Studies on the health status according to the life style and working condition of petroleum refinery workers in South Korea (2012-2016)

June-Hee Lee

The Graduate School

Yonsei University

Department of Public Health

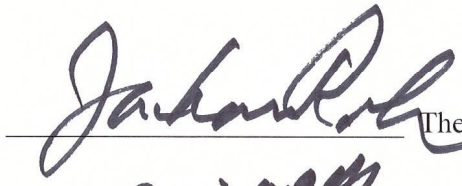
Studies on the health status according to the life style and working condition of petroleum refinery workers in South Korea (2012-2016)

A Dissertation submitted to
the Department of Public Health, Yonsei University
in partial fulfillment of the requirements
for the degree of Doctor of Philosophy

June-Hee Lee

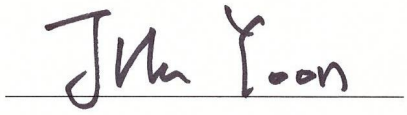
December 2016

This certifies that the doctoral dissertation
of June-Hee Lee is approved.


Thesis Supervisor: Jaehoon Roh


Jong-Uk Won: Thesis Committee Member #1


Jung Mo Nam: Thesis Committee Member #2


Jin-Ha Yoon: Thesis Committee Member #3


Kyung-Jae Lee: Thesis Committee Member #4

The Graduate School
Yonsei University
December 2016

Acknowledgement

As a medical doctor majoring in public health, there are many goals that I first set up. I am happy to feel that I am getting closer to my goals, my dream, receiving my ph. D degree.
First of all, my first and foremost gratitude goes to Professor Jaehoon Roh for teaching and guiding me. My all present appearance was deeply influenced by Professor Jaehoon Roh. I would also like to express my deep and sincere thanks to Professor Jong-Uk Won. As I learned from Professor Jong-Uk Won, whose first concern has always been the improvement of workers' health in Korea . I will always keep workers' health conditions in mind after him. I would like to express my sincere gratitude to Professor Jung Mo Nam. I have been honored to have the opportunity to learn from him. I would also like to express my sincere and heartfelt thanks to Professor Kyung-Jae Lee. Starting with what I have learned so far, I will try to become a person who improves myself further. I would like to express my sincere gratitude to Professor Jin-Ha Yoon. I thank him for helping me to have my research abilities. I will be more enthusiastic to research after your model.

I would like to give my warm thanks to my beloved family. First of all, I would like to express my deep gratitude to my father and mother. Until I can stand up on my own today, I got power and energy from my father and my mother at each critical point. I appreciate my father who has been my sincere supporter and has added the power to my article. And I thank my mother who always loves her son more than herself. Every day is the miracle and every day is precious for me. I would like to give my warm thanks to my father-in-law and mother-in-law. Whenever I have a difficulty, they always helped me as if it were their own concern. They are my beloved parents. I am also sending my deep love to my beloved wife Tai Kyung. I would like to convey this words to her – "what I did best in my life was getting married to you." I am telling you, Yong Won and Yong Ha, I will make every effort to become the father whom my children would be proud of. I hope my children feel that their dad loves them most when they would have grown up. I also would like to thank all the people around me.

I think I couldn't be what I am without their help and co-operation. I think that receiving my doctorate is another start in my life. I had passed through the dark and long tunnel. At that time every day had been painful. Looking back now, the bitter time made me grow. During that time, I was guided by the sense of God. I thank God for leading my life this way. Now, I am opening a new chapter of my life and I hope that I will be able to contribute to this society as a scholar as well as a medical doctor. I am here not by my own effort, but by the help of God and numerous people around me.

December, 2016

June-Hee Lee

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Studies on the health status according to the life style and working condition of petroleum refinery workers in South Korea (2012-2016)

Introduction: The petroleum refinery industry handles a variety of complex chemical substances and employs a large number of people around the world. According to previous research, diseases caused by exposure to chemicals were quite common among workers in refineries until the 1980s. More recently, it is unusual for oil refinery workers to suffer from these serious diseases. However, there is a lack of research that reflects each organizational department's characteristics regarding general diseases or health habits.

Objective: The objective of this study was to identify the occurrence level of general diseases and any differences in lifestyle habits of workers in refineries in Korea compared with the general population. The second objective was to investigate the degree to which chemical exposure affects general diseases in the workplace.

Methods: In this study, we used the results of health examinations from 2012 to 2016 for workers at a large oil refinery in South Korea. In addition, based on the results of KNHANES from 2012 to 2014 as representative of the population, hypertension, diabetes, anemia, hyperlipidemia, liver function abnormality, and kidney function abnormality were calculated using the standardized incidence rate (SIR). Data from 2012 to 2016 were analyzed using a modified generalized estimating equation

(GEE), which is a logistic regression analysis method.

Results: The SIR was calculated for regular salaried workers in the KNHANES. Hypertension showed a low result with an SIR of less than 1, but that of the case of abnormal liver function group showed higher. Results analyzed using the GEE method showed significant results in hypertension with an odds ratio of 1.613 and a 95% confidence interval of 1.009-2.580 in the MEK, TDI, and welding fume exposure departments. In the trichloroethylene exposure category, the odds ratio of hyperlipidemia occurrence was 1.498, and the 95% confidence interval was 1.039 - 2.160, showing significant results. In the toluene and xylene exposure department, the odds ratio for the occurrence of hyperlipidemia was 2.618 and the 95% confidence interval was 1.460-4.694, showing significant results. A significant odds ratio of 2.613 was obtained when the results were reanalyzed for workers who had abnormal liver function.

Conclusion: This study was conducted on workers in a large oil refinery in Korea, and is the first one to identify correlations between general diseases and lifestyle habits. The workers' occurrence rates of hypertension, hyperlipidemia, kidney dysfunction, and anemia were lower than those of ordinary salaried employees; however, their occurrence rate for abnormal liver function was markedly higher. In lifestyle habits, the smoking rate of workers was low while the alcohol consumption rate was quite high. With regard to chemical exposure in each department, when workers were exposed to toluene and xylene, the occurrence rate of hyperlipidemia was high. This study has improved the understanding of the health status of workers in a large oil refinery in Korea, and has shown the impact of chemical exposure and lifestyle habits related to the work environment on chronic diseases.

Key words: Petroleum refinery industry, South Korea, KNHANES, Lifestyle, Working conditions, Chemical exposure

I. Introduction

The petroleum refinery industry handles a variety of complex chemical substances and employs a large number of people around the world. In addition, it is becoming increasingly important to the modern industrial society[1-4]. Despite its importance, there still exist some health concerns on working environment of employees of this industry; substances produced in the refinery industry are absorbed via the respiratory system or skin, and their carcinogenic effect has been already identified by previous research[5-8]. According to previous studies, diseases caused by exposure to chemicals were quite common among workers in refineries until the 1980s[5,9]. In particular, a past cohort study showed that exposure to chemicals had a clear impact on the occurrence of diseases[10-13]. According to the latest research, however, the occurrence of serious diseases has been greatly reduced; this is because the impact of chemical exposure on disease occurrence is better understood than the past, and the work environment is greatly improved. Nowadays, research is actively conducted to investigate long-term exposure to lower concentrations of chemicals, and, unlike previously, more cross-sectional studies are conducted than cohort studies[14-15].

Because of the nature of a refinery that handles crude oil, workers are exposed to a wide range of different chemicals. For instance, there are intermediate byproducts such as solvents, lubrication-oil bases, oils, waxes, and paraffin, as well as benzene, toluene, and xylene (BTX)[16-18]. In addition to these chemicals, various heavy metals are used, and welding fumes are produced during maintenance of basic facilities. Outdoor work should also be taken into account for its impact on health[19-21]. The permissible limits of benzene, which caused many problems in the past, were as high as 100 ppm in the 1930s when its impact on health of employees was not well known. However, since it has been found that benzene affects health and the occurrence of diseases such as leukemia, the upper limit has been reduced to 0.5 ppm, according to the American Conference of Governmental Industrial Hygienists (ACGIH)[22-25]. As demonstrated above, the limits of exposure to chemicals have been

consistently lowered, and this has contributed to the improvements of workers' health[26]. However, most previous studies have focused on serious diseases related to chemical exposure, such as cancers, including leukemia[24,27]. These numerous meta-analysis and cohort studies have already contributed to lowering the limits of exposure to chemicals, and as a result, it is now rare to see refinery workers suffering from such serious diseases[28,29]. Refinery work is one of the highly competitive jobs in Korea because it guarantees stable employment and relatively higher wages. Furthermore, thanks to protection against chemicals and employee benefits for health, the workers' health status is much better than in the past[30,31]. In addition, since Korea enforces special health examinations that are designed to protect workers from exposure to each of the chemicals, the occurrence of diseases arising from chemical exposure is monitored fairly well[32].

However, there is a lack of research on each organizational department's characteristics regarding general diseases or health habits. In this respect, the first objective of this study is to identify the occurrence level of general diseases and any differences in lifestyle habits of workers in refineries in Korea compared with the general population. The second objective is to investigate the degree to which chemical exposure affects general diseases with consideration of the workplace. This study aims to identify the impact of chemical exposure on health in each department with consideration of the workplace characteristics. It is hoped that large refineries in Korea will use this study to implement proper measures to manage chronic diseases in their workers from a managerial perspective and to care for their workers' health.

II. Objectives

The objective of this study is to examine the occurrence level of chronic diseases based on the medical check-up results of refinery workers in Korea and the work environment that contributes to the occurrence of such diseases.

The detailed objectives of this study are:

(1) To calculate the standardized incidence rate (SIR) of refinery workers based on the incidence of chronic diseases among ordinary workers, as calculated using the Korea National Health and Nutrition Examination Survey (KNHANES), and;

(2) To analyze the impact of the characteristics of different departments, which are categorized for each chemical that affects the occurrence of chronic diseases, and the impact of lifestyle habits.

The objective of this study is to analyze the management of diseases to which workers are vulnerable based on the SIR of chronic diseases in refineries in Korea and the factors that affect each of those diseases. This will help to manage the chronic diseases of workers in each department in a tailored way.

III. Study Background

1. Crude Oil Refining

The refining process starts with unloading crude oil. The imported crude oil is unloaded from the oil tanker through pipelines to the oil storage tank, and the stored oil is adjusted for factors including sulfur content and yield; it is then blended to accommodate the refining process before being moved to the refining facility[33-35].

The next step is refining. Crude oil refining refers to processing crude oil and the subsequent manufacture of various petroleum and semi-finished products, which are also called refined oil. The crude distillation unit (CDU) puts crude oil through physical changes such as heating, cooling, and condensing under normal pressure, and uses different boiling points to separate the various components of crude oil. The unit produces petroleum and semi-finished products such as liquid petroleum gases (LPG), light straight run (LSR), naphtha, kerosene, diesel, and bunker fuel oil C (B-C). Next, the middle distillation hydrodesulfurization unit (MDU) adds hydrogen and removes the sulfur and nitrogen compounds contained in light oil, which are hazardous to humans; this results in quality light oil that satisfies the consumer needs[33,36].

The platforming unit (PF) carries out naphtha hydrotreating (NHT), a process that removes sulfur, nitrogen, and metal components, which could dampen the catalytic function of platinum in the back-end catalytic reforming process[37,38].

The catalytic reforming unit is a facility that reacts naphtha that has been desulfurized in the presence of hydrogen with a platinum catalyst, and produces the main gasoline source reformate (a high-octane product). Depending on the catalyst storage and regeneration type, the unit is divided into continuous catalyst regeneration (CCR) platforming and fixed-bed platforming (catalyst regeneration during the non-operation period). The benzene recovery plant (BRP) is a facility that only collects

benzene from the reformate produced in the catalytic reforming process using the N-formylmorpholine (NFM) catalyst to minimize the benzene content in the gasoline reformate[37].

Sulfur recovery is conducted in the sour gas treating unit (SGTU). Gases produced in refining contain a lot of hydrogen sulfide, and the SGTU uses amine to absorb the H_2S. After they are separated from H_2S gases, the remaining gases are re-used as a fuel when the H_2S-containing amine is regenerated, while H_2S gases are sent to the sulfur recovery unit (SRU). The SRU oxidizes H_2S gases sent from the SGTU at a high temperature, then creates and recovers molten sulfur when the gases go through the reactor. Next, when the tail gas treating unit (TGTU) reacts some sulfur compounds that have not been converted to molten sulfur in the SRU above (also known as the tail gas) with hydrogen in the presence of the catalyst, the compounds turn into H_2S and the TGTU sends this converted gas to the SRU. In addition, there is the merox unit, which includes the solid bed merox unit, LPG merox unit, and LSR merox unit, and removes impurities from fuels such as LPG jet fuel[39].

Heavy oil upgrading (HOU) vacuum-distills the atmospheric residue (AR) provided from the CDU, puts it through the hydrogenation reaction, and produces light oil (propane, butane, naphtha, kerosene, and diesel), heavy oil (low sulfur B-C oil), and products such as asphalt and lubricant base oil[40].

Fluid catalytic cracking (FCC) uses the high sulfur atmospheric residue (H/S AR) as a raw material and produces the main product (gasoline) and some light oil through hydrodesulfurization and the FCC reaction[38]. The process moves on to the storage and shipping of finished products and the products are shipped through oil pipelines, railways, or tank cars[35].

2. Hazards to which each department is exposed and a description of each department's role

The hazards to which each department is exposed are summarized below. Types of hazards include noise as a physical factor, and toluene, xylene, dichloromethane, trichlorethylene, carbon monoxide, methyl ethyl ketone (MEK), toluene diisocyanate (TDI), sulfuric acid, welding fumes, perchloroethylene, and trichloroethane as chemical substances[41].

1) Noise exposure

Departments and teams: HCR team, RFCC team, VRHCR team, electrical team, power team, petrochemical team, maintenance team, refinery team, and quality assurance team.

2) Toluene and xylene exposure

Departments and teams: APC team, HOU team, HCR team, RFCC team, VRHCR team, electrical team, power team, petrochemical team, maintenance team, refinery team, and quality assurance team.

3) Dichloromethane exposure

Departments and teams: HCR1 team, HCR2 team, RFCC, VRHCR team 1, electrical team 1, electrical team 2, electrical team 3, petrochemical team 5, maintenance team 1, maintenance team 2, maintenance team 3, and refinery team 2.

4) Trichloromethane and carbon monoxide exposure

Departments and teams: HCR team 1, HCR team 2, RFCC team, VRHCR team 1, electrical team 1, electrical team 2, electrical team 3, petrochemical team 5, maintenance team 1, maintenance team 2, maintenance team 3, refinery team 2, quality assurance team 1, and quality assurance team 2.

5) MEK, TDI, sulfuric acid, and welding fume exposure

Departments and teams: HCR team 2, RFCC team, VRHCR team 2, electrical team 3, process research team, power team 1, power team 2, petrochemical team 1, petrochemical team 5, safety team, crude oil storage team, oil storage team 2, oil storage team 3, maintenance team 1, maintenance team 2, maintenance team 3, oil storage team 1, oil storage team 2, quality assurance team 1, and quality assurance team 2.

6) Trichlorethylene exposure

Departments: petrochemical team 1, petrochemical team 2, maintenance team 1, maintenance team 3, oil storage team 1, and oil storage team 3.

Heavy oil upgrading (HOU) team: responsible for the process that turns heavy oil into light oil.

Vacuum residue hydrocracking (VRHCR) team: responsible for the process that turns asphalt into clean oil.

Residual fluid catalytic cracker (RFCC) team: responsible for the process that dissolves bunker fuel oil C and produces light oil.

Advanced process control (APC) team: develops a system that controls the process by predicting when the valve opens and closes.

Electrical team: maintains and repairs electrical systems.

Petrochemical team: manages refining systems and the control room for each discipline, as well as inspecting the site.

Maintenance team: checks machinery and equipment, and performs maintenance and repair activities.

Oil storage team: stores oil products.

Crude oil storage team: stores unloaded crude oil.

Power team: responsible for providing power so that the system operates smoothly across the plant.

Safety team: responsible for workers' safety and health.

Quality assurance team: quality control and assurance of products (a type of research team).

3. Method based on general check-up to determine workers with medical problems

An official classification method of the general medical check-up conducted for patients in Korea was used to classify patients with each disease in this study. A patient was determined as having hypertension either when their systolic blood pressure was at least 140 mmHg, or when their diastolic blood pressure was 90 mmHg or higher. For diabetes, the fasting blood sugar level was 126 mg/dL or higher. A patient was defined as having hyperlipidemia when either the total cholesterol level was at least 240 mg/dL, triglyceride was at least 200 mg/dL, LDL was 160 mg/dL or higher, or high-density lipoprotein (HDL) was less than 40 mg/dL. A patient was determined as having abnormal kidney function when either creatinine was more than 1.5, or the glomerular filtration rate (GFR) was less than 60 ml/min. Abnormal liver function was defined when aspartate aminotransferase (AST) was more than 50 IU/L or alanine aminotransferase (ALT) was more than 45 IU/L and gamma-glutamyl transpeptidase (G-GTP) was more than 77 IU/L [42,43].

IV. Study Methods

1. Study design

This study used the medical check-up results from 2012 to 2016 for workers in a large oil refinery in Korea. Furthermore, this study acquired and analyzed secondary data, which excluded all personal and identifiable information, and was approved by the institutional review board (IRB) of Yonsei University (2-1040939-AB-N-01-2016-307). Health workers with no disease history were selected as the subjects, and those with hepatitis B, which could impact their liver function, were excluded. The study separated workers who were diagnosed with a particular chronic disease in each year. This study consists of three parts: part I calculates the SIR of chronic diseases as compared to the general population based on the KNHANES; part II analyzes each team's characteristics and lifestyle habits that could impact each disease based on 5 years of accumulated data; and part III excludes other factors and uses the significant findings produced in part II to determine whether the impact would intensify. It also additionally stratifies the subjects according to age to analyze its impact.

Part I. Using the results of the KNHANES from 2012 to 2014 as the population parameter, this study estimated the SIR by calculating the number of patients with hypertension, diabetes, hyperlipidemia, abnormal liver function, and abnormal kidney function in each of those years.

Part II. By analyzing 5 years of data from 2012 to 2016, this study verified the correlations between disease occurrence and team, lifestyle habit, and age for each chemical to which workers were exposed.

Part III. Based on the analyzed findings of part II, this study re-analyzed the significant data, confirmed the overall trends, and additionally analyzed the impact of age by stratifying subjects into age groups.

2. Data and variables

Of the analysis variables, independent variables in this study were set as hypertension, diabetes, hyperlipidemia, abnormal liver function, abnormal kidney function, and anemia, as defined by the general check-up criteria of the National Health Insurance Service. Dependent variables used findings that could be identified in a general check-up, including type of chemical exposure, age, body mass index (BMI), smoking history, alcohol consumption history, appropriate exercise, general condition, pulmonary problems on a chest radiograph, and problems on urine test.

3. Statistical method

Part I used the same criteria as this study's analysis and calculated the SIR of salaried workers in the 5th and 6th data of KNHANES in 2012, 2013 and 2014[44].

Part II used a generalized estimating equation (GEE), a method of logistic regression analysis, and analyzed each team for the chemical to which it was exposed. As binary distinctions such as exposure and non-exposure, and missing data due to department movements and workplace movements were used, this study fitted a marginal model (a modified GEE model), to reduce analytical error in the GEE model[45-48]. All statistical analyses were performed using SAS statistical software version 9.4 (SAS Institute Inc., Cary, NC). All P-values were two-sided and considered significant at $P < 0.05$.

V. Results

The data used in the analysis included 1,461 workers at baseline and 5,805 person-years during the study period.

Table 1-1-1. To study general features of oil refinery workers, the study was performed for a total of 1,270 persons in 2012, 1,369 in 2013, 1,199 in 2014, 998 in 2015, and 969 in 2016. Among them, when considering workers with abnormal findings upon primary examination, the disease that showed the most abnormality during the above 5-year period was diabetes. Hyperlipidemia accounted for the second largest part, followed by hypertension. It was found that 1% of workers had abnormal liver function tests, which increased from 13% to 18% over the 5 years. Less than 1% of workers had anemia in the early part of the study, but this increased to at least 1% in 2016. Less than 1% workers had abnormal kidney functions tests, and this was constant throughout the study. For lifestyle habits, excessive alcohol drinking exceeded 50%, except in 2012.

Table 1-1-1. General characteristics of petroleum refinery factory workers

			2012		2013		2014		2015		2016	
Variable	Category		N	%	N	%	N	%	N	%	N	%
Ages	20-24		34	2.68	31	2.26	9	0.75	9	0.9	7	0.72
	25-29		181	14.25	185	13.51	154	12.84	133	13.33	124	12.8
	30-34		208	16.38	245	17.9	220	18.35	186	18.64	156	16.1
	35-39		109	8.58	97	7.09	90	7.51	92	9.22	118	12.18
	40-44		313	24.65	311	22.72	248	20.68	174	17.43	127	13.11
	45-49		161	12.68	179	13.08	184	15.35	180	18.04	212	21.88
	50-54		147	11.57	183	13.37	157	13.09	128	12.83	128	13.21
	55-59		117	9.21	138	10.08	121	10.09	83	8.32	81	8.36
	60-64		0	0	0	0	16	1.33	13	1.3	16	1.65
Life Style	Smoking	No	808	63.62	889	64.94	775	64.64	702	70.34	667	68.83
		Current	462	36.38	480	35.06	424	35.36	296	29.66	302	31.17
	Alcohol	Adequate	1,032	81.26	464	33.89	541	45.12	365	36.57	397	40.97
		Inadequate	238	18.74	905	66.11	658	54.88	633	63.43	572	59.03
	Exercise	Adequate	1,010	79.53	584	42.66	665	55.46	634	63.53	614	63.36
		Inadequate	260	20.47	785	57.34	534	44.54	364	36.47	355	36.64
Abnormality	Hypertension		142	11.18	247	18.04	136	11.34	118	11.82	174	17.96
	Diabetes		48	3.78	65	4.75	63	5.25	50	5.01	52	5.37
	Anemia		7	0.55	8	0.58	12	1.00	15	1.5	19	1.96
	Hyperlipidemia		337	26.54	399	29.15	288	24.02	293	29.36	321	33.13
	Liver function		167	13.15	203	14.83	190	15.85	164	16.43	176	18.16
	Kidney function		6	0.47	6	0.44	7	0.58	2	0.2	4	0.41
Total			1,270	100	1,369	100	1,199	100	998	100	969	100

Table 1-1-2. In the analysis of full-time salaried employees in the KNHANES, it was found that the hyperlipidemia was the highest, followed by hypertension. The incidence of anemia in the general population was higher than that in the oil refinery workers. However, the ratio of persons with abnormal liver function was lower. For the daily habits, it was shown that smoking was higher, but excessive alcohol drinking was lower than that of the oil refinery workers.

Table 1-1-2. General characteristics of current salary workers in KNHANES (2012-2014)

			2012		2013		2014	
Variable	Category		N	%	N	%	N	%
Ages	20-24		41	4.63	55	5.54	46	5.57
	25-29		70	7.9	85	8.56	58	7.02
	30-34		125	14.11	139	14	131	15.86
	35-39		152	17.16	145	14.6	133	16.10
	40-44		126	14.22	166	16.72	123	14.89
	45-49		117	13.21	119	11.98	85	10.29
	50-54		96	10.84	111	11.18	97	11.74
	55-59		87	9.82	101	10.17	95	11.50
	60-64		72	8.13	72	7.25	58	7.02
Life Style	Smoking	No	505	57.00	529	53.27	447	54.12
		Current	381	43.00	464	46.73	379	45.88
	Alcohol	Adequate	795	89.73	890	89.63	726	87.89
		Inadequate	91	10.27	103	10.37	100	12.11
	Exercise	Adequate	733	82.73	846	85.20	684	82.81
		Inadequate	153	17.27	147	14.80	142	17.19
Abnormality	Hypertension		162	18.28	177	17.82	124	15.01
	Diabetes		44	4.97	57	5.74	41	4.96
	Anemia		34	3.84	42	4.23	53	6.42
	Hyperlipidemia		315	35.55	388	39.07	324	39.23
	Liver function		87	9.82	115	11.58	80	9.69
	Kidney function		4	0.45	4	0.40	2	0.24
Total			886	100	993	100	826	100

Table 1-1-3. When classified according to exposed substances, the substances to which subjects were most exposed were toluene and xylene. More than 90% of workers were exposed to these substances. The next factor was noise and over 70% of workers were exposed. Around 50% of workers were exposed to MEK, TDI, and welding fumes. Only 15% of workers were exposed to TCE, making it the substance with the lowest exposure.

Table 1-1-3. General characteristics of exposure of hazard factors

Vaiable		2012		2013		2014		2015		2016	
		N	%	N	%	N	%	N	%	N	%
Noise exposure	Non-exposure	469	36.93	490	35.79	415	34.61	282	28.26	286	29.51
	Exposure	801	63.07	879	64.21	784	65.39	716	71.74	683	70.49
Toluene and xylene exposure	Non-exposure	83	6.54	83	6.06	81	6.76	48	4.81	45	4.64
	Exposure	1187	93.46	1286	93.94	1118	93.24	950	95.19	924	95.36
Dichloromethane exposure	Non-exposure	869	68.43	974	71.15	809	67.47	725	72.65	723	74.61
	Exposure	401	31.57	395	28.85	390	32.53	273	27.35	246	25.39
Trichloromethane and CO exposure	Non-exposure	869	68.43	894	65.30	809	67.47	645	64.63	646	66.67
	Exposure	401	31.57	475	34.70	390	32.53	353	35.37	323	33.33
Trichlorethylene exposure	Non-exposure	1,068	84.09	1166	85.17	997	83.15	842	84.37	815	84.11
	Exposure	202	15.91	203	14.83	202	16.85	156	15.63	154	15.89
MEK,TDI,welding fume exposure	Non-exposure	655	51.57	678	49.53	596	49.71	425	42.59	429	44.27
	Exposure	615	48.43	691	50.47	603	50.29	573	57.41	540	55.73
Total		1,270	100.00	1,369	100.00	1,199	100.00	998	100.00	969	100.00

Table 1-2-1. Using the results of the survey in 2012, the SIR was calculated. It was found that hypertension was low as 0.56 (95% CI, 0.38-0.74), and was also appeared lower in younger age groups. For diabetes, the ratio was 1.00 and the results were not significant (95% CI, 0.61-1.38). For anemia, the ratio was 1.00 and it was significant (95% CI, 0.02-0.99).

Table 1-2-2. For the hyperlipidemia, the ratio was low at 0.74 (95% CI, 0.61-0.87), and also showed a lower trend even in the stratified results by age group. Although the ratio of abnormality of liver function was higher at 1.61 (95% CI, 1.01-2.24), it showed a lower trend in subjects aged under 34 years. For abnormal kidney function, it was only possible to compare persons in the age group over 55 years; the ratio was low at 1.11 but this was not significant (95% CI, 0.01-2.42).

Table 1-2-1. Standardized incidence rate of 6 categories of abnormalities by KNHANES (2012)

Abnormalities		Hypertension					Diabetes					Anemia				
		KNHANES		Workers			KNHANES		Workers			KNHANES		Workers		
	Category	N	%	N	%	SIR	N	%	N	%	SIR	N	%	N	%	SIR
Ages	20-24	0	0.00	0	0	-	0	0.00	0	0.00	-	3	7.32	0	0	-
	25-29	9	12.86	3	1.66	0.13	1	1.43	0	0.00	-	2	2.86	0	0	-
	30-34	16	12.80	13	6.25	0.49	0	0.00	3	1.44	-	5	4.00	0	0	-
	35-39	26	17.11	8	7.34	0.43	4	2.63	3	2.75	1.05	6	3.95	0	0	-
	40-44	24	19.05	41	13.10	0.69	5	3.97	8	2.56	0.64	4	3.17	0	0	-
	45-49	26	22.22	31	19.25	0.87	10	8.55	15	9.32	1.09	4	3.42	2	1.24	0.36
	50-54	27	28.13	31	21.09	0.75	10	10.42	11	7.48	0.72	4	4.17	1	0.68	0.16
	55-59	19	21.84	15	12.82	0.59	4	4.60	8	6.84	1.49	3	3.45	4	3.42	0.99
	60-64	15	20.83	-	-	-	10	13.89	-	-	-	0	4.17	0	-	-
Total		162	18.28	142	11.18	0.56	44	4.97	48	3.78	1.00	34	3.84	7	0.55	0.51
					95% CI (0.38-0.74)					95% CI (0.61-1.38)					95% CI (0.02-0.99)	

Table 1-2-2. Standardized incidence rate of 6 categories of abnormalities by KNHANES (2012)

Abnormalities		Hyperlipidemia					Liver function					Kidney function				
		KNHANES		Workers			KNHANES		Workers			KNHANES		Workers		
	Category	N	%	N	%	SIR	N	%	N	%	SIR	N	%	N	%	SIR
Ages	20-24	4	9.76	0	0.00	-	3	7.32	0	0.00	-	0	0.00	0	0.00	-
	25-29	18	25.71	24	13.26	0.52	7	10.00	10	5.52	0.47	0	0.00	0	0.00	-
	30-34	44	35.20	35	16.83	0.48	21	16.80	25	12.02	0.73	0	0.00	0	0.00	-
	35-39	56	36.84	34	31.19	0.85	14	9.21	13	11.93	1.31	0	0.00	0	0.00	-
	40-44	48	38.10	108	34.50	0.91	13	10.32	56	17.89	1.58	0	0.00	1	0.32	-
	45-49	47	40.17	52	32.30	0.80	9	7.69	27	16.77	1.91	1	0.85	0	0.00	-
	50-54	46	47.92	50	34.01	0.71	4	4.17	18	12.24	4.92	0	0.00	2	1.36	-
	55-59	28	32.18	34	29.06	0.90	7	8.05	18	15.38	2.25	2	2.30	3	2.56	1.11
	60-64	24	33.33	-	-	-	9	12.50	-	-	-	1	1.39	-	-	-
Total		315	35.55	337	26.54	0.74	87	9.82	167	13.15	1.61	4	0.45	6	0.47	1.11
					95% CI (0.61-0.87)					95% CI (1.01.-2.24)					95% CI (0.01-2.42)	

Table 1-3-1. Using the results of survey in 2013, the SIR was calculated. Hypertension was 0.90 and showed a higher trend in the stratified age group between 35 and 54 years. However, it was not significant. For diabetes, the result was lower at 0.69, but it was also not significant. For anemia, the results tended to be lower at 0.31 (95% CI, 0.07-0.55).

Table 1-3-2. For hyperlipidemia, the SIR showed a lower trend at 0.73 (95% CI, 0.53-0.93). However, it was relatively higher in the stratified age groups; the SIR was 1.02 in the age group between 35 and 39 years, and 1.04 in the age group between 45 and 49 years. For abnormal liver function, it was higher at 1.36 and this was significant. However, it was not as high as in the age group from 25 to 34 years, and showed an increasing in the group over 35 years.

For abnormal kidney function, the SIR was relatively lower at 0.89 (95% CI, 0.55-1.99), but was relatively higher at 1.82 in the age group between 50 and 54 years, and was 1.46 in the age group between 55 and 59 years.

Table 1-3-1. Standardized incidence rate of 6 categories of abnormalities by KNHANES (2013)

Abnormalities		Hypertension					Diabetes					Anemia				
		KNHANES		Workers			KNHANES		Workers			KNHANES		Workers		
	Category	N	%	N	%	SIR	N	%	N	%	SIR	N	%	N	%	SIR
Ages	20-24	3	5.45	1	3.23	0.79	0	0.00	0	0.00	-	1	1.82	0	0.00	-
	25-29	10	11.76	11	5.95	0.46	2	2.35	0	0.54	0.38	3	3.53	0	0.00	-
	30-34	18	12.95	20	8.16	0.58	5	3.60	1	0.00	-	7	5.04	0	0.00	-
	35-39	17	11.72	15	15.46	1.55	1	0.69	3	4.12	1.57	2	1.38	1	1.03	0.75
	40-44	35	21.08	66	21.22	1.03	9	5.42	11	1.61	0.40	4	2.41	3	0.96	0.40
	45-49	24	20.17	52	29.05	1.34	8	6.72	12	5.59	0.65	5	4.20	1	0.56	0.13
	50-54	32	28.83	49	26.78	1.1	11	9.91	18	5.46	0.52	7	6.31	1	0.55	0.09
	55-59	30	29.70	33	23.91	0.82	9	8.91	20	2.90	0.63	8	7.92	2	1.45	0.18
	60-64	8	11.11	-	-	-	12	16.67	-	-	-	0	6.94	-	-	-
Total		177	17.82	247	18.04	0.90	57	5.74	65	4.75	0.69	42	4.23	8	0.51	0.31
					95% CI (0.67-1.14)					95% CI (0.34-1.04)					95% CI (0.07-0.55)	

Table 1-3-2. Standardized incidence rate of 6 categories of abnormalities by KNHANES (2013)

Abnormalities		Hyperlipidemia					Liver function					Kidney function				
		KNHANES		Workers			KNHANES		Workers			KNHANES		Workers		
	Category	N	%	N	%	SIR	N	%	N	%	SIR	N	%	N	%	SIR
Ages	20-24	7	12.73	3	9.68	0.76	2	3.64	2	6.45	1.77	0	0.00	0	0.00	-
	25-29	24	28.24	19	10.27	0.36	13	15.29	19	10.27	0.67	0	0.00	0	0.00	-
	30-34	55	39.57	51	20.82	0.53	25	17.99	30	12.24	0.68	0	0.00	0	0.00	-
	35-39	54	37.24	37	38.14	1.02	16	11.03	17	17.53	1.59	0	0.00	0	0.00	-
	40-44	67	40.36	117	37.62	0.93	21	12.65	60	19.29	1.53	1	0.60	1	0.32	0.54
	45-49	43	36.13	67	37.43	1.04	13	10.92	35	19.55	1.79	1	0.84	0	0.00	-
	50-54	59	53.15	65	35.52	0.67	11	9.91	22	12.02	1.21	1	0.90	3	1.64	1.82
	55-59	54	53.47	40	28.99	0.54	8	7.92	18	13.04	1.65	1	0.99	2	1.45	1.46
	60-64	25	34.72	-	-	-	6	8.33	-	-	-	0	0.00	-	-	-
Total		388	39.07	399	29.15	0.73	115	11.58	203	14.83	1.36	4	0.40	6	0.44	0.89
					95% CI (0.53-0.93)					95% CI (1.02-1.70)					95% CI (0.55-1.99)	

Table 1-4-1. For the results of the survey in 2014, the SIR was calculated. Hypertension showed lower results at 0.62 and this was significant (95% CI, 0.52-0.72). Hypertension showed a lower trend even when subjects were stratified into age groups. For diabetes, it showed higher trend as 1.43, and also appeared to be higher in the stratified age groups. For diabetes, it showed a higher trend as 1.23, but this was not significant.

Table 1-4-2. For hyperlipidemia, it showed a lower trend at 0.72 and this was significant. For abnormal liver function, the general results were higher at 2.93. However, this was not a significant result.

For abnormal kidney function, it was difficult to calculate results from unmatched results according to age.

Table 1-4-1. Standardized incidence rate of 6 categories of abnormalities by KNHANES (2014)

Abnormalities		Hypertension					Diabetes					Anemia				
		KNHANES		Workers			KNHANES		Workers			KNHANES		Workers		
	Category	N	%	N	%	SIR	N	%	N	%	SIR	N	%	N	%	SIR
Ages	20-24	0	0.00	0	0.00	-	0	0.00	0	0.00	3.04	4	8.70	0	0.00	-
	25-29	3	5.17	6	3.90	0.75	0	0.00	0	0.00	2.85	1	1.72	0	0.00	-
	30-34	11	8.40	18	8.18	0.97	1	0.76	0	0.00	1.48	6	4.58	0	0.00	-
	35-39	18	13.53	6	6.67	0.49	4	3.01	1	1.11	1.24	5	3.76	1	1.11	0.30
	40-44	25	20.33	35	14.11	0.69	4	3.25	11	4.44	1.65	11	8.94	1	0.40	0.05
	45-49	21	24.71	31	16.85	0.68	6	7.06	16	8.70	1.48	6	7.06	2	1.09	0.15
	50-54	22	22.68	24	15.29	0.67	9	9.28	17	10.83	1.58	3	3.09	2	1.27	0.41
	55-59	17	17.89	15	12.40	0.69	7	7.37	13	10.74	1.38	13	13.68	5	4.13	0.30
	60-64	7	12.07	1	0.00	0.52	10	17.24	5	31.25	1.31	0	6.90	1	6.25	0.91
Total		124	15.01	136	11.34	0.62	41	4.96	63	5.25	1.23	53	6.42	12	1.00	0.35
						95% CI (0.52-0.72)					95% CI (0.89-1.58)					95% CI (0.22-0.48)

Table 1-4-2. Standardized incidence rate of 6 categories of abnormalities by KNHANES (2014)

Abnormalities		Hyperlipidemia					Liver function					Kidney function				
		KNHANES		Workers			KNHANES		Workers			KNHANES		Workers		
	Category	N	%	N	%	SIR	N	%	N	%	SIR	N	%	N	%	SIR
Ages	20-24	14	34.15	0	0.00	-	3	7.32	1	11.11	1.52	0	0.00	0	0.00	-
	25-29	8	11.43	16	10.39	0.91	5	7.14	10	6.49	0.91	0	0.00	0	0.00	-
	30-34	46	36.80	41	18.64	0.51	20	16.00	34	15.45	0.97	0	0.00	0	0.00	-
	35-39	59	38.82	21	23.33	0.60	18	11.84	16	17.78	1.50	1	0.66	0	0.00	-
	40-44	55	43.65	68	27.42	0.63	12	9.52	56	22.58	2.37	0	0.00	1	0.40	-
	45-49	40	34.19	57	30.98	0.91	2	1.71	38	20.65	12.08	1	0.85	0	0.00	-
	50-54	47	48.96	53	33.76	0.69	7	7.29	17	10.83	1.49	0	0.00	4	2.55	-
	55-59	36	41.38	28	23.14	0.56	10	11.49	15	12.40	1.08	0	0.00	2	1.65	-
	60-64	19	26.39	4	25.00	0.95	3	4.17	3	18.75	4.50	0	0.00	0	0.00	-
Total		324	39.23	288	24.02	0.72	80	9.69	190	15.85	2.93	2	0.24	7	0.58	-
						95% CI (0.61-0.83)					95% CI (0.27-5.59)					

Part II

Table 2-1-1. It was intended to study total hazards between hypertension and oil refinery works and a relationship with other factors. As the results, it was shown that the odds ratio of total hazard was 1.003, but was insignificant. As other significant results, it was identified that increase in age and BMI and inadequate alcohol drinking habit were factors having statistical significant effects.

Table 2-1-2. For the results of workers in departments exposed to toluene and xylene, it was shown that the odds ratio was 0.681, but was insignificant. As other significant results, it was identified that increase in age and BMI, inadequate alcohol drinking habit, and poor general health conditions were factors having significant effects.

Table 2-1-1. Total hazard of hypertension by fit a marginal model with general estimated equation(GEE) method

		Odds Ratio	95% CI		F Value	P Value
Total hazard		1.003	0.854	1.178	0.02	0.973
Age		3.117	1.927	5.04	21.49	<.0001*
Body Mass Index		3.724	2.226	6.232	25.07	<.0001*
Smoking	Inadequate	0.975	0.642	1.48	0.01	0.905
Alcohol Intake	Inadequate	2.147	1.57	2.937	22.89	<.0001*
Exercise	Inadequate	1.269	0.935	1.721	2.34	0.126
General Condition	Normal	1.829	1.265	2.645	10.31	0.001*
Abnormal of chest X-ray	Abnormal	2.056	0.977	4.33	3.6	0.058
Abnormal of urine	Positive	1.543	0.59	4.033	0.78	0.376

Table 2-1-2. Relationship of toluene, xylene exposure and hypertension by fit a marginal model with general estimated equation(GEE) method

		Odds Ratio	95% CI		F Value	P Value
Exposure of Toluene, Xylene		0.681	0.248	1.868	0.56	0.456
Age		3.136	1.938	5.074	21.69	<.0001*
Body Mass Index		3.727	2.228	6.233	25.14	<.0001*
Smoking	Inadequate	0.974	0.642	1.48	0.01	0.903
Alcohol Intake	Inadequate	2.146	1.569	2.935	22.85	<.0001*
Exercise	Inadequate	1.271	0.937	1.723	2.38	0.123
General Condition	Normal	1.826	1.263	2.639	10.25	0.001*
Abnormal of chest X-ray	Abnormal	2.05	0.974	4.318	3.57	0.059
Abnormal of urine	Positive	1.556	0.595	4.067	0.81	0.367

Table 2-1-3. For the results of workers in departments exposed to noise, it was shown that the odds ratio was 0.914, but was insignificant. As other significant results, it was suggested that increase in age and BMI, inadequate alcohol drinking habit, and poor general health conditions were factors having significant effects.

Table 2-1-4. For the results of workers in departments exposed to trichloromethane and CS2, it was shown that the odds ratio was 0.871 4, but was insignificant. As other significant results, it was suggested that increase in age and BMI, inadequate alcohol drinking habit, and poor general health conditions were factors having significant effects.

Table 2-1-3. Relationship of noise exposure and hypertension by fit a marginal model with general estimated equation(GEE) method

		Odds Ratio	95% CI		F Value	P Value
Exposure of Noise		0.914	0.544	1.534	0.120	0.733
Age		3.112	1.924	5.031	21.450	<.0001*
Body Mass Index		3.718	2.222	6.222	25.010	<.0001*
Smoking	Inadequate	0.976	0.642	1.482	0.010	0.908
Alcohol Intake	Inadequate	2.150	1.572	2.941	22.960	<.0001*
Exercise	Inadequate	1.267	0.934	1.719	2.320	0.128
General Condition	Normal	1.829	1.265	2.644	10.300	0.001*
Abnormal of chest X-ray	Abnormal	2.051	0.974	4.319	3.580	0.059
Abnormal of urine	Positive	1.544	0.591	4.037	0.790	0.375

Table 2-1-4. Relationship of trichloromethane, CS2 exposure and hypertension by fit a marginal model with general estimated equation(GEE) method

		Odds Ratio	95% CI		F Value	P Value
Exposure of Trichloromethane, CS2		0.871	0.509	1.491	0.250	0.615
Age		3.142	1.941	5.086	21.730	<.0001*
Body Mass Index		3.709	2.218	6.203	24.960	<.0001*
Smoking	Inadequate	0.979	0.645	1.486	0.010	0.920
Alcohol Intake	Inadequate	2.143	1.567	2.931	22.800	<.0001*
Exercise	Inadequate	1.268	0.935	1.719	2.330	0.127
General Condition	Normal	1.829	1.265	2.644	10.320	0.001*
Abnormal of chest X-ray	Abnormal	2.053	0.976	4.320	3.590	0.058
Abnormal of urine	Positive	1.548	0.593	4.042	0.800	0.372

Table 2-1-5. For the results of workers in departments exposed to dichloromethane, it was shown that the odds ratio was 0.871, but was insignificant. As other significant results, it was suggested that increase in age and BMI, inadequate alcohol drinking habit, and poor general health conditions were factors having significant effects.

Table 2-1-6. For the results of workers in departments exposed to trichloroethylene, it was shown that the odds ratio was 1.122, but was insignificant. As other significant results, it was suggested that increase in age and BMI, inadequate alcohol drinking habit, and poor general health conditions were factors having significant effects.

Table 2-1-5. Relationship of dichloromethane exposure and hypertension by fit a marginal model with general estimated equation(GEE) methods

		Odds Ratio	95% CI		F Value	P Value
Exposure of Dichloromethane		0.762	0.433	1.342	0.890	0.347
Age		3.143	1.944	5.083	21.820	<.0001
Body Mass Index		3.712	2.221	6.205	25.060	<.0001
Smoking	Inadequate	0.981	0.646	1.490	0.010	0.930
Alcohol Intake	Inadequate	2.141	1.566	2.928	22.770	<.0001
Exercise	Inadequate	1.267	0.935	1.718	2.330	0.127
General Condition	Normal	1.828	1.265	2.642	10.300	0.001
Abnormal of chest X-ray	Abnormal	2.053	0.976	4.319	3.590	0.058
Abnormal of urine	Positive	1.547	0.593	4.036	0.800	0.372

Table 2-1-6. Relationship of trichloroethylene exposure and hypertension by fit a marginal model with general estimated equation(GEE) method

		Odds Ratio	95% CI		F Value	P Value
Exposure of Trichloroethylene		1.122	0.548	2.297	0.100	0.752
Age		3.126	1.933	5.057	21.600	<.0001*
Body Mass Index		3.717	2.222	6.218	25.040	<.0001*
Smoking	Inadequate	0.974	0.641	1.478	0.020	0.900
Alcohol Intake	Inadequate	2.145	1.568	2.933	22.820	<.0001*
Exercise	Inadequate	1.270	0.937	1.723	2.370	0.124
General Condition	Normal	1.830	1.266	2.646	10.340	0.001*
Abnormal of chest X-ray	Abnormal	2.060	0.978	4.337	3.620	0.057
Abnormal of urine	Positive	1.542	0.590	4.029	0.780	0.377

Table 2-1-7. For the results of workers in departments exposed to MEK, TDI, and welding fume, the odds ratio was 1.613, which was significant. As other significant results, it was suggested that increase in age and BMI, inadequate alcohol drinking habit, and poor general health conditions were factors having significant effects.

Table 2-1-7. Relationship of MEK, TDI, welding fume exposure and hypertension by fit a marginal model with general estimated equation(GEE) method

		Odds Ratio	95% CI		F Value	P Value
Exposure of MEK, TDI, Welding fume		1.613	1.009	2.580	3.980	0.046*
Age		3.126	1.933	5.057	21.600	<.0001*
Body Mass Index		3.717	2.222	6.218	25.040	<.0001*
Smoking	Inadequate	0.974	0.641	1.478	0.020	0.900
Alcohol Intake	Inadequate	2.145	1.568	2.933	22.820	<.0001*
Exercise	Inadequate	1.270	0.937	1.723	2.370	0.124
General Condition	Normal	1.830	1.266	2.646	10.340	0.001*
Abnormal of chest X-ray	Abnormal	2.060	0.978	4.337	3.620	0.057
Abnormal of urine	Positive	1.542	0.590	4.029	0.780	0.377

Table 2-2-1. It was intended to study total hazards between diabetes and oil refinery works and a relationship with other factors. As the results, it was shown that the odds ratio of total hazard was 1.091, but was insignificant. As other significant results, it was identified that increase in age and abnormal of urine were factors having statistical significant effects.

Table 2-2-2. For the results of workers in departments exposed to toluene and xylene, it was shown that the odds ratio was 1.826, but was insignificant. As other significant results, it was identified that increase in age and BMI, abnormal of urine were factors having significant effects.

Table 2-2-1. Total hazard of diabetes by fit a marginal model with general estimated equation(GEE) method

		Odds Ratio	95% CI		F Value	P Value
Total hazard		1.091	0.805	1.478	0.320	0.574
Age		8.752	2.406	31.844	10.840	0.001*
Body Mass Index		2.797	0.995	7.862	3.810	0.051
Smoking	Inadequate	0.601	0.291	1.242	1.890	0.169
Alcohol Intake	Inadequate	1.643	0.914	2.953	2.750	0.097
Exercise	Inadequate	1.610	0.939	2.761	3.000	0.083
General Condition	Normal	0.975	0.468	2.033	0.000	0.947
Abnormal of chest X-ray	Abnormal	1.144	0.372	3.520	0.060	0.814
Abnormal of urine	Positive	17.372	4.260	70.836	15.860	<.0001*

Table 2-2-2. Relationship of toluene, xylene exposure and diabetes by fit a marginal model with general estimated equation(GEE) method

		Odds Ratio	95% CI		F Value	P Value
Exposure of Toluene, Xylene		1.826	0.234	14.277	0.330	0.566
Age		8.504	2.346	30.828	10.620	0.001*
Body Mass Index		2.835	1.010	7.955	3.920	0.048*
Smoking	Inadequate	0.604	0.292	1.247	1.860	0.173
Alcohol Intake	Inadequate	1.639	0.912	2.944	2.730	0.099
Exercise	Inadequate	1.593	0.928	2.732	2.860	0.091
General Condition	Normal	0.978	0.469	2.038	0.000	0.952
Abnormal of chest X-ray	Abnormal	1.161	0.377	3.571	0.070	0.795
Abnormal of urine	Positive	16.701	4.063	68.651	15.250	<.0001*

Table 2-2-3. For the results of workers in departments exposed to noise, it was shown that the odds ratio was 0.640, but was insignificant. As other significant results, it was suggested that increase in age and abnormal of urine were factors having significant effects.

Table 2-2-4. For the results of workers in departments exposed to trichloromethane and CS2, it was shown that the odds ratio was 0.948, but was insignificant. As other significant results, it was suggested that increase in age and BMI, abnormal of urine were factors having significant effects.

Table 2-2-3. Relationship of noise exposure and diabetes by fit a marginal model with general estimated equation(GEE) method

		Odds Ratio	95% CI		F Value	P Value
Exposure of Noise		0.640	0.251	1.634	0.870	0.351
Age		8.712	2.396	31.677	10.810	0.001*
Body Mass Index		2.796	0.996	7.847	3.810	0.051
Smoking	Inadequate	0.602	0.291	1.243	1.880	0.170
Alcohol Intake	Inadequate	1.655	0.921	2.976	2.840	0.092
Exercise	Inadequate	1.599	0.933	2.740	2.910	0.088
General Condition	Normal	0.976	0.469	2.034	0.000	0.949
Abnormal of chest X-ray	Abnormal	1.142	0.372	3.509	0.050	0.816
Abnormal of urine	Positive	17.364	4.241	71.097	15.760	<.0001*

Table 2-2-4. Relationship of trichloromethane, CS2 exposure and diabetes by fit a marginal model with general estimated equation(GEE) method

		Odds Ratio	95% CI		F Value	P Value
Exposure of Trichloromethane, CS2		0.948	0.371	2.422	0.010	0.911
Age		8.658	2.381	31.488	10.740	0.001*
Body Mass Index		2.817	1.002	7.915	3.860	0.050*
Smoking	Inadequate	0.599	0.290	1.239	1.910	0.167
Alcohol Intake	Inadequate	1.636	0.910	2.939	2.710	0.100
Exercise	Inadequate	1.607	0.937	2.755	2.970	0.085
General Condition	Normal	0.973	0.467	2.029	0.010	0.942
Abnormal of chest X-ray	Abnormal	1.145	0.373	3.522	0.060	0.813
Abnormal of urine	Positive	17.208	4.214	70.274	15.720	<.0001*

Table 2-2-5. For the results of workers in departments exposed to dichloromethane, it was shown that the odds ratio was 0.137, but was insignificant. As other significant results, it was suggested that increase in age and BMI, abnormal of urine were factors having significant effects.

Table 2-2-6. For the results of workers in departments exposed to trichloroethylene, it was shown that the odds ratio was 1.025, but was insignificant. As other significant results, it was suggested that increase in age and BMI, abnormal of urine were factors having significant effects.

Table 2-2-5. Relationship of dichloromethane exposure and diabetes by fit a marginal model with general estimated equation(GEE) method

		Odds Ratio	95% CI		F Value	P Value
Exposure of Dichloromethane		1.137	0.424	3.050	0.060	0.799
Age		8.584	2.362	31.189	10.670	0.001*
Body Mass Index		2.841	1.011	7.987	3.920	0.048*
Smoking	Inadequate	0.597	0.289	1.234	1.940	0.164
Alcohol Intake	Inadequate	1.636	0.910	2.941	2.710	0.100
Exercise	Inadequate	1.603	0.935	2.750	2.940	0.086
General Condition	Normal	0.968	0.464	2.019	0.010	0.932
Abnormal of chest X-ray	Abnormal	1.149	0.374	3.530	0.060	0.809
Abnormal of urine	Positive	17.248	4.210	70.666	15.670	<.0001*

Table 2-2-6. Relationship of trichloroethylene exposure and diabetes by fit a marginal model with general estimated equation(GEE) method

		Odds Ratio	95% CI		F Value	P Value
Exposure of Trichloroethylene		1.025	0.263	3.990	0.000	0.971
Age		8.647	2.378	31.440	10.740	0.001*
Body Mass Index		2.822	1.005	7.922	3.880	0.049*
Smoking	Inadequate	0.599	0.290	1.237	1.920	0.166
Alcohol Intake	Inadequate	1.635	0.910	2.938	2.700	0.100
Exercise	Inadequate	1.606	0.936	2.753	2.960	0.085
General Condition	Normal	0.972	0.466	2.025	0.010	0.939
Abnormal of chest X-ray	Abnormal	1.147	0.373	3.525	0.060	0.811
Abnormal of urine	Positive	17.193	4.198	70.410	15.650	<.0001*

Table 2-2-7. For the results of workers in departments exposed to MEK, TDI, and welding fume, the odds ratio was 0.777, which was insignificant. As other significant results, it was suggested that increase in age and BMI, abnormal of urine were factors having significant effects.

Table 2-2-7. Relationship of MEK, TDI, welding fume exposure and diabetes by Fit a marginal model with general estimated equation(GEE) method

		Odds Ratio	95% CI		F Value	P Value
Exposure of MEK, TDI, Welding fume		0.777	0.323	1.869	0.320	0.573
Age		0.815	0.761	0.874	33.150	<.0001*
Body Mass Index		0.650	0.545	0.775	23.010	<.0001*
Smoking	Inadequate	0.890	0.439	1.802	0.110	0.745
Alcohol Intake	Inadequate	1.643	0.932	2.894	2.950	0.086
Exercise	Inadequate	1.478	0.870	2.509	2.090	0.149
General Condition	Normal	1.225	0.606	2.473	0.320	0.572
Abnormal of chest X-ray	Abnormal	1.114	0.374	3.315	0.040	0.847
Abnormal of urine	Positive	11.961	2.632	54.352	10.330	0.001*

Table 2-3-1. It was intended to study total hazards between hyperlipidemia and oil refinery works and a relationship with other factors. As the results, it was shown that the odds ratio of total hazard was 0.949, but was insignificant. As other significant results, it was identified that increase in age and BMI, smoking, inadequate exercise, poor general condition, abnormal of urine were factors having statistical significant effects.

Table 2-3-2. For the results of workers in departments exposed to toluene and xylene, it was shown that the odds ratio was 2.618, but was significant. As other significant results, it was identified that increase in age and BMI, smoking, inadequate exercise, poor general condition, abnormal of urine were factors having significant effects.

Table 2-3-1. Total hazard of hyperlipidemia by fit a marginal model with general estimated equation(GEE) method

		Odds Ratio	95% CI		F Value	P Value
Total hazard		0.949	0.871	1.035	1.390	0.239
Age		2.514	1.931	3.273	46.910	<.0001*
Body Mass Index		3.853	2.901	5.116	86.870	<.0001*
Smoking	Inadequate	1.465	1.152	1.862	9.700	0.002*
Alcohol Intake	Inadequate	1.055	0.871	1.276	0.300	0.586
Exercise	Inadequate	1.477	1.223	1.785	16.390	<.0001*
General Condition	Normal	0.670	0.525	0.856	10.250	0.001*
Abnormal of chest X-ray	Abnormal	1.130	0.722	1.769	0.290	0.592
Abnormal of urine	Positive	3.077	1.572	6.023	10.760	0.001*

Table 2-3-2. Relationship of toluene, xylene exposure and hyperlipidemia by fit a marginal model with general estimated equation(GEE) method

		Odds Ratio	95% CI		F Value	P Value
Exposure of Toluene, Xylene		2.618	1.460	4.694	10.440	0.001*
Age		2.499	1.921	3.252	46.550	<.0001*
Body Mass Index		3.860	2.908	5.124	87.410	<.0001*
Smoking	Inadequate	1.487	1.170	1.889	10.530	0.001*
Alcohol Intake	Inadequate	1.057	0.874	1.279	0.330	0.568
Exercise	Inadequate	1.466	1.214	1.771	15.760	<.0001*
General Condition	Normal	0.673	0.527	0.859	10.090	0.002*
Abnormal of chest X-ray	Abnormal	1.134	0.725	1.774	0.310	0.580
Abnormal of urine	Positive	3.041	1.553	5.955	10.530	0.001*

Table 2-3-3. For the results of workers in departments exposed to noise, it was shown that the odds ratio was 0.962, but was insignificant. As other significant results, it was suggested that increase in age and BMI, smoking, inadequate exercise, poor general condition, abnormal of urine were were factors having significant effects.

Table 2-3-4. For the results of workers in departments exposed to trichloromethane and CS2, it was shown that the odds ratio was 1.043, but was insignificant. As other significant results, it was suggested that increase in age and BMI, smoking, inadequate exercise, poor general condition, abnormal of urine were factors having significant effects.

Table 2-3-3. Relationship of noise exposure and hyperlipidemia by fit a marginal model with general estimated equation(GEE) method

		Odds Ratio	95% CI		F Value	P Value
Exposure of Noise		0.962	0.732	1.264	0.080	0.783
Age		2.517	1.934	3.276	47.130	<.0001*
Body Mass Index		3.831	2.886	5.085	86.430	<.0001*
Smoking	Inadequate	1.473	1.159	1.873	10.030	0.002*
Alcohol Intake	Inadequate	1.054	0.871	1.276	0.290	0.589
Exercise	Inadequate	1.471	1.218	1.777	16.060	<.0001*
General Condition	Normal	0.670	0.524	0.856	10.300	0.001*
Abnormal of chest X-ray	Abnormal	1.125	0.719	1.760	0.260	0.607
Abnormal of urine	Positive	3.105	1.586	6.078	10.940	0.001*

Table 2-3-4. Relationship of trichloromethane, CS2 exposure and hyperlipidemia by fit a marginal model with general estimated equation(GEE) method

		Odds Ratio	95% CI		F Value	P Value
Exposure of Trichloromethane, CS2		1.043	0.789	1.380	0.090	0.767
Age		2.514	1.931	3.272	46.930	<.0001*
Body Mass Index		3.843	2.893	5.104	86.490	<.0001*
Smoking	Inadequate	1.471	1.157	1.870	9.930	0.002*
Alcohol Intake	Inadequate	1.054	0.871	1.276	0.300	0.586
Exercise	Inadequate	1.473	1.219	1.779	16.150	<.0001*
General Condition	Normal	0.670	0.524	0.855	10.310	0.001*
Abnormal of chest X-ray	Abnormal	1.127	0.720	1.763	0.270	0.601
Abnormal of urine	Positive	3.106	1.587	6.080	10.940	0.001*

Table 2-3-5. For the results of workers in departments exposed to dichloromethane, it was shown that the odds ratio was 1.060, but was insignificant. As other significant results, it was suggested that increase in age and BMI, smoking, inadequate exercise, poor general condition, abnormal of urine were factors having significant effects.

Table 2-3-6. For the results of workers in departments exposed to trichloroethylene, it was shown that the odds ratio was 1.498, but was significant. As other significant results, it was suggested that increase in age and BMI, smoking, inadequate exercise, poor general condition, abnormal of urine were factors having significant effects.

Table 2-3-5. Relationship of dichloromethane exposure and hyperlipidemia by fit a marginal model with general estimated equation(GEE) method

		Odds Ratio	95% CI		F Value	P Value
Exposure of Dichloromethane		1.060	0.792	1.419	0.150	0.694
Age		2.517	1.933	3.276	47.100	<.0001*
Body Mass Index		3.841	2.893	5.100	86.610	<.0001*
Smoking	Inadequate	1.470	1.156	1.869	9.890	0.002*
Alcohol Intake	Inadequate	1.054	0.871	1.276	0.300	0.586
Exercise	Inadequate	1.473	1.219	1.779	16.140	<.0001*
General Condition	Normal	0.670	0.524	0.855	10.310	0.001*
Abnormal of chest X-ray	Abnormal	1.127	0.720	1.763	0.270	0.601
Abnormal of urine	Positive	3.108	1.588	6.085	10.960	0.001*

Table 2-3-6. Relationship of trichloroethylene exposure and hyperlipidemia by fit a marginal model with general estimated equation(GEE) method

		Odds Ratio	95% CI		F Value	P Value
Exposure of Trichloroethylene		1.498	1.039	2.160	4.690	0.030*
Age		2.540	1.951	3.307	47.990	<.0001*
Body Mass Index		3.784	2.850	5.023	84.830	<.0001*
Smoking	Inadequate	1.473	1.159	1.873	10.030	0.002*
Alcohol Intake	Inadequate	1.048	0.866	1.268	0.230	0.633
Exercise	Inadequate	1.480	1.225	1.787	16.520	<.0001*
General Condition	Normal	0.673	0.527	0.860	10.040	0.002*
Abnormal of chest X-ray	Abnormal	1.132	0.723	1.771	0.290	0.588
Abnormal of urine	Positive	3.107	1.588	6.080	10.960	0.001*

Table 2-3-7. For the results of workers in departments exposed to MEK, TDI, and welding fume, the odds ratio was 1.052, which was insignificant. As other significant results, it was suggested that increase in age and BMI, smoking, inadequate exercise, poor general condition, abnormal of urine were factors having significant effects.

Table 2-3-7. Relationship of MEK, TDI, welding fume exposure and hyperlipidemia by fit a marginal model with general estimated equation(GEE) method

		Odds Ratio	95% CI		F Value	P Value
Exposure of MEK, TDI, Welding fume		1.052	0.804	1.377	0.140	0.711
Age		0.943	0.929	0.957	58.180	<.0001*
Body Mass Index		0.713	0.674	0.754	141.730	<.0001*
Smoking	Inadequate	1.581	1.236	2.023	13.290	0.001*
Alcohol Intake	Inadequate	1.049	0.864	1.274	0.240	0.627
Exercise	Inadequate	1.444	1.191	1.750	14.010	0.001*
General Condition	Normal	0.803	0.625	1.032	2.930	0.087
Abnormal of chest X-ray	Abnormal	1.079	0.682	1.707	0.110	0.745
Abnormal of urine	Positive	2.802	1.420	5.527	8.840	0.003*

Table 2-4-1. It was intended to study total hazards between abnormal of liver function and oil refinery works and a relationship with other factors. As the results, it was shown that the odds ratio of total hazard was 1.124, but was insignificant. As other significant results, it was identified that increase in age and BMI, poor general condition, abnormal of urine were factors having statistical significant effects.

Table 2-4-2. For the results of workers in departments exposed to toluene and xylene, it was shown that the odds ratio was 1.588, but was significant. As other significant results, it was identified that increase in age and BMI, poor general condition, abnormal of urine were factors having significant effects.

Table 2-4-1. Total hazard of liver function abnormality by fit a marginal model with general estimated equation(GEE) method

		Odds Ratio	95% CI		F Value	P Value
Total hazard		1.124	0.984	1.284	2.990	0.084
Age		1.711	1.156	2.533	7.220	0.007*
Body Mass Index		3.774	2.493	5.715	39.400	<.0001*
Smoking	Inadequate	1.057	0.741	1.507	0.090	0.760
Alcohol Intake	Inadequate	1.214	0.932	1.581	2.060	0.151
Exercise	Inadequate	1.171	0.902	1.519	1.410	0.235
General Condition	Normal	0.618	0.437	0.875	7.380	0.007*
Abnormal of chest X-ray	Abnormal	0.748	0.367	1.526	0.640	0.425
Abnormal of urine	Positive	2.907	1.225	6.897	5.860	0.016*

Table 2-4-2. Relationship of toluene, xylene exposure and liver function abnormality by fit a marginal model with general estimated equation(GEE) method

		Odds Ratio	95% CI		F Value	P Value
Exposure of Toluene, Xylene		1.588	0.648	3.888	1.020	0.312
Age		1.692	1.142	2.507	6.870	0.009*
Body Mass Index		3.789	2.497	5.747	39.270	<.0001*
Smoking	Inadequate	1.050	0.735	1.499	0.070	0.790
Alcohol Intake	Inadequate	1.216	0.932	1.585	2.080	0.149
Exercise	Inadequate	1.173	0.904	1.524	1.440	0.230
General Condition	Normal	0.622	0.439	0.880	7.200	0.007*
Abnormal of chest X-ray	Abnormal	0.750	0.366	1.537	0.620	0.432
Abnormal of urine	Positive	2.857	1.200	6.799	5.630	0.018*

Table 2-4-3. For the results of workers in departments exposed to noise, it was shown that the odds ratio was 0.797, but was insignificant. As other significant results, it was suggested that increase in age and BMI, poor general condition, abnormal of urine were factors having significant effects.

Table 2-4-4. For the results of workers in departments exposed to trichloromethane and CS2, it was shown that the odds ratio was 0.821, but was insignificant. As other significant results, it was suggested that increase age and BMI, poor general condition, abnormal of urine were factors having significant effects.

Table 2-4-3. Relationship of noise exposure and liver function abnormality by fit a marginal model with general estimated equation(GEE) method

		Odds Ratio	95% CI		F Value	P Value
Exposure of Noise		0.797	0.635	1.000	1.960	0.050
Age		1.008	0.997	1.019	1.340	0.181
Body Mass Index		1.361	1.302	1.422	13.670	<.0001
Smoking	Inadequate	1.196	0.971	1.473	1.680	0.093
Alcohol Intake	Inadequate	1.163	1.000	1.352	1.960	0.050
Exercise	Inadequate	1.064	0.912	1.241	0.780	0.433
General Condition	Normal	1.132	0.925	1.384	1.200	0.229
Abnormal of chest X-ray	Abnormal	1.004	0.682	1.477	0.020	0.983
Abnormal of urine	Positive	1.591	0.940	2.692	1.730	0.084

Table 2-4-4. Relationship of trichloromethane, CS2 exposure and liver function abnormality by fit a marginal model with general estimated equation(GEE) method

		Odds Ratio	95% CI		F Value	P Value
Exposure of Trichloromethane, CS2		0.821	0.528	1.277	0.770	0.381
Age		1.709	1.153	2.532	7.130	0.008*
Body Mass Index		3.765	2.483	5.708	39.000	<.0001*
Smoking	Inadequate	1.050	0.735	1.498	0.070	0.790
Alcohol Intake	Inadequate	1.212	0.930	1.580	2.030	0.154
Exercise	Inadequate	1.176	0.906	1.526	1.490	0.222
General Condition	Normal	0.621	0.439	0.879	7.210	0.007*
Abnormal of chest X-ray	Abnormal	0.747	0.365	1.529	0.640	0.424
Abnormal of urine	Positive	2.886	1.215	6.854	5.770	0.016*

Table 2-4-5. For the results of workers in departments exposed to dichloromethane, it was shown that the odds ratio was 0.880, but was insignificant. As other significant results, it was suggested that increase in age and BMI, poor general condition, abnormal of urine were factors having significant effects.

Table 2-4-6. For the results of workers in departments exposed to trichloroethylene, it was shown that the odds ratio was 0.846, but was insignificant. As other significant results, it was suggested that increase in age and BMI, poor general condition, abnormal of urine were factors having significant effects.

Table 2-4-5. Relationship of dichloromethane exposure and liver function abnormality by fit a marginal model with general estimated equation(GEE) method

		Odds Ratio	95% CI		F Value	P Value
Exposure of Dichloromethane		0.880	0.554	1.395	0.300	0.586
Age		1.699	1.147	2.517	7.000	0.008*
Body Mass Index		3.781	2.494	5.730	39.300	<.0001*
Smoking	Inadequate	1.049	0.735	1.498	0.070	0.791
Alcohol Intake	Inadequate	1.213	0.931	1.581	2.050	0.153
Exercise	Inadequate	1.176	0.906	1.526	1.490	0.223
General Condition	Normal	0.621	0.439	0.879	7.240	0.007*
Abnormal of chest X-ray	Abnormal	0.747	0.365	1.529	0.640	0.425
Abnormal of urine	Positive	2.881	1.213	6.844	5.750	0.017*

Table 2-4-6. Relationship of trichloroethylene exposure and liver function abnormality by fit a marginal model with general estimated equation(GEE) method

		Odds Ratio	95% CI		F Value	P Value
Exposure of Trichloroethylene		0.846	0.469	1.528	0.310	0.580
Age		1.693	1.143	2.508	6.910	0.009*
Body Mass Index		3.813	2.514	5.783	39.680	<.0001*
Smoking	Inadequate	1.045	0.732	1.492	0.060	0.807
Alcohol Intake	Inadequate	1.216	0.933	1.585	2.100	0.148
Exercise	Inadequate	1.175	0.905	1.525	1.470	0.226
General Condition	Normal	0.620	0.438	0.877	7.300	0.007*
Abnormal of chest X-ray	Abnormal	0.747	0.365	1.527	0.640	0.423
Abnormal of urine	Positive	2.884	1.214	6.852	5.750	0.017*

Table 2-4-7. For the results of workers in departments exposed to MEK, TDI, and welding fume, the odds ratio was 0.708, which was insignificant. As other significant results, it was suggested that increase in age and BMI, smoking, inadequate exercise, abnormal of urine were factors having significant effects.

Table 2-4-7. Relationship of MEK, TDI, welding fume exposure and liver function abnormality by fit a marginal model with general estimated equation(GEE) method

		Odds Ratio	95% CI		F Value	P Value
Exposure of MEK, TDI, Welding fume		0.708	0.463	1.081	2.560	0.110
Age		0.995	0.972	1.019	0.150	0.701
Body Mass Index		0.550	0.498	0.607	139.360	<.0001*
Smoking	Inadequate	1.283	0.893	1.842	1.820	0.178
Alcohol Intake	Inadequate	1.187	0.904	1.558	1.520	0.218
Exercise	Inadequate	1.139	0.869	1.491	0.890	0.345
General Condition	Normal	0.862	0.602	1.234	0.660	0.417
Abnormal of chest X-ray	Abnormal	0.901	0.427	1.903	0.070	0.786
Abnormal of urine	Positive	2.518	1.034	6.131	4.140	0.042*

PART III

Table 3-1-1. Reflecting existing study methods, the analysis was performed on workers with hepatic dysfunction who worked in departments with toluene and xylene exposure. The results were shown to be significant with an odds ratio of 0.613. Because of a reduced number of subjects, the 95% CI only widened a little from 1.129-6.048. Other factors having effects included increased age and BMI and inadequate exercise. Abnormal findings in urinary tests which was an existing factor having effects were excluded from the factors having effects.

Table 3-1-1. Relationship of toluene, xylene exposure and hyperlipidemia by general estimated equation(GEE) method (Workers had liver function test abnormality)

		Odds Ratio	95% CI		F Value	P Value
Exposure of Toluene, Xylene		2.613	1.129	6.048	5.040	0.025*
Age		1.710	1.167	2.507	7.580	0.006*
Body Mass Index		2.729	1.626	4.579	14.490	0.000*
Smoking	Inadequate	1.272	0.890	1.819	1.750	0.186
Alcohol Intake	Inadequate	1.306	0.946	1.801	2.650	0.104
Exercise	Inadequate	1.647	1.196	2.267	9.360	0.002*
General Condition	Normal	0.687	0.437	1.082	2.630	0.105
Abnormal of chest X-ray	Abnormal	1.115	0.530	2.346	0.080	0.774
Abnormal of urine	Positive	2.510	0.941	6.699	3.390	0.066

Table 3-1-2. When analyzing these results in the stratified age groups, the results in the age group between 40 and 49 years were found to be significant at 2.16 and 2.11. The result of the age group between 35 and 39 years was calculated as 1.53, but this was insignificant. Although the age group between 50 and 54 years showed 2.92, this was insignificant as the 95% CI was 0.99-8.59.

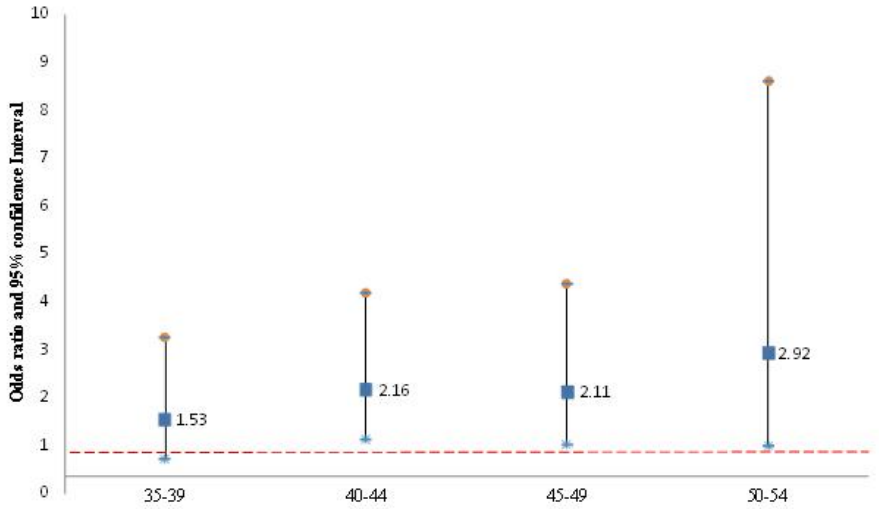


Figure 1. Relationship of toluene, xylene exposure and hyperlipidemia by age (Workers had liver function test abnormality)

Table 3-1-2. Relationship between toluene, xylene exposure and hyperlipidemia by age (Workers had liver function test abnormality)

Variable	Category	N	%	Odds Ratio	95% CI	
Ages	20-24	1	0.12	-	-	-
	25-29	12	1.41	-	-	-
	30-34	51	6	-	-	-
	35-39	49	5.76	1.53	0.72	3.25
	40-44	117	13.76	2.16	1.12	4.18
	45-49	103	12.12	2.11	1.02	4.36
	50-54	46	5.41	2.92	0.99	8.59
	55-59	24	2.82	-	-	-
	60-64	4	0.47	-	-	-

Table 3-2-1. In addition, the effects on development of hypertension in the department exposed to MEK, TDI, and welding fumes, which showed significant results in part II, were analyzed in the stratified age groups. The age group between 35 and 39 years showed the highest result at 1.60, but the result was insignificant. The results were 1.32 in the age group between 40 and 44 years, 1.41 in the age group between 45 and 49 years, and 1.15 in the age group between 50 and 54 years; however, none of these were statistically significant.

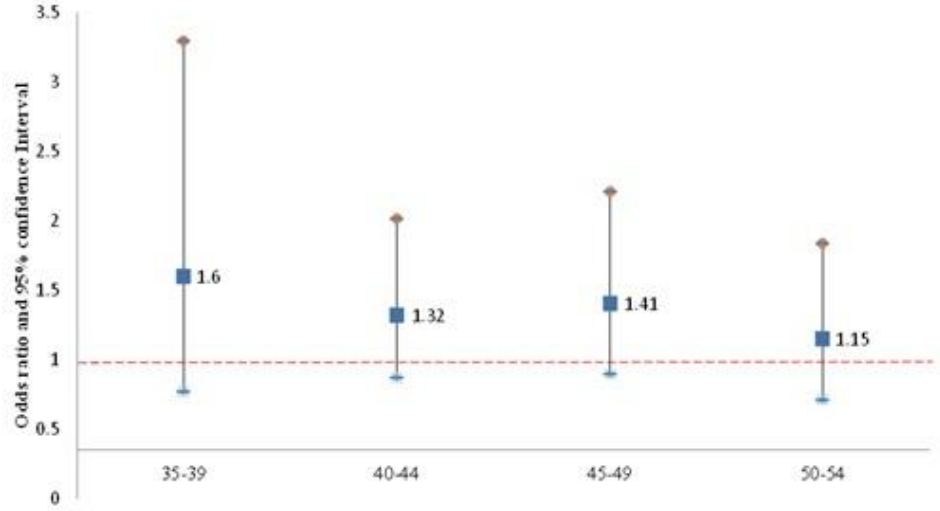


Figure 2. Relationship between MEK, TDI, welding fume exposure and hypertension by age

Table 3-2-1. Relationship between MEK, TDI, welding fume exposure and hypertension by age

Variable	Category	N	%	Odds Ratio	95% CI	
Ages	20-24	1	0.03	-	-	-
	25-29	15	0.50	-	-	-
	30-34	40	1.32	-	-	-
	35-39	29	0.96	1.60	0.77	3.30
	40-44	131	4.33	1.32	0.87	2.02
	45-49	104	3.44	1.41	0.90	2.21
	50-54	80	2.65	1.15	0.71	1.84
	55-59	53	1.75	-	-	-
	60-64	3	0.10	-	-	-

Table 3-3-1. For the relationship between hyperlipidemia and workers in the department exposed to trichloroethylene, analysis by ages was performed. The workers in the age group between 30 and 34 years showed significant results with an odds ratio of 2.39 and a 95% CI of 1.05-5.42. This was the highest result. The age group between 45 and 49 years showed the lowest result at 0.81, which was not statistically significant.

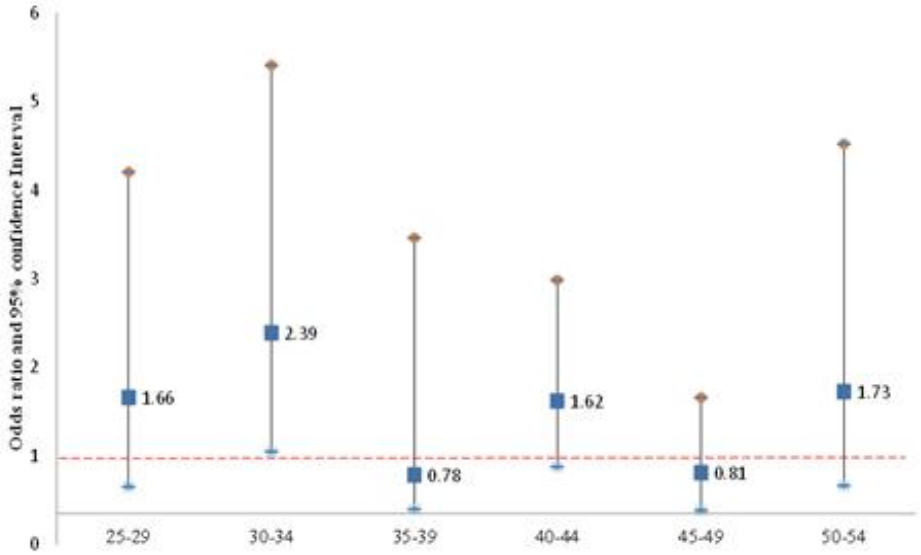


Figure 3. Relationship between trichloroethylene exposure and hyperlipidemia by age

Table 3-3-1. Relationship between trichloroethylene exposure and hyperlipidemia by age

Variable	Category	N	%	Odds Ratio	95% CI	
Ages	20-24	0	0.00	-	-	-
	25-29	25	2.73	1.66	0.65	4.21
	30-34	49	5.34	2.39	1.05	5.42
	35-39	32	3.49	0.78	0.18	3.46
	40-44	81	8.83	1.62	0.88	2.99
	45-49	48	5.23	0.81	0.39	1.66
	50-54	47	5.13	1.73	0.66	4.53
	55-59	10	1.09	1.12	0.23	5.43
	60-64	2	0.22	-	-	-

VI. Discussion

1. Discussion of study methods

This study used data on refinery workers from 2012 to 2016. A modified GEE method based on 5 years of data was used to analyze a total of 5,805 subjects. When selecting the subjects for each year, this study excluded workers with a disease history and only considered the cases in which a disease had newly occurred. Accordingly, based on such findings, we were able to calculate the SIR(Standardized Incidence Rate)[44]. The advantage of this method is that it could properly reflect the impact of the team transfer that takes place for every 3 years in an exposed chemicals and work environment. In particular, given that an individual generally makes lifestyle modifications after being diagnosed with disease, this study could reduce the impact of past disease on nutritional habits by excluding cases with a disease history.

This study used a modified GEE model, which is a method that minimize the bias from the binary distinction of disease presence or absence. Furthermore, it reduces missing data bias caused by department and workplace movements[47,48].

The study adjusted for all kinds of variables that could affect not only the impact of chemical exposure on each team, but also on general health status such as age, BMI, smoking, drinking, exercise habits, general condition, pulmonary disease, and urine problems, and thereby could increase the reliability of each variable's effect.

2. Discussion of results

In regards to the results of this study, part I calculated the SIR and the subjects showed a lower SIR for hypertension, diabetes, anemia, hyperlipidemia, and abnormal kidney function among the 6 disease categories than the general population. Their SIR for hypertension was low at 0.56 (95% CI, 0.38-0.74) in 2012. On the contrary, the subjects' SIR for abnormal liver function was consistently higher than that of the general population. Considering that most refineries are located near the coast, as required by the refinery industry, and a large number of employees live in company houses away from their home, it could be inferred that they are relatively more likely to binge-drink and not to prepare proper meals. In addition, as compared to the general population, refinery workers smoked relatively less but they drank more alcohol; this might have affected irregular liver function, which showed a high SIR among refinery workers. In particular, the finding that the smoking rate was considerably lower in the refinery industry is likely to be because smoking is not recommended in the industry because it is a fire hazard.

Part II classified the total hazard of each disease and the teams exposed to each chemical. It also verified the factors that could affect the occurrence of each disease. Regarding the significant findings of diseases, hypertension showed a higher risk of occurrence as age and BMI increased, which strongly reflects the general characteristics of this disease[49-51]. In addition, the finding that alcohol consumption and general condition were correlated with the occurrence of hypertension could also explain this aspect of hypertension[52]. When it came to the significant findings of an analysis that investigated correlations between chemicals to which teams were exposed and disease occurrence, noise was not significantly correlated with the occurrence of existing hypertension. However, teams exposed to welding fumes were found to have significant correlations with the occurrence of hypertension. The odds ratio was 1.613 and significant, while the correlations between welding fume exposure and hypertension could be confirmed by the existing literature. To some extent, this study supports existing results[53-56].

Age, BMI, and urine problems were confirmed to be correlated with the occurrence of diabetes, and this finding supports the general characteristics of diabetes. However, there was no particular factor in each team that significantly affected the occurrence.

Hyperlipidemia was found to be correlated with age, BMI, smoking, lack of exercise, and problems on abnormal urine test result. In addition, teams exposed to toluene and xylene were found to be the teams that were associated with the occurrence of hyperlipidemia. Re-analysis of those with abnormal liver function in part III also showed that toluene and xylene exposure affected hyperlipidemia[57]. It replicates the findings of previous studies, which showed that chemical exposure could lead to the occurrence of nonalcoholic steatohepatitis (NASH)[58,59]. Workers exposed to toluene and xylene showed that their liver function was affected by these chemicals, and in this regard, manager needs to take better care of workers' liver health. In addition, teams exposed to trichloroethylene were associated with the occurrence of hyperlipidemia[60-62]. This was consistent with the findings of special medical examinations, which showed that trichloroethylene exposure increased the occurrence of hyperlipidemia, and thereby confirmed the findings of the existing study on chemicals to which different teams were exposed.

At first, this study conjectured that it would be the easiest to find correlations between abnormal liver function and chemical exposure; however, it could not find any particular correlations with chemicals to which each team was exposed. Instead, there were significant correlations with age and BMI, like for other diseases. Abnormal liver function also showed significant correlations with the level of alcohol drinking, which confirms existing knowledge[63,64].

There was a relatively low number of people with other diseases like anemia and abnormal kidney function, which did not satisfy the minimum number of subjects required for valid analysis. For this reason, these diseases were not analyzed in this study.

Part III stratified and analyzed workers exposed to toluene and xylene by age groups; this showed significant correlations with the occurrence of hyperlipidemia. It was found that hyperlipidemia significantly occurred in workers in their 40s who were exposed to toluene and xylene. This

significant finding could help to identify age groups vulnerable to disease and to improve health management. In addition, when the occurrence of hyperlipidemia was analyzed in teams exposed to trichloroethylene for each age group, it was found that those in their early 30s were significantly associated with such exposure. This is a significant result even after adjusting for age and is worthy of further consideration. Furthermore, future research could investigate the finding that hyperlipidemia occurred frequently even among young people in teams exposed to trichloroethylene. When the findings of the correlations between hypertension and teams exposed to welding fumes were stratified for each age group, no age group showed significant results for the occurrence of the disease. Nevertheless, hypertension tended to occur more commonly in those in their 40s. If further studies are conducted with a larger number of workers, it will be possible to obtain clearer results.

3. Limitation

This study has several limitations. First, the study could not trace the team transfer history of the subjects, even though it analyzed 5 years of data. However, to overcome this limitation, this study excluded patients with the existing disease and conducted analysis only on those workers whose disease was identified during the check-up. It only analyzed diseases that occurred during work in the current department, and hence minimized any errors.

Second, part I calculated the SIR only for 3 years from 2012 to 2014. This is because the KNHANES was only published up until 2014. In a follow-up study, we are planning to use data from 2015 and 2016 to examine the patterns of disease occurrence.

Third, the healthy worker effect could not be excluded. However, in order to overcome the healthy worker effect and the healthy worker survival effect, this study used a GEE Method, which could reflect the effect of each exposure instead of analyzing patterns based on the existing baseline. By doing so, it analyzed factors that could affect disease occurrence and intended to contribute to improving workers' health.

VII. Conclusion

This study was conducted on workers in a large oil refinery in Korea, and has identified correlations between general diseases and lifestyle habits for the first time.

The workers' occurrence rate of hypertension, diabetes, hyperlipidemia, abnormal kidney function and anemia was lower than that of ordinary salaried employees; however, their occurrence rate of abnormal liver function was markedly higher. In lifestyle habits, the smoking rate was low while the alcohol consumption rate was quite high. This seems to reflect the characteristics of their job, which involves handling flammable hazardous substances.

In regards to chemicals exposed to each department, when workers were in teams exposed to toluene and xylene, the occurrence of hyperlipidemia was high, and the same was true of those with abnormal of liver function, both of which support an existing study on chemical exposure-induced NASH. Teams exposed to trichloroethylene showed significant correlations with hyperlipidemia, which also supports existing research findings. When those results were stratified by age group, those in teams exposed to toluene and xylene and in their 40s showed a high occurrence of hyperlipidemia, while those in teams exposed to trichloroethylene and aged between 30 and 34 had a high hyperlipidemia occurrence. This could be very important information for a company that takes care of workers' health. In teams exposed to welding fumes, significant correlations with hypertension occurrence were found, which reaffirmed the results of prior studies.

This study has improved understanding of the health status of workers in a large oil refinery in Korea, and provided detailed information regarding the impact of chemical exposure and lifestyle habits related to the work environment on chronic diseases. It is hoped that corporate health managers would use this study's conclusions and take care of workers' health with consideration of their age and team allocation.

References

1.International Agency for Research on Cancer. "Diesel and gasoline engine exhausts and some nitroarenes/this publication represents the views and expert opinions of an IARC Working Group on the Evaluation of Carcinogenic Risks to Humans which met in Lyon, 1-8 March 1988." (1989).

2.Huebner, Wendy W., et al. "Mortality experience of a young petrochemical industry cohort: 1979-1992 follow-up study of US-based employees." Journal of occupational and environmental medicine 39.10 (1997): 970-982.

3.Divine, B. J., C. M. Hartman, and J. K. Wendt. "An updated report on the Texaco mortality study 1947–1993." Houston, TX: Texaco (1996).

4.Harandi, Mohsen N., John D. Kushnerick, and Hartley Owen. "Petroleum refinery process and apparatus for the production of alkyl aromatic hydrocarbons from fuel gas and catalytic reformate." U.S. Patent No. 4,992,607. 12 Feb. 1991.

5.Mehlman, Myron A. "Dangerous and cancer-causing properties of products and chemicals in the oil refining and petrochemical industry: VIII. Health effects of motor fuels: Carcinogenicity of gasoline—Scientific update." Environmental research 59.1 (1992): 238-249.

6.Gilman, J. P. W. "Metal carcinogenesis II. A study on the carcinogenic activity of cobalt, copper, iron, and nickel compounds." Cancer Research 22.2 (1962): 158-162.

7.Siemiatycki, Jack, et al. "Listing occupational carcinogens." Environmental health perspectives (2004): 1447-1459.

8.Doll, R., L. G. Morgan, and F. E. Speizer. "Cancers of the lung and nasal sinuses in nickel workers." British Journal of Cancer 24.4 (1970): 623.

9.Mehlman, M. A., and M. S. Legator. "Dangerous and cancer-causing properties of products and chemicals in the oil refining and petrochemical industry-Part II: Carcinogenicity, mutagenicity, and developmental toxicity of 1, 3-butadiene." Toxicology and industrial health 7.3 (1991): 207-222.

10.Smith, Martyn T., Rachael M. Jones, and Allan H. Smith. "Benzene exposure and risk of non-Hodgkin lymphoma." Cancer Epidemiology Biomarkers & Prevention 16.3 (2007): 385-391.

11.Enterline, Philip E. "Respiratory cancer among chromate workers." Journal of Occupational and Environmental Medicine 16.8 (1974): 523-526.

12.Wilkinson, P., et al. "Lymphohaematopoietic malignancy around all industrial complexes that include major oil refineries in Great Britain." Occupational and Environmental Medicine 56.9 (1999): 577-580.

13.Norseth, Tor. "Cancer hazards caused by nickel and chromium exposure." Journal of Toxicology and Environmental Health, Part A Current Issues 6.5-6 (1980): 1219-1227.

14.Symanski, Elaine, Lawrence L. Kupper, and Stephen M. Rappaport. "Comprehensive evaluation of long-term trends in occupational exposure: Part 1. Description of the database." Occupational and environmental medicine 55.5 (1998): 300-309.

15.Lundberg, Ingvar. "Mortality and cancer incidence among Swedish paint industry workers with long-term

exposure to organic solvents." Scandinavian journal of work, environment & health (1986): 108-113.

16.McLean, Joseph D., and Peter K. Kilpatrick. "Effects of asphaltene solvency on stability of water-in-crude-oil emulsions." Journal of Colloid and Interface Science 189.2 (1997): 242-253.

17Anderson, J. W., et al. "Characteristics of dispersions and water-soluble extracts of crude and refined oils and their toxicity to estuarine crustaceans and fish." Marine Biology 27.1 (1974): 75-88.

18Roma-Torres, Joana, et al. "Evaluation of genotoxicity in a group of workers from a petroleum refinery aromatics plant." Mutation Research/Genetic Toxicology and Environmental Mutagenesis 604.1 (2006): 19-27.

19.Nemery, B. "Metal toxicity and the respiratory tract." European Respiratory Journal 3.2 (1990): 202-219.

20.Goyer, Robert A., and Thomas W. Clarkson. "Toxic effects of metals." Casarett & Doull's Toxicology. The Basic Science of Poisons, Fifth Edition, Klaassen, CD [Ed]. McGraw-Hill Health Professions Division, ISBN 71054766 (1996).

21.Fishbein, Lawrence. "Sources, transport and alterations of metal compounds: an overview. I. Arsenic, beryllium, cadmium, chromium, and nickel." Environmental health perspectives 40 (1981): 43.

22.WHO, Benzene, in: WHO (Eds.), Air Quality Guidelines, WHO Regional Office for Europe, Copenhagen, 2000.

23.WHO, Environmental Health Criteria 150: Benzene, World Health Organization, Geneva, 1993.

24.M.T. Smith, L. Zhang, Biomarkers of leukemia: benzene as a model, Environ. Health Persp. 106 (Suppl. 4) (1998) 937–-946.

25.R. Snyder, Overview of the toxicology of benzene, J. Toxicol.Environ. Health, Part A 61 (2000) 339–-346.

26.Savitz, David A., and Rafael Moure. "Cancer Risk among Oil Refinery Workers: A Review of Epidemiologic Studies." Journal of Occupational and Environmental Medicine 26.9 (1984): 662-670.

27.Raabe, Gerhard K., Kim W. Collingwood, and Otto Wong. "An updated mortality study of workers at a petroleum refinery in Beaumont, Texas." American journal of industrial medicine 33.1 (1998): 61-81.

28.Wong, Otto, and Gerhard K. Raabe. "A critical review of cancer epidemiology in the petroleum industry, with a meta-analysis of a combined database of more than 350,000 workers." Regulatory Toxicology and Pharmacology 32.1 (2000): 78-98.

29.Vlaanderen, Jelle, et al. "Occupational benzene exposure and the risk of lymphoma subtypes: a meta-analysis of cohort studies incorporating three study quality dimensions." Environmental health perspectives 119.2 (2011): 159.

30.Eum, Ki-Do, et al. "Psychometric properties of the Korean version of the effort–reward imbalance questionnaire: a study in a petrochemical company." International archives of occupational and environmental health 80.8 (2007): 653-661.

31.Kwon, Hyuck-myun. "The effectiveness of process safety management (PSM) regulation for chemical industry in Korea." Journal of Loss Prevention in the Process Industries 19.1 (2006): 13-16.

32.Kim, Jung-Man. "The health effects of industrial noise." Journal of Korean society of Environmental Engineers 29.2 (2007): 131-137.

33.Beavon, David K. "Petroleum refining process." U.S. Patent No. 2,914,457. 24 Nov. 1959.

34.Wang, Michael, Hanjie Lee, and John Molburg. "Allocation of energy use in petroleum refineries to petroleum products." The International Journal of Life Cycle Assessment 9.1 (2004): 34-44.

35.Gary, James H., Glenn E. Handwerk, and Mark J. Kaiser. Petroleum refining: technology and economics. CRC press, 2007.

36.International Agency for Research on Cancer. "Occupational exposures in petroleum refining; crude oil and major petroleum fuels." IARC monographs on the evaluation of carcinogenic risks to humans 45 (1988).

37.Bland, William F., and Robert L. Davidson. Petroleum processing handbook. McGraw-Hill Companies, 1967.

38.Kaufmann, T. G., et al. "Catalysis science and technology for cleaner transportation fuels." Catalysis Today 62.1 (2000): 77-90.

39.Basu, B., S. Satapathy, and A. K. Bhatnagar. "Merox and related metal phthalocyanine catalyzed oxidation processes." Catalysis Reviews—Science and Engineering 35.4 (1993): 571-609.

40.Ancheyta, Jorge, and James G. Speight, eds. Hydroprocessing of heavy oils and residua. CRC Press, 2007.

41.GS caltex. http://www.gscaltex.com/company/production.aspx. Seoul: 2016

42. Cho, Belong, and Cheol Min Lee. "Current situation of national health screening systems in Korea." Journal of the Korean Medical Association/Taehan Uisa Hyophoe Chi 54.7 (2011).

43.Yeo, Ji-Young, and Hyoung-Sun Jeong. "Determinants of health screening and its effects on health behaviors." Health Policy and Management 22.1 (2012): 49-64.

44.Parkin, D. Maxwell, et al. Cancer incidence in five continents, volume VI. No. 120. international agency for research on cancer, 1992.

45.Hanley, James A., Abdissa Negassa, and Janet E. Forrester. "Statistical analysis of correlated data using generalized estimating equations: an orientation." American journal of epidemiology 157.4 (2003): 364-375.

46.Tom, A. B., Tom AB Snijders Roel J. Bosker, and Roel J. Bosker. Multilevel analysis: An introduction to basic and advanced multilevel modeling. Sage, 1999.

47.O'Connell, A.A., Goldstein, J., Rogers, H.J., & Peng, C.Y.J. (2008). Multilevel logistic models for dichotomous and ordinal data. In A.A. O'Connell & D.B. McCoach (Eds.), Multilevel modeling of educational data (199-242). Charlotte, NC: Information Age Publishing, Inc.

48. Ene, Mihaela, et al. "Multilevel Models for Categorical Data Using SAS® PROC GLIMMIX: The Basics." SAS Global Forum. 2015.49.Bell, A. Colin, Linda S. Adair, and Barry M. Popkin. "Ethnic differences in the association between body mass index and hypertension." American Journal of Epidemiology 155.4 (2002): 346-353.

50'Vonbach, Priska, et al. "Risk factors for gastrointestinal bleeding: a hospital-based case-control study." Drug-Drug Interactions in the Hospital 103 (2007).

51.Cutler, Jeffrey A., et al. "Trends in hypertension prevalence, awareness, treatment, and control rates in United States adults between 1988–1994 and 1999–2004." Hypertension 52.5 (2008): 818-827.

52.Klatsky, Arthur L. "Alcohol and hypertension." Clinica Chimica Acta 246.1 (1996): 91-105.

53.Malo, Jean-Luc, and André Cartier. "Occupational asthma due to fumes of galvanized metal." CHEST Journal 92.2 (1987): 375-377.

54.Hicks, R., et al. "Cardiotoxic and bronchoconstrictor effects of industrial welding fumes containing barium." Toxic Interfaces of Neurones, Smoke and Genes. Springer Berlin Heidelberg, 1986. 416-420.

55.Ibfelt, Else, Jens Peter Bonde, and Johnni Hansen. "Exposure to metal welding fume particles and risk for cardiovascular disease in Denmark: a prospective cohort study." Occupational and Environmental Medicine (2010): oem-2009.

56.MARKHAM, THOMAS N., and CHARLES W. FiShBUrN. "Sensitivity to toluene diisocyanate in an adhesive." Journal of Occupational and Environmental Medicine 9.9 (1967): 471-473.

57.Cotrim, Helma P., et al. "Clinical and histopathological features of NASH in workers exposed to chemicals with or without associated metabolic conditions." Liver International 24.2 (2004): 131-135.

58.Ludwig J, Viggiano T R, McGill D B, Ott B J. Nonalcoholic steatohepatitis. Mayo Clin Proc 1980; 55: 434–8.

59.Cotrim H P, Carvalho F M, Freitas L A, Parana R, Oliveira C J, Valadares C, Andrade Z. Nonalcoholic steatohepatitis (NASH) and occupational exposure: a case–control study among petrochemical workers. J Hepatol 2001; 34(Suppl. 1): 229–30.

60.Pastino, Gina M., Wendy Y. Yap, and Maria Carroquino. "Human variability and susceptibility to trichloroethylene." Environmental Health Perspectives 108.Suppl 2 (2000): 201.

61.ALGhwij, L. M., et al. "Effect of some herbal plants on liver function of rats treated with trichloroethylene." Egyptian Journal of Hospital Medicine (Jan 2012) 46 (2012): 7-16.

62.Lombardo, L. J., et al. "Health Effects of Solvent Exposure in Railroad Workers." Journal of Occupational and Environmental Medicine 39.4 (1997): 362.

63.Hoyumpa Jr, Anastacio M., and Steven Schenker. "Major drug interactions: effect of liver disease, alcohol, and malnutrition." Annual review of medicine 33.1 (1982): 113-149.

64.Vivek, Kapur, et al. "Hepatoprotective activity of “jigrine” on liver damage caused by alcohol, Carbontetrachloride and paracetamol in rats." Indian Journal of Pharmacology 26.1 (1994): 35.

Korean Abstract

우리나라 대형정유 공장근로자의 일반생활습관 및 근무여건에 따른 건강상태에 관한 연구 (2012-2016)

서론: 정유업은 다양한 복합 화학물질을 다루는 산업으로 세계적으로 많은 수의 근로자가 근무하고 있는 산업이다. 또한 현대 산업사회의 근간이 되는 주요 산업으로 그 중요성은 계속 높아지고 있다. 1980년대 이전까지 정유공장에서 일하는 근로자에서 화학 물질 노출에 의한 질병 발생이 흔하였으며 특히 과거에 시행된 코호트 연구들은 백혈병과 같은 중대 질병 발생과의 연관성을 규명해 왔다. 중대 질병을 발생 시키는 물질들에 대한 연구는 많이 이루어져서 현재 보호장구 착용과 물질 노출 기준이 강화 되었다. 근래에는 정유공장에 일한다고 하더라도 이러한 중대 질환에 의하여 고통받는 경우는 드물다. 그러나 일반 질병이나 건강 습관에 대한 부서별 특성을 반영한 연구는 부족한 실정이다. 외국과는 현저히 다른 우리나라 정유공장의 특성상 업무 환경을 반영한 일반 질환에 대한 건강영향을 살펴 보는 것이 본 연구의 목적 중 하나이며 또한 일반 인구 집단과 비교한 대표적인 만성 질환의 발생을 보는 것도 본 연구의 목적이 될 수 있다. 궁극적으로 이를 통하여 우리나라 대형 정유공장 근로자에서 취약한 만성 질병에 대한 실질적인 관리 대책을 마련할 수 있도록 하는 것이 본 연구의 가장 큰 목적이다.

연구목적: 이 연구의 첫번째 목적은 국민건강영양조사를 이용하여 일반근로자의 만성질환 유병률 산출을 통한 정유공장 근로자들의 만성질환 표준 유병률을 산출하여 상대적으로 취약한 질환을 확인하는 것이다. 또한 만성질환 발생에 영향을 주는 노출물질별로 분류된 부서특성의 영향을 분석하고 일반 생활습관에 따른영향을 분석한다. 본 연구결과를 바탕으로 노출물질과 부서환경에 따른 근로자의 만성질환 관리에 맞춤형 관리를 통한 도움이 되고자 한다.

연구방법: 본 연구는 우리나라 일개 대형 정유공장의 2012년에서 2016년까지의 건강검진 결과를 이용하였다. 또한 2012년부터 2014년 까지 국민건강영양조사 결과를 모수로 하여 각 년도별 고혈압, 당뇨, 빈혈, 고지혈증, 간기능 이상, 신장기능 이상 발생자를 산출하여 표준화발생률을 구하였다. 또한 2012부터 2016년 까지 5년간의 자료를 로지스틱 리그레션 분석 방법인 modified generalized estimating equation (GEE) 방식을 사용하여 분석하였다.

연구결과: 국민건강영양조사(KNHANES) 에서 봉급생활자를 대상으로 표준발생률을 산출 하였다. 고혈압은 1 미만으로 낮은 결과를 보였으나 간기능 이상의 경우 유의하게 높은 결과를 보였다.

GEE 방식으로 분석한 결과에서는 메틸에틸케톤, 톨루엔 디아이소시아네이트, 금속흄 노출 부서에서 고혈압 발생 오즈비가 1.613 95% 신뢰구간 (1.009-2.580) 으로 유의한 결과를 보였다. 트리클로로에틸렌 노출 부서에서는 고지혈증 발생 오즈비 1.498 로 95%신뢰구간 (1.039-2.160) 으로 유의한 결과를 보였다. 톨루엔, 자일렌 노출부서에서는 고지혈증 발생 오즈비가 2.618로 95%신뢰구간 (1.460-4.694) 로 유의한 결과를 보였다. 이는 간기능 이상인 근로자를 대상으로 재분석 하였을 때 오즈비 2.613으로 유의한 결과를 보였다.

결론: 본 연구는 대한민국에 있는 일개 대형 정유공장 근로자를 대상으로 한 연구이며 일반 질환과 업무환경 및 생활 습관과의 연관성을 밝힌 첫 연구이다. 고혈압, 고지혈증, 신장기능이상, 빈혈 등의 질환발생은 일반 봉급생활자에 비해 낮게 발생하였으나 당뇨와 간기능 이상은 현저히 높게 발생하였다. 생활습관에서는 흡연은 현저히 낮았으나 음주는 현저히 높았다. 이는 발화가 잘되는 위험물질을 다루는 업무의 특성을 반영하는 결과라 생각된다. 물질노출 부서별 특성으로는 톨루엔, 자일렌 노출 부서에 근무하는 경우 고지혈증 발생이 높았는데 간기능 이상자에서도 같은 유의한 결과를 보여 화학물질 노출에 의한 비알콜성 지방간 발생에 대한 기존의 연구를 뒷받침 하였다. 트리클로로에틸렌 노출 부서에서도 고지혈증 발생과 유의한 영향을 보였는데 본 결과 역시 기존의 연구 결과를 뒷받침 하는 결과이다. 본 연구를 통하여 대한민국의 대형 정유공장 근로자 건강 상태에 대하여 알 수 있었으며 업무 환경과 관련된 노출 물질, 생활 습관 등이 만성 질환에 영향을 주는 요인 들에 대하여 자세히 알 수 있었으며 이는 장기적으로 국내 정유공장 근로자의 건강관리에 도움을 줄 수 있을 것이라 생각한다.

핵심어: 대형정유공장, 대한민국, 국민건강영양조사(KNHANES), 생활습관, 업무환경, 화학물질노출

연세대학교 보건대학원 생명윤리심의위원회
Institutional Review Board, Yonsei University Graduate School of Public Health
서울특별시 서대문구 연세로 50 (우) 120-752
Tel. 02-2228-1520 Fax. 02-313-3292 Email. ygph_irb@yuhs.ac
Homepage. http://gsph.yonsei.ac.kr/postgraduate/irb/intro/

심 의 결 과 통 보 서

수신	성명	이준희	소속(전공)	연세대학교대학원 보건학과
과제번호	2-1040939-AB-N-01-2016-307			
연구과제명	국문	우리나라 일개 대형 정유공장 근로자의 건강 변화 양상과 이에 영향을 주는 요인에 대한 연구 (2012-2016)		
	영문	Research on factors that affect health behavior and oil refinery factory workers in Korea (2012-2016)		
연구목적	■ 학술용		□ 기타	
연구종류	■ 인간대상연구		□ 인체유래물 연구	□기타
연구기관	■ 단일기관		□ 다기관(참여기관 수:)	
심의종류	□ 정규 심의		□ 신속 심의	■ 심의 면제
심의일자	2016년 7월 8일 (금)			
심의대상	■ 연구계획서(신규)		■ 책임연구자	
	□ 연구계획서(보완)		□ 연구대상자 동의서	
	□ 계획서 변경		□ 증례기록서	
	□ 중간보고서		□ 연구대상자 모집 광고	
	□ 중지 또는 종료보고서		□ 연구대상자 작성 일지(Daily)	
	□ 결과보고서		□ 기타 연구대상자에게 제공되는 문서	
	■ 기타: 동의서 면제 사유서			
연구위험수준	■ Level Ⅰ(최소위험)		□ Level Ⅱ(최소위험에서 약간 증가)	
	□ Level Ⅲ(심각한 후유증 초래 가능)		□ Level Ⅳ(사망 또는 기형 초래 가능)	
심의결과	■ 승인	□ 시정승인	□ 보완	□ 반려 □ 중지/보류
과제승인일	2016년 7월 12일 (화)		**만료일**	2017년 2월 28일
심의의견	권고사항: 개인 식별이 불가능하도록 분석용 자료를 생성하고 관리를 철저히 할 수 있도록 함			

연세대학교 보건대학원 생명윤리심의위원회 위원장