creative commons

COMMONS DEED

저작자표시-비영리-변경금지 2.0 대한민국

이용자는 아래의 조건을 따르는 경우에 한하여 자유롭게

- 이 저작물을 복제, 배포, 전송, 전시, 공연 및 방송할 수 있습니다.

다음과 같은 조건을 따라야 합니다:

저작자표시. 귀하는 원저작자를 표시하여야 합니다.

비영리. 귀하는 이 저작물을 영리 목적으로 이용할 수 없습니다.

변경금지. 귀하는 이 저작물을 개작, 변형 또는 가공할 수 없습니다.

- 귀하는, 이 저작물의 재이용이나 배포의 경우, 이 저작물에 적용된 이용허락조건을 명확하게 나타내어야 합니다.
- 저작권자로부터 별도의 허가를 받으면 이러한 조건들은 적용되지 않습니다.

저작권법에 따른 이용자의 권리는 위의 내용에 의하여 영향을 받지 않습니다.

이것은 이용허락규약(Legal Code)을 이해하기 쉽게 요약한 것입니다.

Disclaimer

dCollection

보건학 석사학위논문

Association Between Socio Economic Status and Blood Cadmium and Smoking Status

: KNHANES: 2007-2011

2017년 2월

서울대학교 보건대학원

보건학과 보건학전공

지용호

Abstract

Association Between Socio Economic Status and Blood Cadmium and Smoking Status

: KNHANES: 2007-2011

Yongho Jee

Department of Epidemiology

The Graduate School of Public Health

Seoul National University

Background and aim: Many studies that examined blood cadmium levels by exposure routes, and distribution difference by sex and age have been done. However, studies that examined the association between social economic status such as income level, education level, and occupation level and cadmium level, also regarding the confounding effects of smoking were relatively rare. Therefore, our study aim was to examine the association between socio-economic variables and the blood cadmium level with the confounding effect of smoking.

Methods: Data were drawn from the two independent cross-sectional waves of KNHANES (2007-2009, 2010-2012) and involved years that were containing blood cadmium and cotinine data (2008, 2009, 2010, 2011). We investigated the income level by comparing the cadmium level between the highest income quartile group (Q4) and the lowest income quartile group (Q1). Education level was investigated by comparing the blood cadmium level between the college graduate group and under elementary graduate group. Association with the occupation was investigated by using the occupation classification variable of KNHAENS, comparing the cadmium level between professional and managers, non-manual, skilled, and semiskilled workers, unskilled workers, and unemployed group. Smoking variable was investigated by categorizing smoking status (never, former and current), pack-year into quartile variables. Additionally, urinary cotinine level was used to guarantee the validity of smoking variables. Regarding dietary factor, association between blood cadmium level and intake of rice and barely was analyzed by frequency of rice and barely intake per week.

Results: Blood cadmium level increased by increasing age groups. Participants earning low income, and less education had higher blood cadmium levels. Significant differences were found between never (0.87 μg/L) versus former (0.77 μg/L) and current (1.12 μg/L) smokers. After controlling sex and smoking in men and women, the association between income and cadmium level became substantial decrease. In additional controlling for education, the associations were disappeared. However, there was strong negative association between education and cadmium level even after controlling for smoking history, pack-year, or urinary cotinine. Additionally, blood cadmium increased by intake of rice and barely intake, when rice and barely intake was added in the final multivariable regression model.

Conclusion: In cross sectional data from KNHANES, blood cadmium levels were significantly higher among those with low income and less education levels. These associations were contributed by smoking history, but still remained.

Keyword: Cadmium, smoking, socio-economic status, path analysis

Student Number: 2015-24018

CONTENTS

TABLES

FIGURES

1. INTRODUCTION

1.1 Background

Cadmium is well known as a heavy metal used in our daily life and harmful to human body when it is occupationally and environmentally exposed. Cadmium is toxic even at low exposure levels and has acute and chronic effects on health and environment. Since cadmium is not degradable in nature, once released to the environment and stay in circulation (Nordic Council of ministers.,2003). Human exposure route of cadmium is commonly categorized by occupational exposure and environmental exposure (non-occupational exposure). Occupational route of cadmium exposure is exposed by mining, producing, and consuming non-ferrous metal or plating, welding, usage of storage battery, agricultural chemicals and pesticide production [Lee, Ha., 2011]. Environmental exposure (non-occupational exposure) to cadmium of ordinary person is mainly by food intake such as meat, shellfish, culinary vegetable, food packaged by cadmium container, moreover, exposure to cigarette smoking and dust from polluted soil lead to chronic exposure [Lewis, Metals., 2007, Franzblau, Moline., 2005, Lee., 2009]. Exposure level and the risk of environmental disease by environmental exposure is relatively lower than the occupational exposure, However health effects associated with low level exposure such as rise of blood pressure, kidney function degradation are also reported. However, since environmental exposure has an extensive range worldwide recognized public health hazard and related with vulnerable group such as children, pregnant women and elderly, the potential effects of public health should be concerned. According to the report by Seoul saint Mary's hospital research team, the mean of Korean blood cadmium level was 1.52ug, which was two times higher than United States in 20s~40s, and three times higher in 50~60s [Seoul saint mary hospital research report., 2014]. Rice eating habits are considered to be one of the main factor associated with high cadmium level in Asian countries including

Korea [KFDA, 2007].

There were also many studies that examined the Korean blood cadmium levels by Exposure mechanism, and distribution difference by sex and age [Moon., 2007, Kim et al., 2009., Choi et al., 2013]. However, studies that examined the association between social economic status such as income level, education level, and occupation level and cadmium level, also regarding the confounding effects of smoking were relatively rare.

1.2 Literature review

1.2.1 Environmental exposure and cadmium concentrations

The major natural sources of cadmium are volcanoes and weathering of rocks. Atmosphere Emission from volcanoes are estimated as 140-1,500 tones (Nriagu., 1989). The weathering of rocks releases cadmium to soils and aquatic systems. Anthropogenic cadmium emission was initiated since 1983 to mid of 1990s, throughout that period total emission of cadmium to air decreased about 7,000 tones since the major source of cadmium emission to air was non-ferrous metal production (Pacyna & Pacyna., 2001). Global cadmium release to soil and landfill is estimated as 2,500 to 15,500 tons per year (Nriagu, J. & J. Pacyna., 1988). Five mg/kg or higher level of cadmium levels from river and lake sediments are reported, and average cadmium content of seawater is reported as 5-20 ng (OSPAR., 2002). Due to the water solubility of cadmium and cadmium compounds, they are mobile in soil, more bioavailable, accumulated by microorganisms, molluscs where bio-concentration is high. For animals, cadmium concentrates in internal organs such as kidney and liver (Gašparík., et al 2016).

1.2.2. Social economic status and environmental toxicants

Improved analytical techniques have been able to measure environmental chemicals in blood and urine from large population studies with improved sensitivity and reproducibility (Stokstad, 2004). Significant evidence based on previous studies support that individuals in lower socioeconomic groups suffer from greater burden of environment toxicants (Jemal et al., 2008; Zheng and Land, 2012). Association between socio-economic status and hazards of the chemical environment disproportionately affect those households and individuals (Brown, 1995). Former studies reported that social and racial disparity in toxicant burden such as lead (Iqbal et al., 2008), pesticides (Cox et al., 2007) polychlorinated biphenyls (PCBs) (Borrell et al., 2004; Vrijheid et al., 2012) was associated.

1.2.3. Occupational and non-occupational exposure to cadmium

Cadmium exposure is generally categorized by non-occupational and occupational exposure. Throughout former studies, sources of human exposure to cadmium in the general population are reported as food ingestion, cigarette smoking inhalation and occupation exposure to airborne cadmium particles (Jarup et al., 1998).

1.2.4. Smoking history and cadmium level

According to the animal experiment held by Piascik et al, rates exposed to cadmium enriched cigarette smoke experienced significantly higher cadmium blood level compared to cage control counterparts (Piascik et al., 1985). Also cross-sectional human study based on New York City based cross-sectional heavy metal bio-monitoring study of the general population reported cigarette smoking as a strongly associated factor with increase in blood cadmium (Mckelvey et al., 2007). Results from laboratory surveillance based on National Health and Nutrition Examination Survey, NHANES) also found that significant increase in cadmium levels in blood and urine in smokers and former smokers (Hecht et al., 2013). Approximately 1μg of cadmium is contained in each cigarette, 25~35% is absorbed into the bloodstream (Jarup et al., 1998; Nordberg & Nordberg, 1988; Travis & Haddock, 1980).

1.2.5 Human exposure and health effects

The major route of cadmium exposure to non-smoking general populations is via food (Satarug S et al., 2010). Gastrointestinal absorption of cadmium is influenced by the type of diet and nutritional status. On average, 5% of the total oral intake of cadmium is observed (WHO 1992a). Agricultural products are associated with cadmium in human diet. Atmosphere deposition and direct input are known as important sources of cadmium to agricultural soils (Nordic Council of Ministers., 2003). Average daily cadmium intake in non-polluted areas are reported as 10-40 μg, while the average exposure value in polluted area has been found to be several hundred μg per day (WHO 1992a). 'Provisional Tolerable Weekly Intake (PTWI)' for cadmium was established by the world health organization (WHO) which was μg/kg body weight (WHO 1992a).

1.3 Objectives

Therefore, this study aims to examine the association between socio-economic variables and the blood cadmium level with the confounding effect of smoking, ultimately desire to provide basic evidence for making appropriate policy making against cadmium exposure.

Specific objectives of this study were as follows:

First, understanding the overall blood cadmium level of general Korean population

Second, to identify the relationships between blood cadmium level and socio-economic status, and analyze how smoking status effects the association.

2. METHODS

2.1 Data sources

Data were based on the data from the fourth and fifth Korea National Health and Nutrition Examination Survey (KNHANES IV and V, 2007-2012) by the Korean Centers for Disease Control and Prevention (KCDC) and the Ministry of Health and welfare. Data included on respondents of ages 20 to 87 years Children and adolescents were excluded since heavy metal examination was merely measured for adults. Data were drawn from the two independent cross-sectional waves of KNHANES (2007-2009, 2010-2012) and finally involved years that were containing blood cadmium and cotinine data (2008, 2009, 2010, 2011). The sample size of the participants who had blood and cotinine data was 7,734.

2.2 Measures

2.2.1 Socio-demographic variables

Education level, income and occupation were included as socioeconomic factors in this study. Age was classified into 5 categories (20-29, 30-39, 40-49, 50-59, and ≥60years). Education level was classified in quartile by one's final level of schooling (less than elementary school graduate, middle school graduate, high school graduate, college graduate). Classification of occupation was categorized in 7 groups (managers and professionals, clerical workers, service and sales workers, skill agriculture workers, technicians and associate, elementary occupations, unemployed) based on Korean Standard Classification of Occupations (KCSO) of the Korea National Statistical Office. For the present study, occupation category was reclassified into 4 categories (professional and managers, non-manual, skilled and semiskilled workers, unskilled workers, and unemployment group) based on the Whitehall study (Marmot, M. et al., 1984).

2.2.2 Blood Cadmium level

The data were collected from the Korea National Health and Nutrition Examination Surveys (KNHANES), a nationally representative sample recruited using a multi-stage clustered probability design. Average blood cadmium level for men was 1.24 μg (standard deviation 1.24, minimum 0.02, maximum 8.34) and 1.57 μg (standard deviation 0.62, minimum 0.02, maximum 6.03) for women. Distribution of cadmium level was not normally distributed, but left skewed, therefore log transformed values or geometric mean was used for analysis in this study (Figure 1).

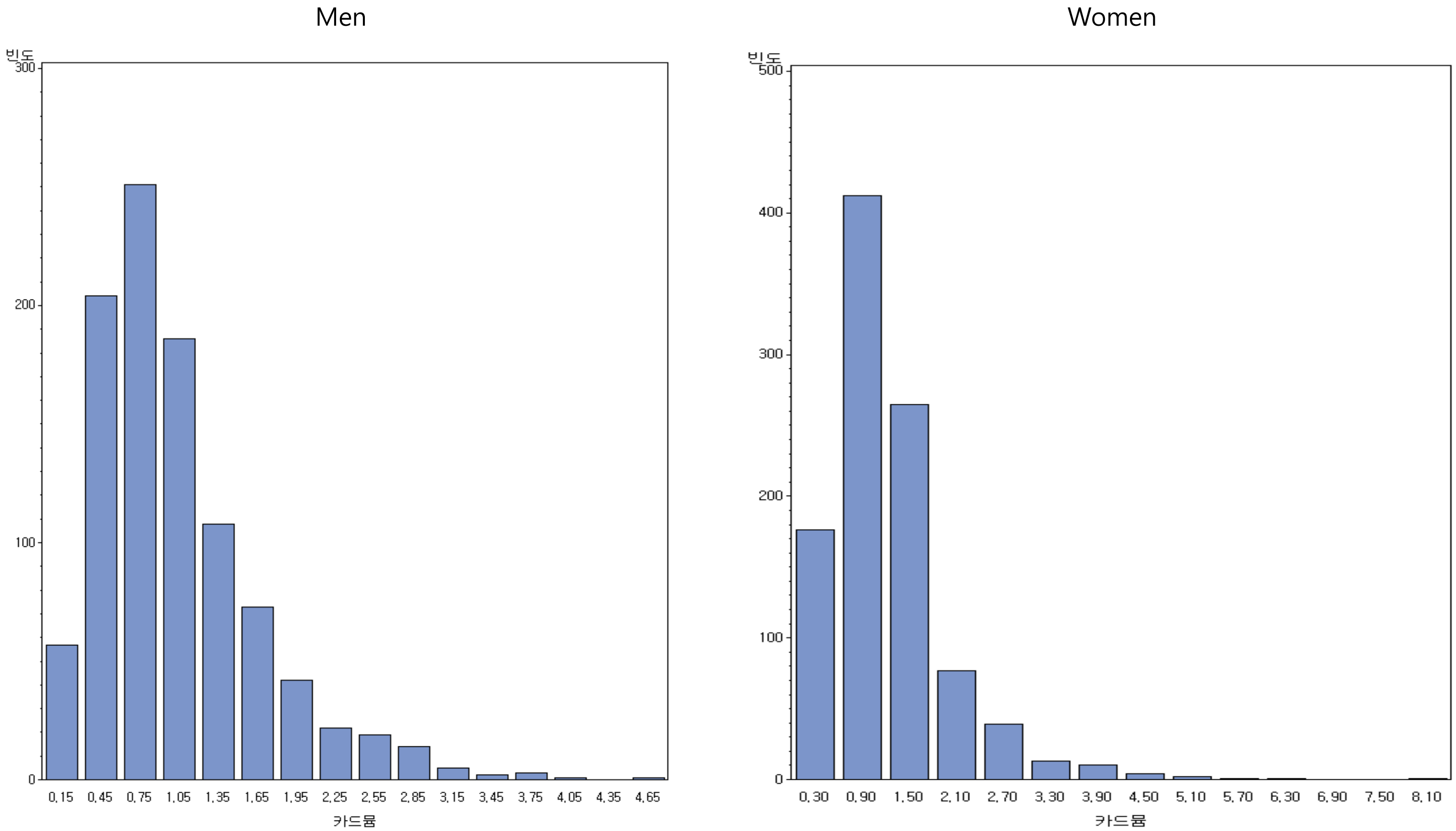


Figure 1. Serum cadmium level in men and women

2.3 Study design

Throughout the literature review, suggested research model aimed to identify the relationships between social economic status, smoking status and blood cadmium level (Figure 2).

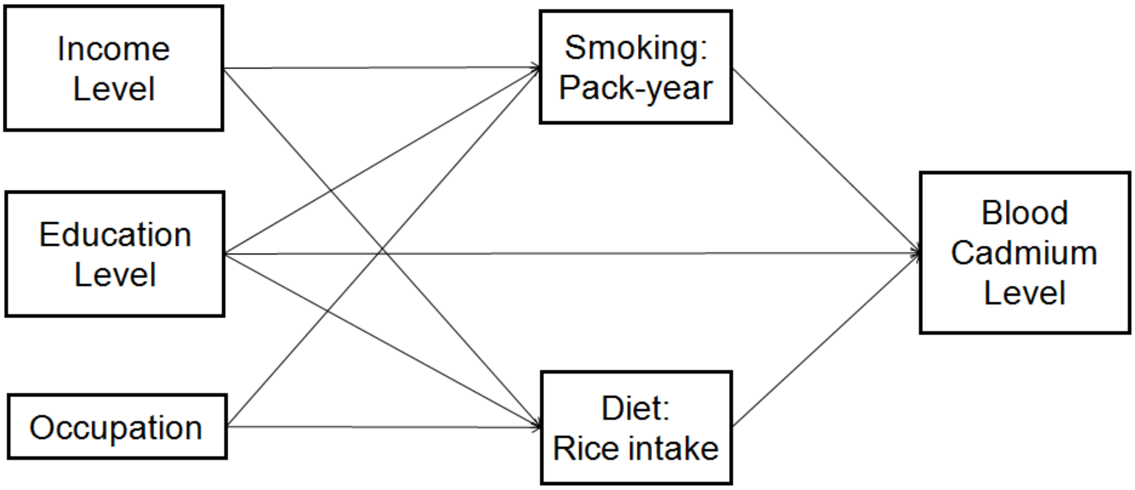


Figure 2. Research design

Two main research hypothesis based on the study design are as follows:

(1) Participants with lower income, lower education, agriculture and fishery engager, industry workers are more likely to have higher blood cadmium level

(2) Smoking status will act as a mediator between social economic status and blood cadmium level.

2.4 Statistical Analysis

The complex sampling design was used for the KNHANES data considering stratification, clusters, and weights to represent the entire South Korean population. The demographic characteristics and the prevalence were presented as weighted percentages to describe nationally representative data using Proc Surveymeans and Proc Surveyreg. Initially, descriptive statistics were computed for all study variables, including frequencies and percentages for categorical variables, means and standard deviation for continuous variables.

Next, we investigated the income level by comparing the cadmium level between the highest income quartile group (Q4) and the lowest income quartile group (Q1). Education level was investigated by comparing the blood cadmium level between the college graduate group and under elementary graduate group. Association with the occupation was investigated by using the occupation classification variable of KNHAENS, comparing the cadmium level between legislators, senior officials and managers group and unemployed group. Smoking variable was investigated by categorizing current smoking status, smoking amount, smoking duration, pack year into quartile variables. Additionally, urinary cotinine level was used to guarantee the validity of smoking variables.

SAS software version 9.4 (SAS Institute, Cary, NC) was used for preliminary analyses, and Mplus version 7.4 was used for the path analyses (Muthén & Muthén 1998–2015).

3. RESULTS

3.1 General characteristics of study participants

The general characteristics of KNHANES study participants are demonstrated in Table 1. Difference in age and sex distribution by year was not noticeable. However, in education level, distribution of university graduates increased by 27.6% in 2008 to 35.8% in 2011 (Table 1).

Distribution of general characteristics of participants stratified by sex was demonstrated in Table 2. Sample size of women (3,913, 51%) was slightly larger than men (3,821, 49%). Average body mass index (BMI) was higher in men. Average cotinine level and number of current smokers in men was approximately 7 times higher than women. Proportion of participants who learned elementary education or less was higher in women (25.5%) than in men (13.5%), also approximately two times higher proportion of unemployed participant was in women (50.2%) than in men (22.5%).

Table 1. General characteristics of the study subjects stratified by year

	2008	2009	2010	2011
Total participants	9,744	10,533	8,958	8,518
Study participants	1,936	1,964	1,916	1,918
Sex, male (%)	49.9	50.0	49.3	49.5
Mean age, y(SD)	45.5 (15.5)	45.5 (15.5)	45.3 (14.5)	45.1 (14.5)
Education				
Less than primary	455 (22.7)	419 (21.2)	359 (18.5)	310 (15.9)
Middle school	242 (12.1)	225 (11.4)	203 (10.5)	209 (10.7)
High school	751 (37.5)	748 (37.8)	694 (35.8)	736 (37.7)
College or more	533 (27.6)	587 (29.7)	683 (35.2)	700 (35.8)
Occupation				
Managers	229 (11.5)	261 (13.2)	283 (14.5)	292 (14.9)
Clerical workers	142 (7.1)	182 (9.2)	211 (10.9)	181 (9.3)
Service workers	250 (12.6)	272 (13.8)	274 (14.2)	265 (13.6)
Agricultural, fishery	156 (7.8)	114 (5.8)	155 (8.0)	114 (5.8)
Craft workers	213 (10.7)	229 (11.6)	217 (11.3)	243 (12.4)
Elementary occupations	199 (10.0)	179 (9.1)	137 (7.1)	157 (8.0)
Unemployed	801 (40.3)	738 (37.4)	651 (33.8)	702 (35.9)
Income				
Bottom quantile (Q1)	497 (25.5)	512 (25.9)	506 (26.1)	466 (23.7)
Second quintile (Q2)	478 (24.5)	497 (25.2)	494 (25.5)	509 (23.7)
Middle quantile (Q3)	491 (25.2)	483 (24.5)	469 (21.2)	491 (25.0)
Fourth quantile (Q4)	485 (24.9)	483 (24.5)	470 (24.2)	502 (25.5)

Table 2. General characteristics of the study subjects stratified by sex*

	Men	Women	Total
N	3,821	3,913	7,734
Age, year	45.4 (15.0)	45.3 (15.0)	45.3 (15.0)
Body mass index, kg/m^2	24.1 (3.1)	23.3 (3.5)	23.7 (3.3)
Serum cadmium, μg/L	1.1 (0.6)	1.2 (0.7)	1.2 (0.7)
Urine cotinine,	667.4 (973.0)	102.4 (376.6)	389.0 (793.5)
Smoking status, %			
Never	19.3	87.6	53.9
Former	35.4	6.3	20.6
Current	45.3	6.1	25.5
Income, %			
Q1 (low)	24.5	25.9	25.2
Q2	25.3	25.2	25.3
Q3	24.4	24.9	24.6
Q4 (high)	25.8	24.0	24.9
Education, %			
Under Elementary	13.5	25.5	19.6.
Middle school	11.4	10.8	11.1
High school	39.4	35.0	37.2
University or more	35.7	25.7	32.1
Occupation†, %			
Professionals, managers	16.4	11.0	13.7
Non-manual, skilled workers	52.8	30.1	41.3
Unskilled workers	8.3	8.8	8.6
Unemployed	22.5	50.2	36.5

*Data are expressed as mean (SD) unless otherwise indicated. †Non-manual or skilled workers included clerical workers, service and sales workers, skilled agriculture, and technicians and associate.

Table 3. Rice and Barley intake of the study subjects stratified by year

	2008	2009	2010	2011
Men				
Rice				
≤7 per week	1 (0.1)	0 (0.0)	6 (0.6)	4 (0.4)
1 per day	8 (0.8)	14 (1.4)	24 (2.6)	24 (2.5)
2 per day	227 (23.7)	254 (26.0)	270 (28.7)	296 (31.3)
3 per day	534 (55.9)	543 (55.6)	427 (45.3)	443 (46.8)
Non response	186 (18.5)	166 (17.0)	215 (22.8)	179 (18.9)
Barley				
≤7 per week	299 (31.3)	318 (32.6)	261 (27.7)	253 (26.7)
1 per day	116 (12.1)	140 (14.3)	147 (15.6)	164 (17.3)
2 per day	169 (17.7)	147 (15.1)	178 (18.9)	206 (21.8)
3 per day	186 (19.5)	206 (21.1)	141 (15.0)	144 (15.2)
Non response	186 (19.5)	166 (17.0)	215 (22.8)	179 (18.9)
Women				
Rice				
≤7 per week	2 (0.2)	2 (0.2)	9 (0.9)	18 (1.9)
1 per day	29 (3.0)	29 (2.9)	57 (5.9)	47 (4.8)
2 per day	268 (27.4)	311 (31.5)	362 (37.2)	373 (38.4)
3 per day	593 (60.5)	544 (55.1)	449 (46.1)	455 (46.8)
Non response	88 (9.0)	101 (10.2)	97 (10.0)	79 (8.1)
Barley				
≤7 per week	298 (30.4)	279 (28.3)	241 (24.7)	189 (19.4)
1 per day	86 (8.8)	93 (9.4)	122 (12.5)	140 (14.4)
2 per day	204 (20.8)	202 (20.5)	258 (26.5)	275 (28.3)
3 per day	304 (31.0)	310 (31.4)	255 (26.2)	289 (29.7)
Non response	88 (9.0)	103 (10.4)	98 (10.1)	79 (8.1)

3.2 Blood cadmium level stratified by general characteristics

Average blood cadmium level for women (1.57 μg, standard deviation 0.62, minimum 0.02, maximum 6.03) was higher than men (1.24 μg, standard deviation 1.24, minimum 0.02, maximum 8.34) (Figure 3). Blood cadmium level was lowest in 20s, and tend to increase by ageing (Figure 4). Blood cadmium level also lower in participants with high income level (Q4) and high education level with university or more (Figure 5 and 6). Regarding to occupation, we reclassified into 4 categories. Among 4 reclassified occupations, blood cadmium level was highest in unskilled workers (Figure 7 and 8).

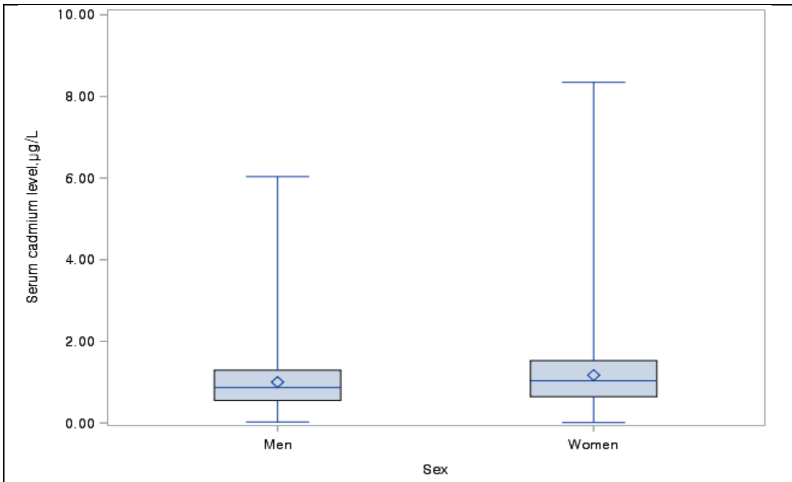


Figure 3. Blood cadmium level stratified by sex

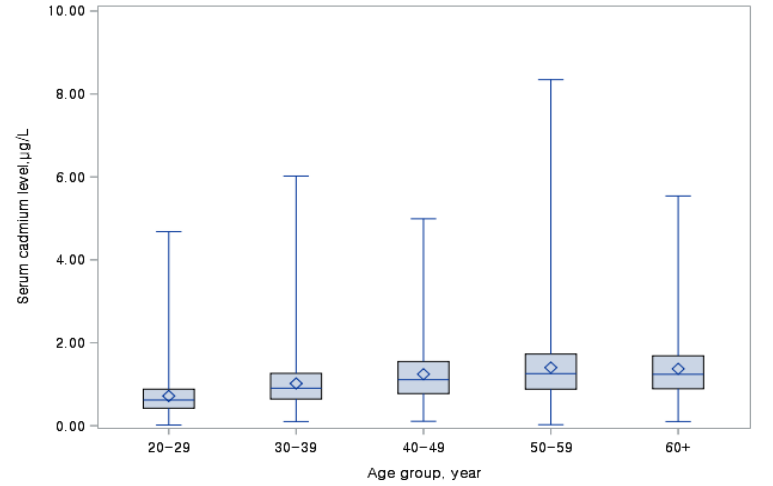


Figure 4. Blood cadmium level stratified by age

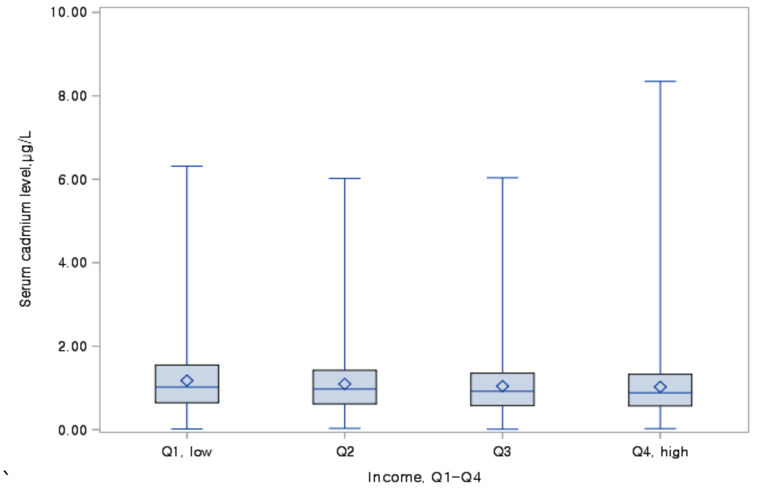


Figure 5. Blood cadmium level stratified by income level

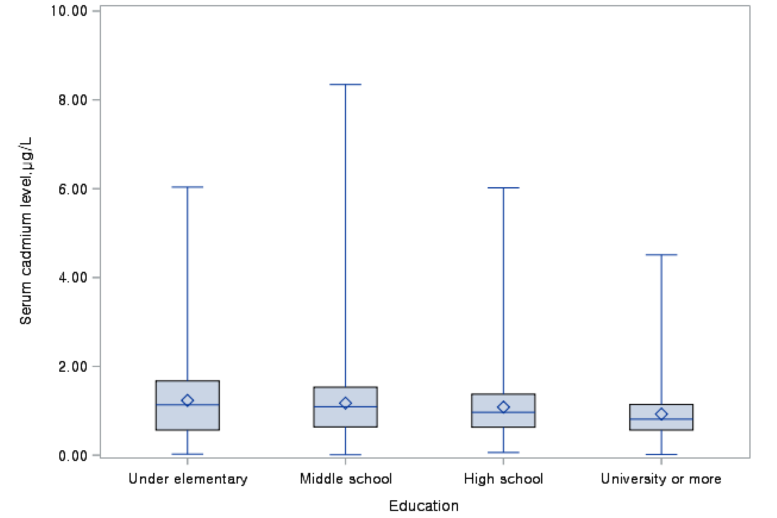


Figure 6. Cadmium level stratified by education level

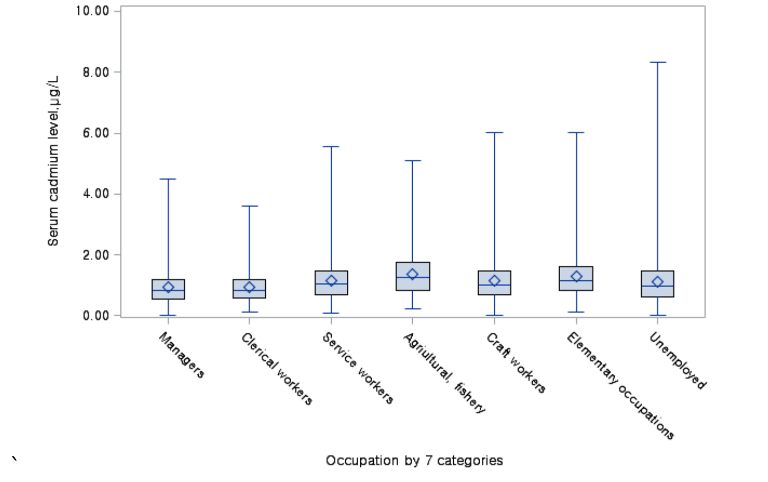


Figure 7. Blood cadmium level stratified by 7 occupation categories

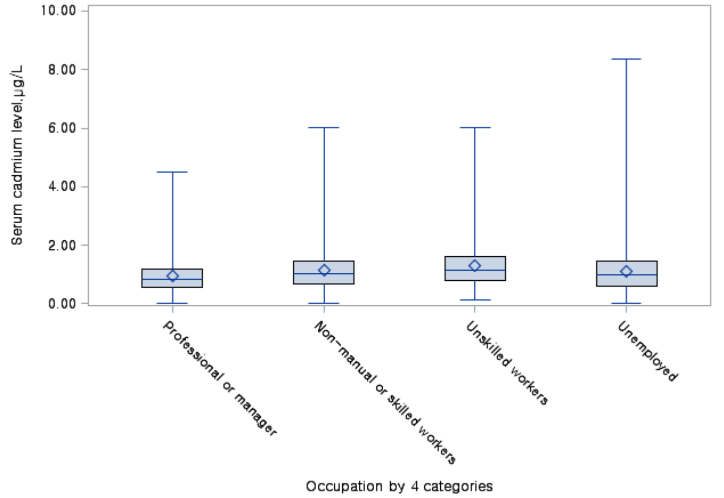


Figure 8. Blood cadmium level stratified by 4 occupation categories

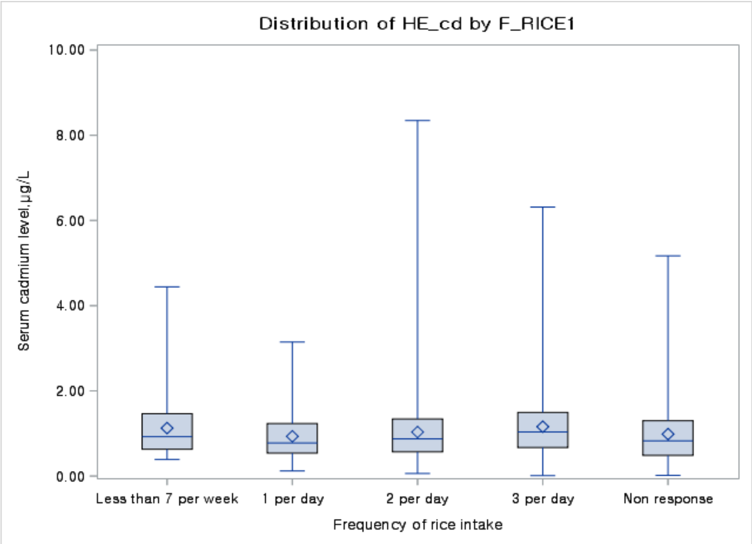


Figure 9. Blood cadmium level stratified by frequency of rice intake

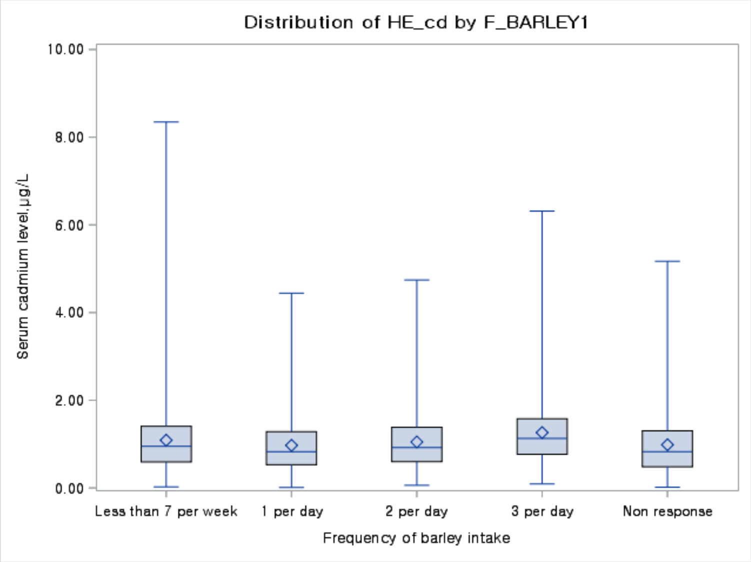


Figure 10. Blood cadmium level stratified by frequency of barley intake

3.3 Blood cadmium level stratified by general characteristics – Weighted analysis

Geometric mean of blood cadmium level stratified by general characteristics is demonstrated in Table 4. Blood cadmium level increased by ageing and was higher in women ($P<0.0001$). By education levels, 13.8% of participants were elementary graduates, and their blood cadmium level was highest (1.33 μg/L), which was 1.73 times (=1.33/0.77) higher than the blood cadmium level of college graduates. Income level was classified into quartiles, Blood cadmium level among the lowest income group (Q1, 0.97μg/L) was 1.13 times higher than the highest income group (Q4, 0.86 μg/L). However, the difference was not large compare to the difference between education stratified cadmium levels. Among four occupation classification, blood cadmium levels of professionals, and managers group (0.79 μg/L) was the lowest, while unskilled workers were highest (1.09 μg/L). Among blood cadmium level stratified by smoking status, current smokers (1.12μg/L) were 1.29 times higher than nonsmokers (0.87μg/L).

Distribution of rice and barely intake were demonstrated in table 5. Regarding rice intake, proportion of people who ate rice 3 times per day was most the largest (54.6%). Also regarding barely intake, proportion of people who ate barely 3 times a day was the largest

Table 4. Characteristics of study participants containing blood cadmium level and cotinine, KNHANES (2008–2011) (N=7,734).

Variables	N	Weighted sample	Weighted %	blood cadmium GM (CI), μg/L ¶	P value
Age					
20-29	1,493	3,497,948	27.8	0.61 (0.59-0.64)	Ref.
30-39	1,568	2,646,615	21.0	0.87 (0.84-0.91)	<.0001
40-49	1,571	2,778,299	22.1	1.08 (1.05-1.11)	<.0001
50-59	1,549	2,235,992	17.7	1.22 (1.18-1.25)	<.0001
≥60	1,553	1,438,462	11.4	1.24 (1.20-1.27)	<.0001
Gender					
Men	3,821	7,121,327	56.5	0.85 (0.83-0.88)	Ref.
Women	3,913	5,475,988	43.5	1.01 (0.98-1.03)	<.0001
Education					
Under Elementary	1,512	1,735,973	13.8	1.33 (1.29-1.38)	Ref.
Middle school	860	1,247,189	9.9	1.18 (1.14-1.24)	<.0001
High school	2,877	5,258,149	41.7	0.88 (0.85-0.90)	<.0001
University or more	2,485	4,356,004	34.6	0.77 (0.75-0.79)	<.0001
Household income					
Q4 (high)	1,950	3,271,804	26.0	0.86 (0.82-0.89)	Ref.
Q3	1,955	3,182,180	25.3	0.89 (0.86-0.92)	0.0948
Q2	1,905	3,102,698	24.6	0.94 (0.91-0.97)	0.0002
Q1 (low)	1,924	3,040,633	24.1	0.97 (0.94-1.01)	<.0001
Occupation					
Professionals, managers	1,055	1,915,934	15.3	0.79 (0.75-0.82)	Ref.
Non-manual, skilled workers	3179	5,408,467	43.1	0.94 (0.92-0.98)	<.0001
Unskilled workers	660	1,037,897	8.3	1.09 (1.04-1.15)	<.0001
Unemployed	2813	4,176,645	33.3	0.90 (0.87-0.93)	<.0001
Smoking status					
Never	4,166	6,137,777	48.7	0.87 (0.85-0.89)	Ref.
Former	1,596	2,603,822	20.7	0.77 (0.74-0.80)	<.0001
Current	1,972	3,855,715	30.6	1.12 (1.09-1.16)	<.0001

KNHANES: Korean National Health and Nutrition Examination Survey

GM: Geometric mean

¶: age adjusted geometric mean with confidential interval (CI)

Table 5. Frequency of rice and barley intake among of study participants containing blood cadmium level and cotinine, KNHANES (2008–2011) (N=6,710).

Variables	N	Weighted sample	Weighted %	blood cadmium GM (CI), μg/L ¶	P value
Frequency of rice intake					
Less than 7 per week	42	73,408	0.6	0.98 (0.80-1.19)	Ref.
1 per day	232	466,400	3.9	0.74 (0.67-0.82)	0.017
2 per day	2,361	4,639,751	39.2	0.90 (0.87-0.93)	<.001
3 per day	3,968	6,466,169	54.6	1.03 (1.01-1.06))	<.001
Non-response	110	191,471	1.6	1.11 (0.97-1.26)	<.001
Total	6,733	11,837,198	100.0	-	
Frequency of barley intake					
Less than 7 per week	2,138	4,148,306	35.0	0.94 (0.91-0.97)	Ref.
1 per day	1,008	2,016,095	17.0	0.86 (0.82-0.90)	<.001
2 per day	1,639	2,898,424	24.5	0.95 (0.92-0.99)	<.001
3 per day	1,835	2,580,201	21.8	1.11 (1.08-1.15)	<.001
Non-response	113	194,173	1.6	1.10 (0.97-1.26)	<.001
Total	6,733	11,837,198	100.0		

KNHANES: Korean National Health and Nutrition Examination Survey

GM: Geometric mean

¶: age adjusted geometric mean with confidential interval (CI)

3.4. General characteristics stratified by income level

In this study, income level was selected as a key variable among social economic status variants. Table 6 is demonstrating the difference in distribution of demographic characteristics stratified by income level. Age distribution stratified by income level was not statistically different (p=0.0611). BMI (data not shown) and sex distribution (p=0.2214) also did not show statistically significant difference. However, distributions of variables such as education level, occupation classification, and smoking prevalence stratified by income level were significantly different, and proportion of managers and professionals were also significantly high in high income level group (Q4, fourth quartile), and smoking prevalence among high income level group was significantly low.

Table 7 demonstrates the association between stratified income level and rice and barely intake. Rice intake by income level did not show statistically significant difference. However barely intake increased in low income group. that is, proportion of people who ate barley less than 7 times per week was 33.1% in Q1, while the proportion was 27.6% in Q4.

Table 6. Demographic characteristics stratified by income level among study participants

	Income level				
	Q1 (low)	Q2	Q3	Q4 (high)	P
Age, year, Weighted sample (Mean)	3,271,804 (41.6)	3,182,180 (41.7)	3,102,698 (41.0)	3,040,633 (40.8)	0.061
Sex, Weighted sample (%)					
Men	1,798,280 (55.0)	1,809,732 (56.9)	1,730,902 (55.8)	1,782,414 (58.6)	0.227
Women	1,473,524 (45.0)	1,372,448 (43.1)	1,371,797 (44.2)	1,258,220 (41.4)	
Education, Weighted sample (%)					
Under Elementary graduate	676,222 (20.7)	484,471 (15.2)	362,585 (11.7)	212,695 (7.0)	<.001
Middle school graduate	453,350 (13.9)	345,617 (10.9)	246,859 (7.8)	201,364 (6.6)	
High school graduate	1,450,308 (44.3)	1,392,345 (43.8)	1287,042 (40.4)	1,128,454 (37.1)	
University graduate or more	691,924 (21.1)	959,746 (30.2)	1,206,213 (37.9)	1,498,120 (49.3)	

Table 6. (continued)

Occupation, Weighted sample (%)					
Professionals, managers	320,294 (9.8)	418,078 (13.2)	526,092 (17.1)	651,470 (21.5)	<.001
Non-manual, skilled workers	1,243,566 (38.2)	1,468,288 (46.3)	1,337,316 (43.4)	1,359,298 (44.9)	
Unskilled workers	389,036 (11.9)	284,743 (9.0)	222,738 (7.2)	141,381 (4.7)	
Unemployed	1,304,313 (40.0)	1,000,493 (31.5)	996,845 (32.3)	874,994 (28.9)	
Smoking status, Weighted sample (%)					
Never	1,537,032 (47.0)	1,507,785 (47.4)	1,558,506 (50.2)	1,534,455 (50.5)	<.001
Former	573,646 (17.5)	677,243 (21.3)	646,072 (20.8)	706,861 (23.2)	
Current	1,161,126 (35.5)	997,152 (31.3)	898,120 (28.9)	799,317 (26.3)	

Table 7. Weighted Frequency of rice and barley intake stratified by income level among study participants

	Income level				
	Q1 (low)	Q2	Q3	Q4 (high)	P
Frequency of rice intake					
Less than 7 per week	24,819 (0.8)	10,154 (0.3)	16,383 (0.5)	13,904 (0.5)	0.214
1 per day	116,057 (3.5)	82,003 (2.6)	109,991 (3.5)	113,988 (3.7)	
2 per day	1,053,883 (32.2)	986,590 (31.0)	1,106,491 (35.7)	1,025,182 (33.7)	
3 per day	1,502,617 (45.9)	1,565,682 (49.2)	1,388,334 (44.7)	1,370,635 (45.1)	
Non-response	574,429 (17.6)	537,750 (16.9)	481,499 (15.5)	516,924 (17.0)	
Frequency of barley intake					
Less than 7 per week	1,081,588 (33.1)	929,771 (29.2)	883,972 (28.5)	838,087 (27.6)	0.041
1 per day	415,412 (12.7)	454,909 (14.3)	445,650 (14.4)	461,798 (15.2)	
2 per day	638,328 (19.5)	637,617 (20.0)	663,859 (21.4)	692,171 (22.8)	
3 per day	561,262 (17.2)	622,133 (19.6)	627,719 (20.2)	529,254 (17.4)	
Non-response	575,214 (17.6)	537,750 (16.9)	481,499 (15.5)	519,324 (17.1)	

3.5 Association between income level and blood cadmium level: Smoking status adjusted multi-variable regression analysis

Table 8 to table 10 demonstrates the trend of association between income level and blood cadmium level by gradually controlling the other variables such as sex, smoking status, education level and occupation level. Especially, smoking status was stratified by never-smokers, former smokers and current smokers. Blood cadmium level, which is the dependent variable in this analysis, was log transformed.

Table 8 is a basic model comparing the blood cadmium level by income level without sex stratification, log transformed blood cadmium level among the lowest income group (Q1) was 0.108 μg/L higher than the highest income group which was the reference group. When sex was further controlled, the association was relatively remained stable. However, after controlling for smoking status, association was somewhat attenuated but significantly remained. Sharp fluctuation demonstrated after controlling for education level, that association between income level and blood cadmium level was totally eliminated. Therefore, the association between blood cadmium level and income level was confounded by smoking status and education level. Following that, occupation was controlled but did not demonstrate big difference in association.

Table 9 to 10 was analyzed after sex stratification; table 9 demonstrates the results analyzing male participants. Association between blood cadmium level and income level resembled with table 8. However, in model 3, after controlling for smoking status, the association between income level and blood cadmium level was non-significant, and the association with smokers increased 0.655 compare to non-smokers. Results in other models were similar with table 8.

Table 10 shows the results from women analysis. Characterfully, the difference on association between blood cadmium level and income level after controlling for smoking status was relatively changeless compare to table 8. Current smokers showed to be increased by 0.295 related with blood cadmium level, however former smokers showed to be decreased by -0.004 which was reverse relationship. The association between smoking and blood cadmium level was maintained even after controlling for education level and occupation classification.

Table 8. Association between income level and blood cadmium level – Men and women (N=7,707)

		Model 1 ß (p)	Model 2 ß (p)	Model 3 ß (p)	Model 4 ß (p)	Model 5 ß (p)
Income Level	Q4 (high)	Ref.	Ref.	Ref.	Ref.	Ref.
	Q3	0.037 (0.112)	0.032 (0.163)	0.014 (0.511)	0.001 (0.969)	0.001 (0.946)
	Q2	0.081 (<.001)	0.078 (<.001)	0.046 (0.033)	0.022 (0.317)	0.022 (0.309)
	Q1 (low)	0.108 (<.001)	0.102 (<.001)	0.046 (0.042)	0.007 (0.776)	0.009 (0.682)
Sex	Men		Ref.	Ref.	Ref.	Ref.
	Women		0.146 (<.001)	0.384 (<.001)	0.371 (<.001)	0.376 (<.001)
Smoking status	Never smoker			Ref.	Ref.	Ref.
	Ex-smoker			0.056 (0.018)	0.057 (0.015)	0.057 (0.016)
	Current smoker			0.546 (<.001)	0.535 (<.001)	0.533 (<.001)
Education	University graduate or more	4			Ref.	Ref.
	High school graduate	3			0.087 (<.001)	0.085 (<.001)
	Mid school graduate	2			0.144 (<.001)	0.140 (<.001)
	Under Elementary graduate	1			0.180 (<.001)	0.176 (<.001)
Occupation	Professionals, managers	1				Ref.
	Non-manual, skilled workers	2				0.020 (0.380)
	Unskilled workers	3				0.008 (0.801)
	Unemployed	4				-.009 (0.685)
R^2		0.205	0.219	0.336	0.343	0.344

Adjusted for age (20-29, 30-39, 40-49, 50-59 and ≥60 years), income level, sex, smoking status, education, and occupation.

Table 9. Association between income level and blood cadmium level – Men (N=3,801)

		Model 1 ß (p)	Model 2 ß (p)	Model 3 ß (p)	Model 4 ß (p)
Income Level	Q4 (high)	Ref.	Ref.	Ref.	Ref.
	Q3	.063 (.046)	.029 (0.253)	.021 (.421)	.022 (0.383)
	Q2	.114 (<.0001)	.068 (0.014)	.050 (.072)	.050 (0.071)
	Q1 (low)	.126 (<.0001)	.050 (0.077)	.020 (.494)	.026 (0.376)
Smoking status	Never smoker		Ref.	Ref.	Ref.
	Ex-smoker		.180 (<.0001)	.177 (<.0001)	.176 (<.001)
	Current smoker		.663 (<.0001)	.655 (<.0001)	.650 (<.001)
Education	University≤	4		Ref.	Ref.
	High school graduate	3		.042 (.057)	.037 (0.104)
	Mid school graduate	2		.129 (<.0001)	.120 (<.001)
	Elementary≥	1		.138 (<.0001)	.130 (<.001)

Table 9. (continued)

Occupation	Professionals, managers	1			Ref.
	Non-manual, skilled	2			.030 (0.261)
	Unskilled workers	3			.007 (0.873)
	Unemployed	4			.038 (0.392)
R^2		0.154	0.363	0.368	0.369

Adjusted for age (20-29, 30-39, 40-49, 50-59 and ≥60 years), income level, sex, smoking status, education, and occupation.

Table 10. Association between income level and blood cadmium level – women (N=3,906)

		Model 1	Model 2	Model 3	Model 4
		ß (p)	ß (p)	ß (p)	ß (p)
Income Level	Q4 (high)	Ref.	Ref.	Ref.	Ref.
	Q3	-.004 (.883)	-.004 (.880)	-.020 (.484)	-.019 (.514)
	Q2	.032 (.265)	.022 (.444)	-.005 (.852)	-.004 (.896)
	Q1 (low)	.076 (.014)	.057 (.063)	.013 (.675)	.017 (.603)
Smoking	Never smoker		Ref.	Ref.	Ref.
	Ex-smoker		-.003 (.950)	-.006 (.888)	-.004 (.926)
	Current smoker		.316 (<.0001)	.292 (<.0001)	.295 (<.0001)
Education	University graduate≤	4		Ref.	Ref.
	High school graduate	3		.125 (<.0001)	.133 (<.0001)
	Mid school graduate	2		.137 (.0007)	.147 (.0003)
	Elementary graduate≥	1		.196 (<.0001)	.206 (<.0001)
Occupation	Professionals, managers	1			Ref.
	Non-manual, skilled workers	2			-.019 (.629)
	Unskilled workers	3			-.067 (.151)
	Unemployed	4			-.032 (.404)
R^2		0.288	0.306	0.315	0.315

Adjusted for age (20-29, 30-39, 40-49, 50-59 and ≥60 years), income level, sex, smoking status, education, and occupation.

3.6 Association between income level and blood cadmium level: Smoking pack year adjusted multi-variable regression analysis

Table 11 to 13 demonstrates the trend of association between income level and blood cadmium level by gradually controlling the other variables such as sex, education level and occupation level. Distinctively, smoking pack year was controlled in these tables, and blood cadmium level was log transformed.

Table 11 is a basic model comparing the blood cadmium level by income level without sex stratification, blood cadmium level among the lowest income group (Q1) was 0.096 μg/L higher than the highest income group which was the reference group. When sex was controlled, the association was relatively remained stable. However, after controlling for smoking pack year, association was somewhat attenuated but significantly remained. Sharp fluctuation demonstrated after controlling for education level, that association between income level and blood cadmium level was totally eliminated. Therefore, the association between blood cadmium level and income level was confounded by smoking pack year and education level. Following that, occupation was controlled but did not demonstrate big difference in association.

Table 12 to 13 was analyzed after sex stratification; table 12 demonstrates the results analyzing men participants. Association between log transformed blood cadmium level and income level was resembled with table6. However, in model 3, after controlling for smoking pack year, the association between income level and blood cadmium level was somewhat attenuated, and the association with 30 pack years increased by 0.704 compare to non-smokers. Results in other models were similar with table 11.

Table 13 shows the results from women analysis. Characterfully, the difference on association between blood cadmium level and income level after controlling for smoking status was relatively changeless compare to table 11. Thirty or more pack year, was related with blood cadmium level by 0.331 compared to never-smokers. Association between smoking pack years and blood cadmium level was stably maintained even after controlling for education level and occupation classification.

Table 11. Association between income level and blood cadmium level – Men and women (N=7,251)

		Model 1	Model 2	Model 3	Model 4	Model 5
		ß (p)	ß (p)	ß (p)	ß (p)	ß (p)
Income Level	Q4 (high)	Ref.	Ref.	Ref.	Ref.	Ref.
	Q3	.038 (0.113)	.033 (.164)	.022 (.341)	.005 (.834)	.005 (.810)
	Q2	.073 (.003)	.072 (.004)	.051 (.030)	.019 (.408)	.019 (.408)
	Q1 (low)	.096 (.0002)	.091 (.001)	.065 (.008)	.014 (.579)	.017 (.502)
Sex	Men		Ref.	Ref.	Ref.	Ref.
	Women		.148 (<.001)	.415 (<.0001)	.396 (<.001)	.405 (<.001)
Pack year	Never smokers			Ref.	Ref.	Ref.
	<10.0			.254 (<.0001)	.249 (<.001)	.247 (<.001)
	10.0-19.9			.450 (<.0001)	.440 (<.001)	.436 (<.001)
	20.0-29.9			.472 (<.0001)	.474 (<.001)	.471 (<.001)
	≥30.0			.512 (<.0001)	.502 (<.001)	.499 (<.001)
Education	University graduate or more	4			Ref.	Ref.
	High school graduate	3			.110 (<.001)	.104 (<.001)
	Mid school graduate	2			.181 (<.001)	.170 (<.001)
	Under Elementary graduate	1			.233 (<.001)	.224 (<.001)

Table 11. (continued)

Occupation	Professionals, managers	1				Ref.
	Non-manual, skilled workers	2				.030 (.233)
	Unskilled workers	3				.039 (.252)
	Unemployed	4				-.012 (.645)
R^2		0.204	0.218	0.277	0.288	0.289

Adjusted for age (20-29, 30-39, 40-49, 50-59 and ≥60 years), income level, sex, smoking status, education, and occupation.

Table 12. Association between income level and blood cadmium level – Men (N=3,665)

		Model 1	Model 2	Model 3	Model 4
		ß (p)	ß (p)	ß (p)	ß (p)
Income Level	Q4 (high)	Ref.	Ref.	Ref.	Ref.
	Q3	.053 (.096)	.032 (.263)	.025 (.372)	.028 (.319)
	Q2	.106 (.002)	.072 (.018)	.059 (.057)	.060 (.051)
	Q1 (low)	.111 (.001)	.080 (.010)	.050 (.111)	.059 (.064)
Pack year	Never smokers		Ref.	Ref.	Ref.
	<10.0		.321 (<.001)	.340 (<.001)	.335 (<.001)
	10.0-19.9		.640 (<.001)	.563 (<.001)	.553 (<.001)
	20.0-29.9		.779 (<.001)	.649 (<.001)	.644 (<.001)
	≥30.0		.881 (<.001)	.704 (<.001)	.701 (<.001)
Education	University graduate or more	4		Ref.	Ref.
	High school graduate	3		.041 (0.072)	.036 (.124)
	Mid school graduate	2		.122 (<.001)	.111 (.0014)
	Under Elementary graduate	1		.133 (<.001)	.123 (.0018)
Occupation	Professionals, managers	1			Ref.
	Non-manual, skilled workers	2			.032 (.270)
	Unskilled workers	3			.056 (.233)
	Unemployed	4			-.063 (.070)
R^2		0.155	0.261	0.295	0.299

Adjusted for age (20-29, 30-39, 40-49, 50-59 and ≥60 years), income level, sex, smoking status, education, and occupation.

Table 13. Association between income level and blood cadmium level – Women (N=3,586)

		Model 1	Model 2	Model 3	Model 4
		ß (p)	ß (p)	ß (p)	ß (p)
Income Level	Q4 (high)	Ref.	Ref.	Ref.	Ref.
	Q3	.009 (.784)	.006 (.860)	-.011 (.721)	-.010 (.758)
	Q2	.021 (.476)	.012 (.694)	-.018 (.561)	-.016 (.601)
	Q1 (low)	.068 (.042)	.054 (.105)	.005 (.882)	-.008 (.806)
Pack year	Never smokers		Ref.	Ref.	Ref.
	<10.0		.155 (<.001)	.142 (.0002)	.144 (.0002)
	10.0-19.9		.244 (.005)	.211 (.014)	.213 (.012)
	20.0-29.9		.339 (.0005)	.335 (.001)	.335 (.001)
	≥30.0		.340 (.036)	.323 (.043)	.331 (.043)
Education	University graduate or more			Ref.	Ref.
	High school graduate			.140 (<.0001)	.147 (<.0001)
	Mid school graduate			.172 (<.0001)	.179 (<.0001)
	Under Elementary graduate			.219 (<.0001)	.226 (<.0001)
Occupation	Professionals, managers				Ref.
	Non-manual, skilled workers				-.012 (.783)
	Unskilled workers				-.057 (.254)
	Unemployed				-.028 (.497)
R^2		0.285	0.295	0.306	0.306

Adjusted for age (20-29, 30-39, 40-49, 50-59 and ≥60 years), income level, sex, smoking status, education, and occupation.

3.7 Association between income level and blood cadmium level: Urinary cotinine adjusted multi-variable regression analysis

Table 14 to 16 demonstrates the trend of association between income level and blood cadmium level by gradually controlling for the other variables such as sex, education level and occupation classification. Urinary cotinine was distinctively controlled in these tables, and blood cadmium level was log transformed.

Table 14 is a basic model comparing the blood cadmium level by income level without sex stratification, log transformed blood cadmium level among the lowest income group (Q1) was 0.096 µg/L higher than the highest income group which was the reference group. When sex was controlled, the association was relatively remained stable. However, after controlling for smoking status, association was somewhat attenuated but significantly remained. Sharp fluctuation demonstrated after controlling for education level, that association between income level and blood cadmium level was totally eliminated. Therefore, the association between blood cadmium level and income level was confounded by urine cotinine and education level. Following that, occupation was controlled but did not demonstrate big difference in association.

Table 15 to 16 was analyzed after sex stratification; table 15 demonstrates the results analyzing men participants. Association between log transformed blood cadmium level and income level resembled with table 14. However, in model 3, after controlling for urinary cotinine year, the association between income level and blood cadmium level was somewhat attenuated, and the association urinary cotinine increased by 0.577 compare to non-smokers. Results in other models were similar with table 14.

Table 16 shows the results from women analysis. Character fully, the difference on association between blood cadmium level and income level after controlling for urinary cotinine was relatively changeless compare to table 14. One hundred or more cotinine level was related with blood cadmium level by 0.346 compared to never smokers. Association between smoking pack years and blood cadmium level was stably maintained even after controlling for education level and occupation classification.

Table 17 and 18 demonstrates the results of multi variable regression model after additionally adding rice and barely intake to the original model which adjusted age, income, smoking pack year, education and occupation.

Table 17 demonstrates the result of model for men. In men, rice intake demonstrated positive association with blood cadmium level. However, blood cadmium level also increased among participants who ate rice less than 7 times a week. Barely intake did not show association with blood cadmium level.

Table 18 demonstrates the result of model for women. In women, both rice intake and barely intake had no association with blood cadmium level.

Table 14. Association between income level and blood cadmium level – Total (N=7,251): cotinine adjusted multi variable regression analysis

		Model 1 ß (p)	Model 2 ß (p)	Model 3 ß (p)	Model 4 ß (p)	Model 5 ß (p)
Income Level	Q4 (high)	Ref.	Ref.	Ref.	Ref.	Ref.
	Q3	.038 (.113)	.033 (.164)	.019 (.395)	.006 (.781)	.007 (.752)
	Q2	.073 (.003)	.072 (.004)	.045 (.039)	.021 (.339)	.021 (.328)
	Q1 (low)	.096 (.0002)	.091 (.001)	.039 (.095)	.0004 (.984)	.004 (.880)
Sex	Men		Ref.	Ref.	Ref.	Ref.
	Women		.148 (<.001)	.345 (<.0001)	.330 (<.001)	.336 (<.001)
Urine cotinine	<10.0			Ref.	Ref.	Ref.
	10.0-49.9			-.024 (.240)	-.029 (.146)	-.029 (.151)
	50.0-99.9			.067 (.215)	.064 (.235)	.063 (.241)
	≥100.0			.528 (<.001)	.516 (<.001)	.514 (<.001)
Education	University≤				Ref.	Ref.
	High school grad				.078 (<.001)	.076 (<.001)
	Mid school grad				.143 (<.001)	.139 (<.001)
	Elementary≥				0.179 (<.001)	.176 (<.001)

Table 14. (continued)

Occupation	Professionals, managers					Ref.
	Non-manual, skilled workers					.020 (.387)
	Unskilled workers					.004 (.902)
	Unemployed					-.010 (.685)
R^2		0.204	0.218	0.353	0.360	0.360

Adjusted for age (20-29, 30-39, 40-49, 50-59 and ≥60 years), income level, sex, smoking status, education, and occupation.

Table 15. Association between income level and blood cadmium level – Men (N=3,665): Urinary cotinine adjusted multi variable regression analysis

		Model 1 ß (p)	Model 2 ß (p)	Model 3 ß (p)	Model 4 ß (p)
Income Level	Q4 (high)	Ref.	Ref.	Ref.	Ref.
	Q3	.053 (.096)	.019 (.463)	.011 (.680)	.013 (.621)
	Q2	.106 (.002)	.055 (.050)	.038 (.173)	.039 (.164)
	Q1 (low)	.111 (.001)	.032 (.263)	.004 (.898)	.011 (.724)
Urine cotinine	<10.0		Ref.	Ref.	Ref.
	10.0-49.9		-.026 (.430)	-.028 (.393)	-.025 (.451)
	50.0-99.9		.083 (.320)	.078 (.347)	.075 (.368)
	≥100.0		.577 (<.001)	.570 (<.001)	.566 (<.001)
Education	University graduate or more			Ref.	Ref.
	High school graduate			.038 (.086)	.034 (.146)
	Mid school graduate			.122 (<.001)	.115 (<.001)
	Under Elementary graduate			.128 (<.001)	.122 (0.001)
Occupation	Professionals, managers				Ref.
	Non-manual, skilled workers				.030 (.258)
	Unskilled workers				.028 (.523)
	Unemployed				-.035 (.288)
R^2		0.155	0.371	0.375	0.376

Adjusted for age (20-29, 30-39, 40-49, 50-59 and ≥60 years), income level, sex, smoking status, education, and occupation.

Table 16. Association between income level and blood cadmium level – Women (N=3,586): Urinary cotinine adjusted multi variable regression analysis

		Model 1 ß (p)	Model 2 ß (p)	Model 3 ß (p)	Model 4 ß (p)
Income Level	Q4 (high)	Ref.	Ref.	Ref.	Ref.
	Q3	.009 (.784)	.052 (.112)	-.001 (.984)	.001 (.968)
	Q2	.021 (.479)	.022 (.440)	-.005 (.859)	-.003 (.919)
	Q1 (low)	.068 (.042)	.015 (.634)	.008 (.799)	.012 (.724)
Urine cotinine	<10.0		Ref.	Ref.	Ref.
	10.0-49.9		-.024 (.326)	-.032 (.191)	-.032 (.199)
	50.0-99.9		.051 (.457)	.053 (.430)	.055 (.420)
	≥100.0		.366 (<.001)	.344 (<.001)	.346 (<.001)
Education	University graduate or more			Ref.	Ref.
	High school graduate			.117 (<.001)	.124 (<.001)
	Mid school graduate			.146 (<.001)	.156 (<.001)
	Under Elementary graduate			.202 (<.001)	.212 (<.001)
Occupation	Professionals, managers				Ref.
	Non-manual, skilled workers				-.018 (.681)
	Unskilled workers				-.069 (.150)
	Unemployed				-.028 (.480)
R^2		0.285	0.322	0.330	0.331

Adjusted for age (20-29, 30-39, 40-49, 50-59 and ≥60 years), income level, sex, smoking status, education, and occupation.

Table 17. Association between income level and blood cadmium level – Men (N=3,013): Pack year adjusted multi variable regression analysis

		Model 1 ß (p)	Model 2 ß (p)	Model 3 ß (p)
Income Level	Q4 (high)	Ref.	Ref.	Ref.
	Q3	0.034 (0.251)	0.034 (.247)	.034 (.249)
	Q2	0.037 (0.258)	0.039 (.229)	.038 (.247)
	Q1 (low)	0.060 (0.078)	0.059 (.085)	.059 (.083)
Pack year	Never smokers	Ref.	Ref.	Ref.
	<10.0	0.292 (<.001)	0.290 (<.001)	.293 (<.001)
	10.0-19.9	0.462 (<.001)	0.458 (<.001)	.462 (<.001)
	20.0-29.9	0.596 (<.001)	0.590 (<.001)	.594 (<.001)
	≥30.0	0.626 (<.001)	0.626 (<.001)	.626 (<.001)
Education	University graduate or more	Ref.	Ref.	Ref.
	High school graduate	.045 (.099)	.043 (.118)	.042 (.123)
	Mid school graduate	.096 (.012)	.089 (.019)	.088 (.020)
	Under Elementary graduate	.148 (.001)	.141 (.001)	.140 (.001)

Table 17. (continued)

Occupation	Professionals, managers	Ref.	Ref.	Ref.
	Non-manual, skilled workers	.015 (.644)	.019 (.555)	.013 (.687)
	Unskilled workers	.063 (.183)	.067 (.158)	.061 (.195)
	Unemployed	-.043 (.267)	-.040 (.309)	-.043 (.268)
Rice	Less than 7 per week	.331 (.010)		.324 (.011)
	1 per day	Ref.		Ref.
	2 per day	.180 (.033)		.187 (.025)
	3 per day	.193 (.021)		.196 (.019)
	Non response	.218 (.057)		.250 (.035)
Barley	Less than 7 per week		.062 (.058)	.058 (.072)
	1 per day		Ref.	Ref.
	2 per day		.005 (.898)	-.005 (.898)
	3 per day		.045 (.235)	.033 (.395)
	Non response		.067 (.439)	NE
R^2		0.257	0.257	0.259

Adjusted for age (20-29, 30-39, 40-49, 50-59 and ≥60 years), income level, sex, smoking pack year, education, and occupation. NE: not estimated

Table 18. Association between income level and blood cadmium level – Women (N=3,287): Pack year adjusted multi variable regression analysis

		Model 1 ß (p)	Model 2 ß (p)	Model 3 ß (p)
Income Level	Q4 (high)	Ref.	Ref.	Ref.
	Q3	.001 (.961)	-.0005 (.987)	-.001 (.982)
	Q2	-.003 (.905)	-.0022 (.938)	-.003 (.925)
	Q1 (low)	.032 (.294)	.034 (.276)	.033 (.279)
Pack year	Never smokers	Ref.	Ref.	Ref.
	<10.0	.153 (.0002)	.152 (.0002)	.155 (.0002)
	10.0-19.9	.195 (.031)	.201 (.025)	.201 (.025)
	20.0-29.9	.293 (.003)	.288 (.005)	.290 (.004)
	≥30.0	.299 (.156)	.316 (.137)	.316 (.137)
Education	University graduate or more	Ref.	Ref.	Ref.
	High school graduate	.130 (<.0001)	.133 (<.0001)	.132 (<.0001)
	Mid school graduate	.175 (<.0001)	.180 (<.0001)	.178 (<.0001)
	Under Elementary graduate	.226 (<.0001)	.233 (<.0001)	.231 (<.0001)

Table 18. (continued)

Occupation	Professionals, managers	Ref.	Ref.	
	Non-manual, skilled workers	-.002 (.958)	-.001 (.986)	-.002 (.971)
	Unskilled workers	.022 (.656)	-.023 (.639)	-.024 (.664)
	Unemployed	.018 (.363)	.017 (.645)	.016 (.662)
Rice	Less than 7 per week	.094 (.341)		.082 (.410)
	1 per day	Ref.		Ref.
	2 per day	.048 (.457)		.035 (.594)
	3 per day	.052 (.437)		.037 (.588)
	Non response	.086 (.469)		.104 (.556)
Barley	Less than 7 per week		-.005 (.891)	-.009 (.810)
	1 per day		Ref.	Ref.
	2 per day		.031 (.417)	.025 (.504)
	3 per day		.030 (.430)	.024 (.570)
	Non response		.049 (.621)	-.019 (.896)
R^2		0.280	0.280	0.281

Adjusted for age (20-29, 30-39, 40-49, 50-59 and ≥60 years), income level, sex, smoking pack year, education, and occupation

3.8. Path analysis between income level and blood cadmium level

Table 19 demonstrates the results of path analysis describing the overall association between blood cadmium level, smoking pack year and social determinants composed by income level, education level and occupation classification in men. Among association between age, education level, income level and smoking pack year, although income was not significant, blood cadmium level tend to increase in older age and low education level. Smoking pack year, income level, education level, age all inclusively demonstrated significant association with blood cadmium level.

The direct relevance from education level to blood cadmium level was -0.036, indirect relevance to blood cadmium by going through smoking pack year was -0.009 (=-0.076 x 0.115). The contents on the right side of table 19 demonstrates the standardized results of the included variables. CFI / TLI in path analysis was 1.000/1.014 and SRMA / RMSEA was 0.000/0.000. R2 of log pack year was 0.193, R2 of Log cadmium was 0.200, R2 of log rice was 0.074.

Table 20 demonstrates the results of path analysis describing the overall association between blood cadmium level, smoking pack year and social determinants composed by income level, education level and occupation classification in women participants.

Unlike the results from the male participants, age, education level, and smoking pack year were significantly associated with blood cadmium level. However, income was no more associated. CFI / TLI in path analysis was 0.993/0.915 and SRMA / RMSEA was 0.020/0.041. R2 of log pack year was 0.057, R2 of Log cadmium was 0.256, R2 of log rice was 0.047.

Figure 10 and 11 demonstrated the path analysis result on blood cadmium level stratified by men and women.

In men, smoking pack year, education level, income was significantly associated with blood cadmium level. However, rice intake was not associated with blood cadmium level. In table 11, for women, smoking pack year and education level was associated with blood cadmium level.

Table 19. Path analysis for serum level of cadmium in men (N=2,950)

		Model results			Standardization model results		
		Estimate	SE	P value	Estimate	SE	P value
Log Pack year	Income	-0.028	0.029	0.335	-.017	0.018	0.334
	Education	-0.076	0.035	0.027	-.047	0.021	0.027
	Age	0.044	0.003	<.001	0.027	0.001	<0.01
Log Rice	Income	-.001	0.004	0.770	-.005	0.016	0.771
	Education	-.014	0.005	0.007	-.052	0.019	0.007
	Age	0.004	0.000	<.001	0.016	0.002	<.001
Log cadmium	Log Pack year	0.115	0.008	<.001	0.310	0.020	<.001
	Income	-.029	0.010	0.002	-.048	0.016	0.002
	Education	-.036	0.012	0.004	-.059	0.021	0.004
	Age	0.007	0.001	<.001	0.011	0.001	<.001
	Log Rice	0.020	0.038	0.595	0.009	0.017	0.594
Intercepts	Log cadmium	-0.632	0.262	0.016	-1.052	0.436	0.016
	Log Pack year	0.486	0.193	0.012	0.300	0.122	0.014
	Log Rice	6.672	0.030	<.001	24.436	1.469	<.001
Residual	Log cadmium	0.289	0.010	<.001	0.800	0.014	<.001
	Log Pack year	2.123	0.141	<.001	0.807	0.017	<.001
	Log Rice	0.069	0.009	<.001	0.926	0.012	<0.01

Table 20. Path analysis for serum level of cadmium in women (N=3,244)

		Model results			Standardization model results		
		Estimate	SE	P value	Estimate	SE	P value
Log Pack year	Income	-.203	0.112	0.071	-.100	0.054	0.067
	Education	-.150	0.161	0.354	-.074	0.080	0.355
	Age	0.017	0.011	0.103	0.009	0.005	0.105
Log Rice	Income	-.001	0.006	0.807	-.004	0.015	0.807
	Education	-.034	0.010	0.001	-.088	0.026	0.001
	Age	0.003	0.001	<.001	0.009	0.002	<.001
Log cadmium	Log Pack year	0.055	0.011	<.001	0.191	0.038	<.001
	Income	-.007	0.010	0.513	-.012	0.018	0.513
	Education	-.033	0.014	0.017	-.056	0.023	0.017
	Age	0.015	0.001	<.001	0.025	0.002	<.001
	Log Rice	0.030	0.021	0.161	0.020	0.014	0.158
Intercepts	Log cadmium	-.722	0.157	<.001	-1.238	0.269	<.001
	Log Pack year	0.430	0.757	0.570	-.212	0.373	0.571
	Log Rice	6.714	0.056	<.001	17.378	1.101	<.001
Residual	Log cadmium	0.253	0.009	<.001	0.744	0.018	<.001
	Log Pack year	3.895	0.360	<.001	0.943	0.028	<.001
	Log Rice	0.142	0.019	<.001	0.953	0.010	<.001

Figure 11. Path analysis on association between age, income, education, smoking pack year and blood cadmium level in men

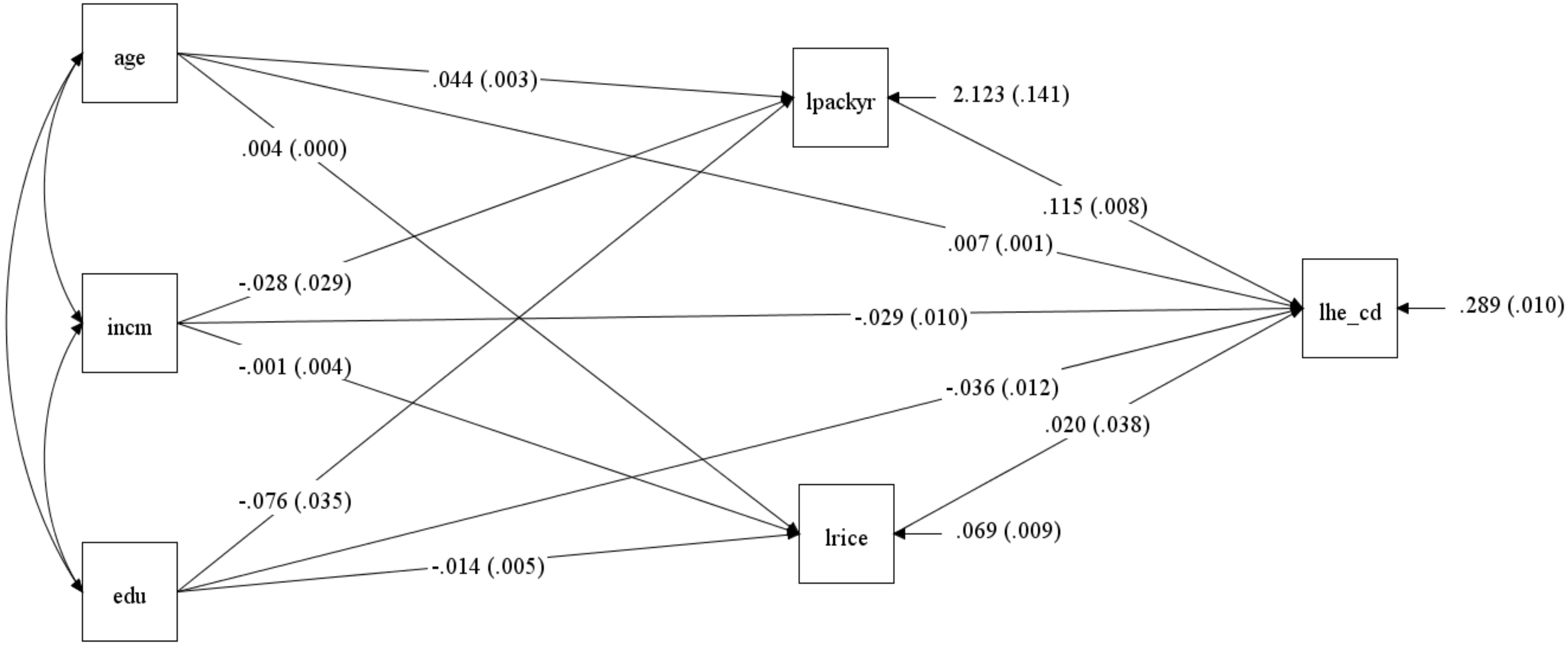
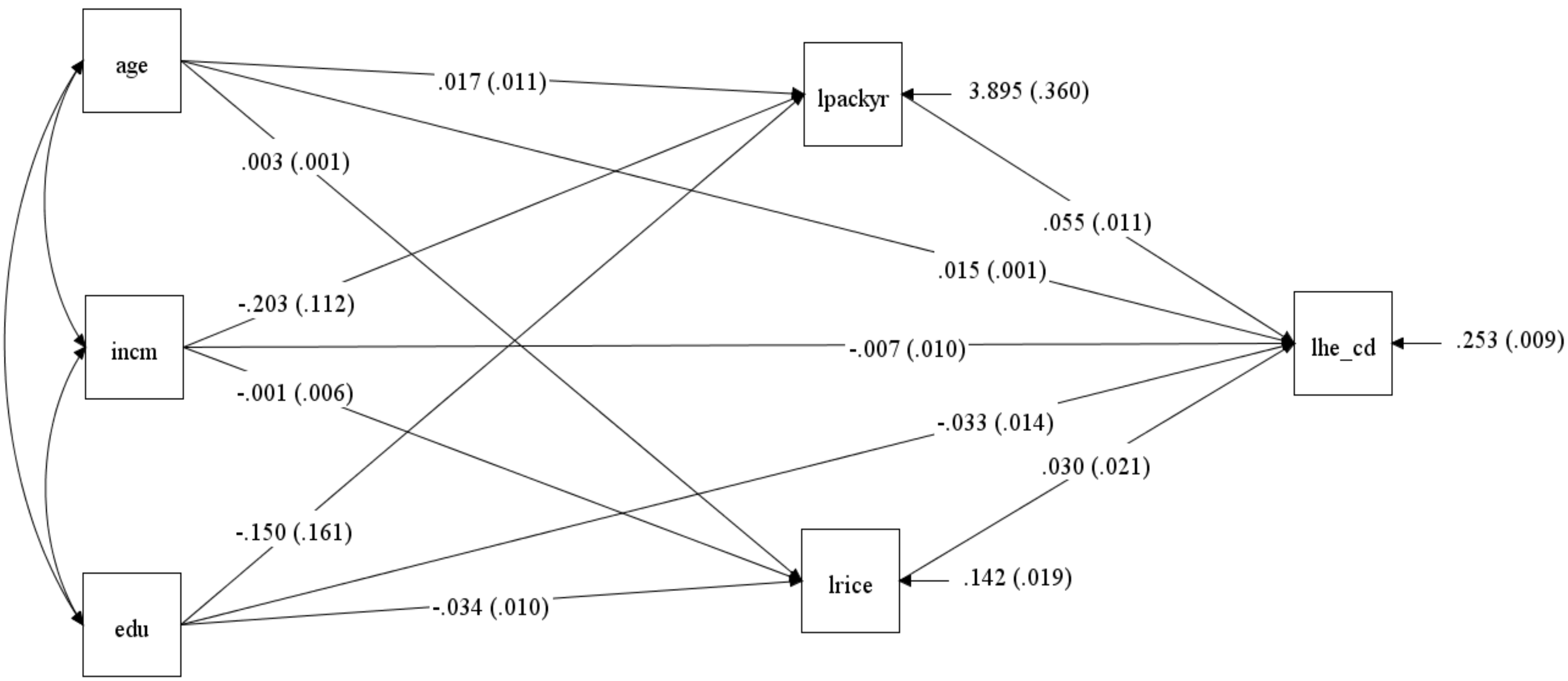


Figure 12. Path analysis on association between age, income, education, smoking pack year and blood cadmium level in women



4. DISCUSSIONS AND CONCLUSIONS

4.1 Interpretation of the results

In this cross sectional data from KNHANES, blood cadmium levels were significantly higher among those with low income and less education levels. However, these results were no more significant after controlling smoking status, only education level was significantly remained. Results from our descriptive analysis made correspondence with existing results regarding health inequity and heavy metal exposure. We aimed to explain the association between blood cadmium level and income level using modeling method by step by step adding cadmium level related factors such as sex, smoking status, BMI, education, occupation.

In this study, the association between income level and blood cadmium level seemed to be related; however, the association decreased by 0.126 to 0.050 in men, 0.076 to 0.057 in women after controlling the smoking status. Sharp decrease in association among men after controlling smoking status seems to reflect the close association between smoking status and blood cadmium level in men. Therefore, association between income level and blood cadmium level can be interpreted as an effect of confounding by smoking status. However, relatively small decrease in association among women could be predicted due to the former studies reported the high prevalence in cadmium level among women (Vather et al., 2006). However low reliability on women's smoking variable seem to be more related with the results in our study. Low smoking prevalence in Asian women due to under-reporting are reported by former study (Jung-Choi et al., 2012).

Though we replaced the self-reported smoking variable among women to urinary cotinine, the results were similar after controlling urinary cotinine variable, and this can be interpreted as the confounding effect of urinary cotinine was not sufficient among women on compare to men.

Therefore, smoking's attribution on association between income level and blood cadmium level was sufficient in men, while the attribution was insignificant in women. In order to analyze the remaining association between income level and blood cadmium level, education level and occupation classification was additionally controlled. As a result, association between income level and blood cadmium level eliminated. Comprehensively, association between income level and blood cadmium level seem to be considered as a confounding by smoking status and education level.

Association between smoking status and cadmium exposure level was reported by former studies, according to an recent meta-analysis reported by Hecht et al, correlation between cigarette smoking and cadmium level was 0.54 (Hecht., et al 2013). The association between cigarette smoking and cadmium level were 0.546 in this study (0.663 in men and 0.316 in women). Supports the formerly reported evidence among association between cigarette smoking and cadmium exposure level. Moreover, this study demonstrated the association not only with cigarette smoking but also pack year and urinary cotinine, which was an advanced results compare to foreign studies.

With respect to gender, women tend to have higher blood cadmium level in this study, and there were several former studies that reported the health effects of toxic metals differ in prevalence or demonstrated differently in men and women. Vather et al reported that cadmium-related health effects are more common among women than men, and hypothesize that this was due to differences in sensitivity to toxic effects or merely reflects the frequency observed higher body burden of cadmium is not clear. Itai-itai disease, known as a combination of kidney damage, osteomalacia and osteoporosis is the most advanced form of cadmium induced disease was reported to cause by consumption of rice that was heavily contaminated by cadmium emitted from mines (Kjellstro¨ m, 1986; Ogawa et al.,2004) and also reported that effected more among exclusively elderly, multiparous women, however this was limited to clarify the direction of the cause and effect of cadmium and risk assessment (Nishijo et al., 2004).

Several former studies reported the association between cadmium and estrogenic effects (Choe et al., 2003; Garcia-Morales et al., 1994; Johnson et al., 2003; Nesatyy et al., 2005; Sogawa et al., 2001; Stoica et al., 2000a). based on the founding on estrogenic effects of cadmium, cadmium was found to act like estrogens in breast cancer cells as a result of its ability to form a high-affinity complex with the hormone binding domain of the estrogen receptor (Garcia-Morales et al., 1994; Stoica et al., 2000a; Wilson et al.,2004). Experience on rats reported than low, single dose of cadmium effected intraperitoneal to ovariectomized rats, which lead to uterine hyperplasia, increased growth of mammary glands, and induction of hormone regulated genes (Johnson et al., 2003).

Table 19 demonstrates the results of path analysis describing the overall association between blood cadmium level, smoking pack year, social determinants, and rice intake composed by income level, education level and occupation classification in women participants. Unlike the results from the men participants, age, education level, smoking pack year was significantly associated with blood cadmium level. However, income and rice intake were no more associated.

4.2 Methodological consideration

This study was designed to analyze the association between social determinants such as income level, education level, occupation classification and blood cadmium level. However, due to the cross sectional design, causal inference on causal relationship is limited. Bradford Hill's criteria for causation is known as a group of guidelines for providing evidence of a causal relationship such as strength (effect size), consistency (reproducibility), specificity, temporality, biological gradient, plausibility, coherence, experiment and analogy (Hill., 1965).

First, when age, income level, occupation classification, and smoking status were controlled, which was 0.386 in men and 0.616 in women. However, when blood cadmium was log transformed and the size of association was exponentially calculated, the association for men was 1.47 and 1.85 for women.

Second, due to the cross sectional design, this study has limitation on guaranteeing the temporality. Education level might have chance to be effected before cadmium exposure. However, cadmium is also known to accumulate in variance tissues and organs (IPCS., 2004). Therefore, clear clarification on the context is limited,

Third, there was dose-response effect between education level and blood cadmium level that, it linear relationship was demonstrated between low education level and high blood cadmium level.

Throughout comprehensive review, association between education level and blood cadmium level was significant although this study was cross sectional. Smoking status worked as a confounder to the association between social economic status and blood cadmium level.

In this study, the association between income level and blood cadmium level seemed to be related; however the association decreased by 0.126 to 0.050 in men, 0.076 to 0.057 in women after controlling the smoking status. Low decrease in women can be refer to the low accuracy of self-reported smoking status, however the variance was not sufficient compare to men participants, even in urinary cotinine controlled model.

Therefore, smoking’s attribution on association between income level and blood cadmium level was sufficient in men, while the attribution was insignificant in women. In order to analyze the remaining association between income level and blood cadmium level, education level and occupation classification was additionally controlled. As a result, association between income level and blood cadmium level eliminated. Comprehensively, association between income level and blood cadmium level seem to be considered as a confounding by smoking status and education level.

4.3 Attribution of smoking on health inequality

Association between mortality and social determinants was the origin of health inequality study. Compare to typical study design on health inequality, outcome variable was replaced from mortality to blood cadmium level replaced mortality, and the results support the reported from former studies that smoking status and lifestyle is associated with health inequality.

The Whitehall I study consists of 18,403 men aged 40-64 who attended the initial screening examination between 1967 and 1969. Men were classified into administrative, professional, executive, clerical, and "other" grades of employment. The "other" grade was the lowest in status and included mainly messengers and other unskilled manual workers. Among those, 17,530 civil servants were classified according to employment grade, and their mortality was recorded over 10 years. There was a steep inverse relation between grade and mortality. Compared with the highest grade (administrators), men in the lowest grade had 3 times the mortality rate from coronary heart disease, from a range of other causes, and from all causes combined. Smoking and other coronary risk factors are more common in the lowest grades, but these differences account for only part of the mortality difference.

The Whitehall II study, a new cohort of 10,314 civil servants (6,900 men and 3,414 women) aged 35-55 working in the London offices of twenty civil-service departments, investigated the degree and causes of the social gradient in morbidity between 1985 and 1988. A self-administered questionnaire was posted to participants who subsequently attended for a screening examination at their place of work. This study focused on psychosocial factors which may influence health, i.e. stressful work environments and lack of social support, as they may influence cardiovascular disease risk.

In twenty years between two studies, there has been no diminution in social class difference in morbidity. An inverse association was found between employment grade and prevalence of angina, electrocardiogram evidence of ischemia, and symptoms of chronic bronchitis. A clear employment-grade difference was found in health-risk behaviors, i.e. smoking, diet, and exercise.

Contribution of smoking to adult mortality can be indirectly estimated from disease-specific death rates using absolute lung cancer rates to indicate proportions due to smoking of mortality from certain other diseases. A study by Jha et al. (2006) applied these methods to 1996 mortality rates at ages 35–69 years in men of three social strata in four countries (England, Wales, Canada, and USA), to quantify approximate contribution of smoking to the social inequalities in adult male mortality. The highest and lowest social strata were based on social class (professional vs. unskilled manual) in England and Wales, neighborhood income (top vs. bottom quintile) in urban Canada, and completed years of education (more than vs. less than 12 years) in the USA and Poland. Approximately two-fold difference between the highest and the lowest social strata was observed for mortality risk among men aged 35-69, and half of difference in mortality was associated with male smoking mortality at age 35-69 years. A study by Mackenbach et al. (2008) compared the magnitude of inequalities in mortality and self-assessed health among more than 54 million persons aged 30-74 years in 22 countries of Europe (both western and eastern) during the 1990s and early 2000s. In this study, magnitude of inequalities in mortality as well as self-assessed health varied by different regions, which appeared to attribute in part to causes of death related to smoking or alcohol use or amenable to medical intervention. Also, the results suggest that inequalities in access to good-quality health care have a role in generating inequalities in mortality. Inequalities in access to health care leading to inequalities in survival from chronic conditions may also partly explain the discrepancy between our results for mortality and those for self-assessed health.

While international comparability of data on socioeconomic inequalities in health or mortality/morbidity is still imperfect, the degree of comparability is likely to decline with increasing geographical coverage. There are differences among countries in various aspects of data collection, and some of these might affect the size of inequalities in health. The history of the smoking epidemic is much less well documented for several countries by region and it is therefore difficult to determine why inequalities in mortality from smoking-related conditions are large, whereas inequalities in smoking are often small.

4.4 Strength and limitation of the study

Strength

One of the major strength of this study is use of representative data source KNHANES. Using representative data source KNHAENS was one of the major strength of this study. The KNHANES is the cross-sectional nationally representative survey of the general population in Korea, annually conducted by Korea Center of Disease Control and Prevention (KCDC) in the Ministry of Health and Welfare. Data are open accessed by online,

Limitation

This study was a cross sectional designed study aimed to analyze the association between socio economic variants and blood cadmium level. Although the design was cross sectional, socio economic determinants are formed throughout long term, and blood cadmium accumulates for a long period in human body. Therefore the risk of inverse association which is common in cross sectional study is relatively low. Lack of consideration on dietary variable is an another limitation in this study since dietary factors are known as a main exposure source of cadmium.

Conclusion

This study was a cross-sectional study aimed to analyze the association between socio-economic variants and blood cadmium level. Association between socio-economic variants and blood cadmium level was partially significant where smoking was confounding. Association with education level still remained after controlling for smoking. In the present study, the association and mechanism on inequality in cadmium exposure by education level was found to be significant. Thus more research to clarify the mechanism of this variance is required. Regarding the results associated with smoking, tobacco control interventions can be an effective policy to improve the health inequity in cadmium exposure.

REFERENCES

Brown P. Race, class, and environmental health: a review and systematization of the literature. Environ Res 1995;69:15–30.

Zheng H, Land KC. Composition and decomposition in US gender-specific self-reported health disparities, 1984–2007. Soc Sci Res 2012;41:477–88.

Iqbal S, Muntner P, Batuman V, Rabito FA. Estimated burden of blood lead levels 5μg/dl in 1999–2002 and declines from 1988 to 1994. Environ Res 2008;107:305–11.

Stokstad E. Pollution gets personal. Science 2004;304:1892–4.

Jarup L, Berglund M, Elinder CG, et al. (1998). Health effects of cadmium exposure – a review of the literature and a risk estimate. Scand J Work Environ Health 24:1–51.

Piascik MT, Champney RB, Kasarskis EJ, Forrester T. (1985). A method for enriching the cadmium content of cigarette smoke and effect of exposure to this smoke on coronary vascular reactivity in the rat. Toxicol Appl Pharmacol 81:525–32.

McKelvey W, Gwynn RC, Jeffery N, Kass D, Thorpe LE, Garg RK, et al. A biomonitoring study of lead, cadmium, and mercury in the blood of New York city adults. Environ Health Perspect 2007;115:1435–41.

Hecht EM, Landy DC, Ahn S, et al. (2013). Hypothesis: cadmium explains, in part, why smoking increases the risk of cardiovascular disease. J Cardiovasc Pharmacol Ther 18:550–4.

Nordberg G, Nordberg M. (1988). Biological monitoring of cadmium. In: Clarkson T, Friberg L, Nordberg G, Sager P, eds. Biological monitoring of toxic metals. New York: Plenium Press, 151–69.

Travis CC, Haddock AG. (1980). Interpretation of the observed age dependency of cadmium body burdens in man. Environ Res 22:46–60.

Nordic Council of Ministers. (2003). Cadmium Review.

Nriagu, J. & J. Pacyna. 1988. Quantitative assessment of worldwide contamination of air, water and soils by trace metals. Nature. 333: 134-139.

Nriagu, J.O 1989. A global assessment of natural sources of atmospheric trace metals. Nature. 338: 47-48

Pacyna J.M. & E.G. Pacyna. 2001. An assessment of global and regional emissions of trace metals to the atmosphere from anthropogenic sources worldwide. Environmental Reviews 9: 269-298.

OSPAR 2002. Cadmium. Hazardous Substances Series. OSPAR Commission 2002.

Gašparík J, Binkowski ŁJ, Jahnátek A, Šmehýl P, Dobiaš M, Lukáč N, Błaszczyk M, Semla M, Massanyi P. Levels of Metals in Kidney, Liver, and Muscle Tissue and their Influence on the Fitness for the Consumption of Wild Boar from Western Slovakia. Biol Trace Elem Res. 2016 Nov 3. [Epub ahead of print] PubMed PMID: 27812912.

Satarug S., Garrett SH., Sens MA., Sens DA., (2010). Cadmium, environmental exposure, and health outcomes. Environ Health Perspect 118:182- 190 (2010).doi:10.1289/ ehp.0901234 avail-able via

WHO 1992a. Cadmium. Environmental Health Criteria 134. World Health Organisation,

International Programme on Chemical Safety (IPCS), Geneva, Switzerland.

Hill, Austin Bradford (1965). "The Environment and Disease: Association or Causation?". Proceedings of the Royal Society of Medicine. 58 (5): 295–300. PMC 1898525Freely accessible. PMID 14283879

Satarug S., Moore MR (2004). Adverse Health Effects of Chronic Exposure to

Low-Level Cadmium in Foodstuffs and Cigarette. Smoke Environmental Health Perspectives • VOLUME 112 | NUMBER 10

IPCS (International Programme on Chemical Safety). (1992) Cadmium. Environmental Health Criteria 134.Geneva:World Health Organization. Available: http://www.inchem.org/ documents/ehc/ehc/ehc134.htm [accessed 4 May 2004].

Marmot, M. G., Shipley, M. J., Rose, G. INEQUALITIES IN DEATH – SPECIFIC EXPLANATIONS OF A GENERAL PATTERN? The Lancet 1984

Marmot, M. G., Smith, G. D, Stansfeld, S., Patel, C., North, F., Head, J., White, I., Brunner, E., Feeney, A. Health inequalities among British civil servants the Whitehall II study. The Lancet 1991

Jha, P., Peto, R., Zatonski, W., Boreham, J., Jarvis, M. J., & Lopez, A. D. Social inequalities in male mortality, and in male mortality from smoking: indirect estimation from national death rates in England and Wales, Poland, and North America. The Lancet 2006

Mackenbach, J. P., Stirbu, I., Roskam, A. J. R., Schaap, M. M., Menvielle, G., Leinsalu, M., & Kunst, A. E. New England Journal of MedicineSocial inequalities in Health in 22 European Countries 2008

Vahter, M., Berglund, M., Akesson, A., Liden, C., 2002. Metals and women's health. Environ. Res. 88, 145–155.

Choe, S.Y., Kim, S.J., Kim, H.G., Lee, J.H., Choi, Y., Lee, H., Kim, Y., 2003. Evaluation of estrogenicity of major heavy metals. Sci. Total Environ. 312, 15–21.

Garcia-Morales, P., Saceda, M., Kenney, N., Kim, N., Salomon, D.S., Gottardis, M.M., Solomon, H.B., Sholler, P.F., Jordan, V.C., Martin, M.B., 1994. Effect of cadmium on estrogen receptor levels and estrogen-induced responses in human breast cancer cells. J. Biol. Chem. 269, 16896–16901.

Johnson, M.D., Kenney, N., Stoica, A., Hilakivi-Clarke, L., Singh, B., Chepko, G., Clarke, R., Sholler, P.F., Lirio, A.A., Foss, C., Reiter, R., Trock, B., Paik, S., Martin, M.B., 2003. Cadmium mimics the in vivo effects of estrogen in the uterus and mammary gland. Nat. Med. 9, 1081–1084.

Nesatyy, V.J., Rutishauser, B.V., Eggen, R.I., Suter, M.J., 2005. Identification of the estrogen receptor Cd-binding sites by chemical modification. Analyst 130, 1087–1097.

Sogawa, N., Onodera, K., Sogawa, C.A., Mukubo, Y., Fukuoka, H., Oda, N., Furuta, H., 2001. Bisphenol A enhances cadmium toxicity through estrogen receptor. Methods Find Exp. Clin. Pharmacol. 23, 395–399.

Stoica, A., Katzenellenbogen, B.S., Martin, M.B., 2000a. Activation of estrogen receptor-alpha by the heavy metal cadmium. Mol. Endocrinol. 14, 545–553.

Wilson, V.S., Bobseine, K., Gray Jr., L.E., 2004. Development and characterization of a cell line that stably expresses an estrogenresponsive luciferase reporter for the detection of estrogen receptor agonist and antagonists. Toxicol. Sci. 81, 69–77.

Kjellstro¨ m, T., 1986. Itai-itai disease. In: Friberg, L., Elinder, C.G., Kjellstro¨ m, T., Nordberg, G.F. (Eds.), Cadmium and Health: A Toxicological and Epidemioloical Appraisal. CRC Press, Boca Raton, FL, pp. 257–290.

Ogawa, T., Kobayashi, E., Okubo, Y., Suwazono, Y., Kido, T., Nogawa, K., 2004. Relationship among prevalence of patients with Itai-itai disease, prevalence of abnormal urinary findings, and cadmium concentrations in rice of individual hamlets in the Jinzu River basin, Toyama prefecture of Japan. Int. J. Environ. Health Res. 14, 243–252.

Nishijo, M., Satarug, S., Honda, R., Tsuritani, I., Aoshima, K., 2004. The gender differences in health effects of environmental cadmium exposure and potential mechanisms. Mol. Cell Biochem. 255, 87–92.

Jung-Choi KH, Khang YH, Cho HJ. Hidden female smokers in Asia: a comparison of self-reported with cotinine-verified smoking prevalence rates in representative national data from an Asian population. Tob Control. 2012 Nov;21(6):536-42. doi: 10.1136/tobaccocontrol-2011-050012. PubMed PMID: 21972062.

SUMMARY IN KOREAN

국문초록

사회 경제적 변수와 흡연력의 혈중 카드뮴 농도와 관련성 분석: 국민건강영영조사 자료를 바탕으로

지용호
보건학과 역학전공
서울대학교 보건대학원

연구배경

카드뮴은 일상 환경에 흔히 존재하는 중금속으로 작업 및 환경적으로 인체에 유입되어 건강에 악영향을 초래하는 것으로 잘 알려져 있다. 카드뮴의 인체 노출 경로는 크게 직업적 노출과 환경적 노출(비 직업적 노출)로 분류된다. 카드뮴의 직업적 노출은 주로 비철금속의 채광, 생산, 소비에 의해 부산물로 발생하며 도금, 용접, 축전지, 살충제 제조, 농약 및 비료 사용 등으로 이루어지며, 금속 및 제품의 가공, 소비, 폐기 등 다양한 활동으로부터 상당량의 카드뮴이 환경으로 방출된다. 일반인의 비 직업적 노출은 주로 카드뮴이 함유된 음식물 (간 등 육류, 패류, 채소류 및 카드뮴 코팅 용기에 보관된 음식물) 섭취 등의 경로로 일어나며, 흡연 혹은 오염된 토양이나 먼지를 마심으로써 만성적으로 노출 될 수 있다.

환경적 노출에 의한 혈중 카드뮴 농도는 상대적으로 낮은 수준이므로 이들 중금속에 의한 전형적인 질병 유발 가능성은 직업적 노출에 비해 다소 낮지만, 혈압상승, 신장 기능저하 등 저 농도에서의 건강 영향도 다수 보고되고 있다. 그런데 환경적 노출은 광범위하고 어린이, 임산부, 노인 등 근로자보다 취약한 집단을 포함하기 때문에 그 잠재적 영향은 공중보건학적으로 반드시 고려되어야 한다. 또한 한국을 비롯한 아시아권 국민들의 높은 카드뮴 농도는

쌀 등 곡식을 주식으로 섭취하는 것이 가장 주요한 원인 중 하나로 추정되어 왔다.

그 동안 한국인의 혈중 카드뮴 농도에 있어 노출 경로와 기전, 성별, 연령별에 따른 분포의 차이에 관한 연구는 다수 이루어졌다. 그러나 소득, 교육수준, 직업, 지역 등 사회경제적 변수와 혈중 카드뮴 농도와의 관련성 연구는 많지 않았다. 특히, 사회경제적 변수와 혈중 카드뮴 농도와의 관련성이 흡연이나 쌀 섭취에 의한 결과인지를 밝힌 연구는 드물었다. 따라서 사회경제적 변수에 따라 카드뮴 농도와 관련성을 알아보는 연구는 향후 유해물질 노출의 사회불평등을 이해하는데 기초자료가 될 것으로 기대한다.

연구방법

1. 분석자료 정보 및 변수 선정

이 연구는 국민건강영양조사 제4기(2007-2009), 제5기 (2010-2012) 자료 중 카드뮴과 코티닌 변수를 포함하고 있는 연도 (2008, 2009, 2010, 2011)의 자료를 통합한 7,734 명을 대상으로 하였다. 소득수준은 국민건강영양조사에서 조사된 소득 사분위수(Q1~Q4)를 활용하여 소득 하위(Q1)와 상위(Q4)의 혈중 카드뮴 농도의 차이를 분석했다. 교육수준은 교육 수준 재 분류 코드변수를 사용하여 초졸 이하(Q1)와 대졸 이상(Q4) 학력 수준간의 혈중 카드뮴 농도 차이를 분석했다. 직업은 직업 분류 변수를 사용하여 전문직 관리자, 숙련직, 비숙련직, 무직으로 재 분류한 후 혈중 카드뮴 농도 차이를 분석했다. 흡연력은 흡연 여부 (비흡연, 과거흡연, 현재흡연), 그리고 흡연 갑년(pack-year)은 4등분으로 나누어 혈중 카드뮴 농도와의 차이를 분석했다. 흡연력의 타당성 관련하여 부가적으로 소변 코티닌 농도를 포함하였다.

2. 자료분석방법

이 연구는 사회경제적변수로서 소득수준, 교육수준, 직업과 혈중 카드뮴 농도와의 관련성에 흡연력과 쌀섭취의 영향을 알아보고자 다양한 흡연력을 단계적으로 통제하여 분석하였다. 궁극적으로 사회경제적 수준과 카드뮴과의 관련성에 대한 직접적인 효과와 흡연력과 쌀섭취에 통한 간접적인 효과로 나누어

보고자 경로 분석을 하였다. 이 연구자료를 모집단에 대한 표본가중치가 포함된 자료이므로 가중치를 고려하여 분석하였다. 통계 분석은 SAS 9.4, 경로분석은 STATA 12.0와 MPLUS 7.4를 사용하였다.

연구결과

연령, 교육수준, 수입수준과 흡연갑년과의 관련성에서 수입은 유의하지 않았지만, 연령이 증가할 수록 교육수준이 낮을수록 카드뮴 농도는 증가함을 보였다. 그런데 흡연갑년, 수입, 교육수준, 연령은 혈중 카드뮴과 모두 유의한 관련성을 보였다. 교육수준이 카드뮴에 미치는 직접관련성은 -0.036 이고, 교육수준이 흡연갑년을 통해서 카드뮴에 영향을 주는 간접 관련성은 -0.01 이었다.

여자에서 사회경제적 변수로서 수입수준과 교육수준을 포함하여 연령을 포함하여 흡연갑년과의 관련성과 이들 변수들이 혈중 카드뮴과 관련성을 종합적으로 파악하는 경로분석결과는 표 15를 통해 나타났다. 남자모형과 달리 여자에서는 연령, 교육수준, 흡연갑년은 카드뮴 농도에 유의한 관련성을 보였다. 그러나 수입은 더 이상 유의한 관련성을 보이지 않았다.

결론

이 연구는 단면적 연구의 한계가 있음에도 불구하고 대표성을 가지고 있는 일반인구집단에서 사회경제적 환경에 따른 혈중 카드뮴 농도에 차이가 있었고, 이러한 관련성에 흡연이 일부 기여한다는 사실을 밝혔다. 산업장 뿐 아니라 생활환경에서도 흔히 노출될 수 있고, 체네 유입 이후 긴 시간의 반감기를 가지고 있는 카드뮴은 산업 현장 근로자 뿐 아니라 일반 인구집단의 건강불평등을 측정할 수 있는 지표로서의 가치를 가질 수 있는 가능성을 시사하였다. 그 동안 잘 알려진 사회경제적 환경에 따른 중금속 노출도 차이를 해석하는데 있어 흡연 요인을 통제한 해석이 필요 하다.

주요어: 카드뮴, 흡연, 사회 경제적 변수, 경로 분석

SAS code

```
LIBNAME JEE 'G:\국민건강영영조사\ALLDATA';

DATA D2008; SET JEE.HN08_ALL;   /* N=9744 */
KEEP YEAR kstrata PSU wt_itvex wt_hm wt_ntr wt_hmnt Age SEX BS1_1 BS2_1 BS3_1 BS3_2   BS6_2
BS6_3   sm_presnt YEAR EDU occp incm REGION town_t
HE_Pb HE_Hg HE_CD HE_Mn HE_As_cr HE_UCOT HE_Frtn BD1 BD1_11 HE_Frtn HE_WT HE_HT HE_BMI
F_RICE F_BARLEY ; RUN;

DATA D2009; SET JEE.HN09_ALL;   /* N=10533 */     ;
KEEP YEAR kstrata PSU wt_itvex wt_hm wt_ntr wt_hmnt Age SEX BS1_1 BS2_1 BS3_1 BS3_2   BS6_2
BS6_3   sm_presnt YEAR EDU occp incm REGION town_t HE_CD HE_PB HE_Hg HE_UCOT
HE_Frtn BD1 BD1_11 HE_Frtn HE_wt HE_HT   HE_BMI F_RICE F_BARLEY     ; RUN;

DATA D2010; SET JEE.HN10_ALL;   /* N=8958 */     ;
KEEP YEAR kstrata PSU wt_itvex wt_hm wt_ntr wt_hmnt Age SEX BS1_1 BS2_1 BS3_1 BS3_2   BS6_2
BS6_3   sm_presnt YEAR EDU occp incm REGION town_t HE_CD HE_PB HE_Hg HE_UCOT
HE_Frtn BD1 BD1_11 HE_Frtn HE_wt HE_HT HE_BMI   F_RICE F_BARLEY     ; RUN;

DATA D2011; SET JEE.HN11_ALL;   /* N=8518 */     ;
KEEP YEAR kstrata PSU wt_itvex wt_hm wt_ntr wt_hmnt Age SEX BS1_1 BS2_1 BS3_1 BS3_2   BS6_2
BS6_3   sm_presnt YEAR EDU occp incm REGION town_t HE_CD HE_PB HE_Hg HE_UCOT
HE_Frtn BD1 BD1_11 HE_Frtn HE_wt HE_HT HE_BMI F_RICE F_BARLEY       ; RUN;

DATA jee.ALL; SET D2008   D2009   D2010   D2011; RUN;   /* 30015 */

DATA ALL; SET JEE.ALL;
wt_ex_pool = wt_itvex * 1/4;   /* 검진 가중치 */
wt_hm_pool = wt_hm * 1/4;    /* 검진 + 중금속 */
wt_ntr_pool = wt_ntr * 1/4;    /* 영양 가중치 */
wt_hmnt_pool = wt_hmnt * 1/4;    /* 중금속 + 검진 + 영양 가중치 */

LHE_CD=LOG(HE_CD);   /* 자연로그, LN ...로그 치환 갸드뭄을 평균 후, EXP 하여 기하 평균 계산 */

if age>=20 & HE_Cd>0 & incm not in (.) & EDU not in (.) & BS3_1 not in (.,9) & HE_BMI NOT IN (.) then anal0=1;
if age>=20 & HE_Cd>0 & incm not in (.) & EDU not in (.) & BS3_1 not in (.,9) & HE_BMI NOT IN (.) & OCCP not in (.) then
anal=1;
if age>=20 & HE_Cd>0 & incm not in (.) & EDU not in (.) & BS3_1 not in (.,9) & HE_BMI NOT IN (.) & OCCP not in (.) & SEX=1
then analM=1;
if age>=20 & HE_Cd>0 & incm not in (.) & EDU not in (.) & BS3_1 not in (.,9) & HE_BMI NOT IN (.) & OCCP not in (.) & SEX=2
then analW=1;

IF YEAR=2008 AND (BS6_2=888 OR BS6_2=999) THEN BS6_2=.; ELSE   /* 과거흡연자 흡연기간 (개월)   2008-   */
IF 2009<=YEAR<=2011 AND (BS6_2=8888 OR BS6_2=9999) THEN BS6_2=.; ELSE   /* 과거흡연자 흡연기간 (개월)   2009-
2011 */

IF (YEAR=2008 OR YEAR=2009) AND (BS2_1=88 OR BS2_1=99) THEN BS2_1=.;       /* 흡연시작연령 2008-2009 */
IF (YEAR=2010 OR YEAR=2011) AND (BS2_1=888 OR BS2_1=999) THEN BS2_1=.; /* 흡연시작연령 2010-2011 */

SMODUR= AGE-BS2_1;    /* 현재흡연자 흡연기간 */
SMODUR=ROUND(SMODUR,.1);

*IF BS3_1=9 THEN BS3_1=.;   /* 현재 흡연 여부 */

IF 20<=AGE<30 THEN AGE1=1; ELSE
IF 30<=AGE<40 THEN AGE1=2; ELSE
IF 40<=AGE<50 THEN AGE1=3; ELSE
IF 50<=AGE<60 THEN AGE1=4; ELSE
IF 60<=AGE          THEN AGE1=5;
```

```
IF INCM=1 THEN INCM1=1; ELSE INCM1=0;
IF INCM=2 THEN INCM2=1; ELSE INCM2=0;
IF INCM=3 THEN INCM3=1; ELSE INCM3=0;
IF INCM=4 THEN INCM4=1; ELSE INCM4=0;    /* REF */

IF BS3_2=888 OR BS3_2=999 THEN BS3_2=.; /* 현재 흡연자 흡연량 */
IF BS6_3=888 OR BS6_3=999 THEN BS6_3=.; /*과거흡연자 흡연량 */

IF (YEAR=2008 OR YEAR=2009) AND BS3_1=8 THEN SMOK=1; ELSE
IF (YEAR=2008 OR YEAR=2009) AND BS3_1=2 THEN SMOK=2; ELSE
IF (YEAR=2008 OR YEAR=2009) AND BS3_1=1 THEN SMOK=3; ELSE
IF 2010<=YEAR<=2011 AND BS3_1=8 THEN SMOK=1; ELSE
IF 2010<=YEAR<=2011 AND BS3_1=3 THEN SMOK=2; ELSE
IF 2010<=YEAR<=2011 AND 1<=BS3_1<=2 THEN SMOK=3;

IF SMOK=2 THEN EXSMOK=1; ELSE EXSMOK=0;
IF SMOK=3 THEN CUSMOK=1; ELSE CUSMOK=0;

IF SMOK=1 THEN AMT=0; ELSE
IF SMOK=2 THEN AMT=BS6_3; ELSE     /*과거흡연자 흡연량 */
IF SMOK=3 THEN AMT=BS3_2;                /* 현재 흡연자 흡연량 */

IF SMOK=1 THEN DUR=0; ELSE
IF SMOK=2 THEN DUR=BS6_2/12; ELSE
IF SMOK=3 THEN DUR=SMODUR;

DUR=ROUND(DUR,.1);

if age>=20 & HE_Cd>0 & incm not in (.) & EDU not in (.) & BS3_1 not in (.,9) & HE_BMI NOT IN (.)
& AMT not in (.) & DUR not in (.) & HE_UCOT not in (.)    then anal1=1;

/*  흡연량 */
IF BS3_1=8 THEN AMT1=1; ELSE
IF 0<AMT<10 THEN AMT1=2; ELSE
IF 10<=AMT<20 THEN AMT1=3; ELSE
IF 20<=AMT<30 THEN AMT1=4; ELSE
IF 30<=AMT THEN AMT1=5;
IF AMT1=2 THEN AMT2=1; ELSE AMT2=0;
IF AMT1=3 THEN AMT3=1; ELSE AMT3=0;
IF AMT1=4 THEN AMT4=1; ELSE AMT4=0;
IF AMT1=5 THEN AMT5=1; ELSE AMT5=0;

/*  흡연기간 */
IF BS3_1=8 THEN DUR1=1; ELSE
IF 0<DUR<10 THEN DUR1=2; ELSE
IF 10<=DUR<20 THEN DUR1=3; ELSE
IF 20<=DUR<30 THEN DUR1=4; ELSE
IF 30<=DUR THEN DUR1=5;


/*  흡연갑년 */
PACKYR = AMT/20*DUR;

IF BS3_1=8 THEN PACKYR1=1; ELSE
IF 0<PACKYR<10 THEN PACKYR1=2; ELSE
IF 10<=PACKYR<20 THEN PACKYR1=3; ELSE
IF 20<=PACKYR<30 THEN PACKYR1=4; ELSE
IF 30<=PACKYR THEN PACKYR1=5;

IF PACKYR1=2 THEN PACKYR2=1; ELSE PACKYR2=0;
```

```
IF PACKYR1=3 THEN PACKYR3=1; ELSE PACKYR3=0;
IF PACKYR1=4 THEN PACKYR4=1; ELSE PACKYR4=0;
IF PACKYR1=5 THEN PACKYR5=1; ELSE PACKYR5=0;

SEX1=SEX-1;

/*  BMI  */
IF    0< HE_BMI <18.5     THEN HE_BMI1=1; ELSE
IF 18.5<= HE_BMI< 25   THEN HE_BMI1=2; ELSE
IF 25 <= HE_BMI <30      THEN HE_BMI1=3; ELSE
IF 30<=HE_BMI                 THEN HE_BMI1=4;
IF HE_BMI1=2 THEN HE_BMI2=1; ELSE HE_BMI2=0;
IF HE_BMI1=3 THEN HE_BMI3=1; ELSE HE_BMI3=0;
IF HE_BMI1=4 THEN HE_BMI4=1; ELSE HE_BMI4=0;

/*  EDUI  */
IF EDU=1 THEN EDU1=1; ELSE EDU1=0;
IF EDU=2 THEN EDU2=1; ELSE EDU2=0;
IF EDU=3 THEN EDU3=1; ELSE EDU3=0;
IF EDU=4 THEN EDU4=1; ELSE EDU4=0; /* REF UNIV*/

IF OCCP=1 THEN OCCP1=1; ELSE OCCP1=0;
IF OCCP=2 THEN OCCP2=1; ELSE OCCP2=0;
IF OCCP=3 THEN OCCP3=1; ELSE OCCP3=0;
IF OCCP=4 THEN OCCP4=1; ELSE OCCP4=0;
IF OCCP=5 THEN OCCP5=1; ELSE OCCP5=0;
IF OCCP=6 THEN OCCP6=1; ELSE OCCP6=0;
IF OCCP=7 THEN OCCP7=1; ELSE OCCP7=0;

IF OCCP=1 THEN ROCCP=1; ELSE
IF 2<=OCCP<=5 THEN ROCCP=2; ELSE
IF OCCP=6 THEN ROCCP=3; ELSE
IF OCCP=7 THEN ROCCP=4;

IF rOCCP=1 THEN rOCCP1=1; ELSE rOCCP1=0;
IF rOCCP=2 THEN rOCCP2=1; ELSE rOCCP2=0;
IF rOCCP=3 THEN rOCCP3=1; ELSE rOCCP3=0;
IF rOCCP=4 THEN rOCCP4=1; ELSE rOCCP4=0;

IF 0<HE_UCOT<10 THEN HE_UCOT1=1; ELSE
IF 10<=HE_UCOT<50 THEN HE_UCOT1=2; ELSE
IF 50<=HE_UCOT<100 THEN HE_UCOT1=3; ELSE
IF 100<=HE_UCOT        THEN HE_UCOT1=4;

IF HE_UCOT1=2 THEN HE_UCOT2=1; ELSE HE_UCOT2=0;
IF HE_UCOT1=3 THEN HE_UCOT3=1; ELSE HE_UCOT3=0;
IF HE_UCOT1=4 THEN HE_UCOT4=1; ELSE HE_UCOT4=0;

** 쌀 섭취량 *;

IF 0<=F_RICE<=6 THEN F_RICE1=1; ELSE
IF F_RICE=7 THEN F_RICE1=2; ELSE
IF F_RICE=8 THEN F_RICE1=3; ELSE
IF F_RICE=9 THEN F_RICE1=4; ELSE F_RICE1=5;

IF F_RICE1=1 THEN F_RICEJ1=1; ELSE F_RICEJ1=0;
IF F_RICE1=2 THEN F_RICEJ2=1; ELSE F_RICEJ2=0;
IF F_RICE1=3 THEN F_RICEJ3=1; ELSE F_RICEJ3=0;
IF F_RICE1=4 THEN F_RICEJ4=1; ELSE F_RICEJ4=0;
IF F_RICE1=5 THEN F_RICEJ5=1; ELSE F_RICEJ5=0;
```

```
IF 0<=F_BARLEY<=6 THEN F_BARLEY1=1; ELSE
IF F_BARLEY=7 THEN F_BARLEY1=2; ELSE
IF F_BARLEY=8 THEN F_BARLEY1=3; ELSE
IF F_BARLEY=9 THEN F_BARLEY1=4; ELSE F_BARLEY1=5;

IF F_BARLEY1=1 THEN F_BARLEYJ1=1; ELSE F_BARLEYJ1=0;
IF F_BARLEY1=2 THEN F_BARLEYJ2=1; ELSE F_BARLEYJ2=0;
IF F_BARLEY1=3 THEN F_BARLEYJ3=1; ELSE F_BARLEYJ3=0;
IF F_BARLEY1=4 THEN F_BARLEYJ4=1; ELSE F_BARLEYJ4=0;
IF F_BARLEY1=5 THEN F_BARLEYJ5=1; ELSE F_BARLEYJ5=0;

label sex= 'Sex';
label HE_CD= 'Serum cadmium level,μg/L';
label AGE1= 'Age group, year';
label incm= 'Income, Q1-Q4';
label edu= 'Education';
label occp= 'Occupation by 7 categories';
label Roccp= 'Occupation by 4 categories';
label F_RICE1= 'Frequency of rice intake';
label F_BARLEY1= 'Frequency of barley intake';
RUN;

PROC FORMAT;
VALUE SEXFMT 1='Men' 2='Women';
VALUE AGEFMT 1='20-29' 2='30-39' 3='40-49' 4='50-59' 5='60+';
VALUE incmFMT 1='Q1, low' 2='Q2' 3='Q3' 4='Q4, high';
VALUE eduFMT 1='Under elementary' 2='Middle school' 3='High school' 4='University or more';
VALUE occpFMT 1='Managers' 2='Clerical workers' 3='Service workers' 4='Agriultural, fishery'
5='Craft workers' 6='Elementary occupations' 7='Unemployed';
VALUE roccpFMT 1='Professional or manager' 2='Non-manual or skilled workers' 3='Unskilled workers'
4='Unemployed';

VALUE F_RICEFMT 1='Less than 7 per week' 2='1 per day' 3='2 per day' 4='3 per day' 5='Non response'    ;
VALUE F_BARFMT 1='Less than 7 per week' 2='1 per day' 3='2 per day' 4='3 per day' 5='Non response'    ;
RUN;


* Table 1*;
PROC MEANS; CLASS YEAR; VAR AGE; WHERE anal0=1; RUN;;
PROC FREQ; TABLE YEAR*SEX; RUN;
PROC FREQ; TABLE anal0*(SEX INCM EDU OCCP rOCCP)*YEAR; RUN;
PROC FREQ; TABLE anal0*SEX*(F_RICE1)*YEAR; RUN;
PROC FREQ; TABLE anal0*SEX*(F_BARLEY1)*YEAR; RUN;

** 기술 통계 **;
PROC MEANS; CLASS SEX; VAR HE_CD; WHERE anal0=1; RUN;
PROC FREQ; TABLE anal0*SEX; FORMAT SEX SEXFMT.; RUN;

PROC SORT; BY SEX; RUN;
PROC BOXPLOT; PLOT HE_CD*SEX;    FORMAT SEX SEXFMT.; RUN;

PROC SORT; BY AGE1; RUN;
PROC BOXPLOT; PLOT HE_CD*AGE1;    FORMAT AGE1 AGEFMT.; RUN;

PROC SORT; BY incm; RUN;
PROC BOXPLOT; PLOT HE_CD*incm;    FORMAT incm incmFMT.; RUN;

PROC SORT; BY edu; RUN;
PROC BOXPLOT; PLOT HE_CD*edu;    FORMAT edu eduFMT.; RUN;
```

```
PROC SORT; BY occp; RUN;
PROC BOXPLOT; PLOT HE_CD*occp;   FORMAT occp occpFMT.; RUN;

PROC SORT; BY roccp; RUN;
PROC BOXPLOT; PLOT HE_CD*roccp;   FORMAT roccp roccpFMT.; RUN;

PROC SORT; BY F_RICE1; RUN;
PROC BOXPLOT; PLOT HE_CD*F_RICE1;   FORMAT F_RICE1 F_RICEFMT.; RUN;

PROC SORT; BY F_BARLEY1; RUN;
PROC BOXPLOT; PLOT HE_CD*F_BARLEY1;   FORMAT F_BARLEY1 F_BARFMT.; RUN;

PROC CHART; VBAR HE_CD; RUN;

* log e e = 1 , log e 2.11 = 0.74, log e 1 = 0,   e= 2.71828...;

* Table 2*;
proc freq; table anal0*sex; run;
proc means; class sex; var age HE_BMI HE_CD LHE_CD HE_UCOT; where anal0=1;run;
proc means; var age HE_BMI HE_CD LHE_CD HE_UCOT; where anal0=1;run;
proc freq; table anal0*(smok incm edu roccp)*SEX; run;

* Table 3 - 가중치 한 빈도 *;
proc surveyfreq data=ALL nomcar;
strata kstrata; cluster PSU; weight wt_ex_pool;
tables anal0*(age1 INCM   EDU rOCCP SMOK);   /*anal0=1 결과 */ run;

* Table 3 - 가중치 한 빈도 - 영양분석 *;
proc surveyfreq data=ALL nomcar;
strata kstrata; cluster PSU; weight wt_ntr_pool;
tables anal0*(F_RICE1 F_BARLEY1 );   /*anal0=1 결과 */ run;

********************여기서 부터 가중치 적용한 프로그램입니다.**;
* Table 3 - 가중치 기하 평균 *;
/** AGE ANALYSIS - 기하평균   **/
PROC SORT; BY AGE1;
PROC SURVEYMEANS DATA=ALL NOMCAR GEOMEAN GMCLM;
domain anal*AGE1;
STRATA kstrata; CLUSTER psu; WEIGHT wt_ex_pool;
VAR   HE_CD ; RUN;

ods output LSMeans=lsmean;
PROC SURVEYREG data=ALL NOMCAR ORDER=FREQ ;
domain anal; strata kstrata; cluster PSU; weight wt_ex_pool; class AGE1;
model LHE_CD=AGE1 /solution;
lsmeans /cl; run; ;

/** BMI ANALYSIS **/
PROC SURVEYMEANS DATA=ALL NOMCAR GEOMEAN GMCLM;
domain anal*HE_BMI1;
STRATA kstrata; CLUSTER psu; WEIGHT wt_ex_pool;
VAR   HE_CD ; RUN; ;

ods output LSMeans=lsmean;
PROC SURVEYREG data=ALL NOMCAR ;
domain anal; strata kstrata; cluster PSU; weight wt_ex_pool; ;
model LHE_CD=HE_BMI2-HE_BMI4 /solution;
lsmeans /cl; run;
```

```
/** GENDER ANALYSIS **/
PROC SURVEYMEANS DATA=ALL NOMCAR GEOMEAN GMCLM;
domain anal*SEX1;
STRATA kstrata; CLUSTER psu; WEIGHT wt_ex_pool;
VAR   HE_CD ; RUN;

ods output LSMeans=lsmean;
PROC SURVEYREG data=ALL NOMCAR ;
domain anal; strata kstrata; cluster PSU; weight wt_ex_pool; class SEX;
model LHE_CD=SEX /solution;
lsmeans /cl; run;

/** EDUCATION ANALYSIS **/
PROC SURVEYMEANS DATA=ALL NOMCAR GEOMEAN GMCLM;
domain anal*EDU;
STRATA kstrata; CLUSTER psu; WEIGHT wt_ex_pool;
VAR   HE_CD ; RUN;

ods output LSMeans=lsmean;
PROC SURVEYREG data=ALL NOMCAR ;
domain anal; strata kstrata; cluster PSU; weight wt_ex_pool;
model LHE_CD=EDU2-EDU4 /solution;
lsmeans /cl; run;

/** INCOME   ANALYSIS **/
PROC SURVEYMEANS DATA=ALL NOMCAR GEOMEAN GMCLM;
domain anal*INCM;
STRATA kstrata; CLUSTER psu; WEIGHT wt_ex_pool;
VAR   HE_CD ; RUN;

ods output LSMeans=lsmean;
PROC SURVEYREG data=ALL NOMCAR ;
domain anal; strata kstrata; cluster PSU; weight wt_ex_pool; class INCM;
model LHE_CD=INCM /solution;
lsmeans /cl; run;

/** rOCCUPATION   ANALYSIS **/
PROC SURVEYMEANS DATA=ALL NOMCAR GEOMEAN GMCLM;
domain anal*rOCCP;
STRATA kstrata; CLUSTER psu; WEIGHT wt_ex_pool;
VAR   HE_CD ; RUN;

ods output LSMeans=lsmean;
PROC SURVEYREG data=ALL NOMCAR ;
domain anal; strata kstrata; cluster PSU; weight wt_ex_pool; class rOCCP;
model LHE  CD=rOCCP2-rOCCP4 /solution;
lsmeans /cl; run;

/** SMOKING   ANALYSIS **/
PROC SURVEYMEANS DATA=ALL NOMCAR GEOMEAN GMCLM;
domain anal*SMOK;
STRATA kstrata; CLUSTER psu; WEIGHT wt_ex_pool;
VAR   HE_CD ; RUN;

ods output LSMeans=lsmean;
PROC SURVEYREG data=ALL NOMCAR order=freq ;
  domain anal; strata kstrata; cluster PSU; weight wt_ex_pool; class SMOK;
model LHE  CD=EXSMOK   CUSMOK/solution;
lsmeans /cl; run;
```

```
/** RICE   ANALYSIS **/
PROC SURVEYMEANS DATA=ALL NOMCAR GEOMEAN GMCLM;
domain anal*F_RICE1;
STRATA kstrata; CLUSTER psu; WEIGHT wt_hmnt_pool;
VAR   HE_CD ; RUN;

ods output LSMeans=lsmean;
PROC SURVEYREG data=ALL NOMCAR order=freq ;
domain anal; strata kstrata; cluster PSU; weight wt_hmnt_pool; class F_RICE1;
model LHE_CD=F_RICEJ1 F_RICEJ3 F_RICEJ4 F_RICEJ5   /solution;
lsmeans /cl; run;

/** BARLEY   ANALYSIS **/
PROC SURVEYMEANS DATA=ALL NOMCAR GEOMEAN GMCLM;
domain anal*F_BARLEY1;
STRATA kstrata; CLUSTER psu; WEIGHT wt_hmnt_pool;
VAR   HE_CD ; RUN;

ods output LSMeans=lsmean;
PROC SURVEYREG data=ALL NOMCAR order=freq ;
  domain anal; strata kstrata; cluster PSU; weight wt_hmnt_pool; class F_BARLEY1;
model LHE_CD=F_BARLEYJ1 F_BARLEYJ3 F_BARLEYJ4 F_BARLEYJ5   /solution;
lsmeans /cl; run;


* Table 4   *;
/** INCM ANALYSIS * 가중 빈도  분석 **/
proc surveyfreq data=ALL nomcar;
strata kstrata; cluster PSU; weight wt_ex_pool;
tables anal0*INCM; run;

/** INCM ANALYSIS * 가중 연령 평균  분석 **/
PROC SURVEYMEANS DATA=ALL NOMCAR;
domain anal0*INCM;
STRATA kstrata; CLUSTER psu; WEIGHT wt_ex_pool;
VAR   AGE; RUN;

** ONEWAY ANOVA    P-VALUE 필요 *;
ods output LSMeans=lsmean;
PROC SURVEYREG data=ALL NOMCAR ;
domain anal0; strata kstrata; cluster PSU; weight wt_ex_pool;     ;
model AGE=INCM /solution;
lsmeans /cl; run;

/** INCM ANALYSIS * 가중 빈도  분석 **/
proc surveyfreq data=ALL nomcar;
strata kstrata; cluster PSU; weight wt_ex_pool;
tables anal0*INCM*(SEX EDU OCCP rOCCP SMOK)/CHISQ;   /*anal=1 결과 BY INCM*/ run;
** 회귀 분석 **

DATA ALL; SET JEE.ALL;
wt_ex_pool = wt_itvex * 1/4;
wt_hm_pool = wt_hm * 1/4;
wt_ntr_pool = wt_ntr * 1/4;    /* 영양 가중치 */
wt_hmnt_pool = wt_hmnt * 1/4;    /* 중금속 + 검진+ 영양 가중치 */

LHE_CD=LOG(HE_CD);   /* 자연로그, LN ... 모든 갸드뭄에 로그 치환 후 평균을 낸 후,  EXP(  ) 하면 원상 복귀 된 것이 기하 평균 */
LHE_UCOT=LOG(HE_UCOT);
```

```
if age>=20 & HE_Cd>0 & incm not in (.) & EDU not in (.) & BS3_1 not in (.,9) & HE_BMI NOT IN (.) & OCCP not in (.) then
anal=1;
if age>=20 & HE_Cd>0 & incm not in (.) & EDU not in (.) & BS3_1 not in (.,9) & HE_BMI NOT IN (.) & SEX=1 & OCCP not in (.)
then analM=1;
if age>=20 & HE_Cd>0 & incm not in (.) & EDU not in (.) & BS3_1 not in (.,9) & HE_BMI NOT IN (.) & SEX=2 & OCCP not in (.)
then analW=1;

IF YEAR=2008 AND (BS6_2=888 OR BS6_2=999) THEN BS6_2=.; ELSE   /* 과거흡연자 흡연기간 (개월)  2008-  */
IF 2009<=YEAR<=2011 AND (BS6_2=8888 OR BS6_2=9999) THEN BS6_2=.; ELSE   /* 과거흡연자 흡연기간 (개월)  2009-
2011 */

IF (YEAR=2008 OR YEAR=2009) AND (BS2_1=88 OR BS2_1=99) THEN BS2_1=.;        /* 흡연시작연령 2008-2009 */
IF (YEAR=2010 OR YEAR=2011) AND (BS2_1=888 OR BS2_1=999) THEN BS2_1=.; /* 흡연시작연령 2010-2011 */
SMODUR= AGE-BS2_1;     /* 현재흡연자 흡연기간 */
SMODUR=ROUND(SMODUR,.1);

*IF BS3_1=9 THEN BS3_1=.;   /* 현재 흡연 여부 */
IF 20<=AGE<30 THEN AGE1=1; ELSE
IF 30<=AGE<40 THEN AGE1=2; ELSE
IF 40<=AGE<50 THEN AGE1=3; ELSE
IF 50<=AGE<60 THEN AGE1=4; ELSE
IF 60<=AGE          THEN AGE1=5;

IF AGE1=2 THEN AGE2=1; ELSE AGE2=0;
IF AGE1=3 THEN AGE3=1; ELSE AGE3=0;
IF AGE1=4 THEN AGE4=1; ELSE AGE4=0;
IF AGE1=5 THEN AGE5=1; ELSE AGE5=0;

IF INCM=1 THEN INCM1=1; ELSE INCM1=0;
IF INCM=2 THEN INCM2=1; ELSE INCM2=0;
IF INCM=3 THEN INCM3=1; ELSE INCM3=0;
IF INCM=4 THEN INCM4=1; ELSE INCM4=0;   /* REF */

IF BS3_2=888 OR BS3_2=999 THEN BS3_2=.; /* 현재 흡연자 흡연량 */
IF BS6_3=888 OR BS6_3=999 THEN BS6_3=.; /*과거흡연자 흡연량 */

IF (YEAR=2008 OR YEAR=2009) AND BS3_1=8 THEN SMOK=1; ELSE
IF (YEAR=2008 OR YEAR=2009) AND BS3_1=2 THEN SMOK=2; ELSE
IF (YEAR=2008 OR YEAR=2009) AND BS3_1=1 THEN SMOK=3; ELSE
IF 2010<=YEAR<=2011 AND BS3_1=8 THEN SMOK=1; ELSE
IF 2010<=YEAR<=2011 AND BS3_1=3 THEN SMOK=2; ELSE
IF 2010<=YEAR<=2011 AND 1<=BS3_1<=2 THEN SMOK=3;

IF SMOK=2 THEN EXSMOK=1; ELSE EXSMOK=0;
IF SMOK=3 THEN CUSMOK=1; ELSE CUSMOK=0;

IF SMOK=1 THEN AMT=0; ELSE
IF SMOK=2 THEN AMT=BS6_3; ELSE     /*과거흡연자 흡연량 */
IF SMOK=3 THEN AMT=BS3_2;            /* 현재 흡연자 흡연량 */

IF SMOK=1 THEN DUR=0; ELSE
IF SMOK=2 THEN DUR=BS6_2/12; ELSE
IF SMOK=3 THEN DUR=SMODUR;

DUR=ROUND(DUR,.1);

PACKYR = AMT/20*DUR;
LPACKYR=LOG(PACKYR);

if age>=20 & HE_Cd>0 & incm not in (.) & EDU not in (.) & BS3_1 not in (.,9) & HE_BMI NOT IN (.)
& AMT not in (.) & DUR not in (.) & PACKYR not in (.) & HE_UCOT not in (.) & OCCP not in (.) then anal1=1;
```

```
if age>=20 & HE_Cd>0 & incm not in (.) & EDU not in (.) & BS3_1 not in (.,9) & HE_BMI NOT IN (.)
& AMT not in (.) & DUR not in (.) & PACKYR not in (.) & HE_UCOT not in (.) & OCCP not in (.) & SEX=1 then
anal1M=1;

if age>=20 & HE_Cd>0 & incm not in (.) & EDU not in (.) & BS3_1 not in (.,9) & HE_BMI NOT IN (.)
& AMT not in (.) & DUR not in (.) & PACKYR not in (.) & HE_UCOT not in (.) & OCCP not in (.) & SEX=2 then
anal1W=1;

/*   흡연량  */
IF BS3_1=8 THEN AMT1=1; ELSE
IF 0<AMT<10 THEN AMT1=2; ELSE
IF 10<=AMT<20 THEN AMT1=3; ELSE
IF 20<=AMT<30 THEN AMT1=4; ELSE
IF 30<=AMT THEN AMT1=5;
IF AMT1=2 THEN AMT2=1; ELSE AMT2=0;
IF AMT1=3 THEN AMT3=1; ELSE AMT3=0;
IF AMT1=4 THEN AMT4=1; ELSE AMT4=0;
IF AMT1=5 THEN AMT5=1; ELSE AMT5=0;

/*   흡연기간  */
IF BS3_1=8 THEN DUR1=1; ELSE
IF 0<DUR<10 THEN DUR1=2; ELSE
IF 10<=DUR<20 THEN DUR1=3; ELSE
IF 20<=DUR<30 THEN DUR1=4; ELSE
IF 30<=DUR THEN DUR1=5;

IF DUR1=2 THEN DUR2=1; ELSE DUR2=0;
IF DUR1=3 THEN DUR3=1; ELSE DUR3=0;
IF DUR1=4 THEN DUR4=1; ELSE DUR4=0;
IF DUR1=5 THEN DUR5=1; ELSE DUR5=0;

/*   흡연갑년  */
IF BS3_1=8 THEN PACKYR1=1; ELSE
IF 0<PACKYR<10 THEN PACKYR1=2; ELSE
IF 10<=PACKYR<20 THEN PACKYR1=3; ELSE
IF 20<=PACKYR<30 THEN PACKYR1=4; ELSE
IF 30<=PACKYR THEN PACKYR1=5;

IF PACKYR1=2 THEN PACKYR2=1; ELSE PACKYR2=0;
IF PACKYR1=3 THEN PACKYR3=1; ELSE PACKYR3=0;
IF PACKYR1=4 THEN PACKYR4=1; ELSE PACKYR4=0;
IF PACKYR1=5 THEN PACKYR5=1; ELSE PACKYR5=0;

SEX1=SEX-1;

/*   BMI   */
IF      0< HE_BMI <18.5       THEN HE_BMI1=1; ELSE
IF 18.5<= HE_BMI< 25   THEN HE_BMI1=2; ELSE
IF 25 <= HE_BMI <30       THEN HE_BMI1=3; ELSE
IF 30<=HE_BMI                    THEN HE_BMI1=4;
IF HE_BMI1=2 THEN HE_BMI2=1; ELSE HE_BMI2=0;
IF HE_BMI1=3 THEN HE_BMI3=1; ELSE HE_BMI3=0;
IF HE_BMI1=4 THEN HE_BMI4=1; ELSE HE_BMI4=0;

/*   EDUI   */
IF EDU=1 THEN EDU1=1; ELSE EDU1=0;
IF EDU=2 THEN EDU2=1; ELSE EDU2=0;
IF EDU=3 THEN EDU3=1; ELSE EDU3=0;
IF EDU=4 THEN EDU4=1; ELSE EDU4=0; /* REF UNIV*/
```

```
IF OCCP=2 THEN OCCP2=1; ELSE OCCP2=0;
IF OCCP=3 THEN OCCP3=1; ELSE OCCP3=0;
IF OCCP=4 THEN OCCP4=1; ELSE OCCP4=0;
IF OCCP=5 THEN OCCP5=1; ELSE OCCP5=0;
IF OCCP=6 THEN OCCP6=1; ELSE OCCP6=0;
IF OCCP=7 THEN OCCP7=1; ELSE OCCP7=0;

IF OCCP=1 THEN ROCCP=1; ELSE
IF 2<=OCCP<=5 THEN ROCCP=2; ELSE
IF OCCP=6 THEN ROCCP=3; ELSE
IF OCCP=7 THEN ROCCP=4;

IF rOCCP=1 THEN rOCCP1=1; ELSE rOCCP1=0; /** professional, manager **/
IF rOCCP=2 THEN rOCCP2=1; ELSE rOCCP2=0;
IF rOCCP=3 THEN rOCCP3=1; ELSE rOCCP3=0;
IF rOCCP=4 THEN rOCCP4=1; ELSE rOCCP4=0;

IF 0<HE_UCOT<10 THEN HE_UCOT1=1; ELSE
IF 10<=HE_UCOT<50 THEN HE_UCOT1=2; ELSE
IF 50<=HE_UCOT<100 THEN HE_UCOT1=3; ELSE
IF 100<=HE_UCOT          THEN HE_UCOT1=4;

IF HE_UCOT1=2 THEN HE_UCOT2=1; ELSE HE_UCOT2=0;
IF HE_UCOT1=3 THEN HE_UCOT3=1; ELSE HE_UCOT3=0;
IF HE_UCOT1=4 THEN HE_UCOT4=1; ELSE HE_UCOT4=0;

** 쌀 섭취량 *;
IF 0<=F_RICE<=6 THEN F_RICE1=1; ELSE
IF F_RICE=7 THEN F_RICE1=2; ELSE
IF F_RICE=8 THEN F_RICE1=3; ELSE
IF F_RICE=9 THEN F_RICE1=4; ELSE F_RICE1=5;

IF F_RICE1=1 THEN F_RICEJ1=1; ELSE F_RICEJ1=0;
IF F_RICE1=2 THEN F_RICEJ2=1; ELSE F_RICEJ2=0;
IF F_RICE1=3 THEN F_RICEJ3=1; ELSE F_RICEJ3=0;
IF F_RICE1=4 THEN F_RICEJ4=1; ELSE F_RICEJ4=0;
IF F_RICE1=5 THEN F_RICEJ5=1; ELSE F_RICEJ5=0;

** 곡물 섭취량 *;
IF 0<=F_BARLEY<=6 THEN F_BARLEY1=1; ELSE
IF F_BARLEY=7 THEN F_BARLEY1=2; ELSE
IF F_BARLEY=8 THEN F_BARLEY1=3; ELSE
IF F_BARLEY=9 THEN F_BARLEY1=4; ELSE F_BARLEY1=5;

IF F_BARLEY1=1 THEN F_BARLEYJ1=1; ELSE F_BARLEYJ1=0;
IF F_BARLEY1=2 THEN F_BARLEYJ2=1; ELSE F_BARLEYJ2=0;
IF F_BARLEY1=3 THEN F_BARLEYJ3=1; ELSE F_BARLEYJ3=0;
IF F_BARLEY1=4 THEN F_BARLEYJ4=1; ELSE F_BARLEYJ4=0;
IF F_BARLEY1=5 THEN F_BARLEYJ5=1; ELSE F_BARLEYJ5=0;
RUN;


* anal, analm, analw   흡연여부 분석;
/*** 남 여 합, table
8*************************************************************************************************************/
/***table 8 model 1*****/
ods output LSMeans=lsmean;     /* output delivery system */
PROC SURVEYREG data=ALL   NOMCAR ;
domain anal; strata kstrata; cluster PSU; weight wt_ex_pool; ; ;
```

```
model LHE_CD=AGE2-AGE5 INCM1 INCM2 INCM3 /solution;
lsmeans /cl; run;

/***table 8 model 2*****/
ods output LSMeans=lsmean;
PROC SURVEYREG data=ALL ORDER=FREQ NOMCAR ;
domain anal;   strata kstrata; cluster PSU; weight wt_ex_pool;
model   LHE_CD=AGE2-AGE5   INCM1 INCM2 INCM3   SEX   /solution;
lsmeans /cl; run;

/***table 8 model 3*****/
ods output LSMeans=lsmean;
PROC SURVEYREG data=ALL ORDER=FREQ NOMCAR ;
domain anal;   strata kstrata; cluster PSU; weight wt_ex_pool;
model   LHE_CD=AGE2-AGE5   INCM1 INCM2 INCM3 SEX EXSMOK CUSMOK     /solution;
lsmeans /cl; run;

/***table 8 model 4*****/
ods output LSMeans=lsmean;
PROC SURVEYREG data=ALL ORDER=FREQ NOMCAR ;
domain anal;   strata kstrata; cluster PSU; weight wt_ex_pool;
model   LHE_CD=AGE2-AGE5   INCM1 INCM2 INCM3 SEX EXSMOK CUSMOK   EDU1-EDU3   /solution;
lsmeans /cl; run;

/***table 8 model 5*****/
ods output LSMeans=lsmean;
PROC SURVEYREG data=ALL ORDER=FREQ NOMCAR ;
domain anal;   strata kstrata; cluster PSU; weight wt_ex_pool;
model   LHE_CD= AGE2-AGE5 INCM1 INCM2 INCM3 SEX   EXSMOK CUSMOK   EDU1-EDU3   rOCCP2-
rOCCP4 /solution;
lsmeans /cl; run;


/***  남  table
9*******************************************************************************************************************/
/***table 9 model 1*****/
ods output LSMeans=lsmean;     /* output delivery system */
PROC SURVEYREG data=ALL   NOMCAR ;
domain analm; strata kstrata; cluster PSU; weight wt_ex_pool; ; ;
model LHE_CD= AGE2-AGE5 INCM1 INCM2 INCM3 /solution;
lsmeans /cl; run;

/***table 9 model 2*****/
ods output LSMeans=lsmean;
PROC SURVEYREG data=ALL ORDER=FREQ NOMCAR ;
domain analm;   strata kstrata; cluster PSU; weight wt_ex_pool;
model   LHE_CD=AGE2-AGE5   INCM1 INCM2 INCM3   EXSMOK CUSMOK /solution;
lsmeans /cl; run;

/***table 9 model 3*****/
ods output LSMeans=lsmean;
PROC SURVEYREG data=ALL ORDER=FREQ NOMCAR ;
domain analm;   strata kstrata; cluster PSU; weight wt_ex_pool;
model   LHE_CD=AGE2-AGE5 INCM1 INCM2 INCM3 EXSMOK CUSMOK EDU1-EDU3   /solution;
lsmeans /cl; run;

/***table 9 model 4*****/
ods output LSMeans=lsmean;
PROC SURVEYREG data=ALL ORDER=FREQ NOMCAR ;
domain analm;   strata kstrata; cluster PSU; weight wt_ex_pool;
```

```
model   LHE_CD=AGE2-AGE5   INCM1 INCM2 INCM3   EXSMOK CUSMOK   EDU1-EDU3   rOCCP2-
rOCCP4 /solution;
lsmeans /cl; run;

/*** 여 table 10
***********************************************************************************************************************/
/*** table 10 model 1   n=3,906 *****/
ods output LSMeans=lsmean;     /* output delivery system */
PROC SURVEYREG data=ALL   NOMCAR ;
domain analw; strata kstrata; cluster PSU; weight wt_ex_pool; ; ;
model LHE_CD=AGE2-AGE5 INCM1 INCM2 INCM3 /solution;
lsmeans /cl; run;

/*** table 10 model 2*****/
ods output LSMeans=lsmean;
PROC SURVEYREG data=ALL ORDER=FREQ NOMCAR ;
domain analw;   strata kstrata; cluster PSU; weight wt_ex_pool;
model   LHE_CD=AGE2-AGE5 INCM1 INCM2 INCM3   EXSMOK CUSMOK /solution;
lsmeans /cl; run;

/*** table 10 model 3*****/
ods output LSMeans=lsmean;
PROC SURVEYREG data=ALL ORDER=FREQ NOMCAR ;
domain analw;   strata kstrata; cluster PSU; weight wt_ex_pool;
model   LHE_CD=AGE2-AGE5 INCM1 INCM2 INCM3 EXSMOK CUSMOK EDU1-EDU3   /solution;
lsmeans /cl; run;

/*** table 10 model 4*****/
ods output LSMeans=lsmean;
PROC SURVEYREG data=ALL ORDER=FREQ NOMCAR ;
domain analw;   strata kstrata; cluster PSU; weight wt_ex_pool;
model   LHE_CD=AGE2-AGE5 INCM1 INCM2 INCM3   EXSMOK CUSMOK   EDU1-EDU3   rOCCP2-
rOCCP4 /solution;
lsmeans /cl; run;


* anal1, anal1m, ana1lw  흡연갑년 분석;
/*** 남 여 합 Table
11***********************************************************************************************************************/
/*** table 11 model 1 ***/
ods output LSMeans=lsmean;     /* output delivery system */
PROC SURVEYREG data=ALL   NOMCAR ;
domain anal1; strata kstrata; cluster PSU; weight wt_ex_pool; ; ;
model LHE_CD=AGE2-AGE5 INCM1 INCM2 INCM3 /solution;
lsmeans /cl; run;

/*** table 11 model 2 ***/
ods output LSMeans=lsmean;
PROC SURVEYREG data=ALL ORDER=FREQ NOMCAR ;
domain anal1;   strata kstrata; cluster PSU; weight wt_ex_pool;
model   LHE_CD=AGE2-AGE5 INCM1 INCM2 INCM3   SEX   /solution;
lsmeans /cl; run;

/*** table 11 model 3 ***/
ods output LSMeans=lsmean;
PROC SURVEYREG data=ALL ORDER=FREQ NOMCAR ;
domain anal1;   strata kstrata; cluster PSU; weight wt_ex_pool;
model   LHE_CD=AGE2-AGE5 INCM1 INCM2 INCM3 SEX PACKYR2-PACKYR5 /solution;
lsmeans /cl; run;
```

```
/*** table 11 model 4 ***/
ods output LSMeans=lsmean;
PROC SURVEYREG data=ALL ORDER=FREQ NOMCAR ;
domain anal1;   strata kstrata; cluster PSU; weight wt_ex_pool;
model   LHE  CD=AGE2-AGE5 INCM1 INCM2 INCM3 SEX PACKYR2-PACKYR5   EDU1-EDU3   /solution;
lsmeans /cl; run;

/*** table 11 model 5 ***/
ods output LSMeans=lsmean;
PROC SURVEYREG data=ALL ORDER=FREQ NOMCAR ;
domain anal1;   strata kstrata; cluster PSU; weight wt_ex_pool;
model   LHE_CD=AGE2-AGE5 INCM1 INCM2 INCM3 SEX   PACKYR2-PACKYR5   EDU1-EDU3   rOCCP2-
rOCCP4 /solution;
lsmeans /cl; run;


/***  남  table
12*****************************************************************************************************************/
/*** table 12 model 1 ***/
ods output LSMeans=lsmean;     /* output delivery system */
PROC SURVEYREG data=ALL   NOMCAR ;
domain anal1m; strata kstrata; cluster PSU; weight wt_ex_pool; ; ;
model LHE  CD=AGE2-AGE5 INCM1 INCM2 INCM3 /solution;
lsmeans /cl; run;

/*** table 12 model 2 ***/
ods output LSMeans=lsmean;
PROC SURVEYREG data=ALL ORDER=FREQ NOMCAR ;
domain anal1m;   strata kstrata; cluster PSU; weight wt_ex_pool;
model   LHE_CD=INCM1 INCM2 INCM3   PACKYR2-PACKYR5 /solution;
lsmeans /cl; run;

/*** table 12 model 3 ***/
ods output LSMeans=lsmean;
PROC SURVEYREG data=ALL ORDER=FREQ NOMCAR ;
domain anal1m;   strata kstrata; cluster PSU; weight wt_ex_pool;
model   LHE_CD=AGE2-AGE5 INCM1 INCM2 INCM3   PACKYR2-PACKYR5   EDU1-EDU3   /solution;
lsmeans /cl; run;

/*** table 12 model 4 ***/
ods output LSMeans=lsmean;
PROC SURVEYREG data=ALL ORDER=FREQ NOMCAR ;
domain anal1m;   strata kstrata; cluster PSU; weight wt_ex_pool;
model   LHE_CD=AGE2-AGE5 INCM1 INCM2 INCM3 PACKYR2-PACKYR5   EDU1-EDU3   rOCCP2-
rOCCP4 /solution;
lsmeans /cl; run;

/***  여  table
13*****************************************************************************************************************/
/*** table 13 model 1 ***/
ods output LSMeans=lsmean;     /* output delivery system */
PROC SURVEYREG data=ALL   NOMCAR ;
domain anal1w; strata kstrata; cluster PSU; weight wt_ex_pool; ; ;
model LHE_CD=AGE2-AGE5 INCM1 INCM2 INCM3 /solution;
lsmeans /cl; run;

/*** table 13 model 2 ***/
ods output LSMeans=lsmean;
PROC SURVEYREG data=ALL ORDER=FREQ NOMCAR ;
domain anal1w;   strata kstrata; cluster PSU; weight wt_ex_pool;
```

```
model   LHE_CD=AGE2-AGE5 INCM1 INCM2 INCM3   PACKYR2-PACKYR5 /solution;
lsmeans /cl; run;

/*** table 13 model 3 ***/
ods output LSMeans=lsmean;
PROC SURVEYREG data=ALL ORDER=FREQ NOMCAR ;
domain anal1w;   strata kstrata; cluster PSU; weight wt_ex_pool;
model   LHE_CD=AGE2-AGE5 INCM1 INCM2 INCM3   PACKYR2-PACKYR5   EDU1-EDU3   /solution;
lsmeans /cl; run;

/*** table 13 model 4 ***/
ods output LSMeans=lsmean;
PROC SURVEYREG data=ALL ORDER=FREQ NOMCAR ;
domain anal1w;   strata kstrata; cluster PSU; weight wt_ex_pool;
model   LHE_CD=AGE2-AGE5 INCM1 INCM2 INCM3    PACKYR2-PACKYR5   EDU1-EDU3   rOCCP2-
rOCCP4 /solution;
lsmeans /cl; run;

* anal1, anal1m, ana1lw   코티닌 분석;
/*** 남 여 합 table 14
*******************************************************************************************************************/
/*** table 14 model 1 ***/

ods output LSMeans=lsmean;     /* output delivery system */
PROC SURVEYREG data=ALL   NOMCAR ;
domain anal1; strata kstrata; cluster PSU; weight wt_ex_pool; ; ;
model LHE_CD=AGE2-AGE5 INCM1 INCM2 INCM3 /solution;
lsmeans /cl; run;

/*** table 14 model 2 ***/
ods output LSMeans=lsmean;
PROC SURVEYREG data=ALL ORDER=FREQ NOMCAR ;
domain anal1;   strata kstrata; cluster PSU; weight wt_ex_pool;
model   LHE_CD=AGE2-AGE5 INCM1 INCM2 INCM3   SEX   /solution;
lsmeans /cl; run;

/*** table 14 model 3 ***/
ods output LSMeans=lsmean;
PROC SURVEYREG data=ALL ORDER=FREQ NOMCAR ;
domain anal1;   strata kstrata; cluster PSU; weight wt_ex_pool;
model   LHE_CD=AGE2-AGE5 INCM1 INCM2 INCM3 SEX HE_UCOT2-HE_UCOT4 /solution;
lsmeans /cl; run;

/*** table 14 model 4 ***/
ods output LSMeans=lsmean;
PROC SURVEYREG data=ALL ORDER=FREQ NOMCAR ;
domain anal1;   strata kstrata; cluster PSU; weight wt_ex_pool;
model   LHE_CD=AGE2-AGE5 INCM1 INCM2 INCM3 SEX HE_UCOT2-HE_UCOT4   EDU1-EDU3   /solution;
lsmeans /cl; run;

/*** table 14 model 5 ***/
ods output LSMeans=lsmean;
PROC SURVEYREG data=ALL ORDER=FREQ NOMCAR ;
domain anal1;   strata kstrata; cluster PSU; weight wt_ex_pool;
model   LHE_CD=AGE2-AGE5 INCM1 INCM2 INCM3 SEX   HE_UCOT2-HE_UCOT4   EDU1-EDU3
rOCCP2-rOCCP4 /solution;
lsmeans /cl; run;

/*** 남 table
15*******************************************************************************************************************/
```

```
/*** table 15 model 1 ***/
ods output LSMeans=lsmean;     /* output delivery system */
PROC SURVEYREG data=ALL   NOMCAR ;
domain anal1m; strata kstrata; cluster PSU; weight wt_ex_pool; ; ;
model LHE_CD=AGE2-AGE5 INCM1 INCM2 INCM3 /solution;
lsmeans /cl; run;

/*** table 15 model 2 ***/
ods output LSMeans=lsmean;
PROC SURVEYREG data=ALL ORDER=FREQ NOMCAR ;
domain anal1m;   strata kstrata; cluster PSU; weight wt_ex_pool;
model   LHE_CD=AGE2-AGE5 INCM1 INCM2 INCM3   HE_UCOT2-HE_UCOT4 /solution;
lsmeans /cl; run;

/*** table 15 model 3 ***/
ods output LSMeans=lsmean;
PROC SURVEYREG data=ALL ORDER=FREQ NOMCAR ;
domain anal1m;   strata kstrata; cluster PSU; weight wt_ex_pool;
model   LHE_CD=AGE2-AGE5 INCM1 INCM2 INCM3   HE_UCOT2-HE_UCOT4   EDU1-EDU3   /solution;
lsmeans /cl; run;

/*** table 15 model 4 ***/
ods output LSMeans=lsmean;
PROC SURVEYREG data=ALL ORDER=FREQ NOMCAR ;
domain anal1m;   strata kstrata; cluster PSU; weight wt_ex_pool;
model   LHE_CD=AGE2-AGE5 INCM1 INCM2 INCM3    HE_UCOT2-HE_UCOT4   EDU1-EDU3   rOCCP2-
rOCCP4 /solution;
lsmeans /cl; run;

/***  여  table
16****************************************************************************************************************************/
/*** table 16 model 1 ***/
ods output LSMeans=lsmean;     /* output delivery system */
PROC SURVEYREG data=ALL   NOMCAR ;
domain anal1w; strata kstrata; cluster PSU; weight wt_ex_pool; ; ;
model LHE_CD=AGE2-AGE5 INCM1 INCM2 INCM3 /solution;
lsmeans /cl; run;

/*** table 16 model 2 ***/
ods output LSMeans=lsmean;
PROC SURVEYREG data=ALL ORDER=FREQ NOMCAR ;
domain anal1w;   strata kstrata; cluster PSU; weight wt_ex_pool;
model   LHE_CD=AGE2-AGE5 INCM1 INCM2 INCM3   HE_UCOT2-HE_UCOT4 /solution;
lsmeans /cl; run;

/*** table 16 model 3 ***/
ods output LSMeans=lsmean;
PROC SURVEYREG data=ALL ORDER=FREQ NOMCAR ;
domain anal1w;   strata kstrata; cluster PSU; weight wt_ex_pool;
model   LHE_CD=AGE2-AGE5 INCM1 INCM2 INCM3   HE_UCOT2-HE_UCOT4   EDU1-EDU3   /solution;
lsmeans /cl; run;

/*** table 16 model 4 ***/
ods output LSMeans=lsmean;
PROC SURVEYREG data=ALL ORDER=FREQ NOMCAR ;
domain anal1w;   strata kstrata; cluster PSU; weight wt_ex_pool;
model   LHE_CD=AGE2-AGE5 INCM1 INCM2 INCM3    HE_UCOT2-HE_UCOT4   EDU1-EDU3   rOCCP2-
rOCCP4 /solution;
lsmeans /cl; run;
```

```
/*** 심사 이후 추가한 쌀, 곡물 모델 **/
/*** 쌀 - 남자  table 17 model 1 ***/
ods output LSMeans=lsmean;
PROC SURVEYREG data=ALL ORDER=FREQ NOMCAR ;
domain anal1M;   strata kstrata; cluster PSU; weight wt_hmnt_pool;
model   LHE_CD=AGE2-AGE5 INCM1 INCM2 INCM3   PACKYR2-PACKYR5   EDU1-EDU3   rOCCP2-rOCCP4 F  RICEJ1 F_RICEJ3-F_RICEJ5   /solution;
lsmeans /cl; run;

/*** 곡물 - 남자 table 17 model 2      ***/
ods output LSMeans=lsmean;
PROC SURVEYREG data=ALL ORDER=FREQ NOMCAR ;
domain anal1M;   strata kstrata; cluster PSU; weight wt_hmnt_pool;
model   LHE_CD=AGE2-AGE5 INCM1 INCM2 INCM3   PACKYR2-PACKYR5   EDU1-EDU3   rOCCP2-rOCCP4 F_BARLEYJ1 F_BARLEYJ3-F_BARLEYJ5   /solution;
lsmeans /cl; run;

/***쌀 + 곡물 – 남자 table 17 model 3   ***/
ods output LSMeans=lsmean;
PROC SURVEYREG data=ALL ORDER=FREQ NOMCAR ;
domain anal1M;   strata kstrata; cluster PSU; weight wt_hmnt_pool;
model   LHE_CD=AGE2-AGE5 INCM1 INCM2 INCM3   PACKYR2-PACKYR5   EDU1-EDU3   rOCCP2-rOCCP4   F_RICEJ1 F_RICEJ3-F_RICEJ5   F_BARLEYJ1 F_BARLEYJ3-F_BARLEYJ5   /solution;
lsmeans /cl; run;

/*** 쌀 - 여자  표 18 model 1 ***/
ods output LSMeans=lsmean;
PROC SURVEYREG data=ALL ORDER=FREQ NOMCAR ;
domain anal1W;   strata kstrata; cluster PSU; weight wt_hmnt_pool;
model   LHE_CD=AGE2-AGE5 INCM1 INCM2 INCM3   PACKYR2-PACKYR5   EDU1-EDU3   rOCCP2-rOCCP4 F_RICEJ1 F_RICEJ3-F_RICEJ5   /solution;
lsmeans /cl; run;

/*** 쌀 - 여자  표 18 model 2 ***/
ods output LSMeans=lsmean;
PROC SURVEYREG data=ALL ORDER=FREQ NOMCAR ;
domain anal1W;   strata kstrata; cluster PSU; weight wt_hmnt_pool;
model   LHE_CD=AGE2-AGE5 INCM1 INCM2 INCM3   PACKYR2-PACKYR5   EDU1-EDU3   rOCCP2-rOCCP4 F_BARLEYJ1 F_BARLEYJ3-F_BARLEYJ5   /solution;
lsmeans /cl; run;

/*** 쌀+곡물 - 여자  표 18 model 3 ***/
ods output LSMeans=lsmean;
PROC SURVEYREG data=ALL ORDER=FREQ NOMCAR ;
domain anal1W;   strata kstrata; cluster PSU; weight wt_hmnt_pool;
model   LHE_CD=AGE2-AGE5 INCM1 INCM2 INCM3   PACKYR2-PACKYR5   EDU1-EDU3   rOCCP2-rOCCP4   F_RICEJ1 F_RICEJ3-F_RICEJ5   F_BARLEYJ1 F_BARLEYJ3-F_BARLEYJ5   /solution;
lsmeans /cl; run;
```

MPLUS 분석

1. sas에서 필요한 자료를 구축한다

D:\MPLUS_CD_2016Men

카드뮴 MPLUS_2016.12.10.SAS

2. stata transfer 를 통해 stata *.dta 로 바꾼다

3. STATA에서, 데이터를 열고, mplus 자료로 전환한다

use "F:\MPLUS\cd\mplus.dta", clear

stata2mplus using "D:\MPLUS_CD_2016Men\mpulsm.dta"

* 이때 기존에 파일 (mplus.dta.dat, mplus.inp)은 지워야 함.

두개 파일이 생성됨: mplus.dta.dat , mplus.dta.dat.inp 가 생성됨

4. mplus 로 가서 mplus.dta.inp 을 open 으로 연다.

```
Title:
   Stata2Mplus conversion for D:\MPLUS_CD_2016Men\mplus.dta.dta
   List of variables converted shown below
   age : 만나이    incm : 소득사분위수(개인)    edu : 교육수준 재분류 코드
   lhe_cd :    lhe_ucot :    lpackyr :    roccp :    lrice :
Data:
   File is D:\MPLUS_CD_2016Men\mplus.dta.dat ;
Variable:
   Names are age incm edu lhe_cd lhe_ucot lpackyr roccp lrice;
   Missing are all (-9999) ;
usevariables age incm edu lhe_cd lpackyr lrice ;
Analysis:
 estimator=MLR
model:
     lpackyr on   incm edu age;
     lrice on incm edu age;
     lhe_cd on lpackyr incm edu age lrice;
output: stdy
```

Path analysis 그림은 diagram 에서 실행.