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Original Article

# The Influence of Safety Climate, Safety Leadership, Workload, and Accident Experiences on Risk Perception: A Study of Korean Manufacturing Workers

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ABSTRACT

*Background:* The purpose of this study was to identify the influence of workers' perceived workload, accident experiences, supervisors' safety leadership, and an organization's safety climate on the cognitive and emotional risk perception.

*Methods:* Six hundred and twenty employees in a variety of manufacturing organizations were asked to complete to a questionnaire. Among them, a total of 376 employees provided valid data for analysis. To test the hypothesis, correlation analysis and hierarchical regression analysis were used. Statistical analyses were conducted using IBM SPSS program, version 23.

*Results:* The results indicated that workload and accident experiences have a positive influence and safety leadership and safety climate have a negative influence on the cognitive and emotional risk perception. Workload, safety leadership, and the safety climate influence perceived risk more than accident experience, especially for the emotional risk perception.

*Conclusion:* These results indicated that multilevel factors (organization, group, and individual) play a critical role in predicting individual risk perceptions. Based on these results, therefore, to reduce risk perception related with unsafe behaviors and accidents, organizations need to conduct a variety of safety programs that enhance their safety climate beyond simple safety-related education and training. Simultaneously, it needs to seek ways to promote supervisors' safety leadership behaviors (e.g., site visits, feedback, safety communication, etc.). In addition, it is necessary to adjust work speed and amount and allocate task considering employees' skill and ability to reduce the workload for reducing risk perception.

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## 1. Introduction

Occupational safety problems are severe in the Republic of Korea: the rate of work-related injuries and illnesses in 2016 was 4.9 cases per 1,000 full-time workers, and the fatality rate was 0.96 per 10,000 full-time workers [1]. The rate is considered very high by Organization for Economic Cooperation and Development (OECD) standards. Therefore, researchers have attempted to examine possible antecedents of safe performance to develop and apply more effective and efficient safety programs.

Among various antecedents, the employees' perceptions of injury or accident risks, meaning the feeling of experiencing an accident or injury in the future at the workplace, have been identified as risk behavior predictors, and they also increased the probability of accidents and health injuries [2]. Risk perception can be defined as the individual's assessment with respect to the likelihood of undesired consequences occurring (i.e., injuries, accidents, diseases) [3], and the level of perceived risk can be different, depending on the type of risk [4,5]. Perceived risk has been included in preventative health models [6] and in the protection motivation theory [7].

Although these models suggest that workers adopt protective behavior when anticipating and wishing to avoid the adverse consequences of risky actions [8], the influence of perceived risk on safety performance (behavior, injuries, and accidents) will differ in the occupational setting. Repeated exposure to various hazards in work settings can lead to risk adaptation, which may be conducive to unsafe behavior and violations by perceiving dangerous

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situations or work as less dangerous than they actually are. In addition, the risk perception of accidents or injuries induces strain (i.e., anxiety, distress, and tension) and reduces physical and psychological resources. Specifically, exposure to a risky working environment leads to physical fatigue, limitations of cognitive processing capacity, and negative emotions, thus encouraging workers to finish work quickly [8,10]. In this process, the possibility of dangerous behavior increases the likelihood of accidents, and injuries. Therefore, it is necessary to study the variables that can reduce the employees' risk perception in occupational settings because the higher it is, the higher the possibility of the accident.

In this regard, workers' attitudes toward safety on the job can influence their risk perceptions, as well as safety management, procedures, and rules [9]. In addition, a significant relationship was found between perceived risk and the safety climate of an organization [10,11]. Wilpert [12] stresses that, in general, many incidents are not caused by a single factor but occur as the result of a chain of factors that interact at various levels of the system. Similarly, perceptions of injury or accident risk are influenced by multilevel factors, including the individual charateristics of himself/herself, work task, work environment, supervisor leadership, organizational climate, government, and culture [13,14].

In the safety research area, there has been a shift from psychological explanations to sociological and organizational frameworks for understanding risk perceptions and risk behavior [15]. Rundmo indicated that testing models of risk perception without identifying the safety climate and the work environment does not seem to be an appropriate strategy [2]. In an occupational setting, the employees' risk judgments have to be related to the "safety climate" and other organizational and social factors that are necessary for safety [16]. However, few studies have examined numerous plausible multilevel antecedents of perceived risk, such as one's workload, accident experience, supervisors' safety leadership, and the organizational safety climate. Identifying the relative influence of various factors that affect risk perception and the correlations among them can help to determine which ones should be prioritized in determining and implementing safety management policies.

Therefore, the purpose of this study was to identify the influence of several plausible multilevel antecedents, namely workers' perceived workload, accident experience, safety leadership, and the safety climate on the risk perception.

## 2. Theoretical background and hypotheses

### 2.1. The safety climate and risk perception

Zohar [17] first introduced the concept of the safety climate to describe employees' perceptions of the value and role of safety in organizations. Specifically, a safety climate is defined as employees' shared perceptions of the importance and the right priority of safety, safety policies, procedures, and practices in their organization [18,19]. The safety climate has been examined as an important antecedent of safety performance (safety behavior, injuries, and accidents) in various work settings [18,20].

Also Safety climate could be related to workers' perceived risk of injuries and accidents [16,20]. Mearns and Flin [21] suggested that employees' risk perceptions were influenced not only by physical working conditions but also by the organizational safety climate. In support of this, Oliver et al [22] found that the safety management, being a subfactor of the safety climate, negatively correlated with perceived physical work environment variables, including hazard perception.

The safety climate is also a precursor of proactive risk management in an organization. Proactive risk management has an impact on employees' safety knowledge and motivation to engage in safe practices. This knowledge and motivation lead to development of the competence of complying with safety procedures and of working safely to the employees [23]. In addition, conducting proactive risk management makes employees feel that the organization is safeguarding their health and safety at work, which leads to a decrease in their risk perception. Based on the aforementioned research findings, we propose that a positive safety climate as an organizational factor may reduce workers' risk perceptions.

**H1**. The safety climate has a negative influence on the perceived risk of an accident.

### 2.2. Safety leadership and risk perception

In recent years, the important role of safety leadership in the field of occupational health and safety is increasingly gaining acceptance. Wu [24] defines safety leadership as "the process of interaction between leaders and followers, through which leaders could exert their influence on members to achieve organizational safety goals under the circumstances of organizational and individual factors." Zohar [25] suggests that the concern for employee safety is expressed and operationalized by supervisors' or leaders' behaviors. The display of consistent supervisory behavior and reactions about safety promotes shared perceptions among the employees concerning the priority of safety. Hofmann and Morgeson [26] proposed that employees have a tendency to commit themselves to safety and to maintain an open communication about it when they have good relationships with their supervisors and managers [27].

Prior research emphasized the importance of leaders in improving employees' safety behavior and safety outcomes [25,26,28–30]. The existing research suggests that safety leadership can serve as an important factor in reducing the level of perceived risk among employees. Nielsen and Cleal [31] reported a negative correlation between authentic leadership and risk perception. Based on the results of the aforementioned research, we propose that a supervisor's positive safety leadership, being a group or team factor, may decrease workers' risk perception.

**H2**. Safety leadership has a negative influence on the perceived risk of an accident.

### 2.3. Workloads, accident experiences, and risk perceptions

A workload can refer to different yet related constructs such as job demands and job overload. However, a workload results from mental processes when performing tasks, depending on the worker's capabilities and the work demands. When employees have an excessive workload or difficult tasks beyond their skills and abilities, this can serve as a stressor for them. A workload has been linked to a number of strains, including anxiety and fatigue [32]. Workload is also relevant to the job demands-resources model of stress which suggests that jobs are stressful when a work demand exceeds the individual's resources to deal with it [33].

Turner et al [34] found that employees reporting high job demands defined the safety role in their jobs more narrowly and that greater strain was associated with more accidents and near misses [34–37]. An increasing workload brings forth higher job strain, indicating the operation of compensatory processes which leads to employees looking for less effortful ways to deal with safety-related goals. Therefore, it will be difficult to ensure that workers with a high workload comply with safety regulations, and it is likely that such employees will perceive a high risk of an accident.

Besides the workload, an accident experience can also influence risk perception. Workers who have witnessed accidents of peers or experienced accidents themselves are more likely to perceive a higher accident risk, even if the probability of an accident is not greater after such an event has occurred. Rundmo [38] found that offshore oil personnel who had suffered an accident themselves felt less safe than those who had not. Workers on high-injury platforms perceived themselves as less reliable than workers on low-injury platforms. Based on the aforementioned research results, we propose that employees' workload and accident experiences, being individual factors, increase risk perception.

**H3**. Workload has a positive influence on perceived accident risk.

**H4**. Accident experience has a positive influence on the perceived risk of an accident.

## 3. Materials and methods

### 3.1. Data collection and participants

We sent e-mails and made phone calls to HR managers or safety officers from 100 randomly selected manufacturing factories in listed in the enterprise information portal (http://sminfo.mss.go.kr) managed by government of the Republic of Korea, explained the research purpose, and asked about the possibility of conducting a questionnaire survey. Of the 100 selected factories, 21 of them agreed to participate in the survey. The questionnaire, along with gifts (coffee coupons), were sent via postal mail. The paper-based survey was distributed at workplace by HR managers or safety officers of the participating manufacturing factories. The consent form was enclosed with the survey, explaining the purpose of the study and ethical guideline and seeking agreement, and signature confirming voluntary participation in this survey was included. From a total of 620 distributed copies, 396 were returned. The response rate was 63.9%. Approximately 3–22 questionnaires were returned from each company. Twenty copies of the questionnaires with a high number of missing or inadequate responses were excluded from the analysis. Valid data provided by 376 employees were available for analysis.

The male to female ratio was 76.6–23.4. The mean age of the sample was 49.53 ($SD$ = 10.43) years, and the work experience ranged from 1 to 41 years with a mean of 16.31 years ($SD$ = 10.21). The number of workers per organization in the sample included less than 10 workers (20.2%), 22–29 (25%), 30–49 (45.7%), and more than 50 (9.1%). The sample included singles (13.3%), married individuals (84%), and a rest category ("etc." 2.7%). The rate of respondents reported either a direct or indirect experience of an accident was 17%.

### 3.2. Measures

#### 3.2.1. Safety leadership

Safety leadership was measured using five items that were extracted from Zohar's group safety climate scale [39] which consists of two subscales: supervisory action and expectation. Sample items are "My supervisor says a good word whenever he sees a job done according to the safety rules" and "My supervisor seriously considers any worker's suggestion for improving safety." The reliability and validity of the Korean version of the leadership scale were verified in Kim and Park's study [40]. Participants indicated their level of agreement with each item on a 5-point scale (1 = strongly disagree, 5 = strongly agree). Cronbach $\alpha$ in the present study was 0.743.

#### 3.2.2. Safety climate

The safety climate was assessed by four subscales used by Griffin and Neal [18] with a total of 16 items, including safety management values, safety communication, safety education and training, and safety systems. The reliability and validity of the Korean version of the safety climate scale were verified in Kim and Park's study [40]. Safety management values were measured by four items that asked about the degree to which executives valued safety in the workplace ($\alpha$ = 0.860). An example item was "I think management is sincere in its efforts to ensure employee safety." Safety communication was assessed by four items that asked how safety issues were communicated ($\alpha$ = 0.859). An example item was "There is open communication about safety issues within this workplace." Safety education and training measured the degree to which the staff was trained in safety procedures with five items ($\alpha$ = 0.876). An example item was "The contents of the health and safety education and training provided by my organization are easy to understand." The safety system (or regulations) was assessed by three items about the effectiveness of the safety system in the organization ($\alpha$ = 0.876). An example item was "Safety regulations of our organization are well operated and they are efficient and useful for preventing risk behaviors." The employees responded on a 5-point scale ranging from "strongly disagree" (1) to "strongly agree" (5).

#### 3.2.3. Workload and accident experience

Workload was measured using five items that were extracted from the occupational stress scale for Korean Employees developed by Jang et al [41]. Sample items included "I did a lot of work and always rushed to meet deadlines." and "Often, I need to do another task before finishing the current task." Cronbach $\alpha$ in the present study was 0.819, and workers responded on a 5-point scale ranging from "very rare" (1) to "very often" (5).

Accident experience was assessed with two items questioning direct or indirect experience. The items were "Have you ever witnessed or heard about an accident indirectly in your organization within one year?" and "Have you ever experienced an accident within one year?" The response scale was binomial ("Yes" or "No").

#### 3.2.4. Risk perception

Risk perception was assessed with five items that were extracted from previous studies [2,10,42]. Risk perception refers to a worker's perception and anxiety about his or her probability of suffering a work-related accident or illness. Accordingly, Rundmo and Sjöberg [43] suggested that an individual's risk perception can be separated into one cognitive component and one emotional one. In this study, the measurement of risk perception was intended to measure both. Sample items were "I am always worried about being injured on the job in this workplace." and "In my workplace, the chances of being involved in an accident are quite large." Employees responded on a 5-point scale ranging from "strongly disagree" (1) to "strongly agree" (5).

The items of risk perception used in this study were translated into Korean from the original questionnaire and back translated into English by professional translators. Then, researchers double checked and refined the items for the correctness of translation. Cronbach $\alpha$ was 0.896 for cognitive risk perception and 0.813 for emotional risk perception.

### 3.3. Statistical analysis

The data collected from the paper-based survey were entered into SPSS (IBM) by research assistants. To ensure the reliability of coding, researcher randomly selected questionnaires and compared the computerized data with the original survey. The Statistical Package for Social Sciences (SPSS) program, version 23.0 (IBM), was

used for statistical analysis. Cronbach α coefficient was calculated to evaluate the internal consistency of the scales measuring the safety climate, safety leadership, workload, and perceived risk. Pearson's r determined the associations among measured variables in this study.

Hierarchical multiple regression analysis was applied for the identification of the predictive factors that were associated with cognitive and emotional risk perception. In step 1, the demographical control variables age, sex, working hours, number of workers, marriage status, and working years were entered. In the next step, the safety climate as an organizational factor, safety leadership as a group or a team factor, and—in sequence—workload and accident experience as individual factors were added to the regression equation. A two-sided $p$ value of less than 0.05 was considered statistically significant.

## 4. Results

Table 1 shows the means, standard deviations, and correlation coefficients of the measured variables. There were positive significant correlations between risk perception, accident experience ($r = 0.26$, $p < 0.05$), and workload ($r = 0.47$, $p < 0.01$) but negative ones between risk perception, safety climate ($r = -0.33$, $p < 0.01$), and safety leadership ($r = -0.40$, $p < 0.01$). In addition, the safety climate was positively associated with safety leadership ($r = 0.66$, $p < 0.01$) but negatively with workload ($r = -0.24$, $p < 0.01$) and accident experience ($r = -0.13$, $p < 0.05$). Safety leadership had a negative significant correlation with workload ($r = -0.36$, $p < 0.01$) but was not significantly associated with accident experience ($r = -0.04$, $p > 0.05$).

The results of hierarchical multiple regression analysis for cognitive risk perception (see Table 2) revealed that the safety climate of organizations ($ß = -0.26$, $t = -4.96$, $p < 0.01$) and supervisors' safety leadership ($ß = -0.21$, $t = -3.13$, $p < 0.01$) negatively affected the perceived risk of accidents, whereas individual workload ($ß = 0.30$, $t = 5.70$, $p < 0.01$) and accident experience ($ß = 0.19$, $t = 3.88$, $p < 0.01$) positively affected. In step 1, the demographic variables displayed no influence on perceived risk [$F(6, 367) = 0.97$, $p > 0.05$]. The safety climate accounted for 8% of cognitive risk perception [$F(7, 366) = 4.40$, $p < 0.01$], 2% of safety leadership [$F(8, 365) = 5.17$, $p < 0.01$], and 14% of accident experience and workload [$F(10, 363) = 11.06$, $p < 0.01$].

**Table 2**
Results of the hierarchical multiple regression analysis for cognitive risk perception

| Step | Step 1 | | Step 2 | | Step 3 | | Step 4 | |
|---|---|---|---|---|---|---|---|---|
| Variables | ß | t | ß | t | ß | t | ß | t |
| Gender* | 0.02 | 0.29 | 0.00 | 0.04 | 0.01 | 0.22 | 0.06 | 1.24 |
| Age | 0.08 | 1.27 | 0.05 | 0.77 | 0.05 | 0.88 | 0.09 | 1.59 |
| Working hours | 0.03 | 0.62 | −0.03 | −0.50 | 0.01 | 0.21 | 0.03 | 0.68 |
| # of Workers | 0.08 | 1.56 | 0.10 | 1.87 | 0.08 | 1.46 | 0.03 | 0.66 |
| Marriage status† | 0.01 | 0.16 | 0.01 | 0.19 | 0.02 | 0.37 | −0.02 | −0.40 |
| Working years | 0.01 | 0.17 | 0.02 | 0.43 | 0.03 | 0.51 | 0.03 | 0.62 |
| Safety climate | | | −0.26** | −4.96 | −0.11 | −1.54 | −0.06 | −0.84 |
| Safety leadership | | | | | −0.21** | −3.13 | −0.14* | −2.12 |
| Accident experience‡ | | | | | | | 0.19** | 3.88 |
| Workload | | | | | | | 0.30** | 5.70 |
| $R^2$ | 0.02 | | 0.08 | | 0.10 | | 0.24 | |
| $F$ | 0.97 | | 4.40** | | 5.17** | | 11.06** | |
| $\Delta R^2$ | | | 0.06 | | 0.02 | | 0.14 | |

Gender, marriage status, and accident experience were dummy variables.
*$p < 0.05$; **$p < 0.01$.
* 0 = female, 1 = male.
† 0 = not married, 1 = married.
‡ 0 = No, 1 = Yes.

For emotional risk perception (see Table 3), safety climate of organizations ($ß = -0.41$, $t = -8.42$, $p < 0.01$) and supervisors' safety leadership ($ß = -0.39$, $t = -6.23$, $p < 0.01$) were negatively related, whereas individual workload ($ß = 0.34$, $t = 7.25$, $p < 0.01$) and accident experience ($ß = 0.09$, $t = 2.04$, $p < 0.05$) were positively related. In step 1, the demographic variables displayed no influence on perceived risk [$F(6, 367) = 1.10$, $p > 0.05$]. The safety climate accounted for 16% of the emotional risk perception variance [$F(7, 366) = 11.25$, $p < 0.01$], 8% of safety leadership [$F(8, 365) = 15.71$, $p < 0.01$], and 12% of accident experience and workload [$F(10, 363) = 21.70$, $p < 0.01$].

**Table 1**
Means, standard deviations, and correlation coefficients among the measured variables

| Variables | 1 | 2 | 3 | 4 | 5 | 6a | 6b | 6c | 6d | 6 | 7 | 8 | 9 | 10a | 10b | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Gender* | — | | | | | | | | | | | | | | | |
| 2. # of Workers | 0.09 | — | | | | | | | | | | | | | | |
| 3. Working hours | −0.00 | 0.20** | — | | | | | | | | | | | | | |
| 4. Age | −0.01 | −0.14** | 0.03 | — | | | | | | | | | | | | |
| 5. Working years | −0.11* | −0.15** | 0.09 | 0.33** | — | | | | | | | | | | | |
| 6a. Safety value | −0.03 | −0.04 | −0.08 | −0.09 | 0.02 | — | | | | | | | | | | |
| 6b. Safety communication | −0.09 | 0.07 | −0.16** | −0.12* | −0.01 | 0.72** | — | | | | | | | | | |
| 6c. Safety education & training | 0.00 | 0.07 | −0.28** | −0.11* | −0.02 | 0.53** | 0.73** | — | | | | | | | | |
| 6d. Safety system | −0.08 | −0.05 | −0.20** | −0.14** | −0.06 | 0.58** | 0.66* | 0.79** | — | | | | | | | |
| 6. Safety climate | −0.06 | 0.01 | −0.21** | −0.13* | −0.03 | 0.80** | 0.88** | 0.89** | 0.90** | — | | | | | | |
| 7. Safety leadership | −0.02 | −0.06 | 0.01 | −0.02 | 0.03 | 0.56** | 0.57** | 0.56** | 0.59** | 0.66** | — | | | | | |
| 8. Workload | −0.08 | 0.16** | −0.05 | −0.08 | −0.08 | −0.20** | −0.20 | −0.18** | −0.23** | −0.24** | −0.36* | — | | | | |
| 9. Accident experience† | −0.09 | −0.01 | 0.06 | 0.04 | 0.02 | −0.04 | −0.07 | −0.19* | −0.14* | −0.13 | −0.04 | 0.24** | — | | | |
| 10a. Cognitive risk perception | 0.02 | 0.08 | 0.05 | 0.08 | 0.02 | −0.23** | −0.21** | −0.18** | −0.28** | −0.26** | −0.29** | 0.40** | 0.27** | — | | |
| 10b. Emotional risk perception | 0.03 | −0.02 | −0.07 | 0.09 | −0.02 | −0.32** | −0.28** | −0.34** | −0.39** | −0.39** | −0.48** | 0.48** | 0.19** | 0.59** | | - |
| 10. Risk perception | 0.02 | 0.05 | 0.01 | 0.08 | 0.00 | −0.29* | −0.25** | −0.26** | −0.35* | −0.33** | −0.40** | 0.47** | 0.26** | 0.95** | 0.82** | — |
| *M* | 0.77 | 2.51 | 8.37 | 49.53 | 16.31 | 4.42 | 4.20 | 3.88 | 3.68 | 4.04 | 4.00 | 2.57 | 0.17 | 2.85 | 2.51 | 2.71 |
| *SD* | 0.42 | 1.10 | 0.71 | 10.40 | 10.21 | 0.59 | 0.59 | 0.67 | 0.80 | 0.57 | 0.61 | 0.74 | 0.38 | 0.90 | 0.83 | 0.78 |

*$p < 0.05$; **$p < 0.01$.
* 0 = female, 1 = male.
† 0 = No, 1 = Yes.

**Table 3**
Results of the hierarchical multiple regression analysis for emotional risk perception

| Step | Step 1 | | Step 2 | | Step 3 | | Step 4 | |
|---|---|---|---|---|---|---|---|---|
| Variables | ß | *t* | ß | *t* | ß | *t* | ß | *t* |
| Gender* | 0.02 | 0.32 | −0.01 | −0.15 | 0.01 | 0.17 | 0.05 | 1.20 |
| Age | 0.08 | 1.25 | 0.03 | 0.53 | 0.04 | 0.79 | 0.08 | 1.57 |
| Working hours | −0.07 | −1.35 | 0.16 | −3.26 | −0.09 | −1.89 | −0.06 | −1.41 |
| # of Workers | 0.00 | −0.03 | 0.02 | 0.37 | −0.02 | −0.47 | −0.07 | −1.67 |
| Marriage status† | 0.05 | 0.87 | 0.04 | 0.80 | 0.06 | 1.11 | 0.02 | 0.46 |
| Working years | −0.04 | 0.67 | −0.02 | −0.42 | −0.02 | −0.36 | −0.01 | −0.28 |
| Safety climate | | | −0.41** | −8.42 | −0.14* | −2.16 | −0.10 | −1.69 |
| Safety leadership | | | | | −0.39** | −6.23 | −0.29 | −4.89 |
| Accident experience‡ | | | | | | | 0.09* | 2.04 |
| Workload | | | | | | | 0.34** | 7.25 |
| $R^2$ | 0.02 | | 0.18 | | 0.26 | | 0.38 | |
| *F* | 1.10 | | 11.25** | | 15.71** | | 21.70** | |
| $\Delta R^2$ | | | 0.16 | | 0.08 | | 0.12 | |

Gender, marriage status, and accident experience were dummy variables.
*$p < 0.05$; **$p < 0.01$.
* 0 = female, 1 = male.
† 0 = not married, 1 = married.
‡ 0 = No, 1 = Yes.

## 5. Discussion

The results of this study indicated that workload and accident experiences positively influenced the perceived risk of an accident, whereas supervisors' safety leadership and safety climate of organizations exhibited a negative impact. All four hypotheses were supported. More specifically, our results revealed that people who work for a company with more positive safety leadership and climate perceive a lower accident risk than those with both lower safety leadership and climate. In addition, workers with a lower workload and accident frequencies have perceptions of less accident risk than those with a higher workload and accident rates. Overall, our findings indicated that multilevel factors play a critical role in predicting individual risk perception.

Our findings are consistent with prior research which suggests that organizational-level predictors play a role in safety outcomes [28,39,44] and risk perception [2,8,10,45]. While multiple-level models are becoming more common in the safety research literature, our findings provide additional evidence that future research should consider the inclusion of predictors at different levels [2,46]. Notably, the results of the regression analysis indicated that the degree of influence that workload, safety leadership, and the safety climate exert on perceived risk was greater than accident experience.

This study extended previous research by systematically examining plausible antecedents of risk perception, including individual, team or department, and organizational-level predictors. A few studies previously discussed the positive effect of safety climates on the decrease of risk perception [2,8,10,23]. However, the influence of safety leadership on risk perception has not been examined yet. This study provides preliminary results in this regard. There are at least two possible explanations for how safety leadership may affect the employees' risk perception. Supervisors showing high safety leadership can have a direct impact on risk perception by positively influencing workers' understanding of safety issues, their motivation to follow safety procedures, and actual safety compliance, as well as participant behavior. Especially, supervisors' safety leadership behaviors such as frequent working site visits, praise and recognition for safety behaviors, corrective feedback for risk behavior, simple on-the-job safety education and training, and various communications related to safety and hazards can lower workers' perception of risk. However, safety leadership may also influence risk perception indirectly through organizational factors, such as the safety climate [31]. Future research should include the role of safety leadership in studies on risk perceptions for industrial safety and health.

In addition, although workload has been considered an important variable in stress research and the job demands-resources model related to safety [45] for decades, the influence of workload on risk perception had not been examined. In the present study, we demonstrated that workload has a positive impact on risk perception. A worker with a high workload experiences great distress, which is likely to lead to an accident and/or burnout. Based on this, we suggest that it is necessary to provide appropriate rest time for the personnel and to adjust their job dispersion and their work speed to reduce the employees' workload.

For risk perception, we divided it into emotional and cognitive components and analyzed them separately. The results indicated that safety climate and safety leadership had greater effects on emotional risk perception than on cognitive perception. The previous studies indicated that anxiety and concerns about accidents are closely related to stress which may affect workers' health and organizational safety [7,35,45]. These findings highlight that supervisors' safety leadership and organizational safety climate are more important than other variables for reducing emotional risk perception, stress and improving health of employees.

Based on our results, ensuring appropriate work hours, work speed, and break time in the manufacturing safety policy would be necessary to reduce workload and risk perception of workers. Furthermore, governmental policies may also be required to promote companies to get involved in planning and implementation of various programs that enhance safety leadership and safety climate at workplace.

The present study had several limitations. One was that the questionnaire of safety leadership focused on line supervisors' safety management behaviors and expectations. Existing safety leadership studies, however, include various subfactors in the concept of safety leadership. Wu et al [47] added safety caring, safety coaching, and safety controlling as subfactors of safety leadership. Lu and Yang [48] incorporated safety motivation, safety policy, and safety concern. Furthermore, Eid et al [27] included self-awareness, relational transparency, moral perspective, and balanced processing. The strength of safety leadership and its subfactors' impact on perceived risk may also vary according to different scales.

Apart from different safety leadership scale, the status and responsibility of the managers associated with safety management are diverse. Specifically, the safety leadership of line supervisors, middle managers, senior managers, managers in safety departments, and executives in the same organization will all have different impacts on risk perception and workers' safety behavior [49]. Future studies should aim to investigate and verify the relative effect of various safety leadership subfactors across different positions on perceived risk, enabling us to develop a richer theory with practical implications in the safety research area.

Another limitation of the present study was that this study used a cross-sectional design. The data were collected during the same time period using only self-report questionnaires. Therefore, it was difficult to overcome the common method bias that potentially inflates the relationships between constructs. Finally, owing to the nature of our data, safety leadership and the safety climate were only assessed at an individual level and not at an aggregated one. Actual group-level safety leadership and an organizational-level safety climate can only be calculated when it is possible to identify the units and organizations to which individuals belong for data aggregation. However, due to the limitation of data collection method, the present study only provided the results of individual-level analysis. Therefore, cautiousness is required to generalize the results in various settings.

These limitations notwithstanding, this study considered multilevel factors (organization, group, and individual) and attempted a broader investigation of workers' risk perceptions. Other variables such as safety knowledge, motivation, personality, and social support must also be investigated to expand risk perception research.

## Conflicts of interest

The authors have no potential conflicts of interest to report relevant to this article.

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