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Original article

Disparities in Workplace Hazards and Organizational Protection Resources by Enterprise Size: A National Representative Study of South Korean Manufacturing Workers

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ABSTRACT

Background: This study aimed to identify the prevalence of workplace hazards and organizational protection resources according to the size of the enterprise in the manufacturing industry of the Republic of Korea.

Methods: We analyzed data of waged workers (weighted $N = 5{,}879$) from the Fifth Korean Working Conditions Survey (2017). Enterprise sizes were categorized as "micro enterprises" (less than five employees), "small enterprises" (5–49 employees) and "medium-large enterprises" (50 or more employees). Self-reported exposure to 18 physical, chemical, ergonomic, and psychological hazards were measured. The presence of organizational protection resources such as a labor union, a safety delegate working at the company, designated spaces to deal with safety, and the provision of health and safety information was evaluated.

Results: Compared to workers in medium-large enterprises, those in micro enterprises showed a higher proportion of exposure to most of physical, chemical, ergonomic, and psychological hazards, except for exposure to solvents, prolonged sitting, and experiencing a state of emotional unrest. On the other hand, workers in micro enterprises had the lowest proportion of access to organizational protection resources.

Conclusion: Our study demonstrates that manufacturing workers at the micro enterprise in the Republic of Korea are exposed to the most hazardous work environment and yet have access to the fewest organizational protection resources.

1. Introduction

Micro-small enterprises (MSEs) are increasing in number. The International Labor Organization defines small-sized enterprises as having up to 50 employees and MSEs as having up to 10 employees, with slight variations across countries [1]. Despite their limited numbers of employees, MSEs play a substantial role as a strong base in the economies of the European Union (EU) and the United States (US) in terms of numbers, job creation, and economic development [2]. Within the 27 countries in the EU, enterprises with fewer than 50 workers employ approximately 64 million individuals, including around 26 million individuals in enterprises with fewer than 10 workers, out of total workforce of approximately 132 million in 2022 [3]. Correspondingly, in the US, the direct, indirect, and induced

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effects of enterprises with fewer than five employees on employment are substantial, with a total of 41.3 million jobs accounting for approximately 31% of all private sector employment in 2011 [4].

Despite the economic prosperity of MSEs, smaller enterprises have higher rates of occupational fatalities and injuries compared with larger enterprises [5–8]. For example, a study of workers in the US found that injured workers in the smallest-sized enterprises reported the longest lost worktime due to injuries [9]. Also, a study of Korean workers found that the rates of occupational injuries and fatalities were highest among workplaces with less than five employees, and the rate decreased as the enterprise size increased [10]. Nonetheless, previous research on MSEs has primarily emphasized economic growth and production efficiency [11–14], while evaluations of workers' safety and health have been under-considered [2,15].

Meanwhile, considering that not all injuries may meet the criteria of the compensation system [16], injury rates presented in the previous studies might have been underreported. Thus, before focusing on occupational injuries, it might be pertinent to explore the perceived workplace hazards and the availability of protection resources in MSEs, which could be the potential determinants of the injuries. In addition, the goal is to be relatively free from potential underestimations compared to reports of occupational injuries. Despite this importance, only a few studies have reported working environments and industrial health characteristics depending on the enterprise size, and even in these cases, the findings were not consistent [10,17]. Sørensen et al. reported that smaller enterprises had higher ergonomic, physical, and chemical risks than large companies, but tended to be better in psychosocial factors [17]. Another study found that compared to companies with more than 50 employees, workers in micro enterprises reported fewer physical and chemical risk factors, relatively more ergonomic risk factors, musculoskeletal disorders, and higher fatality rates from occupational injuries [10]. Meanwhile, manufacturing enterprises with five or less employees conducted workplace safety and health education less frequently than those with 30–49 workers [18].

Previous studies also have a limitation in their reporting of workplace hazards as they have focused on the total industry rather than providing industry-specific results or focusing on a particular industry. For example, a study conducted in the Republic of Korea examined the distribution of hazards and protective resources in workplaces based on enterprise size [10]. However, the analysis was not restricted to a particular industry and industry-specific results were also not provided. A study of Danish workers mentioned that dividing the dataset by both industry groups and the number of employees was challenging due to the small sample sizes and thereby they could not provide the results of a specific industry [17]. These studies might have yielded biased estimates regarding the distribution of workplace hazards because aggregated results could fail to capture the patterns of exposure to hazards among workers specific to each industry. For example, an analysis that combines industries would calculate the proportion of chemical exposure without distinguishing between manufacturing and service workers, potentially resulting in underestimation or overestimation of their actual proportion.

In the Republic of Korea, the manufacturing industry accounts for 29.5% of the national Gross Domestic Product [19]. Moreover, out of total 89,848 occupational injuries reported in the Republic of Korea during 2017, more than a quarter of all occupational injuries occurred in the manufacturing industry [20]. As of 2021, 51.7% of manufacturing enterprises in the Republic of Korea have fewer than five employees ('micro enterprise'), employing 10.9% of all manufacturing workers [21]. Additionally, 45.0% of all manufacturing enterprises have 5–49 employees ('small enterprise'), employing 44.4% of all manufacturing workers [21]. Enterprises with 50 or more employees ('medium-large enterprise') constitute 3.3 % of all manufacturing companies and employ 44.7% of the manufacturing workers [21]. According to data from the Korea Occupational Safety and Health Agency(KOSHA) and the Ministry of Employment and Labor, the occupational fatality rate of micro enterprises in the manufacturing industry was 20.7 per 100,000 people, which is higher than those of small enterprises (12.3 per 100,000 people) and medium-large enterprises (8.1 per 100,000 people) (Fig. 1). Small enterprises are exempt from certain essential regulations of the Occupational Safety and Health (OSH) Act, such as the requirement to operate an occupational health and safety committee or appoint a safety and health manager in the workplace [22]. Furthermore, for cases with less than five employees, such enterprises are not obligated to provide OSH education to their workers. Moreover, they do not impart punishments for serious accidents including one or more deaths, two or more injuries lasting more than six months, or three or more occupational diseases within one year [23] (Supplementary Table 1). Hence, MSEs in the manufacturing industry have fewer organizational protection resources, which can lead to a greater risk of occupational injuries and fatalities. However, no previous study has investigated the distribution of occupational hazards and organizational protection resources among Korean workers in the manufacturing industry according to the enterprise size.

Therefore, to fill this knowledge gap, this study sought to answer the following questions using a nationally representative sample of Korean workers:

(1) Do manufacturing employees of micro and small enterprises have a higher prevalence of occupational hazards compared to those of medium-large enterprises?
(2) Are organizational protection resources less available among manufacturing employees of micro and small enterprises compared to those of medium-large manufacturing enterprises?

2. Methods

2.1. Data collection and participants

This study analyzed data from the Fifth Korean Working Conditions Survey (KWCS) conducted by the Korea Occupational Safety and Health Research Institute in 2017. The survey aimed to investigate the

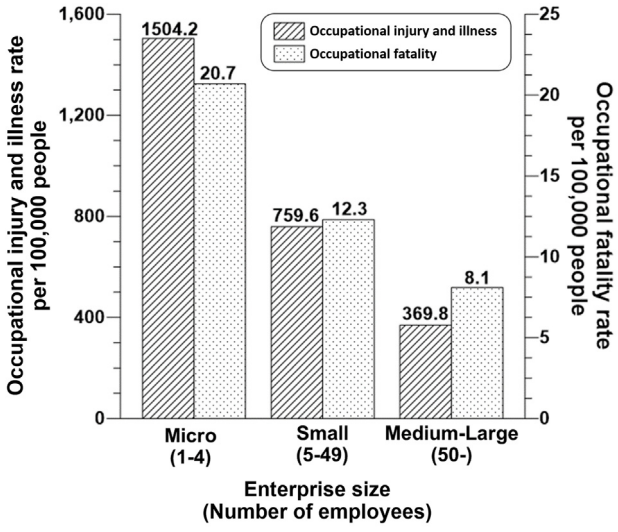

Fig. 1. Occupational injury and illness rate and occupational fatality rate of the manufacturing industry by enterprise size in the Republic of Korea (2017). Note: Occupational injuries and illness rate and occupational fatality rate were calculated based on Census on Establishments and Worker's compensation statistics.

working conditions, hazards at work, and health among workers in the Republic of Korea. The methodology and survey questionnaire were based on those of the European Working Conditions Survey. The data were collected from individuals aged 15 years and older who were economically active in 2017. The fifth edition of the KWCS was used in this study, given the unique circumstances posed by the COVID-19 pandemic as the sixth survey was conducted. Skilled investigators collected data by conducting face-to-face interviews during house-to-house visits. The reliability and validity of the data have been confirmed [24]. Because the KWCS is publicly available under permission from KOSHA, informed consent was not required to use the dataset. This study was exempted from institutional review board approval by the Seoul National University (IRB No. E2310/003-004).

In total, 50,205 workers participated in the fifth KWCS, and our analysis focused on workers in the manufacturing industry (n = 6,120). Those classified as self-employed or non-waged workers were also excluded (n = 994) because only waged workers are considered with regard to enforcement of the Occupational Safety and Health Act and the Serious Accidents Punishment Act. Those who worked in more than one workplace were excluded (n = 858) because it is difficult to calculate the enterprise size accurately when workers work in multiple places at the same time. After excluding data from respondents with any missing information on workplace hazards (n = 9), organizational protection resources (n = 36), enterprise size (n = 8), education (n = 3), and monthly income (n = 28), the final unweighted sample size was 4,184 (Fig. 2). After applying weights variable, the size of the weighted sample was 5,879.

2.2. Measurement

2.2.1. Enterprise size

The enterprise size was measured with the question "How many employees in total work in your company or organization business?" and the answers were 1, 2–4, 5–9, 10–29, 30–49, 50–99, 100–249, 250–299, 300–499, 500–999, 1000–1999, and ≥2000 employees. The responses were divided into three groups depending on the total number of employees working in the workplace: 1–4 (termed micro), 5–49 (small), and 50 or more (medium-large) employees.

2.2.2. Physical, chemical, ergonomic, and psychological hazards

First, self-reported physical and chemical hazards included exposure to vibration, noise, high/low temperatures, fumes and dust, solvents, skin contact with chemicals, tobacco smoke from other people, and direct contact with infectious materials. Second, the questionnaire assessed exposure to ergonomic hazard factors, including painful or tiring postures, lifting or moving people, lifting heavy loads, standing, sitting, and repetitive hand or arm movements. Third, the following psychological hazards were assessed: dealing directly with non-employees, handling angry clients, and the presence of a state of emotional unrest.

Exposure to risk factors was determined with the following request "Please tell me, using the following scale, are you exposed at work to?" for each risk factor. The possible responses were (a) all of the time, (b) almost all of the time, (c) around three-quarters of the time, (d) around half of the time, (e) around one-quarter of the time, (f) almost never, and (g) never. The answers were classified as binary for each risk factor as "exposed" (one-quarter of time or more: a, b, c, d, e) or "non-exposed" (less than one-quarter of time: f, g).

2.2.3. Organizational protection resources

Organizational protection resources were measured by asking "Does the following exist at your company or organization?": (a) Trade union, works council or a similar committee representing employees ('union, council, or committee'), (b) Health and safety delegate or committee ('health and safety delegate'), (c) A regular meeting in which employees can express their views about what is happening in the organization ('regular meetings for expressing opinions'), and (d) A place to deal with safety organizations, safety teams or safety issues in your company ('a place to deal with safety'). Workers could answer "Yes" or "No" for each item.

The KWCS questionnaire examined whether health and safety information was provided, using the following question: "Regarding the health and safety risks related to performance of your job, how well informed would you say you are?" Workers

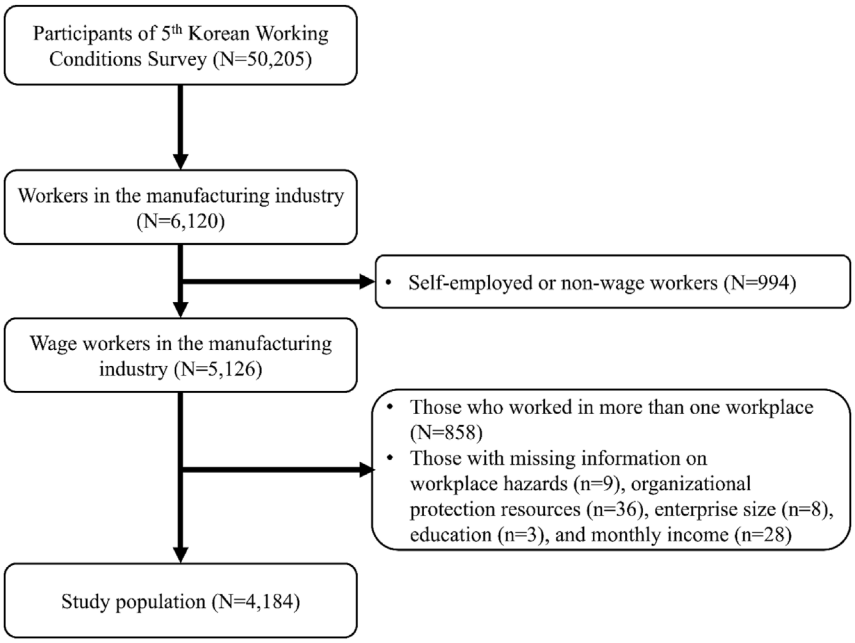

Fig. 2. Flow chart of selecting study population.

could answer on a four-point scale as follows: not at all well informed, not very well informed, well informed, and very well informed. The scales were dichotomized as "No" (not at all well informed, not very well informed) or "Yes" (very well informed, well informed).

2.2.4. Sociodemographic and occupational characteristics

The sociodemographic variables were age (15–29, 30–39, 40-49, 50–59, and ≥60 years old), gender (female and male), education (≤elementary school, middle school, high school, and ≥college), and monthly income (<2000, 2000–2999, 3000–3999, ≥4000 thousand Korean won).

Occupational characteristics covered weekly working hours, years of employment, employment type, and occupation. Weekly working hours were quantified as the actual number of working hours per week, excluding meal times, and were divided into three groups (≤40, 41–52, and ≥53). Work experience were classified as <5, 5–10, and >10 years. Employment types were divided into three groups: permanent, temporary and daily. Occupations were categorized into white-collar (e.g., managers, professionals, and clerks), pink-collar (e.g., service and sales workers), and blue-collar (e.g., craft and trades workers, equipment-machine operating, assembly workers, and elementary workers).

2.3. Statistical analysis

A descriptive analysis was conducted to assess the distribution of (1) sociodemographic and occupational characteristics; (2) physical, chemical, ergonomic, and psychological hazards; (3) organizational protection resources according to the enterprise size. The comparison across the three enterprise sizes was conducted using chi-squared tests for categorical variables. Furthermore, a trend analysis was conducted to ascertain whether the trends of hazard and organizational protection resources were increasing or decreasing based on the enterprise size. STATA/SE version 17.0 (StataCorp., College Station, TX, USA) was used for all statistical analyses. Significance was accepted at $p < 0.05$ after taking into account weighting. Survey weights were applied using the inverse of the probability of an observation being selected into the sample.

3. Results

3.1. Sociodemographic and occupational characteristics

The sociodemographic and occupational characteristics of the study population are presented in Table 1. Among the total of 5,879 manufacturing employees, 422 (7.2%) worked for micro enterprises, 3,149 (53.6%) for small enterprises, and 2,308 (39.3%) for medium-large enterprises. The most common age groups were those in their 50s (29.7%) at micro enterprises, in their 40s (28.2%) at small enterprises, and in their 30s (32.9%) at medium-large enterprises. Smaller enterprises had higher percentages of women, lower levels of education, and longer working hours per week (p for trend <0.001). In addition, the proportion of workers with less than five years of employment was greater for smaller firms. Most manufacturing workers were permanent employees (92.2%), while the proportion of daily employees was higher for smaller firms (p for trend <0.001). Lastly, smaller enterprises had more blue-collar workers, accounting for 70.7% at micro enterprises.

3.2. Physical, chemical, ergonomic psychological hazard exposure levels

Compared to workers in medium-large enterprises, those in micro enterprises showed a higher prevalence of exposure to physical, chemical, ergonomic, and psychological hazards, except for exposure to solvents, prolonged sitting, and experiencing a state of emotional unrest (Table 2). Regarding physical and chemical risks, workers in smaller companies demonstrated increased exposure to low temperatures (p for trend = 0.001) and tobacco smoke from others (p for trend = 0.007). However, in the case of exposure to solvents, the highest prevalence was observed among employees in medium-large enterprise (16.4%), followed by micro (15.1%), and small (13.5%) enterprises (p for trend = 0.023). Employees in smaller sized enterprises were more likely to be exposed to all ergonomic hazards except for sitting and standing (all p for trend <0.05). In particular, the highest proportion of being exposed to repetitive hand or arm movements (83.4%) was reported in micro enterprises. With regard to psychological hazards, workers at smaller enterprises reported a higher prevalence of the experience of dealing directly with non-employees or handing angry clients (p for trend <0.001).

3.3. Organizational protection resources

Along with the higher prevalence of exposure to most occupational hazards among employees of micro enterprises, opposite trends were observed regarding the presence of organizational protection resources (Fig. 3). Distribution of all organizational protection resources differed by enterprise size (all p for trend <0.001). In other words, employees of micro enterprises showed a lower prevalence of organizational protection resources: unions, councils, or committees (2.7%); a health and safety delegate (2.2%); regular meetings for expressing opinions (8.3%); and a place to deal with safety (4.9%). Information about health and safety was available to 58.9% of micro enterprise employees, compared to workers at small enterprises (68.2%) or medium-large (82.6%) enterprises.

4. Discussion

To the best of our knowledge, our study is the first trial to evaluate the distribution of hazards and organizational protection resources in the occupational environment of the Korean manufacturing industry by enterprise size. Our findings highlight the vulnerable working conditions among manufacturing workers in micro enterprises in the Republic of Korea. Employees in the smallest enterprises were more likely to face multifaceted risky situations and have the fewest resources as they are exposed to physical and chemical risks as well as ergonomically hazardous work requiring a high level of psychological demand.

The results for hazard exposure are partially similar to those in previous studies. First, regarding chemical and physical hazards, Sørensen et al. found that workers' skin contact exposure levels as well as the risks of mineral dust and hand vibrations were higher in small firms than in large firms [17]. Similarly, we observed similar trends with regard to skin contact with chemicals, exposure to fumes and dust, and vibration. Second, our study concurs with the previous work by Park et al. in highlighting that employees in smaller organizations report higher levels of ergonomic hazard exposure [10]. In particular, employees at enterprises with less than five employees are at the greatest risk of encountering painful or tiring postures, lifting heavy loads, standing, and engaging in repetitive hand or arm movements.

However, one particular difference in chemical exposure and physical and psychological hazards according to the size of the enterprise was also observed. Park et al. reported that employees of micro enterprises had the lowest self-reported exposure to a majority of physical and chemical hazards, i.e., vibration, noise, fume and dust, solvents, and skin contact with chemicals [10]. This is inconsistent with the result of the present study, which found that

all of the aforementioned risk factors are highest for employees of micro enterprises, except for solvent exposure. Similarly, Sørensen et al. found relatively low levels of emotional demand at enterprises with less than five employees [17]. In their study, they only focused on "emotional demands" without specifically inquiring about psychological hazards. In contrast, our findings show that employees of smaller enterprises are more likely to be exposed to dealing directly with non-employees, and handling angry clients compared to those working at medium-large enterprises.

There are two possible explanations for the differing results. First, the two aforementioned studies investigated the distribution of occupational risks by enterprise size without stratifying by industry sector. This can blur the distribution of results as the hazards from heterogeneous industry sectors with very different properties are all mixed together. This can potentially lead to biased reporting of workplace risk factors, such as higher physical hazards for employees of smaller enterprises. Second, consideration of weighting was needed. If weights are ignored during a statistical analysis, the estimates can be biased. These factors can explain why our results differ from the previous findings. When we conducted an additional analysis investigating the distribution of workplace hazards across all industries without applying survey weights as in previous studies, the prevalence of exposure to physical and chemical hazards followed a similar trend (Supplementary Table 2) [10]. For instance, it was observed that for most physical and chemical hazards, either employees of micro enterprises were the least exposed or those of medium-large enterprises were the most exposed: vibration (micro: 17.0; small: 23.3; medium-large: 24.7; $p < 0.001$), noise (micro: 16.6; small: 21.4; medium-large: 21.3; $p < 0.001$), fumes and dust (micro: 14.0; small: 17.9; medium-large: 16.8; $p < 0.001$), solvents (micro: 7.9; small: 7.9; medium-large: 8.7; $p = 0.163$), and to instances of skin contact with chemicals (micro: 9.1; small: 8.4; medium-large: 10.1; $p = 0.003$).

Another notable finding is that micro enterprises had very few organizational protection resources. This is similar to previous findings showing that micro enterprises had few occupational health and safety and psychosocial risk management resources [25]. One of the widely recognized ways in which enterprises can prevent occupational injuries and fatalities is by engaging in safety activities. In fact, activities such as regular safety meetings

Table 1
Demographic Distribution of Manufacturing Employees by Enterprise size in the Republic of Korea (Weighted *N* = 5,879)

	Total (*N*=5,879)	Enterprise size (No. of employees)				
		Micro (1-4) (*N* = 422)	Small (5–49) (*N* = 3,149)	Medium-Large (50-) (*N* = 2,308)	*P*-value[1]	*P* for trend[2]
	n (%)	*n* (%)	*n* (%)	*n* (%)		
Age (yr)					<0.001	
15–29	920 (15.7)	53 (12.5)	449 (14.3)	418 (18.1)		<0.001
30–39	1,660 (28.2)	72 (4.3)	829 (26.3)	759 (32.9)		<0.001
40–49	1,656 (28.2)	124 (29.4)	888 (28.2)	645 (28.0)		0.623
50–59	1,296 (22.1)	125 (29.7)	762 (24.2)	409 (17.7)		<0.001
≥60	347 (5.9)	48 (11.5)	223 (7.1)	76 (3.3)		<0.001
Gender					<0.001	
Female	1,805 (30.7)	195 (46.3)	1,134 (36.0)	476 (20.6)		<0.001
Male	4,074 (69.3)	227 (53.7)	2,015 (64.0)	1,833 (79.4)		<0.001
Education					<0.001	
≤Elementary school	76 (1.3)	13 (3.2)	47 (1.5)	16 (0.7)		<0.001
Middle school	262 (4.5)	40 (9.6)	165 (5.3)	56 (2.4)		<0.001
High school	2,219 (37.8)	216 (51.2)	1,300 (41.3)	703 (30.5)		<0.001
≥College	3,322 (56.5)	152 (36.1)	1,638 (52.0)	1,532 (66.4)		<0.001
Weekly working hours					<0.001	
≤40	3,450 (58.7)	198 (47.0)	1,739 (55.2)	1,513 (65.5)		<0.001
41–52	1,773 (30.2)	151 (35.9)	1,049 (33.3)	573 (24.8)		<0.001
≥53	656 (11.2)	72 (17.2)	361 (11.5)	223 (9.6)		<0.001
Monthly income (1,000 KRW)					0.566	
<2,000	162 (2.8)	10 (2.4)	91 (2.9)	61 (2.7)		0.892
2,000–2,999	75 (1.3)	10 (2.4)	30 (1.0)	34 (1.5)		0.944
3,000–3,999	52 (0.9)	2 (0.6)	25 (0.8)	24 (1.1)		0.216
≥4,000	5,591 (95.1)	399 (94.6)	3,003 (95.4)	2,188 (94.8)		0.638
Work experience (yr)					<0.001	
<5	2,220 (37.8)	201 (47.7)	1261 (40.0)	758 (32.9)		<0.001
5-10	2,109 (35.9)	154 (36.5)	1159 (36.8)	796 (34.5)		0.114
>10	1,550 (26.4)	67 (15.8)	729 (23.2)	754 (32.7)		<0.001
Employment type					<0.001	
Permanent	5,423 (92.2)	340 (80.6)	2,921 (92.8)	2,162 (93.7)		<0.001
Temporary	367 (6.2)	61 (14.5)	172 (5.5)	134 (5.8)		<0.001
Daily	89 (1.5)	21 (5.0)	56 (1.8)	13 (0.5)		<0.001
Occupation					<0.001	
White collar	2,701 (45.9)	96 (22.7)	1,437 (45.6)	1,168 (50.6)		<0.001
Pink collar	142 (2.4)	28 (6.7)	82 (2.6)	32 (1.4)		<0.001
Blue collar	3,037 (51.7)	298 (70.7)	1,630 (51.8)	1109 (48.0)		<0.001

[1] *P*-value for the chi-square test comparing the socio-demographic distribution of study population across enterprise size groups.
[2] *P*-value for testing for linear trend of socio-demographic distribution of study population across enterprise size groups.

Table 2
Self-reported Exposure to Physical, Chemical, Ergonomic and Psychological Hazards by Enterprise size among manufacturing employees in the Republic of Korea (Weighted N =5,879)

Workplace hazards	Enterprise size (No. of employees)				
	Micro (1–4) (N = 422)	Small (5–49) (N = 3,149)	Medium-Large (50-) (N = 2,308)	P-value[1]	P for trend[2]
	n (%)	n (%)	n (%)		
Physical and chemical hazard					
Vibration	215 (51.0)	1,399 (44.4)	1,029 (44.6)	0.712	0.137
Noise	159 (37.6)	1,100 (34.9)	771 (33.4)	0.421	0.078
High temperatures	122 (29.0)	802 (25.5)	598 (25.9)	0.522	0.515
Low temperatures	110 (26.0)	659 (20.9)	432 (18.7)	0.030	0.001
Fumes and dust	120 (28.4)	874 (27.8)	614 (26.6)	0.733	0.289
Solvents	64 (15.1)	424 (13.5)	379 (16.4)	0.077	0.023
Skin contact with chemicals	77 (18.2)	483 (15.4)	383 (16.6)	0.441	0.825
Tobacco smoke from other people	58 (13.7)	432 (13.7)	255 (11.1)	0.080	0.007
Direct contact with infectious materials	39 (9.3)	235 (7.5)	168 (7.3)	0.579	0.279
Ergonomic hazard					
Painful or tiring postures	279 (66.1)	1,558 (49.5)	1,085 (37.1)	<0.001	<0.001
Lifting or moving people	42 (10.0)	230 (7.3)	143 (6.2)	0.092	0.007
Lifting heavy loads	215 (50.9)	1,204 (38.2)	769 (33.3)	<0.001	<0.001
Standing	265 (62.8)	1,716 (54.5)	1,394 (60.4)	0.002	0.0423
Sitting	336 (79.7)	2,582 (82.0)	1,917 (83.1)	0.484	0.092
Repetitive hand or arm movements	352 (83.4)	2,406 (76.4)	1,702 (73.7)	0.005	<0.001
Psychological hazard					
Dealing directly with non-employees	152 (36.0)	641 (20.4)	351 (15.2)	<0.001	<0.001
Handling angry clients	56 (13.3)	250 (7.9)	131 (5.7)	<0.001	<0.001
State of emotional unrest	55 (13.0)	470 (14.9)	299 (13.0)	0.290	0.216

[1] P-value for the chi-square test comparing the prevalence of exposure to workplace hazards across enterprise size groups.
[2] P-value for the testing for linear trend of the prevalence of exposure to workplace hazards across enterprise size groups.

with employees, job descriptions that include safety duties, regular management communications about safety issues, and employee involvement are associated with fewer injuries and fatalities [26,27]. However, in the Republic of Korea's Enforcement of Occupational Safety and Health Act and the Serious Accidents Punishment Act, exceptions are made for small enterprises, and even more for micro enterprises [22,23]. This can have serious consequences as the least protected are at the workplaces with the highest risk and status quo legislation fails to protect them as well.

There are several explanations for why organizational protection resources and a safety culture may not be established at micro-enterprises. First, findings from European Agency for Safety Health at Work indicate that the context of the country and size of an enterprise play crucial roles in determining the level of OSH management [28,29]. At the national level, certain countries have pursued a strategy of exempting MSEs from specific labor law obligations as such enforcement may hinder the economic contribution and growth of these companies [1]. At the corporate level, companies often resort to adopting a "low-road strategy," which prioritizes competing on price and cutting costs, often at the employee-related costs of wages and working conditions. Consequently, at micro enterprises, the responsibility for industrial accidents has been shifted to the employees, and a mindset of "taking it for granted as the way things have always been done" develops [30]. As a result, given the weak regulations and poor safety culture, MSEs could have a higher risk of fatal accidents and injuries compared with larger firms [31–33]. These might align with the fact that the rate of occupational injury/illness and occupational fatality was particularly higher at MSEs compared with medium-large enterprises in manufacturing industries of the Republic of Korea (Fig. 1).

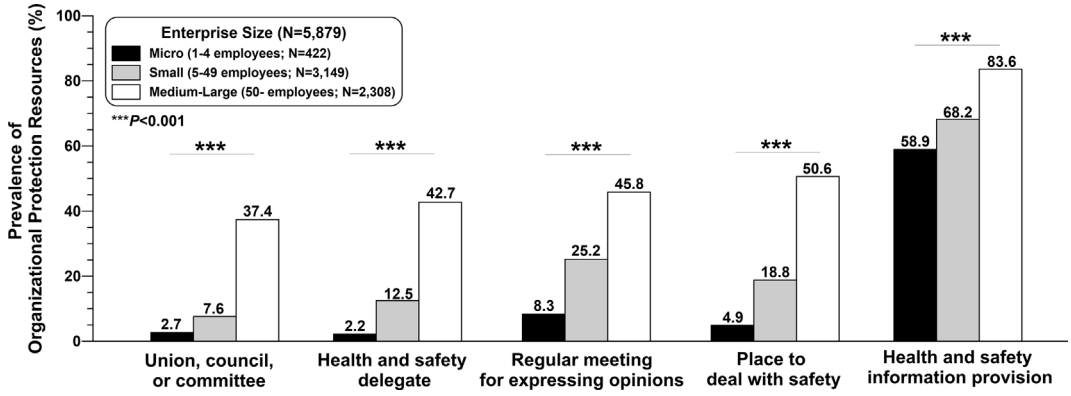

Fig. 3. Prevalence of organizational protection resources among manufacturing employees by enterprise size in the Republic of Korea (Weighted N = 5,879).

To ensure adequate health and safety management at small workplaces, institutional and structural resources and strong enforcement of the relevant legislation are needed. The SESAME project of the EU has provided several recommendations [30]. They noted the need for action-oriented, sector-specific, tailored designs that create institutional pressure by removing exceptions to legal obligations for even the smallest workplaces as well as multifaceted resource support to integrate health and safety into core operations. In addition, the International Labor Organization's report on promoting safety and health in micro, small, and medium enterprises recommends designing interventions and programs that include direct and personal contact with enterprises [1]. Furthermore, economic incentives are the most effective means of ensuring improvements in MSEs because they provide funds to address issues such as upgrading technology and reducing insurance premiums.

Several limitations of our study should be noted. First, because workplace hazards were assessed by using a self-reported questionnaire, there could be a possibility of measurement errors. Second, because the information on safety management activities was not available in our dataset, we should cautiously interpret the results about the distribution of protective resources at workplace. Future studies need to investigate how protective resources at workplace lead to more safety management activities and whether the association varies by enterprise size.

Third, there could be residual differences in workplace hazards among micro- and small enterprises within the manufacturing industry. For example, there may be differences in the number of workers and whether they focus on a single task or work across multiple tasks, influencing the nature and severity of risks workers are exposed to. Also, the manufacturing industry encompasses a wide range of sub-sectors, each with distinct characteristics, processes, and potential hazards, which may lead to variations in the types and levels of risks faced by workers.

Nevertheless, using a nationally representative dataset with a large sample of workers in the Republic of Korea enabled us to analyze the distribution of workplace hazards and protective resources at work as specific as possible even within a specific industry. This study showed that employees of micro and small enterprises in the manufacturing industry are most exposed to workplace risks and lack the resources to protect themselves. Future studies should explore whether these trends are consistent across other industries and examine the potential interaction between enterprise size and the industry sector regarding exposure to workplace hazards and the availability of protective resources at work. Our studies serve to highlight the importance of assessing different working conditions specific to certain industries and the enterprise sizes in future studies and to consider these differences when developing relevant occupational health and safety legislation.

5. Conclusion

This study showed the prevalence of hazard exposure and the presence of organizational protection resources according to the size of the enterprise among manufacturing workers in the Republic of Korea. Employees in smaller enterprises were more likely to be exposed to physical, chemical, ergonomic hazards, and psychological hazards. Meanwhile, they have less access to organizational protection resources such as labor union or safety delegate. These results showed neglected areas in terms of occupational health and safety at MSEs. Addressing these issues might requires a practical and strategic approach that encompasses hazard exposure reductions, legal regulations, resource support, and personal engagement.

CRediT authorship contribution statement

Hye-Lin Lee: Writing – original draft, Visualization, Formal analysis, Conceptualization. **Ji-Hwan Kim:** Writing – review & editing, Formal analysis. **Taesun Kang:** Writing – review & editing. **Garin Lee:** Writing – review & editing. **Hayoung Lee:** Writing – review & editing. **Hee Won Kim:** Writing – review & editing. **Seung-Sup Kim:** Writing – review & editing, Writing – original draft, Supervision, Funding acquisition, Conceptualization.

Conflicts of interest

The authors have no conflict of interest to declare.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.shaw.2024.06.001.

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