Clustering of Korean Workers According to Occupational Risks: Using the Third Korean Working Conditions Survey (2011)

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I wish to thank my parents, my wife, and my babies.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

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Objective: Health problems caused by chronic exposure to various risk factors recently have been recognized as problematic in the occupational setting. To address this concern, we performed cluster analysis to provide a comprehensive examination of occupational risk factors to which individuals are exposed and to identify occupational characteristics.

Methods: The current study analyzed data from the 3rd Korean Working Conditions Survey (KWCS) that were collected by the Korea Occupational Safety & Health Agency in 2011. The KWCS was conducted between June 1 and November 30, 2011. A total of 50,032 workers were surveyed (male: 28,640 (57.2%); female: 21,392 (42.8%)). Cluster analysis was performed on occupational risk factors such as chemicophysical factors, musculoskeletal factors, job stress, working hours, and age of workers. Cluster analysis was also performed by gender.

Results: Workers were divided into 6 clusters: “old age,” “high stress,” “overwork,” “low risk,” “intermediate risk,” and “high risk.” Although there were slight gender differences in the degree of risk factors, clusters could be defined as above. The “old age” group had short working hours and low occupational risk factors due to age, but they also had high overall occupational illness and physical illness. Workers belonging to this cluster (52.8%) were employed in agriculture, fishery, and forestry. The “high stress” group had intermediate levels of other occupational risk factors, and they had intermediate levels of occupational illness. The “overwork” group had intermediate levels of other occupational risk factors. Of the self-employed without employees, 31.3% belonged to this cluster, whereas 33.8% of unpaid family workers belonged to the cluster. Occupational illness in this cluster was intermediate, but mental illness was high. The “high risk” group had high levels of occupational risk factors and high occupational illness. Blue-collar workers mainly belong to this cluster. With the “low risk” group as the reference, the odds ratio (OR) for occupational illness was 3.4 (95% CI, 3.15–3.62) in this cluster.

Conclusions: A comprehensive plan and appropriate measures are required to prevent occupational illness. Risk factors have been examined according to occupational category and business type in the past. However, this study revealed that workers under the same occupational category can be classified into different clusters depending on the risk factors to which they are exposed. Therefore, such characteristics must be taken into consideration when implementing policies for the prevention of occupational illness.

Key word: Occupational exposure, Occupational illness, Cluster analysis, KWCS

Ⅰ. INTRODUCTION

1. Occupational Illness

As a result of working environment measurement, 7,270 workplaces (25.3%) among 28,781 implementing workplaces were found to have exceeded the reference value in the latter half of 2007. Looking into details, most of hazard factors that exceeded exposure limit are noises (92.4%). Dusts and chemical substances are only responsible for 4.1% and 3.3%, and the percentage goes down to 0.6% for dusts and 0.5% for chemical substances in workplaces that exceeded the exposure limit by more than a factor of two.[1] With substantial improvement in working environment and reduced exposure to harmful environment compared to the past, traditional occupational illnesses excluding pneumoconiosis and noise-induced hearing loss have become rare.[2]

Health problems caused by chronic exposure and complexly caused by various risk factors[3] have lately been problematic. For example in case of noise-induced hearing loss, damage from simultaneous exposure to noise and toluene is larger than independent exposure to noise and toluene because of interaction,[4] and psychological and mental factors are known to affect musculoskeletal diseases.[5-7] Stress, overwork, physical activities, chemical substances, and physical risk factors are known to have complex effect on cardiovascular diseases.[8-12] In case of multiple chemical sensitivity, exposure of many low concentration compounds have influence.[3,13]

However, traditional methods used in the past have difficulty in evaluating the complex effect of exposure.[14] Due to such difficulties, workers who think they suffer from an occupational disease experience difficulty in receiving Workers' compensation for the disease. This is well reflected by 36.1% acceptance rate of occupational disease in 2010.[15]

Occupational illness is not only caused by a single factor but also interaction of different factors. Therefore, various situations should be taken into consideration instead of focusing on a single hazard factor in order to examine an occupational illness.

Same occupational groups often share similar risk factors.[16-18] While people working for the same type of occupation have high probability of being exposed to similar risk factors[19-21], risk factors can differ depending on specific tasks they perform within the same occupation type. In such case, one can be exposed to risk factors commonly encountered by a completely different occupation type. This was neglected in the traditional methods of examining risk factors according to occupation type, which resulted in underestimation of occupational diseases related to occupation type.

On this account, it is necessary to comprehensively examine various occupational risk factors to which individuals are exposed and find out occupational characteristics through reclassification.

2. Working Conditions Survey

Working environment has rapidly changed according to changes in the industrial environment and society, but much of information about working environment is unknown.[22] Information well known is limited to general information about facilities, equipment and chemical substances exposed. In addition, overall survey on various risk factors to which workers are exposed during work was not conducted. Such survey was individually conducted on each workplace by working environment measurement, musculoskeletal risk factor survey and job stress survey. In fact, there was lack of information about psychosocial work-related factors of actual workers such as employment type, working hours, gender-related difference and shift pattern of vulnerable workers and no data was available to examine the entire nation.

Accordingly, Europe started to conduct European Working Conditions Survey (EWCS) at every 4-5 years since 1991 on members of EU. EWCS provided basic data on working environment by investigating information about labor population and aged workers in Europe, determinants of working speed, competition and productivity.[23,24] Also, EWCS was performed for comparison between the EU countries.

Based on this, Korea implemented Korean Working Conditions Survey (KWCS) in 2006. KWCS was approved by the Statistics Korea (approval no. 38002) and has been conducted by Korea Occupational Safety & Health Agency for overall examination on working environment including working types, employment types, occupational types,

business types, exposure to risk factors and employment stability of employed persons aged 15 years and older based on EWCS and Labour Force Survey (LFS) of the UK.[25,26] Also, KWCS was carried out for comparison with EWCS.

Accordingly, this study intends to summarize various risk factors to which workers are exposed and to analyze their characteristics using data from the 3rd KWCS.

3. Cluster Analysis

Cluster analysis is an exploratory statistical analysis method that organizes homogeneous group depending on characteristics of variables used. The purpose of cluster analysis is to understand the target group and to efficiently use the cluster by dividing many observed individuals into several groups.[27]

Difference from discriminant analysis is that there is no information known in relation to the cluster in advance. Also, while group classification is given in discriminant analysis, cluster analysis is conducted in order to create clusters.

Factor analysis is a method of binding similar variables by analyzing the correlation between variables. This method is mainly used for classification of variables, and cluster analysis is a method that classifies subjects based on similarity among variables.

It is most important to determine which variables to use in cluster analysis. If many variables can be used, cluster analysis can be performed after reducing the dimension of variables through factor analysis.

Cluster analysis clusters observed values in the order of similarity after measuring similarity of variables. Clustering methods include hierarchical method and non-hierarchical method. Hierarchical clustering refers to a method in which each individual starts out as a cluster of one entity. Non-hierarchical clustering is a method that creates

clusters using initial seed. The result of non-hierarchical clustering can depend largely on the value of initial seed.[28]

In this study, workers will be clustered into groups exposed to similar risk factors depending on various occupational risk factors to examine occupational characteristics.

Ⅱ. OBJECTIVES

The purpose of this study was to examine the association between occupational illness and occupational risk factors by using cluster analysis.

Specifically,

(1) To cluster the occupational risk factors, such as chemicophysical risk factors, musculoskeletal risk factors, job stress, and working hours.

(2) To investigate the occupational categories, employment status, employment type, and occupational illness by clusters.

(3) To estimate the association between clusters and occupational illness by logistic regression.

Ⅲ. METHODS

1. Study Participants

This study was carried out by using data from the 3rd KWCS conducted by Korea Occupational Safety & Health Agency in 2011. KWCS was conducted between June 1 and November 30, 2011. 50,000 households were visited to interview employed persons aged 15 years and older. Surveyors were trained before conducting the survey through questionnaire. The district studied by 2005 Population and Housing Census was used as the sampling frame. Primary stratification was done into 16 provinces and metropolitan cities, and secondary stratification was done into cities and Gun (boroughs). Tertiary stratification was conducted by housing type (apartment, general). Sampling error is ±1.0% (95% confidence interval).

50,032 subjects were surveyed, among which 28,640 (57.2%) were males and 21,392 (42.8%) were females.

This study was approved by the Institutional Review Board, Yonsei University Graduate School of Public Health (Approval No. 2013-243). Informed consent was waived by the board.

2. Variables

Occupation type was divided into 9 categories (professionals, executives & administrators, clerks, sales workers, service workers, skilled workers, semi-skilled workers, non-skilled workers, and agriculture·fishery·forestry workers). Survey on occupation type was carried out by providing an occupation type card with an example and allowing the subjects to select a category on the card.

Employment work status was divided into ‘self-employed without employees’, ‘self-employed with employees’, ‘employed’, ‘unpaid family workers’, ‘leave of absence’, ‘other type workers’, and ‘et cetera’.

Employment types were ‘regular workers’, ‘temporary workers’, and ‘day laborers’.

For occupational illness, subjects were asked about hearing problem, skin trouble, back pain, muscular pain in the shoulders, neck or arms, muscular pain on the lower extremity such as hips, legs, knees and feet, headache, eye fatigue, abdominal pain, dyspnea, cardiovascular disease, injury (from accident), depressive or anxiety disorder, general fatigue, insomnia or sleep disturbance, and other symptoms experienced within the past 1 year. If they had such experience, they were asked about whether the pain was caused by work. When subjects appealed about back pain, muscular pain in the shoulders, neck or arms, and muscular pain on the lower extremity such as hips, legs, knees and feet, occupational illness was classified as physical illness. Depressive or anxiety disorder,

general fatigue, and insomnia or sleep disturbance were classified as mental illness, and other symptoms were classified as other illnesses.

Chemicophysical risk factors and musculoskeletal risk factors were surveyed using Likert 7-point scale on ‘Exposed all the time’, ‘Mostly during working hours’, ‘3/4 of working hours’, ‘Half of working hours’, ‘1/4 of working hours’, ‘Rarely exposed’, and ‘Never exposed’. Chemicophysical risk factors included ‘vibration’, ‘noise’, ‘high temperature’, ‘smoke, fume and dust’, ‘inhalation of organic solvent’, ‘skin exposure of chemical products’, ‘cigarette smoke’, and ‘contact with infectious materials such as waste, body fluid and experimental material’. Subjects received a store of 63 points when they were exposed to all 9 items, which was converted to 100 points. Musculoskeletal risk factors included ‘exhausting or painful posture’, ‘lifting work’, ‘pulling or pushing heavy objects’, ‘standing work’, ‘repetitive hand or arm motions’, and ‘computer work’. In the same manner as chemicophysical risk factors, 6 items were scored and converted to 100 points.

Job stress was divided 5 domains including job demand, job autonomy, interpersonal conflict, job insecurity, and lack of reward.

Job demand was divided into ‘work at extremely fast speed’, ‘strict deadline’, ‘suspension of task by other unexpected tasks’, ‘strict quality standard’, ‘self-assessment on work quality’, ‘settlement of unexpected problems’, and ‘sufficient time for completion of task’.

Job autonomy was divided into ‘ability to engage in private work during working hours’, ‘ability to change the order of tasks’, ‘ability to change work method’, ‘ability to change work speed / working ratio’, ‘ability to select persons to work with’, ‘ability to take a break when wanted’, ‘ability to affect important decision making’.

Interpersonal conflict was divided into ‘supported by colleagues’, ‘there is an extremely good fried at work’, ‘supported by superior’, ‘feedback by superior about work’, ‘treated respectfully by superior’, ‘conflicts resolved by superior’, ‘tasks planned out and organized by superior’, and ‘encouraged by superior to participate in important decision making processes’.

Jog insecurity was divided into ‘possibility of unemployment within 6 months’ and ‘possibility of reemployment’.

Lack of reward was surveyed on ‘receiving appropriate reward about the work performed’.

Each domain was given a score of 20 points, and total score was converted to 100-point scale.

Working hours were based on total weekly working hours excluding lunch time and commuting time.

3. Cluster Analysis

Cluster analysis was performed on occupational risk factors such as chemicophysical risk factor score, musculoskeletal risk factor score and job stress risk score, working hours, and age of workers. Cluster analysis was carried out on individuals.

Hierarchical method was used for cluster analysis, and ward method was used to determine similarity. Ward method is a method that calculates sum of squares (sum of squares on the distance from the center of cluster to the observed value) in the cluster among connectable cluster groups and links clusters that show least sum of squares.

$$\mathrm{ESS(error\ sum\ of\ squares)} = \sum_{i} \mathrm{ESS_i}$$

$$\mathrm{ESS_i} = \sum_{h}\sum_{k}(X_{ihk} - \overline{X_{ik}})^2$$

X_{ihk} : h-th observed value of k-th variable in i-th cluster

$\overline{X_{ik}}$: mean of k-th variable in i-th cluster

Where clusters are merged into a new cluster so that

$$E(C_i, C_j) = \frac{\left\|\overline{X_i} - \overline{X_j}\right\|^2}{\frac{1}{N_i} + \frac{1}{N_j}}$$

$\overline{X_i}, \overline{X_j}$: central vectors of clusters C_i and C_j

$\left\|\overline{X_i} - \overline{X_j}\right\|$: norm of $\overline{X_i} - \overline{X_j}$

N_i, N_j : number of observed value vectors that belong to C_i and C_i

between clusters C_i and C_j returns minimum value.

Comparison of statistical values was performed using Chi-square test and ANOVA test. Logistic regression was carried out with cluster as independent variable and occupational illness as dependent variable. Confidence level was 95% and statistical significance level was 0.05. Statistical analyses were performed with SAS software.[29]

Ⅳ. RESULTS

1. Clusters

Number of clusters for cluster analysis was determined as 6 with consideration on dendrogram.

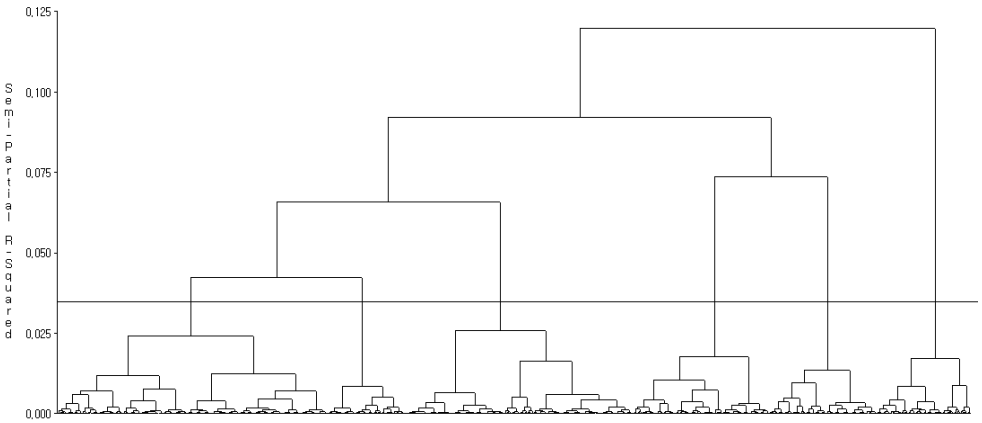

Figure 1. The dendrogram of workers by cluster analysis using chemicophysical risk factor score, musculoskeletal risk factor score, job stress score, working hours, and age

Number of clusters for cluster analysis on males conducted by gender was determined as 6 with consideration on dendrogram.

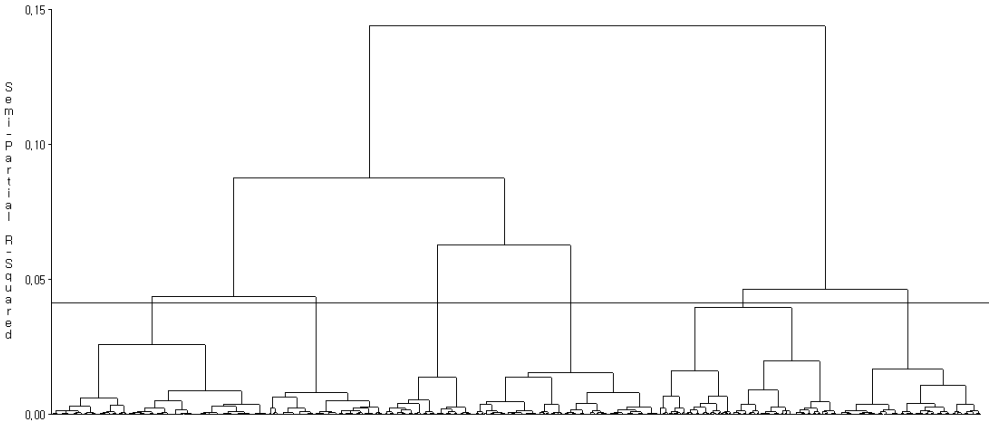

Figure 2. The dendrogram of workers (male) by cluster analysis using chemicophysical risk factor score, musculoskeletal risk factor score, job stress score, working hours, and age

Number of clusters for cluster analysis on females was determined as 6 with consideration on dendrogram.

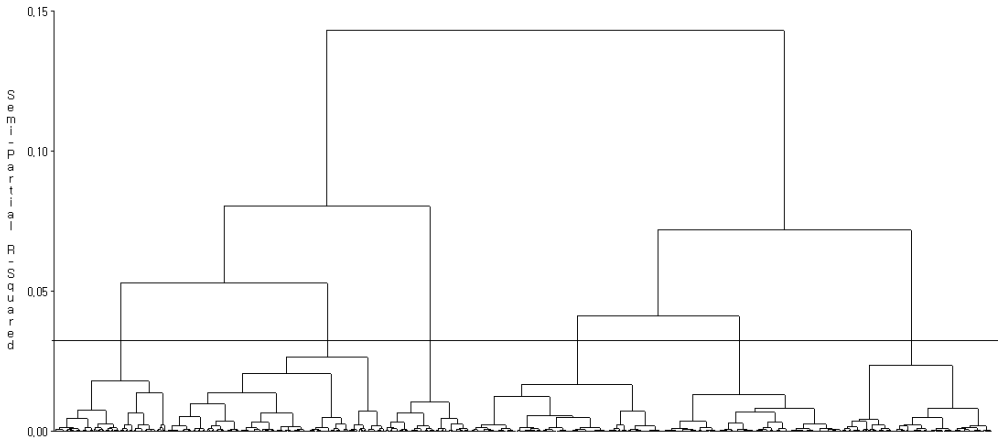

Figure 3. The dendrogram of workers (female) by cluster analysis using chemicophysical risk factor score, musculoskeletal risk factor score, job stress score, working hours, and age

2. Overall Workers

Mean age of subjects is 46.0 years (SD, 13.4) with highest age distribution of 40-49 years at 28.7%. 28,640 subjects (57.2%) are males and 21,392 (42.8%) are females. Largest number of occupation type is 10,538 (21.1%) for sales workers and smallest number is 282 (0.6%) for executives and administrators. Largest number of employment status is 29,711 (59.4%) for employed, followed by 13,674 (27.3%) for self-employed without employees. Largest number of employment type is 23,264 (78.3%) for regular workers, and smallest number is 1,918 (6.5%) for day laborers. 25,993 workers (52.0%) responded that they have an occupational illness, among which 12,916 workers (25.8%) specifically answered that they have a mental illness. 20,225 workers (40.4%) responded with a physical illness and 8,862 workers (17.2%) had other illnesses.

Table 1. General characteristics for workers in the third Korean Working Condition Survey

	Number	Percent
Age		
<20	317	0.6
20-29	4,998	10.0
30-39	11,570	23.1
40-49	14,341	28.7
50-59	10,704	21.4
60≤	8,102	16.2
Sex		
male	28,640	57.2
female	21,392	42.8
Occupational category		
professionals	2,814	5.6
executive, administrative	282	0.6
clerks	8,348	16.7
sales workers	10,538	21.1
service workers	10,261	20.5
skilled workers	4,876	9.8
semi-skilled workers	3,463	6.9
non-skilled workers	4,851	9.7
agriculture, fishery, forestry	4,599	9.2
Employment status		
self-employed without employees	13,674	27.3
self-employed with employees	3,831	7.7
employed	29,711	59.4
unpaid family workers	1,829	3.7
leave of absence	987	2.0
Employment type		
regular workers	23,264	78.3
temporary workers	4,529	15.2
day laborers	1,918	6.5
Occupational illness(all)		
yes	25,993	52.0
no	24,039	48.0
Occupational illness(mental)		
yes	12,916	25.8
no	37,116	74.2
Occupational illness(physical)		
yes	20,225	40.4
no	29,807	59.6
Occupational illness(other)		
yes	8,862	17.7
no	41,170	82.3

Chemicophysical risk factor score is 23.7 (SD, 11.0), musculoskeletal risk factor score is 40.1 (SD, 12.4), and job stress score is 33.9 (SD, 15.5) when converted to converted to 100-point scale. Weekly working hours are 50.6 hours (SD, 15.8).

Table 2. Occupational risk factor score for workers in the third Korean Working Condition Survey

	Mean	S.D.
Chemicophysical risk factor score	23.7	11.0
Musculoskeletal risk factor score	40.1	12.4
Job stress score	33.9	15.5
Working hours (week)	50.6	15.8

Looking at the characteristics of each cluster divided into 6 clusters by cluster analysis, cluster 1 has highest mean age of 66.3 years, intermediate chemicophysical risk factor score of 23.7, intermediate musculoskeletal risk factor score of 37.6, intermediate job stress score of 35.8, and lowest weekly working hours of 36.9 hours. Cluster 2 has lowest mean age of 38.2 years, lowest chemicophysical risk factor score of 17.0, lowest musculoskeletal risk factor score of 30.5, lowest job stress score of 28.9, and low weekly working hours of 42.6. Cluster 3 has low mean age of 41.2 years, intermediate chemicophysical risk factor score of 23.0, high musculoskeletal risk factor score of 46.0, low job stress score of 30.5, and intermediate weekly working hours of 51.4. Cluster 4 has intermediate mean age of 43.9 years, high chemicophysical risk factor score of 25.5, high musculoskeletal risk factor score of 38.5, highest job stress score of 56.2, and intermediate weekly working hours of 50.4. Cluster 5 has intermediate mean age of 44.2 years, highest chemicophysical risk factor score of 44.4, highest musculoskeletal risk factor score of 55.5, high job stress score of 38.7, and high weekly working hours of 53.5. Cluster 6 has high mean age of 55.0 years, low chemicophysical risk factor score of 21.1, low musculoskeletal risk factor score of 36.8, intermediate job stress score of 31.7, and highest weekly working hours of 71.4.

That is, cluster 1 is “old age” group with highest mean age, intermediate risk factor scores, and lowest weekly working hours. Cluster 2 is the “low risk” group with lowest mean age, chemicophysical risk factor score and musculoskeletal risk factor score, and low weekly working hours. Cluster 3 is the “intermediate risk” group with low mean age, and job stress score, high musculoskeletal risk factor score, and intermediate other risk factors. Cluster 4 is the “high stress” group with intermediate mean age, highest job stress

score, high chemicophysical risk factor score, and intermediate other risk factors. Cluster 5 is the “high risk” group with intermediate mean age, highest chemicophysical risk factor score and musculoskeletal risk factor score, and high other risk factors. Cluster 6 is the “overwork” group with high mean age, highest working hours, intermediate job stress, and low other risk factors. Exposure level of each risk factor for each cluster shows statistically significant difference (P<0.001).

Table 3. Distribution of risks by clusters

	Cluster 1 (old age)		Cluster 2 (low risk)		Cluster 3 (intermediate risk)		Cluster 4 (high stress)		Cluster 5 (high risk)		Cluster 6 (overwork)		P-value*
	Means	S.D.	Means	S.D.	Means	S.D.	Means	S.D.	Means	S.D.	Means	S.D.	
Age	66.3	8.2	38.2	9.6	41.2	10.0	43.9	9.7	44.2	10.8	55.0	10.1	<0.001
Chemicophysical risk factors	23.7	9.5	17.0	5.0	23.0	7.7	25.5	7.7	44.4	12.2	21.1	7.7	<0.001
Musculoskeletal risk factors	37.6	10.5	30.5	8.1	46.0	10.3	38.5	8.9	55.5	11.1	36.8	9.9	<0.001
Job stress	35.8	14.1	28.9	14.4	30.5	11.5	56.2	11.5	38.7	17.0	31.7	13.9	<0.001
Working hours(week)	36.9	13.0	42.6	11.4	51.4	11.6	50.4	10.8	53.5	12.3	71.4	13.9	<0.001

* ANOVA analysis

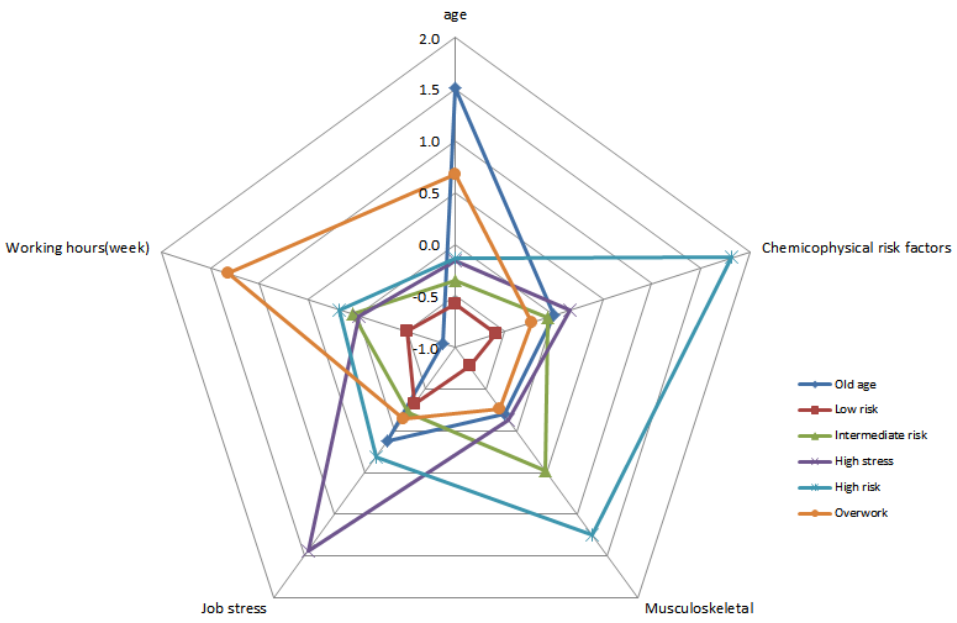

Figure 4. Distribution of risks by clusters. Which scores were converted to z-score

Looking at occupational categories, professionals, executives & administrators, and clerks were mainly distributed in “low risk” group. Sales workers, service workers, skilled workers, and semi-skilled workers were mainly distributed in “intermediate risk” group. Non-skilled workers and agriculture, fishery, forestry workers were mainly distributed in “old age” group.

Table 4. Distribution of occupational categories by clusters

	Old age		Low risk		Intermediate risk		High stress		High risk		Overwork		P-value*
	N	%	N	%	N	%	N	%	N	%	N	%	
Professionals	145	5.2	1,248	44.4	1,087	38.6	146	5.2	108	3.8	80	2.8	
Executives and administrators	45	16.0	116	41.1	74	26.2	20	7.1	13	4.6	14	5.0	
Clerks	323	3.9	4,194	50.2	2,801	33.6	646	7.7	218	2.6	166	2.0	
Sales workers	565	5.4	2,623	24.9	3,214	30.5	631	6.0	510	4.8	2,995	28.4	
Service workers	615	6.0	2,402	23.4	3,481	33.9	866	8.4	903	8.8	1,994	19.4	<0.001
Skilled workers	296	6.1	669	13.7	1,573	32.3	536	11.0	1,432	29.4	370	7.6	
Semi-skilled workers	304	8.8	433	12.5	908	26.2	569	16.4	804	23.2	445	12.9	
Non-skilled workers	1,164	24.0	615	12.7	1,030	21.2	690	14.2	782	16.1	570	11.8	
Agriculture, fishery, forestry workers	2,429	52.8	259	5.6	623	13.6	123	2.7	364	7.9	801	17.4	

* Chi-square analysis

Self-employed without employees were mainly distributed in “overwork” and “intermediate risk” group. Self-employed with employees were mainly distributed in “intermediate risk” and “overwork” group. Employed were mainly distributed in “intermediate risk” and “low risk” group. Unpaid family workers were mainly distributed in “overwork” and “intermediate risk” group. Leave of absence was mainly distributed in “low risk” and “intermediate risk” group.

Table 5. Distribution of employment status by clusters

	Old age		Low risk		Intermediate risk		High stress		High risk		Overwork		P-value*
	N	%	N	%	N	%	N	%	N	%	N	%	
Self-employed without employees	2,947	21.6	1,765	12.9	3,069	22.4	443	3.2	1,171	8.6	4,279	31.3	<0.001
Self-employed with employees	209	5.5	791	20.7	1,331	34.7	201	5.3	413	10.8	886	23.1	
Employed	2,209	7.4	9,359	31.5	9,728	32.7	3,458	11.6	3,366	11.3	1,591	5.4	
Unpaid family workers	345	18.9	258	14.1	410	22.4	80	4.4	117	6.4	619	33.8	
Leave of absence	176	17.8	386	39.1	253	25.6	45	4.6	67	6.8	60	6.1	

* Chi-square analysis

Regular workers were mainly distributed in "intermediate risk" and "low risk" group. Temporary workers were mainly distributed in "low risk" and "intermediate risk" group. Day laborers were mainly distributed in "old age" and "high risk" group.

Table 6. Distribution of employment types by clusters

	Old age		Low risk		Intermediate risk		High stress		High risk		Overwork		P-value*
	N	%	N	%	N	%	N	%	N	%	N	%	
Regular workers	1,096	4.7	7,672	33.0	8,279	35.6	2,534	10.9	2,469	10.6	1,214	5.2	<0.001
Temporary workers	600	13.3	1,347	29.7	1,134	25.0	624	13.8	523	11.6	301	6.7	
Day laborers	513	26.8	340	17.7	315	16.4	300	15.6	374	19.5	76	4.0	

* Chi-square analysis

Overall occupational illness was high in "high risk" and "old age" group and low in "low risk" and "intermediate risk" group. Mental illness was high in "high risk" and "overwork" group and low in "low risk" and "intermediate risk" group. Physical illness was high in "old age" and "high risk" group and low in "low risk" and "intermediate risk" group. Other illnesses were high in "high risk" and "high stress" group and low in "low risk" and "overwork" group.

Table 7. Distribution of occupational illness by clusters

	Old age		Low risk		Intermediate risk		High stress		High risk		Overwork		P-value*
	N	%	N	%	N	%	N	%	N	%	N	%	
All													
yes	3,706	63.0	4,558	36.3	7,627	51.6	2,421	57.3	3,378	65.8	4,303	57.9	<0.001
no	2,180	37.0	8,001	63.7	7,164	48.4	1,806	42.7	1,756	34.2	3,132	42.1	
Mental													
yes	1,789	30.4	2,073	16.5	3,671	24.8	1,285	30.4	1,683	32.8	2,415	32.5	<0.001
no	4,097	69.6	10,486	83.5	11,120	75.2	2,942	69.6	3,451	67.2	5,020	67.5	
Physical													
yes	3,239	55.0	2,983	23.8	5,934	40.1	1,794	42.4	2,760	53.8	3,515	47.3	<0.001
no	2,647	45.0	9,576	76.2	8,857	59.9	2,433	57.6	2,374	46.2	3,920	52.7	
Other													
yes	1,037	17.6	1,666	13.3	2,652	17.9	886	21.0	1,390	27.1	1,231	16.6	<0.001
no	4,849	82.4	10,893	86.7	12,139	82.1	3,341	79.0	3,744	72.9	6,204	83.4	

* Chi-square analysis

When odds ratio (OR) of occupational illness among clusters was examined using "low risk" group as the reference, OR was significantly high at 3.4 (95% CI, 3.15-3.62) in "high risk" group and 3.0 (95% CI, 2.80-3.18) in "old age" group. OR for mental illness was significantly high at 2.5 (95% CI, 2.29-3.66) in "high risk" group and 2.4 (95% CI, 2.27-2.60) in "overwork" group. OR for physical illness was significantly high at 3.9 (95% CI, 3.68-4.20) in "old age" group and 3.7 (95% CI, 3.49-4.00) in "high risk" group. OR for other illnesses was significantly high at 2.4 (95% CI, 2.24-2.63) in "high risk" group and 1.7 (95% CI, 1.58-1.90) in "high stress" group.

Table 8. Odds ratio from logistic regression model relating clusters and occupational illness

	OR	95%CI
All		
Low risk	1	-
Old age	3.0	2.80-3.18
Intermediate risk	1.9	1.78-1.96
High stress	2.4	2.19-2.53
High risk	3.4	3.15-3.62
Overwork	2.4	2.27-2.56
Mental		
Low risk	1	-
Old age	2.2	2.05-2.38
Intermediate risk	1.7	1.57-1.77
High stress	2.2	2.04-2.40
High risk	2.5	2.29-3.66
Overwork	2.4	2.27-2.60
Physical		
Low risk	1	-
Old age	3.9	3.68-4.20
Intermediate risk	2.2	2.04-2.27
High stress	2.4	2.20-2.55
High risk	3.7	3.49-4.00
Overwork	2.9	2.71-3.06
Other		
Low risk	1	-
Old age	1.4	1.29-1.52
Intermediate risk	1.4	1.34-1.53
High stress	1.7	1.58-1.90
High risk	2.4	2.24-2.63
Overwork	1.3	1.20-1.41

3. **Male Workers**

As a result of dividing workers by gender, mean age of male subjects is 46.5 years (SD, 13.1) and highest age distribution is 28.0% for 40-49 years. Largest number of occupational category is 5,209 (18.2%) for clerks and smallest number is 268 (0.9%) for executives and administrators. Largest number of employment status is 17,346 (60.6%) for employed, followed by 8,174 (28.5%) for self-employed without employees. Largest number of employment type is 14,264 (82.2%) for regular workers and smallest number is 1,108 (6.4%) for day laborers. 14,463 workers (50.5%) responded that they have an occupational illness, among which 7,045 (24.6%) answered they have a mental illness. 10,576 workers (36.9%) had physical illness and 5,117 (17.9%) had other illnesses.

Table 9. General characteristics for workers (male) in the third Korean Working Condition Survey

	Number	Percent
Age		
<20	173	0.6
20-29	2,320	8.1
30-39	6,810	23.8
40-49	8,020	28.0
50-59	6,472	22.6
60≤	4,845	16.9
Occupational category		
professionals	1,541	5.4
executive, administrative	268	0.9
clerks	5,209	18.2
sales workers	4,927	17.2
service workers	4,057	14.2
skilled workers	4,309	15.1
semi-skilled workers	2,920	10.2
non-skilled workers	2,597	9.1
agriculture, fishery, forestry	2,812	9.8
Employment status		
self-employed without employees	8,174	28.5
self-employed with employees	2,676	9.3
employed	17,346	60.6
unpaid family workers	118	0.4
leave of absence	326	1.1
Employment type		
regular workers	14,264	82.2
temporary workers	1,974	11.4
day laborers	1,108	6.4
Occupational illness(all)		
yes	14,463	50.5
no	14,177	49.5
Occupational illness(mental)		
yes	7,045	24.6
no	21,595	75.4
Occupational illness(physical)		
yes	10,576	36.9
no	18,064	63.1
Occupational illness(other)		
yes	5,117	17.9
no	23,523	82.1

Chemicophysical risk factor score is 25.4 (SD, 12.0), musculoskeletal risk factor score is 40.2 (SD, 12.7), and job stress score is 34.0 (SD, 15.6) when converted to 100-point scale. Weekly working hours are 51.6 hours (SD, 14.9).

Table 10. Occupational risk factor score for workers (male) in the third Korean Working Condition Survey

	Mean	S.D.
Chemicophysical risk factor score	25.4	12.0
Musculoskeletal risk factor score	40.2	12.7
Job stress score	34.0	15.6
Working hours (week)	51.6	14.9

Looking at the characteristics of each cluster divided into 6 clusters by cluster analysis, cluster 1 has highest mean age of 58.8 years, intermediate chemicophysical risk factor score of 24.6, intermediate musculoskeletal risk factor score of 36.1, intermediate job stress score of 34.0, and lowest weekly working hours of 41.9 hours. Cluster 2 has low mean age of 39.1 years, lowest chemicophysical risk factor score of 17.8, lowest musculoskeletal risk factor score of 32.9, lowest job stress score of 22.3, and intermediate weekly working hours of 51.7. Cluster 3 has intermediate mean age of 41.0 years, high chemicophysical risk factor score of 30.3, high musculoskeletal risk factor score of 47.6, low job stress score of 27.3, and intermediate weekly working hours of 51.7. Cluster 4 has lowest mean age of 36.0 years, low chemicophysical risk factor score of 18.2 intermediate musculoskeletal risk factor score of 37.4, high job stress score of 45.8, and low weekly working hours of 44.3. Cluster 5 has intermediate mean age of 48.2 years, highest chemicophysical risk factor score of 38.8, highest musculoskeletal risk factor score of 51.8, highest job stress score of 48.0, and high weekly working hours of 54.6. Cluster 6 has high mean age of 57.9 years, intermediate chemicophysical risk factor score of 20.2, low musculoskeletal risk factor score of 34.8, intermediate job stress score of 30.4, and highest weekly working hours of 73.7.

That is, cluster 1 is “old age” group with highest mean age, intermediate risk factor scores, and lowest working hours. Cluster 2 is the “low risk” group with low mean age, lowest chemicophysical risk factor score, musculoskeletal risk factor score, and job stress score, and intermediate working hours. Cluster 3 is the “intermediate risk” group with intermediate mean age and working hours, low job stress score, and high chemicophysical risk factor score and musculoskeletal risk factor score. Cluster 4 is the

“high stress” group with high job stress score, lowest mean age, low chemicophysical risk factor score and working hours, and intermediate musculoskeletal risk factor score. Cluster 5 is the “high risk” group with intermediate mean age, highest chemicophysical risk factor score, musculoskeletal risk factor score, and job stress score, and high working hours. Cluster 6 is the “overwork” group with high mean age, highest working hours, intermediate chemicophysical risk factor score and job stress score, and low musculoskeletal risk factor score. Exposure level of each risk factor for each cluster shows statistically significant difference (P<0.001).

Table 11. Distribution of risks by clusters (male)

	Cluster 1 (old age)		Cluster 2 (low risk)		Cluster 3 (intermediate risk)		Cluster 4 (high stress)		Cluster 5 (high risk)		Cluster 6 (overwork)		P-value*
	Means	S.D.	Means	S.D.	Means	S.D.	Means	S.D.	Means	S.D.	Means	S.D.	
Age	58.8	9.9	39.1	8.9	41.0	9.2	36.0	8.4	48.2	12.3	57.9	9.4	<0.001
Chemicophysical risk factors	24.6	8.1	17.8	5.7	30.3	8.8	18.2	5.8	38.8	14.8	20.2	6.6	<0.001
Musculoskeletal risk factors	36.1	9.0	32.9	9.1	47.6	10.6	37.4	10.4	51.8	12.9	34.8	9.4	<0.001
Job stress	34.0	12.1	22.3	10.3	27.3	9.6	45.8	11.3	48.0	15.8	30.4	12.9	<0.001
Working hours (week)	41.9	11.6	51.7	11.7	51.7	11.1	44.3	10.4	54.6	13.2	73.7	14.8	<0.001

* ANOVA analysis

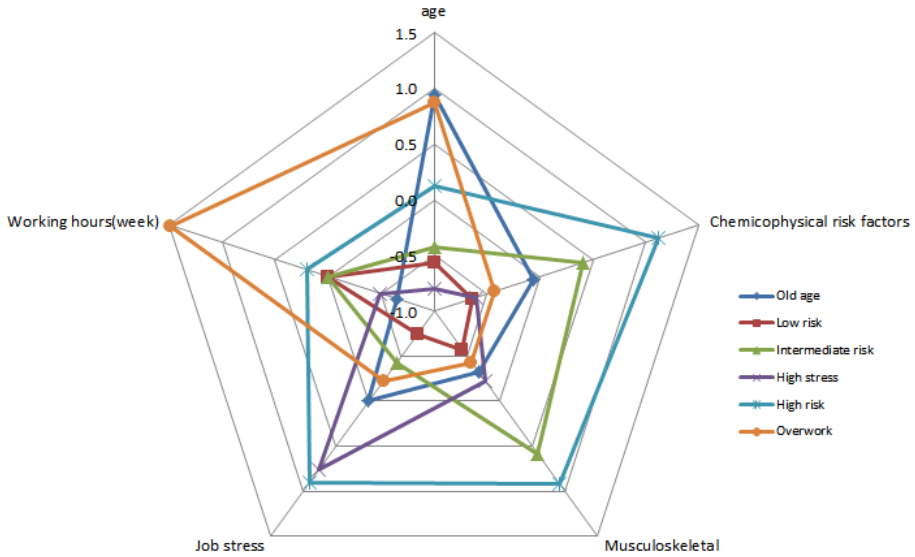

Figure 5. Distribution of risks by clusters (male). Which scores were converted to z-score

Looking at occupational categories, professionals, executives & administrators, clerks, sales workers, and service workers were mainly distributed in "low risk" group. Skilled workers, semi-skilled workers, and non-skilled workers were mainly distributed in "high risk" group. Agriculture, fishery, forestry workers were mainly distributed in "old age" group.

Table 12. Distribution of occupational categories by clusters (male)

	Old age		Low risk		Intermediate risk		High stress		High risk		Overwork		P-value*
	N	%	N	%	N	%	N	%	N	%	N	%	
Professionals	241	15.6	609	39.5	308	20.0	232	15.1	112	7.3	39	2.5	
Executives and administrators	87	32.5	108	40.3	32	11.9	18	6.7	18	6.7	5	1.9	
Clerks	741	14.2	2,083	40.0	735	14.1	1,261	24.2	317	6.1	72	1.4	
Sales workers	576	11.7	1,639	33.3	657	13.3	523	10.6	488	9.9	1,044	21.2	
Service workers	535	13.2	1,053	26.0	605	14.9	606	14.9	627	15.5	631	15.6	<0.001
Skilled workers	686	15.9	621	14.4	1,083	25.1	367	8.5	1,389	32.2	163	3.8	
Semi-skilled workers	601	20.6	323	11.1	482	16.5	247	8.5	1,060	36.3	207	7.1	
Non-skilled workers	608	23.4	180	6.9	300	11.6	248	9.6	930	35.8	331	12.8	
Agriculture, fishery, forestry workers	1,592	56.6	97	3.5	204	7.3	32	1.1	557	19.8	330	11.7	

* Chi-square analysis

Self-employed without employees were mainly distributed in "old age" group. Self-employed with employees and employed were mainly distributed in "low risk" group. Unpaid family workers and leave of absence were mainly distributed in "old age" group.

Table 13. Distribution of employment status by clusters (male)

	Old age		Low risk		Intermediate risk		High stress		High risk		Overwork		P-value*
	N	%	N	%	N	%	N	%	N	%	N	%	
Self-employed without employees	2,558	31.3	1,264	15.5	1,023	12.5	268	3.3	1,300	15.9	1,761	21.5	
Self-employed with employees	451	16.9	824	30.8	538	20.1	147	5.5	326	12.2	390	14.6	
Employed	2,537	14.6	4,525	26.1	2,800	16.1	3,082	17.8	3,765	21.7	637	3.7	<0.001
Unpaid family workers	33	28.0	18	15.3	16	13.6	10	8.5	22	18.6	19	16.1	
Leave of absence	88	27.0	82	25.2	29	8.9	27	8.3	85	26.1	15	4.6	

* Chi-square analysis

Regular workers were mainly distributed in "low risk" group. Temporary workers and day laborers were mainly distributed in "high risk" group.

Table 14. Distribution of employment types by clusters (male)

	Old age		Low risk		Intermediate risk		High stress		High risk		Overwork		P-value*
	N	%	N	%	N	%	N	%	N	%	N	%	
Regular workers	1,962	13.8	4,181	29.3	2,451	17.2	2,489	17.5	2,687	18.8	494	3.5	<0.001
Temporary workers	357	18.1	301	15.3	257	13.0	434	22.0	498	25.2	127	6.4	
Day laborers	218	19.7	43	3.9	92	8.3	159	14.4	580	52.4	16	1.4	

* Chi-square analysis

Overall occupational illness was high in "high risk" and "old age" group and low in "low risk" and "high stress" group. Mental illness was high in "high risk" and "overwork" group and low in "low risk" and "high stress" group. Physical illness was high in "high risk" and "old age" group and low in "low risk" and "high stress" group. Other illnesses were high in "high risk" and "intermediate risk" group and low in "low risk" and "high stress" group.

Table 15. Distribution of occupational illness by clusters (male)

	Old age		Low risk		Intermediate risk		High stress		High risk		Overwork		P-value*
	N	%	N	%	N	%	N	%	N	%	N	%	
All													
yes	3,103	54.8	2,241	33.4	2,236	50.8	1,559	44.1	3,523	64.1	1,515	53.7	<0.001
no	2,564	45.2	4,472	66.6	2,170	49.2	1,975	55.9	1,975	35.9	1,307	46.3	
Mental													
yes	1,513	26.7	1,022	15.2	1,136	25.8	787	22.3	1,743	31.7	844	29.9	<0.001
no	4,154	73.3	5,691	84.8	3,270	74.2	2,747	77.7	3,755	68.3	1,978	70.1	
Physical													
yes	2,423	42.8	1,472	21.9	1,648	37.4	989	28.0	2,871	52.2	1,173	41.6	<0.001
no	3,244	57.2	5,241	78.1	2,758	62.6	2,545	72.0	2,627	47.8	1,649	58.4	
Other													
yes	1026	18.1	829	12.3	836	19.0	555	15.7	1421	25.9	450	15.9	<0.001
no	4641	81.9	5884	87.7	3570	81.0	2979	84.3	4077	74.1	2372	84.1	

* Chi-square analysis

When OR of occupational illness among clusters was examined using "low risk" group as the reference, OR was significantly high at 3.6 (95% CI, 3.30-3.84) in "high risk" group and 2.4 (95% CI, 2.25-2.60) in "old age" group. OR for Mental illness was significantly high at 2.6 (95% CI, 2.37-2.82) in "high risk" group and 2.4 (95% CI, 2.14-2.64) in "overwork" group. OR for physical illness was significantly high at 3.9 (95% CI, 3.60-4.21) in "high risk" group and 2.7 (95% CI, 2.46-2.88) in "old age" group. OR for other illnesses was significantly high at 2.5 (95% CI, 2.25-2.72) in "high risk" group and 1.7 (95% CI, 1.50-1.85) in "intermediate risk" group.

Table 16. Odds ratio from logistic regression model relating clusters and occupational illness (male)

	OR	95%CI
All		
Low risk	1	-
Old age	2.4	2.25-2.60
Intermediate risk	2.1	1.90-2.22
High stress	1.6	1.45-1.71
High risk	3.6	3.30-3.84
Overwork	2.3	2.11-2.53
Mental		
Low risk	1	-
Old age	2.1	1.86-2.22
Intermediate risk	1.9	1.76-2.13
High stress	1.6	1.44-1.77
High risk	2.6	2.37-2.82
Overwork	2.4	2.14-2.64
Physical		
Low risk	1	-
Old age	2.7	2.46-2.88
Intermediate risk	2.1	1.96-2.31
High stress	1.4	1.26-1.52
High risk	3.9	3.60-4.21
Overwork	2.5	2.30-2.78
Other		
Low risk	1	-
Old age	1.6	1.42-1.73
Intermediate risk	1.7	1.50-1.85
High stress	1.3	1.18-1.49
High risk	2.5	2.25-2.72
Overwork	1.3	1.19-1.53

4. Female Workers

As a result of dividing workers by gender, mean age of female subjects is 45.3 years (SD, 13.7), and highest age distribution is 29.6% for 40-49 years. Largest number of occupational category is 6,204 (29.0%) for service workers and smallest number is 14 (0.1%) for executives and administrators. Largest number of employment status is 12,365 (57.8%) for employed, followed by 5,500 (25.7%) for self-employed without employees. Largest number of employment type is 9,000 (72.8%) for regular workers and smallest number is 810 (6.6%) for day laborers. 11.816 workers (55.2%) responded that they have an occupational illness, among which 5,871 (27.4%) answered they have a mental illness. 9,649 workers (45.1%) had physical illness and 3,745 (17.5%) had other illnesses.

Table 17. General characteristics for workers (female) in the third Korean Working Condition

	Number	Percent
Age		
<20	144	0.7
20-29	2,678	12.5
30-39	4,760	22.3
40-49	6,321	29.6
50-59	4,232	19.8
60≤	3,257	15.2
Occupational category		
professionals	1,273	6.0
executive, administrative	14	0.1
clerks	3,139	14.7
sales workers	5,611	26.2
service workers	6,204	29.0
skilled workers	567	2.7
semi-skilled workers	543	2.5
non-skilled workers	2,254	10.5
agriculture, fishery, forestry	1,787	8.4
Employment status		
self-employed without employees	5,500	25.7
self-employed with employees	1,155	5.4
employed	12,365	57.8
unpaid family workers	1,711	8.0
leave of absence	661	3.1
Employment type		
regular workers	9,000	72.8
temporary workers	2,555	20.7
day laborers	810	6.6
Occupational illness(all)		
yes	11,816	55.2
no	9,576	44.8
Occupational illness(mental)		
yes	5,871	27.4
no	15,521	72.6
Occupational illness(physical)		
yes	9,649	45.1
no	11,743	54.9
Occupational illness(other)		
yes	3,745	17.5
no	17,647	82.5

Chemicophysical risk factor score is 21.4 (SD, 9.0), musculoskeletal risk factor score is 40.0 (SD, 12.2), and job stress score is 33.7 (SD, 15.3) when converted to 100-point scale. Weekly working hours are 49.3 hours (SD, 16.9).

Table 18. Occupational risk factor score for workers (female) in the third Korean Working Condition Survey

	Mean	S.D.
Chemicophysical risk factor score	21.4	9.0
Musculoskeletal risk factor score	40.0	12.2
Job stress score	33.7	15.3
Working hours (week)	49.3	16.9

Looking at the characteristics of each cluster divided into 6 cluster by cluster analysis, cluster 1 has low mean age of 39.0 years, low chemicophysical risk factor score of 18.0, intermediate musculoskeletal risk factor score of 37.0, lowest job stress score of 22.0, and low weekly working hours of 39.8. Cluster 2 has lowest mean age of 37.4 years, lowest chemicophysical risk factor score of 16.0, lowest musculoskeletal risk factor score of 31.9, high job stress score of 40.9, and intermediate weekly working hours of 49.0. Cluster 3 has intermediate mean age of 44.1 years, high chemicophysical risk factor score of 22.9, high musculoskeletal risk factor score of 46.8, highest job stress score of 44.7, and intermediate weekly working hours of 48.7. Cluster 4 has intermediate mean age of 48.6 years, intermediate chemicophysical risk factor score of 18.9, low musculoskeletal risk factor score of 32.3, low job stress score of 22.8, and highest weekly working hours of 69.4. Cluster 5 has high mean age of 49.5 years, highest chemicophysical risk factor score of 37.2, highest musculoskeletal risk factor score of 51.4, intermediate job stress score of 34.8, and high weekly working hours of 54.3. Cluster 6 has highest mean age of 68.5 years, intermediate chemicophysical risk factor score of 20.7, intermediate musculoskeletal risk factor score of 38.2, intermediate job stress score of 35.0, and lowest weekly working hours of 30.9.

That is, cluster 1 is “intermediate risk” group with low mean age, chemicophysical risk factor score, and working hours, lowest job stress score, and intermediate musculoskeletal risk factor score. Cluster 2 is the “low risk” group with lowest mean age, chemicophysical risk factor score and musculoskeletal risk factor score, high job stress score and intermediate working hours. Cluster 3 is the “high stress” group with intermediate mean age, and working hours, highest job stress score, and high

chemicophysical risk factor score, and musculoskeletal risk factor score. Cluster 4 is the "overwork" group with intermediate mean age, and chemicophysical risk factor score, highest working hours, and low musculoskeletal risk factor score, and job stress score. Cluster 5 is the "high risk" group with high mean age, and working hours, highest chemicophysical risk factor score and musculoskeletal risk factor score, and intermediate job stress score. Cluster 6 is the "old age" group with highest mean age, lowest working hours, and intermediate other risk factors. Exposure level of each risk factor for each cluster shows statistically significant difference (P<0.001).

Table 19. Distribution of risks by clusters (female)

	Cluster 1 (intermediate risk)		Cluster 2 (low risk)		Cluster 3 (high stress)		Cluster 4 (overwork)		Cluster 5 (high risk)		Cluster 6 (old age)		P-value*
	Means	S.D.	Means	S.D.	Means	S.D.	Means	S.D.	Means	S.D.	Means	S.D.	
Age	39.0	8.6	37.4	9.7	44.1	12.4	48.6	11.1	49.5	12.5	68.5	8.3	<0.001
Chemicophysical risk factors	18.0	5.6	16.0	3.3	22.9	6.6	18.9	5.7	37.2	10.1	20.7	7.5	<0.001
Musculoskeletal risk factors	37.0	10.6	31.9	9.1	46.8	11.5	32.3	8.4	51.4	10.2	38.2	10.9	<0.001
Job stress	22.0	9.7	40.9	10.6	44.7	13.6	22.8	11.7	34.8	15.3	35.0	12.5	<0.001
Working hours(week)	39.8	9.9	49.0	9.8	48.7	15.3	69.4	14.8	54.3	14.0	30.9	13.4	<0.001

* ANOVA analysis

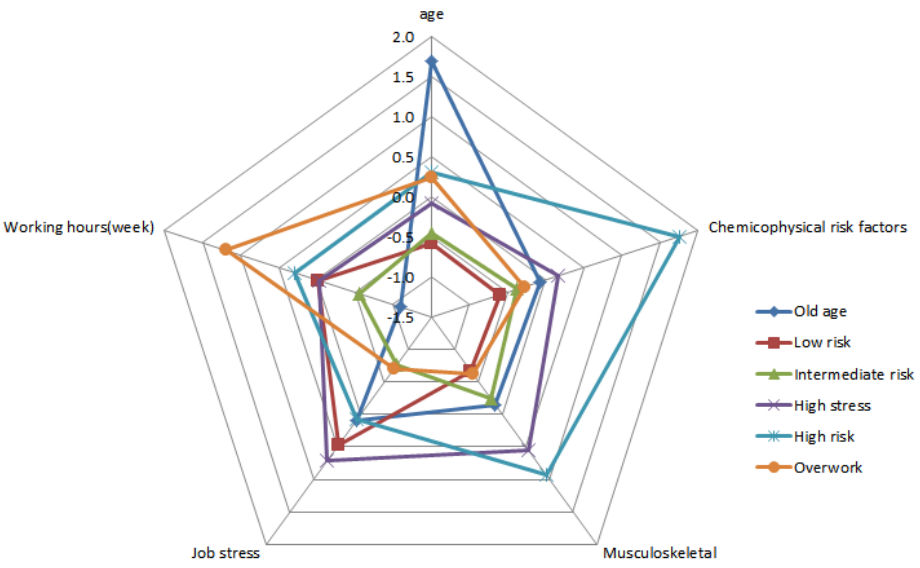

Figure 6. Distribution of risks by clusters (female). Which scores were converted to z-score

Looking at occupational categories, professionals, executives & administrators, and clerks were mainly distributed in "intermediate risk" group. Sales workers were mainly distributed in "overwork" group. Service workers were mainly distributed in "high stress" group. Skilled workers and semi-skilled workers were mainly distributed in "high risk" group. Non-skilled workers were mainly distributed in "high stress" group. Agriculture, fishery, forestry workers were mainly distributed in "old age" group.

Table 20. Distribution of occupational categories by clusters (female)

	Old age		Low risk		Intermediate risk		High stress		High risk		Overwork		P-value*
	N	%	N	%	N	%	N	%	N	%	N	%	
Professionals	28	2.2	278	21.8	651	51.1	218	17.1	47	3.7	51	4.0	
Executives and administrators	0	0.0	2	14.3	8	57.1	4	28.6	0	0.0	0	0.0	
Clerks	27	0.9	1,110	35.4	1,275	40.6	494	15.7	93	3.0	140	4.5	
Sales workers	209	3.7	1,207	21.5	894	15.9	1,165	20.8	450	8.0	1,686	30.1	
Service workers	268	4.3	1,101	17.8	1,095	17.7	1,729	27.9	825	13.3	1,186	19.1	<0.001
Skilled workers	27	4.8	76	13.4	94	16.6	143	25.2	162	28.6	65	11.5	
Semi-skilled workers	26	4.8	70	12.9	71	13.1	149	27.4	157	28.9	70	12.9	
Non-skilled workers	462	20.5	199	8.8	268	11.9	790	35.1	452	20.1	83	3.7	
Agriculture, fishery, forestry workers	889	49.8	35	2.0	64	3.6	282	15.8	375	21.0	142	8.0	

* Chi-square analysis

Self-employed without employees and self-employed with employees were mainly distributed in "overwork" group. Employed were mainly distributed in "high stress" group. Unpaid family workers were mainly distributed in "overwork" group. Leave of absence were mainly distributed in "intermediate risk" group.

Table 21. Distribution of employment status by clusters (female)

	Old age		Low risk		Intermediate risk		High stress		High risk		Overwork		P-value*
	N	%	N	%	N	%	N	%	N	%	N	%	
Self-employed without employees	913	16.6	556	10.1	576	10.5	846	15.4	826	15.0	1,783	32.4	<0.001
Self-employed with employees	30	2.6	179	15.5	204	17.7	197	17.1	158	13.7	387	33.5	
Employed	639	5.2	3,066	24.8	3,211	26.0	3,511	28.4	1,217	9.8	721	5.8	
Unpaid family workers	253	14.8	165	9.6	160	9.4	317	18.5	314	18.4	502	29.3	
Leave of absence	101	15.3	112	16.9	269	40.7	103	15.6	46	7.0	30	4.5	

* Chi-square analysis

Regular workers were mainly distributed in "intermediate risk" group. Temporary workers and day laborers were mainly distributed "high stress" group.

Table 22. Distribution of employment types by clusters (female)

	Old age		Low risk		Intermediate risk		High stress		High risk		Overwork		P-value*
	N	%	N	%	N	%	N	%	N	%	N	%	
Regular workers	196	2.2	2,462	27.4	2,620	29.1	2,320	25.8	820	9.1	582	6.5	<0.001
Temporary workers	269	10.5	515	20.2	483	18.9	862	33.7	304	11.9	122	4.8	
Day laborers	174	21.5	89	11.0	108	13.3	329	40.6	93	11.5	17	2.1	

* Chi-square analysis

Overall occupational illness was high in "high risk" and "old age" group and low in "intermediate risk" and "low risk" group. Mental illness was high in "high risk" and "old age" group and low in "intermediate risk" and "low risk" group. Physical illness was high in "high risk" and "old age" group and low in "low risk" and "intermediate risk" group. Other illnesses were high in "high risk" and "high stress" group and low in "overwork", "intermediate risk" and "low risk" group.

Table 23. Distribution of occupational illness by clusters (female)

	Old age		Low risk		Intermediate risk		High stress		High risk		Overwork		P-value*
	N	%	N	%	N	%	N	%	N	%	N	%	
All													
yes	1,310	67.7	1,872	45.9	1,849	41.8	3,014	60.6	1,859	72.6	1,912	55.9	<0.001
no	626	32.3	2,206	54.1	2,571	58.2	1,960	39.4	702	27.4	1,511	44.1	
Mental													
yes	619	32.0	884	21.7	783	17.7	1,519	30.5	1,037	40.5	1,029	30.1	<0.001
no	1,317	68.0	3,194	78.3	3,637	82.3	3,455	69.5	1,524	59.5	2,394	69.9	
Physical													
yes	1,219	63.0	1,292	31.7	1,407	31.8	2,545	51.2	1,625	63.5	1,561	45.6	<0.001
no	717	37.0	2,786	68.3	3,013	68.2	2,429	48.8	936	36.5	1,862	54.4	
Other													
yes	333	17.2	618	15.2	673	15.2	952	19.1	659	25.7	510	14.9	<0.001
no	1,603	82.8	3,460	84.8	3,747	84.8	4,022	80.9	1,902	74.3	2,913	85.1	

* Chi-square analysis

When OR of occupational illness among clusters was examined using "low risk" group as the reference, OR was significantly high at 3.1 (95% CI, 2.81-3.47) in "high risk" group and 2.5 (95% CI, 2.20-2.76) in "old age" group. OR for mental illness was significantly high at 2.5 (95% CI, 2.21-2.74) in "high risk" group and 1.7 (95% CI, 1.50-1.92) in "old age" group. OR for physical illness was significantly high at 3.7 (95% CI, 3.37-4.15) in "high risk" group and 3.7 (95% CI, 3.27-4.11) in "old age" group. OR of other illnesses was significantly high at 1.9 (95% CI, 1.72-2.19) in "high risk" group and 1.3 (95% CI, 1.19-1.48) in "high stress" group.

Table 24. Odds ratio from logistic regression model relating clusters and occupational illness (female)

	OR	95%CI
All		
Low risk	1	-
Old age	2.5	2.20-2.76
Intermediate risk	0.8	0.78-0.92
High stress	1.8	1.67-1.97
High risk	3.1	2.81-3.47
Overwork	1.5	1.36-1.63
Mental		
Low risk	1	-
Old age	1.7	1.50-1.92
Intermediate risk	0.8	0.70-0.87
High stress	1.6	1.44-1.75
High risk	2.5	2.21-2.74
Overwork	1.6	1.40-1.72
Physical		
Low risk	1	-
Old age	3.7	3.27-4.11
Intermediate risk	1.0	0.92-1.10
High stress	2.3	2.07-2.46
High risk	3.7	3.37-4.15
Overwork	1.8	1.65-1.99
Other		
Low risk	1	-
Old age	1.2	1.01-1.35
Intermediate risk	1.0	0.89-1.13
High stress	1.3	1.19-1.48
High risk	1.9	1.72-2.19
Overwork	1.0	0.86-1.11

Ⅴ. DISCUSSION

1. Overall Cluster Characteristics

Workers are divided into 6 clusters according to age, chemicophysical risk factors, musculoskeletal risk factors, job stress, and working hours.

Cluster 1 is the “old age” group with highest mean age, lowest working hours, and intermediate other risk factors. 24.0% of all non-skilled workers and 52.8% for agriculture, fishery, and forestry workers belong to this cluster. 26.8% for all day laborers belong to this cluster. This cluster has 63.0% of subjects appealing about occupational illness, with highest rate of 55.0% for physical illness. When cluster 2 is used as the reference, the OR is 3.0 (95% CI, 2.80-3.18) for occupational illness and 3.9 (95% CI, 3.68-4.20) for physical illness.

Cluster 2 is the “low risk” group with lowest mean age, lowest chemicophysical risk factor score, musculoskeletal risk factor score and job stress score, and low weekly working hours. 44.4% of all professionals, 41.1% of executives and administrators, and 50.2% of clerks belong to this cluster. 29.7% for temporary workers belong to this cluster. Occupational illness is lowest at 36.3%, and mental illness, physical illness and other illnesses are also lowest.

Cluster 3 is the “intermediate risk” group with low mean age, low job stress score, intermediate chemicophysical risk factor score and weekly working hours, and high musculoskeletal risk factor score. 30.5% for all sales workers, 33.9% for service workers, 32.3% of skilled workers, and 26.2% of semi-skilled workers belong to this cluster. 34.7% of all self-employed with employees and 32.7% of employed belong to this cluster. Also, 35.6% for all regular workers belong to this cluster. Occupational illness is low at 51.6%, mental illness is low at 24.8%, physical illness is low at 40.1%, and other illnesses are intermediate at 17.9%.

Cluster 4 is the “high stress” group with highest job stress score, intermediate mean age, musculoskeletal risk factor score and weekly working hours, and high chemicophysical risk factor score. Occupational illness is intermediate at 57.3%. Mental illness and physical illness are intermediate and other illnesses are high. With cluster 2 as the reference, the OR for other illnesses is 1.7 (95% CI, 1.58-1.90).

Cluster 5 is the “high risk” group with highest chemicophysical risk factor score and musculoskeletal risk factor score, high job stress score and weekly working hours, and intermediate mean age. Occupational illness is highest at 65.8%. Mental illness and other illnesses are highest, and physical illness is high. With cluster 2 as the reference, the OR is 3.4 (95% CI, 3.15-3.62) for occupational illness, 2.5 (95% CI, 2.29-3.66) for mental illness, 3.7 (95% CI, 3.49-4.00) for physical illness, and 2.4 (95% CI, 2.24-2.63) for other illnesses.

Cluster 6 is the “overwork” group with highest weekly working hours, high mean age, intermediate job stress score, and low other risk factors. 31.3% of all self-employed without employees and 33.8% of unpaid family workers belong to this cluster. Occupational illness of this cluster is intermediate at 57.9%. Mental illness is high at 32.5%, physical illness is intermediate at 47.3%, and other illnesses are low at 16.6%. With cluster 2 as the reference, the OR for mental illness is 2.4 (95% CI, 2.27-2.60).

2. Cluster Characteristics of Male

Male workers are divided into 6 clusters according to age, chemicophysical risk factors, musculoskeletal risk factors, job stress, and working hours.

Cluster 1 is the “old age” group with highest mean age, lowest working hours, and intermediate other risk factors. 56.6% of all agriculture, fishery, and forestry workers belong to this cluster. 31.3% of all self-employed without employees and 28.0% of unpaid family workers belong to this cluster. Occupational illness of this cluster is high at 54.8% and physical illness is high at 42.8%. With cluster 2 as the reference, the OR is 2.4 (95% CI, 2.25-2.60) for occupational illness and 2.7 (95% CI, 2.46-2.88) for physical illness.

Cluster 2 is the “low risk” group with low mean age, lowest chemicophysical risk factor score, musculoskeletal risk factor score and job stress score, and low weekly working hours. 39.5% of all professionals, 40.3% of executives and administrators, 40.0% of clerks, 33.3% of sales workers, and 26.0% of service workers belong to this cluster. 30.8% of all self-employed with employees and 26.1% of employed belong to this cluster. In addition, 29.3% of all regular workers belong to this cluster. Occupational illness is lowest at 33.4%, and mental illness, physical illness and other illnesses are lowest.

Cluster 3 is the “intermediate risk” group with intermediate mean age and weekly working hours, low job stress score, and high musculoskeletal risk factor score.

Occupational illness is intermediate at 50.8%, mental illness is intermediate at 25.8%, physical illness is intermediate at 37.4%, and other illnesses are high at 19.0%.

Cluster 4 is the “high stress” group with lowest mean age, low weekly working hours and chemicophysical risk factor score, intermediate musculoskeletal risk factor score, and high job stress score. Occupational illness is low at 44.1%. Mental illness, physical illness, and other illnesses are low.

Cluster 5 is the “high risk” group with highest chemicophysical risk factor score, musculoskeletal risk factor score and job stress score, high weekly working hours, and intermediate mean age. 32.3% of all skilled workers, 36.3% of semi-skilled workers, and 35.8% of non-skilled workers belong to this cluster. 25.2% of all temporary workers and 52.4% of day laborers belong to this cluster. Occupational illness is highest at 64.1%. Mental illness, physical illness and other illnesses are highest. With cluster 2 as the reference, the OR is 3.6 (95% CI, 3.30-3.84) for occupational illness, 2.6 (95% CI, 2.37-2.82) for mental illness, 3.9 (95% CI, 3.60-4.21) for physical illness, and 2.5 (95% CI, 2.25-2.72) for other illnesses.

Cluster 6 is the “overwork” group with highest weekly working hours, high mean age, low musculoskeletal risk factor score, and intermediate other risk factors. Occupational illness of this cluster is intermediate at 53.7%, mental illness is high at 29.9%, physical illness is intermediate at 41.6%m, and other illnesses are intermediate at

15.9%. With cluster 2 as the reference, the OR for mental illness is 2.4 (95% CI, 2.14-2.64).

3. Cluster Characteristics of Female

Female workers are divided into 6 clusters according to age, chemicophysical risk factors, musculoskeletal risk factors, job stress, and working hours.

Cluster 1 is the “intermediate risk” group with lowest job stress score, low chemicophysical risk factor score and weekly working hours, and intermediate musculoskeletal risk factor score. 51.1% of all professionals, 57.1% of executives and administrators, and 40.6% of clerks belong to this cluster. Also, 29.1% of all regular workers belong to this cluster. Occupational illness of this cluster is lowest at 41.8% and mental illness is lowest at 17.7%. Physical illness and other illnesses are low.

Cluster 2 is the “low risk” group with lowest mean age, lowest chemicophysical risk factor score and musculoskeletal risk factor score, high job stress score, and intermediate weekly working hours. Occupational illness is low at 45.9% and physical illness is lowest at 31.7%. Mental illness and other illnesses are low.

Cluster 3 is the “high stress” group with intermediate mean age and weekly working hours, highest job stress score, and high chemicophysical risk factor score and musculoskeletal risk factor score. 27.9% of all service workers and 35.1% of non-skilled workers belong to this cluster. 28.4% of all employed belong to this cluster. 33.7% of all temporary workers and 40.6% of day laborers belong to this cluster. Occupational illness

is intermediate at 60.6%, mental illness is intermediate at 30.5%, physical illness is intermediate at 51.2%, and other illnesses are high at 19.1%.

Cluster 4 is the “overwork” group with highest weekly working hours, intermediate mean age, low musculoskeletal risk factor score and job stress score, and intermediate chemicophysical risk factor score. 30.1% of all sales workers belong to this cluster. 32.4% of all self-employed without employees 33.5% of self-employed with employees, and 29.3% of unpaid family workers belong to this cluster. Occupational illness is intermediate at 55.9%. Mental illness and physical illness are intermediate. Other illnesses are lowest.

Cluster 5 is the “high risk” group with highest chemicophysical risk factor score and musculoskeletal risk factor score, high weekly working hours, high mean age, and intermediate job stress score. 28.6% of all skilled workers and 28.9% of semi-skilled workers belong to this cluster. Occupational illness is highest at 72.6%. Mental illness, physical illness, and other illnesses are highest. With cluster 2 as the reference, the OR is 3.1 (95% CI, 2.81-3.47) for occupational illness, 2.5 (95% CI, 2.21-2.74) for mental illness, 3.7 (95% CI, 3.37-4.15) for physical illness, and 1.9 (95% CI, 1.72-2.19) for other illnesses.

Cluster 6 is the “old age” group with highest mean age, lowest weekly working hours, and intermediate other risk factors. 49.8% of all agriculture, fishery, and forestry workers belong to this cluster. Occupational illness of this cluster is high at 67.7%,

mental illness is high at 32.0%, physical illness is high at 63.0%, and other illnesses are intermediate at 17.2%. With cluster 2 as the reference, the OR is 2.5 (95% CI, 2.20-2.76) for occupational illness, 1.7 (95% CI, 1.50-1.92) for mental illness, and 3.7 (95% CI, 3.27-4.11) for physical illness.

4. Cluster Characteristics of Occupational Factors

Clusters can be classified into “old age”, “low risk”, “intermediate risk”, “high stress”, “high risk”, and “overwork” according to cluster characteristics by gender and characteristics of overall workers. Similar trends are shown by occupational illnesses according to characteristics of each cluster. “Old age” group has high rate of occupational illness and physical illness. Females also have high mental illness. “Overwork” group has intermediate rate of occupational illness and high rate of mental illness in males. Occupational illness and mental illness are both intermediate in females.

Occupational characteristics show difference according to gender. For males, 56.6% of all agriculture, fisher, forestry workers, 31.3% of all self-employed without employees, and 28.0% of unpaid family workers belong to “old age” group. For females, 49.8% of all agriculture, fishery, and forestry workers belong to this cluster. However, 32.4% of all self-employed without employees and 29.3% of unpaid family workers belong to “overwork” group.

For males, 39.5% of all professionals, 40.3% of executives and administrators, 40.0% of clerks, 33.3% of sales workers, and 26.0% of service workers belong to “low risk” group. 30.8% of all self-employed with employees and 26.1% of employed belong to this cluster. Also, 29.3% of all regular workers belong to this cluster. On the contrary for females, 51.1% of all professionals, 57.1% of executives and administrators, and 40.6% of clerks belong to “intermediate risk” cluster. 27.9% of all service workers belong to

“high stress” group. 30.1% of all sales workers belong to “overwork” group. 32.4% of all self-employed without employees belong to “overwork” group and 28.4% of all employed belong to “high stress” group. Also, 29.1% of all regular workers belong to “intermediate risk” group.

For males, 32.3% of all skilled workers, 36.3% of semi-skilled workers, and 35.8% of non-skilled workers belong to “high risk” group. 25.2% of all temporary workers and 52.4% of day laborers belong to this group. For females, 28.6% of all skilled workers and 28.9% of semi-skilled workers belong to “high risk” group. On the contrary, 35.1% non-skilled workers belong to “high stress” group. 33.7% of all temporary workers and 40.6% of day laborers belong to “high stress” group.

5. Discussion of Cluster Characteristics

"Old age" group has short working hours and low occupational risk factors due to age, but they have high overall occupational illness and physical illness. It is a well-known fact that bodily functions are degenerated and work capacity is reduced in general with increasing age. This limits occupations for aged workers.[30] In case of illnesses, risk of occupational illnesses and accidents is increased, but there also are many previous illnesses unrelated with the work.[31]

According to Aleksic et al., high strain and passive jobs are taken by young people with low education level.[32] Chang et al. suggest that psychosocial distress is often seen in young workers.[33] In general, people with strong decision making rights are old and have high education level. Thus, people with high occupational stress tend to be young and have low education level.[34] In addition, many occupations that can be selected by young people with low education level are stressful. However, since health problems caused by stress are chronic illnesses that are not revealed instantly such as cardiovascular diseases[12], rates of occupational illness and mental illness are not high.

Johnson et al. report that occupational group with low wage has a tendency to perform irregular tasks and overwork to make up for low income.[35] Males with high education level and high income tend to overwork, but they have high degree of satisfaction about occupation. On the other hand, part-time workers have low degree of satisfaction about occupation.[36] The flexibility and variability of working hours appeared

inversely related to health and psychosocial well-being.[37] Therefore, “overwork” group has large number of self-employed without employees and unpaid family workers with high rate of mental illness.[38]

Generally, blue collar workers show high rate of occupational illness.[39,40] Skilled blue collar workers with high age have many musculoskeletal risk factors[41] and are likely to be exposed to chemicophysical risk factors. However, not all blue collar workers belong to “high risk” group. Considerable portion is included in “intermediate risk” group.

Considerable number of most occupational groups is included in “intermediate risk” group and “low risk” group. Level of occupational illness for these groups is intermediate or low in males and low in females. For males, office, service and sales workers mainly belong to “low risk” group. For females, office, service and sales workers belong to “low risk” and “intermediate risk” groups. Many skilled workers belong to “intermediate risk” group for males.

Workers of Korea can be largely divided into 6 clusters: “old age”, “high stress”, “overwork”, “low risk”, “intermediate risk”, and “high risk”. Although there are slight differences in the degree of risk factors between males and females, clusters can be defined as above. Occupational characteristics according to cluster differ in males and females, but difference in occupational illness is not large. For instance, most of male sales workers are included in “low risk” group while female sales workers belong to “overwork” group.

High stress and overwork do not necessarily mean high level of occupational illness, but “high risk” immediately shows high level of occupational illness. In comparison to “low risk” group, the OR reaches 3.4. In addition, “high risk” group is simultaneously exposed to many intensive occupational risk factors. Therefore, “high risk” group must be comprehensively approached through many risk factors instead of focusing on a single risk factor.

Selection bias of this study was minimized based on Working Condition Survey approved by the Statistics Korea. This study is representative of risk factors and occupational illnesses to which Korean workers are exposed. However, there may be differences between risk factors felt by workers and actual risk factors because this study was conducted by survey. In addition, risk factors to which workers are exposed were comprehensively examined by cluster analysis instead of observing individual risk factors. Since clusters were classified using statistical method, information about which individual belongs to which cluster was not provided. There are limitations in practical application of this study results. A future study is deemed necessary about how each individual is included in which cluster according to risk factors they encounter.

Ⅵ. CONCLUSION

As a result of performing cluster analysis on various risk factors of Korean workers, workers were classified into 6 clusters. The clusters are called “old age”, “high stress”, “overwork”, “low risk”, “intermediate risk”, and “high risk”. Occupational characteristics and occupational illnesses showed difference according to risk factor characteristics of each cluster.

A comprehensive consideration and appropriate measures are required to prevent occupational illness. Risk factors were examined according to occupational category and business type in the past, but workers under the same occupational category can be classified as different clusters depending on risk factors to which they are exposed. Therefore, such characteristics must be taken into consideration when implementing policies for prevention of occupational illness.

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ABSTRACT (IN KOREAN)

군집분석을 이용한 직업적 위험요인에 따른 직업적 특성

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서론: 노출수준이 감소함에 따라 단일 위험요인에 의한 문제보다, 저농도의 만성적인 복합적인 위험요인에 의한 노출이 문제가 되고 있다. 이에 직업적인 위험요인으로 군집분석을 시행하여 각 군집을 형성하고 이에 따른 직업적인 특성을 보고자 한다.

방법: 한국산업안전보건연구원에서 2011 년 6 월 1 일부터 11 월 30 일 까지 조사한 제 3 차 근로환경조사 대상자 총 50,032 명(남자 28,640 명, 여자 21,392 명)을 대상으로 하였다. 조사 대상자인 근로자들이 노출되는 위험요인인 근골격계위험요인, 물리화학적위험요인, 직무스트레스, 근로시간과 근로자의 나이로 군집분석을 시행하였고, 성별을 나누어서도 시행하였다.

결과: 군집분석 결과 전체 근로자는 총 6 개의 군집으로 나뉘어 지고, 각 군집은 “고연령”, “고스트레스”, “과로”, “저위험”, “중간위험”, “고위험” 군으로 특성 지울 수 있었다. 남성과 여성을 층화하여 시행한 군집분석도 마찬가지로 분류 할 수 있었다. “고연령” 군의 경우 근로시간이 적고, 노출되는 위험요인도 적다. 주로 농어업군이 포함되고, 직업관련성질환은 많았고, 특히나 육체적 질환이 많았다. “고스트레스” 군의 경우 다른 위험인자는 중간 정도 이고, 직업관련성 질환도 중간 정도였다. “과로” 군의 경우 다른 위험인자는 중간 정도이고, 고용원이 없는 자영업자나 무급가족종사자가 많은 편이었다. 직업관련성 질환은 중간 정도였지만, 정신적 질환은 많은 편이었다. “고위험” 군의 경우 연령이 많은 기술생산직이 많았고, 모든 위험요인은 많았고, 직업관련성 질환도 가장 많았다. 저위험군과 비교하여 로지스틱 회귀분석을 시행한 결과 OR 3.4 (95%CI, 3.15-3.62) 였다.

고찰: 직업관련성질환을 예방하기 위해서는 종합적인 고려가 필요하고, 이에 적합한 조치가 필요하다. 이전까지의 직종 및 업종에 따라 위험요인을 파악하였지만, 같은 직종 내에서도 노출되는 위험요인에 따라서 서로 다른 군집에 포함이 된다. 때문에 직업관련성 질환을 예방하기 위해서는 각 군집의 특성을 이해할 필요가 있다.

핵심되는 말: 직업적 노출, 직업성 질환, 군집분석, 근로환경조사