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Original article

In-house Contractors' Exposure to Risks and Determinants of Industrial Accidents; With Focus on Companies Handling Hazardous Chemicals

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ABSTRACT

Background: The series of serious industrial accidents in recent years at contractors to large companies has highlighted risk outsourcing as a real and urgent problem. This study aims to review the difference in the degree of risk exposure and the occurrence of industrial accidents depending on the type of company relations. Among in-house contractors, the focus will be on those handling hazardous chemicals that include companies for which outsourcing requires approval.

Methods: This study uses the 9th wave of the Industrial Safety and Health Survey (2018). For determining the degree of risk exposure, the occurrence of industrial accidents, and industrial accident rate, multivariate, logistic, and fractional logit, regression analyses were used, respectively.

Results: First, In-house contractors' degree of risk exposure is higher than that of the client companies. In particular, this gap is even greater for companies dealing with chemicals. Second, among only those that handle hazardous chemicals, in-house contractors do show a significantly higher rate of industrial accident occurrence. Third, In-house contractors have a significantly higher rate of industrial accidents from diseases than client companies.

Conclusion: The analysis supports the intent of the legal amendment that strengthens the protection of in-house contracted workers who handle hazardous chemicals. Second, the results of this study suggest that safety and health management must go beyond legal compliance and ensure that it has substance and effectiveness. Last, there should be policy consideration is necessary to reduce attempts to hide industrial accidents.

1. Introduction

The heightened global competition since the 1990s economic crisis raised firms' needs for cost-cutting and employment flexibility, which were met by an increase in indirect employment. A general term that includes temporary agency work, service contract, and in-house contracting, "indirect employment" is defined as "a form of employment where workers hired by others are directly included or combined into one's business" [1]. "temporary placement of workers" means engaging a worker employed by a temporary work agency to work for, and under the direction and supervision of, a user company in accordance with the terms and conditions of a contract on temporary placement of workers, while maintaining his/her employment relationship with the temporary work agency (Act on the Protection, etc. of Temporary Agency Workers article 2). A "contract" for work becomes effective when one of the parties has agreed to perform a certain job, and the other has agreed to pay remuneration for the result of such work (Civil Act article 664). "Service contract" is where the transaction is not for goods but for services (work performance) such as cleaning or security, and thus is used differently with "contracting." In-house contracting refers either to the contractor performing tasks contracted out or entrusted by the client company in the establishment of the client company to fulfill its obligations (Guidelines for the Protection of Working Conditions of Workers of In-House contractors, July 18, 2011) [2]. It is such nature that precludes indirect employment from the principles of ordinary employment relations that occur between the employer and employee.

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Indirect employment can and does become a social issue due to inequality in the working conditions and environment between indirectly hired and directly hired workers; that is, indirectly hired workers are not only exposed to job insecurity but also receive lower wages and benefits than directly hired regular workers [3]. Most importantly, they are often the victims of major industrial accidents, a fact that has led to criticisms of "outsourcing of risks" [4]. In short, indirectly hired workers experience not only inequality in working conditions compared to regular workers but also inequality in health and safety in the working environment [5].

"Industrial accidents" refers to the death, injury, or disease of employees caused by structures, equipment, raw materials, gas, vapor, powder, dust, etc., related to their duties or by their work or other duties (Act on Occupational Safety and Health article 2). Or, it includes an occupational injury and an occupational disease. An occupational injury is defined as any personal injury, disease, or death resulting from an unexpected and unplanned occurrence of an occupational accident; it is, therefore, distinct from an occupational disease, which is a result of an exposure over a period of time to risk factors arising from work activity [6]. The series of serious industrial accidents in recent years at contractors to large companies has highlighted risk outsourcing as a real and urgent problem [7]. The trend in Korea's overall industrial accidents has remained stable, with consistent improvement over the years. But the problem is that "serious accidents," defined as severe accidents or those that involve a large number of injuries, are not decreasing. More problematic yet, the share of indirectly contracted workers out of serious accident victims has been on the rise [8].

Particularly controversial has been the issue of the in-house contractors. Although the work contracted out is often hazardous and risky and thus requires specialized skills or equipment, these contractors are mostly small and ill-funded. And given that performance of the work takes place outside of the subcontractor's workplace, they are limited in trying to improve the working environment. This makes it difficult to impose health and safety responsibilities solely on the contractor.

Thus, the amended Industrial Safety and Health Act of 2019 imposes broader responsibility on the client company to clarify accountability of risk factors. The provisions that limit contracting is one of the attempts to prevent the outsourcing of risks. The provisions consist of prohibition of contracting of hazardous work (Article 58) and approval of contracting and prohibition of subcontracting (Articles 59 and 60). And given the history of industrial accidents in the course of handling chemicals (poisoning, etc.), it now requires approval for in-house contracting of work that involves four hazardous chemicals; materials containing at least 1% (by weight) of sulfur, hydrogen fluoride, nitric acid, and hydrogen chloride. In-house contracting for retrofitting, disassembling and/or removal of equipment handing such materials or working inside such equipment requires additional approval [9].

But so far in Korea, there has been no analysis on workplace accident or disease occurrences based on companies' relations (i.e., in-house contracting) using data generated with representative samples over a certain size. This shortfall can be attributed to the difficulty in acquiring data. The only available data of this nature is an analysis of absenteeism and nonhealth of in-house contracted workers owing to work accidents or injuries using the 2nd wave of Work Environment Survey (2010) [10,11].

This study aims to review the difference in industrial accidents depending on the type of company relations using the 2018 Industrial Safety and Health Survey, which is a set of nationally certified statistics published by the Korea Occupational Safety and Health Agency (KOSHA). Among in-house contractors, the focus will be on those handling hazardous chemicals that include companies for which outsourcing requires approval. First, it will be determined whether there indeed is transfer of risks to in-house contractors by analyzing the degree of risk exposure depending on the type of company relations and the handling hazardous chemicals (research question1). Next, it will be assessed whether there are any differences in the probability and the level of industrial accidents depending on such factors with control of health & safety management factors (research question 2). Last, the determinants that reduce industrial accidents will be reviewed, and implications will be presented based on the findings.

2. Materials and method

2.1. Subjects and study sample

This study uses the 9th wave of the Industrial Safety and Health Survey (2018). Conducted by KOSHA every three years since 2002, the survey aims to understand the health and safety status in workplaces and provide empirical data necessary for policymaking. Since 2015, the survey population was changed to all workplaces with 50 or more employees and was recognized as nationally certified statistics in 2018. The sampling frame is the list of workplaces registered under Industrial Compensation Accident Insurance and was distributed as a mixed sample using proportional distribution after Neyman allocation and priority allocation. Excluding construction companies, data from 2,015 manufacturers and 2,155 nonmanufacturers were identified. Out of this 4,170, those with missing values or outliers were excluded. In the end, a total of 4,088 firms were included for data analysis. This study has been approved by the Public Institutional Bioethics Committee designated by the Ministry of Health and Welfare.

2.2. Measures

First, the variables used to analyze whether a risk is transferred to in-house contractors **(research question 1)** are defined as follows. The degree of risk exposure used as the dependent variable is the sum of the number of workers exposed to the following seven risk factors surveyed by the company; (1) Mental and psychological factors; (2) Chemicals; (3) Physical risks; (4) Ergonomic risks; (5) Biological risks; (6) Dangerous tools; (7) Working in dangerous environment.

Among the above risks, the criteria for hazardous chemicals (2) are as follows: organic chemicals, metals, acid and alkali, and gaseous materials: organic chemicals (particulates, organic solvents, etc.); metals (lead, chrome, etc.); acids and alkali (phosphate acid, acetic acid, etc.); gaseous materials (ammonia, chloride, fluoride, etc.). The companies with workers handling these chemicals are defined as hazardous chemical handling companies.

An in-house contractor can be determined using the company relations variable. Namely, intercompany relations were surveyed as: (1) Client company; (2) Client company and contractor; (3) In-house partner of the client company; (4) External partner of the client company; (5) Neither client company nor a contractor. Out of these, "in-house partner of the client company" is the topic of this study.

The following were used as control variables: the size of the workplace (number of full-time workers, revenue), organizational features (existence of a union, shift system, share of regular workers), industrial features (share of production workers, manufacturing or not), and employee demographics (share of older-than-55, share of female workers, share of foreign workers).

Next, in the analysis of differences in the probability and the level of industrial accidents **(research question 2)**, the dependent variable is defined as follows. First, the probability of industrial accidents is the occurrence rate, which is whether industrial

accidents occurred or not in 2017. And the level of industrial accidents means industrial accident rate, which is the number workers with occupational injury or disease divided by the total number of employees of the company.

In addition to the control variables used in the degree of risk exposure analysis, health and safety management factors were added along with the risk exposure level for industrial accident analysis. For controlling the impact of health and safety management factors on the probability and level of industrial accidents, four variables are included: whether there is a safety and health organization in place (e.g., persons in charge of safety and health management, occupational health, and safety committee); response to psychological/social risks (work-related stress, bullying or harassment, work-related violence); whether education is given (nonoffice workers); safety and health expenditures in 2017. The existence of an occupational health and safety committee is assessed by the following four options: (1) Installed; (2) Labor-management council plays the role; (3) Not installed but discussed between labor and management; (4) Not installed. As it likely reflects the company's perception of the need for such a committee, the responses have been reverse-coded as an ordinal variable. The safety and health expenditures of 2017 (personnel maintenance expenses, safety and health organization operation expenses, activity expenses, safety facility, and protection equipment investment expenses, education expenses, health diagnosis and health management expenses, and work environment measurement expenses) are investigated by the following sequence variables: (1) less than 50 million won; (2) more than 50 and less than 100 million won; (3) more than 100 and less than 300 million won; (4) more than 300 and less than 500 million won; (5) more than 500 and less than 1,000 million won. Response to psychological/social risks was scored between 0 to 3, depending on the existence of a response process.

2.3. Statistical analysis

For determining the degree of risk exposure by in-house contractors, this study used multivariate regression analysis (research question 1). Then logit regression analysis was used to determine the difference in industrial accident occurrence by company relations, and fractional logit regression is used to determine the difference in industrial accident rate (research question 2). As the industrial accident rate is a ratio variable, fractional logit is used in this case (which is a type of generalized linear model, which in turn is a quasi-likelihood estimation). It is an appropriate model when the dependent variable is greater than or equal to 0 and less than or equal to 1 [12]. It is used as fractional logit command (fracreg logit) in Stata ver 15. Cross-sectional weights were applied in all analyses, and $p < 0.05$ were considered statistically significant.

3. Results

3.1. The risk exposure of in-house contractors handling dangerous chemicals

Table 1 shows the level of risk exposure according to company relationships. Model 1 shows the analysis of all workplaces, and model 2 is the analysis of only those that handle hazardous chemicals. It confirms that in-house contractors' degree of risk exposure is higher than that of the other company relationships

Table 1
The risk exposure of in-house contractors handling dangerous chemicals

Dependent variable: Degree of risk exposure		All workplace	Workplaces handling dangerous chemicals
		(1)	(2)
Relations	Primary & sub	−3.684	−5.751
		(−0.88)	(−0.78)
	In-house partner	**39.73*****	**67.79*****
		(5.30)	(5.26)
	External partner	1.030	−6.850
		(0.15)	(−0.47)
	Neither primary nor sub	−2.542	−3.156
		(−1.08)	(−0.54)
Workplace size	**Number of workers**	**9.209*****	**14.19*****
		(5.83)	(4.57)
	Sales amount	0.832	**3.719****
		(1.83)	(2.85)
Industrial characteristics	Ratio of production worker	**7.332***	11.75
		(2.41)	(1.48)
	Nonmanufacturing industry	**13.72*****	**−15.30***
		(5.27)	(−2.34)
Organizational characteristics	Ratio of regular worker	1.887	12.14
		(0.58)	(1.15)
	Rotation	**13.60*****	**11.50****
		(7.54)	(2.68)
	Union	**15.75*****	**15.03****
		(6.07)	(2.96)
Demographic characteristics	Ratio of aged above 55y	4.180	16.92
		(0.92)	(0.96)
	Ratio of foreigner	7.939	−2.374
		(0.55)	(−0.09)
	Ratio of women	**−17.83*****	**−44.78*****
		(−4.94)	(−5.17)
	_cons	4.903	29.38*
		(1.14)	(2.54)
	N	4088	1291
	R-sq	0.147	0.153
	F ratio	30.12***	11.24***

*p < 0.05.
**p < 0.01.
***p < 0.001.
Statistically significant variables and regression coefficients (excluding constant terms).

when industrial characteristics, workplace size, organizational characteristics, and demographic characteristics are controlled for. In both analyzes, in-house contractors have a significantly higher level of risk exposure than other companies. In particular, when dealing with hazardous chemicals, the difference (67.79) was 1.7 times higher than the difference between in-house contractors and client companies (39.73). As for control factors and degree of risk exposure in both models, when there are more employees (company size), risk exposure increases when there is a shift system in place. And the higher such risk, the higher the unionization rate. In workplaces with high risk, the number of female workers was significantly low. In the case of Model 2, which analyzes only companies that handle hazardous chemicals, unlike Model 1, it appears that the manufacturing industry shows a higher level of risk.

3.2. The industrial accidents of in-house contractors handling dangerous chemicals

Table 2 shows the correlated factors of industrial accident occurrence. Models 1–3 show analyses of all workplaces, and models 4–6 are analyses of only those that handle hazardous chemicals.

Models 1 and 4 control for workplace size, industrial characteristics, organizational characteristics, and demographics. Models 2 and 5 additionally include the degree of risk exposure, and models 3 and 6 also include safety and health management factors to control for risk.

First, when all workplaces are analyzed, in-house contractors do not show significantly higher industrial accident occurrence rate. But among only those that handle hazardous chemicals, in-house contractors do show a significantly higher rate of industrial accident occurrence. The same finding is observed when the number of risk-exposed workers and safety and health management factors are controlled for. In addition, aside from in-house contractors, independent workplaces (with no contracting relations) show a higher industrial accident occurrence rate than client companies in models 2–3.

As for control variables, when the total headcount and revenue are high (workplace size), when the share of production workers is high (industrial characteristics), and when there is a shift system (organizational characteristics), the higher the industrial accident

Table 2
The industrial accident occurrence of in-house contractors handling dangerous chemicals

Dependent variable: Occurrence of industrial accident		All workplace			Workplaces handling dangerous chemicals		
		(1)	(2)	(3)	(4)	(5)	(6)
Relations	Client & partner	−0.136	−0.116	−0.245	−0.692	−0.684	−0.837
		(−0.58)	(−0.49)	(−0.98)	(−1.65)	(−1.62)	(−1.85)
	In-house partner	0.400	0.232	0.229	**0.828***	**0.655***	**0.684***
		(1.91)	(1.10)	(1.07)	(2.55)	(2.04)	(2.11)
	External partner	0.196	0.187	0.0849	0.119	0.121	0.0908
		(0.57)	(0.53)	(0.23)	(0.21)	(0.21)	(0.16)
	Neither client nor partner	0.258	**0.278***	0.281*	0.332	0.340	0.372
		(1.88)	(2.02)	(1.97)	(1.43)	(1.48)	(1.55)
Workplace size	**Number of workers**	**0.350*****	**0.312*****	0.293***	**0.392*****	**0.359*****	**0.351*****
		(5.87)	(5.14)	(4.46)	(4.10)	(3.66)	(3.35)
	Sales amount	**0.0936****	**0.0894****	0.0710*	**0.232*****	**0.222*****	**0.224*****
		(3.28)	(3.09)	(2.28)	(3.72)	(3.57)	(3.57)
Industrial characteristics	**Ratio of production worker**	**0.578*****	**0.553*****	0.574**	0.519	0.496	0.602
		(3.48)	(3.29)	(3.22)	(1.77)	(1.68)	(1.92)
	Nonmanufacturing industry	−0.194	−0.131	0.0399	0.251	0.217	0.246
		(−1.38)	(−0.91)	(0.26)	(0.95)	(0.81)	(0.87)
Organizational characteristics	Ratio of regular worker	0.0732	0.0690	0.0614	0.205	0.181	0.0905
		(0.38)	(0.36)	(0.30)	(0.52)	(0.46)	(0.22)
	Rotation	**0.270****	**0.223***	0.166	0.0893	0.0645	0.00624
		(2.81)	(2.31)	(1.65)	(0.55)	(0.40)	(0.04)
	Union	0.105	0.0308	−0.0258	−0.195	−0.234	−0.258
		(0.91)	(0.26)	(−0.21)	(−1.11)	(−1.33)	(−1.41)
Demographic characteristics	Ratio of aged above 55y	**1.373*****	**1.373*****	1.459***	**2.298*****	**2.258*****	**2.214*****
		(6.01)	(5.96)	(5.93)	(4.32)	(4.23)	(4.08)
	Ratio of foreigner	**1.298***	**1.280***	1.410*	**2.259****	**2.244****	**2.237****
		(2.41)	(2.29)	(2.28)	(2.97)	(2.94)	(2.72)
	Ratio of women	−0.0672	0.0335	−0.00725	−0.588	−0.477	−0.228
		(−0.37)	(0.18)	(−0.04)	(−1.71)	(−1.36)	(−0.62)
Degree of Risk Exposure			**0.00402*****	0.00324***		**0.00245***	**0.00246***
			(5.44)	(4.26)		(2.36)	(2.32)
Safety & Health Management	Person in charge S&H M.			0.252*			−0.122
				(1.97)			(−0.58)
	Occupational S&H committee			0.0441			0.00528
				(0.97)			(0.06)
	S&H expenditure			0.0366			0.0614
				(1.11)			(1.22)
	S&H Education for nonoffice worker			0.347			**−0.892****
				(1.83)			(−2.68)
	Response to psychological/social risks			−0.0604			−0.116
				(−1.64)			(−1.96)
	Cons	−3.640***	−3.746***	−4.143***	−4.621***	−4.661***	−3.854***
		(−13.33)	(−13.44)	(−12.64)	(−8.36)	(−8.38)	(−6.35)
N		4088	4088	3715	1291	1291	1245
Chi_sq		173.01***	196.28***	192.05***	86.29***	87.83***	95.44***

*$p < 0.05$.
**$p < 0.01$.
***$p < 0.001$.
Statistically significant variables and regression coefficients (excluding constant terms).

occurrence rate. And it is also found that among workplaces with a higher share of 55-or-older and foreign workers, the high-risk workplaces that have a shift system (un-preferred by young domestic workers) have a higher rate of industrial accidents. As for the variable of safety and health management organization, workplaces that have such an organization have higher industrial accident rates. This indicates that the workplaces that are legally required to create such an organization have a relatively high rate of industrial accident occurrence.

Safety and health training for nonoffice workers at workplaces that handle chemicals has a significant negative correlation with industrial accident occurrence rate.

Table 3 shows the industrial accident rate, which is the percentage of workers experiencing industrial accidents out of total workers. Models 1 to 4 show the analysis of all workplaces, while models 5 and 6 are only of workplaces that handle hazardous chemicals. Model 1 shows the total occurrence of industrial accidents, model 2 shows the industrial accident occurrence rate caused by occupational injury, and models 3 to 6 show the industrial accident occurrence rate caused by disease.

First, models 1 to 4 (analyzing all workplaces) show that in-house contractors have a significantly higher rate of industrial accidents from diseases than client companies. On the other hand, external partners show a lower industrial accident occurrence rate than client companies.

By control variables, when there are more workers, the total industrial accident rate and industrial accident rate from events are lower. In manufacturing, when there are more 55-or-older workers and production workers, the accident rate is higher. But for the industrial accident rate from disease, only the share of foreign workers was a significant variable.

When reviewing only chemical-handling workplaces for the correlation between disease-related industrial accident rate and other variables (models 5 and 6), it shows that in-house contracting had a significantly higher accident rate caused by disease when controlling for company size, organizational characteristics, industrial characteristics, and demographics (models 5). But it is no longer significant when the degree of risk exposure and safety and health management variables are included (models 6). It can be construed that the disease-related industrial accident occurrence

Table 3
The industrial accident rate of in-house contractors handling dangerous chemicals

Dependent variable: Industrial accident rate		All workplace				Workplaces handling dangerous chemicals	
		All the industrial accidents	Caused by occupational injury	Caused by occupational disease		Caused by occupational disease	
		(1)	(2)	(3)	(4)	(5)	(6)
Relations	**Client & partner**	−0.130	−0.104	−0.504	−0.357	**−12.58*****	**−13.37*****
		(−0.49)	(−0.38)	(−0.56)	(−0.39)	(−25.92)	(−30.92)
	In-house partner	0.0375	−0.247	**1.534*****	**1.009***	**1.605***	0.773
		(0.12)	(−0.71)	(3.37)	(2.57)	(1.96)	(1.49)
	External partner	0.108	0.177	**−11.84*****	**−12.14*****	**−12.46*****	**−12.49*****
		(0.27)	(0.44)	(−49.60)	(−39.68)	(−33.90)	(−24.15)
	Neither client nor partner	0.147	0.162	−0.0909	0.0314	−0.590	−0.579
		(0.93)	(0.99)	(−0.19)	(0.06)	(−0.74)	(−0.69)
Workplace size	**Number of workers**	**−0.198****	**−0.207****	−0.136	−0.366	−0.105	**−0.488***
		(−2.68)	(−2.71)	(−0.50)	(−1.76)	(−0.27)	(−2.06)
	Sales amount	0.0140	0.0125	0.0365	−0.0134	0.0952	0.0179
		(0.31)	(0.26)	(0.36)	(−0.12)	(0.93)	(0.15)
Industrial characteristics	**Ratio of production worker**	**0.664****	**0.649***	0.789	0.778	1.057	1.204
		(2.62)	(2.40)	(1.64)	(1.41)	(1.36)	(1.44)
	Nonmanufacturing industry	**−0.319***	**−0.342***	−0.146	−0.0112	−0.176	0.207
		(−2.29)	(−2.40)	(−0.30)	(−0.02)	(−0.23)	(0.27)
Organizational characteristics	Ratio of regular worker	0.0111	0.0142	−0.0303	−0.108	−0.0904	−0.102
		(0.05)	(0.06)	(−0.06)	(−0.19)	(−0.08)	(−0.09)
	Rotation	**0.309***	**0.358***	−0.174	−0.214	−0.173	−0.585
		(1.98)	(2.17)	(−0.51)	(−0.67)	(−0.30)	(−1.50)
	Union	−0.0301	−0.0620	0.301	0.00616	−0.338	−0.594
		(−0.18)	(−0.36)	(0.75)	(0.02)	(−0.62)	(−1.09)
Demographic characteristics	**Ratio of aged above 55y**	**1.144*****	**1.180*****	0.714	0.840	1.756	1.648
		(3.66)	(3.54)	(1.10)	(1.26)	(1.42)	(1.83)
	Ratio of foreigner	0.949	0.713	**2.726****	**2.393****	**4.276*****	**4.463*****
		(1.64)	(1.16)	(2.77)	(2.77)	(3.42)	(4.35)
	Ratio of women	−0.439	−0.418	−0.652	−0.721	−1.262	−0.962
		(−1.45)	(−1.31)	(−1.17)	(−1.23)	(−1.18)	(−1.02)
Degree of Risk Exposure					**0.00663*****		**0.00847*****
					(3.79)		(5.37)
Safety & Health Management	Person in charge S&H M.				0.195		0.412
					(0.38)		(0.61)
	Occupational S&H committee				−0.0753		−0.212
					(−0.45)		(−0.99)
	S&H expenditure				0.145		0.211
					(1.45)		(1.86)
	S&H Education for nonoffice worker				−0.262		−1.623
					(−0.34)		(−1.72)
	Response to psychological/social risks				0.167		−0.0161
					(1.41)		(−0.13)
	Cons	−6.411***	−6.476***	−9.185***	−9.341***	−9.640***	−8.379***
		(−14.09)	(−13.34)	(−10.81)	(−8.10)	(−7.17)	(−8.69)
N		4088	4088	4088	3715	1291	1245
Chi_sq		130.51***	124.9***	3608.82***	2897.32***	2378.71***	2550.93***

*$p < 0.05$.
**$p < 0.01$.
***$p < 0.001$.
Statistically significant variables and regression coefficients (excluding constant terms).

rate was mediated by the high degree of risk exposure of this particular group.

4. Analysis of the results

In-house contractors, especially those who handle hazardous chemicals, are exposed to a significantly higher risk of industrial accidents. And even when controlling for such risk, industrial accident occurrence rate at chemical-handling workplaces was higher for in-house contractors. Especially, the risk of occupational disease is concentrated on in-house contracted workers.

First, this highlights the need to strengthen the protection of in-house indirectly employed workers from work-related disease. An industrial accident caused by occupational injury has a big impact on the public's awareness. But in the case of disease coming from a long-drawn-out exposure to risks, it might be difficult for the workers of the contractor with a short service duration to prove the causation or identify accountability.

Second, the results of this study suggest that safety and health management must go beyond legal compliance and ensure that it has substance and effectiveness. For promoting performance and minimizing the risks, there have been many studies on Safety and Environment Management Systems (HSE-MS). Effective HSE-MS will result in injury reduction, environment protection, performance improvement, and a distinctive leadership position in the world [13]. Einarsson and Brynjarsson (2008) suggested an approach for a human factor program as a learning experience. From these observations, a more holistic system view is proposed involving authorities and contractors [14,15]. However, in Korea, it appears that only the transfer of risk from the client company to the contractor is made, and the HSE-MS practice has not been well implemented.

For the client company to deliver accurate information to contractors and their workers about dangerous work is critical, but currently, it is done mostly through documentation. The method of communication should change from a paper-based administrative method to one that can demonstrably show that it was effectively implemented. What might be additionally necessary are video-recording (instead of documentation) and big data analysis capability to administratively screen through large data and confirm that the proper training was implemented.

Third, it is obvious that as important as preventing industrial accidents is protecting workers' right to health after an accident occurs. For reducing attempts to hide industrial accidents, there should be penalties against not only the occurrence of accidents but also against the attempt to conceal such occurrences.

Data used in this analysis are from the Industrial Accident Insurance data. The incidences of noninsurance compensation (i.e., provided by the company) or accidents occurring in noninsurance covered workplaces are thus not included. Table 2 shows that independent workplaces (with no contracting relations) have a higher rate of industrial accidents than the client companies. This is probably because these companies feel less reluctant to record events as "industrial accidents," which would increase the nominal accident rate. A reverse effect is observed in Table 3. It shows a much lower disease-related industrial accidents in external partner companies, and one of the reasons might be that these companies feel compelled to hide industrial accidents in order to win contracts [16].

5. Conclusion

When other variables are controlled for, findings from international empirical studies have been mixed on whether indirect employment or outsourced employment are exposed to bigger risks or more prone to industrial accidents compared to regular employment [17–19].

But there are a series of findings in Korea using the secondary nationwide data from the Work Environment Survey (2010) that show in-house contracted workers are exposed to more occupational risks and likelier to miss work or show signs of ill health due to work-related accidents or illness [10,11]. There are also industry-specific studies such as shipbuilding that conclude that in-house contracted workers have a weaker safety environment and higher job stress [16,20].

This study finds its significance in having gone beyond workers' subjective sense of risk exposure or health to utilizing nationally certified statistical data at the company level to assess the impact of company relations (i.e., in-house contracting) on the degree of risk exposure and industrial accident occurrence.

The analysis supports the intent of the legal amendment that strengthens the protection of in-house contracted workers who handle hazardous chemicals that are likely to cause occupational disease.

Last, the limitations of this study include its data, which is from companies with 50 or more employees, while the industrial accident occurrence rate is higher in smaller workplaces. Interpretation of the findings must account for this limitation.

Conflicts of interest

The author declares that there are no conflicts of interests regarding the publication of this article.

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