects are permanent (WHO, 2016). In severe cases anemia, seizures, coma, or death may occur (Shukla, Shukla, & Tiwari, 2018). As for now, there is no known level of lead exposure that is considered safe for human (WHO, 2016; ATSDR, 2007; CDC, 2005). Signs and symptoms of lead poisoning may be different in adults and children. The main Signs and symptoms of lead poisoning in adults are headache, abdominal pain, memory loss, kidney failure, male reproductive problems, weakness, and pain or tingling in the extremities (Pearce, 2007). A study revealed lead encephalopathy is characterized by sleeplessness and restlessness. In severe cases of lead encephalopathy, the affected person may suffer from acute psychosis, confusion and reduced consciousness. The classical picture includes a dark blue lead line on the gum. There was a research reported the workers in a Battery Manufacturing Plant that 51.6% of the workers at the assembly section had personal illness such as diabetes and allergy. Almost half of them (45.2%) had BLLs more than 60 μg/dl which are higher than safety levels for the workers who contact to lead. Many workers were recorded to be weakness, fatigue of muscle, mood swings and forgetfulness (Lormphongs et al., 2004).

2.3 Signs and symptoms of lead poisoning

Adverse health effects of lead depend on its concentrations and time of exposure to the toxicants. Harmful effects may range from annoyance, irritation, asymptomatic physical change and even death. The International Agency for Research on Cancer (IARC) classified lead as a possible human carcinogen based on sufficient animal data and insufficient human data in 1987. There are strong associations have been found between BLLs and increased risk of all cancer. Even 5-9 μg/dl of lead in blood a significant association with the risk of disease could be found (Lustberg & Silbergeld, 2002; Menke, Muntner, Batuman, Silbergeld, & Guallar, 2006; Schober, Mirel, Graubard, Brody, & Flegal, 2006). Some epidemiological data provide increasing evidence that environmental and occupational exposures to lead may be associated with increased cancer risks (Fu & Boffetta, 1995). Lead may act as a carcinogen by increasing the possibility of fixed damage to DNA, either by inhibiting DNA repair or by displacing zinc in DNA binding proteins (Hartwig & Schwerdtle, 2002). Moreover, Lead exposure is causes of health effects in multiple organ systems (A, 2004; Landrigan, 1990; Parkinson, Hodgson, Bromet, Dew, & Connell, 1987; Patrick, 2006b; Pourmand et al., 2012; Wu et al., 1996). Some evidences showed that low dose of lead exposure can lead to adverse renal and cardiovascular effects, cognitive dysfunction, and adverse reproductive outcomes. Lead poisoning can cause many signs and symptoms which vary depending on the concentration of lead exposure, the duration of lead exposure and the individual (Coyle, Kosnett, & Hipkins, 2005; Karri, Saper, & Kales, 2008). Symptoms are nonspecific and may be subtle, and someone with elevated lead levels may have no symptoms (Tiwari, Tripathi, & Tiwari, 2013). Symptoms usually develop over weeks to months as lead builds up in the body during a chronic exposure, but acute symptoms from brief, intense exposures also occur (Rajesh Kumar, 2014). Chronic lead toxicity often presents gradually and is nonspecific. Abdominal colic, dizziness, nausea, vomiting, constipation, fatigue, anemia, renal impairment, hepatic disorder, and CNS dysfunction are characteristic signs and symptoms of acute lead poisoning (WHO, 2016; ATSDR, 2007; CDC, 2005). Adverse health effects of lead exposure impact many organs and systems as following:

2.3.1 Signs and symptoms of lead poisoning on Kidney

Although high BLL (more than 60 µg/dl) causes dysfunction of renal, lower level of blood lead (10 µg/dl) damage has been reported. There are two types of renal functional abnormalities can be possible, one is acute nephropathy and another is chronic nephropathy. Acute nephropathy gives rise to abnormal excretion of glucose, phosphates and amino acids. Acute lead poisoning and consequent nephropathy are usually observed in children aged 3 months to 6 years (Mitra, Haque, Islam, & Bashar, 2009). In addition, a study of lead in WHO revealed acute lead exposure is known to cause proximal renal tubular damage. On the other hand, chronic nephropathy is much more severe and can lead to unalterable functional and morphological changes, including glomerular and tubulointerstitial changes, resulting in renal breakdown, hyperuricemia, and hypertension (Rastogi, 2008). Epidemiological studies showed that BLL are related to renal function and has an impact on age-related decreases in renal function in the general population (R. Kim et al., 1996; Staessen et al., 1992). Studies showed that even exposure to low levels of lead, it is associated with chronic kidney disease in the general population (Huang et al., 2013; Muntner, He, Vupputuri, Coresh, & Batuman, 2003; Muntner, Menke, DeSalvo, Rabito, & Batuman, 2005; Navas-Acien et al., 2009). Furthermore, environmental lead exposure might influence progressive diabetic nephropathy (Lin et al., 2006). It was revealed that lead exposure hastens progressive chronic kidney disease by accelerating microvascular and tubulointerstitial injury in chronic kidney disease rat model (Roncal et al., 2007). Research studies have found that long-term exposure to ≤ 5 μg/dL of lead decreased renal function and increased risk of high blood pressure. BLL lower than 10 μg/dL also caused of tremor (Kosnett et al., 2007). Therefore, this research study need to check kidney function by measuring glomerular filtration rate (GFR) which is the best test to measure a level of kidney function and determine a stage of kidney disease. GFR is calculated from the result of blood creatinine test, age, and gender. If the GFR number is low, it means kidneys are not working (Stevens & Levey, 2009). The table 1 shows the stages of Chronic Kidney Disease (CKD) by GFR calculation (Inker & S. Levey, 2014).

Table 1: the stages of Chronic Kidney Disease (CKD)

Stage	Description	GFR
1	Kidney damage with normal kidney function	≥ 90
2	Kidney damage with mild loss of kidney function	60-89
3a	Mild to moderate loss of kidney function	44-59
3b	Moderate to severe loss of kidney function	30-44
4	Severe loss of kidney function	15-29
5	Kidney failure	< 15

2.3.2 Signs and symptoms of lead poisoning on Liver

Acute exposure to lead in vitro studies showed a reduction in cytochrome p450 content (Korashy & El-Kadi, 2012) and an alteration of cholesterol metabolism in hepatic (Ademuyiwa, Agarwal, Chandra, & Behari, 2009). Lead together with low lipopolysaccharide stimulates intercellular signaling between Kupffer cells and hepatocytes resulting in proteolytic enzyme activity (Sipos et al., 2003). It has been shown that higher lead concentration causes liver damage by free radicals, and the normal biochemical process of the hepatobiliary system and precipitates into gallstones may be disturbed by low lead concentrations (Sipos et al., 2003). From these reviews, it was shown that lead cause hepatic disease. So this study would like to check liver function by measuring the amount of alanine aminotransferase (ALT) and aspartate aminotransferase (AST). ALT is found mainly in the liver. It is measured to see if the liver is damaged or diseased. Low levels of ALT are normally found in the blood. But when the liver is damaged or diseased, it releases ALT into the bloodstream, which makes ALT levels go up. Most increases in ALT levels are caused by liver damage. As for AST, this enzyme is found in many tissues throughout the body, including the brain, heart, muscles, kidney, and liver. Low levels of AST are normally found in the blood. It is released into the bloodstream if any of these organs or tissues is affected by disease or injury. It means that AST is not a specific indicator for liver damage. However, the AST test have to be done at the same time with the ALT test. The ratio of AST to ALT sometimes can help determine whether the liver has been damaged. Therefore, both ALT and AST levels are reliable tests for liver damage in the same time. As for male, the normal level of ALT is 0-41 U/L and the normal level of AST is 0-37 U/L which are the standard level of Phramongkutklao Hospital Laboratory.

2.3.3 Signs and symptoms of lead poisoning on Erythropoiesis

Lead exposure significantly affects the erythropoiesis through limiting the synthesis of hemoglobin by inhibiting three key enzymes including D-aminolevulinic acid dehydrogenase (ALAD), Aminolevulinic acid synthase (ALAS), and Ferrochelatase (mitochondrial enzyme) that involved in the synthesis pathway of heme. Therefore, the combined inhibition of these three key enzymes blocks the production of heme in the heme synthesis pathway (Flora, Gupta, & Tiwari, 2012). Others studies reveal that erythrocytes are the most vulnerable cells to this oxidative stress (OS). Reactive oxygen species (ROS) causes oxidation of polyunsaturated fatty acids of erythrocyte cell membrane. The fluidity of cell membrane is decreased and the brittleness of cell membranes is increased making erythrocytes vulnerable to membrane damage. Thus, it reduces the circulating erythrocytes' life span (Hegazy, Zaher, Abd el-hafez, Morsy, & Saleh, 2010; Selvaraj, Bobby, & Sathiyapriya, 2006). These toxic effects of lead result in decreased survival of erythrocytes and development of anemia. One of the original observed hematological effects of lead showed basophilic stippling of erythrocytes, which is a biomarker for finding lead toxicity. These red blood cell aggregates are degradation products of ribonucleic acid (Patrick, 2006a). In less serious cases, the most obvious sign of lead poisoning is disturbance of hemoglobin synthesis, and long-term lead exposure may lead to anemia. One case of acute lead toxicity reported that patient was admitted and noted to be anemic with a BLL of

94.8 μg/dL. Basophilic stippling was demonstrated in this case (Breyre & Green-McKenzie, 2016). Therefore, this study also analyzes complete blood count (CBC) for checking anemia among workers which will be diagnosed by medical doctor of Phramongkutklao Hospital.

2.3.4 Signs and symptoms of lead poisoning on Cardiovascular

Lead poisoning causes cardiovascular damage with potentially fatal impacts including high blood pressure and cardiovascular disease. Exposure to low level of lead can cause high blood pressure in both animals and humans. It also causes other major disorders like peripheral vascular disease, cerebrovascular accidents, and ischemic coronary heart disease. There are many evidence of causal relationship of exposure to lead and hypertension was reported but it is applicable only in cases of cardiovascular outcomes of lead toxicity (Flora et al., 2012). Chronic exposure to low level of lead might have both direct and indirect effects on the development of hypertension. Possible mechanisms of lead toxicity on developing hypertension such as nephrotoxicity, direct action on vascular smooth muscle, disruption of cellular calcium regulation that increases contractility of end arteriole smooth muscle, changes in permeability of blood vessels and catecholamine content of myocardium and blood vessels (Hertz-Picciotto & Croft, 1993; H. Hu et al., 1996). In 19^{th} century, there were cases of increased blood pressure associated with nephrosclerosis have been reported in high lead exposure people. An increase of BLLs from lower than 12 μg/dL to more than 25 μg/dL resulted in increases in blood pressure of 1.4-4 mmHg diastolic and 1.48 mmHg systolic (Hertz-Picciotto & Croft, 1993). As for this study, diastolic and systolic pressure will be measure to check cardiovascular system. However, there are many factors that relate to high blood pressure such as history of hypertension, history of cardiovascular disease, renal disease, used antihypertensive or hypoglycemic medication, and obese people respectively. These should be concerned before study.

2.3.5 Signs and symptoms of lead poisoning on Skeleton

Two compartments within bone Human bones are the target site of lead storage in the body (Renner, 2010). At the bone surface, exchangeable pool is present and in the deeper cortical bone, non-exchangeable pool is located. From the exchangeable pool, lead can enter easily into the plasma but can leave from the non-exchangeable pool and it can move to the surface only when bone is actively being reabsorbed (Patrick, 2006a). In adults, it has been shown that bones contribute to release lead about 40-70% into blood. In contrast, around 85-95% of the lead is stored in adult bones and around 70% in children bones. It is likely that the accumulation and the mobilization of lead in bones depend on several factors such as levels of lead exposure, age, gestation, and race respectively.

2.3.6 Signs and symptoms of lead poisoning on Reproductive system

Lead toxicity can cause of many reproductive adverse effects in both men and women. As for men, it causes chromosomal damage, abnormal spermatogenesis, infertility, abnormal prostatic function, and changes in serum testosterone. Likewise, women are more susceptible to infertility, premature membrane rupture, miscarriage, pregnancy, hypertension, and premature delivery. Moreover, it has been found that lead directly affects the developmental stages of the fetus during the gestation period (Saleh, El-Aziz, El-Fark, & El-Gohary, 2009).

2.3.7 Signs and symptoms of lead poisoning on Nervous system

Many research studies have been found that the increase of BLLs in children caused of lower intelligent quotient (IQ) level (Carrington, Devleesschauwer, Gibb, & Bolger, 2019; Desrochers-Couture et al., 2018; Taylor, Kordas, Golding, & Emond, 2017a, 2017b). BLL in children < 10 μg/dl has been considered acceptable, but recent data indicate that there may be adverse health effects of lead at lower levels of exposure than previously anticipated. Fetuses are more sensitive to lead exposure too (Liu et al., 2014). Lead is extremely and selectively toxic to the CNS. The role of the BBB is critical in the development of neurological disorders seen in heavy metal poisoning because the BBB serves as the duct by which neurotoxins enter the brain through circulation (Tobwala, Wang, Carey, Banks, & Ercal, 2014). Lead neurotoxicity has been investigated and caused by disruption of neurotransmitter systems (Fortune & Lurie, 2009).

2.3.8 General signs and symptoms of lead poisoning

It is shown that there are many adverse health effects on human organs and systems. Moreover, there are general signs and symptoms of chronic lead exposure as following (OSHA):

- Loss of appetite
- Colic abdominal pain
- Constipation
- Nausea and Vomiting
- Headache or Dizziness
- Metallic taste in the mouth
- Lead line on the gum
- Numbness
- Excessive tiredness and Weakness
- Fine tremors
- Nervous irritability
- Muscle and joint pain
- Wrist and Foot drop
- Insomnia

A case report showed that patient who was treated Ayurvedic herbal medicine with lead as an aphrodisiac presented to the emergency department with abdominal pain, loss of appetite, weight loss, nausea, and vomiting after treatment (Breyre & Green-McKenzie, 2016). Iranian man who smoked 10 g of opium/week for one year and a half was reported as an emergency with severe colic pain, constipation, nausea, vomiting, and anorexia. He had experienced fatigued and easily irritated for several weeks and had also felt that there are pins and needle prick on around his arms and legs. Moreover, his lead concentration in serum was substantially elevated and he demonstrated Burton's line (Azizi, Ferguson, Dluzewski, Hussain, & Klein, 2016). Wrist and foot drop and purple-blue lines within gingival tissue called Bruton's lines were found with high BLL (77 μg/dL) (Sakai, 2000; Shiri, Ansari, Ranta, & Falah-Hassani, 2007).

2.4 Biomarkers of Lead Exposure

Environmental and biological monitoring is used for the evaluation of exposure to industrial chemicals, and provides a tool for assessing workers' exposure to chemicals. Biomarker is also used for the measures of biological monitoring in the field of industrial health. Because there are different routes of exposure for different toxic substances, choosing an appropriate media for the biomonitoring is the most important task (Skerfving & Bergdahl, 2007). As for the purposes of biomonitoring, possible markers are defined in different biological media such as blood (Ivanenko et al., 2013; Rodrigues, Batista, Nunes, Passos, & Barbosa, 2008), blood plasma or serum (Michalke et al., 2015), urine (Ivanenko et al., 2013; Kuiper, Rowell, Nriagu, & Shomar, 2014; Roca, Sanchez, Perez, Pardo, & Yusa, 2016), hair (Molina-Villalba et al., 2015), and nails (Kuiper et al., 2014). However, all these media have drawbacks. In some cases, blood and urine would not indicate the exposure as low levels of some metals are quickly eliminated from the blood after long time intakes (Lanphear et al., 2005). In contrast, hair and nails are accumulating the contaminants for long time, allowing for integral assessment for occupational exposure. Meanwhile, hair and nails have quite high probability of external contamination during sampling and sample preparation (Velghe, Capiau, & Stove, 2016). Therefore, the methodology is rather strict. There are many biomarkers of lead exposure in human. Bone lead measurements are an indicator of cumulative exposure. Measurements of urinary lead levels and hair have been used to assess lead exposure. However, the most common and accurate method of assessing lead exposure is analysis of lead in whole blood and hair which are the representative of soft tissue lead.

2.4.1 Blood Lead Level

A measure of lead in the blood is called blood lead level (BLL). The amount of lead in the blood and tissues, as well as the time course of exposure, determines toxicity. BLL is often measured in micrograms of lead per deciliter of blood (μg/dL). More than 98% of lead are found in blood cells (deSilva, 1981; Schutz, Bergdahl, Ekholm, & Skerfving, 1996). The relationship between BLLs and the concentration of lead in exposure sources is curve line (King, Conchie, Hiett, & Milligan, 1979). The half-life for lead in blood and other soft tissue is about 28-36 days (Barbosa, Tanus-Santos, Gerlach, & Parsons, 2005; Sakai, 2000). Erythrocytes are bound to the lead over 95% of the blood lead (Cavalleri, Minoia, Pozzoli, & Baruffini, 1978). Many studies have reported significantly associations between BLLs and various adverse health effect outcomes. However, some studies have been statistically weak, with the magnitude of the effect relatively small. Weaknesses of association may occur because BLL is not a sufficiently sensitive biomarker of exposure or dose at the target organs or because the relationships involved are biologically irrelevant and are only found because of an uncontrolled confounding factor (H. Hu, Rabinowitz, & Smith, 1998; Sakai, 2000). However, diagnosis and treatment of exposure to lead are based on BLL. BLL for adults has been designated 10 μg/dL as the reference. And BLL higher than 10 μg/dL are considered elevated by CDC. The U.S. Occupational Safety and Health Administration (OSHA) designated Lead Standards require that the workers who work in construction industry must be removed from lead exposure when BLLs are ≥ 50 μg/dL and the general industry workers must be removed when BLLs are ≥ 60 μg/dL. Then the workers will be allowed to return to work when the BLL is less than 40 μg/dL. Blood lead samplings must be measured at least every 6 months to all workers who are exposed above the action level for more than 30 days per year, at least every 2 months for the workers whose last blood sampling indicated a BLL ≥ 40 μg/dL, and at least monthly during the removal period of each employee removed from exposure to lead due to an elevated BLL (OSHA, 2004). BLL among workers in the communication radio-repair plants will be measured in this study. However, studies suggest that the measurement of amount of lead in the blood is not useful in creating a retrospective designation (Bellinger, Stiles, & Needleman, 1992; Rabinowitz et al., 1976).

2.4.2 Hair Lead Level

Recently, blood or urine are better sources for determining lead exposure, whereas human hair better reflects long-term exposure and human hair grows approximately 10 mm/month (Gil et al., 2011). Hair analysis has been widely used for the biomonitoring of human exposure to contaminants and for estimation of the nutritional status of individuals. Many researchers have reported that mineral analysis from human hair is a good marker of environmental pollution. Thus, using hair as a biomarker of the environmental exposure to several trace elements has become a common practice (Mehra & Juneja, 2004; Ozden et al., 2007; Strumylaite et al., 2004). In addition, the International Atomic Energy Agency (IAEA) accepts the use of mineral analysis of hair for measuring the levels of toxic trace elements including lead in humans (International Atomic Energy Agency, 1976). Some research studies used hair as an indicator of heavy metal to determine occupational exposures and adult populations reported that human hair has proved to be a vehicle of excretion of contaminants from the body, including heavy metals whose levels are up to 10-fold higher than the concentrations that found in blood or urine (Bader, Dietz, Ihrig, & Triebig, 1999; Kono et al., 1990) because of the binding between metal cations and sulfur molecules within keratin present in the hair matrix (Bencko, 1995). Hair lead content is often measured in micrograms of lead per grams of hair (μg/g). The advantage of hair is that it is a storage tissue and retains trace elements over an extended period of time (Foo et al., 1993; Laker, 1982). Metal body burden of trace or toxic elements is better reflected in hair than in blood because hair gives a record of relatively long time periods, whereas blood shows momentary levels that fluctuate with time. Moreover, human hair is more stable and easier accessible for sampling and analysis than blood (Dongarrà, Varrica, Tamburo, & D'Andrea, 2012). Hair can be kept without technical problems (Mehra & Juneja, 2004). It is also better accepted by the population due to it is a painless and non-invasive method (Kempson & Lombi, 2011). Conversely, hair analysis has many limitations. First, reference of lead levels in human hair have not been described to date yet and there is insufficient data to determine reference ranges for lead (Esteban & Castano, 2009). It has to be compared with the levels that found in the literature reviews as a reference. Second, the contamination of external lead from the environment and the failure to remove it clearly in washing procedures have to be concerned. Some evidences revealed that among the investigated lead content in hair was the mostly meaningful environmental marker of exposure to this metal in the human organism and depended on some factors such as sex, age, hair care, and smoking habits respectively (Barbosa et al., 2005; Nowak & Chmielnicka, 2000). Many studies significantly confirm the differences between exposed and unexposed residents, and exposure to contaminants gives higher hair arsenic, cadmium and lead levels (Gil et al., 2011; Hao et al., 2015; Massaquoi et al., 2015; Wang et al., 2009). Analysis of hair is used for the diagnosis of reference ranges of arsenic, cadmium, and lead in many countries such as Italy, Poland, and Russia (K. Chojnacka, Zielińska, Górecka, Dobrzański, & Górecki, 2010; G. Dongarrà et al., 2011; Skalny et al., 2015). However, the half-life for lead in hair is not shown. Studies reviewed that hair is one of the excretory pathway of lead.

This study conducts to investigate lead contents among workers from whole blood (BLL) and from hair (HLL). Although it is understood that lead concentration in hair does not reflect the amount of lead in the body, it has been reported that HLL correlates with BLL (Chlopicka et al., 1998; Foo et al., 1993).

2.5 Factors Related to Lead Poisoning

It is reported that the children absorbed more lead than adults. They were more susceptible to develop lead toxicity, particularly neurological toxicity even at low level exposure (Gleason, Nanavaty, & Fagliano, 2019; Landrigan, 1990; Woolf, Goldman, & Bellinger, 2007). Some study showed that alcohol greatly increased lead absorption by damaging the body's ability to regulate the absorption of iron. There is significant data that indicates that alcohol may also increase the susceptibility of some organs, to lead toxicity, by depleting calcium, zinc and magnesium levels (Bechetoille et al., 1983; Cezard, Demarquilly, Boniface, & Haguenoer, 1992; Flora et al., 1991; Gupta & Gill, 2000). The mean BLL of the workers who worked more than 8 hours in a day were statistically higher than the workers who worked up to 8 hours in a day. It was found that the workers who smoked had higher mean BLL than nonsmokers (Ahmad et al., 2014). A study found a significantly relation between personal air lead levels and BLL among workers in the crystal industry (Pierre et al., 2002). Smoking on site was significantly associated with higher BLL among Bridge Painters (Rodrigues et al., 2010). Another potential source of lead is lead-based paints, which were withdrawn from the market for residential use in developed countries because of toxicity concerns. However, paints containing lead are still being used for certain industrial applications (Johnson, Sahu, B. Mathur, & C. Agarwal, 2019). Moreover, the composition of lead in food may be highly variable. Others factors such as age, interactions between elements and genetics may to a greater or lesser extent modify the metabolism of the trace element and its mobilization from the blood to the hair compartment (Chojnacka, Gorecka, & Gorecki, 2006; Khalique et al., 2005; Paschal, DiPietro, Phillips, & Gunter, 1989). The concentration of lead in hair has been shown to be influenced by place of residence and by use of hair dyeing (Ozden et al., 2007; Wilhelm, Lombeck, Hafner, & K Ohnesorge, 1989).

2.6 Lead Poisoning Risk Assessment

Risk is a probability or likelihood taking into account the possible harmful effects on individual people or society that exposure to hazardous chemical (National Academy of Science, 1983). Hazardous chemicals are substances that cause harmful effects to human. The hazardous chemical of this study is lead. Lead surveys must always be carried out by workers. There was a study showed that many workers had lacked knowledge and understanding about lead poisoning. They should have adequate knowledge, training and expertise in understanding hazards and associated risks from lead exposure (Lormphongs et al., 2003). And, they should know the work activities that uses and produces lead. However, it is critical to avoid the inhalation of lead dust or fume.

In terms of health risk analysis, it is a process of prioritizing risks based on the probability of the risk occurring and the impact it would have on health. Quantitative risk assessment is a numeric estimate of the risk effect on the study objectives. It is a process which consists of 4 steps including hazard identification, dose response assessment, exposure assessment, and risk characterization to evaluate the magnitude of health risk.

Risk assessment for lead poisoning will be designed to identify the lead hazards and management strategies in this study because it appears that some of lead exposure effects, particularly changes in the levels of certain blood enzymes, may occur at BLL as low as to be essentially without a threshold. The Agency's Reference Dose (RfD) Work Group discussed inorganic lead and lead compounds and considered it inappropriate to develop an RfD for inorganic lead. Moreover, U.S.EPA is not providing a review of current literature concerning the health effects of lead at this time. However, a tolerable daily intake (TDI) of lead for developmental and central nervous system effects has derived at 3.6×10^{-3} mg/kg-day by the National Institute for Public Health and the Environment (RIVM). Therefore, the study used this value as the RfD for lead.

The results of the lead poisoning risk assessment will estimate the probability of the occurrence of any given probable magnitude of adverse health effects over a specified time period and area. Furthermore, the risk assessment will bring to create a precaution or protective guideline for the workers. The guideline will provide general information on lead with regard to chemical health and safety issues for workers using or exposed to lead while and after working.

2.7 Manufacturing Process of Using Lead

Lead is widely used in many industrial processes (D'Souza, Dsouza, Menezes, & Venkatesh, 2011). The major sources of lead pollution are mining and smelting of lead ores, refining and processing of compounds, lead contaminated in food and drink containers, waste incineration, lead contaminated in soil, and lead in paint respectively (Flora, Gupta, & Tiwari, 2013; Mielke & Reagan, 1998; Ziemacki, Viviano, & Merli, 1989). General population was mainly exposed to lead through the ingestion of contaminated drinking water and food and by the inhalation of lead particulate in air (D'Souza et al., 2011). It was found that the critical route of lead exposure was ingestion at 99% of total lead intake, while inhalation was at 1% of total lead intake (Pizzol, Thomsen, & Andersen, 2010). In case of Europe adult consumers, lead dietary exposure in ranged from 0.36-1.24, up to 2.43 ng kg^{-1} body weight per day in high consumers (EFSA, 2010).

Lead Acid Battery Workers were at high risk of lead exposure because of the possibility of coming in direct contact with lead. Inhalation of lead might also occur by air borne lead particulate matter and by fumes during melting to recover lead (Ahmad et al., 2014; Basit, Karim, & Munshi, 2015; Howard Hu, Shih, Rothenberg, & Schwartz, 2007; Lormphongs et al., 2003; Wu et al., 1996). Some previous data showed that the airborne lead levels at work place where contacted with lead was between 0.156-2.617 mg/m^3 (the standard level of the Ministry of Labor and Social Welfare of Thailand 0.20 mg/m^3) in the years from 1999 to 2002 (Lormphongs et al., 2003). At a manufacturer of solder alloys consisted mainly of lead about 30-90%. Smelter operators were exposed to lead when tapping furnaces and in other activities directly related to recycling the lead from scrap material. It was reported that lead concentration in the air of solder products plant that were detectable by

ICP analysis were measured in the largest quantities on the filters. For the CFC samples, this represented concentration ranges of 10 to 471 μg/m^3 lead (geometric mean is at 84 μg/m^3). For reference, the OSHA Action Level for lead is 30 μg/m^3, while the Permissible Exposure Limit is set at 50 μg/m^3 (Harper & Pacolay, 2006). In a Battery Manufacturing Plant showed airborne lead levels from personal sampling at the assembly section were 26-603.2 μg/m^3 which were more than the standard level of the Ministry of Labor and Social Welfare of Thailand (200 μg/m^3) (Lormphongs et al., 2004). For bridge painters are exposed to lead through the dust that was generated during bridge surface preparation tasks, such as abrasive blasting, grinding, scraping and sanding. Some workers may be exposed to low levels of lead for long period, and others may be exposed to acute with high levels (Rodrigues et al., 2010).

2.8 Knowledge, Awareness and PPE used of Lead Poisoning

Although many programs undertaken to lower lead level cycling in the environment human exposure to lead remains of concern to public health (Li et al., 2013). As to knowledge on risk of contact with lead, all workers at the assembly section in battery manufacturing plant had never gotten the education about the toxicity of lead and the prevention against it. Many workers had lacked knowledge and understanding about lead poisoning (Lormphongs et al., 2003). After giving education, many workers were noticed and understood the lead toxicity and then changed the attitude toward their work and improved personal hygiene such as washing their hands before drinking or having lunch (Lormphongs et al., 2003). There are several studies of awareness of personal hygiene and changing of behavioral on heavy metal health effects. One research showed that the workers quitted smoking in the working site, wore suitable clothes, took off working clothes at a factory and washed them every day (Lormphongs et al., 2003). Some researchers showed that nonsmoking workers and excellent personal hygiene are the best way to decrease BLL (Karita et al., 2005; Rodrigues et al., 2010). Occupational health education should be repeated at least every 6 months (Lormphongs et al., 2003). As for PPE, it is specified to the workers who work with lead in Material Safety Data Sheet of Lead

(Lead MSDS) for protecting them from lead poisoning. The appropriate selection and use of PPE can help prevent or limit exposure to lead. The PPE of this research comprise goggles, work clothing, Dust respirator and Gloves. There was the study showed that activated carbon fabric (ACF) mask could prevent lead absorption. It was provided to eight workers who worked in battery plants. After using ACF mask, BLLs among those who were under treatment for high BLLs were substantially decreased. BLLs from Three of them who were not treated for lead also decreased too. The researcher suggested that ACF could has a usefulness in preventing further lead exposure (Kuruvilla et al., 2008). Some study reported that many of the works who worked with lead had used cotton masks as PPE to reduce their BLLs although some of them had used no mask (Lormphongs et al., 2004). It was a study showed that the characteristics of 16 workers with higher BLLs failed to use engineering or PPE controls (Reynolds et al., 1999). Protective gloves are the most popular types of PPE because hands direct contact with many sources of mechanical and chemical hazards. For the chemical hazards form of poisonous including acids, organic solvents, detergent solutions and heavy metal which can be absorbed through the skin (Emilia, Agnieszka, & Katarzyna, 2015). In terms of high BLLs, Patients with lead contents more than 100 µg/dL almost always warrant chelation. Patients with BLL of 80-99 µg/dL with or without symptoms might benefit from therapy. Patients having 50-79 µg/dL lead levels with symptoms should be considered for treatment. In adults, the decision to use chelation therapy is ultimately clinical but may be guided by BLL (Breyre & Green-McKenzie, 2016).

All information about lead poisoning will be used as a guideline after investigation of lead concentrations among communication radio-repair workers. It will be the benefit for the workers. Moreover, this study hopes to see the workers can work happily and have better life.

2.9 Communication radio-repair plant

As for this study, the communication radio-repair plant of the Signal battalion are the organic units of Signal department, Royal Thai Army (RTA) which were established in Fort Kamphaeng Phet Akarayothin at Krathum Baen district, Samutsakhon province. The duty of this plant is to repair the communication radios of RTA. The appearance of the plant is closed system with air condition. There are 147 workers inside the plant which consist of the communication radio repair worker and clerk. All of them are male. Communication radio repair workers use lead for soldering while they are working. One problem is many workers including repair workers and clerk do not use personal protective equipment (PPE) during work. Moreover, some workers may be exposed to low levels of lead for long period, and others may be exposed to acute with high levels. Therefore, it is interesting to study the effects of lead exposure in the RTA's workers.

There are 5 sections in the plant including clerical officer (CO), high frequency radio-repair (HF), very high frequency radio-repair (VHF), field telephone repair (FT), and carrier wave radio-repair (CW) sections. The position of each section are shown in the workplace chart figure 1.

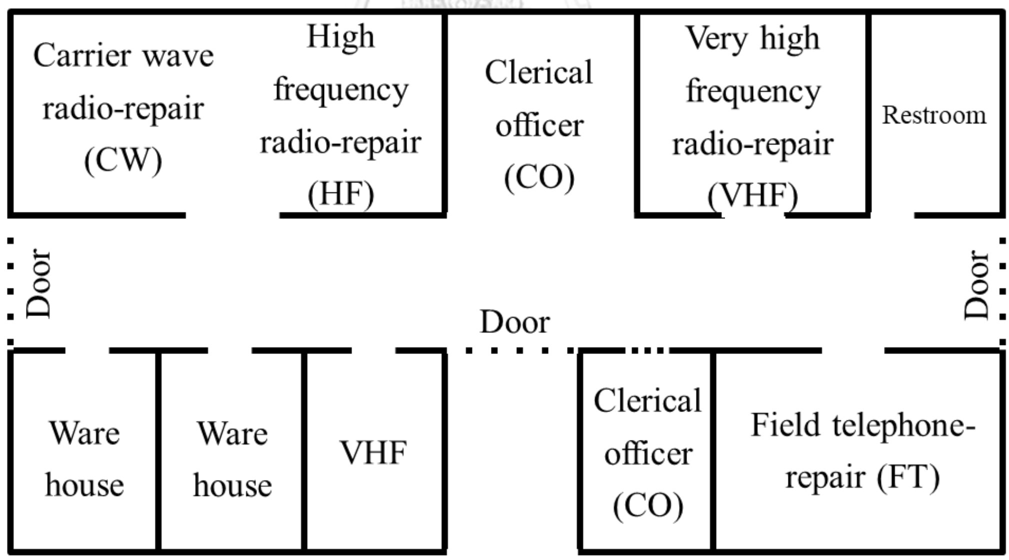


Figure 1: *Workplace Chart of the Communication radio repair plant*

CHAPTER III
METHODOLOGY

3.1 Research Design

Longitudinal study design was used in this research study during August 2017 - March 2018 aims to investigate the occupational exposure to lead from BLL and HLL and to determine the association between the occupational lead exposure and Signs and symptoms of lead poisoning among communication radio-repair workers in Signal department, Royal Thai Army at Samutsakhon province, Thailand. The commander of communication radio-repair plants had allowed the researcher and team to collect data already.

3.2 Study Population and Area

The participants of this research study were 147 workers who work inside the communication radio-repair plants of Signal Department, Royal Thai Army at Krathum Baen district, Samutsakhon province, Thailand. The following criteria were used for selecting the participants.

Inclusion Criteria

1. Male workers.
2. Workers who work in the plants at least 3 months.
3. Workers who agree and also sign the consent form.

Exclusion Criteria

1. Workers whose hobbies or extra jobs relate to heavy metal lead.
2. Workers who used to work inside Battery plant.
3. Workers who are heart disease, hepatic disease, renal dysfunction, anemia, and cancer before working here (in case of study Signs and symptoms of lead poisoning) which the plats had the health data of all workers already.
4. There is bullet inside the body.

3.3 Sampling Technique

Communication radio-repair plant of Signal Department, RTA at Samutsakhon province were purposive selected to study by the researcher. The workers who work inside the plant were divided into 2 groups which were exposed group and low exposed group (Figure 2 and 3). Exposed group is the workers who working in 4 sections including high frequency radio-repair (HF), very high frequency radio-repair (VHF), field telephone repair (FT) and carrier wave radio-repair (CW) sections. They work as the communication radio repair worker. On the other hand, low exposed group is the workers who do not repair communication radio but work as the office workers inside the plants. There is only one section in this group which is clerical officer (CO) section. In case of study airborne lead concentrations, the workers in each section who were collected blood and hair samples were randomly selected to collect personal air samples (Figure 4). Moreover, workers who signed the consent form and met the inclusion were invited to be the participants of this study.

3.4 Sample and Sample size

There were 147 workers from communication radio-repair plant of the Signal department, RTA at Samutsakhon province, Thailand. They were divided into 2 groups which were exposed group and low exposed group. Then, the workers who related to inclusion criteria were asked to be the participants for this study. After recruiting by inclusion and exclusion criteria, the number of the participants was 50-70% of all workers which were enough to study as my research design and data analysis. The participants were given written inform consent before participated in the study.

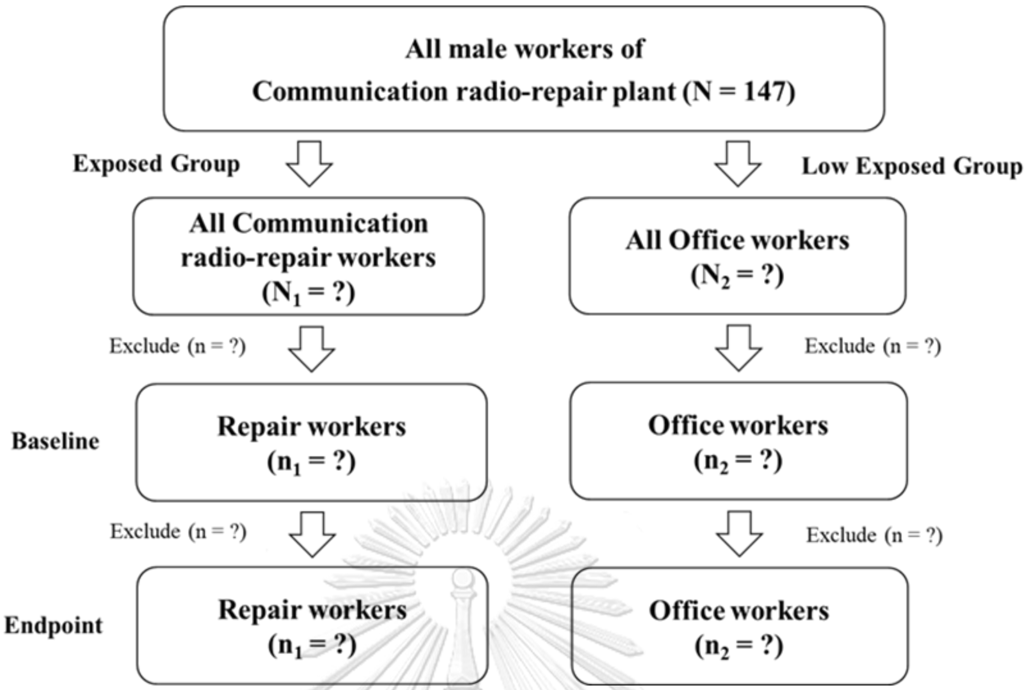


Figure 2: *Sampling flow chart for blood collection*

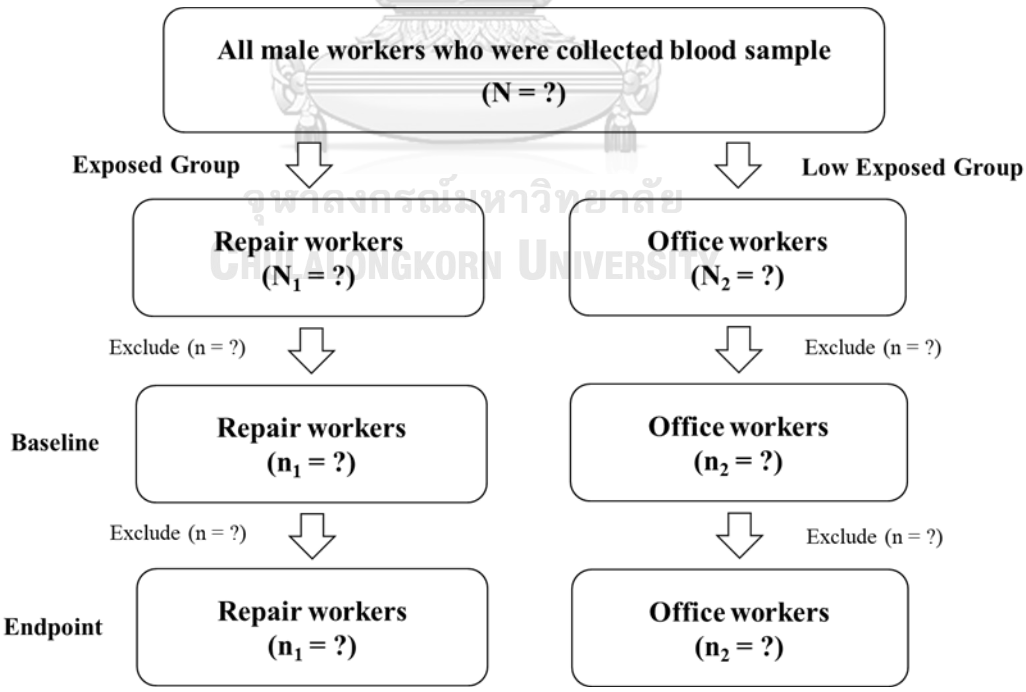


Figure 3: *Sampling flow chart for hair collection*

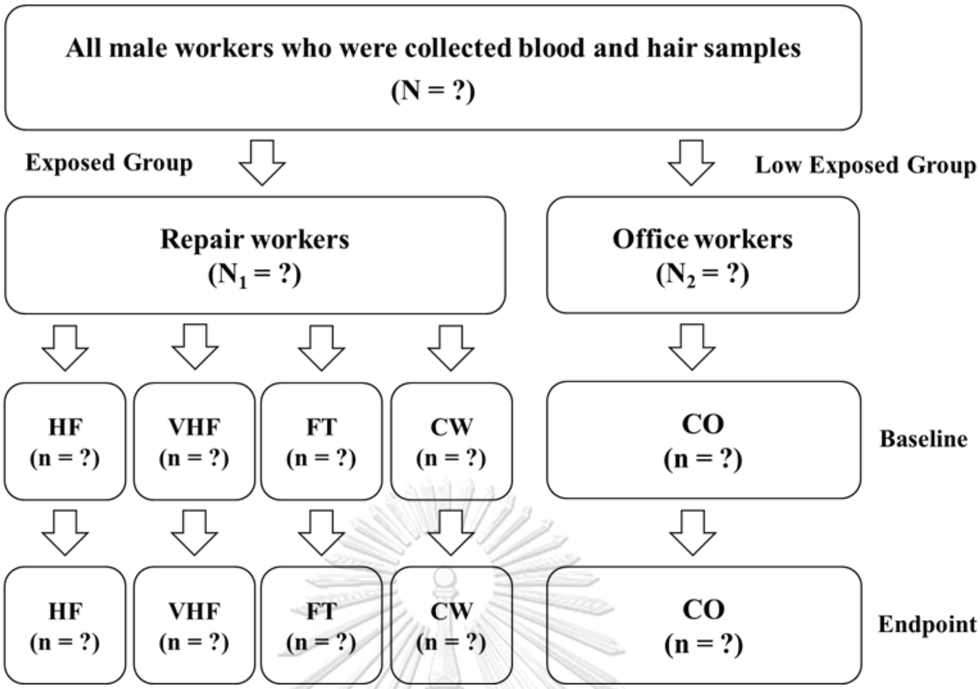


Figure 4: *Sampling flow chart for air collection*

3.5 Measurement Tools

3.5.1 Questionnaires

- Demographic Characteristics
- Health Behaviors
- Working Conditions
- Knowledge of lead poisoning, Awareness of PPE use and personal hygiene and Use of PPE for lead (KAP)
- Signs and symptoms of lead poisoning

3.5.2 Air sampling instruments

- Personal sampling pump (Model 224-PCXR7-8, SKC Inc. USA)
- Mixed cellulose ester (MCE) filters (0.8 μm pore size, 37 mm diameter) (SKC Inc. USA)
- 3-piece cassette filter

3.5.3 Blood collection instruments

- Blood collection needles and syringe
- Vacuum Blood Collection Tube

3.5.4 Hair collection instruments

- Stainless steel scissors
- Plastic bags
- Acetone
- Deionized water (Milli-Q Millipore 18.2 $M\Omega\ cm^{-1}$)

3.5.5 Hair digestion instruments and reagents

- High-pressure polytetrafluoroethylene (PTFE) digestion containers (50 ml)
- Digestion vessel
- Fume Hood
- Electric evaporation block
- 15 ml polycarbonate tube
- Hydrogen peroxide, 30% H_2O_2 (w/w), reagent grade
- Nitric acid, conc. (Merck, USA)

3.5.6 Instruments for analyzed airborne lead, blood lead and hair lead

- Graphite Furnace Atomic Absorption Spectrophotometer (Model 4100 ZL, Perkin Elmer, USA)
- Lead hollow cathode lamp or electrode dischargeless lamp
- Regulators, two-stage, for Argon
- Fume Hood
- Hotplate Stirrer, surface temperature 140°C
- Automatic Pipette (Pipetman, Gilson, France)
- Bottles, polyethylene, 100 mL
- Laboratory glassware (Pyrex, England); 10 and 100 mL volumetric flask, beakers with watch glass covers and assorted volumetric pipets as needed (Clean all glassware with conc. nitric acid and rinse thoroughly with distilled or deionized water before use)

3.5.7 Chemicals and reagents for analyzed airborne lead, blood lead and hair lead

- Nitric acid, conc. (Merck, USA)
- Nitric acid, 5% (v/v) (Merck, USA)
- Hydrogen peroxide, 30% H_2O_2 (w/w), reagent grade
- Calibration stock solution
- Matrix Modifier, Place 0.2 g $NH_4H_2PO_4$ and 0.3 g $Mg(NO_3)_2$ in a 100-mL volumetric flask. Add 2 mL conc. HNO_3 and bring to volume with distilled or deionized water
- Argon, prepurified.
- Distilled or deionized water.

3.6 Data collection

3.6.1 General characteristics of the participants

We walked through survey and collected the General characteristics data of the participants including Demographic Characteristics, Health Behaviors, and Working Conditions by using the questionnaires. Demographic Characteristics, Health Behaviors, and Working Conditions data were collected 2 times at baseline (at 1st month) (Appendix C for Thai version and Appendix D for English version) and endpoint (at 6th month) (Appendix E for Thai version and Appendix F for English version). The participants answered the questionnaires by themselves at baseline and endpoint. However, Working Conditions data were collected every month too (Appendix G for Thai version and Appendix H for English version). The monthly data of Working Conditions were gotten from the plants. The questionnaires as follows:

- Demographic Characteristics at baseline and endpoint
  - Age
  - Weight
  - Height
  - Education levels
  - Marital status
  - Study at Signal school
  - Health status
- Health Behaviors at baseline and endpoint
  - Smoking status
  - Alcohol drinking
  - Sea food consumption
  - Drinking milk
  - Exercise
- Working Conditions at baseline and endpoint
  - Working experience (years)
  - Working hours (hours/day)
  - Working days/week

- Exposure hours/day
- Work load (Communication radios/week)
- Type of communication radio
- Roll of lead/month

- Working Conditions every month
    - Work load of each sections (Communication radios/week)
    - Roll of lead/month in each sections

3.6.2 Signs and symptoms of lead poisoning

Signs and symptoms of lead poisoning among participants were collected 2 times at baseline (at 1st month) (Appendix C for Thai version and Appendix D for English version) and endpoint (at 6th month) (Appendix E for Thai version and Appendix F for English version) by using the questionnaires. The participants checked the list of signs and symptoms by themselves. Signs and symptoms of lead poisoning lists that relate to lead poisoning as follows:

- Loss of appetite
- Colic abdominal pain
- Constipation
- Nausea and Vomiting
- Headache or Dizziness
- Metallic taste in the mouth
- Numbness
- Excessive tiredness and Weakness
- Fine tremors
- Nervous irritability
- Muscle and joint pain
- Insomnia
- Hypertension
- Lead line on the gum
- Wrist and Foot drop

Some Signs and symptoms of lead poisoning which are Lead line on the gum and Wrist and Foot drop were diagnosed by the researcher that was trained from the Occupational medicine doctor. In addition, the National Heart, Lung, and Blood Institute (NHLBI) identify that a systolic blood pressure of 140 mmHg or higher, or a diastolic blood pressure of 90 mmHg or higher, was considered to be hypertension.

3.6.3 Knowledge of lead exposure, Awareness of PPE use and personal hygiene and Use of PPE (KAP)

KAP of lead poisoning data were collected by using questionnaires (Appendix C for Thai version and Appendix D for English version) as follow:

- KAP of Lead Poisoning
  - Knowledge of lead poisoning
  - Awareness of personal hygiene
  - Awareness of PPE use
  - Use of PPE (Lead MSDS) and working-station exhaust ventilator

Knowledge data was collected only at baseline (at 1st month) because this research study did not give any knowledge to the participants, whereas Awareness, and Practice data of participants were collected at baseline (at 1st month) and endpoint (at 6th month) because both data had the effects on lead level change of the participants. After that, KAP data were changed to be a score.

Knowledge of lead poisoning was assessed by asking participants to respond “True”, “False” and “I don’t know”. Five of Knowledge questions had both facts and common myths about lead poisoning, risk factors, route of exposure and protection from lead poisoning, etc. For example, “Blood test only way to detect lead poisoning” and “The most route of lead exposure for workers is inhalation”. Each correct answer was worth 1 point and each incorrect answer or “I don’t know” were worth 0 point; the range of possible knowledge scores was from 0 to the number of knowledge questions. Scores for this knowledge section were range from 0 to 5 (Lormphongs et al., 2004; McLaughlin, Humphries, Nguyen, Maljanian, &

McCormack, 2004). The high score meant the workers had more knowledge about toxicity of lead and how to protect themselves from lead poisoning.

Awareness of PPE use and personal hygiene referred to the study samples views and beliefs about the importance of work hygiene, their thoughts, feelings and desires concerning workplace safety, and their commitment to using PPE and prioritizing safety issues. A Likert three-point scale was used for this part of the questionnaire. Six items of Awareness section had both positive and negative questions. In positive items, two points was given for “I agree”, 0 point was given for “I disagree” and 1 point was given for “Not bothered”. In negative items, the points were given in reverse. Some example items were as follows: “It is very important to wash your hand after finishing working” (positive item) and “Sometimes it is necessary to ignore safety rules in order to speed up work and increase production” (negative item). Scores for this awareness section were range from 0 to 12 (Navidian, Rostami, & Rozbehani, 2015). Those scoring higher demonstrate a more suitable awareness towards the personal hygiene.

Use of PPE and working-station exhaust ventilator were evaluated by asking subjects about use of lead protection equipment including goggles, work uniform, dust respirator, gloves, and working-station exhaust ventilator to respond “Every time”, “Never” and “Sometimes”. Some example items were as follows: “Do you use dust respirator while you are working?” and “Do you use gloves while you are working?” Two points for use of PPE and working-station exhaust ventilator score was given for the “Every time” response, 1 point for the “Sometimes” and 0 point for the “Never” responds. Scores for this section were range from 0 to 10 (Navidian et al., 2015; Olson, Grosshuesch, Schmidt, Gray, & Wipfli, 2009). All parts of measurement questionnaire including knowledge, awareness and use of PPE and also the reminder posters were developed by the team researcher.

The workers used time around 15-20 minutes to answer all questionnaires. The validity of these questionnaires which were General characteristics, Signs and symptoms of lead poisoning, and KAP of lead poisoning were established by using index of item objective congruence (IOC) that the three professional expertise in the field gave scores and IOC value was greater than 0.5. IOC value of this questionnaire was 0.93. On the other hand, the reliability of questionnaires was tested only two sections. First, knowledge of lead poisoning (items 28-32) was established with Kuder Richardson (KR20) equal or more than 0.7. KR20 value of this section was 0.77. Second, awareness of PPE use and personal hygiene (items 33-38) was established with Cronbach's alpha equal or more than 0.7. Cronbach's alpha value of this section was 0.72.

3.6.4 Air sampling collection

Airborne lead concentrations were measured from the air samples 2 times at baseline (at 1st month) and endpoint (at 6th month). The workers of each section in the plant who were collected both blood and hair samples were randomly selected to collect the personal air samples by using personal air sampling pumps. The air samples were collected by using filter cassettes containing MCE filter (0.8 µm pore size, 37 mm diameter) connected to the personal air sampling pump and attached it to the workers. The filter cassette was attached near breathing zone of the worker. The air samplings were collected for 8 hours in duration of work per day. All personal air sampling pumps were calibrated before and after use, and setting a flow rate of 2.0 L/min follow the NIOSH Method 7300 (Schlecht, O'Connor, Safety, & Health, 2003).

Figure 5: *This figure shows Air Sampling Equipment*

Figure 6: This figure shows how to attach air sampling equipment

3.6.5 Blood collection

Blood samples were collected to measure lead levels in the body and to assess anemia, hepatic function, and kidney function among participants. Blood lead levels (BLLs) were measured 2 times at baseline (at 1^{st} month) and endpoint (at 6^{th} month). On the other hand, anemia, hepatic function, and kidney function were assessed only one time at baseline. Because this study did not give the workers any intervention to protect them from lead poisoning so only one time for analyzing anemia, hepatic function, and kidney function was enough. Blood samples were collected by medical technicians. Blood was drawn by venipuncture of the antecubital vein. As for lead levels measuring, 5 mL of blood samples were kept into vacuum blood collection tubes, stored at $4^{\circ}C$ and maintained at this temperature prior to analysis (Garza & Becan-McBride, 1999). In terms of assessing anemia, hepatic function, and kidney function, 5 mL of blood samples were kept into vacuum blood collection tubes, stored at $4^{\circ}C$ and maintained at this temperature prior to analysis (Specimen Collection Guidelines – CDC) at Phramongkutklao Hospital laboratory. Complete blood count (CBC) was helped to diagnose anemia, Aspartate aminotransferase (AST) and Alanine aminotransferase (ALT) were measured for checking liver function and Glomerular filtration rate (GFR) was measured for checking kidney function.

3.6.6 Hair collection and digestion

Hair samples were collected to measure lead levels in terms of excretory pathway among participants for 2 times at baseline (at 1^{st} month) and endpoint (at 6^{th} month). We informed the participants before the team researcher went to cut their hair about 1 month. All participants had to wash their hair at the day of sample collection. The collection was performed in the morning before working. Hair samples were taken from the occipital region of the head only proximal parts of hair strands (0.5-1.0 cm) by using stainless steel scissors about 0.5-1 g for reducing the influence of potential exogenous contamination. The samples were stored in new plastic bags (Bencze, 1990). After hair collection, each hair sample was washed five times with acetone and deionized water (Milli-Q Millipore 18.2 $M\Omega\ cm^{-1}$) without detergent following the sequence acetone-water-water-water- acetone (International Atomic Energy Agency, 1976). Then, each hair sample was air-dried at 50°C to a constant weight and stored in plastic bags before digestion (International Atomic Energy Agency, 1976; Schuhmacher, Domingo, Llobet, & Corbella, 1991). Samples were placed in 50 ml high-pressure polytetrafluoroethylene (PTFE) digestion containers with 2 ml 30% H_2O_2 and 6 ml 65% HNO_3 and the sealed containers were placed in a digestion vessel at 160°C for 8 h. After digestion the sample solutions were evaporated on an electric evaporation block until about 2 ml solution remained. The remaining solutions were transferred to a clean 15 mL polycarbonate tube and made up to final volume with deionized water for lead measurement (Zhou et al., 2016).

3.6.7 Laboratory analysis

Lead levels in blood and hair of the workers and lead concentrations in the air at workplace were measured by using Graphite Furnace Atomic Absorptions (GFAAS) at Armed Forces Research Institute of Medical Sciences (AFRIMS). GFAAS was calibrated before and after use which follow the NIOSH Method 7105 (Schlecht et al., 2003). In case of CBC, AST, ALT, and GFR, blood samples were sent to Phramongkutklao Hospital for diagnosing and measuring. Fully automatic blood analyzer was used to measure CBC for diagnosing anemia. Chemistry analyzer was used to measure AST and ALT for checking liver function and GFR for checking kidney function.

3.6.8 Lead Risk Assessment

Quantitative Risk Method was used to determine the risk effects of lead exposure among workers. There were 4 steps for assessing lead exposure including hazard identification, does response assessment, exposure assessment, and risk characteristic. Hazard identification for lead was the information of lead poisoning. In terms of dose response assessment, there was no appropriate reference dose (RfD) and minimal risk level (MRL) of lead for now. However, this study used a tolerable daily intake (TDI) of lead for developmental and central nervous system effects which conducted by the National Institute for Public Health and the Environment

(RIVM) as the RfD. The variables in exposure assessment step were gotten from the above data which consisted of ALC, body weight, exposure duration, and average time. Inhalation rate was gotten from Exposure Factors Handbook 2011 Edition by U.S.EPA.

From data collection, if the researcher found the high level of lead in blood and/or hair among workers or high ALC the researcher suggested the workers to go to see the doctor. For high ALC, the researcher suggested the commander of the plant to solve the problems. Fortunately, these adverse events did not occur while studying.

3.7 Data Analysis (Statistics)

3.7.1 Statistical analysis

Data were analyzed by the Statistical Package for the Social Sciences (SPSS) program version 16.0 for Windows and differences of 0.05 or less were considered significant.

- Descriptive statistic including frequency, percentage, median, mean, and standard deviation was used to describe demographic characteristics, health behaviors, working conditions, KAP of lead exposure, airborne lead concentrations, BLL, HLL, and Signs and symptoms of lead poisoning among the RTA communication radio-repair workers at baseline and endpoint.
- Chi-square test, Fisher's exact test, Independent T-test, and Mann–Whitney U test were used to compare demographic characteristics, health behaviors, working conditions, KAP of lead exposure, BLL, HLL, and Signs and symptoms of lead poisoning between exposed and low exposed group at baseline and endpoint.
- One-way ANOVA was used to compare airborne lead concentrations in each section at baseline and endpoint.
- Wilcoxon Signed Ranks test, Dependent T-test, and McNemar's test were used to compare AP of lead exposure, airborne lead concentrations, BLL, HLL, and Signs and symptoms of lead poisoning within exposed and low exposed group at baseline and endpoint.

- Binary logistic regression was used to access the association among health risk factors including demographic characteristics, health behaviors, and working conditions with lead levels (BLL and HLL) and Signs and symptoms of lead poisoning and to determine the association between the lead level (BLL and HLL) and Signs and symptoms of lead poisoning among the RTA communication radio-repair workers at baseline and endpoint.
- Linear regression was used to assess the association among airborne lead concentrations with BLL and HLL among the RTA communication radio-repair workers at baseline and endpoint.
- Spearman's correlation was used to determine the correlation of KAP for lead exposure and lead level (BLL and HLL) between two groups and to determine the correlation between BLL and HLL among the RTA communication radio-repair workers at baseline and endpoint.

3.7.2 Health risk assessment

Health risk from occupational lead exposure among communication radio-repair workers was assessed by 4 steps as follow:

- **Hazard identification**

Lead can cause several adverse effects on every human systems and organs such as kidney damage, disruption of nervous systems, brain damage, a rise in blood pressure, disruption of the biosynthesis of hemoglobin and anemia. These were called lead poisoning.

- **Dose response assessment**

Reference dose (RfD) is an estimate of the daily oral exposure to a potential hazard of the human without adverse health effects during a lifetime. The units of RfD is expressed in mg/kg/day. U.S.EPA reveals that there is no RfD for lead because No observable adverse effects level (NOAEL) and Lowest observed adverse effect level (LOAEL) cannot be specified. ATSDR did not derive minimal risk levels (MRLs) for lead. Moreover, National Institutes of Health (NIH) has the evidences that MRLs for lead have not been evaluated due to the lowest BLLs are associated with the adverse effects. However, a tolerable daily intake (TDI) of lead for developmental and central nervous system effects has derived at 3.6×10^{-3} mg/kg-day by the National Institute for Public Health and the Environment (RIVM). Therefore, the study used this value as the RfD for lead.

- **Inhalation Exposure assessment**

Averages daily dose (ADD) which are often used in dose-response equations to estimate effects or risk are widely used in exposure assessments. ADD from lead exposure via inhalation route was calculated by a formula as follows:

$$\text{ADD (mg/kg-day)} = (C \times InhR \times ED) / (BW \times AT)$$

Where:

C = Contaminant concentration in inhaled air (µg/m^3), (RME)

InhR = Inhalation rate (m^3/day)

ED = Exposure duration (days)

BW = Body weight (kg)

AT = Average time (days)

Note: RME = reasonable maximum exposure

- **Risk characteristic**

After got RfD form Does response assessment and ADD form Exposure assessment, Risk Characterization for non-cancer was calculated by a formula as follows:

$$\text{HQ (hazard quotient)} = ADD / RfD$$

Note: If HQ exceeds 1, there may be concern for potential non-carcinogenic effects.

3.8 Ethical Consideration

The researcher strictly adhered to the principles of human rights protection and ethical codes of conduct. Before data collection commenced, the study proposal was submitted to the Institutional Review Board on Research Involving Human Subjects of the Chulalongkorn University and the Royal Thai Army Medical Department. After approval was granted, a letter issued by the Graduate School was submitted to the director of the Signal department RTA to ask for permission to conduct the study. After the permission was given, the researcher approached the prospective subjects to introduce himself, to explain the study objectives and data collection procedures, and to ask for cooperation in data collection. The information sheet was distributed, and the prospective subjects were informed that their participation in the study was based purely on a voluntary basis and that they had the right to decide to participate in the study or refuse to participate in the study. They were also told that they could withdraw from the study any time if they wished without having to give explanation. Furthermore, they were assured that the data collected from them would be kept strictly confidential and only the researcher and research assistants would have access the data. The data would be reported only group data and would be electronically destroyed after the study was completed. After the prospective subjects agreed to take part in the study, they were asked to sign the informed consent form to indicate their willingness.

The research conducted after the final approval was granted by Ethics Review Committee of Chulalongkorn University (serial no.062.1/60) and Institutional Review Board, Royal Thai Army Medical Department (serial no.S056h/60). The researcher was well aware of the research ethics. Therefore, the data was collected from Signal Department Royal Thai Army would be considered confidential and used only for research purposes. All information obtained in this study could not be referred back to the individual.

3.9 Limitation

- This research study did not investigate the risk of lead exposure in each worker's house.
- Differential loss to follow up could introduce bias.

3.10 Expected Benefit and Application

- To produce evidence on BLL, HLL and adverse health effects of the workers in the plant as well as sources of the exposure in the area of the plants and surroundings.
- To bring about early detection for those with lead poisoning and precaution for those at risk.
- The results of this study will provide the information about occupational hazard of the workers, which will be essential for prevention program.

CHAPTER IV
RESULTS

The longitudinal study design was used to investigate the exposure to lead from BLL and HLL and to determine the association between the occupational lead exposure and signs and symptoms of lead poisoning among communication radio-repair workers in Signal department, Royal Thai Army at Krathum Baen district, Samutsakhon province, Thailand during August 2017 - March 2018. From the recruitment of 147 workers inside the communication radio-repair plant by inclusion and exclusion criteria, there were 66 communication radio-repair workers in the exposed group and 54 office workers in the low exposed group at baseline. And at endpoint or 6 months later, there were 54 workers in the exposed group and 48 workers in the low exposed group. These workers were collected blood sample (Figure 7).

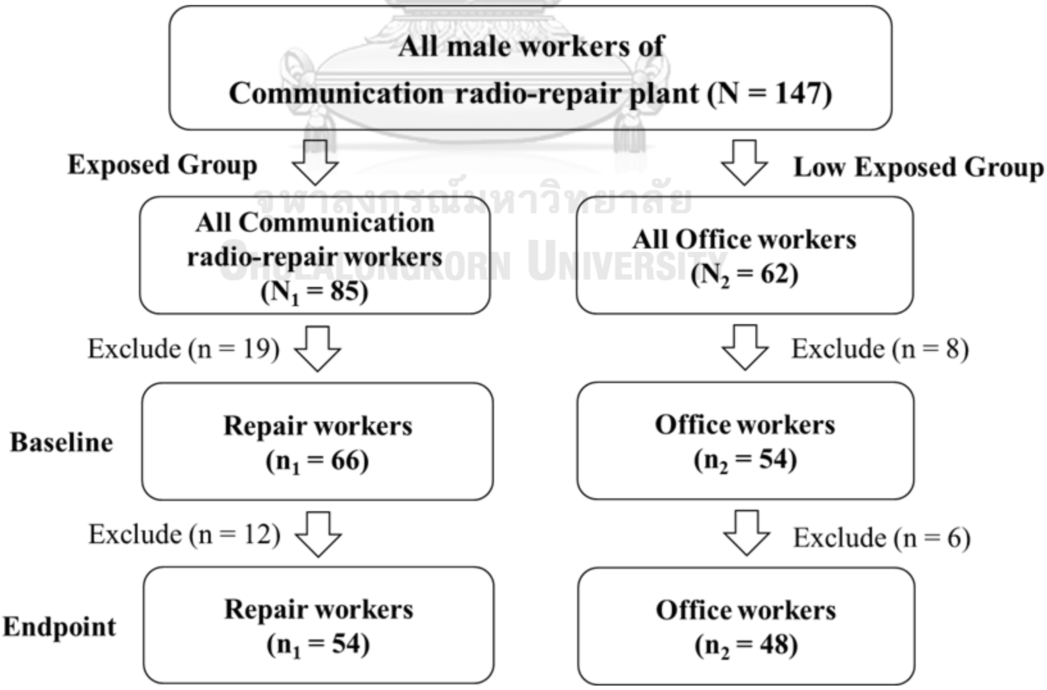


Figure 7: *Result of sampling flow chart for blood collection*

For the HLL study, some workers who were collected blood samples were not willing to bring their hair to study. Moreover some workers had little hair. Therefore, there were 52 communication radio-repair workers in the exposed group and 34 office workers in the low exposed group at baseline. And there were 39 workers in the exposed group and 25 workers in the low exposed group at endpoint (Figure 8).

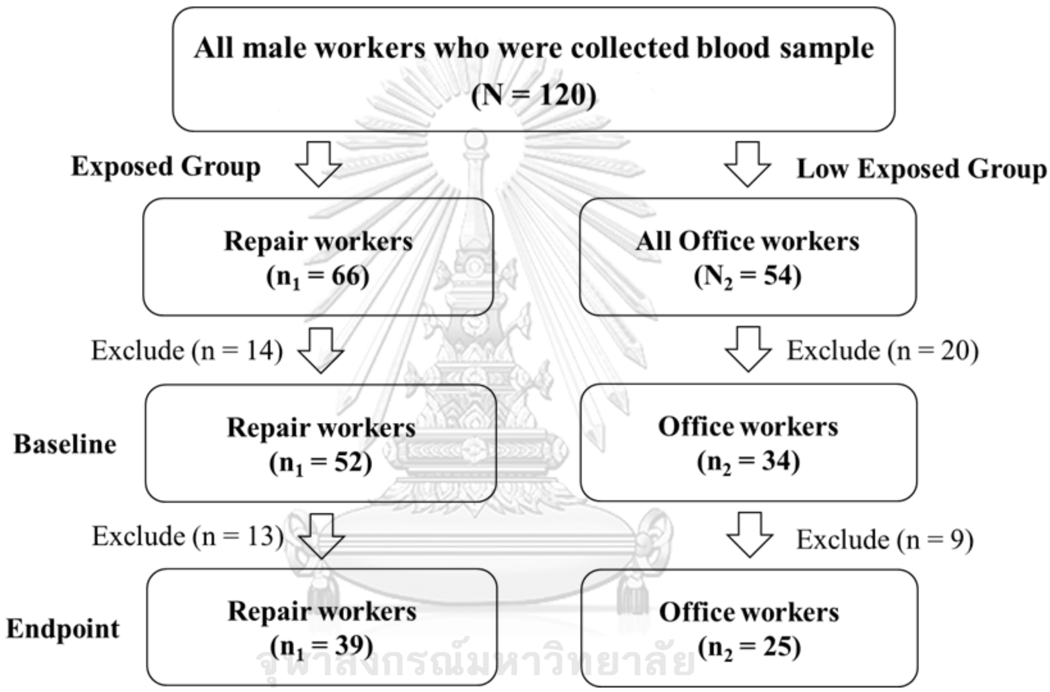


Figure 8: *Result of sampling flow chart for hair collection*

In terms of airborne lead concentrations, the workers from 5 sections who were collected both blood and hair samples were randomized to collected personal air samples during working for eight hours. Finally, there were 10 workers in clerical officer section (CO), 8 workers in high frequency radio-repair section (HF), 8 workers in very high frequency radio-repair section (VHF), 8 workers in field telephone-repair section (FT), and 7 workers in carrier wave radio-repair section (CW) at baseline. In addition, there were 10 workers in CO section, 6 workers in HF section, 8 workers in VHF section, 8 workers in FT section, and 5 workers in CW section at endpoint (Figure 9).

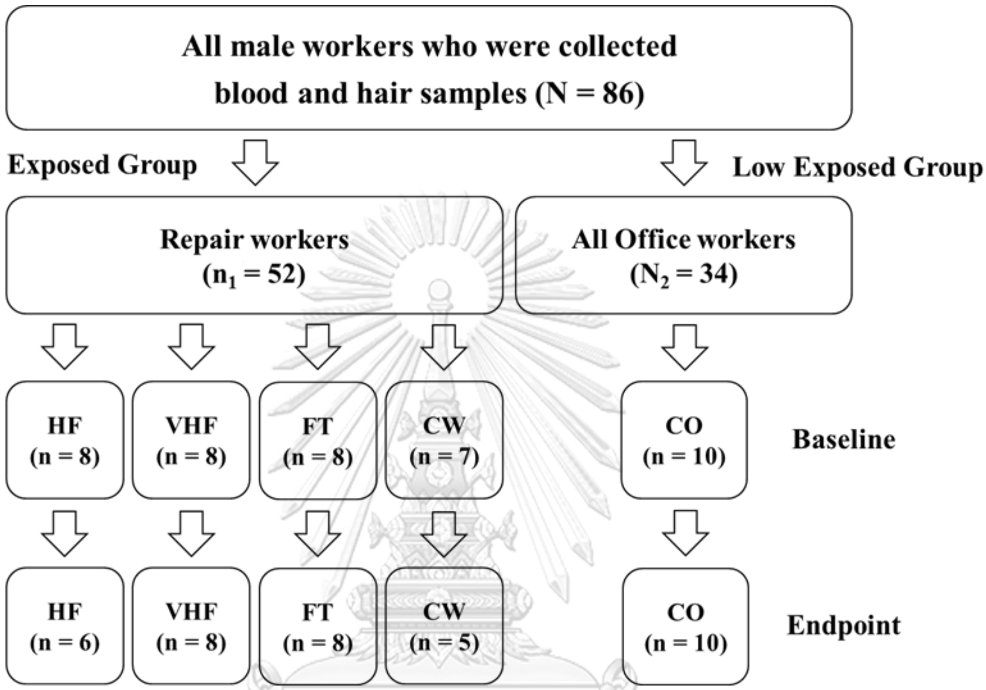


Figure 9: *Result of sampling flow chart for air collection*

The results of this study are presented in 6 parts which are:

4.1 Description and comparison of all variables between two groups at baseline and endpoint which consisted of:

4.1.1 Personal characteristics including demographic characteristics, health behaviors, and working conditions

4.1.2 Airborne lead concentration (ALC)

4.1.3 Knowledge, Awareness, and PPE Used (KAP) of lead exposure

4.1.4 Blood lead level (BLL)

4.1.5 Hair lead level (HLL)

4.1.6 Signs and symptoms of lead poisoning

4.2 Correlation between BLL and HLL among workers at baseline and endpoint.

4.3 Correlation of KAP of lead exposure with BLL and HLL among workers at baseline and endpoint.

4.4 Association among health risk factors including demographic characteristics, health behaviors, working conditions, and ALC with lead levels (BLL and HLL) and signs and symptoms of lead poisoning among workers at baseline and endpoint.

4.4.1 Association between health risk factors and BLL

4.4.2 Association between health risk factors and HLL

4.4.3 Association between health risk factors and signs and symptoms of lead poisoning

4.5 Association between the occupational lead exposure (BLL and HLL) and signs and symptoms of lead poisoning among workers at baseline and endpoint.

4.5.1 Association between BLL and signs and symptoms of lead poisoning

4.5.2 Association between HLL and signs and symptoms of lead poisoning

4.6 Health risk assessment of lead exposure among workers at baseline and endpoint.

4.1 The description and comparison of all variables between two groups at baseline and endpoint

4.1.1 Personal Characteristics

Table 2 showed the general characteristics among workers and the comparison of general characteristics between two groups at baseline. For Demographic characteristics at baseline, mean±S.D. of age among workers in exposed and low exposed groups were 36.9±10.1 and 41.3±10.7 years, respectively. There were significant different of age at P-value = 0.024. There were 85.2% of workers in low exposed group and 66.7 % in exposed group graduated from Signal school. The significant different of study at Signal school were shown at P-value = 0.033. However, there were no difference among BMI, marital status, and education levels. In terms of working conditions and health behaviors, there were no differences of these parameters among workers.

Table 2: *The comparison of personal characteristics between two groups at baseline.*

Personal characteristics at baseline	Exposed Group (n = 66)		Low Exposed Group (n = 54)		*P-value*
Demographic characteristics					
	Mean	S.D.	Mean	S.D.	
Age (Years)	36.9	10.1	41.3	10.7	0.024[a,*]
Body Mass Index (BMI) (kg/m^2)	25.4	3.7	25.8	3.6	0.551[a]
	n	%	n	%	
Marital Status					0.849[b]
Single	22	33.3	19	35.2	
Couple	44	66.7	35	64.8	

Personal characteristics at baseline	Exposed Group (n = 66)		Low Exposed Group (n = 54)		*P-value*
	n	%	n	%	
Education levels					
< Bachelor's Degree	46	69.7	32	59.3	0.254[b]
≥ Bachelor's Degree	20	30.3	22	40.7	
Study at Signal school					
No	22	33.3	8	14.8	0.033[b,*]
Yes	44	66.7	46	85.2	
Working conditions					
Working experience					
≤ 10 years	27	40.9	17	31.5	0.343[b]
> 10 years	39	59.1	37	68.5	
Working hour					
< 7 hrs/day	31	47.0	17	31.5	0.095[b]
≥ 7 hrs/day	35	53.0	37	68.5	
Health behaviors					
Smoking status					
No	38	57.6	30	55.6	0.855[b]
Yes	28	42.4	24	44.4	
Alcohol drinking					
No	23	34.8	16	29.6	0.564[b]
Yes	43	65.2	38	70.4	
Milk drinking					
No	9	13.6	15	27.8	0.068[b]
Yes	57	86.4	39	72.2	
Seafood consumption					
1-3 days/week	57	86.4	46	85.2	1.000[b]
4-7 days/week	9	13.6	8	14.8	

Personal characteristics at baseline	Exposed Group (n = 66)		Low Exposed Group (n = 54)		*P-value*
	n	%	n	%	
Exercise status					
1-3 days/week	39	59.1	25	46.3	0.199[b]
4-7 days/week	27	40.9	29	53.7	

Note: [a] - Independent T-test / [b] - Chi-squared test / * - Significance at *P-value* less than 0.05 level

The general characteristics among workers and the comparison of general characteristics between two groups at endpoint were shown in **Table 3**. For demographic characteristics, the results showed that nearly 50% of low exposed group graduated with Bachelor's Degree or higher. On the other hand 75.9% of exposed group graduated with lower than Bachelor's degree. There was a significant difference of education levels between two groups at *P-value* = 0.024. Like at baseline, more workers of low exposed group graduated from Signal school than exposed group at *P-value* = 0.032. For working conditions, there were no difference between both groups. In case of health behaviors, there was a significant difference only milk drinking between two groups at *P-value* = 0.021 which exposed group had more drinking milk than low exposed group (90.7 % and 72.9 %, respectively) **(Table 3).**

Table 3: The comparison of personal characteristics between two groups at endpoint.

Personal characteristics at endpoint	Exposed Group (n = 54)		Low Exposed Group (n = 48)		*P-value*
Demographic characteristics					
	Mean	S.D.	Mean	S.D.	
Age (Years)	36.9	10.7	39.6	11.6	0.215[a]
Body Mass Index (BMI) (kg/m^2)	25.1	3.4	25.3	3.6	0.685[a]
	n	%	n	%	
Marital Status					
Single	22	33.3	19	35.2	0.849[b]
Couple	44	66.7	35	64.8	
Education levels					
< Bachelor's Degree	41	75.9	26	54.2	0.024[b,*]
≥ Bachelor's Degree	13	24.1	22	45.8	
Study at Signal school					
No	17	31.5	6	12.5	0.032[b,*]
Yes	37	68.5	42	87.5	
Working conditions					
Working experience					
≤ 10 years	21	38.9	18	37.5	1.000[b]
> 10 years	33	61.1	30	62.5	
Working hour					
< 7 hrs/day	22	40.7	16	33.3	0.539[b]
≥ 7 hrs/day	32	59.3	32	66.7	

Personal characteristics at endpoint	Exposed Group (n = 54)		Low Exposed Group (n = 48)		*P-value*
Health behaviors					
Smoking status					
No	33	61.1	31	64.6	0.838[b]
Yes	21	38.9	17	35.4	
Alcohol drinking					
No	17	31.5	14	29.2	0.832[b]
Yes	37	68.5	34	70.8	
Milk drinking					
No	5	9.3	13	27.1	0.021[b,*]
Yes	49	90.7	35	72.9	
Seafood consumption					
1-3 days/week	47	87.0	42	87.5	1.000[b]
4-7 days/week	7	13.0	6	12.5	
Exercise status					
1-3 days/week	30	55.6	22	45.8	0.428[b]
4-7 days/week	24	44.4	26	54.2	

Note: [a] - Independent T-test / [b] - Chi-squared test / * - Significance at *P-value* less than 0.05 level

4.1.2 Airborne Lead Concentration (ALC)

Table 4 showed data of ALC and the comparison of ALC among sections at baseline. There were 41 workers for the comparison of ALC, the workers were divided into 5 sections which consisted of 10 workers in clerical officer section (CO), 8 workers in high frequency radio-repair section (HF), 8 workers in very high frequency radio-repair section (VHF), 8 workers in field telephone-repair section (FT), and 7 workers in carrier wave radio-repair section (CW). The highest mean$\pm$S.D. concentration of lead in the air was found in HF section which was 17.8 ± 9.2 µg/m^3. Mean$\pm$S.D. of ALC in VHF section was 13.9 ± 7.9 µg/m^3. The lowest mean$\pm$S.D. of ALC was found in CO section which was 3.1 ± 1.6 µg/m^3. One-way ANOVA revealed that there were significant differences of ALC between HF and CO at P-value = 0.002 and between VHF and CO at P-value = 0.042.

Table 4: The comparison of airborne lead concentration (ALC) among sections at baseline.

Sections	ALC Mean±S.D. (μg/m³)	Sections				
		CO (n = 10)	HF (n = 8)	VHF (n = 8)	FT (n = 8)	CW (n = 7)
		P-value				
CO (n = 10)	3.1±1.6	-	0.002*	0.042*	0.287	0.898
HF (n = 8)	17.8±9.2	0.002*	-	0.870	0.370	0.062
VHF (n = 8)	13.9±7.9	0.042*	0.870	-	0.911	0.387
FT (n = 8)	10.5±8.7	0.287	0.370	0.911	-	0.871
CW (n = 7)	6.6±4.5	0.898	0.062	0.387	0.871	-

Note: One-way ANOVA (Post HOC; Scheffe) was used to compare mean of ALC in each sections/ CO, Clerical Officer section; HF, High Frequency radio-repair section; VHF, Very High Frequency radio-repair section; FT, Field Telephone-repair section; CW, Carrier Wave radio-repair section / * - Significance at *P-value* less than 0.05 level.

Table 5 showed data of ALC and the comparison of ALC between each section at endpoint. There were 37 workers for the comparison of ALC. they were divided into 5 sections which consisted of 10 workers in CO section, 6 workers in HF section, 8 workers in VHF section, 8 workers in FT section, and 5 workers in CW section. The highest mean±S.D. concentration of lead in the air was found in HF section which was 34.5±9.1 μg/m^3. Mean±S.D. of ALC in VHF section was 31.6±7.4 μg/m^3. The lowest Mean±S.D. of ALC was found in CO section which was 19.3±5.0 μg/m^3. One-way ANOVA revealed that there were significant differences of ALC between HF and CO at *P-value* = 0.012 and between VHF and CO at *P-value* = 0.035.

Table 5: *The comparison of airborne lead concentration (ALC) among sections at endpoint.*

Sections	ALC Mean±S.D. (μg/m^3)	Sections				
		CO (n = 10)	HF (n = 6)	VHF (n = 8)	FT (n = 8)	CW (n = 5)
		P-value				
CO (n = 10)	19.3±5.0	-	0.012*	0.035*	0.217	0.227
HF (n = 6)	34.5±9.1	0.012*	-	0.970	0.654	0.865
VHF (n = 8)	31.6±7.4	0.035*	0.970	-	0.932	0.992
FT (n = 8)	28.1±9.5	0.217	0.654	0.932	-	0.999
CW (n = 5)	29.4±6.2	0.227	0.865	0.992	0.999	-

Note: One-way ANOVA (Post HOC; Scheffe) was used to compare mean of ALC in each sections/ CO, Clerical Officer section; HF, High Frequency radio-repair section; VHF, Very High Frequency radio-repair section; FT, Field Telephone-repair section; CW, carrier wave radio-repair section / * - Significance at *P-value* less than 0.05 level.

The comparison of ALC among sections between baseline and endpoint was shown in **Table 6**. The results revealed that, mean ALC of all sections at endpoint were significantly higher than mean ALC of all sections at baseline.

Table 6: *The comparison of airborne lead concentration (ALC) among sections between baseline and endpoint.*

ALC	**Sections**				
	CO (n = 10)	**HF** (n = 6)	**VHF** (n = 8)	**FT** (n = 8)	**CW** (n = 5)
	Mean±S.D.	Mean±S.D.	Mean±S.D.	Mean±S.D.	Mean±S.D.
baseline	3.1±1.6	19.4±10.2	13.9±7.9	10.5±8.7	7.7±4.9
endpoint	19.3±5.0	34.5±3.7	31.6±7.4	28.2±9.5	29.4±6.2
P-value	< 0.001*	0.021*	0.001*	0.001*	< 0.001*

Note: Dependent T-test was used to compare mean of airborne lead concentration (ALC) within section between baseline and endpoint/ CO, Clerical Officer section; HF, High Frequency radio-repair section; VHF, Very High Frequency radio-repair section; FT, Field Telephone-repair section; CW, carrier wave radio-repair section / * - Significance at *P-value* less than 0.05 level.

4.1.3 Knowledge, Awareness, and PPE used (KAP) of lead exposure

Table 7 showed the comparison of KAP for lead exposure within and between two groups at baseline and endpoint. Median knowledge score of both groups was 1 point at baseline. There was no significant difference of knowledge of lead exposure between groups. Knowledge score at endpoint was not measured. In terms of awareness of lead exposure, median awareness score of both groups was 8.5 points at baseline and 8 points at endpoint. Furthermore, there were no significant differences of awareness for lead exposure within and between both groups. For PPE used of lead exposure at baseline, median PPE used score of exposed group was 2 points and of low exposed group was 1.5 points. However, there was no difference of PPE used for lead exposure between groups. At endpoint, median PPE used score of exposed group was 3 points and of low exposed group was 2 points. The result showed the significant difference for PPE used of lead exposure between groups at P-value = 0.021. Moreover, median score for PPE used of lead exposure in exposed group at endpoint was significant higher than at baseline (P-value = 0.036).

Table 7: *The comparison of Knowledge, Awareness, and PPE used (KAP) of lead exposure within and between two groups at baseline (n of exposed group = 66 and n of low exposed group = 54) and endpoint (n of exposed group = 54 and n of low exposed group = 48).*

KAP of lead exposure	Exposed Group	Low Exposed Group	*P-value* between group
	Median (% score)	Median (% score)	
Knowledge (Total score = 5)			
baseline	1.0 (31.2%)	1.0 (24.8%)	0.100
endpoint	-	-	-
Awareness (Total score = 12)			
baseline	8.5 (70.1%)	8.5 (69.9%)	0.709
endpoint	8.0 (69.7%)	8.0 (64.0%)	0.791
P-value within group	0.645	0.624	
PPE Used (Total score = 10)			
baseline	2.0 (25.8%)	1.5 (22.0%)	0.105
endpoint	3.0 (33.4%)	2.0 (24.7)	0.021*
P-value within group	0.036*	0.358	

Note: Mann–Whitney U test was used to compare median for KAP of lead exposure between two groups/ Wilcoxon Signed Ranks test was used to compare median for AP of lead exposure within groups/ * - Significance at *P-value* less than 0.05 level.

4.1.4 Blood Lead Level (BLL)

The comparison of BLL within and between two groups at baseline and endpoint was shown in **Table 8**. The findings of BLL among workers at baseline showed that median BLL of exposed group and low exposed group were 2.3 and 1.0 µg/dl, respectively. Median BLL of exposed group and low exposed group at endpoint were 5.5 and 4.1 µg/dl, respectively. There were significant differences among BLL between two groups at baseline and endpoint at *P-value* < 0.001. Moreover, Wilcoxon Signed Ranks test showed that median BLL of both groups at endpoint were significantly higher than median BLL of both groups at baseline (*P-value* < 0.001).

Table 8: *The comparison of blood lead level (BLL) within and between two groups at baseline (n of exposed group = 66 and n of low exposed group = 54) and endpoint (n of exposed group = 54 and n of low exposed group = 48).*

Blood lead level	**Exposed Group**	**Low Exposed Group**	***P-value*** between group
	Median (µg/dL)	Median (µg/dL)	
baseline	2.3	1.0	< 0.001*
endpoint	5.5	4.1	< 0.001*
P-value within group	< 0.001*	< 0.001*	

Note: Mann–Whitney U test was used to compare median of BLL between two groups**/** Wilcoxon Signed Ranks test was used to compare median of BLL within groups/ * - Significance at *P-value* less than 0.05 level.

4.1.5 Hair Lead Level (HLL)

The comparison of HLL within and between two groups at baseline and endpoint was shown in Table 9. The findings of HLL among workers at baseline showed that median HLL of exposed group and low exposed group were 1.4 and 1.3 µg/g, respectively. There was no significant difference among HLL between two groups at baseline. In case of HLL among workers at endpoint, median HLL of exposed group and low exposed group were 2.9 and 1.8 µg/g, respectively. And there was a significant difference among HLL between two groups at endpoint (*P-value* < 0.001). In addition, Wilcoxon Signed Ranks test showed that median HLL of both groups at endpoint were significantly higher than median HLL of both groups at baseline (*P-value* < 0.001).

Table 9: *The comparison of hair lead level (HLL) within and between two groups at baseline (n of exposed group = 52 and n of low exposed group = 34) and endpoint (n of exposed group = 39 and n of low exposed group = 25).*

Hair lead level	**Exposed Group**	**Low Exposed Group**	***P-value*** between group
	Median (µg/g)	Median (µg/g)	
baseline	1.4	1.3	0.135
endpoint	2.9	1.8	< 0.001*
P-value within group	< 0.001*	< 0.001*	

Note: Mann–Whitney U test was used to compare median of HLL between two groups**/** Wilcoxon Signed Ranks test was used to compare median of HLL within groups/ * - Significance at *P-value* less than 0.05 level.

4.1.6 Signs and symptoms of lead poisoning

Signs and symptoms of lead poisoning between two groups at baseline and endpoint were shown in Table 10. Twelve signs and symptoms of lead poisoning were collected from the questionnaires including loss of appetite, constipation, nausea or vomit, excessive tiredness and weakness, headache or dizziness, fine tremors, colic pain, metallic taste in the mouth, nervous irritability, muscle and joint pain, insomnia, and numbness. Two signs and symptoms which were wrist and foot drop and lead line on the gum were diagnosed by medical doctor. These signs and symptoms were collected 2 times at baseline and endpoint. The workers who had systolic blood pressure equal to or more than 140 mmHg or diastolic blood pressure equal to or more than 90 mmHg and the workers who took antihypertensive drugs were assessed as a hypertension. Hypertension was also assessed at baseline and endpoint. Anemia was estimated from HCT levels, hepatic function was assessed from AST and ALT levels, and kidney function was assessed from GFR level. However, HCT, AST, ALT, and GFR levels were collected and evaluated only at baseline.

From data collection, wrist and foot drop and lead line on the gum were not found. For this study, 5 signs and symptoms consisting of muscle and joint pain, excessive tiredness and weakness, and nervous irritability, hypertension, and headache or dizziness were highly found in exposed group at baseline and endpoint. The comparison for signs and symptoms at baseline showed that there were 4 signs and symptoms including loss of appetite, excessive tiredness and weakness, nervous irritability, and muscle and joint pain with significant difference between both groups at *P-value* = 0.022, 0.004, 0.004, and 0.001, respectively. For the comparison of those at endpoint, there were significant difference of loss of appetite, nausea or vomit, excessive tiredness and weakness, headache or dizziness, nervous irritability, and muscle and joint pain at *P-value* = 0.009, 0.028, 0.002, 0.044, 0.001, and 0.001, respectively. There were no differences of the others between two groups at both incidents.

Table 10: *The comparison of Signs and symptoms of lead poisoning between two groups at baseline (n of exposed group = 66 and n of low exposed group = 54) and endpoint (n of exposed group = 54 and n of low exposed group = 48).*

Signs and symptoms of lead poisoning	Exposed Group		Low Exposed Group		***P-value*** between group
	n	%	n	%	
Loss of appetite					
baseline	9	13.6	1	1.9	$0.022^{c,*}$
endpoint	10	18.5	1	2.1	$0.009^{b,*}$
P-value within group	0.500^{d}		1.000^{d}		
Constipation					
baseline	6	9.1	5	9.3	1.000^{c}
endpoint	7	13.0	4	8.3	0.534^{b}
P-value within group	1.000^{d}		1.000^{d}		
	n	%	n	%	
Nausea or Vomit					
baseline	5	7.6	0	0	0.063^{c}
endpoint	6	11.1	0	0	$0.028^{c,*}$
P-value within group	1.000^{d}		-		
Excessive tiredness and Weakness					
baseline	26	39.4	8	14.8	$0.004^{b,*}$
endpoint	22	40.7	6	12.5	$0.002^{b,*}$
P-value within group	0.690^{d}		1.000^{d}		
Headache or Dizziness					
baseline	22	33.3	11	20.4	0.151^{b}
endpoint	15	27.8	5	10.4	$0.044^{b,*}$
P-value within group	0.629^{d}		0.180^{d}		

Signs and symptoms of lead poisoning	Exposed Group		Low Exposed Group		*P-value* between group
Fine tremors					
baseline	7	10.6	4	7.4	0.752[c]
endpoint	9	16.7	3	6.3	0.130[b]
P-value within group	0.375[d]		1.000[d]		
Colic pain					
baseline	1	1.5	2	3.7	0.588[c]
endpoint	1	1.9	0	0	1.000[c]
P-value within group	1.000[d]		0.500[d]		
Metallic taste in the mouth					
baseline	0	0	1	1.9	0.450[c]
endpoint	1	1.9	0	0	1.000[c]
P-value within group	1.000[d]		-		
Nervous irritability					
baseline	25	37.9	9	16.7	0.014[b,*]
endpoint	20	37.0	4	8.3	0.001[b,*]
P-value within group	0.664[d]		0.125[d]		
Muscle and joint pain					
baseline	33	50.0	10	18.5	0.001[b,*]
endpoint	21	38.9	5	10.4	0.001[b,*]
P-value within group	0.286[d]		0.267[d]		
Insomnia					
baseline	16	24.2	8	14.8	0.254[b]
endpoint	13	24.1	4	8.3	0.060[b]
P-value within group	1.000[d]		1.000[d]		
Numbness					
baseline	4	6.1	2	3.7	0.689[c]

Signs and symptoms of lead poisoning	Exposed Group		Low Exposed Group		*P-value* between group
endpoint	9	16.7	5	10.4	0.402[b]
P-value within group	0.070[d]		0.625[d]		
Hypertension					
baseline	20	30.3	16	29.6	1.000[b]
endpoint	18	33.3	10	20.8	0.187[b]
P-value within group	1.000[d]		1.000[d]		
Hepatic Function					
High AST levels	9	13.6	6	11.1	0.785[b]
Hepatic Function					
High ALT levels	18	27.3	8	14.8	0.121[b]
Kidney Function					
Mild loss of kidney function (2nd stage of GFR levels)	30	45.5	26	48.1	0.855[b]
	Mean ± S.D.		Mean ± S.D.		
Anemia					
HCT Levels	44.7 ± 2.9		44.5 ± 3.1		0.788[a]

Note: [a] - Independent T-test / [b] - Chi-squared test / [c] - Fisher's exact test / [d] - McNemar's test / * - Significance at *P-value* less than 0.05 level. AST level, ALT level, GFR level, and HCT level were analyzed only at baseline.

4.2 Correlation between Blood lead level and Hair lead level among workers at baseline and endpoint.

Table 11 showed the correlation between BLL and HLL among workers at baseline and endpoint. Median BLL among workers at baseline is 1.6 μg/dL and at endpoint is 4.8 μg/dL. For HLL, median HLL among workers at baseline is 1.4 μg/g and at endpoint is 2.7 μg/g. Low positive correlation between BLL and HLL among workers were found at baseline (r_s = 0.351 and *P-value* = 0.001) and at endpoint (r_s = 0.263 and *P-value* = 0.036).

Table 11: *Correlation between BLL and HLL among workers at baseline (n = 86) and endpoint (n = 64)*

All workers				
Correlation between BLL and HLL	**BLL** Median (μg/dL)	**HLL** Median (μg/g)	r_s	***P-value***
baseline	1.6	1.4	0.351	0.001*
endpoint	4.8	2.7	0.263	0.036*

Note: Spearman's correlation was used to determine correlation between BLL and HLL/ * - Significance at *P-value* less than 0.05 level

4.3 Correlation of KAP for lead exposure with Blood lead level and Hair lead level among workers at baseline and endpoint.

Correlations between KAP of lead exposure and BLL of two groups at baseline and endpoint were shown in **Table 12**. At baseline, there was a low positive correlation between BLL and awareness score of lead exposure in exposed group (r_s = 0.366 and *P-value* = 0.003). At endpoint, there were no correlations between awareness and PPE used score of lead exposure and BLL of two groups.

Table 12: *Correlation between KAP of lead exposure and BLL of two groups at baseline and endpoint.*

KAP of lead exposure	BLL at baseline		BLL at endpoint	
	Exposed Group (n = 66)	Low Exposed Group (n = 54)	Exposed Group (n = 54)	Low Exposed Group (n = 48)
Knowledge score				
r_s	-0.191	-0.217	-	-
p-value	0.124	0.116		
Awareness score				
r_s	0.366	0.049	0.085	-0.271
p-value	0.003*	0.727	0.541	0.063
PPE used score				
r_s	0.224	-0.242	-0.161	0.052
p-value	0.071	0.077	0.243	0.725

Note: Spearman's correlation was used to determine the correlation between KAP of lead exposure and BLL / * – Significance at *P-value* less than 0.05 level

Correlations between KAP of lead exposure and BLL of two groups at baseline and endpoint were shown in **Table 13**. At baseline, there was a low negative correlation between BLL and knowledge score of lead exposure in exposed group (r_s = -0.291 and *P-value* = 0.038). At endpoint, there were no correlations between awareness and PPE used score of lead exposure and BLL of two groups.

Table 13: *Correlation of KAP of lead exposure and HLL between two groups at baseline and endpoint.*

KAP of lead exposure	HLL at baseline		HLL at endpoint	
	Exposed Group (n = 52)	Low Exposed Group (n = 34)	Exposed Group (n = 39)	Low Exposed Group (n = 25)
Knowledge score				
r_s	-0.291	-0.059	-	-
p-value	0.038*	0.738		
Awareness score				
r_s	-0.062	0.268	0.214	-0.165
p-value	0.668	0.120	0.191	0.431
PPE used score				
r_s	0.268	-0.080	0.003	-0.092
p-value	0.057	0.647	0.986	0.662

Note: Spearman's correlation was used to determine the correlation between KAP of lead exposure and HLL / * – Significance at *P-value* less than 0.05 level

The independent variables of this study including demographic characteristics, working conditions, health behaviors, and airborne lead concentration might be the health risk factors of lead poisoning. There were 5 demographic characteristics consisting of age, BMI, marital status, education level, and study at Signal school. Working experience and working hour were the working conditions. Smoking status, alcohol drinking, milk drinking, seafood consumption, and exercise were the health behaviors. All of these health risk factors were gathered to find the association with BLL, HLL, and signs and symptoms of lead poisoning among workers. There were 120 workers at baseline and 102 workers at endpoint for BLL and signs and symptoms of lead exposure analysis. For HLL analysis, there were 86 workers at baseline and 64 workers at endpoint. By the way, 41 workers at baseline and 37 workers at endpoint were randomized to collect personnel airborne lead concentration.

4.4 Association among health risk factors with lead level (BLL and HLL) and signs and symptoms of lead poisoning among workers at baseline and endpoint.

Health risk factors that might relate to lead poisoning consisted of demographic characteristics, working conditions, health behaviors, and ALC. Age, BMI, marital status, education level, and study at Signal school were demographic characteristics. Working experience and working hour were working conditions. The last was health behaviors which comprised smoking status, alcohol drinking, milk drinking, seafood consumption, and exercise. These all factors were considered to determine the association with lead level including BLL and HLL and Signs and symptoms of lead poisoning.

4.4.1 Association between health risk factors and Blood lead level

In case of the association between BLL and each health risk factors at baseline, the results showed an association between BLL and study at Signal school (OR = 0.382 and *P-value* = 0.030). Furthermore, there was a trend association with milk drinking also (OR = 1.812 and *P-value* = 0.205). Therefore, study at Signal school and milk drinking were considered to assess the multiple association with BLL **(Table 14).**

Table 14: *Bivariate analysis of each health risk factors associated with BLL among workers (n = 120) at baseline.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Demographic characteristics					
Age	-0.004	0.017	0.064	0.800	0.996 (0.962-1.030)
BMI	0.026	0.051	0.268	0.605	1.027 (0.929-1.134)
Marital status					
Single	Ref.				
Couple	0.023	0.385	0.004	0.951	1.024 (0.481-2.177)
Education level					
< Bachelor's Degree	Ref.				
≥ Bachelor's Degree	-0.095	0.383	0.062	0.804	0.909 (0.429-1.926)
Study at Signal school					
No	Ref.				
Yes	-0.961	0.442	4.734	0.030*	0.382 (0.161-0.909)
Working conditions					
Working experience					
≤ 10 years	Ref.				
> 10 years	0.091	0.379	0.058	0.810	1.095 (0.521-2.303)
Working hour					
< 7 hrs/day	Ref.				
≥ 7 hrs/day	-0.195	0.373	0.272	0.602	0.823 (0.396-1.710)
Health behaviors					
Smoking status					
No	Ref.				
Yes	0.059	0.369	0.025	0.873	1.061 (0.515-2.184)

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Alcohol drinking					
No	Ref.				
Yes	0.332	0.392	0.717	0.397	1.394 (0.646-3.005)
Milk drinking					
No	Ref.				
Yes	0.594	0.469	1.608	0.205#	1.812 (0.723-4.538)
Seafood					
consumption	Ref.				
1-3 days/week	0.454	0.531	0.731	0.393	1.574 (0.556-4.456)
4-7 days/week					
Exercise					
1-3 days/week	Ref.				
4-7 days/week	-0.206	0.367	0.315	0.575	0.814 (0.397-1.670)

Blood lead level (0 $\leq$ 1.54 μg/dL and 1 > 1.54 μg/dL). B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * *P-value* less than 0.05 level. # *P-value* is between 0.05 and 0.25. A bivariate analysis of each variable was first done, and then the variables with *P-value* $\leq$ 0.25 was included in the multivariate analysis.

Multiple binary logistic regression revealed that study at Signal school associated with BLL (*P-value* = 0.029) at baseline. Study at Signal school showed a decrease 0.377-fold odd of BLL (OR = 0.377 and 95% CI = 0.157-0.903). However, milk drinking was not related to BLL **(Table 15).**

Table 15: *Multivariate analysis of each health risk factors associated with BLL among workers (n = 120) at baseline.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Study at Signal school					
No	Ref.				
Yes	-0.976	0.446	4.795	0.029*	0.377 (0.157-0.903)
Milk drinking					
No	Ref.				
Yes	0.621	0.480	1.676	0.195	1.861 (0.727-4.764)

Blood lead level (0 ≤ 1.54 μg/dL and 1 > 1.54 μg/dL). B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first.
* Significance at *P-value* less than 0.05 level.

Logistic regression showed that there was a significant association between airborne lead concentration and BLL (*P-value* = 0.021) at baseline. When ALC increased, the 1.168-fold odd increase of BLL was shown (OR = 1.168 and 95% CI = 1.024-1.331) **(Table 16).**

Table 16: *Bivariate analysis of airborne lead concentration (ALC) associated with BLL among workers (n = 41) at baseline.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
ALC	0.155	0.067	5.360	0.021*	1.168 (1.024-1.331)

Blood lead level (0 $\leq$ 1.54 µg/dL and 1 > 1.54 µg/dL). B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * Significance at *P-value* less than 0.05 level.

Multiple binary logistic regression revealed that ALC still associated with BLL even though the result was adjusted by working hour (*P-value* = 0.021) at baseline. When ALC increased, the 1.170-fold odd increase of BLL was shown (OR = 1.170 and 95% CI = 1.024-1.338) **(Table 17).**

Table 17: *Multivariate analysis of airborne lead concentration (ALC) associated with BLL among workers (n = 41) at baseline.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
ALC	0.157	0.068	5.326	0.021*	1.170 (1.024-1.338)
Working hour					
< 7 hrs/day	Ref.				
$\geq$ 7 hrs/day	-0.243	0.754	0.103	0.748	0.785 (0.179-3.441)

Blood lead level (0 $\leq$ 1.54 µg/dL and 1 > 1.54 µg/dL). B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * Significance at *P-value* less than 0.05 level.

In case of the association between BLL and each health risk factors at endpoint, the results showed the associations between BLL and BMI (OR = 0.881 and *P-value* = 0.044) and alcohol drinking (OR = 4.686 and *P-value* = 0.002). In addition, there were the trend associations with age (OR = 0.979 and *P-value* = 0.240), smoking status (OR = 2.010 and *P-value* = 0.093), and seafood consumption (OR = 2.885 and *P-value* = 0.097). Therefore, BMI, alcohol drinking, age, smoking status, and seafood consumption were considered to assess the multiple association with BLL **(Table 18).**

Table 18: *Bivariate analysis of each health risk factors associated with BLL among workers (n = 102) at endpoint.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Demographic characteristics					
Age	-0.021	0.018	1.381	$0.240^{\#}$	0.979 (0.945-1.014)
BMI	-0.127	0.063	4.062	0.044*	0.881 (0.779-0.997)
Marital status					
Single	Ref.				
Couple	-0.445	0.426	1.091	0.296	0.641 (0.278-1.476)
Education level					
< Bachelor's Degree	Ref.				
≥ Bachelor's Degree	-0.258	0.420	0.377	0.539	0.773 (0.339-1.760)
Study at Signal school					
No	Ref.				
Yes	-0.491	0.478	1.057	0.304	0.612 (0.240-1.561)

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Working conditions					
Working experience					
≤ 10 years	Ref.				
> 10 years	-0.274	0.409	0.451	0.502	0.760 (0.341-1.693)
Working hour					
< 7 hrs/day	Ref.				
≥ 7 hrs/day	-0.357	0.411	0.753	0.386	0.700 (0.313-1.567)
Health behaviors					
Smoking status					
No	Ref.				
Yes	0.698	0.416	2.820	0.093#	2.010 (0.890-4.538)
Alcohol drinking					
No	Ref.				
Yes	1.545	0.492	9.848	0.002*	4.686 (1.786-12.295)
Milk drinking					
No	Ref.				
Yes	0.128	0.522	0.060	0.807	1.136 (0.408-3.163)
Seafood consumption					
1-3 days/week	Ref.				
4-7 days/week	1.059	0.638	2.759	0.097#	2.885 (0.826-10.068)
Exercise					
1-3 days/week	Ref.				
4-7 days/week	-0.241	0.398	0.368	0.544	0.786 (0.360-1.713)

Blood lead level (0 ≤ 4.90 μg/dL and 1 > 4.90 μg/dL). B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * *P-value* less than 0.05 level. # *P-value* is between 0.05 and 0.25. A bivariate analysis of each variable was first done, and then the variables with *P-value* ≤ 0.25 were included in the multivariate analysis.

Multiple binary logistic regression revealed that only alcohol drinking associated with BLL (*P-value* = 0.014) at endpoint. Drink alcohol would increase 3.672-fold odd of BLL (OR = 3.672 and 95% CI = 1.296-10.407). However, BMI, smoking status and seafood consumption were not related to BLL **(Table19).**

Table 19: *Multivariate analysis of each health risk factors associated with BLL among workers (n = 102) at endpoint.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
BMI	-0.075	0.070	1.144	0.285	0.928 (0.810-1.064)
Smoking status					
No	Ref.				
Yes	0.331	0.458	0.524	0.469	1.393 (0.568-3.417)
Alcohol drinking					
No	Ref.				
Yes	1.301	0.531	5.991	0.014*	3.672 (1.296-10.407)
Seafood consumption					
1-3 days/week	Ref.				
4-7 days/week	0.916	0.690	1.765	0.184	2.500 (0.647-9.665)

Blood lead level (0 $\leq$ 4.90 µg/dL, 1 > 4.90 µg/dL). B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * Significance at *P-value* less than 0.05 level.

Logistic regression showed that there was a significant association between ALC and BLL (*P-value* = 0.005) at endpoint. When ALC increase, the increase 1.161-fold odd of BLL was shown (OR = 1.161 and 95% CI = 1.046-1.289) **(Table 20).**

Table 20: *Bivariate analysis of airborne lead concentration (ALC) associated with BLL among workers (n = 37) at endpoint.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
ALC	0.149	0.053	7.828	0.005*	1.161 (1.046-1.289)

Blood lead level (0 ≤ 4.90 μg/dL and 1 > 4.90 μg/dL). B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * Significance at *P-value* less than 0.05 level.

Multiple binary logistic regression revealed that ALC still associated with BLL even though the result was adjusted by working hour (*P-value* = 0.005) at endpoint. When ALC increase, the increase 1.164-fold odd of BLL was shown (OR = 1.164 and 95% CI = 1.046-1.296) **(Table 21).**

Table 21: *Multivariate analysis of airborne lead concentration (ALC) associated with BLL among workers (n = 37) at endpoint.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
ALC	0.152	0.055	7.723	0.005*	1.164 (1.046-1.296)
Working hour					
< 7 hrs/day	Ref.				
≥ 7 hrs/day	-0.283	0.862	0.108	0.743	0.754 (0.139-4.080)

Blood lead level (0 ≤ 4.90 μg/dL, 1 > 4.90 μg/dL). B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * Significance at *P-value* less than 0.05 level.

4.4.2 Association between health risk factors and Hair lead level

In case of the association between HLL and each health risk factors at baseline, the results showed the associations between HLL and BMI (OR = 1.290 and *P-value* = 0.004) and study at Signal school (OR = 0.173 and *P-value* = 0.004). In addition, there was a trend association with age (OR = 1.041 and *P-value* = 0.075). Therefore, BMI, study at Signal school and age were considered to assess the multiple association with HLL **(Table 22).**

Table 22: *Bivariate analysis of each health risk factors associated with HLL among workers (n = 86) at baseline.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Demographic characteristics					
Age	0.041	0.023	3.178	0.075#	1.041 (0.996-1.089)
BMI	0.255	0.089	8.126	0.004*	1.290 (1.083-1.537)
Marital status					
Single	Ref.				
Couple	0.113	0.475	0.056	0.812	1.119 (0.441-2.841)
Education level					
< Bachelor's Degree	Ref.				
≥ Bachelor's Degree	-0.444	0.474	0.877	0.349	0.642 (0.253-1.624)
Study at Signal school					
No	Ref.				
Yes	-1.754	0.613	8.200	0.004*	0.173 (0.052-0.575)

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Working conditions					
Working experience					
≤ 10 years	Ref.				
> 10 years	0.325	0.467	0.484	0.486	1.384 (0.554-3.456)
Working hour					
< 7 hrs/day	Ref.				
≥ 7 hrs/day	0.400	0.449	0.793	0.373	1.491 (0.619-3.595)
Health behaviors					
Smoking status					
No	Ref.				
Yes	-0.094	0.433	0.047	0.829	0.910 (0.389-2.129)
Alcohol drinking					
No	Ref.				
Yes	-0.426	0.464	0.843	0.359	0.653 (0.263-1.621)
Milk drinking					
No	Ref.				
Yes	-0.570	0.541	1.109	0.292	0.566 (0.196-1.634)
Seafood consumption					
1-3 days/week	Ref.				
4-7 days/week	0.000	0.584	0.000	1.000	1.000 (0.318-3.142)
Exercise					
1-3 days/week	Ref.				
4-7 days/week	-0.093	0.431	0.047	0.829	0.911 (0.391-2.122)

Hair lead level (0 ≤ 1.43 μg/g and 1 > 1.43 μg/g). B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * *P-value* less than 0.05 level. # *P-value* is between 0.05 and 0.25. A bivariate analysis of each variable was first done, and then the variables with *P-value* ≤ 0.25 were included in the multivariate analysis.

Multiple binary logistic regression revealed that age, BMI, and study at Signal school associated with HLL (OR = 1.077 and *P-value* = 0.010, OR = 1.272 and *P-value* = 0.012, and OR = 0.103 and *P-value* = 0.002, respectively) at baseline **(Table23).**

Table 23: *Multivariate analysis of each health risk factors associated with HLL among workers (n = 86) at baseline.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Age	0.074	0.029	6.590	0.010*	1.077 (1.018-1.139)
BMI	0.240	0.096	6.289	0.012*	1.272 (1.054-1.535)
Study at Signal school					
No	Ref.				
Yes	-2.277	0.722	9.942	0.002*	0.103 (0.025-0.422)

Hair lead level (0 $\leq$ 1.43 μg/g and 1 > 1.43 μg/g). B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * Significance at *P-value* less than 0.05 level.

Logistic regression showed that there was no association between ALC and HLL at baseline **(Table 24).**

Table 24: *Bivariate analysis of airborne lead concentration (ALC) associated with HLL among workers (n = 41) at baseline.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
ALC	0.051	0.040	1.683	0.195	1.053 (0.974-1.137)

Hair lead level (0 $\leq$ 1.43 μg/g and 1 > 1.43 μg/g). B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * Significance at *P-value* less than 0.05 level.

Multiple binary logistic regression revealed that ALC was not associated with HLL even though the result was adjusted by working hour at baseline **(Table 25).**

Table 25: *Multivariate analysis of airborne lead concentration (ALC) associated with HLL among workers (n = 41) at baseline.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
ALC	0.051	0.040	1.634	0.201	1.052 (0.973-1.138)
Working hour					
< 7 hrs/day	Ref.				
≥ 7 hrs/day	0.501	0.694	0.521	0.470	1.650 (0.423-6.433)

Hair lead level (0 ≤ 1.43 μg/g and 1 > 1.43 μg/g). B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * Significance at *P-value* less than 0.05 level.

In case of the association between HLL and each health risk factors at endpoint, the results showed the associations between HLL and education level (OR = 0.156 and *P-value* = 0.002). Moreover, there were trend associations with BMI and milk drinking (OR = 1.191 and *P-value* = 0.053 and OR = 2.952 and *P-value* = 0.108, respectively). Therefore, education level, BMI, and milk drinking were considered to assess the multiple association with HLL **(Table 26).**

Table 26: *Bivariate analysis of each health risk factors associated with HLL among workers (n = 64) at endpoint.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Demographic characteristics					
Age	0.014	0.026	0.291	0.589	1.014 (0.963-1.068)
BMI	0.174	0.090	3.740	0.053#	1.191 (0.998-1.421)
Marital status					
Single	Ref.				
Couple	0.430	0.624	0.476	0.490	1.538 (0.453-5.226)
Education level					
< Bachelor's Degree	Ref.				
≥ Bachelor's Degree	-1.861	0.609	9.322	0.002*	0.156 (0.047-0.514)
Study at Signal school					
No	Ref.				
Yes	-0.352	0.635	0.307	0.579	0.703 (0.202-2.443)
Working conditions					
Working experience					
≤ 10 years	Ref.				
> 10 years	-0.084	0.581	0.021	0.885	0.919 (0.294-2.872)

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Working hour					
< 7 hrs/day	Ref.				
≥ 7 hrs/day	0.573	0.522	1.205	0.272	1.773 (0.638-4.927)
Health behaviors					
Smoking status					
No	Ref.				
Yes	-0.318	0.512	0.387	0.534	0.727 (0.267-1.983)
Alcohol drinking					
No	Ref.				
Yes	-0.439	0.543	0.653	0.419	0.645 (0.222-1.869)
Milk drinking					
No	Ref.				
Yes	1.083	0.674	2.577	0.108#	2.952 (0.787-11.073)
Seafood consumption					
1-3 days/week	Ref.				
4-7 days/week	-0.704	0.702	1.006	0.316	0.495 (0.125-1.957)
Exercise					
1-3 days/week	Ref.				
4-7 days/week	0.126	0.502	0.063	0.802	1.134 (0.424-3.037)

Hair lead level (0 ≤ 2.64 µg/g and 1 > 2.64 µg/g). B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * *P-value* less than 0.05 level. # *P-value* is between 0.05 and 0.25. A bivariate analysis of each variable was first done, and then the variables with *P-value* ≤ 0.25 were included in the multivariate analysis.

Multiple binary logistic regression revealed that education level and milk drinking associated with HLL (*P-value* = 0.002 and *P-value* = 0.046, respectively) at endpoint. BMI was not related to HLL **(Table 27).**

Table 27: *Multivariate analysis of each health risk factors associated with HLL among workers (n = 64) at endpoint.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Education level					
< Bachelor's Degree	Ref.				
≥ Bachelor's Degree	-2.039	0.652	9.781	0.002*	0.130 (0.036-0.467)
Milk drinking					
No	Ref.				
Yes	1.573	0.787	3.994	0.046*	4.820 (1.031-22.537)
BMI	0.199	0.107	3.472	0.062	1.220 (0.990-1.505)

Hair lead level (0 ≤ 2.64 μg/g and 1 > 2.64 μg/g). B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * Significance at *P-value* less than 0.05 level.

Binary logistic regression showed that there was no association between ALC and HLL at endpoint **(Table 28).**

Table 28: *Bivariate analysis of airborne lead concentration (ALC) associated with HLL among workers (n = 37) at endpoint.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
ALC	0.047	0.040	1.368	0.242	1.048 (0.969-1.133)

Hair lead level (0 $\leq$ 2.64 µg/g and 1 > 2.64 µg/g). B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * Significance at *P-value* less than 0.05 level.

Multiple binary logistic regression revealed that ALC was not associated with HLL even though the result was adjusted by working hour at endpoint **(Table 29).**

Table 29: *Multivariate analysis of airborne lead concentration (ALC) associated with HLL among workers (n = 37) at endpoint.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
ALC	0.046	0.040	1.326	0.249	1.047 (0.968-1.132)
Working hour					
< 7 hrs/day	Ref.				
$\geq$ 7 hrs/day	0.817	0.749	1.190	0.275	2.263 (0.522-9.819)

Hair lead level (0 $\leq$ 2.64 µg/g and 1 > 2.64 µg/g). B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * Significance at *P-value* less than 0.05 level.

4.4.3 Association between health risk factors and Signs and symptoms of lead poisoning

There was no association between each health risk factors and loss of appetite at baseline. There was a trend association between alcohol drinking and loss of appetite (*P-value* = 0.146). However, the multivariate association between health risk factors and loss of appetite among workers at baseline was not found. Therefore, multivariate analysis of health risk factors associated with loss of appetite was not shown **(Table 30).**

Table 30: *Bivariate analysis of each health risk factors associated with loss of appetite among workers (n = 120) at baseline.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Demographic characteristics					
Age	0.004	0.031	0.016	0.898	1.004 (0.944-1.068)
BMI	-0.122	0.106	1.310	0.252	0.885 (0.719-1.091)
Marital status					
Single	Ref.				
Couple	-0.274	0.676	0.164	0.685	0.760 (0.202-2.862)
Education level					
< Bachelor's Degree	Ref.				
≥ Bachelor's Degree	-0.248	0.718	0.119	0.730	0.780 (0.191-3.189)
Study at Signal school					
No	Ref.				
Yes	-0.767	0.683	1.260	0.262	0.464 (0.122-1.772)

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Working conditions					
Working experience					
≤ 10 years	Ref.				
> 10 years	0.904	0.815	1.233	0.267	2.471 (0.501-12.194)
Working hour					
< 7 hrs/day	Ref.				
≥ 7 hrs/day	-0.480	0.717	0.448	0.503	0.619 (0.152-2.523)
Health behaviors					
Smoking status					
No	Ref.				
Yes	0.736	0.674	1.192	0.275	2.087 (0.557-7.818)
Alcohol drinking					
No	Ref.				
Yes	1.558	1.073	2.109	0.146#	4.750 (0.580-38.907)
Milk drinking					
No	Ref.				
Yes	-0.597	0.731	0.666	0.415	0.551 (0.131-2.309)
Seafood consumption					
1-3 days/week	Ref.				
4-7 days/week	0.460	0.838	0.301	0.583	1.583 (0.306-8.182)
Exercise					
1-3 days/week	Ref.				
4-7 days/week	-0.296	0.673	0.194	0.660	0.744 (0.199-2.782)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * *P-value* less than 0.05 level. # *P-value* is between 0.05 and 0.25. A bivariate analysis of each variable was first done, and then the variables with *P-value* ≤ 0.25 were included in the multivariate analysis.

There was no association between each health risk factors and constipation at baseline. However, there were the trend associations of constipation with BMI, study at Signal school, and working experience (OR = 0.888 and P-value = 0.243, OR = 3.625 and P-value = 0.229, and OR = 0.446 and P-value = 0.206). The table did not show seafood consumption because this factor could not be determined the association with constipation at baseline **(Table 31).**

Table 31: *Bivariate analysis of each health risk factors associated with constipation among workers (n = 120) at baseline.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Demographic characteristics					
Age	-0.031	0.031	0.959	0.327	0.970 (0.912-1.031)
BMI	-0.118	0.101	1.361	0.243#	0.888 (0.728-1.084)
Marital status					
Single	Ref.				
Couple	0.356	0.706	0.254	0.614	1.427 (0.358-5.697)
Education level					
< Bachelor's Degree	Ref.				
≥ Bachelor's Degree	-0.396	0.706	0.315	0.575	0.673 (0.169-2.685)
Study at Signal school					
No	Ref.				
Yes	1.288	1.071	1.446	0.229#	3.625 (0.444-29.575)
Working conditions					
Working experience					
≤ 10 years	Ref.				
> 10 years	-0.807	0.638	1.602	0.206#	0.446 (0.128-1.557)

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Working hour					
< 7 hrs/day	Ref.				
≥ 7 hrs/day	-0.246	0.636	0.150	0.699	0.782 (0.225-2.722)
Health behaviors					
Smoking status					
No	Ref.				
Yes	-0.778	0.704	1.223	0.269	0.459 (0.116-1.824)
Alcohol drinking					
No	Ref.				
Yes	-0.189	0.660	0.082	0.774	0.828 (0.227-3.015)
Milk drinking					
No	Ref.				
Yes	0.129	0.817	0.025	0.874	1.138 (0.229-5.647)
Exercise					
1-3 days/week	Ref.				
4-7 days/week	-0.348	0.635	0.300	0.584	1.416 (0.408-4.919)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first; * *P-value* less than 0.05 level. # *P-value* is between 0.05 and 0.25. A bivariate analysis of each variable was first done, and then the variables with *P-value* ≤ 0.25 were included in the multivariate analysis.

Multiple binary logistic regression revealed that there was an association between constipation and working experience (OR = 0.178 and *P-value* = 0.042) among workers which was adjusted by marital status, education level, study at Signal school, and smoking status at baseline **(Table32).**

Table 32: *Multivariate analysis of each health risk factors associated with constipation among workers (n = 120) at baseline.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Marital status					
Single	Ref.				
Couple	1.625	0.966	2.829	0.093	5.077 (0.764-33.723)
Education level					
< Bachelor's Degree	Ref.				
≥ Bachelor's Degree	-0.850	0.784	1.176	0.278	0.427 (0.092-1.986)
Study at Signal school					
No	Ref.				
Yes	1.619	1.147	1.991	0.158	5.048 (0.533-47.817)
Working experience					
≤ 10 years	Ref.				
> 10 years	-1.726	0.849	4.137	0.042*	0.178 (0.034-0.939)
Smoking status					
No	Ref.				
Yes	-1.228	0.830	2.189	0.139	0.293 (0.058-1.490)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * Significance at *P-value* less than 0.05 level.

There was no association between each health risk factors and nausea or vomit at baseline. There was a trend association between seafood consumption and nausea or vomit (*P-value* = 0.118). However, the multivariate association between health risk factors and nausea or vomit among workers at baseline was not found. Therefore, multivariate analysis of health risk factors associated with nausea or vomit among workers was not shown. The table did not show milk drinking because this factor could not be determined the association with nausea or vomit at baseline **(Table 33).**

Table 33: *Bivariate analysis of each health risk factors associated with nausea or vomit among workers (n = 120) at baseline.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Demographic characteristics					
Age	0.001	0.043	0.001	0.981	1.001 (0.919-1.090)
BMI	0.018	0.124	0.021	0.885	1.018 (0.799-1.297)
Marital status					
Single	Ref.				
Couple	0.758	1.135	0.446	0.504	2.133 (0.231-19.734)
Education level					
< Bachelor's Degree	Ref.				
≥ Bachelor's Degree	-0.796	1.135	0.492	0.483	0.451 (0.049-4.172)
Study at Signal school					
No	Ref.				
Yes	0.299	1.138	0.069	0.793	1.349 (0.145-12.561)

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Working conditions					
Working experience					
≤ 10 years	Ref.				
> 10 years	0.871	1.135	0.589	0.443	2.389 (0.259-22.075)
Working hour					
< 7 hrs/day	Ref.				
≥ 7 hrs/day	0.000	0.933	0.000	1.000	1.000 (0.161-6.219)
Health behaviors					
Smoking status					
No	Ref.				
Yes	-0.143	0.932	0.024	0.878	0.867 (0.139-5.385)
Alcohol drinking					
No	Ref.				
Yes	0.680	1.135	0.359	0.549	1.974 (0.213-18.276)
Seafood consumption					
1-3 days/week	Ref.				
4-7 days/week	1.492	0.954	2.445	0.118#	4.444 (0.685-28.828)
Exercise					
1-3 days/week	Ref.				
4-7 days/week	-0.284	0.932	0.093	0.761	0.753 (0.121-4.677)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * *P-value* less than 0.05 level. # *P-value* is between 0.05 and 0.25. A bivariate analysis of each variable was first done, and then the variables with *P-value* ≤ 0.25 were included in the multivariate analysis.

The results showed the associations between health risk factors including study at Signal school and exercise and excessive tiredness and weakness (OR = 0.398 and *P-value* = 0.038 and OR = 0.299 and *P-value* = 0.007, respectively). Therefore, study at Signal school and exercise were considered to assess the multiple association with excessive tiredness and weakness **(Table 34).**

Table 34: *Bivariate analysis of each health risk factors associated with excessive tiredness and weakness among workers (n = 120) at baseline.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Demographic characteristics					
Age	0.013	0.019	0.446	0.504	1.013 (0.975-1.052)
BMI	0.060	0.055	1.194	0.274	1.062 (0.953-1.183)
Marital status					
Single	Ref.				
Couple	-0.070	0.425	0.027	0.870	0.933 (0.405-2.146)
Education level					
< Bachelor's Degree	Ref.				
≥ Bachelor's Degree	0.196	0.420	0.218	0.641	1.217 (0.534-2.773)
Study at Signal school					
No	Ref.				
Yes	-0.921	0.445	4.290	0.038*	0.398 (0.166-0.952)
Working conditions					
Working experience					
≤ 10 years	Ref.				
> 10 years	0.083	0.423	0.038	0.844	1.086 (0.475-2.487)

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Working hour					
< 7 hrs/day	Ref.				
≥ 7 hrs/day	-0.237	0.410	0.335	0.563	0.789 (0.353-1.763)
Health behaviors					
Smoking status					
No	Ref.				
Yes	0.376	0.407	0.855	0.355	1.457 (0.656-3.237)
Alcohol drinking					
No	Ref.				
Yes	-0.176	0.428	0.169	0.681	0.839 (0.363-1.939)
Milk drinking					
No	Ref.				
Yes	-0.051	0.503	0.010	0.919	0.950 (0.354-2.548)
Seafood consumption					
1-3 days/week	Ref.				
4-7 days/week	0.379	0.554	0.469	0.494	1.461 (0.494-4.325)
Exercise					
1-3 days/week	Ref.				
4-7 days/week	-1.208	0.445	7.372	0.007*	0.299 (0.125-0.715)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * *P-value* less than 0.05 level. # *P-value* is between 0.05 and 0.25. A bivariate analysis of each variable was first done, and then the variables with *P-value* ≤ 0.25 were included in the multivariate analysis.

Multiple binary logistic regression revealed that there was an association between exercise and excessive tiredness and weakness among workers at baseline (OR = 0.307 and *P-value* = 0.009) **(Table 35).**

Table 35: *Multivariate analysis of each health risk factors associated with excessive tiredness and weakness among workers (n = 120) at baseline.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Study at Signal school					
No	Ref.				
Yes	-0.881	0.461	3.650	0.056	0.414 (0.168-1.023)
Exercise					
1-3 days/week	Ref.				
4-7 days/week	-1.182	0.451	6.857	0.009*	0.307 (0.127-0.743)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * Significance at *P-value* less than 0.05 level.

The results showed that there was no association between health risk factors and headache or dizziness. However, there were the trend associations of health risk factors including study at Signal school, smoking status, and milk drinking with headache or dizziness (OR = 2.258 and *P-value* = 0.132, OR = 3.079 and *P-value* = 0.079, and OR = 2.164 and *P-value* = 0.192, respectively). Therefore, study at Signal school, smoking status, and milk drinking were considered to assess the multiple association with headache or dizziness **(Table 36).**

Table 36: *Bivariate analysis of each health risk factors associated with headache or dizziness among workers (n = 120) at baseline.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Demographic characteristics					
Age	0.003	0.019	0.028	0.868	1.003 (0.966-1.042)
BMI	0.038	0.056	0.470	0.493	1.039 (0.932-1.159)
Marital status					
Single	Ref.				
Couple	-0.134	0.427	0.098	0.755	0.875 (0.379-2.022)
Education level					
< Bachelor's Degree	Ref.				
≥ Bachelor's Degree	0.440	0.420	1.095	0.295	1.553 (0.681-3.539)
Study at Signal school					
No	Ref.				
Yes	0.815	0.540	2.273	$0.132^{\#}$	2.258 (0.783-6.510)

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Working conditions					
Working experience					
≤ 10 years	Ref.				
> 10 years	-0.161	0.421	0.146	0.703	0.852 (0.373-1.943)
Working hour					
< 7 hrs/day	Ref.				
≥ 7 hrs/day	0.211	0.422	0.250	0.617	1.235 (0.540-2.826)
Health behaviors					
Smoking status					
No	Ref.				
Yes	-0.764	0.435	3.079	0.079[#]	0.466 (0.198-1.093)
Alcohol drinking					
No	Ref.				
Yes	0.140	0.442	0.100	0.752	1.150 (0.484-2.734)
Milk drinking					
No	Ref.				
Yes	0.772	0.591	1.706	0.192[#]	2.164 (0.679-6.894)
Seafood					
consumption	Ref.				
1-3 days/week	-0.242	0.612	0.156	0.693	0.785 (0.236-2.607)
4-7 days/week					
Exercise					
1-3 days/week	Ref.				
4-7 days/week	0.268	0.410	0.429	0.513	1.308 (0.586-2.919)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * *P-value* less than 0.05 level. [#] *P-value* is between 0.05 and 0.25. A bivariate analysis of each variable was first done, and then the variables with *P-value* ≤ 0.25 were included in the multivariate analysis.

Multiple binary logistic regression revealed that there was no association for study at Signal school, smoking status, and milk drinking with headache or dizziness among workers at baseline **(Table 37).**

Table 37: *Multivariate analysis of each health risk factors associated with headache or dizziness among workers (n = 120) at baseline.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Study at Signal school					
No	Ref.				
Yes	0.813	0.549	2.192	0.139	2.254 (0.769-6.610)
Smoking status					
No	Ref.				
Yes	-0.751	0.442	2.884	0.089	0.472 (0.198-1.123)
Milk drinking					
No	Ref.				
Yes	0.782	0.602	1.689	0.194	2.185 (0.672-7.104)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first.

The results showed the association of BMI and milk drinking with fine tremors among workers at baseline (OR = 0.775 and *P-value* = 0.033, and OR = 0.106 and *P-value* = 0.001, respectively). And, there were the trend associations of health risk factors including study at Signal school, working experience, and smoking status with fine tremors (OR = 3.625 and *P-value* = 0.229, OR = 2.821 and *P-value* = 0.198, and OR = 2.489 and *P-value* = 0.165, respectively). Therefore, BMI, milk drinking, study at Signal school, working experience, and smoking status were considered to assess the multiple association with fine tremors **(Table 38).**

Table 38: *Bivariate analysis of each health risk factors associated with fine tremors among workers (n = 120) at baseline.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Demographic characteristics					
Age	0.019	0.030	0.404	0.525	1.019 (0.961-1.082)
BMI	-0.255	0.120	4.557	0.033*	0.775 (0.613-0.979)
Marital status					
Single	Ref.				
Couple	0.919	0.807	1.298	0.255	2.507 (0.516-12.190)
Education level					
< Bachelor's Degree	Ref.				
≥ Bachelor's Degree	0.065	0.658	0.010	0.921	1.068 (0.294-3.879)
Study at Signal school					
No	Ref.				
Yes	1.288	1.071	1.446	0.229#	3.625 (0.444-29.575)

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Working conditions					
Working experience					
≤ 10 years	Ref.				
> 10 years	1.037	0.806	1.655	0.198#	2.821 (0.581-13.695)
Working hour					
< 7 hrs/day	Ref.				
≥ 7 hrs/day	-0.649	0.637	1.040	0.308	0.522 (0.150-1.820)
Health behaviors					
Smoking status					
No	Ref.				
Yes	0.912	0.656	1.930	0.165#	2.489 (0.688-9.008)
Alcohol drinking					
No	Ref.				
Yes	0.274	0.707	0.150	0.698	1.315 (0.329-5.257)
Milk drinking					
No	Ref.				
Yes	-2.248	0.680	10.927	0.001*	0.106 (0.028-0.400)
Seafood consumption					
1-3 days/week	Ref.				
4-7 days/week	0.331	0.830	0.159	0.690	1.393 (0.274-7.081)
Exercise					
1-3 days/week	Ref.				
4-7 days/week	0.054	0.635	0.007	0.933	0.948 (0.273-3.291)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * *P-value* less than 0.05 level. # *P-value* is between 0.05 and 0.25. A bivariate analysis of each variable was first done, and then the variables with *P-value* ≤ 0.25 were included in the multivariate analysis.

Multiple binary logistic regression revealed that there were the associations for BMI and milk drinking with fine tremors among workers at baseline (OR = 0.728 and *P-value* = 0.020, and OR = 0.067 and *P-value* = 0.001, respectively) **(Table 39).**

Table 39: *Multivariate analysis of each health risk factors associated with fine tremors among workers (n = 120) at baseline.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
BMI	-0.317	0.136	5.402	0.020*	0.728 (0.557-0.952)
Milk drinking					
No	Ref.				
Yes	-2.699	0.787	11.765	0.001*	0.067 (0.014-0.314)
Study at Signal school					
No	Ref.				
Yes	1.779	1.325	1.802	0.179	5.923 (0.441-79.519)
Smoking status					
No	Ref.				
Yes	1.168	0.776	2.268	0.132	3.216 (0.703-14.709)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * Significance at *P-value* less than 0.05 level.

There was a trend association between BMI and colic pain (OR = 0.774 and *P-value* = 0.239). Therefore, the multivariate association between health risk factors and colic pain among workers at baseline was not determined. The table did not show the factors including alcohol drinking, milk drinking and exercise because these factors could not be determined the association with colic pain at baseline **(Table 40).**

Table 40: *Bivariate analysis of each health risk factors associated with colic pain among workers (n = 120) at baseline.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Demographic characteristics					
Age	-0.015	0.056	0.067	0.795	0.985 (0.882-1.101)
BMI	-0.256	0.217	1.386	0.239#	0.774 (0.506-1.185)
Marital status					
Single	Ref.				
Couple	-1.386	1.240	1.249	0.264	0.250 (0.022-2.843)
Education level					
< Bachelor's Degree	Ref.				
≥ Bachelor's Degree	1.348	1.240	1.182	0.277	3.850 (0.339-43.761)
Study at Signal school					
No	Ref.				
Yes	-0.417	1.243	0.112	0.737	0.659 (0.058-7.538)
Working conditions					
Working experience					
≤ 10 years	Ref.				
> 10 years	0.150	1.240	0.015	0.904	1.162 (0.102-13.197)

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Health behaviors					
Smoking status					
No	Ref.				
Yes	0.986	1.239	0.633	0.426	2.680 (0.236-30.388)
Seafood consumption					
1-3 days/week	Ref.				
4-7 days/week	1.149	1.254	0.840	0.359	3.156 (0.270-36.859)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first; * *P-value* less than 0.05 level. # *P-value* is between 0.05 and 0.25. A bivariate analysis of each variable was first done, and then the variables with *P-value* $\leq$ 0.25 were included in the multivariate analysis.

Age and BMI could be determined the association with metallic taste in the mouth at baseline. There was no association between each health risk factors and metallic taste in the mouth among workers at baseline. Therefore, the multivariate association between health risk factors and metallic taste in the mouth among workers at baseline was not determined **(Table 41).**

Table 41: *Bivariate analysis of each health risk factors associated with metallic taste in the mouth among workers (n = 120) at baseline.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Demographic characteristics					
Age	0.093	0.116	0.647	0.421	1.098 (0.875-1.378)
BMI	0.057	0.257	0.049	0.824	1.059 (0.640-1.753)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first; * *P-value* less than 0.05 level. # *P-value* is between 0.05 and 0.25. A bivariate analysis of each variable was first done, and then the variables with *P-value* $\leq$ 0.25 were included in the multivariate analysis.

There was an association between alcohol drinking and nervous irritability among workers at baseline (OR = 0.411 and *P-value* = 0.035). Moreover, there were the trend associations of health risk factors including education level and smoking status with nervous irritability (OR = 1.725 and *P-value* = 0.190 and OR = 0.525 and *P-value* = 0.130, respectively). Therefore, alcohol drinking, education level and smoking status were considered to assess the multiple association with nervous irritability **(Table 42).**

Table 42: *Bivariate analysis of each health risk factors associated with nervous irritability among workers (n = 120) at baseline.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Demographic characteristics					
Age	0.009	0.019	0.208	0.648	1.009 (0.971-1.048)
BMI	0.029	0.055	0.271	0.603	1.029 (0.923-1.147)
Marital status					
Single	Ref.				
Couple	0.113	0.431	0.069	0.792	1.120 (0.481-2.606)
Education level					
< Bachelor's Degree	Ref.				
≥ Bachelor's Degree	0.545	0.416	1.716	0.190#	1.725 (0.763-3.901)
Study at Signal school					
No	Ref.				
Yes	0.111	0.474	0.055	0.815	1.117 (0.441-2.828)

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Working conditions					
Working experience					
≤ 10 years	Ref.				
> 10 years	0.083	0.423	0.038	0.844	1.086 (0.475-2.487)
Working hour					
< 7 hrs/day	Ref.				
≥ 7 hrs/day	-0.405	0.410	0.980	0.322	0.667 (0.299-1.488)
Health behaviors					
Smoking status					
No	Ref.				
Yes	-0.645	0.425	2.295	0.130#	0.525 (0.228-1.208)
Alcohol drinking					
No	Ref.				
Yes	-0.890	0.421	4.463	0.035*	0.411 (0.180-0.938)
Milk drinking					
No	Ref.				
Yes	0.211	0.522	0.164	0.686	1.235 (0.444-3.437)
Seafood consumption					
1-3 days/week	Ref.				
4-7 days/week	-0.698	0.671	1.080	0.299	0.498 (0.133-1.856)
Exercise					
1-3 days/week	Ref.				
4-7 days/week	-0.143	0.407	0.124	0.725	0.866 (0.390-1.925)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * *P-value* less than 0.05 level. # *P-value* is between 0.05 and 0.25. A bivariate analysis of each variable was first done, and then the variables with *P-value* ≤ 0.25 were included in the multivariate analysis.

Multiple binary logistic regression showed that there was an association between alcohol drinking and nervous irritability among workers at baseline (OR = 0.408 and *P-value* = 0.035) **(Table 43).**

Table 43: *Multivariate analysis of each health risk factors associated with nervous irritability among workers (n = 120) at baseline.*

Factors	**B**	**S.E.**	**Wald**	***P-value***	**OR (95% CI)**
Alcohol drinking					
No	Ref.				
Yes	-0.896	0.425	4.451	0.035*	0.408 (0.177-0.938)
Education level					
< Bachelor's Degree	Ref.				
≥ Bachelor's Degree	0.555	0.425	1.706	0.191	1.743 (0.757-4.009)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * Significance at *P-value* less than 0.05 level.

There was no association between health risk factors and muscle and joint pain among workers at baseline. By the way, there were the trend associations of working hour and smoking status with muscle and joint pain (OR = 0.487 and *P-value* = 0.064 and OR = 1.903 and *P-value* = 0.095, respectively). Therefore, working hour and smoking status were considered to assess the multiple association with muscle and joint pain **(Table 44).**

Table 44: *Bivariate analysis of each health risk factors associated with muscle and joint pain among workers (n = 120) at baseline.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Demographic characteristics					
Age	0.020	0.018	1.160	0.281	1.020 (0.984-1.057)
BMI	0.019	0.052	0.138	0.710	1.020 (0.920-1.130)
Marital status					
Single	Ref.				
Couple	0.112	0.404	0.077	0.781	1.119 (0.507-2.468)
Education level					
< Bachelor's Degree	Ref.				
≥ Bachelor's Degree	-0.008	0.399	0.000	0.984	0.992 (0.454-2.170)
Study at Signal school					
No	Ref.				
Yes	0.147	0.445	0.109	0.742	1.158 (0.484-2.769)
Working conditions					
Working experience					
≤ 10 years	Ref.				
> 10 years	0.442	0.405	1.187	0.276	1.555 (0.703-3.442)

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Working hour					
< 7 hrs/day	Ref.				
≥ 7 hrs/day	-0.720	0.389	3.432	0.064#	0.487 (0.227-1.043)
Health behaviors					
Smoking status					
No	Ref.				
Yes	0.644	0.386	2.784	0.095#	1.903 (0.894-4.054)
Alcohol drinking					
No	Ref.				
Yes	-0.004	0.406	0.000	0.992	0.996 (0.449-2.209)
Milk drinking					
No	Ref.				
Yes	0.138	0.482	0.081	0.775	1.148 (0.446-2.952)
Seafood consumption					
1-3 days/week	Ref.				
4-7 days/week	0.546	0.529	1.069	0.301	1.727 (0.613-4.866)
Exercise					
1-3 days/week	Ref.				
4-7 days/week	-0.303	0.384	0.620	0.431	0.739 (0.348-1.569)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * *P-value* less than 0.05 level. # *P-value* is between 0.05 and 0.25. A bivariate analysis of each variable was first done, and then the variables with *P-value* ≤ 0.25 were included in the multivariate analysis.

Multiple binary logistic regression showed that there was no association between health risk factors and muscle and joint pain among workers at baseline **(Table 45).**

Table 45: *Multivariate analysis of each health risk factors associated with muscle and joint pain among workers (n = 120) at baseline.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Working hour					
< 7 hrs/day	Ref.				
$\geq$ 7 hrs/day	-0.710	0.393	3.260	0.071	0.492 (0.227-1.063)
Smoking status					
No	Ref.				
Yes	0.632	0.391	2.613	0.106	1.882 (0.874-4.052)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first.

There was an association between smoking status and insomnia among workers at baseline (OR = 2.658 and *P-value* = 0.038). And, there was a trend association of education level with insomnia (OR = 2.200 and *P-value* = 0.089). Therefore, smoking status and education level were considered to assess the multiple association with insomnia **(Table 46).**

Table 46: *Bivariate analysis of each health risk factors associated with insomnia among workers (n = 120) at baseline.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Demographic characteristics					
Age	0.006	0.022	0.075	0.784	1.006 (0.964-1.050)
BMI	-0.040	0.066	0.366	0.545	0.961 (0.845-1.093)
Marital status					
Single	Ref.				
Couple	-0.182	0.474	0.148	0.700	0.833 (0.329-2.110)
Education level					
< Bachelor's Degree	Ref.				
≥ Bachelor's Degree	0.788	0.464	2.889	0.089[#]	2.200 (0.886-5.461)
Study at Signal school					
No	Ref.				
Yes	-0.762	0.489	2.433	0.119	0.467 (0.179-1.216)
Working conditions					
Working experience					
≤ 10 years	Ref.				
> 10 years	0.421	0.496	0.720	0.396	1.523 (0.577-4.023)

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Working hour					
< 7 hrs/day	Ref.				
≥ 7 hrs/day	-0.511	0.459	1.236	0.266	0.600 (0.244-1.477)
Health behaviors					
Smoking status					
No	Ref.				
Yes	0.977	0.471	4.308	0.038*	2.658 (1.056-6.689)
Alcohol drinking					
No	Ref.				
Yes	0.452	0.581	0.761	0.383	1.571 (0.569-4.338)
Milk drinking					
No	Ref.				
Yes	-0.368	0.539	0.465	0.495	0.692 (0.241-1.991)
Seafood consumption					
1-3 days/week	Ref.				
4-7 days/week	-0.711	0.790	0.811	0.368	0.491 (0.104-2.310)
Exercise					
1-3 days/week	Ref.				
4-7 days/week	0.167	0.457	0.134	0.715	1.182 (0.483-2.893)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * *P-value* less than 0.05 level. # *P-value* is between 0.05 and 0.25. A bivariate analysis of each variable was first done, and then the variables with *P-value* ≤ 0.25 were included in the multivariate analysis.

Multiple binary logistic regression showed that there was an association of health risk factors including smoking status and education level with insomnia among workers at baseline (OR = 3.253 and *P-value* = 0.017 and OR = 2.794 and *P-value* = 0.037, respectively) **(Table 47).**

Table 47: *Multivariate analysis of each health risk factors associated with insomnia among workers (n = 120) at baseline.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Smoking status					
No	Ref.				
Yes	1.180	0.496	5.648	0.017*	3.253 (1.230-8.604)
Education level					
< Bachelor's Degree	Ref.				
≥ Bachelor's Degree	1.027	0.493	4.335	0.037*	2.794 (1.062-7.349)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * Significance at *P-value* less than 0.05 level.

There was no association between health risk factors and numbness among workers at baseline. However, there were the trend associations of education level and smoking status with insomnia (OR = 4.000 and *P-value* = 0.119 and OR = 0.247 and *P-value* = 0.208, respectively). Therefore, education level and smoking status were considered to assess the multiple association with numbness **(Table 48).**

Table 48: *Bivariate analysis of each health risk factors associated with numbness among workers (n = 120) at baseline.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Demographic characteristics					
Age	0.023	0.040	0.337	0.561	1.024 (0.946-1.107)
BMI	-0.047	0.123	0.144	0.704	0.954 (0.750-1.215)
Marital status					
Single	Ref.				
Couple	0.994	1.113	0.798	0.372	2.703 (0.305-23.938)
Education level					
< Bachelor's Degree	Ref.				
≥ Bachelor's Degree	1.386	0.889	2.434	0.119#	4.000 (0.701-22.823)
Study at Signal school					
No	Ref.				
Yes	0.534	1.116	0.229	0.632	1.706 (0.191-15.212)
Working conditions					
Working experience					
≤ 10 years	Ref.				
> 10 years	1.108	1.112	0.992	0.319	3.028 (0.342-26.793)

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Working hour					
< 7 hrs/day	Ref.				
≥ 7 hrs/day	1.255	1.112	1.274	0.259	3.507 (0.397-31.003)
Health behaviors					
Smoking status					
No	Ref.				
Yes	-1.398	1.112	1.582	0.208#	0.247 (0.028-2.182)
Alcohol drinking					
No	Ref.				
Yes	0.916	1.113	0.677	0.410	2.500 (0.282-22.161)
Milk drinking					
No	Ref.				
Yes	-0.738	0.898	0.675	0.411	0.478 (0.082-2.780)
Seafood consumption					
1-3 days/week	Ref.				
4-7 days/week	0.203	1.128	0.032	0.857	1.225 (0.134-11.179)
Exercise					
1-3 days/week	Ref.				
4-7 days/week	-0.588	0.886	0.440	0.507	0.556 (0.098-3.155)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * *P-value* less than 0.05 level. # *P-value* is between 0.05 and 0.25. A bivariate analysis of each variable was first done, and then the variables with *P-value* ≤ 0.25 were included in the multivariate analysis.

Multiple binary logistic regression revealed that there was no association between health risk factors and numbness among workers at baseline **(Table 49).**

Table 49: *Multivariate analysis of each health risk factors associated with numbness among workers (n = 120) at baseline.*

Factors	**B**	**S.E.**	**Wald**	***P-value***	**OR (95% CI)**
Education level					
< Bachelor's Degree	Ref.				
≥ Bachelor's Degree	1.245	0.893	1.922	0.166	3.472 (0.597-20.171)
Smoking status					
No	Ref.				
Yes	-1.225	1.123	1.190	0.275	0.294 (0.032-2.654)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * Significance at *P-value* less than 0.05 level.

There was an association between BMI and AST levels among workers at baseline (OR = 1.159 and *P-value* = 0.037). In addition, there was a trend association of working experience with AST levels (OR = 2.562 and *P-value* = 0.164). Therefore, BMI and working experience were considered to assess the multiple association with AST levels **(Table 50).**

Table 50: *Bivariate analysis of each health risk factors associated with AST levels among workers (n = 120) at baseline.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Demographic characteristics					
Age	0.030	0.027	1.291	0.256	1.031 (0.978-1.086)
BMI	0.148	0.071	4.328	0.037*	1.159 (1.009-1.332)
Marital status					
Single	Ref.				
Couple	0.043	0.585	0.005	0.942	1.043 (0.332-3.285)
Education level					
< Bachelor's Degree	Ref.				
≥ Bachelor's Degree	0.245	0.566	0.188	0.665	1.278 (0.422-3.873)
Study at Signal school					
No	Ref.				
Yes	-0.100	0.626	0.025	0.873	0.905 (0.265-3.088)
Working conditions					
Working experience					
≤ 10 years	Ref.				
> 10 years	0.941	0.676	1.939	0.164#	2.562 (0.681-9.636)

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Working hour					
< 7 hrs/day	Ref.				
≥ 7 hrs/day	0.685	0.616	1.234	0.267	1.984 (0.593-6.640)
Health behaviors					
Smoking status					
No	Ref.				
Yes	-0.157	0.563	0.077	0.781	0.855 (0.284-2.575)
Alcohol drinking					
No	Ref.				
Yes	-0.043	0.586	0.005	0.941	0.958 (0.304-3.021)
Milk drinking					
No	Ref.				
Yes	0.544	0.797	0.466	0.495	1.723 (0.362-8.208)
Seafood consumption					
1-3 days/week	Ref.				
4-7 days/week	0.486	0.706	0.472	0.492	1.625 (0.407-6.489)
Exercise					
1-3 days/week	Ref.				
4-7 days/week	-0.636	0.581	1.196	0.274	0.529 (0.169-1.655)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * *P-value* less than 0.05 level. # *P-value* is between 0.05 and 0.25. A bivariate analysis of each variable was first done, and then the variables with *P-value* ≤ 0.25 were included in the multivariate analysis.

Multiple binary logistic regression revealed that there was no association between health risk factors and AST levels among workers at baseline **(Table 51).**

Table 51: *Multivariate analysis of each health risk factors associated with AST levels among workers (n = 120) at baseline.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
BMI	0.134	0.073	3.329	0.068	1.143 (0.990-1.320)
Working experience					
≤ 10 years	Ref.				
> 10 years	0.727	0.691	1.106	0.293	2.068 (0.534-8.012)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first.

There were the associations of ALT levels with BMI and exercise among workers at baseline (OR = 1.246 and *P-value* = 0.001 and OR = 0.338 and *P-value* = 0.026, respectively). In addition, there was a trend association of smoking status with ALT levels (OR = 1.719 and *P-value* = 0.224). Therefore, BMI, exercise and smoking status were considered to assess the multiple association with ALT levels **(Table 52).**

Table 52: *Bivariate analysis of each health risk factors associated with ALT levels among workers (n = 120) at baseline.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Demographic characteristics					
Age	0.017	0.021	0.666	0.414	1.017 (0.976-1.061)
BMI	0.220	0.062	11.361	0.001*	1.246 (1.096-1.416)

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Marital status					
Single	Ref.				
Couple	0.197	0.477	0.170	0.680	1.217 (0.478-3.098)
Education level					
< Bachelor's Degree	Ref.				
$\geq$ Bachelor's Degree	-0.022	0.465	0.002	0.963	0.979 (0.393-2.437)
Study at Signal school					
No	Ref.				
Yes	-0.375	0.490	0.585	0.444	0.688 (0.263-1.796)
Working conditions					
Working experience					
$\leq$ 10 years	Ref.				
> 10 years	0.334	0.475	0.495	0.482	1.397 (0.551-3.543)
Working hour					
< 7 hrs/day	Ref.				
$\geq$ 7 hrs/day	0.511	0.473	1.165	0.281	1.667 (0.659-4.215)
Health behaviors					
Smoking status					
No	Ref.				
Yes	0.542	0.446	1.476	0.224[#]	1.719 (0.717-4.121)
Alcohol drinking					
No	Ref.				
Yes	-0.337	0.461	0.535	0.464	0.714 (0.289-1.761)

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Milk drinking					
No	Ref.				
Yes	0.062	0.560	0.012	0.912	1.064 (0.355-3.189)
Seafood consumption					
1-3 days/week	Ref.				
4-7 days/week	0.487	0.586	0.690	0.406	1.627 (0.516-5.129)
Exercise					
1-3 days/week	Ref.				
4-7 days/week	-1.084	0.488	4.932	0.026*	0.338 (0.130-0.880)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * *P-value* less than 0.05 level. # *P-value* is between 0.05 and 0.25. A bivariate analysis of each variable was first done, and then the variables with *P-value* $\leq$ 0.25 were included in the multivariate analysis.

Multiple binary logistic regression showed the associations between ALT levels and health risk factors including BMI and exercise among workers at baseline (OR = 1.250 and *P-value* = 0.001 and OR = 0.327 and *P-value* = 0.035, respectively) **(Table 53).**

Table 53: *Multivariate analysis of each health risk factors associated with ALT levels among workers (n = 120) at baseline.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
BMI	0.223	0.067	11.127	0.001*	1.250 (1.096-1.425)
Smoking status					
No	Ref.				
Yes	0.933	0.511	3.334	0.068	2.541 (0.934-6.915)
Exercise					
1-3 days/week	Ref.				
4-7 days/week	-1.119	0.531	4.449	0.035*	0.327 (0.115-0.924)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * Significance at *P-value* less than 0.05 level.

There were the associations of GFR levels with age, BMI, marital status, and working experience among workers at baseline (OR = 1.065 and *P-value* = 0.001, OR = 1.149 and *P-value* = 0.013, OR = 2.573 and *P-value* = 0.020, and OR = 2.647 and *P-value* = 0.014, respectively). In addition, there was a trend association of GFR levels with working hour and exercise (OR = 1.863 and *P-value* = 0.102 and OR = 1.686 and *P-value* = 0.157, respectively). Therefore, age, BMI, marital status, working experience, working hour and exercise were considered to assess the multiple association with GFR levels **(Table 54).**

Table 54: *Bivariate analysis of each health risk factors associated with GFR levels among workers (n = 120) at baseline.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Demographic characteristics					
Age	0.063	0.019	10.795	0.001*	1.065 (1.026-1.106)
BMI	0.139	0.055	6.232	0.013*	1.149 (1.030-1.281)
Marital status					
Single	Ref.				
Couple	0.945	0.405	5.455	0.020*	2.573 (1.164-5.685)
Education level					
< Bachelor's Degree	Ref.				
≥ Bachelor's Degree	-0.088	0.384	0.053	0.818	0.915 (0.431-1.943)
Study at Signal school					
No	Ref.				
Yes	0.361	0.428	0.711	0.399	1.435 (0.620-3.321)
Working conditions					
Working experience					
≤ 10 years	Ref.				
> 10 years	0.973	0.397	5.998	0.014*	2.647 (1.215-5.769)
Working hour					
< 7 hrs/day	Ref.				
≥ 7 hrs/day	0.622	0.380	2.676	0.102[#]	1.863 (0.884-3.925)
Health behaviors					
Smoking status					
No	Ref.				
Yes	-0.173	0.370	0.219	0.640	0.841 (0.407-1.737)

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Alcohol drinking					
No	Ref.				
Yes	-0.274	0.391	0.493	0.428	0.760 (0.353-1.634)
Milk drinking					
No	Ref.				
Yes	-0.167	0.457	0.134	0.715	0.846 (0.346-2.071)
Seafood consumption					
1-3 days/week	Ref.				
4-7 days/week	0.018	0.525	0.001	0.972	1.019 (0.364-2.847)
Exercise					
1-3 days/week	Ref.				
4-7 days/week	0.523	0.370	2.000	0.157#	1.686 (0.817-3.480)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * *P-value* less than 0.05 level. # *P-value* is between 0.05 and 0.25. A bivariate analysis of each variable was first done, and then the variables with *P-value* $\leq$ 0.25 were included in the multivariate analysis.

Multiple binary logistic regression showed the associations between GFR levels and health risk factors including age and BMI among workers at baseline (OR = 1.061 and *P-value* = 0.003 and OR = 1.143 and *P-value* = 0.030, respectively) **(Table 55).**

Table 55: *Multivariate analysis of each health risk factors associated with GFR levels among workers (n = 120) at baseline.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Age	0.059	0.020	8.611	0.003*	1.061 (1.020-1.104)
BMI	0.133	0.061	4.714	0.030*	1.143 (1.013-1.289)
Working hour					
< 7 hrs/day	Ref.				
$\geq$ 7 hrs/day	0.402	0.417	0.929	0.335	1.495 (0.660-3.385)
Exercise					
1-3 days/week	Ref.				
4-7 days/week	0.676	0.419	2.606	0.106	1.967 (0.865-4.472)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * Significance at *P-value* less than 0.05 level.

There were the associations of hypertension with age, BMI, working experience, seafood consumption, and exercise among workers at baseline (OR = 1.062 and *P-value* = 0.003, OR = 1.191 and *P-value* = 0.003, OR = 2.625 and *P-value* = 0.035, OR = 3.167 and *P-value* = 0.031, and OR = 0.381 and *P-value* = 0.023, respectively). In addition, there was a trend association of hypertension with education level (OR = 0.515 and *P-value* = 0.136). Therefore, age, BMI, working experience, seafood consumption, exercise, and education level were considered to assess the multiple association with hypertension **(Table 56).**

Table 56: *Bivariate analysis of each health risk factors associated with hypertension among workers (n = 120) at baseline.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Demographic characteristics					
Age	0.060	0.021	8.534	0.003*	1.062 (1.020-1.106)
BMI	0.175	0.059	8.801	0.003*	1.191 (1.061-1.336)
Marital status					
Single	Ref.				
Couple	0.419	0.435	0.927	0.336	1.521 (0.648-3.570)
Education level					
< Bachelor's Degree	Ref.				
≥ Bachelor's Degree	-0.663	0.445	2.221	0.136#	0.515 (0.215-1.232)
Study at Signal school					
No	Ref.				
Yes	-0.208	0.452	0.211	0.646	0.813 (0.335-1.970)

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Working conditions					
Working experience					
≤ 10 years	Ref.				
> 10 years	0.965	0.485	4.449	0.035*	2.625 (1.071-6.435)
Working hour					
< 7 hrs/day	Ref.				
≥ 7 hrs/day	0.234	0.412	0.323	0.570	1.264 (0.564-2.831)
Health behaviors					
Smoking status					
No	Ref.				
Yes	-0.261	0.406	0.413	0.521	0.770 (0.348-1.708)
Alcohol drinking					
No	Ref.				
Yes	-0.054	0.424	0.016	0.898	0.947 (0.413-2.174)
Milk drinking					
No	Ref.				
Yes	0.050	0.501	0.010	0.921	1.051 (0.394-2.807)
Seafood consumption					
1-3 days/week	Ref.				
4-7 days/week	1.153	0.535	4.641	0.031*	3.167 (1.110-9.038)
Exercise					
1-3 days/week	Ref.				
4-7 days/week	-0.964	0.423	5.199	0.023*	0.381 (0.166-0.873)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * *P-value* less than 0.05 level. # *P-value* is between 0.05 and 0.25. A bivariate analysis of each variable was first done, and then the variables with *P-value* ≤ 0.25 were included in the multivariate analysis.

Multiple binary logistic regression showed the associations of hypertension with health risk factors including age, BMI, seafood consumption, and exercise among workers at baseline (OR = 1.059 and *P-value* = 0.012, OR = 1.180 and *P-value* = 0.010, OR = 4.475 and *P-value* = 0.014, and OR = 0.372 and *P-value* = 0.038, respectively) **(Table 57).**

Table 57: *Multivariate analysis of each health risk factors associated with hypertension among workers (n = 120) at baseline.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Age	0.057	0.023	6.367	0.012*	1.059 (1.013-1.107)
BMI	0.166	0.064	6.665	0.010*	1.180 (1.041-1.338)
Education level					
< Bachelor's Degree	Ref.				
≥ Bachelor's Degree	-0.765	0.517	2.193	0.139	0.465 (0.169-1.281)
Seafood consumption					
1-3 days/week	Ref.				
4-7 days/week	1.498	0.613	5.978	0.014*	4.475 (1.346-14.874)
Exercise					
1-3 days/week	Ref.				
4-7 days/week	-0.988	0.476	4.316	0.038*	0.372 (0.147-0.946)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * Significance at *P-value* less than 0.05 level.

There was no association between loss of appetite and health risk factors at endpoint. However, there were the trend associations with education level, working experience, and smoking status (OR = 0.391 and *P-value* = 0.247, OR = 3.083 and *P-value* = 0.165, and OR = 2.212 and *P-value* = 0.218, respectively). Therefore, education level, working experience, and smoking status were considered to assess the multiple association with loss of appetite **(Table 58).**

Table 58: *Bivariate analysis of each health risk factors associated with loss of appetite among workers (n = 102) at endpoint.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Demographic characteristics					
Age	0.021	0.029	0.519	0.471	1.021 (0.965-1.081)
BMI	-0.091	0.103	0.792	0.374	0.913 (0.747-1.116)
Marital status					
Single	Ref.				
Couple	0.844	0.812	1.079	0.299	2.325 (0.473-11.428)
Education level					
< Bachelor's Degree	Ref.				
≥ Bachelor's Degree	-0.940	0.812	1.342	0.247#	0.391 (0.080-1.917)
Study at Signal school					
No	Ref.				
Yes	-0.286	0.723	0.157	0.629	0.751 (0.182-3.097)

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Working conditions					
Working experience					
≤ 10 years	Ref.				
> 10 years	1.126	0.810	1.931	0.165#	3.083 (0.630-15.093)
Working hour					
< 7 hrs/day	Ref.				
≥ 7 hrs/day	0.043	0.663	0.004	0.948	1.044 (0.285-3.830)
Health behaviors					
Smoking status					
No	Ref.				
Yes	0.794	0.644	1.520	0.218#	2.212 (0.626-7.819)
Alcohol drinking					
No	Ref.				
Yes	0.744	0.813	0.837	0.360	2.105 (0.427-10.367)
Milk drinking					
No	Ref.				
Yes	-0.642	0.734	0.766	0.382	0.526 (0.125-2.217)
Seafood					
consumption	Ref.				
1-3 days/week	-0.418	1.094	0.146	0.702	0.658 (0.077-5.615)
4-7 days/week					
Exercise					
1-3 days/week	Ref.				
4-7 days/week	-0.160	0.641	0.063	0.802	0.852 (0.243-2.991)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * *P-value* less than 0.05 level. # *P-value* is between 0.05 and 0.25. A bivariate analysis of each variable was first done, and then the variables with *P-value* ≤ 0.25 were included in the multivariate analysis.

Multiple binary logistic regression showed that there was no association between loss of appetite and health risk factors among workers at endpoint **(Table 59).**

Table 59: *Multivariate analysis of each health risk factors associated with loss of appetite among workers (n = 102) at endpoint.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Education level					
< Bachelor's	Ref.				
Degree	-0.819	0.823	0.990	0.320	0.441 (0.088-2.213)
≥ Bachelor's					
Degree					
Working experience					
≤ 10 years	Ref.				
> 10 years	1.042	0.818	1.622	0.203	2.835 (0.570-14.094)
Smoking status					
No	Ref.				
Yes	0.685	0.657	1.087	0.297	1.983 (0.547-7.187)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * Significance at *P-value* less than 0.05 level.

There was no association between constipation and health risk factors at endpoint. However, a trend association of constipation and marital status was shown at *P-value* = 0.115. Therefore, multivariate analysis of health risk factors associated with constipation at endpoint was not determined **(Table 60).**

Table 60: *Bivariate analysis of each health risk factors associated with constipation among workers (n = 102) at endpoint.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Demographic characteristics					
Age	0.033	0.030	1.240	0.265	1.034 (0.975-1.095)
BMI	0.025	0.091	0.075	0.784	1.025 (0.858-1.224)
Marital status					
Single	Ref.				
Couple	1.691	1.072	2.490	0.115[#]	5.424 (0.664-44.299)
Education level					
< Bachelor's Degree	Ref.				
≥ Bachelor's Degree	0.101	0.665	0.023	0.880	1.106 (0.301-4.069)
Study at Signal school					
No	Ref.				
Yes	1.160	1.077	1.159	0.282	3.188 (0.386-26.322)
Working conditions					
Working experience					
≤ 10 years	Ref.				
> 10 years	-0.334	0.643	0.270	0.603	0.716 (0.203-2.525)

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Working hour					
< 7 hrs/day	Ref.				
≥ 7 hrs/day	0.043	0.663	0.004	0.948	1.044 (0.285-3.830)
Health behaviors					
Smoking status					
No	Ref.				
Yes	-0.511	0.710	0.517	0.472	0.600 (0.149-2.415)
Alcohol drinking					
No	Ref.				
Yes	-0.303	0.667	0.207	0.649	0.738 (0.200-2.731)
Milk drinking					
No	Ref.				
Yes	0.832	1.083	0.590	0.442	2.297 (0.275-19.180)
Exercise					
1-3 days/week	Ref.				
4-7 days/week	-0.160	0.641	0.063	0.802	0.852 (0.243-2.991)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first; * *P-value* less than 0.05 level. # *P-value* is between 0.05 and 0.25. A bivariate analysis of each variable was first done, and then the variables with *P-value* ≤ 0.25 were included in the multivariate analysis.

There was no association between nausea or vomit and health risk factors among workers at endpoint. However, there were the trend associations with age, BMI, and working experience (OR = 0.100 and *P-value* = 0.927, OR = 0.725 and *P-value* = 0.062, and OR = 0.287 and *P-value* = 0.161, respectively). Therefore, age, BMI, and working experience were considered to assess the multiple association with nausea or vomit. The table did not show alcohol drinking because this factor could not be determined the association with nausea and vomit at endpoint **(Table 61).**

Table 61: *Bivariate analysis of each health risk factors associated with nausea or vomit among workers (n = 102) at endpoint.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Demographic characteristics					
Age	-0.075	0.046	2.705	0.100#	0.927 (0.848-1.015)
BMI	-0.322	0.172	3.493	0.062#	0.725 (0.517-1.016)
Marital status					
Single	Ref.				
Couple	-0.047	0.893	0.003	0.958	0.954 (0.166-5.492)
Education level					
< Bachelor's Degree	Ref.				
≥ Bachelor's Degree	-0.047	0.892	0.003	0.958	0.955 (0.166-5.487)
Study at Signal school					
No	Ref.				
Yes	-0.580	0.901	0.415	0.520	0.560 (0.096-3.271)

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Working conditions					
Working experience					
≤ 10 years	Ref.				
> 10 years	-1.249	0.892	1.961	0.161[#]	0.287 (0.050-1.647)
Working hour					
< 7 hrs/day	Ref.				
≥ 7 hrs/day	-0.556	0.844	0.434	0.510	0.574 (0.110-2.998)
Health behaviors					
Smoking status					
No	Ref.				
Yes	-0.182	0.891	0.042	0.838	0.833 (0.145-4.781)
Milk drinking					
No	Ref.				
Yes	0.073	1.128	0.004	0.948	1.076 (0.118-9.809)
Seafood consumption					
1-3 days/week	Ref.				
4-7 days/week	-2.821	1.138	0.087	0.767	1.400 (0.150-13.028)
Exercise					
1-3 days/week	Ref.				
4-7 days/week	-0.693	0.890	0.607	0.436	0.500 (0.087-2.860)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first; * *P-value* less than 0.05 level. [#] *P-value* is between 0.05 and 0.25. A bivariate analysis of each variable was first done, and then the variables with *P-value* ≤ 0.25 were included in the multivariate analysis.

Multiple binary logistic regression revealed that there was no association between nausea or vomit and health risk factors among workers at endpoint **(Table 62).**

Table 62: *Multivariate analysis of each health risk factors associated with nausea or vomit among workers (n = 102) at endpoint.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Age	-0.053	0.046	1.338	0.247	0.948 (0.866-1.038)
BMI	-0.251	0.172	2.129	0.145	0.778 (0.556-1.090)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * Significance at *P-value* less than 0.05 level.

There were the associations between excessive tiredness and weakness and health risk factors including study at Signal school and alcohol drinking among workers at endpoint (OR = 0.299 and *P-value* = 0.016 and OR = 3.447 and *P-value* = 0.036, respectively). Therefore, study at Signal school and alcohol drinking were considered to assess the multiple association with excessive tiredness and weakness **(Table 63).**

Table 63: *Bivariate analysis of each health risk factors associated with excessive tiredness and weakness among workers (n = 102) at endpoint.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Demographic characteristics					
Age	0.001	0.020	0.004	0.947	1.001 (0.963-1.041)
BMI	-0.040	0.066	0.366	0.545	0.961 (0.843-1.094)
Marital status					
Single	Ref.				
Couple	0.243	0.485	0.252	0.616	1.276 (0.493-3.301)

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Education level					
< Bachelor's Degree	Ref.				
≥ Bachelor's Degree	0.085	0.465	0.034	0.855	1.089 (0.438-2.707)
Study at Signal school					
No	Ref.				
Yes	-1.207	0.499	5.845	0.016*	0.299 (0.112-0.796)
Working conditions					
Working experience					
≤ 10 years	Ref.				
> 10 years	0.148	0.461	0.104	0.747	1.160 (0.470-2.862)
Working hour					
< 7 hrs/day	Ref.				
≥ 7 hrs/day	0.533	0.481	1.231	0.267	1.705 (0.664-4.373)
Health behaviors					
Smoking status					
No	Ref.				
Yes	0.119	0.456	0.068	0.794	1.126 (0.461-2.754)
Alcohol drinking					
No	Ref.				
Yes	1.237	0.592	4.375	0.036*	3.447 (1.081-10.990)
Milk drinking					
No	Ref.				
Yes	-0.343	0.558	0.377	0.539	0.710 (0.238-2.119)

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Seafood consumption					
1-3 days/week	Ref.				
4-7 days/week	-0.820	0.803	1.041	0.308	0.441 (0.091-2.127)
Exercise					
1-3 days/week	Ref.				
4-7 days/week	-0.143	0.445	0.104	0.748	0.867 (0.363-2.071)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * *P-value* less than 0.05 level. # *P-value* is between 0.05 and 0.25. A bivariate analysis of each variable was first done, and then the variables with *P-value* ≤ 0.25 were included in the multivariate analysis.

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Multiple binary logistic regression revealed that there were the associations between excessive tiredness and weakness and health risk factors including study at Signal school and alcohol drinking among workers at endpoint (OR = 0.276 and *P-value* = 0.014 and OR = 3.744 and *P-value* = 0.031, respectively) **(Table 64).**

Table 64: *Multivariate analysis of each health risk factors associated with excessive tiredness and weakness among workers (n = 102) at endpoint.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Study at Signal school					
No	Ref.				
Yes	-1.286	0.521	6.090	0.014*	0.276 (0.099-0.767)
Alcohol drinking					
No	Ref.				
Yes	1.320	0.612	4.653	0.031*	3.744 (1.128-12.422)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * Significance at *P-value* less than 0.05 level.

There was an associations between headache or dizziness and study at Signal school among workers at endpoint (OR = 0.336 and *P-value* = 0.043). Moreover, there was a trend association with working hour (OR = 0.519 and *P-value* = 0.193). Therefore, study at Signal school and working hour were considered to assess the multiple association with headache or dizziness **(Table 65).**

Table 65: *Bivariate analysis of each health risk factors associated with headache or dizziness among workers (n = 102) at endpoint.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Demographic characteristics					
Age	-0.011	0.023	0.229	0.632	0.989 (0.946-1.034)
BMI	-0.055	0.076	0.525	0.469	0.946 (0.815-1.099)
Marital status					
Single	Ref.				
Couple	0.136	0.542	0.063	0.802	1.145 (0.396-3.311)
Education level					
< Bachelor's Degree	Ref.				
≥ Bachelor's Degree	-0.244	0.540	0.205	0.651	0.783 (0.272-2.256)
Study at Signal school					
No	Ref.				
Yes	-1.091	0.538	4.107	0.043*	0.336 (0.117-0.965)
Working conditions					
Working experience					
≤ 10 years	Ref.				
> 10 years	0.173	0.521	0.110	0.740	1.189 (0.428-3.297)

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Working hour					
< 7 hrs/day	Ref.				
$\geq$ 7 hrs/day	-0.657	0.504	1.697	0.193#	0.519 (0.193-1.393)
Health behaviors					
Smoking status					
No	Ref.				
Yes	0.402	0.505	0.634	0.426	1.495 (0.555-4.026)
Alcohol drinking					
No	Ref.				
Yes	0.023	0.544	0.002	0.966	1.023 (0.353-2.971)
Milk drinking					
No	Ref.				
Yes	0.238	0.688	0.120	0.730	1.269 (0.329-4.889)
Seafood consumption					
1-3 days/week	Ref.				
4-7 days/week	-0.332	0.813	0.167	0.683	0.717 (0.146-3.527)
Exercise					
1-3 days/week	Ref.				
4-7 days/week	-0.201	0.501	0.161	0.689	0.818 (0.307-2.183)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * *P-value* less than 0.05 level. # *P-value* is between 0.05 and 0.25. A bivariate analysis of each variable was first done, and then the variables with *P-value* $\leq$ 0.25 were included in the multivariate analysis.

Multiple binary logistic regression revealed that there was an association between headache or dizziness and study at Signal school among workers at endpoint (OR = 0.319 and *P-value* = 0.037) **(Table 66).**

Table 66: *Multivariate analysis of each health risk factors associated with headache or dizziness among workers (n = 102) at endpoint.*

Factors	**B**	**S.E.**	**Wald**	***P-value***	**OR (95% CI)**
Study at Signal school					
No	Ref.				
Yes	-1.141	0.548	4.336	0.037*	0.319 (0.109-0.935)
Working hour					
< 7 hrs/day	Ref.				
$\geq$ 7 hrs/day	-0.722	0.519	1.933	0.164	0.486 (0.176-1.344)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * Significance at *P-value* less than 0.05 level.

There was no association between fine tremors and health risk factors among workers at endpoint. However, there were the trend associations with age and smoking status (OR = 1.044 and *P-value* = 0.142 and OR = 2.665 and *P-value* = 0.118, respectively). Therefore, age and smoking status were considered to assess the multiple association with fine tremors **(Table 67).**

Table 67: *Bivariate analysis of each health risk factors associated with fine tremors among workers (n = 102) at endpoint.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Demographic characteristics					
Age	0.043	0.029	2.151	0.142[#]	1.044 (0.986-1.105)
BMI	-0.082	0.098	0.701	0.402	0.922 (0.761-1.116)
Marital status					
Single	Ref.				
Couple	0.405	0.703	0.332	0.564	1.500 (0.378-5.952)
Education level					
< Bachelor's Degree	Ref.				
≥ Bachelor's Degree	0.357	0.627	0.324	0.569	1.429 (0.418-4.880)
Study at Signal school					
No	Ref.				
Yes	0.420	0.814	0.266	0.606	1.522 (0.309-7.498)
Working conditions					
Working experience					
≤ 10 years	Ref.				
> 10 years	0.693	0.701	0.979	0.322	2.000 (0.507-7.894)

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Working hour					
< 7 hrs/day	Ref.				
$\geq$ 7 hrs/day	0.194	0.650	0.089	0.764	1.214 (0.340-4.340)
Health behaviors					
Smoking status					
No	Ref.				
Yes	0.980	0.626	2.450	0.118#	2.665 (0.781-9.091)
Alcohol drinking					
No	Ref.				
Yes	0.866	0.807	1.152	0.283	2.377 (0.489-11.555)
Milk drinking					
No	Ref.				
Yes	-0.511	0.724	0.498	0.481	0.600 (0.145-2.481)
Seafood consumption					
1-3 days/week	Ref.				
4-7 days/week	-0.526	1.090	0.233	0.629	0.591 (0.070-4.999)
Exercise					
1-3 days/week	Ref.				
4-7 days/week	0.425	0.622	0.467	0.494	1.530 (0.452-5.183)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * *P-value* less than 0.05 level. # *P-value* is between 0.05 and 0.25. A bivariate analysis of each variable was first done, and then the variables with *P-value* $\leq$ 0.25 were included in the multivariate analysis.

Multiple binary logistic regression revealed that there was no association between fine tremors and health risk factors among workers at endpoint **(Table 68).**

Table 68: *Multivariate analysis of each health risk factors associated with fine tremors among workers (n = 102) at endpoint.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Age	0.047	0.031	2.341	0.126	1.049 (0.987-1.114)
Smoking status					
No	Ref.				
Yes	1.042	0.640	2.656	0.103	2.836 (0.810-9.932)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * Significance at *P-value* less than 0.05 level.

Age and BMI could be determined the association with colic pain at endpoint. There was no association between colic pain and health risk factors among workers at endpoint. Therefore, multivariate analysis of health risk factors associated with colic pain at endpoint was not determined **(Table 69).**

Table 69: *Bivariate analysis of each health risk factors associated with colic pain among workers (n = 102) at endpoint.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Demographic characteristics					
Age	0.502	0.441	1.297	0.255	1.653 (0.696-3.923)
BMI	-0.149	0.346	0.187	0.666	0.861 (0.437-1.696)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first; * *P-value* less than 0.05 level. # *P-value* is between 0.05 and 0.25. A bivariate analysis of each variable was first done, and then the variables with *P-value* $\leq$ 0.25 were included in the multivariate analysis.

Age and BMI could be determined the association with metallic taste in the mouth at endpoint. There was no association between metallic taste in the mouth and health risk factors among workers at endpoint. Therefore, multivariate analysis of health risk factors associated with metallic taste in the mouth at endpoint was not determined **(Table 70).**

Table 70: *Bivariate analysis of each health risk factors associated with metallic taste in the mouth among workers (n = 102) at endpoint.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Demographic characteristics					
Age	-0.146	0.158	0.849	0.357	0.864 (0.634-1.179)
BMI	-0.319	0.401	0.633	0.426	0.727 (0.331-1.595)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first; * *P-value* less than 0.05 level. # *P-value* is between 0.05 and 0.25. A bivariate analysis of each variable was first done, and then the variables with *P-value* ≤ 0.25 were included in the multivariate analysis.

There was no association between nervous irritability and health risk factors among workers at endpoint. However, there was a trend association with alcohol drinking (OR = 2.647 and *P-value* = 0.103). Therefore, multivariate analysis of health risk factors associated with nervous irritability at endpoint was not determined **(Table 71).**

Table 71: *Bivariate analysis of each health risk factors associated with nervous irritability among workers (n = 102) at endpoint.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Demographic characteristics					
Age	0.001	0.021	0.002	0.966	1.001 (0.960-1.043)
BMI	-0.015	0.069	0.049	0.824	0.985 (0.861-1.127)
Marital status					
Single	Ref.				
Couple	-0.058	0.496	0.014	0.907	0.943 (0.357-2.496)
Education level					
< Bachelor's Degree	Ref.				
≥ Bachelor's Degree	0.182	0.485	0.141	0.707	1.200 (0.464-3.106)
Study at Signal school					
No	Ref.				
Yes	-0.467	0.529	0.779	0.377	0.627 (0.222-1.769)
Working conditions					
Working experience					
≤ 10 years	Ref.				
> 10 years	-0.188	0.476	0.156	0.693	0.829 (0.326-2.105)

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Working hour					
< 7 hrs/day	Ref.				
≥ 7 hrs/day	-0.014	0.482	0.001	0.977	0.986 (0.383-2.539)
Health behaviors					
Smoking status					
No	Ref.				
Yes	0.014	0.482	0.001	0.977	1.014 (0.394-2.609)
Alcohol drinking					
No	Ref.				
Yes	0.973	0.597	2.657	0.103#	2.647 (0.821-8.533)
Milk drinking					
No	Ref.				
Yes	-0.274	0.587	0.218	0.640	0.760 (0.240-2.403)
Seafood consumption					
1-3 days/week	Ref.				
4-7 days/week	-0.029	0.704	0.002	0.967	0.971 (0.244-3.861)
Exercise					
1-3 days/week	Ref.				
4-7 days/week	-0.388	0.472	0.675	0.411	0.679 (0.269-1.711)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * *P-value* less than 0.05 level. # *P-value* is between 0.05 and 0.25. A bivariate analysis of each variable was first done, and then the variables with *P-value* ≤ 0.25 were included in the multivariate analysis.

There was no association between muscle and joint pain and health risk factors among workers at endpoint. However, there was a trend association with study at Signal school (OR = 0.427 and *P-value* = 0.093). Therefore, multivariate analysis of health risk factors associated with muscle and joint pain at endpoint was not determined **(Table 72).**

Table 72: *Bivariate analysis of each health risk factors associated with muscle and joint pain among workers (n = 102) at endpoint.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Demographic characteristics					
Age	0.023	0.021	1.240	0.266	1.023 (0.983-1.066)
BMI	-0.015	0.067	0.048	0.827	0.986 (0.865-1.123)
Marital status					
Single	Ref.				
Couple	0.098	0.490	0.040	0.842	1.103 (0.422-2.882)
Education level					
< Bachelor's Degree	Ref.				
≥ Bachelor's Degree	-0.215	0.488	0.194	0.660	0.807 (0.310-2.099)
Study at Signal school					
No	Ref.				
Yes	-0.852	0.507	2.820	0.093[#]	0.427 (0.158-1.153)
Working conditions					
Working experience					
≤ 10 years	Ref.				
> 10 years	-0.013	0.467	0.001	0.978	0.987 (0.395-2.467)

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Working hour					
< 7 hrs/day	Ref.				
≥ 7 hrs/day	-0.069	0.468	0.022	0.883	0.933 (0.373-2.336)
Health behaviors					
Smoking status					
No	Ref.				
Yes	-0.383	0.485	0.624	0.430	0.681 (0.263-1.765)
Alcohol drinking					
No	Ref.				
Yes	0.491	0.526	0.873	0.350	1.634 (0.583-4.578)
Milk drinking					
No	Ref.				
Yes	0.217	0.619	0.123	0.726	1.242 (0.369-4.177)
Seafood consumption					
1-3 days/week	Ref.				
4-7 days/week	-0.150	0.701	0.046	0.831	0.861 (0.218-3.404)
Exercise					
1-3 days/week	Ref.				
4-7 days/week	-0.154	0.455	0.115	0.735	0.857 (0.351-2.093)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * *P-value* less than 0.05 level. # *P-value* is between 0.05 and 0.25. A bivariate analysis of each variable was first done, and then the variables with *P-value* ≤ 0.25 were included in the multivariate analysis.

There was no association between insomnia and health risk factors among workers at endpoint. However, there were the trend associations with age, BMI, education level, and working experience (OR = 0.959 and *P-value* = 0.100, OR = 0.878 and *P-value* = 0.143, OR = 1.909 and *P-value* = 0.230, and OR = 0.485 and *P-value* = 0.177, respectively). Therefore, age, BMI, education level, and working experience were considered to assess the multiple association with insomnia. The table did not show the factors including milk drinking and seafood consumption because these factors could not be determined the association with insomnia at endpoint **(Table 73).**

Table 73: *Bivariate analysis of each health risk factors associated with insomnia among workers (n = 102) at endpoint.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Demographic characteristics					
Age	-0.042	0.025	2.698	$0.100^{\#}$	0.959 (0.912-1.008)
BMI	-0.130	0.089	2.141	$0.143^{\#}$	0.878 (0.738-1.045)
Marital status					
Single	Ref.				
Couple	0.165	0.580	0.081	0.777	1.179 (0.378-3.676)
Education level					
< Bachelor's Degree	Ref.				
≥ Bachelor's Degree	0.647	0.539	1.441	$0.230^{\#}$	1.909 (0.664-5.490)
Study at Signal school					
No	Ref.				
Yes	-0.439	0.595	0.544	0.461	0.645 (0.201-2.069)

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Working conditions					
Working experience					
≤ 10 years	Ref.				
> 10 years	-0.724	0.536	1.822	0.177#	0.485 (0.169-1.387)
Working hour					
< 7 hrs/day	Ref.				
≥ 7 hrs/day	-0.488	0.536	0.829	0.363	0.614 (0.214-1.756)
Health behaviors					
Smoking status					
No	Ref.				
Yes	-0.102	0.555	0.034	0.855	0.903 (0.305-2.679)
Alcohol drinking					
No	Ref.				
Yes	0.414	0.617	0.450	0.502	1.513 (0.451-5.074)
Exercise					
1-3 days/week	Ref.				
4-7 days/week	-0.380	0.538	0.499	0.480	0.684 (0.238-1.964)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first; * *P-value* less than 0.05 level. # *P-value* is between 0.05 and 0.25. A bivariate analysis of each variable was first done, and then the variables with *P-value* ≤ 0.25 were included in the multivariate analysis.

Multiple binary logistic regression revealed that there was no association between insomnia and health risk factors among workers at endpoint **(Table 74).**

Table 74: *Multivariate analysis of each health risk factors associated with insomnia among workers (n = 102) at endpoint.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Age	-0.032	0.038	0.681	0.409	0.969 (0.899-1.044)
BMI	-0.096	0.091	1.102	0.294	0.909 (0.760-1.086)
Education level					
< Bachelor's Degree	Ref.				
≥ Bachelor's Degree	0.519	0.552	0.886	0.347	1.681 (0.570-4.958)
Working experience					
≤ 10 years	Ref.				
> 10 years	-0.043	0.820	0.003	0.958	0.958 (0.192-4.780)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first.

There was no association between numbness and health risk factors among workers at endpoint. However, there were the trend associations with marital status, education level, working experience, and working hour (OR = 7.429 and *P-value* = 0.059, OR = 2.143 and *P-value* = 0.190, OR = 4.353 and *P-value* = 0.064, and OR = 4.154 and *P-value* = 0.073, respectively). Therefore, marital status, education level, working experience, and working hour were considered to assess the multiple association with numbness **(Table 75).**

Table 75: *Bivariate analysis of each health risk factors associated with numbness among workers (n = 102) at endpoint.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Demographic characteristics					
Age	0.023	0.026	0.799	0.372	1.024 (0.972-1.078)
BMI	-0.002	0.084	0.001	0.977	0.998 (0.847-1.176)
Marital status					
Single	Ref.				
Couple	2.005	1.061	3.571	0.059$^{\#}$	7.429 (0.928-59.450)
Education level					
< Bachelor's Degree	Ref.				
≥ Bachelor's Degree	0.762	0.581	1.718	0.190$^{\#}$	2.143 (0.686-6.698)
Study at Signal school					
No	Ref.				
Yes	0.632	0.804	0.618	0.432	1.881 (0.389-9.086)

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Working conditions					
Working experience					
$\leq$ 10 years	Ref.				
> 10 years	1.471	0.794	3.434	0.064#	4.353 (0.919-20.625)
Working hour					
< 7 hrs/day	Ref.				
$\geq$ 7 hrs/day	1.424	0.794	3.217	0.073#	4.154 (0.876-19.690)
Health behaviors					
Smoking status					
No	Ref.				
Yes	-0.077	0.600	0.016	0.898	0.926 (0.286-2.999)
Alcohol drinking					
No	Ref.				
Yes	-0.281	0.605	0.216	0.642	0.755 (0.231-2.469)
Milk drinking					
No	Ref.				
Yes	-0.283	0.710	0.159	0.690	0.753 (0.187-3.032)
Seafood consumption					
1-3 days/week	Ref.				
4-7 days/week	-0.719	1.083	0.441	0.507	0.487 (0.058-4.071)
Exercise					
1-3 days/week	Ref.				
4-7 days/week	0.379	0.581	0.425	0.514	1.460 (0.468-4.558)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * *P-value* less than 0.05 level. # *P-value* is between 0.05 and 0.25. A bivariate analysis of each variable was first done, and then the variables with *P-value* $\leq$ 0.25 were included in the multivariate analysis.

Multiple binary logistic regression revealed that there was no association between numbness and health risk factors among workers at endpoint **(Table 76).**

Table 76: *Multivariate analysis of each health risk factors associated with numbness among workers (n = 102) at endpoint.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Marital status					
Single	Ref.				
Couple	1.556	1.159	1.802	0.180	4.738 (0.489-45.929)
Education level					
< Bachelor's Degree	Ref.				
≥ Bachelor's Degree	0.910	0.631	2.079	0.149	2.484 (0.721-8.555)
Working experience					
≤ 10 years	Ref.				
> 10 years	1.061	0.898	1.396	0.237	2.889 (0.497-16.782)
Working hour					
< 7 hrs/day	Ref.				
≥ 7 hrs/day	1.397	0.819	2.909	0.088	4.041 (0.812-20.113)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first.

There was no association between AST levels and health risk factors among workers at endpoint. However, there was a trend association with exercise (OR = 0.467 and *P-value* = 0.195). Therefore, multivariate analysis of health risk factors associated with AST levels at endpoint was not determined **(Table 77).**

Table 77: *Bivariate analysis of each health risk factors associated with AST levels among workers (n = 102) at endpoint.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Demographic characteristics					
Age	0.028	0.026	1.182	0.277	1.028 (0.978-1.081)
BMI	0.070	0.077	0.820	0.365	1.073 (0.922-1.248)
Marital status					
Single	Ref.				
Couple	-0.052	0.594	0.008	0.930	0.949 (0.296-3.040)
Education level					
< Bachelor's Degree	Ref.				
≥ Bachelor's Degree	-0.051	0.592	0.007	0.931	0.950 (0.298-3.033)
Study at Signal school					
No	Ref.				
Yes	0.727	0.800	0.825	0.364	2.068 (0.431-9.917)
Working conditions					
Working experience					
≤ 10 years	Ref.				
> 10 years	0.249	0.590	0.178	0.673	1.283 (0.404-4.079)

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Working hour					
< 7 hrs/day	Ref.				
≥ 7 hrs/day	0.568	0.624	0.828	0.363	1.764 (0.519-5.992)
Health behaviors					
Smoking status					
No	Ref.				
Yes	0.136	0.572	0.057	0.812	1.146 (0.373-3.516)
Alcohol drinking					
No	Ref.				
Yes	0.641	0.685	0.875	0.349	1.898 (0.496-7.269)
Milk drinking					
No	Ref.				
Yes	0.382	0.808	0.223	0.637	1.465 (0.300-7.143)
Seafood consumption					
1-3 days/week	Ref.				
4-7 days/week	0.655	0.728	0.810	0.368	1.925 (0.462-8.015)
Exercise					
1-3 days/week	Ref.				
4-7 days/week	-0.762	0.588	1.679	0.195#	0.467 (0.147-1.478)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * *P-value* less than 0.05 level. # *P-value* is between 0.05 and 0.25. A bivariate analysis of each variable was first done, and then the variables with *P-value* ≤ 0.25 were included in the multivariate analysis.

There was an association between ALT levels and BMI among workers at endpoint (OR = 1.209 and *P-value* = 0.009). Moreover, there was a trend association with exercise (OR = 0.442 and *P-value* = 0.112). Therefore, BMI and exercise were considered to assess the multiple association with ALT levels **(Table 78).**

Table 78: *Bivariate analysis of each health risk factors associated with ALT levels among workers (n = 102) at endpoint.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Demographic characteristics					
Age	0.019	0.022	0.717	0.397	1.019 (0.976-1.064)
BMI	0.190	0.073	6.796	0.009*	1.209 (1.048-1.394)
Marital status					
Single	Ref.				
Couple	0.525	0.563	0.869	0.351	1.691 (0.561-5.097)
Education level					
< Bachelor's Degree	Ref.				
≥ Bachelor's Degree	-0.332	0.536	0.385	0.535	0.717 (0.251-2.050)
Study at Signal school					
No	Ref.				
Yes	0.677	0.675	1.006	0.316	1.967 (0.524-7.382)
Working conditions					
Working experience					
≤ 10 years	Ref.				
> 10 years	0.267	0.516	0.268	0.605	1.306 (0.475-3.589)

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Working hour					
< 7 hrs/day	Ref.				
≥ 7 hrs/day	0.490	0.534	0.843	0.358	1.633 (0.573-4.648)
Health behaviors					
Smoking status					
No	Ref.				
Yes	0.045	0.505	0.008	0.929	1.046 (0.389-2.814)
Alcohol drinking					
No	Ref.				
Yes	-0.172	0.523	0.108	0.742	0.842 (0.302-2.347)
Milk drinking					
No	Ref.				
Yes	0.310	0.686	0.204	0.651	1.364 (0.355-5.232)
Seafood consumption					
1-3 days/week	Ref.				
4-7 days/week	0.168	0.709	0.056	0.812	1.183 (0.295-4.751)
Exercise					
1-3 days/week	Ref.				
4-7 days/week	-0.817	0.514	2.528	0.112#	0.442 (0.161-1.209)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * *P-value* less than 0.05 level. # *P-value* is between 0.05 and 0.25. A bivariate analysis of each variable was first done, and then the variables with *P-value* ≤ 0.25 were included in the multivariate analysis.

Multiple binary logistic regression revealed that there was an association between ALT levels and BMI among workers at endpoint (OR = 1.201 and *P-value* = 0.012) **(Table 79).**

Table 79: *Multivariate analysis of each health risk factors associated with ALT levels among workers (n = 102) at endpoint.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
BMI	0.183	0.073	6.371	0.012*	1.201 (1.042-1.384)
Exercise					
1-3 days/week	Ref.				
4-7 days/week	-0.755	0.533	2.005	0.157	0.470 (0.165-1.337)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * Significance at *P-value* less than 0.05 level.

There were the associations of GFR levels with age, marital status, and working experience among workers at endpoint (OR = 1.067 and *P-value* = 0.001, OR = 2.819 and *P-value* = 0.021, and OR = 3.000 and *P-value* = 0.011, respectively). Moreover, there were the trend associations with BMI, study at Signal school, working hour, and exercise (OR = 1.105 and *P-value* = 0.097, OR = 1.923 and *P-value* = 0.184, OR = 1.943 and *P-value* = 0.113, and OR = 2.036 and *P-value* = 0.078, respectively). Therefore, age, marital status, working experience, BMI, study at Signal school, working hour, and exercise were considered to assess the multiple association with GFR levels **(Table 80).**

Table 80: *Bivariate analysis of each health risk factors associated with GFR levels among workers (n = 102) at endpoint.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Demographic characteristics					
Age	0.065	0.020	10.594	0.001*	1.067 (1.026-1.110)
BMI	0.100	0.060	2.758	0.097#	1.105 (0.982-1.244)
Marital status					
Single	Ref.				
Couple	1.037	0.450	5.317	0.021*	2.819 (1.168-6.804)
Education level					
< Bachelor's Degree	Ref.				
≥ Bachelor's Degree	-0.258	0.420	0.377	0.539	0.773 (0.339-1.760)
Study at Signal school					
No	Ref.				
Yes	0.654	0.492	1.765	0.184#	1.923 (0.733-5.047)

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Working conditions					
Working experience					
≤ 10 years	Ref.				
> 10 years	1.099	0.430	6.518	0.011*	3.000 (1.291-6.973)
Working hour					
< 7 hrs/day	Ref.				
≥ 7 hrs/day	0.664	0.419	2.509	0.113#	1.943 (0.854-4.420)
Health behaviors					
Smoking status					
No	Ref.				
Yes	-0.149	0.411	0.131	0.717	0.862 (0.385-1.929)
Alcohol drinking					
No	Ref.				
Yes	-0.077	0.431	0.032	0.859	0.926 (0.398-2.156)
Milk drinking					
No	Ref.				
Yes	-0.414	0.523	0.628	0.428	0.661 (0.237-1.840)
Seafood consumption					
1-3 days/week	Ref.				
4-7 days/week	0.673	0.609	1.223	0.269	1.960 (0.595-6.461)
Exercise					
1-3 days/week	Ref.				
4-7 days/week	0.711	0.403	3.114	0.078#	2.036 (0.924-4.486)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * *P-value* less than 0.05 level. # *P-value* is between 0.05 and 0.25. A bivariate analysis of each variable was first done, and then the variables with *P-value* ≤ 0.25 were included in the multivariate analysis.

Multiple binary logistic regression revealed that there was an association between GFR levels and age among workers at endpoint (OR = 1.062 and *P-value* = 0.003) **(Table 81).**

Table 81: *Multivariate analysis of each health risk factors associated with GFR levels among workers (n = 102) at endpoint.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Age	0.060	0.020	8.546	0.003*	1.062 (1.020-1.105)
BMI	0.087	0.067	1.688	0.194	1.091 (0.957-1.244)
Exercise					
1-3 days/week	Ref.				
4-7 days/week	0.745	0.436	2.916	0.088	2.106 (0.896-4.951)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * Significance at *P-value* less than 0.05 level.

There were the associations of hypertension with smoking status among workers at endpoint (OR = 2.559 and *P-value* = 0.039). In addition, there were the trend associations with age, BMI, marital status, working experience, and alcohol drinking (OR = 1.036 and *P-value* = 0.088, OR = 1.114 and *P-value* = 0.093, OR = 2.106 and *P-value* = 0.152, OR = 2.286 and *P-value* = 0.095, and OR = 1.871 and *P-value* = 0.230, respectively). Therefore, smoking status, age, BMI, marital status, working experience, and alcohol drinking were considered to assess the multiple association with hypertension **(Table 82).**

Table 82: *Bivariate analysis of each health risk factors associated with hypertension among workers (n = 102) at endpoint.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Demographic characteristics					
Age	0.035	0.021	2.909	0.088#	1.036 (0.995-1.079)
BMI	0.108	0.064	2.817	0.093#	1.114 (0.982-1.263)
Marital status					
Single	Ref.				
Couple	0.745	0.520	2.052	0.152#	2.106 (0.760-5.837)
Education level					
< Bachelor's Degree	Ref.				
≥ Bachelor's Degree	-0.134	0.472	0.081	0.776	0.874 (0.347-2.207)
Study at Signal school					
No	Ref.				
Yes	-0.453	0.509	0.794	0.373	0.636 (0.235-1.722)

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Working conditions					
Working experience					
≤ 10 years	Ref.				
> 10 years	0.827	0.496	2.783	0.095#	2.286 (0.865-6.037)
Working hour					
< 7 hrs/day	Ref.				
≥ 7 hrs/day	0.308	0.470	0.430	0.512	1.360 (0.542-3.415)
Health behaviors					
Smoking status					
No	Ref.				
Yes	0.939	0.455	4.270	0.039*	2.559 (1.050-6.237)
Alcohol drinking					
No	Ref.				
Yes	0.626	0.522	1.439	0.230#	1.871 (0.672-5.205)
Milk drinking					
No	Ref.				
Yes	0.336	0.616	0.298	0.585	1.400 (0.418-4.685)
Seafood consumption					
1-3 days/week	Ref.				
4-7 days/week	0.584	0.619	0.890	0.346	1.793 (0.533-6.038)
Exercise					
1-3 days/week	Ref.				
4-7 days/week	-0.143	0.445	0.104	0.748	0.867 (0.363-2.071)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * *P-value* less than 0.05 level. # *P-value* is between 0.05 and 0.25. A bivariate analysis of each variable was first done, and then the variables with *P-value* ≤ 0.25 were included in the multivariate analysis.

Multiple binary logistic regression revealed that there was an association between hypertension and smoking status among workers at endpoint (OR = 2.840 and *P-value* = 0.028) **(Table 83).**

Table 83: *Multivariate analysis of each health risk factors associated with hypertension among workers (n = 102) at endpoint.*

Factors	B	S.E.	Wald	*P-value*	OR (95% CI)
Age	0.034	0.022	2.342	0.126	1.035 (0.990-1.081)
BMI	0.106	0.068	2.400	0.121	1.111 (0.972-1.270)
Smoking status					
No	Ref.				
Yes	1.044	0.474	4.845	0.028*	2.840 (1.121-7.195)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. Reference category: first. * Significance at *P-value* less than 0.05 level.

4.5 Association between the occupational lead exposure (BLL and HLL) and signs and symptoms of lead poisoning among workers at baseline and endpoint.

This study aims to determine the effects of the occupational lead exposure on health effects. Therefore, Binary logistic regression was used to find the association between BLL and adverse health effects including signs and symptoms of lead poisoning from the questionnaires, hepatic function, kidney function and blood pressure.

4.5.1 Association between BLL and Signs and symptoms of lead poisoning

At baseline, the results revealed the relationship of BLL with 7 signs and symptoms of lead poisoning including loss of appetite, nausea or vomit, weakness, headache or dizziness, nervous irritability, insomnia, and hypertension (OR = 2.118 and *P-value* = 0.005, OR = 1.799 and *P-value* = 0.044, OR = 1.346 and *P-value* = 0.044, OR = 1.389 and *P-value* = 0.029, OR = 1.463 and *P-value* = 0.014, OR = 1.745 and *P-value* = 0.003, and OR = 1.384 and *P-value* = 0.040, respectively). The association with colic pain and metallic taste in the mouth could not be analyzed because of low prevalence of these two signs and symptoms. Therefore, the table did not show these two signs and symptoms. In terms of hepatic and kidney functions, the association with BLL was not found **(Table 84).**

Table 84: Association between BLL and Signs and symptoms of lead poisoning among workers (n = 120) at baseline.

Signs and symptoms of lead poisoning	B	S.E.	Wald	*P-value*	OR (95% CI)
Loss of Appetite	0.750	0.267	7.925	0.005*	2.118 (1.256-3.572)
Constipation	0.022	0.247	0.008	0.930	1.022 (0.630-1.659)
Nausea or Vomit	0.587	0.291	4.076	0.044*	1.799 (1.017-3.180)
Weakness	0.297	0.147	4.068	0.044*	1.346 (1.008-1.796)
Headache or Dizziness	0.329	0.150	4.788	0.029*	1.389 (1.035-1.864)
Fine tremors	0.504	0.262	3.702	0.054	1.655 (0.991-2.767)
Nervous irritability	0.380	0.155	6.058	0.014*	1.463 (1.081-1.980)
Muscle and joint pain	0.256	0.141	3.280	0.070	1.292 (0.979-1.704)
Insomnia	0.557	0.186	8.948	0.003*	1.745 (1.212-2.513)
Numbness	0.362	0.304	1.420	0.233	1.436 (0.792-2.606)
Hepatic Function, AST	0.134	0.192	0.490	0.484	1.144 (0.785-1.665)
Hepatic Function, ALT	0.121	0.166	0.531	0.466	1.129 (0.815-1.564)
Kidney Function, GFR	0.067	0.141	0.225	0.636	1.069 (0.812-1.408)
Hypertension	0.325	0.158	4.202	0.040*	1.384 (1.014-1.887)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. All signs and symptoms of lead poisoning were adjusted for age (years), BMI (Kg/m^2), smoking status, alcohol drinking, milk drinking, seafood consumption (days/week), exercise (days/week), and working hour (hrs/day). * Significance at *P-value* less than 0.05 level.

At endpoint, the results showed the relationship of BLL with 6 signs and symptoms of lead poisoning including weakness, headache or dizziness, nervous irritability, muscle and joint pain, insomnia, and hypertension (OR = 1.848 and *P-value* = 0.001, OR = 1.474 and *P-value* = 0.008, OR = 3.715 and *P-value* < 0.001, OR = 3.807 and *P-value* < 0.001, OR = 1.477 and *P-value* = 0.011, and OR = 1.388 and *P-value* = 0.020, respectively). The association with nausea or vomit, colic pain and metallic taste in the mouth could not be analyzed because of low prevalence of these three signs and symptoms. Therefore, these three signs and symptoms were not shown in the table. In terms of hepatic and kidney functions, the associations with BLL was not found **(Table 85).**

__Table 85:__ Association between BLL and signs and symptoms of lead poisoning among workers (n = 102) at endpoint.

Signs and symptoms of lead poisoning	B	S.E.	Wald	*P-value*	OR (95% CI)
Loss of Appetite	0.191	0.149	1.653	0.199	1.211 (0.904-1.621)
Constipation	0.017	0.175	0.009	0.924	1.017 (0.722-1.432)
Weakness	0.614	0.182	11.395	0.001*	1.848 (1.294-2.640)
Headache or Dizziness	0.388	0.145	7.109	0.008*	1.474 (1.108-1.960)
Fine tremors	0.137	0.152	0.819	0.366	1.147 (0.852-1.545)
Nervous irritability	1.313	0.318	17.029	<0.001*	3.715 (1.992-6.930)
Muscle and joint pain	1.337	0.317	17.824	<0.001*	3.807 (2.047-7.081)
Insomnia	0.390	0.153	6.492	0.011*	1.477 (1.094-1.994)
Numbness	0.185	0.152	1.487	0.223	1.204 (0.894-1.621)
Hepatic Function, AST	0.211	0.145	2.122	0.145	1.235 (0.930-1.640)
Hepatic Function, ALT	0.244	0.137	3.149	0.076	1.276 (0.975-1.670)
Kidney Function, GFR	0.196	0.115	2.920	0.087	1.217 (0.972-1.524)
Hypertension	0.328	0.141	5.380	0.020*	1.388 (1.052-1.831)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. All Signs and symptoms of lead poisoning were adjusted for age (years), BMI (Kg/m^2), smoking status, alcohol drinking, milk drinking, seafood consumption (days/week), exercise (days/week), and working hour (hrs/day). * Significance at *P-value* less than 0.05 level.

4.5.2 Association between HLL and signs and symptoms of lead poisoning

There was no any association between HLL and signs and symptoms of lead poisoning at baseline. The association with colic pain and metallic taste in the mouth could not be analyzed because of low prevalence of these two signs and symptoms. Therefore, these three signs and symptoms were not shown in the table. In terms of hepatic and kidney functions, the associations with HLL were not found **(Table 86).**

Table 86: *Association between HLL and signs and symptoms of lead poisoning among workers (n = 86) at baseline.*

Signs and symptoms of lead poisoning	B	S.E.	Wald	*P-value*	OR (95% CI)
Loss of Appetite	0.633	0.402	2.478	0.115	1.883 (0.856-4.140)
Constipation	-0.239	0.571	0.175	0.675	0.787 (0.257-2.412)
Nausea or Vomit	0.096	0.615	0.024	0.876	1.100 (0.329-3.676)
Weakness	0.048	0.275	0.030	0.863	1.049 (0.611-1.799)
Headache or Dizziness	-0.083	0.276	0.091	0.763	0.920 (0.535-1.581)
Fine tremors	-0.485	0.561	0.747	0.388	0.616 (0.205-1.849)
Nervous irritability	0.054	0.292	0.035	0.852	1.056 (0.596-1.870)
Muscle and joint pain	0.282	0.246	1.312	0.252	1.325 (0.819-2.145)
Insomnia	0.299	0.283	1.112	0.292	1.348 (0.774-2.350)
Numbness	-2.679	1.599	2.808	0.094	0.069 (0.003-1.576)
Hepatic Function, AST	0.391	0.489	0.640	0.424	1.479 (0.567-3.855)
Hepatic Function, ALT	0.719	0.369	3.788	0.052	2.052 (0.995-4.231)
Kidney Function, GFR	0.097	0.244	0.159	0.690	1.102 (0.683-1.777)
Hypertension	0.490	0.320	2.342	0.126	1.632 (0.872-3.057)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. All signs and symptoms of lead poisoning were adjusted for age (years), BMI (Kg/m^2), smoking status, alcohol drinking, milk drinking, seafood consumption (days/week), exercise (days/week), and working hour (hrs/day). * Significance at *P-value* less than 0.05 level.

At endpoint, the results showed the associations between HLL and 2 signs and symptoms of lead poisoning including nervous irritability and muscle and joint pain (OR = 2.514 and *P-value* = 0.005 and OR = 2.448 and *P-value* = 0.007, respectively). The association with nausea or vomit, colic pain and metallic taste in the mouth could not be analyzed because of low prevalence of these three signs and symptoms. Therefore, these three signs and symptoms were not shown in the table. In terms of hepatic and kidney functions, the associations with HLL were not found **(Table 87).**

Table 87: *Association between HLL and signs and symptoms of lead poisoning among workers (n = 64) at endpoint.*

Signs and symptoms of lead poisoning	B	S.E.	Wald	*P-value*	OR (95% CI)
Loss of Appetite	0.273	0.368	0.551	0.458	1.314 (0.639-2.704)
Constipation	0.791	0.488	2.626	0.105	2.206 (0.847-5.744)
Weakness	0.321	0.275	1.367	0.242	1.379 (0.805-2.361)
Headache or Dizziness	0.451	0.277	2.660	0.103	1.570 (0.913-2.699)
Fine tremors	0.229	0.373	0.375	0.540	1.257 (0.605-2.613)
Nervous irritability	0.922	0.332	7.726	0.005*	2.514 (1.312-4.815)
Muscle and joint pain	0.895	0.331	7.307	0.007*	2.448 (1.279-4.685)
Insomnia	0.485	0.360	1.814	0.178	1.625 (0.802-3.292)
Numbness	0.165	0.321	0.264	0.607	1.180 (0.629-2.213)
Hepatic Function, AST	0.175	0.497	0.124	0.725	1.191 (0.450-3.152)
Hepatic Function, ALT	0.639	0.466	1.883	0.170	1.894 (0.761-4.719)
Kidney Function, GFR	-0.064	0.244	0.069	0.792	0.938 (0.581-1.514)
Hypertension	0.195	0.290	0.450	0.502	1.215 (0.688-2.145)

B, regression coefficient; S.E., standard error; OR, odds ratio; CI, confidence interval. All signs and symptoms of lead poisoning were adjusted for age (years), BMI (Kg/m^2), smoking status, alcohol drinking, milk drinking, seafood consumption (days/week), exercise (days/week), and working hour (hrs/day). * Significance at *P-value* less than 0.05 level.

4.6 Lead poisoning risk assessment

For exposure assessment, ADD from lead via inhalation route was calculated by a formula as follows:

$$\text{ADD (mg/kg-day)} = (C \times InhR \times ED) / (BW \times AT)$$

Where:

C = Contaminant concentration in inhaled air (mg/m^3), (RME)

InhR = inhalation rate (m^3/day)

ED = exposure duration (days)

BW = body weight (kg)

AT = average time (days)

The reasonable maximum exposure (RME) is the worst-case scenario that evaluates exposure that higher than average. The 95th percentile is used to evaluate RME because the situation involves the uncertainty of concentration value (Jaipieam, Visuthismajarn, Siriwong, Borjan, & Robson, 2009; Taneepanichskul, Siriwong, Siripattanakul, & Robson, 2010). Therefore, values of these variables at baseline were shown in (**Table 88)** and variables at endpoint were shown in **(Table 89)**.

Table 88: *Values of the variables for calculating ADD for lead exposure at baseline.*

Variables	Values
C of exposed group (RME)	0.0308 mg/m^3
C of low exposed group (RME)	0.0056 mg/m^3
InhR	20 m^3/day
ED of exposed group (average)	15.5 (years) × 240 (days/year) = 3,720 days
ED of low exposed group (average)	17 (years) × 240 (days/year) = 4,080 days
BW of exposed group (average)	72.0 kg
BW of low exposed group (average)	72.0 kg
AT of exposed group (average)	15.5 (years) × 240 (days/year) = 3,720 days
AT of low exposed group (average)	17 (years) × 240 (days/year) = 4,080 days

From the formula;

$$ADD = (C \times InhR \times ED) / (BW \times AT)$$

Therefore, ADD of exposed group $= (0.0308 \times 20 \times 3{,}720) / (72 \times 3{,}720)$

$= 0.0086$ mg/kg-day

Therefore, ADD of low exposed group $= (0.0056 \times 20 \times 4{,}080) / (72 \times 4{,}080)$

$= 0.0016$ mg/kg-day

Next step, Risk Characterization for non-cancer was calculated by a formula as follows:

HQ (hazard quotient) = ADD (mg/kg-day) / RfD (mg/kg-day)

Therefore, HQ of exposed group $= 0.0086 / (3.6 \times 10^{-3})$

$= 2.4$

Therefore, HQ of low exposed group $= 0.0016 / (3.6 \times 10^{-3})$

$= 0.4$

The results showed that HQ of low exposed group was less than 1 but HQ of exposed group was higher than 1. Therefore, the adverse health effects for lead exposure of low exposed group was not at risk. On the other hand, the adverse health effects for lead exposure can be occurred with a chance of 2.4 times in exposed group at baseline.

Table 89: *Values of the variables for calculating ADD for lead exposure at endpoint.*

Variables	Values
C of exposed group (RME)	0.0452 mg/m^3
C of low exposed group (RME)	0.0301 mg/m^3
InhR	20 m^3/day
ED of exposed group (average)	15.5 (years) × 240 (days/year) = 3,720 days
ED of low exposed group (average)	17 (years) × 240 (days/year) = 4,080 days
BW of exposed group (average)	72 kg
BW of low exposed group (average)	70 kg
AT of exposed group (average)	15.5 (years) × 240 (days/year) = 3,720 days
AT of low exposed group (average)	17 (years) × 240 (days/year) = 4,080 days

From the formula;

$$ADD = (C \times InhR \times ED) / (BW \times AT)$$

$$\text{Therefore, ADD of exposed group} = (0.0452 \times 20 \times 3{,}720) / (72 \times 3{,}720)$$

$$= 0.0126 \text{ mg/kg-day}$$

$$\text{Therefore, ADD of low exposed group} = (0.0301 \times 20 \times 4{,}080) / (70 \times 4{,}080)$$

$$= 0.0089 \text{ mg/kg-day}$$

Next step, Risk Characterization for non-cancer was calculated by a formula as follows:

$$\text{HQ (hazard quotient)} = \text{ADD (mg/kg-day) / RfD (mg/kg-day)}$$

$$\text{Therefore, HQ of exposed group} = 0.0126 / (3.6 \times 10^{-3})$$

$$= 3.5$$

$$\text{Therefore, HQ of low exposed group} = 0.0089 / (3.6 \times 10^{-3})$$

$$= 2.5$$

The results showed that HQ of both groups were higher than 1. Therefore, the adverse health effects for lead exposure can be occurred with a chance of 2.5 and 3.5 times in low exposed and exposed groups, respectively.

CHAPTER V
DISCUSSION

5.1 Personal Characteristics

The personal characteristics including age, education level, milk drinking, and study at Signal school of both groups are different in this study. Mean±S.D. age of low exposed group (41.3±10.7 years) is higher than another group (36.9±10.1 years) at baseline. Age might have the effects on some signs and symptoms. For example, older age can affect the kidney function such as a decline in kidney number and size, tubulointerstitial changes, and a thickening of the basement membrane of glomerular (Newbold, Sandison, & Howie, 1992; Nyengaard & Bendtsen, 1992). In addition, studies revealed that age associated with volume of liver and related to hepatic blood flow which effect on the hepatic clearance (Schmucker, 2005; Tan, Eastment, Poudel, & Hubbard, 2015; Wynne et al., 1989). At endpoint the result of education levels showed that workers in low exposed group graduated with Bachelor's degree or higher more than another group (45.8% and 24.1%, respectively). And, about 85% of low exposed groups and about 67% of exposed group studied at Signal school at both baseline and endpoint. The workers who graduated from Signal school and graduated with Bachelor's degree or higher should have more knowledge of lead poisoning than others. For the last personal characteristic, workers in exposed group drink milk more than workers in low exposed group. A study showed the protection effect on lead peripheral neurotoxicity in lead workers from drinking milk about 700 g/day (Chuang et al., 2004). Moreover, a study revealed that drinking milk could decrease of lead level in hair (Michalak et al., 2014).

5.2 Airborne lead concentration (ALC)

The highest mean lead concentration in the air was found in high frequency radio-repair section at endpoint at 34.5 μg/m^3. The standard lead level of Thai Ministry of Labor and Social Welfare in the air is 200 μg/m^3 and NIOSH recommended permissible exposure limit (REL) for lead is a Time Weighted Average (TWA) of 30 μg/m^3 over 8-hours. Therefore, ALCs of this plant did not exceed the standard of Thai law and NIOSH as well. The using of working-station exhaust ventilator as a PPE while working might be a reason of this good effect. But, the average of ALC in that section was high when compare to the standard of OSHA which required Permissible Exposure Limit (PEL) action level for lead in general industry is a TWA of 30 μg/m^3 over 8-hours. However, some studies suggested that the REL of NIOSH and PEL of OSHA may be too high to protect the adverse health effects.

The results showed the significant difference of ALC between high frequency radio-repair (HF) with very high frequency radio-repair (VHF) sections (exposed group) and clerical officer (CO) section (low exposed group) at baseline and endpoint even though working experience and working hour of both group were not different. It may be because the workers in HF and VHF sections are exposed to lead directly while working. In addition, work load or number of repaired radios per month in HF and VHF sections were higher than field telephone-repair (FT) and carrier wave radio-repair (CW) sections but data were not shown. That why ALCs of FT and CW sections were not different from CO section. In addition, the results of all ALCs of each sections at endpoint were significantly greater than ALCs at baseline. Due to baseline of the study was set at the last quarter of the year, work load at baseline was less than at endpoint. Another possible reason is when workers know the low lead level in blood result at baseline, the awareness of the workers at endpoint may reduce. Our finding showed the lower awareness of lead exposure at endpoint but not significant.

5.3 Knowledge, Awareness, and PPE Used (KAP) of lead exposure

KAP of lead exposure might be the factors that causes the effects on lead levels change in the body which also may be the cause of the adverse health effects on workers.

For knowledge of lead exposure, knowledge was measured only at baseline because the study did not educate the workers about lead exposure. The high knowledge score meant that the workers should have more knowledge about lead toxicity and how to protect themselves from lead poisoning. By the way, they had very low knowledge score. The median score of both groups were 1 from 5 points. Like a study by Lormphongs et al. in 2003 which revealed that many workers lacked knowledge about lead poisoning. They should have adequate knowledge, training and expertise in understanding lead exposure (Lormphongs et al., 2003).

In terms of awareness for lead exposure, high awareness score meant that the workers should have more awareness about how to use the appropriate PPE and awareness of personal hygiene during soldering. The results showed that workers of both groups had high awareness of lead exposure at both baseline and endpoint. However, there was a tendency that the awareness of lead exposure among workers decreased but not statistically significant. That might be the result from the low lead level in blood of each worker at baseline, resulting in less awareness at endpoint.

In case of PPE used, it is specified to the workers who use lead in Lead MSDS for protecting them from lead toxicity. This plant provides the workers in exposed group all PPE including goggles, work uniform, dust respirator, gloves, and exhaust ventilator. The total scores of PPE used are 10 points. The median scores of PPE used in exposed group was 3 points which was significant greater than low exposed group for 1 point at endpoint. Because the workers in low exposed group did not receive any PPE. There is a kind of PPE that both groups use differently, namely working-station exhaust ventilator. Most of workers in exposed group sometimes use this item while working. In fact, they have to use it every time that they are soldering. However, the result showed that PPE used scores for lead exposure of both groups was also low. Moreover, median PPE used score of exposed group at endpoint was significant higher than their score at baseline for 1 point but still low. The same as previous discussion, workers in exposed group at endpoint used working-station exhaust ventilator more than at baseline. It is a good practice used because the main pathway for lead exposure is inhalation route. Therefore, the working-station exhaust ventilator might protect them from exposure to lead. Some studies that focused on inhalation pathway reported that the workers who worked with lead had used masks could reduce their BLL (Kuruvilla et al., 2008; Lormphongs et al., 2004).

From the results of knowledge, awareness and PPE used for lead exposure, the workers should get knowledge and awareness for changing their behavior and attitude as same as the study of Lormphongs' team in 2004. After giving them the education, many workers were understood the lead poisoning and then changed the attitude toward their work and improved personal hygiene such as washing their hands before eating or drinking (Lormphongs et al., 2004). In addition, the behavior of using PPE should be increased especially for mask and working-station exhaust ventilator (H. Y. Chuang, Lee, Chao, Wang, & Hu, 1999).

5.4 Blood lead level (BLL)

BLL is the one biomarker for measuring lead level in human body. More than 98% of lead are found in blood cells (deSilva, 1981; Schutz et al., 1996). The amount of lead in the blood, as well as the time course of exposure, determines toxicity.

The BLL results showed that median BLL of exposed group was greater than BLL of low exposed group at both baseline and endpoint. The direct exposed to lead of exposed group while working might be the main reason of this finding. Because working conditions of both groups were not different. A result showed that median BLL of both groups at endpoint were higher than at baseline. Although working conditions of both times were not different lead levels in the blood were related to personal lead concentrations in the air (*P-value* = 0.005). Airborne lead concentrations among workers at endpoint were also higher than at baseline. In 2009-2015, CDC designated 10 µg/dL of BLL for adults as a level of concern. Higher than 10 µg/dL is considered as an elevated BLL. Later in 2015, NIOSH designated 5 µg/dL of whole blood as the reference BLL for adults. However, median BLLs among workers in this study at baseline and endpoint were lower than 5 µg/dL except for exposed group at endpoint which was 5.5 µg/dL of lead level in blood. Therefore, that amount of lead should prompt further medical investigation especially the workers in exposed group. Moreover, there is no save level of lead exposure now.

5.5 Hair lead level (HLL)

Most clinical methods for occupational exposure to toxic elements rely on blood analysis. However, the appropriate specimen depends on several factors, such as toxicokinetics, the specimen collection procedure, and the potential for specimen contamination. Hair is one specimen that is easily and noninvasively collected, and easily stored and transported to the laboratory for analysis (Barbosa et al., 2005). For another advantage, hair is an inert and homogenous material. It can be stored for long time and used for later control re-analyses. Hair analysis has been widely used for the biomonitoring of human exposure to contaminants and for estimation of the nutritional status of individuals. The advantage of hair is that it is a storage tissue and retains trace elements over an extended period of time (Foo et al., 1993; Laker, 1982). Using hair as a biomarker of the environmental exposure to several trace elements has become a common practice (Mehra & Juneja, 2004; Ozden et al., 2007; Strumylaite et al., 2004). One study suggested that level of lead in hair was the mostly meaningful environmental marker of exposure to lead in the human organism (Nowak & Chmielnicka, 2000).

The lead levels in hair of the study showed that median HLL of exposed group was greater than HLL of low exposed group at endpoint the same as the results of BLL. Besides, there is a study that showed the geometric mean for HLL of the ceramic plant workers (7.6 µg/g) was significantly higher than the persons who did not expose to lead (3.2 μg/g) (Strumylaite et al., 2004). Similar findings have been revealed in other studies (Bache, Lisk, Scarlett, & Carbone, 1991; Zaborowska, Wiercinski, & Maciejewska-Kozak, 1989). The direct exposed to lead of exposed group while working might also be the main reason of this finding. A result showed that median HLL of both groups at endpoint were higher than at baseline. Even though this study showed that HLL did not relate to ALC, ALC among workers at endpoint was higher than at baseline that was why the higher HLL at endpoint was shown. However, analysis of hair has limitations. Because HLL reference has not been described yet and there are insufficient data to determine reference ranges for lead (Esteban & Castano, 2009). Half-life for lead in blood is about 1 month but half-life for lead in hair is not shown for now. The HLL results have to be compared with the levels found in other studies as a reference. By the way, there was no study of lead levels in hair among the same participants. Moreover, the contamination of external lead from the environment and the failure to clearly remove it in hair washing procedures has to be concerned.

5.6 Signs and symptoms of lead poisoning

Prolonged low-lead exposure may cause the adverse health effects. Signs and symptoms of lead poisoning vary. Lead can affect many organs and systems of the body because the mechanisms of lead toxicity including perturbations of ion homeostasis and transport, protein binding, oxidative stress, and inflammation, can occur to all cell types. In addition, lead can be distributed throughout the body as well. The United States Environmental Protection Agency (U.S.EPA) indicates that there are many signs and symptoms of lead poisoning. For this study, eighteen signs and symptoms of lead poisoning were determined at baseline and endpoint except for anemia, hepatic and kidney functions which were evaluated only at baseline. Fortunately, anemia, wrist and foot drop and lead line on the gum which had to be diagnosed by medical doctor were not found. Five signs and symptoms of lead poisoning in exposed group were mostly found, about 30-50% at baseline and endpoint including muscle and joint pain, excessive tiredness and weakness, and nervous irritability, hypertension, and headache or dizziness.

5.7 Correlation between BLL and HLL among workers at baseline and endpoint

Our findings revealed low positive correlation between BLL and HLL among workers at baseline and endpoint (r_s = 0.351 and *P-value* = 0.001 and r_s = 0.263 and *P-value* = 0.036, respectively). Likewise, a study showed mean lead level of blood and hair in 280 healthy Brazilian were 11.52 µg/dL and 2.5 µg/g, respectively which revealed a positive weak correlation between BLL and HLL (r = 0.22 and *P-value* < 0.001) (Rodrigues et al., 2008). The weak correlation between BLL and HLL might depend on lead intake and the different kinetics of lead appearance in blood and hair. For example, there were studies showed the strong correlations in lead-battery workers, while the correlations were low in the control group (Clayton & Wooller, 1983; Niculescu, Dumitru, Botha, Alexandrescu, & Manolescu, 1983). In addition, individual factors including age, genetics, and interactions between elements might be a lesser or greater extents modifying the metabolism of lead from the blood to the hair compartment (Chojnacka et al., 2006; Khalique et al., 2005; Paschal et al., 1989). However, there was a study that showed the opposite results from other research by suggesting that no correlation of BLL and HLL was observed. Age and hair coloration also did not relate to level of lead in hair (Tracqui et al., 1994).

5.8 Association among health risk factors with lead level (BLL and HLL) and signs and symptoms of lead poisoning among the workers

5.8.1 Health risk factors and BLL

Because low exposed group which had lower BLL study at Signal school more than in exposed group. Therefore, the findings showed a negative association between BLL and study at Signal school. From face to face interviewed we found that Signal school did not teach anything about lead poisoning. Furthermore, there was a significant association of BLL with ALC at baseline and endpoint. The discussion above showed that directly exposed to lead while working might be the cause of higher BLL in exposed group. Moreover, BLL related to ALC at both times because the higher ALC of HF with VHF sections (exposed group) was found when compare to low exposed group. When lead is in the air, the small particles will be into the lungs. Then, they are absorbed into bloodstream. Multiple binary logistic regression showed the association between alcohol drinking and BLL at endpoint. The same as other research studies which reported that alcohol may increase the susceptibility of some organs, to lead toxicity, by depleting, levels of magnesium zinc and calcium (Bechetoille et al., 1983; Flora et al., 1991; Gupta & Gill, 2000).

5.8.2 Health risk factors and HLL

Our findings at baseline showed the relationship of HLL and age. Similar to the study of Strumylaite (2004) that showed a positive significant association between log lead in hair and age (Strumylaite et al., 2004). Another research reported that people older than 30 years old had higher HLL than those lower than 30 years old (Nowak, 1998). BMI related to HLL at baseline also. This result is similar to one research which reported that BMI associated with lead levels in blood in Chinese adult. That may be an important risk factor for Cardiovascular Disease (CVD) (C. Chen et al., 2017). There was an association between HLL and study at Signal school at baseline. If non-study at Signal school was shown increase in a 0.103-fold odds of HLL more than study at Signal school. In addition, there was an association between HLL and education level at endpoint. If workers graduated with lower than Bachelor’s degree there would show an increase of a 0.130-fold odds of HLL more than the workers graduated with Bachelor’s degree or higher. The study at Signal school and education level associated with HLL because low exposed group had lower HLL study at Signal school and graduated higher than exposed group. For milk drinking, the positive relationship with HLL at endpoint was also found. The result is different from a study which reported that drinking of milk could decrease level of lead in hair (Michalak et al., 2014) because calcium in milk will stop the lead from being absorbed into the body. Others food that contain high calcium could decrease content of lead as well. However, the result of this study was not the same as other research results because exposed group which had greater BLL drinks milk significantly higher than low exposed group. For another factor, it is surprising that the association between HLL and ALC was not found because the finding showed the relationship of BLL and ALC and the relationship of BLL and HLL.

5.8.3 Health risk factors and signs and symptoms of lead poisoning

Lead poisoning is very difficult to detect. Signs and symptoms of lead poisoning are not specific even people who look healthy can have high lead levels in blood. Therefore, relationships between signs and symptoms and various health risk factors were determine as well. There were 9 signs and symptoms including constipation, headache or dizziness, excessive tiredness or weakness, fine tremors, nervous irritability, insomnia, ALT levels, GFR levels, and hypertension related to health risk factors. For example, nervous irritability associated with alcohol drinking. Drinking alcohol associated with the dramatic changes in mood such as sadness and irritability was studied in 1998 (Moeller & Dougherty, 2001; F. G. Moeller, Dougherty, Lane, Steinberg, & Cherek, 1998). Insomnia related to smoking status as same as the study in Taiwan people (Chen, Steptoe, Chen, Ku, & Lin, 2017). For hepatic function, ALT levels related to BMI and exercise. High BMI has been identified as a factor of elevated ALT level. A study revealed that BMI was a strong risk factor of high ALT level in Koreans (J. Kim & Jo, 2010). There was a study reported that ALT levels were increased significantly after exercise in healthy men (Pettersson et al., 2008). In case of GFR levels, the association with age and BMI was found. It is certain that age related to GFR levels because GFR was calculated by using age. The older has the lower GFR in normal situation. For BMI, the meta-analysis of adults in 40 countries, researchers investigated that BMI, waist circumference, and waist-to-height ratio were associated with higher risk of GFR decline (Chang et al., 2019). In terms of hypertension, many risk factors are the causes. A study showed that blood pressure percentiles are steadily increased by BMI and age and most obese or overweight adults are hypertensive which is the same as in this study that showed the positive association of hypertension with age and BMI (Hosseini et al., 2015). Due to seafood contain a higher amount of sodium it may cause high blood pressure. Likewise this study revealed the positive association between hypertension and seafood consumption. In addition, the negative association of hypertension with exercise was found. One reason is regular physical activity makes the heart stronger which can pump more blood with less effort.

5.9 Association between lead levels (BLL and HLL) and signs and symptoms of lead poisoning among workers

Lead poisoning can cause many signs and symptoms which varies depending on the concentration, the duration of lead exposure and the individual (Coyle et al., 2005; Karri et al., 2008). Signs and symptoms are nonspecific and may be subtle, and those with elevated lead levels may have no symptoms (Tiwari et al., 2013).

For this study, our findings showed the association of signs and symptoms including loss of appetite, nausea and vomiting, excessive tiredness or weakness, headache or dizziness, nervous irritability, muscle and joint pain, insomnia, and hypertension with BLL. These signs and symptoms may occur slowly or may be caused by other factors, toxicity for lead can be overlooked. While exposure to high lead level may cause anemia, and kidney, liver and brain damage. Unfortunately, exposed to very high level of lead can cause death. A study showed that lead have the effect on the central nervous system which causes insomnia (Kosnett et al., 2007). When focus on hypertension, exposure to low level of lead can cause high blood pressure in both animals and humans. There are a lot of evidence of causal relationship of exposure to lead and hypertension was reported but it is applicable only in cases of cardiovascular outcomes of lead toxicity (Flora et al., 2012). Chronic exposure to low level of lead might have both direct and indirect effects on the development of hypertension. Possible mechanisms of lead toxicity on developing hypertension such as nephrotoxicity, direct action on vascular smooth muscle, disruption of cellular calcium regulation that increases contractility of end arteriole smooth muscle, changes in permeability of blood vessels and catecholamine content of myocardium and blood vessels (Hertz-Picciotto & Croft, 1993; H. Hu et al., 1996). There were cases of increased blood pressure associated with nephrosclerosis have been reported in high lead exposure people. An increase of BLL from lower than 12 μg/dL to more than 25 μg/dL resulted in increases in blood pressure of 1.4-4 mmHg diastolic and 1.48 mmHg systolic (Hertz-Picciotto & Croft, 1993). By the way, this study did not find the relation between lead level and kidney function.

Regarding to HLL, only nervous irritability and muscle and joint pain associated with it at endpoint. The associations might be found when the high lead level in the body because the associations at baseline were not found.

5.10 Lead poisoning risk assessment among workers

Nowadays, there is no appropriate RfD or NOAEL value of lead. A tolerable daily intake (TDI) of lead which is conducted by the National Institute for Public Health and the Environment was used as the RfD (3.6×10^{-3} mg/kg-day) in this study. The reasonable maximum exposure (RME) is the worst-case scenario that evaluates exposure that higher than average. The 95th percentile is used to evaluate RME because the situation involves the uncertainty of concentration value (Jaipieam et al., 2009; Taneepanichskul et al., 2010). After calculation the result showed health effects of lead exposure are at risk. RME concentration of exposed group at baseline, exposed group and low exposed group at endpoint were higher than the standard of OSHA which is at 30 μg/m^3. Moreover, NIOSH suggested 5 μg/dL of BLL as the reference for adults, median BLL among workers in exposed group at endpoint was 5.5 μg/dL. Therefore, the results of BLL and ALC related to the risk assessment were found. However, risk assessment of this study showed only inhalation pathway. The risk may also come from ingestion pathway. The risk might be higher than the result of this study.

CHAPTER VI
CONCLUSION

6.1 Conclusions

The first hypothesis is rejected because the study showed that low lead level in blood and hair were found among communication radio-repair workers in the Signal school department RTA. The study may conclude that the highest median BLL of the communication radio-repair workers at endpoint cause by direct exposed to lead while working which related to lead concentrations in the air that were measured. However, lead level in blood was still lower than the health concerned standard.

The second hypothesis about the correlation lead level in blood and hair among workers is accepted because a low positive correlation between BLL and HLL was found. For low level of lead in hair, it may cause of low BLL.

The third hypothesis about exposure to lead has the effects on signs and symptoms of lead poisoning among workers is accepted because the association of signs and symptoms of lead poisoning including loss of appetite, nausea and vomiting, excessive tiredness or weakness, headache or dizziness, nervous irritability, muscle and joint pain, insomnia, and hypertension with BLL was shown. In addition, there were also the associations of nervous irritability and muscle and joint pain with HLL **(Table 90)**.

Table 90: *Summary table of the associations between lead level (BLL and HLL) and signs and symptoms of lead poisoning.*

Signs and symptoms of lead poisoning	BLL		HLL	
	Baseline	Endpoint	Baseline	Endpoint
Loss of Appetite	**	-	-	-
Constipation	-	-	-	-
Nausea or Vomit	*	-	-	-
Weakness	*	**	-	-
Headache or Dizziness	*	**	-	-
Fine tremors	-	-	-	-
Nervous irritability	*	***	-	*
Muscle and joint pain	-	***	-	*
Insomnia	**	*	-	-
Numbness	-	-	-	-
Hepatic Function, AST	-	-	-	-
Hepatic Function, ALT	-	-	-	-
Kidney Function, GFR	-	-	-	-
Hypertension	*	*	-	-

* Significance at *P-value* less than 0.05 level, ** Significance at *P-value* less than 0.01 level, *** Significance at *P-value* less than 0.001 level

The last hypothesis of the study is accepted because lead poisoning assessment among workers in communication radio-repair plant may be getting risk for exposure to low dose of lead. The results showed that health effects for lead exposure can be occurred with a chance of 1.6 and 2.4 times in low exposed and exposed groups, respectively.

The study also found that the workers had little knowledge about lead poisoning and low of PPE used during work although they concern about lead poisoning.

6.2 Benefits of this study

6.2.1 This study helps to identify problems that may occur with workers in this plant.

6.2.2 This study hopes to make the workers have morale.

6.2.3 Making supervisors and workers aware of lead poisoning and know the risks that may occur from lead exposure.

6.3 Limitations of the study

6.3.1 An error from reporting signs and symptoms of lead poisoning in questionnaire may occur because of subjective bias based on individual remembering. However, the researchers solved the problem by using face to face interview for everyone.

6.3.2 BLL reflects recently the amount of lead in the human body but may not indicate an accumulated exposure. Because lead can be stored in the bone, and it's released from bone into the bloodstream at differing rates which depending on age, gender, and other factors. Therefore, the study of lead accumulation in bone is interesting for determining lead poisoning.

6.4 Recommendations for further study

6.4.1 A longitudinal study should be employed to follow the lead poisoning among workers in this plant for further study. Because some signs and symptoms of lead poisoning have not shown in the low dose of lead exposure. Recent evidence from epidemiological and toxicological studies suggests that chronic low level of lead exposure can damage the heart, kidneys, liver and brain.

6.4.2 Since lead directly affects the brain or nervous system, there should be a measurement of the brain function as well.

6.4.3 The results of the research showed that workers had little knowledge about lead poisoning. Although workers were aware of lead poisoning but the use of PPE was also low. Therefore, increasing of knowledge and awareness for lead poisoning should be provided as a preventive measure among workers. Moreover, the use of PPE should be promoted as a habit of all workers especially in repair workers.

6.4.4 This study focuses only on inhalation pathway for health risk assessment of lead exposure. However, the ingestion pathway should be concerned because larger lead particles that cannot get into the lungs can be coughed up and swallowed. Furthermore, the workers may not wash their hands before the meal. Finally, this research study did not investigate the health risk assessment of lead exposure in workers' house.

6.4.5 The results of the research may use for create a preventive program of lead poisoning prevention as an intervention for the plant workers. Then, the study of intervention should be conducted in the further study.

APPENDICES

APPENDIX A
THE ETHICAL APPROVAL DOCUMENTS

AF 01-12

คณะกรรมการพิจารณาจริยธรรมการวิจัยในคน กลุ่มสหสถาบัน ชุดที่ 1 จุฬาลงกรณ์มหาวิทยาลัย
254 อาคารจามจุรี 1 ชั้น 2 ถนนพญาไท เขตปทุมวัน กรุงเทพฯ 10330
โทรศัพท์/โทรสาร: 0-2218-3202 E-mail: eccu@chula.ac.th

COA No. 107/2560

ใบรับรองโครงการวิจัย

โครงการวิจัยที่ 062.1/60 : พิษของสารตะกั่วต่อพนักงานซ่อมวิทยุสื่อสาร กรมการทหารสื่อสาร กองทัพบก จังหวัดสมุทรสาคร

ผู้วิจัยหลัก : ร้อยเอกมนัสวี ทองศฤงคลี

หน่วยงาน : วิทยาลัยวิทยาศาสตร์สาธารณสุข จุฬาลงกรณ์มหาวิทยาลัย

คณะกรรมการพิจารณาจริยธรรมการวิจัยในคน กลุ่มสหสถาบัน ชุดที่ 1 จุฬาลงกรณ์มหาวิทยาลัย ได้พิจารณา โดยใช้หลัก ของ The International Conference on Harmonization – Good Clinical Practice (ICH-GCP) อนุมัติให้ดำเนินการศึกษาวิจัยเรื่องดังกล่าวได้

ลงนาม.. (รองศาสตราจารย์ นายแพทย์ปรีดา ทัศนประดิษฐ) ประธาน

ลงนาม.. (ผู้ช่วยศาสตราจารย์ ดร.นันทรี ชัยชนะวงศาโรจน์) กรรมการและเลขานุการ

วันที่รับรอง : 24 พฤษภาคม 2560 **วันหมดอายุ** : 23 พฤษภาคม 2561

เอกสารที่คณะกรรมการรับรอง
1) โครงการวิจัย
2) ข้อมูลสำหรับกลุ่มประชากรหรือผู้มีส่วนร่วมในการวิจัยและใบยินยอมของกลุ่มประชากรหรือผู้มีส่วนร่วมในการวิจัย
3) ผู้วิจัย
4) แบบสอบถาม

เลขที่โครงการวิจัย 062.1/60
วันที่รับรอง 24 พ.ค. 2560
วันหมดอายุ 23 พ.ค. 2561

<u>เงื่อนไข</u>

1. ข้าพเจ้ารับทราบว่าเป็นการผิดจริยธรรม หากดำเนินการเก็บข้อมูลการวิจัยก่อนได้รับการอนุมัติจากคณะกรรมการพิจารณาจริยธรรมการวิจัยฯ
2. หากใบรับรองโครงการวิจัยหมดอายุ การดำเนินการวิจัยต้องยุติ เมื่อต้องการต่ออายุต้องขออนุมัติใหม่ล่วงหน้าไม่ต่ำกว่า 1 เดือน พร้อมส่งรายงานความก้าวหน้าการวิจัย
3. ต้องดำเนินการวิจัยตามที่ระบุไว้ในโครงการวิจัยอย่างเคร่งครัด
4. ใช้เอกสารข้อมูลสำหรับกลุ่มประชากรหรือผู้มีส่วนร่วมในการวิจัย ใบยินยอมของกลุ่มประชากรหรือผู้มีส่วนร่วมในการวิจัย และเอกสารเชิญเข้าร่วมวิจัย (ถ้ามี) เฉพาะที่ประทับตราคณะกรรมการเท่านั้น
5. หากเกิดเหตุการณ์ไม่พึงประสงค์ร้ายแรงในสถานที่เก็บข้อมูลที่ขออนุมัติจากคณะกรรมการ ต้องรายงานคณะกรรมการภายใน 5 วันทำการ
6. หากมีการเปลี่ยนแปลงการดำเนินการวิจัย ให้ส่งคณะกรรมการพิจารณารับรองก่อนดำเนินการ
7. โครงการวิจัยไม่เกิน 1 ปี ส่งแบบรายงานสิ้นสุดโครงการวิจัย (AF 03-12) และบทคัดย่อผลการวิจัยภายใน 30 วัน เมื่อโครงการวิจัยเสร็จสิ้น สำหรับโครงการวิจัยที่เป็นวิทยานิพนธ์ให้ส่งบทคัดย่อผลการวิจัย ภายใน 30 วัน เมื่อโครงการวิจัยเสร็จสิ้น

Figure 10: *Approved from Ethics Review Committee of Chulalongkorn University*

RL 01 2560

คณะอนุกรรมการพิจารณาโครงการวิจัย กรมแพทย์ทหารบก

317/5 ถนนราชวิถี เขตราชเทวี กรุงเทพฯ 10400

ที่ IRBRTA...315.... **/2561** **รหัสโครงการ: S056h/60**

ชื่อโครงการวิจัย :	พิษของสารตะกั่วต่อพนักงานซ่อมวิทยุสื่อสาร กรมการทหารสื่อสารกองทัพบก จังหวัดสมุทรสาคร [Lead Poisoning among Communication Radio-repair Workers in Signal Department Royal Thai Army, Samutsakhon Province]
เลขที่โครงการวิจัย :	-
ชื่อผู้วิจัยหลัก:	ร้อยเอก มนัสวี ทองศฤงคลี
สังกัดหน่วยงาน :	กรมยุทธศึกษาทหารบก (ยศ.ทบ.)
สถานที่ทำการวิจัย:	กองร้อยทหารสื่อสารซ่อมบำรุงเขตหลัง (ร้อย ส.ซบร.เขตหลัง) กรมการทหารสื่อสาร กองทัพบก ค่ายกำแพงเพชรอัครโยธินจังหวัดสมุทรสาคร

เอกสารรับรอง :

(1) แบบรายงานการส่งโครงร่างการวิจัยเพื่อพิจารณาครั้งแรก ฉบับที่ 1 ลงวันที่ 1 พฤศจิกายน 2560
(2) โครงร่างการวิจัย ฉบับที่ 2 ลงวันที่ 26 กุมภาพันธ์ 2561
(3) เอกสารชี้แจงข้อมูลแก่ผู้เข้าร่วมโครงการวิจัย และหนังสือแสดงเจตนายินยอมเข้าร่วมการวิจัย ฉบับที่ 2 ลงวันที่ 26 กุมภาพันธ์ 2561
(4) แบบสอบถาม (ฉบับภาษาไทยและภาษาอังกฤษ) ฉบับที่ 1 ลงวันที่ 1 พฤศจิกายน 2560
(5) ประวัติผู้วิจัย ร.อ.มนัสวี ทองศฤงคลี ฉบับที่ 1 ลงวันที่ 1 พฤศจิกายน 2560
(6) ประวัติที่ปรึกษา รศ.ดร.วัฒน์สิทธิ์ ศิริวงศ์ ฉบับที่ 1 ลงวันที่ 1 พฤศจิกายน 2560

ขอรับรองว่าโครงการดังกล่าวข้างต้นได้ผ่านการพิจารณารับรองจากคณะอนุกรรมการพิจารณาโครงการวิจัย กรมแพทย์ทหารบกว่าสอดคล้องกับแนวทางจริยธรรมสากล ได้แก่ ปฏิญญาเฮลซิงกิ รายงานเบลมองต์แนวทางจริยธรรมสากลสำหรับการวิจัยในมนุษย์ของสภาองค์การสากลด้านวิทยาศาสตร์การแพทย์ (CIOMS) และแนวทางการปฏิบัติการวิจัยที่ดี (ICH GCP)

วันที่รับรองด้านจริยธรรมของโครงร่างการวิจัย:	6 มีนาคม 2561
วันสิ้นสุดการรับรอง:	5 มีนาคม 2562
ความถี่ของการส่งรายงานความก้าวหน้าของการวิจัย:	1 ปี

พันเอกหญิง [signature]

(แสงแข ชำนาญวนกิจ)

ประธานคณะอนุกรรมการพิจารณาโครงการวิจัย

กรมแพทย์ทหารบก

สำนักงานคณะอนุกรรมการพิจารณาโครงการวิจัย พบ.

Figure 11: *Approved from Ethics Review Committee of Royal Thai Army Medical Department*

APPENDIX B
PERSONAL DATA QUESTIONNAIRE (THAI VERSION)

รหัสผู้ทำแบบสอบถาม..........

แบบสอบถาม **"พิษจากตะกั่วต่อเจ้าหน้าที่ในโรงงานซ่อมวิทยุสื่อสาร กรมการทหารสื่อสาร กองทัพบก"** (ครั้งที่ 1) ผู้จัดทำขอความร่วมมือจากท่าน ตอบแบบสอบถามชุดนี้ ตามความคิดของท่านโดยอิสระ เพื่อเป็นประโยชน์ในการใช้เป็นข้อมูลทำการศึกษาวิจัย

คำชี้แจง โปรดกรอกข้อมูล หรือทำเครื่องหมาย ✓ ลงในช่องว่างให้ชัดเจน

<u>ส่วนที่ 1 ข้อมูลทั่วไป</u>

1. อายุ .... ปี
2. น้ำหนัก .... กก. ส่วนสูง .... ซ.ม.
3. สถานที่ทำงาน ....
4. ตำแหน่งงานปัจจุบัน ....
5. สถานภาพสมรส ☐ โสด ☐ คู่ ☐ หม้าย ☐ แยกกันอยู่
6. ที่อยู่ภูมิลำเนาเดิม (จังหวัด) ....
7. ที่อยู่ปัจจุบัน (จังหวัด) ....
8. ระดับการศึกษาสูงสุด ☐ ประถมศึกษา ☐ มัธยมศึกษาตอนต้น ☐ มัธยมศึกษาตอนปลาย
   ☐ อาชีวศึกษา ☐ ปริญญาตรี ☐ สูงกว่าปริญญาตรี
   ☐ อื่นๆระบุ ....
9. ท่านจบการศึกษาจากโรงเรียนนายสิบ (สื่อสาร) หรือไม่
   ☐ ใช่ ☐ ไม่ใช่ (ระบุ) ....
10. ท่านสูบบุหรี่หรือไม่ (หากไม่สูบ ข้ามข้อ 11) ☐ สูบ ☐ ไม่สูบ
11. ท่านสูบบุหรี่เฉลี่ยวันละ ☐ ไม่ถึง 1 ซอง/วัน ☐ 1-2 ซอง/วัน ☐ มากกว่า 2 ซอง/วัน
12. ท่านดื่มเครื่องดื่มแอลกอฮอล์หรือไม่ (หากไม่ดื่ม ข้ามข้อ 13) ☐ ดื่ม ☐ ไม่ดื่ม
13. ท่านดื่มเครื่องดื่มแอลกอฮอล์เฉลี่ยกี่วันต่อสัปดาห์
   ☐ 1-2 วัน/สัปดาห์ ☐ 3-4 วัน/สัปดาห์
   ☐ 5-7 วัน/สัปดาห์ ☐ อื่นๆ ระบุ ....
14. ท่านดื่มนมหรือไม่ (หากไม่ดื่ม ข้ามข้อ 15) ☐ ดื่ม ☐ ไม่ดื่ม

15.ท่านดื่มนมหรือไม่เฉลี่ยกี่วันต่อสัปดาห์

☐ 1-2 วัน/สัปดาห์ ☐ 3-4 วัน/สัปดาห์

☐ 5-7 วัน/สัปดาห์ ☐ อื่นๆ ระบุ ....

16.ท่านทานอาหารทะเลหรือไม่ (หากไม่ทาน ข้ามข้อ 17) ☐ ทาน ☐ ไม่ทาน

17.ท่านทานอาหารทะเลเฉลี่ยกี่วันต่อสัปดาห์

☐ 1-2 วัน/สัปดาห์ ☐ 3-4 วัน/สัปดาห์

☐ 5-7 วัน/สัปดาห์ ☐ อื่นๆ ระบุ ....

18.ท่านออกกำลังกายหรือไม่

☐ ทุกวัน ☐ 3-5 วัน/สัปดาห์ ☐ น้อยกว่า 3 วัน/สัปดาห์ ☐ ไม่เลย

<u>ส่วนที่ 2 ข้อมูลการทำงาน</u>

19.ท่านทำงานที่โรงงานซ่อมฯตั้งแต่อายุ .... ปี

20.ระยะเวลาที่ท่านทำงานที่โรงงานซ่อมฯ .... ปี

21.ระยะเวลาในการปฏิบัติงานในแต่ละวันเฉลี่ย .... ชั่วโมง/วัน และ .... วัน/สัปดาห์

22.ลักษณะงานที่ทำ

☐ ซ่อมวิทยุสื่อสาร ระบุชนิดของวิทยุสื่อสาร ....

☐ ตรวจงานซ่อม ระบุชนิดของวิทยุสื่อสาร ....

☐ อื่นๆ ระบุ ....

23.ท่านซ่อมวิทยุสื่อสารเฉลี่ย .... เครื่อง/สัปดาห์

24.ปกติท่านใช้ตะกั่วบัดกรีกี่ม้วนต่อเดือน .... ม้วน/เดือน

25.ท่านเคยซ่อมวิทยุสื่อสารชนิดอื่น (นอกจากข้อ 23) มาก่อนหรือไม่

☐ ไม่เคย ☐ เคย ระบุ .... ทำมานาน .... ปี

26.ช่วงเวลา 6 เดือนที่ผ่านมา ท่านทำงาน ณ ที่ตั้งตลอดหรือไม่

☐ ใช่ ☐ ไม่ใช่ ระบุ (สถานที่) ....

27.ปัจจุบันท่านทำงานพิเศษหรืองานอดิเรกอย่างอื่นที่เกี่ยวข้องกับโลหะหนักจำพวกตะกั่วหรือไม่

☐ ไม่มี ☐ มี ระบุ .... ทำมานาน .... ปี

<u>ส่วนที่ 3 การประเมินด้านความรู้ ความตระหนัก และการปฏิบัติ</u>

ความรู้

28.การตรวจสารตะกั่วในร่างกาย สามารถตรวจได้จากทางเลือดเท่านั้น

☐ ใช่ ☐ ไม่ใช่ ☐ ไม่แน่ใจ

29.สารตะกั่วสามารถเข้าสู่ร่างกายได้มากที่สุดโดยผ่านทางการหายใจ

☐ ใช่ ☐ ไม่ใช่ ☐ ไม่แน่ใจ

30.สารตะกั่วเมื่อเข้าสู่ร่างกาย จะสะสมมากที่สุดที่กระดูกและฟัน

☐ ใช่ ☐ ไม่ใช่ ☐ ไม่แน่ใจ

31.พิษของสารตะกั่ว สามารถทำให้ผู้ชายเป็นหมันได้

☐ ใช่ ☐ ไม่ใช่ ☐ ไม่แน่ใจ

32.ระดับของสารตะกั่วในเลือดที่ยอมรับได้ในผู้ที่ทำงานใกล้ชิดตะกั่วคือ น้อยกว่า 40 µg/dl

☐ ใช่ ☐ ไม่ใช่ ☐ ไม่แน่ใจ

ความตระหนัก

33.ท่านสามารถทานอาหารหรือดื่มเครื่องดื่มในบริเวณที่ท่านปฏิบัติงาน

☐ เห็นด้วย ☐ เฉยๆ ☐ ไม่เห็นด้วย

34.ท่านต้องล้างมือทุกครั้งหลังปฏิบัติงานเสร็จ

☐ เห็นด้วย ☐ เฉยๆ ☐ ไม่เห็นด้วย

35.บางครั้งการทำงานต้องอาศัยความรวดเร็วในการทำงาน จึงไม่จำเป็นต้องใช้อุปกรณ์ป้องกันส่วนบุคคลทุกครั้งในขณะปฏิบัติงาน

☐ เห็นด้วย ☐ เฉยๆ ☐ ไม่เห็นด้วย

36.ท่านควรสวมหน้ากากในขณะซ่อมวิทยุสื่อสารทุกครั้ง

☐ เห็นด้วย ☐ เฉยๆ ☐ ไม่เห็นด้วย

37.ท่านควรสวมถุงมือในขณะซ่อมวิทยุสื่อสารทุกครั้ง

☐ เห็นด้วย ☐ เฉยๆ ☐ ไม่เห็นด้วย

38.ท่านสามารถใส่เสื้อขณะปฏิบัติงานกลับบ้าน

☐ เห็นด้วย ☐ เฉยๆ ☐ ไม่เห็นด้วย

การปฏิบัติ

39.ท่านใช้อุปกรณ์ดังต่อไปนี้ในขณะปฏิบัติงานหรือไม่

- หน้ากาก ☐ ทุกครั้ง ☐ บางครั้ง ☐ ไม่ใช้
- ถุงมือ ☐ ทุกครั้ง ☐ บางครั้ง ☐ ไม่ใช้
- ชุดปฏิบัติงาน ☐ ทุกครั้ง ☐ บางครั้ง ☐ ไม่ใช้
- แว่นตานิรภัย ☐ ทุกครั้ง ☐ บางครั้ง ☐ ไม่ใช้
- เครื่องดูดควัน ☐ ทุกครั้ง ☐ บางครั้ง ☐ ไม่ใช้

ส่วนที่ 4 ประวัติสุขภาพ

40.ท่านมีโรคประจำตัวก่อนเข้าทำงานหรือไม่

☐ ไม่มี ☐ มี ระบุ ....

41.ปัจจุบันท่านมีโรคประจำตัวหรือไม่

☐ ไม่มี ☐ มี ระบุ ....

42.ท่านมียาประจำตัวหรือไม่ ☐ ไม่มี ☐ มี ระบุ..

43.ใน 1 เดือนที่ผ่านมา ท่านมีอาการเหล่านี้หรือไม่ ตอบได้มากกว่า 1 ข้อ

☐ เบื่ออาหาร
☐ ท้องผูก
☐ คลื่นไส้ อาเจียน
☐ เหนื่อยง่าย และอ่อนล้า
☐ ปวดศีรษะหรือวิงเวียนศีรษะ
☐ สั่นเล็กน้อย
☐ ปวดท้องบริเวณรอบสะดือ
☐ ลิ้นมีความรู้สึกรับรสโลหะ
☐ หงุดหงิดง่าย
☐ ข้อมือหรือข้อเท้าตก
☐ ปวดบริเวณกล้ามเนื้อและข้อต่อ
☐ นอนไม่หลับ
☐ มึนงง
☐ มีเส้นสีน้ำเงินบนเหงือก

44.ความดันโลหิตของท่าน .... มม.ปรอท

45.ท่านเคยมีประวัติโรคพิษจากสารตะกั่วหรือไม่

☐ ไม่เคย ☐ เคย ระบุ ....

46.ท่านเคยทานยาขับสารตะกั่วออกจากร่างกายหรือไม่

☐ ไม่เคย ☐ เคย ระบุ ....

ส่วนที่ 5 ผลการตรวจความปกติของ ไต ตับ และโลหิตจาง

47.ระดับความปกติของไต (วัดจากค่า GFR; หน่วย mL/min/1.73 m^2)

☐ ปกติ ($\geq$90) ☐ ลดลงเล็กน้อย (60-89) ☐ ปานกลาง (30-59)

☐ รุนแรง (15-29) ☐ ไตล้มเหลว (<15)

48.ความปกติของตับ

- AST (ค่าปกติ 0-37 U/L) ☐ ปกติ ☐ ผิดปกติ
- ALT (ค่าปกติ 0-41 U/L) ☐ ปกติ ☐ ผิดปกติ

49.ผลการตรวจหาภาวะโลหิตจาง

☐ ปกติ ☐ ผิดปกติ

APPENDIX C
PERSONAL DATA QUESTIONNAIRE (ENGLISH VERSION)

Questionnaire Code ....

Questionnaire **"Lead Poisoning among Communication Radio-repair Workers in Royal Thai Army Signal Department"** (1st time)

Please fill your information in the blank and mark ✓ into the ☐.

Part 1 General information

1. Age.......................... Years
2. Weight................ Kg. Height .... cm.
3. Workplace (Office) ....
4. Job description ....
5. Marital status ☐ Single ☐ Couple ☐ Widow ☐ Divorce
6. Hometown (Province) ....
7. Recently Address (Province) ....
8. Highest Education levels

   ☐ Primary School ☐ Secondary School ☐ High School

   ☐ Vocational ☐ Bachelor Degree ☐ > Bachelor Degree

   ☐ Others...
9. Do you graduate from Sergeant School (Signal sector)

   ☐ Yes ☐ No (please specify) ....
10. Do you smoke? (If no, skip question number 11)

   ☐ Yes ☐ No
11. How many cigarettes do you smoke per day?

   ☐ < 1 pack ☐ 1-2 pack ☐ > 2 pack
12. Do you drink alcohol? (If no, skip question number 13)

   ☐ Yes ☐ No
13. How often do you drink alcohol per week?

   ☐ 1-2 days ☐ 3-4 days

   ☐ 5-7 days ☐ other (please specify) ....

14.Do you drink milk? (If no, skip question number 15)

☐ Yes ☐ No

15.How often do you drink milk per week?

☐ 1-2 days/week ☐ 3-4 days/week

☐ 5-7 days/week ☐ other (please specify) ....

16.Do you eat sea food? (If no, skip question number 17)

☐ Yes ☐ No

17. How often do you eat sea food (days/week)?

☐ 1-2 days/week ☐ 3-4 days/week

☐ 5-7 days/week ☐ other (please specify) ....

18. Do you exercise?

☐ Everyday ☐ $\geq$ 3 days/week

☐ < 3 days/week ☐ None

<u>Part 2 Working conditions</u>

19.When did you start working here ....years

20.Work duration................... years

21.Average of work duration .... hours/day and .... days/week

22.What is the type of your work?

☐ Repair communication radio (please specify type of communication radio)

....

☐ Inspector (please specify type of communication radio)

....

☐ Others (please specify)

....

23.How many communication radios do you repair per week? ....

24.How many roll of soldering lead that you use per month? .... rolls/month

25.Have you ever repaired other communication radios (from question 26)?

☐ No ☐ Yes (please specify).................... How long.........years

26.Did you work at your installation during last 3 months?

☐ Yes ☐ No (please specify; places)..

27.Do you have any hobbies or extra jobs related with heavy metal lead?

☐ No ☐ Yes (please specify)................................ How long.......... years

Part 3 Knowledge, Awareness, and Practice (KAP) of Lead Poisoning

Knowledge of lead poisoning

28.Blood test is only way to detect lead poisoning.

☐ True ☐ False ☐ I do not know

29. The most route of lead exposure for workers is inhalation.

☐ True ☐ False ☐ I do not know

30. Most of lead will accumulated in the bones and teeth.

☐ True ☐ False ☐ I do not know

31. Lead causes decrease of sperms.

☐ True ☐ False ☐ I do not know

32. Blood lead level of workers should be less than 40 μg/dl.

☐ True ☐ False ☐ I do not know

Awareness of PPE use and personal hygiene

33. You can eat or drink while you are working.

☐ Agree ☐ Not bothered ☐ Disagree

34. It is very important to wash your hand after finishing working.

☐ Agree ☐ Not bothered ☐ Disagree

35. Sometimes it is necessary to ignore safety rules in order to speed up work and increase production.

☐ Agree ☐ Not bothered ☐ Disagree

36. You should wear a mask during work every time.

☐ Agree ☐ Not bothered ☐ Disagree

37. You should use gloves during work every time.

☐ Agree ☐ Not bothered ☐ Disagree

38. You can wear work uniform back home

☐ Agree ☐ Not bothered ☐ Disagree

PPE use

39. Do you use these equipment during work?

- Goggles	☐ Every time	☐ Sometimes	☐ Never
- Work uniform	☐ Every time	☐ Sometimes	☐ Never
- Dust respirator	☐ Every time	☐ Sometimes	☐ Never
- Gloves	☐ Every time	☐ Sometimes	☐ Never
- Exhaust ventilator	☐ Every time	☐ Sometimes	☐ Never

Part 4 Personal health history

40. Do you have any Underlying Diseases before working here?

☐ No ☐ Yes (please specify)..

41. Do you have any Underlying Diseases now?

☐ No ☐ Yes (please specify)..

42. Do you have any medicine that you take every day?

☐ No ☐ Yes (please specify)..

43. Have you ever had these signs and symptoms for 1 month? (You can choose more than 1 item)

☐ Loss of appetite	☐ Constipation
☐ Nausea or Vomit	☐ Excessive tiredness and Weakness
☐ Headache or Dizziness	☐ Fine tremors
☐ Colic pain	☐ Metallic taste in the mouth
☐ Nervous irritability	☐ Wrist and Foot drop
☐ Muscle and joint pain	☐ Insomnia
☐ Numbness	☐ Lead line on the gum

44. How much blood pressure do you have? .... mm.Hg.

45. Have you ever been lead poisoning?

☐ No ☐ Yes, How long.............years ago

46. Have you ever taken drug to excrete lead from body?

☐ No ☐ Yes (please specify)...........................How long.............years

Part 5 Result of Kidney function, Liver function, and Anemia

47. Kidney function (GFR; mL/min/1.73 m^2)

☐ Normal (≥90) ☐ Mild decrease (60-89)

☐ Moderate decrease (30-59) ☐ Severe decrease (15-29)

☐ Kidney failure (<15)

48. Liver function

- AST (Normal level 0-37 U/L) ☐ Normal ☐ Abnormal
- ALT (Normal level 0-41 U/L) ☐ Normal ☐ Abnormal

49. Anemia

☐ No ☐ Yes

APPENDIX D

PERSONAL DATA QUESTIONNAIRE (THAI VERSION)

รหัสผู้ทำแบบสอบถาม..........

แบบสอบถาม **"พิษจากตะกั่วต่อเจ้าหน้าที่ในโรงงานซ่อมวิทยุสื่อสาร กรมการทหารสื่อสาร กองทัพบก"** (ครั้งที่ 2) ผู้จัดทำขอความร่วมมือจากท่าน ตอบแบบสอบถามชุดนี้ ตามความคิดของท่านโดยอิสระ เพื่อเป็นประโยชน์ในการใช้เป็นข้อมูลทำการศึกษาวิจัย

คำชี้แจง โปรดกรอกข้อมูล หรือทำเครื่องหมาย ✓ ลงในช่องว่างให้ชัดเจน

<u>**ส่วนที่ 1 ข้อมูลทั่วไป**</u>

1. อายุ .... ปี
2. น้ำหนัก .... กก. ส่วนสูง .... ซ.ม.
3. สถานที่ทำงาน ....
4. ตำแหน่งงานปัจจุบัน ....
5. สถานภาพสมรส ☐ โสด ☐ คู่ ☐ หม้าย ☐ แยกกันอยู่
6. ที่อยู่ภูมิลำเนาเดิม (จังหวัด) ....
7. ที่อยู่ปัจจุบัน (จังหวัด) ....
8. ระดับการศึกษาสูงสุด ☐ ประถมศึกษา ☐ มัธยมศึกษาตอนต้น ☐ มัธยมศึกษาตอนปลาย ☐ อาชีวศึกษา ☐ ปริญญาตรี ☐ สูงกว่าปริญญาตรี ☐ อื่นๆระบุ ....
9. ท่านจบการศึกษาจากโรงเรียนนายสิบ (สื่อสาร) หรือไม่
   ☐ ใช่ ☐ ไม่ใช่ (ระบุ) ....
10. ท่านสูบบุหรี่หรือไม่ (หากไม่สูบ ข้ามข้อ 11) ☐ สูบ ☐ ไม่สูบ
11. ท่านสูบบุหรี่เฉลี่ยวันละ ☐ ไม่ถึง 1 ซอง/วัน ☐ 1-2 ซอง/วัน ☐ มากกว่า 2 ซอง/วัน
12. ท่านดื่มเครื่องดื่มแอลกอฮอล์หรือไม่ (หากไม่ดื่ม ข้ามข้อ 13) ☐ ดื่ม ☐ ไม่ดื่ม
13. ท่านดื่มเครื่องดื่มแอลกอฮอล์เฉลี่ยกี่วันต่อสัปดาห์
    ☐ 1-2 วัน/สัปดาห์ ☐ 3-4 วัน/สัปดาห์
    ☐ 5-7 วัน/สัปดาห์ ☐ อื่นๆ ระบุ ....
14. ท่านดื่มนมหรือไม่ (หากไม่ดื่ม ข้ามข้อ 15) ☐ ดื่ม ☐ ไม่ดื่ม

15.ท่านดื่มนมหรือไม่เฉลี่ยกี่วันต่อสัปดาห์

☐ 1-2 วัน/สัปดาห์ ☐ 3-4 วัน/สัปดาห์

☐ 5-7 วัน/สัปดาห์ ☐ อื่นๆ ระบุ ....

16.ท่านทานอาหารทะเลหรือไม่ (หากไม่ทาน ข้ามข้อ 17) ☐ ทาน ☐ ไม่ทาน

17.ท่านทานอาหารทะเลเฉลี่ยกี่วันต่อสัปดาห์

☐ 1-2 วัน/สัปดาห์ ☐ 3-4 วัน/สัปดาห์

☐ 5-7 วัน/สัปดาห์ ☐ อื่นๆ ระบุ ....

18.ท่านออกกำลังกายหรือไม่

☐ ทุกวัน ☐ 3-5 วัน/สัปดาห์ ☐ น้อยกว่า 3 วัน/สัปดาห์ ☐ ไม่เลย

<u>ส่วนที่ 2 ข้อมูลการทำงาน</u>

19.ท่านทำงานที่โรงงานซ่อมฯตั้งแต่อายุ .... ปี

20.ระยะเวลาที่ท่านทำงานที่โรงงานซ่อมฯ .... ปี

21.ระยะเวลาในการปฏิบัติงานในแต่ละวันเฉลี่ย .... ชั่วโมง/วัน และ .... วัน/สัปดาห์

22.ลักษณะงานที่ทำ

☐ ซ่อมวิยุสื่อสาร ระบุชนิดของวิทยุสื่อสาร ....

☐ ตรวจงานซ่อม ระบุชนิดของวิทยุสื่อสาร ....

☐ อื่นๆ ระบุ ....

23.ท่านซ่อมวิทยุสื่อสารเฉลี่ย .... เครื่อง/สัปดาห์

24.ปกติท่านใช้ตะกั่วบัดกรีกี่ม้วนต่อเดือน .... ม้วน/เดือน

25.ท่านเคยซ่อมวิทยุสื่อสารชนิดอื่น (นอกจากข้อ 23) มาก่อนหรือไม่

☐ ไม่เคย ☐ เคย ระบุ .... ทำมานาน .... ปี

26.ช่วงเวลา 6 เดือนที่ผ่านมา ท่านทำงาน ณ ที่ตั้งตลอดหรือไม่

☐ ใช่ ☐ ไม่ใช่ ระบุ (สถานที่) ....

27.ปัจจุบันท่านทำงานพิเศษหรืองานอดิเรกอย่างอื่นที่เกี่ยวข้องกับโลหะหนักจำพวกตะกั่วหรือไม่

☐ ไม่มี ☐ มี ระบุ .... ทำมานาน .... ปี

<u>ส่วนที่ 3 การประเมินด้านความตระหนัก และการปฏิบัติ</u>

ความตระหนัก

28.ท่านสามารถทานอาหารหรือดื่มเครื่องดื่มในบริเวณที่ท่านปฏิบัติงาน

☐ เห็นด้วย ☐ เฉยๆ ☐ ไม่เห็นด้วย

29.ท่านต้องล้างมือทุกครั้งหลังปฏิบัติงานเสร็จ

☐ เห็นด้วย ☐ เฉยๆ ☐ ไม่เห็นด้วย

30.บางครั้งการทำงานต้องอาศัยความรวดเร็วในการทำงาน จึงไม่จำเป็นต้องใช้อุปกรณ์ป้องกันส่วนบุคคลทุกครั้งในขณะปฏิบัติงาน

☐ เห็นด้วย ☐ เฉยๆ ☐ ไม่เห็นด้วย

31.ท่านควรสวมหน้ากากในขณะซ่อมวิทยุสื่อสารทุกครั้ง

☐ เห็นด้วย ☐ เฉยๆ ☐ ไม่เห็นด้วย

32.ท่านควรสวมถุงมือในขณะซ่อมวิทยุสื่อสารทุกครั้ง

☐ เห็นด้วย ☐ เฉยๆ ☐ ไม่เห็นด้วย

33.ท่านสามารถใส่เสื้อขณะปฏิบัติงานกลับบ้าน

☐ เห็นด้วย ☐ เฉยๆ ☐ ไม่เห็นด้วย

การปฏิบัติ

34.ท่านใช้อุปกรณ์ดังต่อไปนี้ในขณะปฏิบัติงานหรือไม่

- หน้ากาก	☐ ทุกครั้ง	☐ บางครั้ง	☐ ไม่ใช้
- ถุงมือ	☐ ทุกครั้ง	☐ บางครั้ง	☐ ไม่ใช้
- ชุดปฏิบัติงาน	☐ ทุกครั้ง	☐ บางครั้ง	☐ ไม่ใช้
- แว่นตานิรภัย	☐ ทุกครั้ง	☐ บางครั้ง	☐ ไม่ใช้
- เครื่องดูดควัน	☐ ทุกครั้ง	☐ บางครั้ง	☐ ไม่ใช้

ส่วนที่ 4 ประวัติสุขภาพ

35.ท่านมีโรคประจำตัวก่อนเข้าทำงานหรือไม่

☐ ไม่มี ☐ มี ระบุ ....

36.ปัจจุบันท่านมีโรคประจำตัวหรือไม่

☐ ไม่มี ☐ มี ระบุ ....

37.ท่านมียาประจำตัวหรือไม่ ☐ ไม่มี ☐ มี ระบุ...

38.ใน 1 เดือนที่ผ่านมา ท่านมีอาการเหล่านี้หรือไม่ ตอบได้มากกว่า 1 ข้อ

☐ เบื่ออาหาร	☐ ท้องผูก
☐ คลื่นไส้ อาเจียน	☐ เหนื่อยง่าย และอ่อนล้า
☐ ปวดศีรษะหรือวิงเวียนศีรษะ	☐ สั่นเล็กน้อย
☐ ปวดท้องบริเวณรอบสะดือ	☐ ลิ้นมีความรู้สึกรับรสโลหะa
☐ หงุดหงิด	☐ ข้อมือหรือข้อเท้าตก
☐ ปวดบริเวณกล้ามเนื้อและข้อต่อ	☐ นอนไม่หลับ
☐ มึนงง	☐ มีเส้นสีน้ำเงินบนเหงือก

39.ความดันโลหิตของท่าน .... มม.ปรอท

40.ท่านเคยมีประวัติโรคพิษจากสารตะกั่วหรือไม่

☐ ไม่เคย ☐ เคย ระบุ ....

41.ท่านเคยทานยาขับสารตะกั่วออกจากร่างกายหรือไม่

☐ ไม่เคย ☐ เคย ระบุ ....

APPENDIX E
PERSONAL DATA QUESTIONNAIRE (ENGLISH VERSION)

Questionnaire Code ....

Questionnaire **"Lead Poisoning among Communication Radio-repair Workers in Royal Thai Army Signal Department"** (2nd time)

Please fill your information in the blank and mark ✓ into the ☐.

Part 1 General information

1. Age.......................... Years
2. Weight................ Kg. Height .... cm.
3. Workplace (Office) ....
4. Job description ....
5. Marital status ☐ Single ☐ Couple ☐ Widow ☐ Divorce
6. Hometown (Province) ....
7. Recently Address (Province) ....
8. Highest Education levels

   ☐ Primary School ☐ Secondary School ☐ High School

   ☐ Vocational ☐ Bachelor Degree ☐ > Bachelor Degree

   ☐ Others..
9. Do you graduate from Sergeant School (Signal sector)

   ☐ Yes ☐ No (please specify) ....

10. Do you smoke? (If no, skip question number 11)

    ☐ Yes ☐ No

11. How many cigarettes do you smoke per day?

    ☐ < 1 pack ☐ 1-2 pack ☐ > 2 pack

12. Do you drink alcohol? (If no, skip question number 13)

    ☐ Yes ☐ No

13. How often do you drink alcohol per week?

☐ 1-2 days ☐ 3-4 days

☐ 5-7 days ☐ other (please specify) ....

14.Do you drink milk? (If no, skip question number 15)

☐ Yes ☐ No

15.How often do you drink milk per week?

☐ 1-2 days/week ☐ 3-4 days/week

☐ 5-7 days/week ☐ other (please specify) ....

16.Do you eat sea food? (If no, skip question number 17)

☐ Yes ☐ No

17. How often do you eat sea food per week?

☐ 1-2 days ☐ 3-4 days

☐ 5-7 days ☐ other (please specify) ....

18. Do you exercise?

☐ Everyday ☐ ≥ 3 days/week

☐ < 3 days/week ☐ None

Part 2 Working conditions

19.When did you start working here ....years

20.Work duration.................... years

21.Average of work duration .... hours/day and .... days/week

22.What is the type of your work?

☐ Repair communication radio (please specify type of communication radio)

....

☐ Inspector (please specify type of communication radio)

....

☐ Others (please specify)

....

23.How many communication radios do you repair per week? ....

24.How many roll of soldering lead that you use (rolls/month)? ....

25.Have you ever repaired other communication radios (from question 26)?

☐ No ☐ Yes (please specify)..................... How long.........years

26.Did you work at your installation during last 3 months?

☐ Yes ☐ No (please specify; places)..

27.Do you have any hobbies or extra jobs related with heavy metal lead?

☐ No ☐ Yes (please specify).................................... How long........... years

Part 3 Awareness and Practice of Lead Poisoning

Awareness of PPE use and personal hygiene

28. You can eat or drink while you are working.

☐ Agree ☐ Not bothered ☐ Disagree

29. It is very important to wash your hand after finishing working.

☐ Agree ☐ Not bothered ☐ Disagree

30. Sometimes it is necessary to ignore safety rules in order to speed up work and increase production.

☐ Agree ☐ Not bothered ☐ Disagree

31. You should wear a mask during work every time.

☐ Agree ☐ Not bothered ☐ Disagree

32. You should use gloves during work every time.

☐ Agree ☐ Not bothered ☐ Disagree

33. You can wear work uniform back home

☐ Agree ☐ Not bothered ☐ Disagree

PPE use

34. Do you use these equipment during work?

- Goggles ☐ Every time ☐ Sometimes ☐ Never
- Work uniform ☐ Every time ☐ Sometimes ☐ Never
- Dust respirator ☐ Every time ☐ Sometimes ☐ Never
- Gloves ☐ Every time ☐ Sometimes ☐ Never

- Exhaust ventilator ☐ Every time ☐ Sometimes ☐ Never

Part 4 Personal health history

35. Do you have any Underlying Diseases before working here?

☐ No ☐ Yes (please specify)..

36. Do you have any Underlying Diseases now?

☐ No ☐ Yes (please specify)..

37. Do you have any medicine that you take every day?

☐ No ☐ Yes (please specify)..

38. Have you ever had these signs and symptoms for 1 month? (You can choose more than 1 item)

☐ Loss of appetite ☐ Constipation

☐ Nausea or Vomit ☐ Excessive tiredness and Weakness

☐ Headache or Dizziness ☐ Fine tremors

☐ Colic pain ☐ Metallic taste in the mouth

☐ Nervous irritability ☐ Wrist and Foot drop

☐ Muscle and joint pain ☐ Insomnia

☐ Numbness ☐ Lead line on the gum

39. How much blood pressure do you have? .... mm.Hg.

40. Have you ever been lead poisoning?

☐ No ☐ Yes, How long.............years ago

41. Have you ever taken drug to excrete lead from body?

☐ No ☐ Yes (please specify)...........................How long.............years

APPENDIX F
PLANT DATA QUESTIONNAIRE (THAI VERSION)

แบบสอบถาม **"พิษจากตะกั่วต่อเจ้าหน้าที่ในโรงงานซ่อมวิทยุสื่อสาร กรมการทหารสื่อสาร กองทัพบก"** (ประจำเดือน) ผู้จัดทำขอความร่วมมือ ตอบแบบสอบถามชุดนี้ ตามความเป็นจริง เพื่อเป็นประโยชน์ในการใช้เป็นข้อมูลทำการศึกษาวิจัย

คำชี้แจง โปรดกรอกข้อมูลลงในช่องว่างให้ชัดเจน

<u>ข้อมูลการทำงาน</u>

1. จำนวนวิทยุสื่อสารที่แต่ละแผนกซ่อมได้ กี่เครื่องต่อสัปดาห์

   แผนก...ซ่อมวิทยุสื่อสารเฉลี่ย .... เครื่อง/สัปดาห์

   แผนก...ซ่อมวิทยุสื่อสารเฉลี่ย .... เครื่อง/สัปดาห์

   แผนก...ซ่อมวิทยุสื่อสารเฉลี่ย .... เครื่อง/สัปดาห์

   แผนก...ซ่อมวิทยุสื่อสารเฉลี่ย .... เครื่อง/สัปดาห์

   แผนก...ซ่อมวิทยุสื่อสารเฉลี่ย .... เครื่อง/สัปดาห์

   แผนก...ซ่อมวิทยุสื่อสารเฉลี่ย .... เครื่อง/สัปดาห์

2. จำนวนตะกั่วบัดกรีที่แต่ละแผนกใช้ กี่ม้วนต่อเดือน

   แผนก...ใช้ตะกั่วบัดกรี .... ม้วน/เดือน

   แผนก...ใช้ตะกั่วบัดกรี .... ม้วน/เดือน

   แผนก...ใช้ตะกั่วบัดกรี .... ม้วน/เดือน

   แผนก...ใช้ตะกั่วบัดกรี .... ม้วน/เดือน

   แผนก...ใช้ตะกั่วบัดกรี .... ม้วน/เดือน

   แผนก...ใช้ตะกั่วบัดกรี .... ม้วน/เดือน

APPENDIX G

PLANT DATA QUESTIONNAIRE (ENGLISH VERSION)

Questionnaire **"Lead Poisoning among Communication Radio-repair Workers in Royal Thai Army Signal Department"** (Monthly)

Please fill your information in the blank.

Working conditions

1. How many communication radios do each sections repair per week?

   Sections................................... How many....... communication radios/week

   Sections................................... How many....... communication radios/week

   Sections................................... How many....... communication radios/week

   Sections................................... How many....... communication radios/week

   Sections................................... How many....... communication radios/week

   Sections................................... How many....... communication radios/week

2. How many roll of soldering lead that each sections use per month (rolls/month)?

   Sections................................... How many....... rolls/month

   Sections................................... How many....... rolls/month

   Sections................................... How many....... rolls/month

   Sections................................... How many....... rolls/month

   Sections................................... How many....... rolls/month

   Sections................................... How many....... rolls/month

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VITA

NAME	Capt.Manasawee Thongsringklee
DATE OF BIRTH	10 Jul 1984
PLACE OF BIRTH	Bangkok
INSTITUTIONS ATTENDED	College of Public Health Sciences
HOME ADDRESS	103 Soi.Bangwak154, Bangphai, Bangkhae, Bangkok 10160
PUBLICATION	Health Effects of Low Level Exposure to Lead among Communication Radio Repair Workers at Samutsakhon province, Thailand