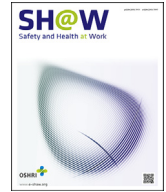




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## Original Article

# The High-risk Groups According to the Trends and Characteristics of Fatal Occupational Injuries in Korean Workers Aged 50 Years and Above

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## ABSTRACT

**Background:** Due to an increasing number of workers aged 50 years and above, the number of those employed is also on the rise, and those workers aged 50 and over has exceeded 50% of the total fatal occupational injuries. Therefore, it is necessary to implement the selection and concentration by identifying the characteristics of high-risk groups necessary for an effective prevention against and reduction of fatal occupational injuries.

**Methods:** This study analyzed the characteristics of high-risk groups and the occupational injury fatality rate per 10,000 workers among the workers aged 50 and over through a multi-dimensional analysis by sex, employment status of workers, industry and occupation by targeting 4,079 persons who died in fatal occupational injuries from January 2007 to December 12.

**Results:** The share of the workers aged 50 years and above is increasing every year in the total fatal occupational injuries occurrence, and the high-risk groups include 'male workers' by sex, 'daily workers' by worker's status, 'craft and related-trades workers' by occupation, and 'mining' by industry.

**Conclusion:** The most frequent causal objects of fatal occupational injuries of the workers aged 50 years and above are found out to be 'installment and dismantlement of temporary equipment and material on work platforms including scaffold' in the construction industry and 'mobile crane, conveyor belt and fork lifts' in the manufacturing industry.

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## 1. Introduction

The world population of people aged 65 years and above is estimated to increase from 8.2% in 2015 to 17.6% in 2060, and the median age increases from 29.6 years to 37.3 years, while the number of Korean people aged 65 years and above is presumed to surge from 13.1% to 40.1%, and the median age increases from 40.8 years to 57.9 years. Also, the average global fertility rate is 2.56 persons, and fertility rate in advanced countries is 1.64 persons, is 2.35 persons in Asia, and is 1.50 persons in Europe. Korea's old age dependency ratio is lower than that of the advanced countries but is estimated to surpass after 2030 [1]. Among the working age population (15–64 years old), those aged 30–49 years, who are the most active age group, accounted for 49% in 2005 but are estimated to decline continuously to 42% in 2020 and 37% in 2050. The ratio of the workers aged 50 years and above took up 25% in 2010 and is

projected to exceed 33% in 2020, accelerating the aging of the workforce [1–3]. According to the economically active population trends, those aged below and above 50 years showed a higher increase rate as it moved from 2000 to 2014, and those aged 60 years and above also resumed an increase [3,4].

Also, if one examines elderly workers aged 50 years and above by employment status, the self-employed had the highest rate in 2013, followed by the regular workers, temporary workers, daily workers, and unpaid family business workers. By industry, the agriculture had the highest percentage, followed by forestry, fishery, whole and retail sale manufacturing, accommodation and food service activities, and construction. By occupation type, the elementary workers had the highest employment percentage, followed by the skilled agriculture, forestry and fishery workers, the sales workers, and the service workers [4,5]. Such aging of workforce can not only increase occupational illnesses, accidents, and

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deaths due to the degenerating physical, mental, and physiological functions caused by a lack of sensory function, balance function, and motor control ability but can also lead to a deterioration in the quality of work ability [6–9]. In addition, among the total occupational injuries, the index values of workers aged 45 years and above showed a trend of steady increase from 2001 to 2010 every year [10], and among the total fatal occupational injuries, the number of the workers aged 50 years and above is very high [11]. Therefore, the prevention of the fatal occupational injuries among elderly workers aged 50 years and above requires an accurate understanding of the characteristics and attributes of the age group, the identification of high-risk groups which need the focus of prevention efforts, and the optimization of intervention time when the resources and capacities need to be strengthened to reduce the fatal occupational injuries.

## 2. Materials and methods

To faithfully fulfill its purpose, this study used the administration information sources including the Korea Workers' Compensation and Welfare Service's industrial accident compensation applications and industrial accident surveys and the Korea Occupational Safety and Health Agency's major industrial accident investigation reports. Based on these reports, the study established a database of 7,993 persons who died from occupational incidents caused by material agencies from January 1, 2007 to December 31, 2013 by classifying their variable attributes into 25 subgroups including individual and occupational characteristics, accident types, material agencies, unsafe acts, or unsafe conditions. To calculate the rate of occupational injury fatality per 10,000 workers by personal and occupational characteristics, the data of economic activity population survey of the National Statistical Office were reworked and used as the parameter value.

It used the final analysis data of 4,079 persons or 51% of the total fatal occupational injuries, who are elderly workers aged 50 years and above, who fulfilled the purpose of the study. The first analysis content included the demographic and occupational characteristics analysis; the second was the in-depth analysis of fatal accident causes and the trend of occupational injury fatality rates per 10,000 workers; and the third was the detailed characteristics of high-risk groups for prevention of fatal occupational injury accidents and the policy proposals.

## 3. Results

### 3.1. Characteristics and major causes of annual fatal industrial accidents of the workers aged 50 years and above.

The numbers of employees aged 50 years and above were increased: 6,711,000 persons in 2007, 6,935,800 persons in 2008,

7,187,900 persons in 2009, 7,528,400 persons in 2010, 7,968,500 persons in 2011, 8,460,200 persons in 2012, and 8,894,600 persons in 2013.[3]. Also the numbers of fatal occupational injuries gradually increased: 490 persons in 2007, 531 persons in 2008, 573 persons in 2009, 607 persons in 2010, 655 persons in 2011, 619 persons in 2012, and 604 persons in 2013. The total number of fatal occupational injuries over a period of 7 years from 2007 to 2013 amounted to 7,993 persons, whereas the number of fatal injuries of the elderly workers aged 50 years and above was 4,079 persons in total. In 2007, the workers aged 50 years and above took up 42.1% of the total annual fatal occupational injuries, and the percentage of the workers aged 50 years and above in comparison to that of the total occupational injury workers showed an increasing tendency [Table 1](#).

From the results of analysis of the fatal occupational injuries of the male workers aged 50 years and above based on the database of fatal occupational injuries accumulated for a period of 7 years from 2007 to 2013, the causal object for 40.7% of fatal occupational injuries is building, structure, and surface, followed by the equipment and machinery (23.3%) and transportation (19.3%). In female workers aged 50 years and above, causal objects for 28.7% of fatal occupational injuries are the equipment and machinery and building, structure, and surface, followed by transportation (23.9%). All in all, there was a statistically significant relation between sex and causal object ( $\chi^2$  value = 27.420,  $p$  = 0.001).

Based on the type of accident, in the male elderly workers aged 50 years and above, "fall of persons" accounted for the highest percentage (38.7%), followed by "struck against objects" (18.8%) and "buried and rolled over by objects and tripping of persons" (9.9%). In the female elderly workers aged 50 years and above, "struck by objects" had the highest percentage (30.3%), followed by "buried and rolled over by objects and tripping of persons" (20.2%) and "fall of persons" (15.4%). A statistically significant relation between sex and type of accidents was observed ( $\chi^2$  value = 80.587,  $p$  = 0.000).

In the analysis of unsafe behaviors at the time of a fatal occupational accidents of the male workers aged 50 years and above, "negligent job performance and noncompliance of procedure" accounted for the highest percentage of the total fatal occupational injuries of the group at 24.9%, followed by "neglect of and failure to identify dangerous structures" (24.1%) and "inappropriate use of protective clothing and gear" (17.6%). In case of the female workers aged 50 years and above, "negligent job performance and noncompliance of procedure" took up the highest percentage of the total fatal occupational injury of the group at 26.2%, followed by "neglect of and failure to identify dangerous structures" (25.7%), "negligence during job performance" (17.6%), and "inappropriate use and maintenance of facility, machinery and materials" (17.5%). All in all, a statistically significant relation between sex and unsafe behaviors was observed ( $\chi^2$  value = 29.137,  $p$  = 0.000).

**Table 1**

The distribution of victims of fatal occupational injuries and fatality rates per 10,000 Korean workers aged 50 years and above.

Division	Number of employees aged above 50 y	Total victims of fatal occupational injuries	Victims of fatal occupational injuries aged above 50 y (%)	Occupational injury fatality rate per 10,000 workers aged above 50 y
2007	6,711,000	1,165	490 (42.1)	0.730
2008	6,935,800	1,245	531 (42.6)	0.766
2009	7,187,900	1,162	573 (49.3)	0.797
2010	7,528,400	1,204	607 (50.4)	0.806
2011	7,968,500	1,140	655 (57.4)	0.822
2012	8,460,200	1,076	619 (57.5)	0.732
2013	8,894,600	1,001	604 (50.3)	0.679
Total		7,993	4,079 (50.0)	

In the results based on the employment status of the fatal occupational injuries of the male workers aged 50 years and above, “struck against objects” accounted for the highest percentage of the fatal occupational injuries of regular workers at 25.6% and “equipment and machinery” took up the highest percentage at 33.2% among the material agencies of injuries. The most frequent cause of accidents among the daily workers was found out to be “fall of persons” with the highest percentage at 50.6%, and the most common material agency of their fatal injuries was “building, structure, and surface” with the highest percentage at 56.4%. In the case of the temporary workers aged 50 years and above, the most frequent cause of accidents turned out to be “fall of persons” with the highest percentage at 36.9%, and the most common material agency of their fatal injuries was “building, structure, and surface” with the highest percentage at 41.0%. In the case of the part-time workers aged 50 years and above, the most frequent cause of accidents turned out to be “stuck and caught in objects” with the highest percentage at 37.5%, and the most common material agency of their fatal injuries was “equipment and machinery” with the highest percentage at 37.5%. All in all, by the employment status, a statistically significant relation between accident type and causal object was observed ( $\chi^2$  value = 490.330,  $p = 0.000$ ;  $\chi^2$  value = 540.609,  $p = 0.000$ , respectively). In addition, looking at types of works at the time of fatal occupational accidents, “transportation, loading and unloading, and operation works” took up the highest percentage of fatal occupation injuries among all status of workers groups including regular workers, daily workers, temporary workers, and part-time workers. The percentage of the fatal occupational injuries caused by unsafe behaviors showed variations in the rankings by employment status; the regular workers had the highest percentage at 25.7% in the category of “negligent job performance and noncompliance of procedure”; the daily workers showed the highest percentage at 29.8 in “neglect of and failure to identify dangerous structures”. In the case of temporary workers, “neglect of and failure to identify dangerous structures” took up the highest percentage at 24.5%, followed by “inappropriate use of protective clothing and gear” (23.9%). In the case of part-time workers, “inappropriate use of protective clothing and gear” took up the highest percentage at 37.5% ( $\chi^2$  value = 377.438,  $p = 0.000$ ).

According to the results of the cross analysis between occupation, industry, and causal object by sex, the male workers aged 50 years and above showed the highest percentage of fatal occupational injuries at 47.1% in the category of “craft and related trade workers”. In contrast, the female workers aged 50 years and above revealed the highest percentage of fatal occupational injuries at 58.0% in the category of “elementary workers”. Considering this, a statistically significant relation between sex and occupation was observed ( $\chi^2$  value = 148.313,  $p = 0.000$ ). Also, in the fatal occupational injuries of the male workers aged 50 years and above by industry and causal object, the construction industry showed the highest percentage at 48.9%, and “building, structure, and surface” was the most frequent causal object of fatal occupational injuries with the highest rate at 40.7%. In the case of the female workers aged 50 years and above, the manufacturing industry showed the highest percentage at 27.7%, followed by the construction industry (22.3%). In terms of the causal object of injuries, both “equipment, structure, and surface” and “building, structure, and surface” accounted for the highest percentage at 28.7%. Statistically significant relations between sex and industry and between sex and causal object were observed ( $\chi^2$  value = 218.019,  $p = 0.000$  and  $\chi^2$  value = 27.420,  $p = 0.000$ , respectively). The most frequent accident type of fatal occupational injuries among the male workers aged 50 years and above was “fall of persons” with the highest percentage at 38.7%, equivalent to about four workers out of every 10 persons. In the case of the female counterparts, the most common accident

type of fatal occupational injuries was “struck against objects” with the highest percentage at 30.3%, equivalent to about three workers out of every 10 persons. In addition, looking at types of works at the time of fatal occupational accidents, both male and female workers aged 50 years and above showed the highest percentages at 35.8% and 46.0%, respectively, in the category of “transportation, loading and unloading, and operation works”. A statistically significant relations between sex and accident type of fatal industrial accidents were observed ( $\chi^2$  value = 97.028,  $p = 0.000$ ). Also, in the fatal occupational injuries by unsafe behaviors, the male workers aged 50 years and above showed the highest percentage at 24.9% in the category of “negligent job performance and noncompliance of procedure”, followed by “neglect of and failure to identify dangerous structures” (24.1%). In contrast, their female counterparts showed the highest percentage at 26.2% in the category of “negligent job performance and noncompliance of procedure”, followed by “negligence during job performance” (25.7%). All in all, a statistically significant relation between sex and unsafe behaviors was observed ( $\chi^2$  value = 29.137,  $p = 0.000$ ).

### 3.2. Trend of occupational injury fatality rates per 10,000 workers by sex, employment status, occupation, and industry

In the occupational injury fatality rates per 10,000 workers by sex, the male occupational injury fatality rates per 10,000 workers stood at 1.16‰ in 2007, which gradually increased to 1.32‰ in 2011 before it dropped again to 1.12‰ in 2013. In contrast, the female occupational injury fatality rates per 10,000 was recorded at a

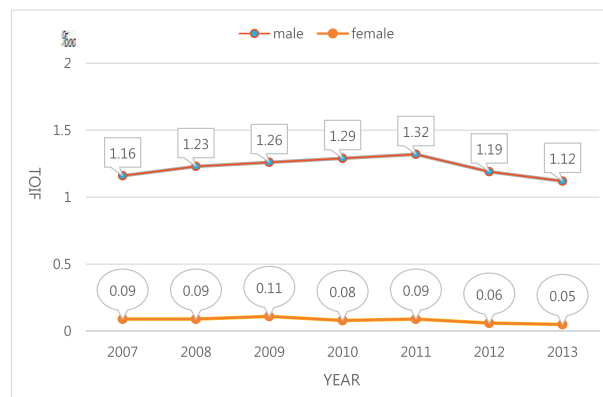


Fig. 1. The trend of occupational injury fatality rates per 10,000 Korean workers aged 50 y and above by sex in year.

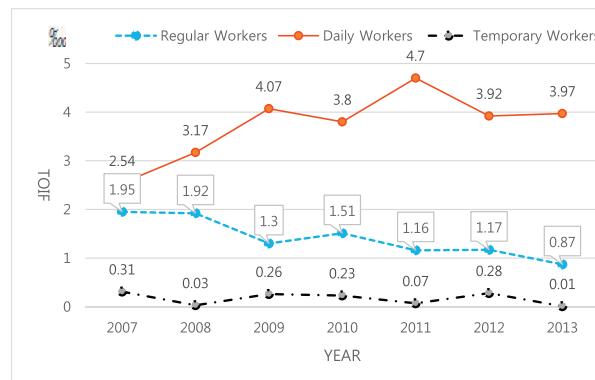


Fig. 2. The trend of occupational injury fatality rates per 10,000 Korean workers aged 50 y and above by employment status in year.

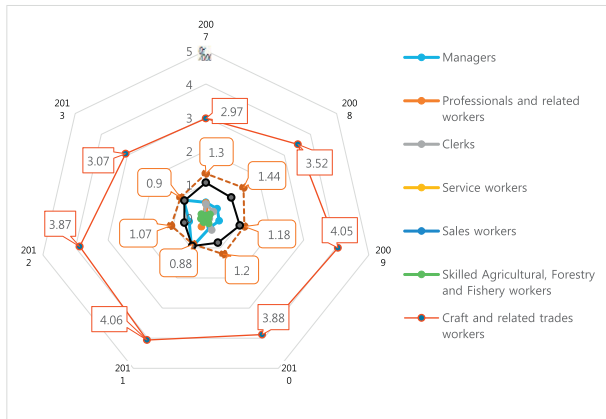


Fig. 3. The trend of occupational injury fatality rates per 10,000 Korean workers aged 50 y and above by occupation in year.

relatively lower 0.09‰ and remained at a standstill until 2011, but after that, it showed a slow declining tendency [Fig. 1]. In the employment status, the daily workers showed the highest occupational injury fatality rate per 10,000 workers and especially at as much as 4.70‰, equivalent to 4.7 workers per 10,000 persons in 2011. In contrast, the temporary workers had the lowest occupational injury fatality rate per 10,000 workers at approximately 0.17‰ every year [Fig. 2].

By occupation, the craft and related trade workers had the highest fatal occupational injury rate, followed by equipment and machine operating and assembling workers and elementary workers, and the other occupation groups showed the fatal occupational injury rate of less than 1.00 ‰ [Fig. 3]. If one examines the

occupational injury fatality rates per 10,000 workers by industry, the mining and quarrying industry experienced the repeated fluctuations and showed the highest occupational injury fatality rate at 23.1‰ in 2002, equivalent to 23 workers per 10,000 workers. And the second highest fatal occupational injury fatality rate per 10,000 workers was recorded in 2009 by the sewerage, waste management, materials recovery, and remediation activities industry, which showed an increasing tendency until 2009 but showed a declining tendency afterward [Fig. 4].

### 3.3. Trend of occupational injury fatality rates per 10,000 workers by sex\*industry and sex\*occupation

In the cross-sectional analysis by sex and industry, the mining and quarrying industry showed the highest occupational injury fatality rate per 10,000 workers among the male workers aged 50 years and above, followed by the sewerage, waste management, materials recovery, and remediation activities industry and the construction industry. In case of the female workers aged 50 years and above, the sewerage, waste management, materials recovery, and remediation activities industry showed the highest occupational injury fatality rate per 10,000 workers, followed by construction industry, and was 15.4‰ in 2009 [Fig. 5].

According to the results of the cross analysis between sex and occupation, the craft and related trades workers had the highest occupational injury fatality rate per 10,000 workers among the male workers aged 50 years and above. In contrast, the equipment and machine operating and assembling workers had the highest occupational injury fatality rate per 10,000 workers among the female workers aged 50 years and above [Fig. 6].

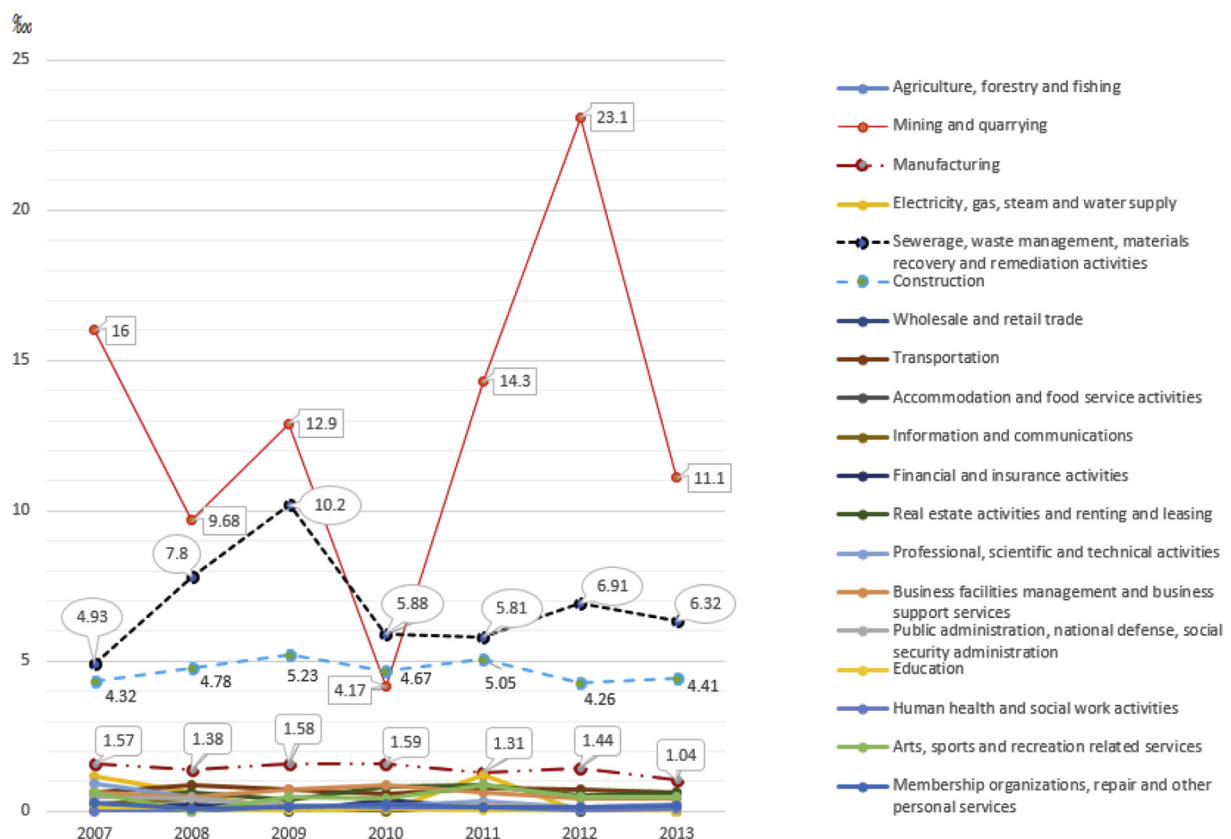
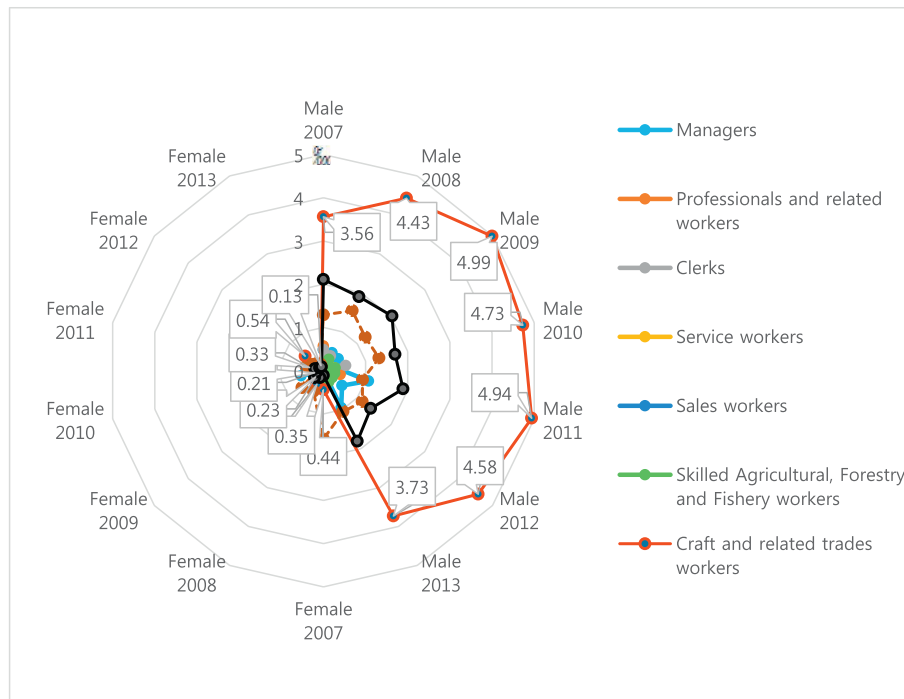


Fig. 4. The trend of occupational injury fatality rates per 10,000 Korean workers aged 50 y and above by industry in year.



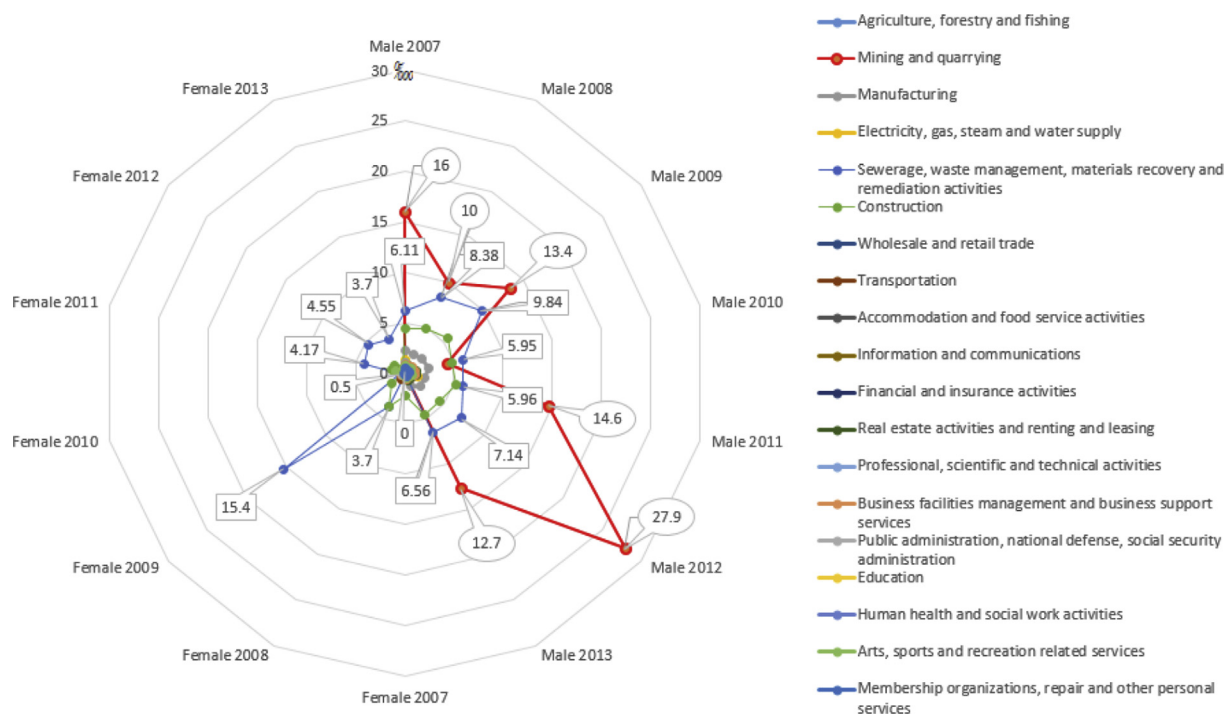


**Fig. 5.** The trend of occupational injury fatality rates per 10,000 Korean workers aged 50 and above by occupation\*sex in year.

#### 3.4. Trend of occupational injury fatality rates per 10,000 workers by employment status\* industry and employment status\*occupation

The results of the cross-sectional analysis by employment status and industry and occupation on the occupational injury fatality rates per 10,000 workers of the elderly workers aged 50 years and above are as follows: At first, in regular workers aged 50 years and above, the mining and quarrying industry showed the highest occupational injury fatality rate per 10,000 workers, followed by

the sewerage, waste management, materials recovery, and remediation activities industry and construction industry. The top three industries had occupational fatality rates per 10,000 workers of over 5.00‰. In the daily workers aged 50 years and above, the sewerage, waste management, materials recovery, and remediation activities industry had the highest fatal occupational injury rate, followed by construction industry. Especially, the occupational injury fatality rates per 10,000 workers in the sewerage, waste management, materials recovery, and remediation activities



**Fig. 6.** The trend of occupational injury fatality rates per 10,000 Korean workers aged 50 and above by industry\*sex in year.

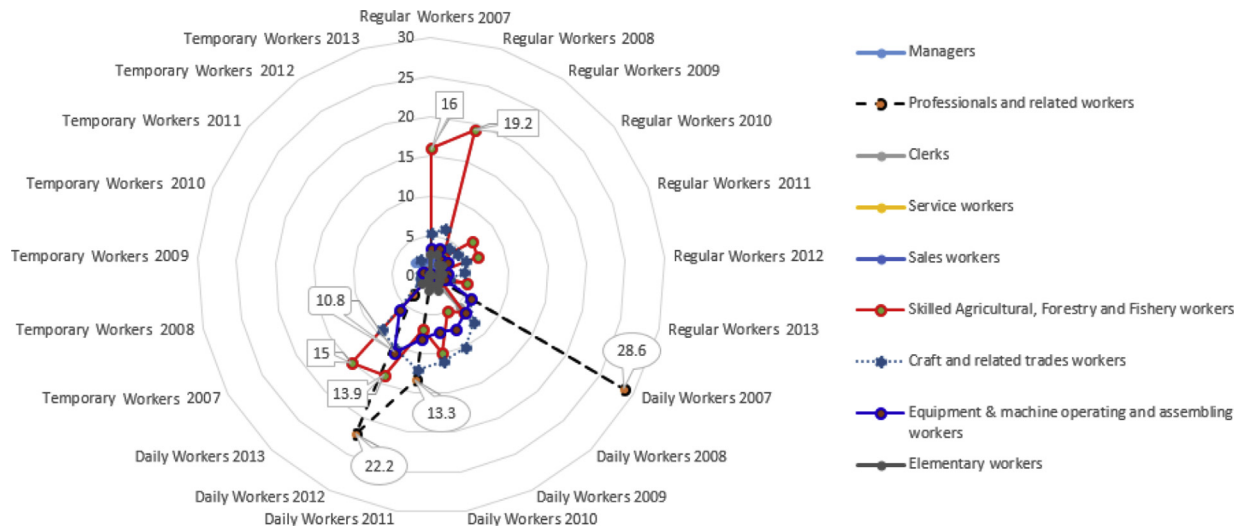


Fig. 7. The trend of occupational injury fatality rates per 10,000 Korean workers aged 50 y and above by occupation\*employment status in year.

industry were extremely very high after 2009. Also in the temporary workers, the construction had the highest fatal occupational injury rate, followed by the sewerage, waste management, materials recovery, and remediation activities industry [Fig. 7].

In the results of the occupational injury fatality rates per 10,000 workers of the regular workers aged 50 years and above by occupation, the skilled agriculture, forestry, and fishery workers showed the highest occupational injury fatality rate per 10,000 workers, followed by the craft and related trades workers, the equipment and machine operating and assembling workers, and the elementary workers. By occupation, in daily workers aged 50 years and above, the professionals and related workers displayed the highest occupational injury fatality rate per 10,000 workers, followed by the craft and related trades workers, the equipment and machine operating and assembling workers, and the skilled agriculture, forestry, and fishery workers. Especially, the

occupational injury fatality rates per 10,000 workers among the skilled agriculture, forestry, and fishery workers showed an overall increasing tendency after repeated increases and decreases, and among the temporary workers, the craft and related trades workers showed the highest occupational injury fatality rate per 10,000 workers but had an extremely wide fluctuation (or variation) every year [Fig. 8].

#### 4. Discussion

Among the total number of 7,993 victims of fatal occupational injuries for 7 years from 2007 to 2013, the workers aged 50 years and above accounted for 51% or 4,079 victims. The percentage of the workers aged 50 years and above against the total annual fatal occupational injuries stood at 42.1% in 2007 and showed an increasing trend every year. In 2012, it surpassed the half of the

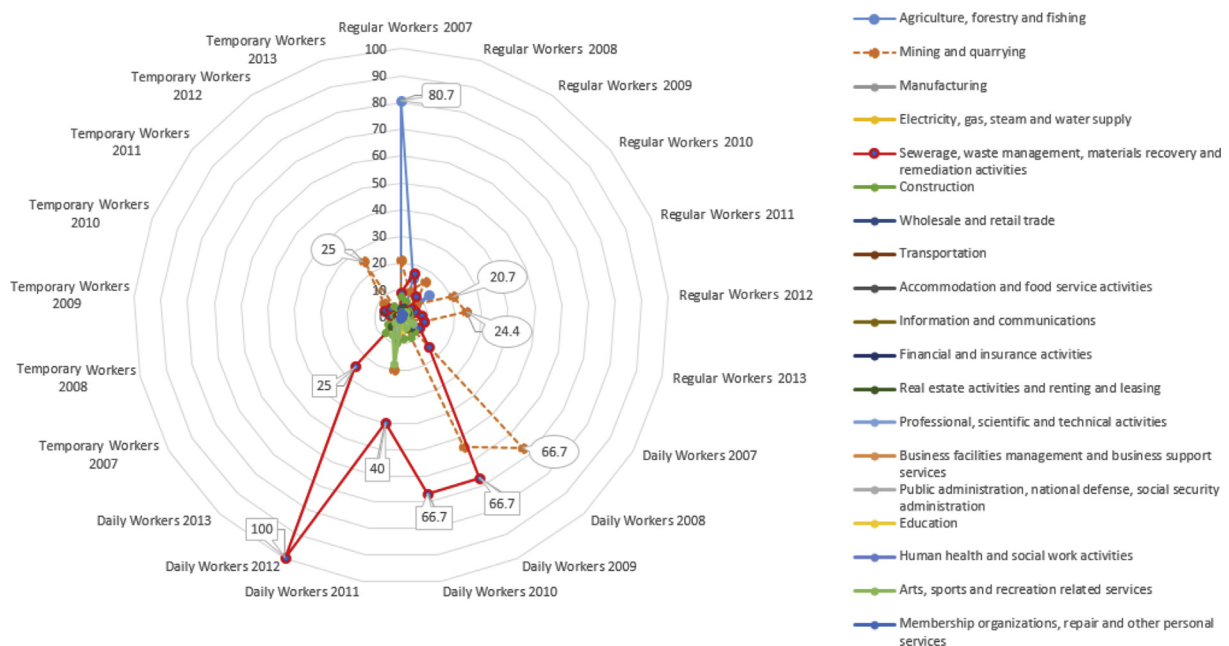


Fig. 8. The trend of occupational injury fatality rates per 10,000 Korean workers aged 50 y and above by industry\*employment status in year.

**Table 2**

Victims and share of fatal occupational injuries of the workers aged 50 years and above by causal objects.

Division	Sex*				Employment status†							
	Male		Female		Regular		Daily		Temporary		Part-time	
	Victims	%	Victims	%	Victims	%	Victims	%	Victims	%	Victims	%
Equipment and machinery	902	23.3	54	28.7	569	33.2	340	16.5	35	21.1	3	37.5
Portable, manual labor machine and tools	43	1.1	1	0.5	15	0.9	27	1.3	1	0.6	0	0
Parts, appendage, and materials	306	7.9	13	6.9	152	8.9	145	7	16	9.6	0	0
Building, structure, and surface	1,578	40.7	54	28.7	377	22.0	1,165	56.4	68	41	2	25.0
Container, furniture, and tools	75	1.9	5	2.7	52	3.0	23	1.1	4	2.4	0	0
Chemical materials and chemical products	67	1.7	3	1.6	42	2.4	22	1.1	2	1.2	0	0
Transportation modes	747	19.3	45	23.9	447	26.1	241	11.7	38	22.9	2	25.0
Humans, animals and plants	124	3.2	6	3.2	43	2.5	79	3.8	1	0.6	1	12.5
Working environment, natural phenomena including atmospheric condition	23	0.6	3	1.6	12	0.7	10	0.5	1	0.6	0	0
Others	14	0.4	4	2.1	6	0	12	0.6	0	0	0	0
Total	3,879	100	188	100	1,715	100	2,064	100	166	100	8	100

\*  $\chi^2 = 27.420$ ,  $p = 0.000$ .†  $\chi^2 = 540.609$ ,  $p = 0.000$ .

total fatal occupational injuries with a percentage of 57.5%. This can be ascribed to the fact that when those aged 50 years and above re-enter the labor market [4], the middle-aged and senior workers have relatively weakened motor, sensory, and cognitive functions due to rapid physical aging [7,9]. Among the 4,079 workers aged 50 years and above, who were the victims of fatal industrial accidents, the male high-risk groups with the highest occupational fatality rates were “construction” among the industry subcategories, “craft and related trades workers” among the occupation subcategories, “fall of persons” among the type of accident subcategories, “building, structure, and surface” among the causal object subcategories, “transportation, loading and unloading, and operation works” by the subcategories of the content of work at the time of accident, and “negligent job performance and noncompliance of procedure” among the unsafe behavior subcategories. In contrast, the female high-risk groups include “manufacturing” and “construction” by industry, “elementary workers” by employment status of worker, “struck against objects” by cause of accident, and “equipment and machinery” by causal object (Tables 2–4).

In the characteristics of the high-risk groups of the workers aged 50 years, by the employment status of worker, the “equipment and machine operating and assembling workers” in the manufacturing

industry were the highest risk group among the regular workers, and the craft and related trades workers in the construction were the highest risk group among the daily workers and temporary workers. Also, the craft and related trades workers in the “membership organizations, repair, and other personal services” were the highest risk group among the part-time workers. According to the analysis results of causal objects and causes of fatal occupation accidents, “equipment and machinery”, “struck by objects”, and “stuck and caught in objects” took up the highest percentage of fatal occupational injuries among the regular workers and part-time workers, and “building, structure, and surface” and “fall of persons” took up the highest percentage of fatal occupational injuries among the daily workers and part-time workers. And the fatal industrial accidents occur most frequently among regular workers, daily workers, temporary workers, and part-time workers, when they engage in the transportation, loading and unloading, and operation works. Other articles reported that those workers aged 50 years and above were exposed to the highest risk when they installed or dismantled the work platform including scaffold and temporary structures in the construction industry [11–14]. In addition, they reported that “fall of persons” were the most frequent material agency of fatal industrial accidents in the

**Table 3**

Victims and share of fatal occupational injuries of the workers aged 50 years and above by accident type.

Division	Sex*				Employment status†							
	Male		Female		Regular		Daily		Temporary		Part-time	
	Victims	%	Victims	%	Victims	%	Victims	%	Victims	%	Victims	%
Fall of height	1,506	38.7	29	15.4	407	23.6	1,045	50.6	62	36.9	1	12.5
Buried, crushed, and tripped over by objects	386	9.9	38	20.2	197	11.4	189	9.2	19	11.3	2	25
Struck against objects	733	18.8	57	30.3	441	25.6	263	12.7	37	22	2	25
Stuck by falling objects	279	7.2	10	5.3	123	7.1	151	7.3	8	4.8	0	0
Caught by equipment and objects	315	8.1	22	11.7	235	13.6	82	4	13	7.7	3	37.5
Collapse of objects	219	5.6	3	1.6	53	3.1	160	7.7	5	3	0	0
Contact with extreme temperatures	22	0.6	1	0.5	14	0.8	6	0.3	1	0.6	0	0
Exposure to or contact with chemical substances	64	1.6	3	1.6	30	1.7	33	1.6	1	0.6	0	0
Oxygen deficiency	98	2.5	4	2.1	48	2.8	44	2.1	6	3.6	0	0
Explosion (fire), burst	142	3.6	17	9	105	6.1	42	2	7	4.2	0	0
Electrocution	92	2.4	4	2.1	47	2.7	42	2	7	4.2	0	0
Violent acts	29	0.7	0	0	20	1.2	6	0.3	2	1.2	0	0
Other & unclassifiable causes	6	0.2	0	0	3	0.2	2	0.1	0	0	0	0
Total	3,891	100	188	100	1,723	100	2,065	100	168	100	8	100

\*  $\chi^2 = 80.587$ ,  $p = 0.000$ .†  $\chi^2 = 490.330$ ,  $p = 0.000$ .

**Table 4**

Victims and share of fatal occupational injuries of the workers aged 50 years and above by unsafe behaviors.

Division	Sex*				Employment status†							
	Male		Female		Regular		Daily		Temporary		Part-time	
	Victims	%	Victims	%	Victims	%	Victims	%	Victims	%	Victims	%
Inappropriate use and maintenance of facility, machinery & materials	490	12.9	32	17.5	316	18.7	187	9.2	16	9.8	0	0
Neglect of and failure to identify dangerous structures	917	24.1	28	15.3	289	17.1	609	29.8	40	24.5	0	0
Negligent job performance & noncompliance of procedure	948	24.9	48	26.2	435	25.7	525	25.7	30	18.4	2	25
Unsafe working posture	6	0.2	0	0	1	0.1	5	0.2	0	0	0	0
Negligence during job performance	597	15.7	47	25.7	381	22.5	168	8.2	33	20.2	2	25
Reckless and unnecessary acts and actions	117	3.1	7	3.8	66	3.9	52	2.5	2	1.2	1	12.5
Inappropriate use of protective clothing and gear	669	17.6	16	8.7	169	10	472	23.1	39	23.9	3	37.5
Other unsafe behaviors	64	1.7	5	2.7	36	2.1	25	1.2	3	1.8	0	0
Total	3808	100	183	100	1693	100	2043	100	163	100	8	100

\*  $\chi^2 = 29.137$ ,  $p = 0.000$ .†  $\chi^2 = 377.438$ ,  $p = 0.000$ .

construction industry; “stuck and caught in objects” in the most common material agency of fatal industrial accidents in the manufacturing industry [10,15].

According to the results of the trend analysis of fatal occupational injuries by year, the study observed the existence of changes in the top rankings depending on sex, employment status, occupations, and industries. This indicates that the strategy of “selection and concentration” should be differentiated by sex, employment status, occupation, and industry to prevent the fatal occupation injuries of the workers aged 50 years and above [15,16]. By sex, the female workers aged 50 years and above are more exposed to fatal occupational injuries than male workers, and the highest risk groups included daily workers by employment status, craft and related trades workers by occupation, and the mining and quarrying industry by industry. Especially, “sewerage, waste management, materials recovery, and remediation activities” and “construction industry” are the two industries with the highest risks, which need the focus on efforts to prevent and reduce the fatal occupation injuries of females and daily workers who are the most vulnerable demographic groups among the workers aged 50 years and above. In contrast, “equipment- and machine operating and assembling workers” and “craft and related trades workers” are the high risk occupations.

Based on the analysis results, the study offers policy suggestions for the prevention of fatal occupational injuries of the workers aged 50 years and above. First, the safety management and supervision system and job training programs need to be strengthened due to an increasing tendency of entering into new jobs different from their previous jobs. Second, because the highest frequent causes of fatal industrial accidents may vary depending on male and female workers aged 50 years and above, it is necessary to develop on-the-job training programs in consideration of sex characteristics and to provide differentiated safety education. Third, given that workplaces of less than 10 regular workers in the manufacturing industry and construction projects with the budget of less than two billion won experienced high percentages of fatal industrial accidents, it is necessary to reinforce the safety management and supervision system as well as education programs for those who work in workplaces vulnerable to industrial accidents and to provide technical and financial support to improve the workers' safety. However, as those vulnerable workplaces account for more than 80% of the total, it is difficult to offer a direct administrative support and to enforce the safety management and supervision. Given this, it can be effective to establish and implement a safety and health management governance by linking the safety health-related universities, civil prevention organizations, and workers' health centers within the concerned local unit as footholds.

## Conflicts of interest

The authors declare that there are no conflicts of interests regarding the publication of this article.

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## Appendix A. Supplementary data

Supplementary data related to this article can be found at <http://doi.org/10.1016/j.shaw.2018.01.005>.

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