박사학위논문

Three Essays on Corporate Safety Management and Workers' Safety Behavior

- Focused on Manufacturing Industry -

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한 성 대 학 교 대 학 원

지식서비스&컨설팅학과

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ABSTRACT

Three Essays on Corporate Safety Management and Workers' Safety Behavior
- Focused on Manufacturing Industry -

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This dissertation deals with safety management and workers' safety behavior from three perspectives of safety management in companies: safety leadership, safety management practices, and safety culture.

The first essay examines the effects of safety leadership and trust in leader on workers' safety behavior. We studied whether leaders' safety leadership and trust in leader affect workers' safety behavior through improvement of workers' involvement and safety knowledge by targeting the manufacturing industry, which has the second highest number of industrial accidents after the construction industry, and confirmed that safety leadership and trust in leader have a positive effect on workers' safety behavior. The second essay examines the impact of safety

management practices on workers' safety behavior and finds that safety management practices such as safety training, workers' involvement, safety rules and procedures, and safety leadership have a positive impact on workers' safety behavior by improving workers' safety knowledge and safety motivation. The third essay examines the impact of safety culture on workers' safety behavior and finds that an organizational safety culture consisting of reporting culture, just culture, flexible culture, and learning culture enhances safety climate and safety motivation, leading to workers' safety behavior.

The coefficient of determination (R^2) of the three research models for the dependent variable, safety behavior, was 0.582 for the safety management practices model, 0.517 for the safety leadership model, and 0.506 for the safety culture model. Therefore, the safety management practices model has the highest coefficient of determination.

The contributions of this study are as follows. First, until now safety research has been focused on the construction, aviation, military, and school sectors, but this study contributed to the revitalization of safety research in the manufacturing industry, which has the second highest number of industrial accidents after construction, by focusing on manufacturing workers. Second, for corporate safety managers, it confirms the importance of managing worker involvement, safety knowledge, safety climate, and safety motivation as mediators in driving workers' safety behavior. Third, the empirical study confirmed the correlation between the variables that can be used as a reference for the operation of a company's safety and health management system.

【Keywords】Safety Leadership, Trust in Leader, Workers' Involvement, Safety Knowledge, Safety Management Practices, Safety Culture, Safety Climate, Safety Motivation, Safety Behavior

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Chapter 1. A study on the effects of safety leadership and trust in leader on safety behavior mediated by workers' involvement and safety knowledge*

This study empirically investigated the relationship between workers' safety behavior and safety leadership, trust in leader, workers' involvement, and safety knowledge in the enterprise. It analyzed the role of the factors to identify and analyze factors that enhance workers' safety behavior that contribute to the prevention of major accidents. When industrial accidents occur, companies have to bear huge loss costs due to direct costs of compensating the victims and indirect costs such as human loss, material loss, production loss, and time loss. Based on the results of previous studies, this study investigated the effects of managerial safety leadership and workers' trust in leader on safety behavior through the mediation of workers' involvement and safety knowledge among production, technical, and labor workers in the manufacturing industry. Statistical analysis was conducted on 271 manufacturing workers using SPSS and PLS. The results showed that safety leadership and trust in leader can lead to workers' involvement and positively affect workers' safety knowledge acquisition, which can lead to workers' safety behavior.

【Key Words】Safety Leadership, Trust in Leader, Workers' Involvement, Safety Knowledge, Safety Behavior

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1.1 Introduction

As of 2023, the population of South Korea is 51.41 million, and the total number of workers, including wage and non-wage workers, is 24.94 million. Workers account for 48.5% of the total population (Statistics Korea, Economically Active Population Survey, 2023). Since 1980, workers have been demanding workers' rights and a safe environment. In response, the Korean government has enacted laws to protect workers and mandated employers to take various measures to ensure workers' safety and health. More recently, the Serious Accident Punishment Act was enacted to punish those in charge of management if a serious accident occurs while violating their obligations to ensure the safety and health of workers. Despite these legal and institutional measures, the number of occupational accidents has not improved. According to statistics from the Ministry of Employment and Labor, the industrial accident rate in 2022 was 0.65%, an increase of 0.02% from the previous year. The number of injured workers was 130,348 in 2022, up 6.2% from the previous year, and as of 2021, Korea's occupational fatality rate (the rate of deaths within one year of an accident) was 4.3 per 100,000 workers, compared to 0.7 in Germany, 0.8 in Sweden, 1.5 in Japan, and 2.1 in Spain, among other OECD countries. The economic losses due to industrial accidents are also increasing every year, and according to the Ministry of Employment and Labor's e-Employment Labor Index, the estimated economic losses due to industrial accidents in Korea will reach KRW 25 trillion in 2018, KRW 29 trillion in 2019, and KRW 32 trillion in 2022. When an industrial accident occurs, companies have to bear huge loss costs due to direct costs of compensating the victims, as well as indirect costs such as human loss, material loss, production loss, and time loss. These losses can be a significant sunk cost for organizations. As a result, organizations seek to reduce these costs. As

a result, companies take various measures to prevent major accidents. Among them, many studies have been actively implemented to systematize various measures to strengthen the safety behavior of workers, such as safety rules and regulations and safety behavior itself. Heo and Lee (2022) state that corporate management is undergoing a paradigm shift from profit-driven management to sustainable management, and ESG management is becoming a new management paradigm. ESG management is becoming a necessity of the times, and sustainable management through ESG requires changes and expenditures that are burdensome for companies (Cho & Lee, 2023). From the perspective of sustainability management, safety-related management can be seen to be in line with the recently emerging ESG management. In particular, a number of studies have shown that the safety knowledge, attitudes, and influence of managers who supervise workers are closely related to workers' safety behaviors (Greenleaf, 1977; Covey, 2004). This study is different in that it examines how managerial safety leadership, along with leader trust, influences worker safety knowledge and worker engagement, which ultimately influences worker safety behavior.

Therefore, this study aims to empirically examine the relationship between workers' safety behavior and managerial safety leadership, trust in leader, workers' involvement, and safety knowledge, and to analyze the role of the variables in the process, in order to enhance workers' safety behavior that contributes to the prevention of critical accidents in companies. Accordingly, this study aims to determine, first, the impact of managerial safety leadership and trust in leader on workers' involvement in safety. Second, it seeks to determine the impact of administrative safety leadership and trust in leader on safety knowledge. Third, we want to determine the impact of worker participation on safety behavior. Fourth, we want to determine the effect of safety knowledge on safety behavior.

1.2 Literature Review

1.2.1 Safety Leadership

In the field of occupational safety, the concept of safety has been studied since the 1980s and has been actively studied since the 2000s. In particular, many studies have been conducted to prevent industrial accidents, and many studies have emphasized the importance of safety leadership by managers. Bass (1985) defined safety leadership as 'Give & Take'. Bass (1985) defined safety leadership as 'Give & Take', in which leaders give what they want from workers (Give) and take safety behaviors from workers (Take) so that mutual satisfaction between leaders and workers is sustained. In addition, Wu et al. (2010) referred to safety leadership as a mutual alignment process between leaders and employees that is created when leaders strongly exert their influence on employees to achieve organizational goals. In particular, site managers are responsible for maintaining a safe workplace through safety management, supervision, and instruction of workers in the field. Therefore, the safety management behavior and safety awareness of site managers directly affect the safety level of the work site and the occurrence of disasters. In Australia, the New South Wales Minerals Council (NSWMC, 2005) defines safety leadership as 'influencing and changing the values and beliefs of workers to change their behaviors, attitudes, and habits and to improve the safety culture of the site,' which means that workers' values and beliefs recognize that safety is important and fundamental to be considered in all activities, and that they believe that if they work in a safety-conscious manner, it will be recognized by their colleagues, supervisors, and management. The UK's Health and Safety Executive (2003) explained that it is very difficult to achieve good safety performance without effective safety leadership within an organization. The U.S. Federal Safety Commissioner (2006) also emphasized that safety

performance in an organization is linked to the development of a safety culture and that executive safety leadership plays a key role. Wu et al. (2008) argued that safety leadership and safety climate are important predictors of organizational safety performance and that safety climate plays a mediating role between safety leadership and safety performance. Zohar (2002) explained that managers who support safety activities, directly and indirectly, influence the safety culture of the company, and Moon et al. (2013) suggested that organizational culture, managerial leadership behavior, and organizational vision are decisive factors for successfully managing an organization. In addition, Zohar (2002) stated that leaders who are willing to encourage subordinates' safety participation and implement safety systems can strengthen subordinates' desire to improve the safety climate.

1.2.2 Trust in Leader

Belief in a leader begins with trust in that leader. Trust has been studied in a variety of dimensions, including the willingness of a person to rely on another person's intentions or behavior with positive expectations (Rousseau et al., 1998), and trust in leader in the safety field refers to the willingness of workers to rely on a leader with positive expectations that the leader will achieve safety goals (Conchie et al., 2006). Trust in leader is an important factor in leadership, moderating the influence of leadership or directly influencing workers' behavior and attitudes (Dirks & Ferrin, 2002). Higher levels of trust in leader are associated with greater expectations and willingness to rely on the leader, which leads workers to form an active interaction with the leader, which in turn increases their receptivity to the leader's influence (Conchie et al., 2006). Therefore, the degree to which workers trust the leader may have an effect on the degree to which they accept safety leadership and the

influence of that leadership on their behavior. Youn et al. (2015) found that restaurant employees' perceived organizational fairness positively influenced emotional and cognitive trust, job performance, and cooperative behavior in East Asia; emotional trust positively influenced cognitive trust; and both emotional and cognitive trust had a significant positive effect on job performance and cooperative behavior.

1.2.3 Workers' Involvement

When workers are engaged and committed to the organization, the organization's performance increases and improves. Workers' involvement plays an important role in many ways. In particular, workers' involvement affects the effectiveness of an safety and health management system, which is described as a range of processes and structures that enable and sometimes encourage employees to contribute to and influence decisions directly or indirectly (Pawlowska, 2013). Safety and health management system models also emphasize active employee participation as an important factor in improving safety performance (Walters & Frick, 2000), and workers' involvement in safety and health management is critical to the success of Safety and health management and safety performance (Redinger et al. 2002). Worker participation in the United States tends to focus more on personal influence over the workplace and the role in decision-making related to employees' daily work experiences (Cohen & Cleveland, 1983). An engaged manager seeks input from other individuals or groups before making a final decision, especially on decisions that affect employees. Empowering employees gives them the authority and responsibility to make necessary decisions and involves both employees and management in setting goals. It encourages employees to do their best as individuals and as a team, while allowing managers to plan, monitor, lead, and mentor (Cohen & Cleveland, 1983). Seo (2005)

studied management commitment, supervisor support, peer support, employee involvement, and competence level as mediators in the relationship between safety climate and safety behavior.

1.2.4 Safety Knowledge

Research was conducted on the division of knowledge into tacit and formal knowledge, the performance of tacit and formal knowledge, and the methods and corporate performance of sharing tacit and formal knowledge. Research has been conducted to measure and analyze the sharing of safety knowledge and its performance. Safety knowledge refers to an individual's knowledge and skills about how to comply with safety regulations or engage in safety activities to stay safe (Neal & Griffin, 2002). Campbell et al. (1993) argued that the determinants of safety implementation include knowledge, skills, and motivation, that knowledge and skills are the main determinants that are essential for safety implementation, and that the level of safety knowledge of organizational members affects safety implementation. Ahn and Park (2005) found that the higher the employees' procedural and general knowledge of safety and positive attitudes toward safety, the higher their safety awareness and the greater their propensity to participate in safety-related activities voluntarily, and the higher the safety knowledge, the lower the number of accidents. In a study by Jung (2017), safety knowledge was found to have the greatest impact on safety climate and safety implementation, and the higher the safety knowledge of hospital organization members, the higher the safety implementation. Lee (2005) found that safety knowledge was the most influential factor in safety implementation. Kim and Park (2002) revalidated Neal et al.'s (2000) safety climate and safety behavior model and confirmed that the path of safety knowledge on safety implementation is significant. They viewed safety climate as a single

factor, including management values, communication, training, and safety systems, and studied safety knowledge as a mediator of safety climate and safety behavior.

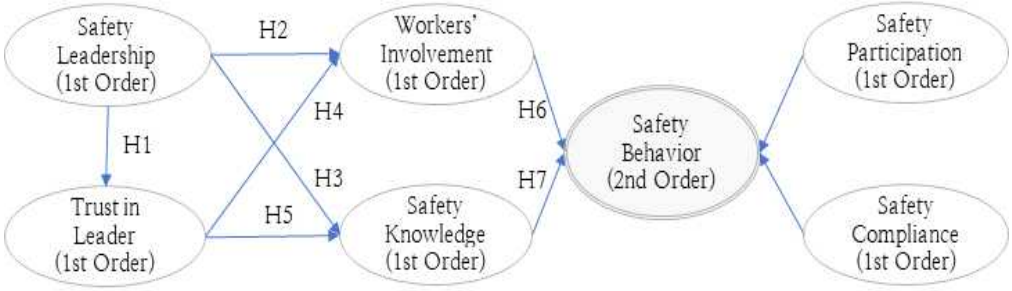
1.2.5 Safety Behavior

Safety behavior is an important factor in maintaining and developing a safe organization, and various studies have been conducted on safety behavior. Neal et al. (2000), a leading researcher on safety behavior, defines safety behavior as the behavior of workers to secure their own safety, and safety behavior is composed of compliance behavior and participation behavior. Compliance behavior is a basic, core, but passive safety behavior in which workers comply with work procedures and rules to maintain safety, and participation behavior is a participatory behavior such as voluntary participation in safety training and safety-related opinions, which are active and proactive safety activities but do not have a direct and immediate impact on safety (Kim, 2015). Garavan and O'Brien (2001) stated that safety behaviors cause workers to avoid hazards while performing their jobs. They also defined safety behavior as the implementation of procedures to reduce exposure to potentially harmful risk variables and injuries. Lee and Cho (2014) conducted a statistical analysis of the survey results and found that five factors were the main factors affecting safety behavior: safety training and training, safety organization system, perceived safety importance, perceived top management's value of safety, safety knowledge, and safety-related communication. Park (2014) found that organizational safety leadership and support affect workers' safety awareness and safety behavior, and continuous efforts to activate safety and health activities affect safety leadership, workers' safety awareness, and safety behavior.

1.3 Research Design and Methodology

1.3.1 Research Model

This study aims to determine the effect of safety leadership on workers' involvement in safety. Second, we will examine the effect of safety leadership on safety knowledge. Third, we will examine the effect of trust in leader on workers' involvement in safety. Fourth, we want to determine the effect of trust in leader on safety knowledge. Fifth, we want to understand the effect of workers' involvement on safety behavior. Sixth, we want to understand the effect of safety knowledge on safety behavior.



〈Figure 1-1〉 Research Model

1.3.2 Hypothesis Formulation

1.3.2.1 Safety Leadership and Trust in Leader

Dirks & Ferrin (2002) found that leaders' participative leadership behaviors tend to increase members' trust by influencing the extent to which members perceive the leader as trustworthy, fair, and genuine. Huang et al. (2010) found that leaders' participative leadership behaviors elicit affective trust among members by demonstrating a willingness to initiate social exchange processes. On the other hand, whether a leader's participative leadership can successfully activate desirable behaviors and

attitudes in members depends on the extent to which the leader demonstrates behaviors consistent with the ideal leader (Lord et al., 1984). Therefore, when the perceived level of participative leadership is high enough, members will be ready and willing to take specific actions in response.

The relationship between participative leadership and trust in leader is based on social exchange theory, which states that when people choose an action, they calculate the costs and benefits of that action, and when they conclude that the two are somewhat balanced, they take action. According to social exchange theory, participative leadership helps to improve job performance and organizational citizenship behavior because it increases the leader's credibility and encourages employees to reciprocate. In addition, Miao et al. (2014) found that participative leadership significantly improves employees' job performance through emotional trust, inducing inferences about the relationship base with the leader and the leader's personality, and thus forming trust in leader. Furthermore, it has been confirmed that the openness, consideration, and competence of leaders perceived by employees through participative leadership behaviors and the fairness of organizational procedures significantly affect trust in leaders (Kwon, 2000). Based on the above theories and previous studies, it can be predicted that employees who experience safety leadership that actively engages employees, encourages communication, and treats employees' opinions fairly will perceive the leader as fair and trustworthy and will develop trust in leader. Therefore, the following hypotheses were formulated.

H1: Safety leadership will have a positive effect on trust in leader.

1.3.2.2 Safety Leadership and Workers' Involvement

Clarke and Ward (2006) argued that managerial leadership is an important factor in achieving safety performance, as it can drive worker safety behavior, workers' involvement, and communication in the workplace. In other words, managerial leadership can act as a positive factor and create a safety climate in the organization. According to Durham et al. (1997), empowering leaders with safety leadership urges employees to participate in decision-making and share knowledge, and encourage members to express personal opinions and make appropriate suggestions. When employees' opinions are accepted, they are more willing to share information, and when they are empowered to make decisions about their work, they typically exchange knowledge with other members of the team to facilitate the decision-making process. These behaviors ensure that they have enough information to make rational decisions. Therefore, an empowering leader with safety leadership can stimulate knowledge sharing through the active participation of employees (Xue et al., 2011). Arnold et al. (2000) argued that coaching behaviors of safety leadership empowering leaders lead to employee engagement by empowering team members to problem solve together on safety-related issues and provide opportunities for employees to share knowledge. Therefore, based on these previous studies, the following hypotheses were formulated.

H2: Safety leadership will have a positive effect on workers' involvement.

1.3.2.3 Safety Leadership and Safety Knowledge

Basahel (2021) found that safety leadership, such as proposing incentive programs, recognizing workers' safety behaviors, involving workers in decision-making, proposing effective safety training programs, and providing input on safety issues, effectively influences individuals'

safety attitudes, motivation, and knowledge. In addition, scholars in the field of knowledge management have investigated many factors that can influence knowledge sharing in organizations, among which transformational leadership has been found to play a significant role in promoting knowledge sharing through employee motivation (Bryant, 2003). Bai et al. (2016) studied whether various factors such as trust, task conflict, and relationship conflict affect employees' knowledge sharing, and among them, leadership is an important factor in causing employees' knowledge sharing behavior. Ireland et al. (2003) emphasized that leaders' open communication and knowledge sharing with employees stimulates the same behavior in employees, and Pinho et al. (2012) stated that authentic leadership provides opportunities to develop a collective environment, improve knowledge, and expand individual and collective confidence. Therefore, safety leadership will have a positive impact on the role of activating safety knowledge by motivating employees. Based on these previous studies, the following hypotheses were formulated.

H3: Safety leadership will have a positive effect on safety knowledge.

1.3.2.4 Trust in Leader and Workers' Involvement

Leaders and members are relationships and positions that exist within an organization or team. Leaders represent the organization or team and influence members to achieve common goals. Therefore, a positive attitude toward the leader can influence a positive attitude toward the organization (Lee et al., 2017). Employees are more likely to trust their leaders when they see them helping them in difficult situations. This trust in the leader has a number of positive effects on the organization, firstly by influencing the development of collaborative relationships. When employees trust their leaders, they form more collaborative relationships with them, which can lead to improved organizational performance

through collaborative interactions with leaders to achieve organizational goals (Brower et al., 2000). Also, when all employees trust their leaders, they are more likely to work together to increase performance and achieve organizational goals (Solomon & Flores, 2003). Higher levels of trust in leaders lead to more positive attitudes toward the work that the leader directs and the organization that the leader represents and to increased organizational commitment, such as workers' involvement (Dirks & Ferrin, 2002). Therefore, trust in leaders is likely to have a positive impact on workers' involvement and change. Based on these previous studies, we formulate the following hypotheses.

H4: Trust in leader will have a positive effect on workers' involvement.

1.3.2.5 Trust in Leader and Safety Knowledge

Because employees perceive an organization based on the actions of its leaders, trusting leaders makes them more attached to the organization and improves organizational commitment (Lau et al., 2008). Furthermore, Dienesch et al. (1986) explain that organizational commitment can be enhanced when employees have a good relationship with their leader. When there is a high level of interaction, such as when employees trust their leaders, they become attached to both the organization and the leader (Lee et al., 2005). And employees with good relationships are more likely to receive additional job benefits, challenging training, and opportunities (Cheung et al., 2009). Thus, a close relationship with a leader can lead to more enterprising behavior in an organization (Costigan et al., 2006). Leader behavior is an important factor in creating a sense of psychological safety within an organization. When employees feel included, supported, open, and trusted by their leaders, their sense of psychological safety increases (Cho et al., 2018). Through an empirical study, Edmondson (1999) proved that psychological safety positively affects learning behavior, which in turn positively affects performance. On

the other hand, Anald et al. (2021) found that the most important factor in an individual's willingness to share knowledge is the level of trust between individuals, and Civi (2000) found that how an individual perceives the organization, supervisor, and colleagues is an important determinant of knowledge sharing. Therefore, leaders play a very important role in creating social exchange relationships that increase trust in teams (Gagne, 2009). Based on the above discussion, it can be predicted that when a trusting relationship is formed between members, including the leader, knowledge sharing can be activated, which in turn can increase the safety-related knowledge of members. Based on these previous studies, we formulated the following hypotheses.

H5: Trust in leader will have a positive effect on safety knowledge.

1.3.2.6 Workers' Involvement and Safety Behavior

Cappelli and Rogovsky (1998) studied the impact of workers' involvement on worker organizational citizenship behavior through a survey of supervisors and matched workers in eight U.S. companies in 1992 and found that workers' involvement had a positive effect on organizational citizenship behavior. In a 1992 study at a Veterans Affairs Medical Center (VAMC) in New Jersey, a program was implemented to reduce lost-time injury cases, which included involving all employees in all phases of the safety program. The program dramatically reduced lost-time injury cases within one year of implementation (Garrett & Perry, 1996). Employee involvement influenced safety behavior, which resulted in fewer lost-time injuries. Using data from the 2012 Occupational Safety and Health Trends Survey conducted by the Korea Occupational Safety and Health Institute, Lee and Cho (2014) analyzed the impact of occupational safety and health management activities on accident rates via employee participation and accident prevention activities

and found that employee participation had a positive effect on accident prevention activities. Vinodkumar and Bhasi (2010) verified that workers' involvement is closely related to safety participation among safety behaviors. In addition, Keffane and Delhomme (2013) reported that workers' involvement predicts safety compliance among safety behaviors in a study to determine the performance of road safety policy implementation in France. Thus, it can be seen that workers' involvement has a positive effect on safety engagement and safety compliance, which are components of safety behavior. Based on these previous studies, we formulated the following hypotheses.

H6: Workers' involvement will have a positive effect on safety behavior.

1.3.2.7 Safety Knowledge and Safety Behavior

KAB approach identifies the interaction of knowledge, attitude, and behavior, and shows the correlation between knowledge and behavior. Christian et al. (2009) found that safety knowledge is the most predictive variable among the variables that predict safety behavior. Neal et al. (2000) considered safety knowledge and safety motivation as determinants of safety performance and safety compliance and safety involvement as components of safety performance. Kim and Park (2002) revalidated Neal et al.'s (2000) safety climate and safety behavior model and confirmed that the path of safety knowledge on safety performance is significant. Beseler and Stallones (2010) studied the effect of safety knowledge on safety behavior in a study of farm workers in Colorado, USA, and found that safety knowledge had a positive effect on safety behavior. In a study by Clayton and Griffith (2004), improved food safety knowledge was reported to have a positive effect on behavior. Vinodkurma and Bhasi (2010) also found that safety knowledge affects safety compliance and safety participation. Therefore, it can be concluded that sharing and

improving safety knowledge will have a positive impact on safety participation and safety compliance. Based on these previous studies, we formulated the following hypotheses.

H7: Safety knowledge will have a positive effect on safety behavior.

1.4 Construct Definition and Questionnaires

1.4.1 Definition of Constructs

The measurement tool was constructed based on survey questions from existing studies that were validated based on previous research. The questionnaire was administered to employees who are currently working at a manufacturing site. All survey items were measured on a 5-point Likert scale, and the survey was conducted online through an internet survey. The operational definitions of the variables and related literature are summarized in 〈Table 1-1〉.

〈Table 1-1〉 Operational Definitions and Related Literature of Variables

Variable	Operational Definitions	Related Literature
Safety Leadership	Leadership that is both transformational and dynamic and transactional for effective safety practices	Clarke (2012)
Trust in Leader	Confidence that members have a favorable disposition toward the leader and can trust the leader's promises or actions	Cook & Wall (1980)
Workers' Involvement	A variety of processes and structures that encourage workers to contribute to and influence decisions, both directly and indirectly	Pawlowska (2013)
Safety Knowledge	Workers' knowledge and skills about how to comply with safety regulations or participate in safety	Neal & Griffin (2002)

Variable		Operational Definitions	Related Literature
		activities to stay safe	
Safety Behavior	Safety Participation	Behavior that don't directly impact safety but help make the workplace safer	Neal et al. (2000)
	Safety Compliance	Key safety behavior required of individuals to stay safe	

1.4.2 Questionnaires of Constructs

Safety leadership was measured with a total of 10 items, which were adapted from Bass and Avolio's (1990) Multifactor Leadership Questionnaire by Barling et al. (2002) to fit the safety concept. Trust in leader was measured with a total of three items and was adapted from a scale developed by Conchie and Donald (2006). workers' involvement was measured using a 5-item scale developed by Varonen and Matilla (2000). Safety knowledge was measured using a six-item scale developed by Neal and Griffin (2002). Safety behavior was measured with a total of 11 items, with six items related to safety participation and five items related to safety compliance developed by Neal et al. (2000). The measurement variables and survey questions are summarized as shown in 〈Table 1-2〉.

〈Table 1-2〉 Measurement Variables and Questionnaires

Variable	Measurement Variable		Questionnaires	Source
Independent Variable	Safety Leadership	Transformational and transactional leadership	10(9)	Barling et al. (2002)
	Trust in Leader	Confidence that a leader's promises or actions can be trusted	3(3)	Conchie & Donald (2006)
Mediating	Workers'	Processes for	5(4)	Varonen &

Variable	Measurement Variable		Questionnaires	Source
Variable	Involvement	involving workers in safety decisions		Mattila (2000)
	Safety knowledge	Safety-related workers' knowledge and skills	6(6)	Neal & Griffin (2002)
Dependent Variable	Safety Participation	Helpful behavior to keep your workplace safe	6(4)	Neal et al. (2000)
	Safety Compliance	safety behavior to stay safe	5(4)	
Demographic questions			12	
Total number of questionnaires			47(42)	

* Number of final adopted survey questions in parentheses

1.5 Data Collection and Sample Characteristics

1.5.1 Data Collection

To validate the research model, a survey was conducted among workers in both skilled and clerical positions in the manufacturing industry across the country. A total of 271 out of 300 copies of the online survey were used in the final analysis.

1.5.2 General Characteristics of the Sample

The demographic characteristics of the survey participants are shown in 〈Table 1-3〉 below.

〈Table 1-3〉 General Characteristics of the Sample

Description		Frequency(people)	Rate(%)
Gender	Male	222	81.9%
	Female	49	18.1%

Description		Frequency(people)	Rate(%)
	Sum	271	100%
Age	20-29 years old	13	4.8%
	30-39 years old	87	32.1%
	40-49 years old	106	39.1%
	50-59 years old	53	19.6%
	Age 60 and older	12	4.4%
	Sum	271	100%
Workplace location	Seoul, Gyeonggi	112	41.3%
	Chungcheong-do	49	18.1%
	Gyeongsang-do	86	31.7%
	Jeolla-do	20	7.4%
	Gangwon & Jeju-do	4	1.5%
	Sum	271	100%

1.6 Analysis and Results

1.6.1 Evaluation of the Measurement Model

SmartPLS Ver.4.0 based on PLS (Partial Least Square) was used to analyze reliability, convergent validity, and discriminant validity. According to the proposed method, variables with factor loadings of 0.7 or less were removed one by one. Among the measures, one item each from safety leadership and workers' involvement was removed due to low factor loadings. In addition, two items were removed from safety participation, the first factor of safety behavior, due to low factor loadings, one item was removed from safety compliance due to low factor loadings, and the last item of safety compliance was measured with a reverse scale, which was used to check for possible dishonest responses from respondents. For reliability analysis, Cronbach's Alpha

Value was examined and was deemed adequate as it met the recommended level of 0.7 or higher (Hair Jr. et al., 2014). Discriminant validity was determined by comparing the square root value of the mean variance extracted for the factor with the correlation coefficient with other factors, and the significance was confirmed as the square root value of the mean variance extracted for the factor shown in the diagonal columns of the table as shown in 〈Table 1-5〉 exceeds the value to the left or to the right of the variable, and the discriminant validity was evaluated as significant according to the analysis results (Fornell & Larcker, 1981).

1.6.2 Evaluation of Structural Model: Hypothesis Testing

The results of the study are briefly summarized as follows. First, safety leadership was positively related to trust in leader. Second, safety leadership was positively related to workers' involvement. Third, safety leadership was positively related to safety knowledge. Fourth, trust in leader had a positive effect on workers' involvement. Fifth, trust in leader had a positive effect on safety knowledge. Sixth, workers' involvement had a positive effect on safety behavior. Seventh, safety knowledge had a positive effect on safety behavior. Safety behavior is a second-order factor consisting of safety participation and safety compliance, and was analyzed using the latent variable score according to the two-stage analysis (Hair et al., 2017). The determination coefficient value of the model for the dependent variable, R^2 is 0.517, and 〈Table 1-6〉 is a table summarizing the results of the hypothesis test.

〈Table 1-4〉 Convergent Validity and Reliability Analysis Results

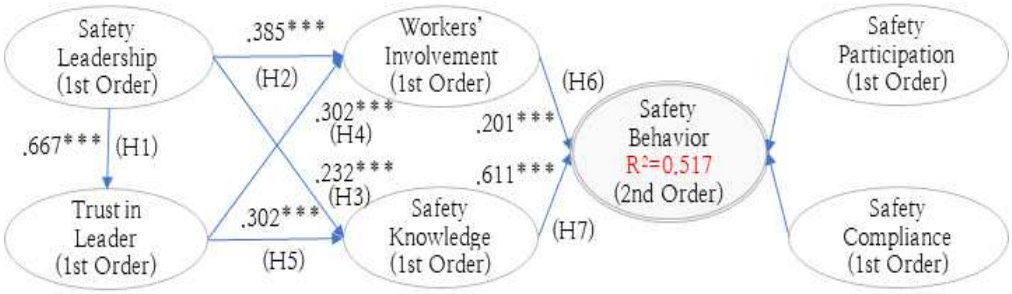
Variable	Indicator	Factor Loading	Cronbach's Alpha	CR	AVE
Safety Leadership	safety leadership 2	0.822	0.929	0.933	0.612
	safety leadership 3	0.824			
	safety leadership 4	0.826			
	safety leadership 5	0.804			
	safety leadership 6	0.858			
	safety leadership 7	0.832			
	safety leadership 8	0.805			
	safety leadership 9	0.723			
	safety leadership 10	0.799			
Trust in Leader	trust in leader 1	0.927	0.908	0.910	0.845
	trust in leader 2	0.915			
	trust in leader 3	0.929			
Workers' Involvement	workers' involvement 2	0.848	0.893	0.903	0.700
	workers' involvement 3	0.860			
	workers' involvement 4	0.910			
	workers' involvement 5	0.867			
Safety Knowledge	safety knowledge 1	0.816	0.892	0.893	0.650
	safety knowledge 2	0.849			
	safety knowledge 3	0.822			
	safety knowledge	0.809			

Variable		Indicator	Factor Loading	Cronbach's Alpha	CR	AVE
		4				
		safety knowledge 5	0.808			
		safety knowledge 6	0.766			
Safety Behavior	Safety Participation	safety participation 3	0.784	0.835	0.840	0.669
		safety participation 4	0.812			
		safety participation 5	0.868			
		safety participation 6	0.835			
	Safety Compliance	safety compliance 1	0.833	0.841	0.842	0.677
		safety compliance 2	0.835			
		safety compliance 3	0.823			
		safety compliance 5	0.823			

〈Table 1-5〉 Discriminant Validity Analysis Results

Variable	Safety Leadership	Safety knowledge	Safety Compliance	Safety Participation	Trust in Leader	Workers' Involvement
Safety Leadership	0.782					
Safety Knowledge	0.404	0.806				
Safety Compliance	0.383	0.642	0.823			

Variable	Safety Leadership	Safety knowledge	Safety Compliance	Safety Participation	Trust in Leader	Workers' Involvement
Safety Participation	0.514	0.570	0.602	0.818		
Trust in Leader	0.644	0.425	0.439	0.486	0.919	
Workers' Involvement	0.566	0.397	0.294	0.443	0.563	0.837



〈Figure 1-2〉 Research Model Analysis Results(***p〈0.01,**p〈0.05,*p〈0.1)

〈Table 1-6〉 Summary of Hypothesis Testing Results

No.	Hypothesis	Results
H1	Safety leadership will have a positive effect on trust in leader.	Accept
H2	Safety leadership will have a positive effect on workers' involvement.	Accept
H3	Safety leadership will have a positive effect on workers' safety knowledge.	Accept
H4	Trust in leader will have a positive effect on workers' involvement.	Accept
H5	Trust in leader will have a positive effect on workers' safety knowledge.	Accept
H6	Workers' involvement will have a positive effect on safety behavior.	Accept
H7	Safety knowledge will have a positive effect on safety behavior.	Accept

Each of the six hypotheses was accepted, and it was found that safety leadership has a positive effect on safety behavior through safety knowledge and workers' involvement, and trust in leader has a positive effect on safety behavior through workers' involvement and safety knowledge. The mediating effect analysis of this study is shown in 〈Table 1-7〉, and it can be seen that all mediating effects are significant. The mediating effects and serial multiple mediating effects were tested according to the methodology of Baron and Kenny (1986) and Hayes (2009). In addition, after confirming the existence of mediating effects according to the mediation analysis procedure of Baron and Kenny (1986), the Sobel test was conducted to identify the mediating effects, and the results are shown in 〈Table 1-8〉, and the formula is as follows.

Formula 1 : $Z=\frac{a\times b}{\sqrt{a^2\times SE_b^2+b^2\times SE_a^2}}$ (a: The unstandardized regression coefficient from Step 2, b: the unstandardized regression coefficient from Step 3, SEa: The standard error value of the unstandardized coefficient from Step 2, SEb: unstandardized coefficient standard error value from Step 3).

In order for there to be a mediating effect, the independent variable must have a significant effect on the dependent variable in Step 1, the independent variable must have a significant effect on the mediator in Step 2, and the independent variable and mediator must have a significant effect on the dependent variable at the same time in Step 3. If the parameter is significant and the independent variable is not significant in Step 3, there is a full mediating effect; if both the independent variable and the parameter are significant, look at the regression coefficient, and if the regression coefficient of the independent variable in

Step 3 is smaller than the regression coefficient of the independent variable in Step 1, there is a partial mediating effect.

〈Table 1-7〉 Mediating Effects

Path	Path Coefficient	T Statistic	p Value
Safety Leadership → Trust in Leader → Workers' Involvement	0.201	3.927	0.000
Safety Leadership → Trust in Leader → Safety Knowledge	0.201	3.358	0.001
Safety Leadership → Safety Knowledge → Safety Behavior	0.142	2.738	0.006
Safety Leadership → Safety Knowledge → Safety Behavior	0.078	2.888	0.004
Trust in Leader → Workers' Involvement → Safety Behavior	0.061	2.428	0.015
Trust in Leader → Safety Knowledge → Safety Behavior	0.185	3.154	0.002

〈Table 1-8〉 Sobel Test Z Value

Path	Z Value
Safety Leadership → Safety Knowledge	6.965***

(***: p〈0.01; **: p〈0.05; *: p〈0.1)

In 〈Table 1-7〉 and 〈Table 1-8〉 and following the methodology of Baron and Kenny (1986), we can see that the absolute values of the Z values in the Sobel test are all significant at the 0.01 level of significance, safety leadership has a partial mediating effect on safety knowledge

through trust in leader.

1.7 Conclusions

1.7.1 Summary

In this study, we examined the effects of safety leadership and trust in leader on workers' involvement and safety knowledge by conducting a study on field workers in a manufacturing company. In addition, we examined the effects of workers' involvement and safety knowledge on safety behavior and the mediating effects of workers' involvement and safety knowledge on the relationship between safety leadership and trust in leader and safety behavior. Based on the results of this study, it was confirmed that safety leadership and trust in leader influence workers' involvement and safety knowledge, and workers' involvement and safety knowledge influence safety behavior. Furthermore, it was verified that workers' involvement and safety knowledge mediate the relationship between safety leadership and trust in leader and safety behavior. Therefore, it is recommended that managers' safety leadership and trust in leader should be enhanced by improving workers' involvement and safety knowledge to drive safety behavior. The significance of this study is that it identified the effects of safety leadership and trust in leader on safety behavior through the mediation of workers' involvement and safety knowledge, and identified the positive influence relationship of managerial safety leadership and trust in leader on safety behavior.

1.7.2 Implications

The theoretical implications are as follows. First, safety leadership and trust in leader are key variables that drive safety behavior among field workers. In turn, sound safety leadership positively affects safety behaviors

through workers' involvement and improved safety knowledge. In contrast, strong trust in leaders positively affects safety behaviors through facilitating safety knowledge sharing activities and mediating workers' voluntary participation. Second, the validation of the relationship between various variables that can affect safety behavior provides a perspective on safety behavior from the perspective of mediated effects, which are not only direct effects but also indirect effects. The mediation effect shows that among the variables, safety knowledge has a higher path coefficient than workers' involvement, suggesting that having safety knowledge is a more important factor for safety behavior than workers' involvement in the management of the occupational health and safety management system.

The practical implications are as follows. First, this study provides a direction for the prevention of major accidents by studying the factors that can lead to worker safety behaviors that are necessary to reduce accidents in the manufacturing sector, given the recent increase in social attention to safety and the importance of safety. Second, it is meaningful in that it confirms how workers' involvement and safety knowledge are related to safety behavior. Third, by confirming that workers' involvement and safety knowledge has a positive effect on safety behavior, this study provides evidence that safety managers should incorporate more policies to improve workers' involvement and safety knowledge into their safety and health management systems.

1.7.3 Limitations and Suggestions

Despite these implications, there are some limitations to this study. First, there are various sectors in the manufacturing industry, so there may be differences in the specific industries, and further research is needed. Second, it is necessary to deepen the study by considering other factors that may affect safety behavior in addition to the independent

variables of safety leadership and trust in leader. Third, there is a limitation that we should have analyzed the impact relationship on whether safety behavior actually affects disaster reduction. In addition, various studies on MZ generation have been conducted recently, and it is necessary to theoretically examine the differences between the current generation by conducting a multi-group analysis on the differences between MZ and non-MZ generations and the impact of the differences between generations on safety in future studies.

Chapter 2. A study on the effects of safety management practices on safety behavior mediated by safety knowledge and safety motivation

This study empirically investigated the relationship between workers' safety behavior and safety management practices, safety knowledge, and safety motivation in enterprises and identified and analyzed the factors that strengthen workers' safety behavior that contribute to the prevention of serious accidents in enterprises by analyzing the role of the factors. When industrial accidents occur, companies have to bear huge loss costs, not only direct costs of compensating the victims but also indirect costs such as human loss, material loss, production loss, and time loss. Therefore, more and more companies are establishing and implementing a safety and health management system. Based on the results of previous studies, this study investigated the effects of safety management practices on safety behavior through the mediation of workers' safety knowledge and safety motivation on production labor workers in the manufacturing industry. Statistical analysis was conducted on 271 manufacturing workers using SPSS and PLS, and the results showed that safety management practices can lead to workers' safety behavior by enhancing workers' safety knowledge and strengthening safety motivation.

【Key Words】 Safety Management Practices, safety knowledge, Safety Motivation, safety behavior, Safety Training, workers' involvement, safety rules and procedures, safety leadership, Safety Participation, Safety Compliance

2.1 Introduction

On January 27, 2022, the Serious Accident Punishment Act to Secure the Safety and Health of Workers came into effect. The Serious Accident Punishment Act imposes a duty on the person in charge of management to ensure the safety and health of all persons working in a business or workplace. It is now possible to be punished if a major industrial accident occurs because the person in charge of management does not fulfill his or her duty to ensure safety and health. As a result, more and more companies are establishing and implementing a safety and health management system, known as a safety management system. Despite this increase in legal and institutional measures to ensure the safety and health of workers, the number of industrial accidents has not improved. According to statistics from the Ministry of Employment and Labor, the industrial accident rate in 2022 was 0.65%, an increase of 0.02% year-on-year, and the number of injured workers was 130,348 as of 2022, an increase of 6.2% year-on-year. As of 2021, Korea's occupational fatality rate was 4.3 deaths per 100,000 workers, which is significantly higher than other OECD countries such as Germany (0.7), Sweden (0.8), Japan (1.5), and Spain (2.1). The economic losses caused by industrial accidents are also significant, and according to the e-Employment and Labor Index published by the Ministry of Employment and Labor, the estimated economic losses due to industrial accidents in Korea are 25 trillion won in 2018, 29 trillion won in 2019, and 32 trillion won in 2022. When an industrial accident occurs, companies have to bear significant losses due to direct costs of compensation for victims and indirect costs such as human losses, material losses, production losses, and time losses. These losses can result in significant sunk costs for the company. As a result, organizations must continually strive to reduce these costs. As the media reports of collapses

caused by poor workmanship, such as missing rebar in the construction sector, have shown, companies that neglect safety can suffer great damage to their future sustainable business management due to consumer rejection and corporate image. This can have a negative impact on ESG management, which is based on the principle of pursuing sustainable development through eco-friendly and socially responsible management and transparent management in the long term. Recently, corporate management has been undergoing a paradigm shift from profit-oriented management to sustainable management, and ESG management is becoming a new management paradigm (Heo & Lee, 2022). Cho and Lee (2023) argue that ESG management is becoming a necessity of the times and that sustainable management through ESG requires changes and expenditures that are burdensome for companies. Establishing and implementing a safety management system that meets these rapidly changing times is a very important task from the perspective of ESG management. As the importance of safety is becoming increasingly important, a growing number of studies have examined the relationship between safety culture, safety climate, and safety behavior. This study is differentiated in that it seeks to examine the impact of safety management practices on safety behavior through the mediation of safety knowledge and safety motivation on workers' safety behaviors in the domestic manufacturing industry.

Therefore, this study aims to empirically investigate the relationship between safety behavior and safety management implementation factors, safety knowledge, and safety motivation and to analyze the role of the variables in the process so as to secure the safety behavior of workers that contributes to the prevention of major accidents in enterprises. Accordingly, this study aims to determine, first, the impact of safety management practices on safety knowledge. Second, the effect of safety

management practices on safety motivation is examined. Third, the effect of safety knowledge on safety behavior is examined. Fourth, to determine the effect of safety motivation on safety behavior. Fifth, to determine the effect of safety management practices on safety behavior. Sixth, to determine whether safety knowledge and safety motivation mediate the relationship between safety management practices and safety behavior.

2.2 Literature Review

2.2.1 Safety Management Practices

Safety management can be said to be concerned with the actual practices, roles, and functions associated with maintaining safety (Kirwan, 1998). Safety management is considered a sub-concept of overall organizational management, which is actually the implementation of the various safety management practices that make up an organization's safety management system. A safety management system is a mechanism that is integrated into an organization and designed to control risks that may affect the health and safety of workers (Labodova, 2004). A safety management system includes programs, processes, and procedures with a function to oversee their development, implementation, and ongoing management. Safety management systems typically have a clear delineation of functions, roles, responsibilities, duties, and authorities. Kozlowski and Klein (2000) conceptualize the safety management practices that comprise a safety management system as a score, with the safety management practices representing a fairly high level of control by the organization's managers. It is not a concept that is constructed through a process of employee perception, as is the case with safety climate or management commitment (Guldenmund, 2000). On the other hand, Wachter and Yorio (2014) argue that actions that utilize worker perceptions, such as worker engagement and workplace sacrifice, can also be considered as

outcomes of objective safety management practices and help to understand their function and impact from a worker performance perspective. In a study of hospital settings, Vredenburgh (2002) included worker involvement, safety training, employment practices, reward systems, management safety leadership, communication, and feedback as safety management practices. When planning for safety management practices, it is important to include safety management practices that are commonly recognized by workers so that they can play a role in creating a safe environment Vinodkurma and Bhasi (2010), Cohen (1977), Cohen et al. (1975), DePasquale and Geller (1999), Harper et al. (1997), Shafai-Sahrai (1971), Shannon et al. (1996), Smith et al. (1975) found that organizations with lower accident rates have higher levels of safety officers, management is personally involved in safety activities, good training for new employees, frequent training for existing employees, safety posters for hazard identification, well-defined promotion and job assignment procedures, frequent safety-related communication between workers and supervisors, frequent safety inspections, prioritization of safety in decision-making at work meetings, thorough investigations of accidents, more frequent attendance of senior managers at safety meetings, and more empowerment of employees. The study included safety training, workers' involvement, safety rules & procedures, and safety leadership, among other safety management practices.

2.2.2 Safety Training

Christoffel and Gallagher (2006) defined safety training as providing workers with knowledge about safety and health, changing attitudes toward risk and safety in a desirable direction, and reducing accidents by inducing safe behavior. Safety training can also be defined as the extent to which continuous and systematic safety training is conducted in an

organization and how employees perceive the effectiveness of safety training (Zohar, 1980). In the case of Korea, Article 3(9) of the Misfortune and the Safety Supervision Basic Law in 2013 defined safety culture activities as activities aimed at creating a society that is safe from disasters and other accidents by raising the value and awareness of safety and making safety a way of life through safety training, safety training, publicity, etc, Article 8-2 (Establishment of the National Disaster Management Fund) of the Misfortune and the Safety Supervision Basic Law stipulates that the Minister of the Interior and Safety shall establish the National Disaster Fund to secure the financial resources necessary for the prevention, preparation, response and recovery of disasters and the smooth implementation of safety culture activities. Simon and Piquard (1991) believe that safety training is the most important safety assurance mechanism that induces workers' knowledge, attitudes, and behaviors and that the level of safety can be increased through training, especially hazard anticipation training. In addition, companies with lower accident rates are characterized by higher levels of safety training (Zohar,1980). Vredenburgh (2002) found that perceived risk levels increase compliance with safety-related instructions and that training is essential to ensure that all workers are aware of the hazards in the workplace. Furthermore, Randles et al. (2010) emphasized that safety programs and safety training must be systematically implemented to be effective in order to improve the quality of safety in an organization. Anderson (2005) stated that most safety training emphasizes the principles of the behavior-based model with a focus on knowledge development. The findings of Burke et al. (2006) that increased behavior-based training reduces negative safety enforcement outcomes suggest that corporate safety training needs to shift from knowledge transfer to behavioral modeling or on-the-job demonstration. In a meta-analysis of safety climate-related models,

Guldenmund (2000) found that the safety training component was one of the most frequently presented constructs.

2.2.3 Workers' Involvement

Workers' involvement affects the effectiveness of a safety management system, and Pawlowska et al. (2013) describe workers' involvement as a process that enables employees to contribute to and influence safety-related decisions, both directly and indirectly. When workers are engaged and committed to the organization, organizational performance improves. While organizational safety management policies and managerial commitment and execution are important in ensuring safety, it has been identified that the level of workers' involvement is critical to establishing a safety culture and improving safety performance because workers on the ground are more aware of the hazards of the actual work process than anyone else (Cheyne et al., 1998; Neal et al., 2000). Workers' involvement in the United States tends to focus more on personal influence over the workplace and the role in decision-making related to employees' daily work experiences (Cohen & Cleveland, 1983). An participative manager seeks input from other individuals or groups before making a final decision, especially on decisions that affect employees. Empowering employees gives them the authority and responsibility to make necessary decisions and involves both employees and management in setting goals. It encourages employees to do their best as individuals and as a team while allowing managers to plan, monitor, lead, and mentor (Cohen & Cleveland, 1983). The content of worker participation consists of various forms, such as participation in safety-related councils, participation in hazard and risk factor identification and sub-accident reporting activities, and participation in safety inspection activities. In Korea, the Guidelines on Workplace Risk Assessment, which were revised

in June 2023, allowed workers to participate in the entire process of risk assessment instead of only identifying hazards and risk factors, establishing reduction measures, and implementing reduction measures. As such, Korea is also moving toward more active worker participation in safety-related fields, making worker participation even more important.

2.2.4 Safety Rules and Procedures

Safety rules and procedures factor can be defined as workers' perceptions of how well the organization encourages and enforces current safety rules and procedures (Cox & Cheyne, 2000). Hood (1994) stated that safety incidents are sometimes caused by the misapplication of safety procedures or the absence of safety procedures. Hale and Swuste (1998) refer to safety rules and procedures as defined modes of behavior in response to anticipated situations, such as those established prior to an event and accepted as a way of operating within a system to achieve a required level of safety or to improve safety. Vidal-Gomel (2007) also states that the implementation of safety rules and procedures is the result of a process of conceptualizing the properties of the rules and understanding the situation and is one of the safety measures available to the worker. On the other hand, safety requirements cannot fully control the activities of workers because they cannot fully respond to the diversity, variability, and unpredictability of the situation. Therefore, they must be able to adapt and respond to the characteristics of the situation. Reason (1998) states that most accidents caused by safety management failures support the need for audits of the implementation of safety management practices and the development of audit tools and suggests that investigations into the implementation of safety management practices should form part of the assessment of the safety environment in an organization. Particularly in the chemical industry, which is a high-risk

industry, safety manuals and related legislation are very important, and inspections by middle managers (safety managers or task leader) to ensure their implementation are essential to induce safe behavior in workers (Vinodkurma & Bhasi, 2010). Cox and Cheyne (2000) and Mearns et al. (2003) considered safety rules and procedures as an important element of safety management practices and showed a significant relationship with accident rates.

2.2.5 Safety Leadership

In the field of occupational safety, the concept of safety has been studied since the 1980s and has been actively studied since the 2000s. In particular, many studies have been conducted to prevent industrial accidents, and many studies have emphasized the importance of safety leadership by managers. Bass (1985) described safety leadership as a give-and-take, in which the leader gives what the worker wants and receives safety behavior from the worker so that mutual satisfaction between the leader and the worker is sustained. In addition, Wu et al. (2010) described safety leadership as a process of mutual alignment between leaders and members that is created when leaders strongly exert their influence on members to achieve organizational goals. In particular, site managers are responsible for maintaining a safe workplace through safety management, supervision, and instruction of workers in the field. Therefore, the safety management behavior and safety awareness of site managers directly affect the safety level of the work site and the occurrence of disasters. In Australia, the New South Wales Minerals Council (NSWMC, 2005) defined safety leadership as influencing and changing the values and beliefs of workers to change their behaviors, attitudes, and habits and to improve the safety culture of the site. Therefore, it means that workers' values and beliefs recognize that safety

is important and fundamental to be considered in all activities and that they believe that if they work with safety in mind, it will be recognized by their colleagues, supervisors, and management. Zohar (2002) explained that managers who support safety activities have a direct and indirect impact on the safety culture of a company, and leaders who encourage subordinates to participate in safety and implement safety systems can strengthen their subordinates' desire to improve the safety climate. Moon et al. (2013) suggested that organizational culture, managerial leadership behavior, and organizational vision are decisive factors in successfully managing an organization.

2.2.6 Safety Knowledge

Knowledge refers to high-value information that is immediately linked to actual decision-making or behavior through the combination of human experiences, situations, and cognitive activities (Davenport et al., 1998). Shin and Shin (2007) stated that safety knowledge means knowing safety-related information such as causes of injuries and ways to protect and prevent injuries, or practical information that threatens safety. Meanwhile, Neal and Griffin (2002) defined safety knowledge as an individual's knowledge and skills on how to comply with safety regulations or participate in safety activities to maintain safety. Most companies have invested heavily in safety training and training to improve the safety knowledge of their workers and to maintain and improve their knowledge. The main types of knowledge that workers are expected to have within the company include safe work practices, safety laws and regulations, and safe work procedures for various tasks. Campbell et al. (1993) argued that the determinants of safety implementation include knowledge, skills, and motivation and that knowledge and skills are the main determinants that are essential for safety implementation and the

level of safety knowledge of organizational members affects safety implementation. Ahn and Park (2005) found that the higher the employees' procedural and general knowledge of safety and positive attitudes toward safety, the higher their safety awareness and the greater their propensity to participate in safety-related activities voluntarily, and the higher the safety knowledge, the lower the number of accidents. In a study by Jung (2017), safety knowledge was found to have the greatest impact on safety climate and safety implementation, and the higher the safety knowledge of hospital organization members, the higher the safety implementation. Lee & Oh (2005) found that safety knowledge was the most influential factor in safety implementation. Kim and Park (2002) revalidated Neal et al.'s (2000) safety climate and safety behavior model and confirmed that the path of safety knowledge on safety implementation is significant. They viewed safety climate as a single factor that includes safety leadership, safety communication among members, safety training, and safety systems and studied safety knowledge as a mediator of safety climate and safety behavior.

2.2.7 Safety Motivation

Neal and Griffin (2006) defined safety motivation as the willingness of an individual to engage in safety behaviors or to comply with safety-related matters. Thus, safety motivation is a state in which an individual is committed to acting safely and attaches importance to safety behaviors in order to achieve organizational safety goals (Neal et al., 2000). Safety motivation determines the willingness to be safe, the direction, extent, and duration of behavior (Campbell et al., 1993), and is a continuous effort to achieve safety goals under any circumstances. In addition, Ahn (2014) viewed safety motivation as a continuous effort to achieve a goal or task in safety matters, even in the presence of other

constraining circumstances or obstacles. Safety motivation means caring about the issue of safety and the intensity of motivation can be said to be the employees' passion and commitment to safety in terms of the energy and vigor they put into performing goal-oriented tasks (Woo, 2014). Deci (1971) categorized motivation into intrinsic motivation and extrinsic motivation. Intrinsic motivation is a motivation that induces a person to have a sense of reward for a task through a sense of satisfaction or accomplishment in performing a task without any other special reward. In other words, intrinsic motivation means that when a worker receives a task from a manager and uses creative judgment to achieve it, he or she achieves the task given by the manager or achieves more than the task, the reward in the process of performing the task, the sense of accomplishment when the task is completed, etc. Extrinsic motivation refers to drivers such as rewards provided by factors outside of the job, such as money, rewards, and punishments. It is concerned only with the outcome of a task rather than the activity or process of performing it. For example, being rewarded by your manager for successfully completing a task is an example of extrinsic motivation. To elicit extrinsic motivation, it is important to clearly recognize the task, describe the process of performing the task and its results, create a sense of competition among members, and clarify the rewards for the results.

2.2.8 Safety Behavior

Several studies have proposed indicators of safety performance, including participation in safety activities (Cheyne et al., 1998), minor accidents (Zohar, 2000), observation of safety behaviors (Glendon & Litherland, 2001), and workers' compliance with safety rules and procedures (Marchand et al., 1998). Burke and Dunlap (2002) defined safety performance as job-wide behaviors that promote the safety and

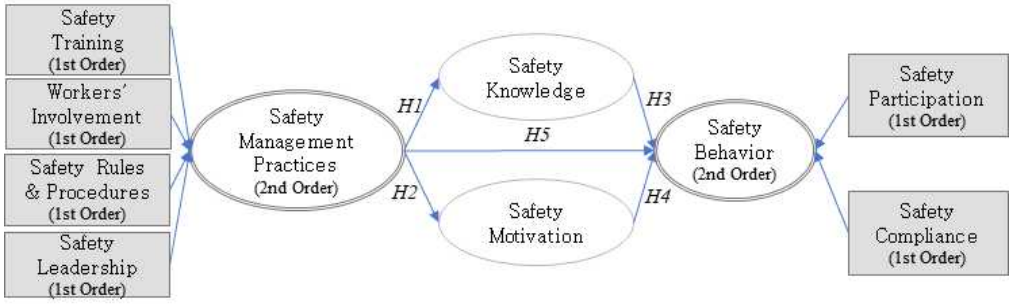
well-being of organizational stakeholder groups and extended groups. Neal and Griffin (2006) stated that safety behavior of organizational members is a fundamental factor in safety performance, where safety behavior refers to all actions performed to ensure safety. Wu et al. (2010) stated that safety behavior is an essential element of safety performance and is influenced by various factors. Neal et al. (2000) stated that safety behavior in organizations refers to behaviors such as following safety procedures and regulations set by the organization, wearing safety equipment, etc., while performing their job duties. In other words, safety behavior can be seen as the behavior of workers to eliminate, control, and isolate dangerous factors during work. Neal and Griffin (1997) divided safety behaviors into two types: safety participation and safety compliance; safety participation refers to behaviors such as active efforts to change the environment of the workplace to be safe or to promote safety, such as safety-related training and meetings, establishing safety goals, and making safety-related suggestions, and safety compliance refers to the implementation of safety procedures to prevent hazards as a core activity that individuals should perform to prevent safety accidents in advance or to maintain safety in the workplace. Safety participation behavior is a participatory behavior such as voluntarily participating in safety training and providing safety-related opinions, which is an active and proactive safety activity but does not have a direct and immediate impact on safety, while safety compliance behavior is a basic and core but passive safety behavior in which workers move in compliance with work procedures and rules to maintain safety (Kim, 2015). Garavan and O'Brien (2001) stated that safety behaviors are behaviors that cause workers to avoid risks while performing their jobs and are the implementation of procedures to reduce exposure to potentially harmful risk variables and injuries. Lee and Cho (2014)

conducted a statistical analysis of a survey and found that five factors were the main factors affecting safety behavior: safety training and safety organization system, safety importance perception, top management's valuation of safety, safety knowledge, and safety-related communication. Park (2014) found that organizational safety leadership and support affect workers' safety awareness and safety behavior, and continuous efforts to activate safety and health activities affect safety leadership, workers' safety awareness, and safety behavior.

2.3 Research Design and Methodology

2.3.1 Research Model

In this study, we first examine the impact of safety management practices on safety knowledge. Second, this study aims to determine the effect of safety management implementation factors on safety motivation. Third, this study aims to identify the effect of safety knowledge on safety behavior. Fourth, the effect of safety motivation on safety behavior. Fifth, the effect of safety management practice factors on safety behavior. Sixth, to determine whether safety knowledge and safety motivation mediate the relationship between safety management practices and safety behavior.



〈Figure 2-1〉 Research Model

2.3.2 Hypothesis Formulation

2.3.2.1 Safety Management Practices and Safety Knowledge

Vinodkumar and Bhasi (2010) state that safety management practices, as perceived by employees, are part of the safety climate, and the safety management system, which encompasses safety management practices, reflects the organization's commitment to safety, which has a significant impact on employees' safety perceptions and safety knowledge. A key component of any successful organization, any successful accident prevention program, and any occupational safety and health program is effective safety training. Safety training can improve workers' safety knowledge, attitudes, and behaviors. Safety training can also be a means of making accidents more predictable (Vinodkumar & Bhasi, 2010). Cox and Cheyne (2000) stated that worker involvement is a critical factor in safety management, and Neal and Griffin (2006), based on theories of job performance established by Borman and Motowidlo (1993), categorized performance into antecedents, determinants, and components of performance. In the case of safety management performance, we studied the effects of five antecedents, which are organizational characteristics such as management's safety leadership, communication, safety practices, safety training, and safety devices, on safety behavior through safety knowledge and safety motivation. The results of the study showed that the five antecedents influenced safety behavior through safety knowledge and safety motivation. In addition, Hill and Ainsworth (2001) found that increased worker involvement in construction sites increased safety knowledge, which in turn reduced the number of safety incidents. Zohar (2000) stated that safety rules and procedures are an essential component of safety behavior and represent a major factor in creating a safety climate in which safety behaviors can be performed, and hazards can be detected, and Hofmann and Stetzer (1996) stated that safety

performance is related to safety knowledge, skills, and other measures of safety climate. Scholars in the field of knowledge management have investigated many factors that can influence knowledge sharing in organizations, among which transformational leadership has been shown to play a significant role in facilitating knowledge sharing through employee motivation (Bryant, 2003). Bai et al. (2016) studied whether various factors such as trust, task conflict, and relationship conflict affect employees' knowledge sharing, among which leadership is an important factor in generating employees' knowledge sharing behavior. In addition, Pinho et al. (2012) found that authentic leadership provides opportunities to develop a collective environment, improve knowledge, and expand individual and collective confidence. According to Durham et al. (1997), an empowering leader with safety leadership urges employees to participate in decision-making and share knowledge and encourages members to express personal opinions and make appropriate suggestions. Therefore, based on these previous studies, we formulated the following hypotheses.

H1: Safety management practices will have a positive effect on safety knowledge.

2.3.2.2 Safety Management Practices and Safety Motivation

In a study on safety motivation in the workplace, Hedlund et al. (2016) found that safety training significantly increased awareness of safety behaviors and intrinsic safety motivation. Vinodkumar and Bhasi (2010) stated that safety management practices perceived by employees are part of safety climate, and Payne et al. (2009) stated that safety climate affects safety knowledge and safety motivation, and safety knowledge and safety motivation affect safety behavior. In a study on the determinants of safety motivation and its relationship with safety behavior

of Air Force pilots, Woo (2014) found that safety climate had the greatest impact on safety motivation and that safety support from management, safety training, and communication had positive effects, while reprimands from superiors and flight briefing confirmation had negative effects. Ahn (2014) found that safety climate, including management's safety leadership, safety training, and safety prevention activities, had a positive effect on safety motivation. Christian et al. (2009) also found that safety climate affects safety motivation to perform tasks reliably and safely. The extent to which workers are aware of the safety rules and procedures established and implemented within the organization is a key element of the safety management system. Therefore, safety rules and procedures are also considered a safety management system (Vinodkumar & Bhasi, 2010). A safety management system, including safety rules and procedures, consists of a set of policies and practices that aim to reduce unsafe behavior by positively influencing employee attitudes and behaviors toward hazards; the goal is to increase worker awareness, understanding, safety motivation, and commitment (Fernandez-Muniz et al., 2007). A supervisor's transformational safety leadership exerts its influence through the interaction of leadership with subordinates in a holistic process in which the supervisor examines the current state of safety, creates a vision for improving it, and devises various ways to achieve that vision (Petersen, 2004); therefore, transformational safety leadership positively affects subordinates' safety motivation in that during this interaction, by praising and encouraging subordinates' safety engagement behaviors, a reinforcing effect occurs in which subordinates feel satisfied and rewarded, and the increased safety motivation reinforces safety engagement behaviors. Basahel (2021) found that safety leadership, such as offering incentive programs, recognizing workers' safety behaviors, involving workers in decision-making, offering

effective safety training programs, and providing input on safety issues, effectively influences individual safety attitudes, motivation, and knowledge. Wachter and Yorio (2014) stated that safety management practice elements are structured to influence workers' knowledge, skills, motivation, decision-making, attitudes, and perceptions and utilize an interconnected system to enable workers to work safely and without accidents, resulting in a sustainable competitive advantage. Based on these previous studies, we formulated the following hypotheses.

H2: Safety management practices will have a positive effect on safety motivation.

2.3.2.3 Safety Knowledge and Safety Behavior

Shin et al. (2014) found that among variables such as safety motivation, affective commitment, and safety knowledge, safety knowledge had the strongest direct effect on safety behavior. In addition, Mohamadfam et al. (2015) found that safety knowledge is one of the best predictors of safety behavior. Sharing safety knowledge, especially on construction sites, can be an effective way to drive safety behavior, even when safety training is lacking. Neal et al. (2000) found that worker safety motivation and safety knowledge can predict worker safety involvement and safety compliance levels. Zohar (1980) stated that safety knowledge influences an individual's safety behavior, and studies have confirmed the effects of worker safety motivation and safety knowledge on safety behavior. Borgheipour et al. (2020) found that workers' safety behavior is positively influenced by worker safety knowledge and safety motivation. In a study on the impact of individual and organizational factors on the safety behavior of airline mechanics, Yoon (2022) found that safety knowledge influenced the safety behavior of airline mechanics. Other studies have also found that safety knowledge has a positive

impact on safety performance (Neal et al., 2000; Probst & Brubaker, 2001). Jung (2017) found that safety knowledge affects safety climate and safety performance within a hospital organization and that more safety knowledge has a greater impact on safety behavior. Based on these previous studies, we set the following hypotheses.

H3: Safety knowledge will have a positive effect on safety behavior.

2.3.2.4 Safety Motivation and Safety Behavior

Sulistiobudi and Kadiyono (2017) found that motivation plays an important role in goal achievement. They discuss motivational climate, which is described as an individual's perception of their expectations regarding a motivational situation. The idea is that a motivating situation will orient and engage the individual in working toward achieving the goal. Kim and Park (2002) tested Neal et al.'s (2000) safety climate-safety behavior model on Korean workers and found that safety climate influences safety knowledge and safety motivation, and safety knowledge and safety motivation significantly influence safety compliance behavior, which is following safety instructions in the course of work. Ahn (2013) argued that a high degree of motivation leads to increased self-efficacy and performance, and motivation has a positive effect on the performance of a given task. The importance of safety motivation for workers' safety behaviors is that during the motivation process, they specifically strive to satisfy their personal needs and achieve organizational goals. This can be viewed as channeling the energy into goal-oriented behavior for the individual and performance-oriented behavior for the organization. Neal et al. (2000) stated that workers' safety behaviors require knowledge and skills and that a lack of worker safety knowledge negatively affects safety behaviors, resulting in a lack of motivation to comply with safety regulations or engage in safety behaviors, which negatively affects safety behaviors. This shows that motivation is an

important factor in determining employees' safety behavior. Campbell et al. (1993) argued that motivation is a key factor in work performance, determining the direction, extent, and duration of behavior and that safety behavior, in particular, depends on the characteristics of safety motivation. In the field of safety, safety motivation is a determinant of safety behavior, which directly affects safety compliance behavior and safety engagement behavior, and antecedents such as safety climate can influence safety behavior, which is an outcome through the mediation of safety motivation, which is a determinant (Neal & Griffin, 2006). Neal and Griffin (2006) stated that it is difficult for employees to perform safety behaviors if they do not have sufficient safety knowledge or motivation, and employees will not perform safety behaviors if they do not have sufficient motivation to comply with safety regulations or engage in safety behaviors. This suggests that motivation is a very important factor in driving voluntary safety behavior. Based on these previous studies, we formulated the following hypotheses.

H4: Safety motivation will have a positive effect on safety behavior.

2.3.2.5 Safety Management Practices and Safety Behavior

Florio (1960) stated that safety training is necessary to optimize the level of activity that will reduce the national accident rate. A study by Mayer and Salovey (1995) found that students learn new material through experience and attach their meaning to the experience. They also suggested that experiential learning involves the active participation of the subject interacting with the object or environment in a concrete situation and that experiential learning provides an opportunity for learners to increase their memory and learn meaningfully because they are interested and actively engaged. They learn in an environment that is similar to the real world. Workers' involvement in management has been used as a

participatory activity aimed at increasing organizational efficiency and improving competitiveness in terms of human resource management as part of industrial democracy and management strategy through systems such as collective bargaining. Previous studies have been primarily concerned with how employee participation in management affects organizational performance, job satisfaction, and loyalty to the organization (Miller & Monge, 1986). Cappelli and Rogovsky (1998) studied the effect of worker involvement on workers' organizational citizenship behavior through a survey of supervisors. They matched workers in eight U.S. companies in 1992 and found that worker involvement positively affected organizational citizenship behavior. Vinodkumar and Bhasi (2010) verified that Workers' Involvement is strongly related to safety engagement in safety behaviors. In addition, Keffane and Delhomme (2013) reported that Workers' Involvement predicts safety compliance among safety behaviors in a study to determine the performance of road safety policy implementation in France. Walters and Frick (2000) emphasize that active employee participation in the safety management system is an important factor in improving safety performance. Zohar (2000) found that safety rules and procedures are a critical conceptual component of safety climate and that the existence of institutionalized procedures is an organizational variable that has a significant impact on the outcome of individual safety behavior. On the other hand, empirical studies have shown that supervisors' safety leadership positively influences subordinates' safety motivation and, ultimately, safety participation behavior (Neal et al., 2000). The U.K.'s Health and Safety Executive (2003) explained that achieving good safety performance is very difficult without effective organizational safety leadership. The U.S. Federal Safety Commissioner (2006) also emphasized that creating a safety culture is essential to driving safety performance in

an organization and that executive safety leadership plays an important role. Based on these previous studies, we formulated the following hypotheses.

H5: Safety management practices will positively affect safety behavior.

2.3.2.6 Mediating Effects

Based on the theory of Campbell et al. (1993), who presented the theories of job performance, Neal and Griffin (1997) categorized safety management performance into antecedents of safety performance (safety management practice factors), determinants of safety performance, and components of safety performance. Neal et al. (2000) considered safety climate, consisting of safety leadership, safety training, workers' involvement, safety communication, and safety rules and procedures, as antecedents of safety performance; safety knowledge and safety motivation as determinants of safety performance; and safety behavior (safety engagement, safety performance) as components of safety performance. In another study, Pousette et al. (2008) used safety knowledge and safety motivation as variables to measure personal attitudes toward safety. Self-rated safety behavior was measured by three safety behavior scales: structural safety behavior (related to participation in organizational safety activities), interactive safety behavior (related to safety activities in daily work through interaction with co-workers and management), and personal safety behavior (safety behaviors that promote personal protection). Meanwhile, Vinodkurma and Bhasi (2010), in a study of workers in a government-owned chemical plant in India, found that safety management practice factors influence safety behaviors (safety participation, safety compliance) through the mediation of safety knowledge and safety motivation. Based on these previous studies, the following hypotheses were developed.

H6: Safety knowledge will mediate the relationship between safety management practices and safety behavior.

H7: Safety motivation will mediate the relationship between safety management practices and safety behavior.

2.4 Construct Definition and Questionnaires

2.4.1 Definition of Constructs

The measurement tool was constructed based on survey questions from existing studies that were validated based on previous research. The questionnaire was administered to employees who are currently working in the manufacturing industry. All survey items were measured on a 5-point Likert scale, and the survey was conducted online through an internet survey. The operational definitions of the variables, related literature, and survey questions are summarized in 〈Table 2-1〉.

〈Table 2-1〉 Operational Definitions and Related Literature of Variables

Variable		Operational Definitions	Related Literature
Safety Management Practices	Safety Training	Education focused on developing the knowledge, skills, habits, and attitudes necessary to prevent death and injury	Reason (1998)
	Workers' Involvement	A variety of processes and structures that encourage workers to contribute and influence decisions, directly or indirectly	Pawlowska (2013)
	Safety Rules & Procedures	Workers' perceptions of how well the organization recommends and enforces current safety rules and procedures	Cox & Cheyne (2000)
	Safety Leadership	Leadership that is both transformational and dynamic	Barling et al.

Variable		Operational Definitions	Related Literature
		and transactional for effective safety practices	(2002)
Safety Knowledge		Workers' knowledge and skills about how to comply with safety regulations or participate in safety activities to stay safe	Neal & Griffin (2002)
Safety Motivation		Motivating individuals to make efforts and engage in safe behavior to achieve safety goals or safety outcomes	Neal & Griffin (2006)
Safety Behavior	Safety Participation	Behavior that don't directly impact safety but help make the workplace safer	Neal et al. (2000)
	Safety Compliance	Key safety behavior required of individuals to stay safe	

2.4.2 Questionnaires of Constructs

The safety training questionnaire was measured with a total of five questions, five of which are related to process culture and learning culture, which constitute the safety culture developed by Reason (1998). Workers' Involvement was measured with five questions, and the scale developed by Varonen and Matilla (2000) was used. Safety rules and procedures were measured using a 5-item scale developed by Cox and Cheyne (2000). safety leadership was measured using a 10-item scale developed by Barling et al. (2002) based on Bass and Avolio's (1990) Multifactor Leadership Questionnaire and modified to fit the safety concept. Safety knowledge was measured using a six-item scale developed by Neal and Griffin (2002). Safety motivation was measured using a six-item scale developed by Neal and Griffin (2006). safety behaviors were measured with a total of 11 items, with six items related to safety participation and five items related to safety compliance developed by Neal et al. (2000). The measurement variables and survey questions are summarized in 〈Table 2-2〉.

〈Table 2-2〉 Measurement Variables and Questionnaires

Variable	Measurement Variable		Questionnaires	Source
Independent Variable	Safety Training	Knowledge needed to prevent death and injury	5(4)	Reason (1997)
	Workers' Involvement	Processes for involving workers in safety decisions	5(5)	Varonen & Mattila (2000)
	Safety Rules & Procedures	Workers' perception of safety rules and procedures	5(4)	Cox & Cheyne (2000)
	Safety Leadership	Transformational and transactional leadership	10(8)	Barling et al. (2002)
Mediating Variable	Safety Knowledge	Safety-related workers' knowledge and skills	6(6)	Neal & Griffin (2002)
	Safety Motivation	Motivating safety behavior	6(5)	Neal & Griffin (2006)
Dependent Variable	Safety Participation	Helpful behavior to keep your workplace safe	6(4)	Neal et al. (2000)
	Safety Compliance	safety behavior to stay safe	5(3)	
Demographic questions			12	
Total number of questionnaires			60(51)	

* Number of final adopted survey questions in parentheses

2.5 Data Collection and Sample Characteristics

2.5.1 Data Collection

To validate the research model, a survey was conducted among workers in both skilled and clerical positions in the manufacturing industry across the country. A total of 271 out of 300 copies of the online survey were used in the final analysis.

2.5.2 General Characteristics of the Sample

The demographic characteristics of the survey participants are shown in 〈Table 2-3〉 below.

〈Table 2-3〉 General Characteristics of the Sample

Description		Frequency(people)	Rate(%)
Gender	Male	222	81.9%
	Female	49	18.1%
	Sum	271	100%
Age	20-29 years old	13	4.8%
	30-39 years old	87	32.1%
	40-49 years old	106	39.1%
	50-59 years old	53	19.6%
	Age 60 and older	12	4.4%
	Sum	271	100%
Workplace location	Seoul, Gyeonggi	112	41.3%
	Chungcheong-do	49	18.1%
	Gyeongsang-do	86	31.7%
	Jeolla-do	20	7.4%
	Gangwon & Jeju-do	4	1.5%
	Sum	271	100%

2.6 Analysis and Results

2.6.1 Evaluation of the Measurement Model

SmartPLS Ver.4.0 based on PLS (Partial Least Square) was used to analyze reliability, convergent validity, and discriminant validity. According to the proposed method, variables with factor loadings of 0.7 or less were removed one by one. Among the measured items, one item each in the safety training and safety rules and procedures items and two items in the safety leadership item were removed due to low factor loadings. One item was removed from the Safety Motivation scale due to low factor loadings, and the fourth item in the Safety Motivation scale was reverse-scaled to check for potentially dishonest responses from respondents. Two items from the first factor of safety behavior, safety engagement, and safety compliance were removed due to low factor loadings. For reliability analysis, Cronbach's Alpha Value was examined and was deemed adequate as it met the recommended level of 0.7 or higher (Hair Jr. et al., 2014). Discriminant validity was determined by comparing the square root value of the mean variance extracted for the factor with the correlation coefficient with other factors, and significance was confirmed as the square root value of the mean variance extracted for the factor shown in the diagonal columns of the table as shown in 〈Table 2-5〉 exceeds the value to the left or right of the variable, and the discriminant validity was evaluated as significant according to the analysis results (Fornell & Larcker, 1981).

2.6.2 Evaluation of Structural Model: Hypothesis Testing

The results of the study are summarized below. First, safety management practices were positively related to safety knowledge. Second, safety management practices were positively related to safety motivation.

Third, safety knowledge had a positive effect on safety behavior. Fourth, safety motivation had a positive effect on safety behavior. Fifth, safety management practices had a positive effect on safety behavior. Sixth, safety knowledge mediated the relationship between safety management practices and safety behavior. Seventh, safety motivation mediated the relationship between safety management practices and safety behavior. Safety management implementation factors consist of safety training, worker participation, safety rules and procedures, and safety leadership, and safety behavior is a second-order factor consisting of safety participation and safety compliance and was analyzed using latent variable scores according to the two-stage analysis (Hair et al., 2017), and the determination coefficient value of the model for the dependent variable, R^2 is 0.582, and 〈Table 2-6〉 summarizes the results of the hypothesis test.

〈Table 2-4〉 Convergent Validity and Reliability Analysis Results

Variable		Indicator	Factor Loading	Cronbach's Alpha	CR	AVE
Safety Management Practices	Safety Training	safety training_2	0.860	0.894	0.896	0.759
		safety training_3	0.900			
		safety training_4	0.876			
		safety training_5	0.849			
	Workers' Involvement	workers' involvement 1	0.774	0.899	0.914	0.712
		workers' involvement 2	0.825			
		workers' involvement 3	0.852			
		workers' involvement 4	0.898			

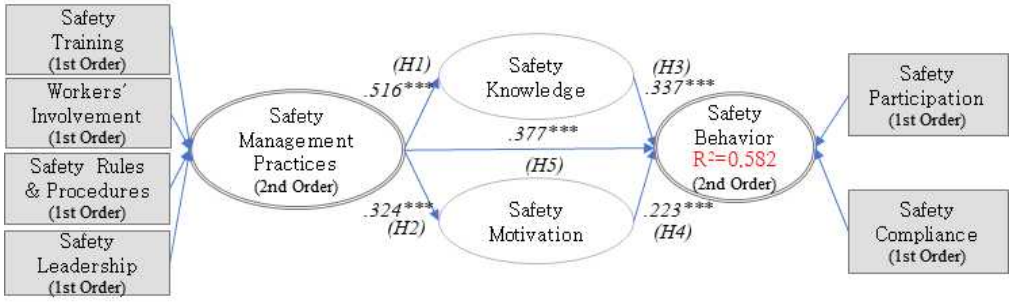
Variable		Indicator	Factor Loading	Cronbach's Alpha	CR	AVE
		workers' involvement 5	0.864			
	Safety Rules & Procedures	safety rules & procedures 1	0.828	0.870	0.876	0.720
		safety rules & procedures 2	0.866			
		safety rules & procedures 4	0.796			
		safety rules & procedures 5	0.902			
	Safety Leadership	safety leadership 3	0.798	0.933	0.935	0.682
		safety leadership 4	0.816			
		safety leadership 5	0.835			
		safety leadership 6	0.838			
		safety leadership 7	0.808			
		safety leadership 8	0.865			
		safety leadership 9	0.831			
		safety leadership 10	0.814			
Safety Knowledge		safety knowledge 1	0.812	0.896	0.897	0.659
		safety knowledge 2	0.847			
		safety knowledge 3	0.820			
		safety knowledge 4	0.810			
		safety knowledge 5	0.812			
		safety knowledge 6	0.769			
Safety Motivation		safety motivation 1	0.852	0.905	0.907	0.724
		safety motivation 2	0.868			
		safety motivation 3	0.855			

Variable		Indicator	Factor Loading	Cronbach's Alpha	CR	AVE
		safety motivation 5	0.854			
		safety motivation 6	0.825			
Safety Behavior	Safety Participation	safety participation 3	0.782	0.844	0.851	0.682
		safety participation 4	0.811			
		safety participation 5	0.866			
		safety participation 6	0.841			
	Safety Compliance	safety compliance 1	0.883	0.763	0.789	0.679
		safety compliance 2	0.853			
		safety compliance 4	0.727			

〈Table 2-5〉 Discriminant Validity Analysis Results

Variable	Safety Rules & Procedures	Safety Compliance	safety knowledge	Safety Leadership	Safety Motivation	Safety Participation	Safety Training	Workers' Involvement
Safety Rules & Procedures	0.849							
Safety Compliance	0.408	0.824						
safety knowledge	0.526	0.591	0.812					
Safety Leadership	0.550	0.435	0.434	0.826				
Safety Motiva	0.314	0.525	0.600	0.282	0.851			

Variable	Safety Rules & Procedures	Safety Compliance	safety knowledge	Safety Leadership	Safety Motivation	Safety Participation	Safety Training	Workers' Involvement
tion								
Safety Participation	0.536	0.572	0.596	0.547	0.466	0.826		
Safety Training	0.717	0.432	0.385	0.575	0.200	0.503	0.871	
Workers' Involvement	0.791	0.363	0.434	0.585	0.308	0.481	0.731	0.844



〈Figure 2-2〉 Research Model Analysis Results(***p〈0.01,**p〈0.05,*p〈0.1)

〈Table 2-6〉 Summary of Hypothesis Testing Results

No.	Hypothesis	Results
H1	Safety management practices will have a positive effect on safety knowledge.	Accept
H2	Safety management practices will have a positive effect on safety motivation.	Accept
H3	Safety knowledge will have a positive effect on safety behavior.	Accept

No.	Hypothesis	Results
H4	Safety motivation will have a positive effect on safety behavior.	Accept
H5	Safety management practices will have a positive effect on safety behavior.	Accept
H6	Safety knowledge will mediate the relationship between safety management practices and safety behavior.	Accept
H7	Safety motivation will mediate the relationship between safety management practices and safety behavior.	Accept

All seven hypotheses were accepted, and it was confirmed that safety management practice factors have a positive effect on safety behavior through safety knowledge and safety motivation. The mediating effect analysis of this study is shown in 〈Table 2-7〉, and it can be seen that all mediating effects are significant. The mediating effects and serial multiple mediating effects were tested according to the methodology of Baron and Kenny (1986) and Hayes (2009). In addition, after confirming the existence of mediating effects according to the mediation analysis procedure of Baron and Kenny (1986), Sobel Test was conducted to identify the mediating effects, and the results are shown in 〈Table 2-8〉, and the formula is as follows.

Formula 1 : $Z=\frac{a\times b}{\sqrt{a^2\times SE_b^2+b^2\times SE_a^2}}$ (a: The unstandardized regression coefficient from Step 2, b: the unstandardized regression coefficient from Step 3, SEa: The standard error value of the unstandardized coefficient from Step 2, SEb: unstandardized coefficient standard error value from Step 3).

In order for there to be a mediating effect, the independent variable

must have a significant effect on the dependent variable in Step 1, the independent variable must have a significant effect on the mediator in Step 2, and the independent variable and mediator must have a significant effect on the dependent variable at the same time in Step 3. If the parameter is significant and the independent variable is not significant in Step 3, there is a full mediating effect; if both the independent variable and the parameter are significant, look at the regression coefficient, and if the regression coefficient of the independent variable in Step 3 is smaller than the regression coefficient of the independent variable in Step 1, there is a partial mediating effect.

〈Table 2-7〉 Mediating Effects

Path	Path coefficient	T Statistic	p Value
Safety Management Practices → Safety Knowledge → Safety Behavior	0.174	5.307	0.000
Safety Management Practices → Safety Motivation → Safety Behavior	0.072	3.563	0.000

〈Table 2-8〉 Sobel Test Z Value

Path	Z Value
Safety Knowledge → Safety Behavior	7.883***
Safety Motivation → Safety Behavior	5.131***

(***: p<0.01; **: p<0.05; *: p<0.1)

Based on 〈Table 2-7〉 and 〈Table 2-8〉 and following the methodology of Baron and Kenny (1986), we can see that the absolute values of the Z values in the Sobel test are all significant at the 0.01

level of significance and that safety management practices have a partial mediating effect on safety behavior through safety knowledge and safety motivation.

2.7 Conclusions

2.7.1 Summary

In this study, we examined the influence of safety management practices on safety knowledge and safety motivation by conducting a study on field workers in a manufacturing company. In addition, the effect of safety knowledge and safety motivation on safety behavior was examined, and the mediating effect of safety knowledge and safety motivation on the relationship between safety management implementation factors and safety behavior was examined. Based on the results of this study, it was confirmed that safety management practice factors affect safety knowledge and safety motivation, and safety knowledge and safety motivation affect safety behavior. Furthermore, it was verified that safety knowledge and safety motivation mediate the relationship between safety management practices and safety behavior. Therefore, based on the management of safety management practices, it is necessary to improve workers' safety knowledge and safety motivation to lead to safety behavior. The significance of this study is that it identified the effects of safety management practices on safety behavior through the mediation of safety knowledge and safety motivation, and identified the positive influence of the management of safety management practices on safety behavior.

2.7.2 Implications

The theoretical implications are as follows. First, we confirm that

safety management practices are a key determinant of safety behavior among field workers. In turn, the management of safety management practices in the enterprise has a positive impact on safety behavior through the improvement of workers' safety knowledge and safety motivation. Second, the verification of the relationship between different variables that can affect safety behavior provides a perspective on safety behavior from the perspective of mediating effects, which are not only direct effects but also indirect effects. We find that safety management practices influence safety behavior through the mediation of safety knowledge and safety motivation. The mediation analysis shows that safety knowledge has a stronger effect on safety behavior than safety motivation, indicating that workers' safety knowledge is an important factor in driving safety behavior.

The practical implications are as follows. First, this study contributes to the revitalization of safety research in the manufacturing sector, which has been under-researched, by focusing on workers in the manufacturing industry, which has the second highest number of occupational accidents after the construction industry. Second, this study is significant in that it confirms how safety knowledge and safety motivation are related to safety behavior. Third, by confirming that safety knowledge and safety motivation have a positive influence on safety behavior, this study provides evidence that corporate safety managers should reflect more policies to improve workers' safety knowledge and safety motivation in their safety and health management systems.

2.7.3 Limitations and Suggestions

Despite these implications, there are a few limitations to this study. First, there is a limitation of needing to be able to analyze the impact relationship on whether safety behavior actually affects disaster reduction. Second, it is necessary to deepen the study by considering other factors

that may affect safety behavior as variables in addition to the independent variables of safety management practices, safety knowledge, and safety motivation. Third, complementing quantitative data with qualitative insights will provide a more comprehensive understanding of the factors that influence safety behavior. Qualitative research methods such as focus group interviews can provide valuable context to quantitative findings.

Chaper 3. Investigating the Impact of Safety Culture on Safety Behavior mediated by safety climate and safety motivation through the Combination of PLS-SEM and NCA

This study empirically investigated the relationship between workers' safety behaviors in the manufacturing industry and safety culture, safety climate, and safety motivation and analyzed the role of these factors to identify and analyze factors that strengthen workers' safety behaviors that contribute to preventing major accidents in companies. According to Korea Occupational Safety and Health Agency's industrial accident survey data, the accident rate of manufacturing workers is the second highest in the construction industry, and when an accident occurs, companies have to bear not only direct costs but also indirect costs such as human loss, material loss, production loss, and time loss, resulting in huge loss costs. Based on the results of previous studies, this study investigated the effects of corporate safety culture on safety behavior through the mediation of safety climate and safety motivation among production and labor workers in the manufacturing industry. Statistical analysis was conducted on 271 manufacturing workers using SPSS and PLS, and the results showed that corporate safety culture can lead to workers' safety behavior by influencing safety climate and enhancing workers' safety motivation.

【Key Words】 Safety Culture, Safety Climate, Safety Motivation, safety behavior, Reporting Culture, Just Culture, Flexible Culture, Learning Culture, Safety Participation, Safety Compliance

3.1 Introduction

Wood (1991) theoretically defined safety as freedom from hazards or the absence of hazardous situations. A safe state is one in which countermeasures are in place to prevent people from being harmed even if there is a source of danger, and that fact has been confirmed. In recent years, it has been said that safety is not simply the absence of disasters or accidents but also the prediction of hidden dangers and the establishment of countermeasures against them. In this sense, it can be said that safety is a state that is created. In industrial sites, safety measures are often established for workers by installing safety passages, safety partitions, and safety devices. Safety at industrial sites is important to protect the lives and safety of workers, but it is also an important factor that affects the productivity and long-term growth of companies. Therefore, to ensure the safety of workers, Korea enacted the Serious Accident Punishment Act on January 27, 2022. The Serious Accident Punishment Act imposes a duty on the person in charge of management to ensure the safety and health of all persons working in a business or workplace. If a major industrial accident occurs because the person in charge of management fails to fulfill their duty to ensure safety and health, they can be punished. As a result, more and more companies are establishing safety and health management systems and striving to establish a safety culture. The term safety culture first appeared after the Chernobyl nuclear disaster in 1986. Since the Chernobyl nuclear accident, there have been many attempts to find the cause of accidents by expanding the complex and organic systemic causes of accidents instead of looking for a single source of failure. While previous attempts to find the cause of accidents have focused on technical and human errors, there is a growing trend to look at the behavior of the entire organization under the influence of organizational culture. As a result, various studies

have been conducted to strengthen safety culture among the factors that affect organizational safety activities, but there are still differences in the perception of safety culture, and there is still a lack of systematization efforts and applied methodology research by industry. Until now, most studies have assumed that accidents in the field are caused by unsafe human behavior. However, recent analyses have shown that worker misbehavior that can lead to safety incidents originates from external factors that have been disseminated through the system over time. Therefore, if we want to reduce accidents, we need to make systematic efforts at both the individual and organizational levels to eliminate potential contributing factors. Recently, corporate management has been undergoing a paradigm shift from profit-oriented management to sustainable management, and ESG management is becoming a new management paradigm (Heo & Lee, 2022). Cho and Lee (2023) argue that ESG management is emerging as a necessity of the times and that sustainable management through ESG requires changes and expenditures that are burdensome for companies. Establishing a safety culture and improving the safety atmosphere in the workplace is a very important task from the perspective of ESG management. As safety is becoming increasingly important, a growing body of literature examines the relationship between safety culture, safety climate, and safety behavior. The key to realizing a safety culture is to show the link between an organization's safety culture and the safety behavior of its workers, which can be called safety performance. By consistently showing changes in safety performance, you can demonstrate that your efforts to improve safety culture are actually having an impact on safety performance. This, in turn, influences worker safety behavior, which in turn acts as a virtuous cycle to achieve higher safety levels within the organization. This study is differentiated in that it seeks to examine the effect of safety

culture on workers' safety behavior through the mediation of safety climate and safety motivation in the context of Korean manufacturing firms. Therefore, this study aims to empirically identify the relationship between workers' safety behavior and safety culture, safety climate, and safety motivation and to analyze the role of the variables in the process so as to secure workers' safety behavior that contributes to the prevention of major accidents in companies. Accordingly, this study aims to determine, first, the impact of safety culture on safety climate. Second, we will examine the effect of safety climate on safety motivation. Third, the effect of safety climate on safety motivation is examined. Fourth, we want to determine the effect of safety climate on safety behavior. Fifth, we want to determine if safety climate mediates the relationship between safety culture and safety motivation. Sixth, we want to determine if safety climate mediates the relationship between safety culture and safety behavior. Seventh, we want to determine if safety motivation mediates the relationship between safety climate and safety behavior.

3.2 Literature Review

3.2.1 Safety Culture

The term safety culture was first used in INSAG-1 (1986), a report by the International Atomic Energy Agency (IAEA) International Nuclear Safety Advisory Group (INSAG) following the Chernobyl nuclear accident. Later, the IAEA's International Nuclear Safety Advisory Group published and presented Basic Safety Principles for the Safe Operation of Nuclear Power Plants (INSAG-3,1988) as the most important safety principles for establishing a safety culture. INSAG-4 (1991) defined safety culture as the attitudes and dispositions of the nuclear power plant organization and personnel to give priority to all safety issues commensurate with their importance. The definition relates safety culture

to individual attitudes and mindsets and organizational behavior, and emphasizes that effective methods must be developed to assess the extent of safety culture, even though these issues are intangible. The U.K. Health and Safety Commission (1993) provided a number of characteristics expected of a positive safety culture, defining the concept as the product of individual and group values, attitudes, perceptions, competencies, and behavior patterns that determine an organization's commitment to, style of, and proficiency in managing health and safety. Organizations with a positive safety culture are said to be characterized by communication-based on mutual trust, shared awareness of the importance of safety, and confidence in the effectiveness of preventive measures. Wiegmann et al. (2004) define safety culture as the enduring values by which everyone in an organization puts the safety of workers and the public first. It is a culture in which individuals and groups take responsibility for their own safety, act to ensure that safety is maintained, engage in dialogue to promote safety concerns, actively seek to learn, learn from mistakes to modify behavior, and reward to ensure that these values are consistently sustained. Safety culture is considered a sub-aspect of organizational culture (Cooper, 2000) and is perceived as a higher level of abstraction than safety climate (Reichers & Schneider, 1990). It is argued that safety culture and safety climate are complementary and independent concepts rather than one single concept (Yule, 2003). Geller et al. (1989) identified environmental factors, facility factors, and behavioral factors as influencing safety culture, each of which interacts organically with each other, and changes in one factor will, at some point, affect the other two. Based on the literature on organizational culture, Reason (1998) identified five important components of safety culture. They are Informed Culture, Reporting Culture, Just Culture, Flexible Culture, and Learning Culture. On the other hand, Cooper

(2000) examines safety culture in terms of psychological, behavioral, and situational dimensions. Psychological aspects are explained as beliefs, attitudes, and values of individuals and organizations; behavioral aspects are individual and organizational behaviors, and situational aspects are organizational safety policies, operating procedures, and management systems.

3.2.2 Safety Climate

Empirical research on safety climate has evolved considerably since the work of Zohar (1980). Zohar (1980) first used the term safety climate in an empirical study of the Israeli manufacturing industry, defining it as the sum of the overall perceptions that workers share about their work environment (Yule, 2003). Wu et al. (2010) defined safety climate as organizational members' perceptions of personal and organizational factors that influence their safety behaviors about the organization's safety culture. Niskanen (1994) defined safety climate as a set of attributes that can be perceived about a particular work organization and can be triggered by the policies and practices that the organization imposes on its workers. Also, Cabrera et al. (1997) referred to safety climate as the shared perceptions of organizational members about the work environment and organizational safety policies. Meanwhile, Donald and Canter (1994) defined safety climate as the shared attitudes of members within an organization toward safety, which also includes the responsibility and control of disaster prevention. Guldenmund (2000) noted that there is some overlap in the concepts of safety culture and safety climate, stating that safety culture is characterized by shared basic beliefs, values, and attitudes about work and the organization as a whole, while safety climate is more operational and refers to day-to-day perceptions of the work environment, work

practices, and organizational policies and management. Hale (2000) suggests that safety climate is a sub-concept of safety culture and can be viewed as a relatively small and changeable concept that refers to perceptions of workplace policies, procedures, and mastery associated with safety. Coyle et al. (1995) define organizational climate as employees' perceptions of the social and organizational environment in which they work, emphasizing that climate is a phenomenon that changes daily and can be influenced by context. Furthermore, climate is influenced by what work is done, how work is done, and who is doing the work. Safety climate is a specialized subset of organizational climate that emphasizes the importance of safety. Organizational climate is generally a shared perception of how things work within an organization and can be thought of as the perception of formal and informal organizational policies, practices, and procedures (Schneider & Rentsch, 1988). Zohar (1980), who pioneered the study of safety climate, identified the following as components of safety climate: safety training, management commitment to safety, status of the safety manager, status of the safety committee, level of risk in the workplace, social status, safety behavior, work pace for safety, and the effect of safety behavior on promotion. Brown and Holmes (1986), building on the work of Zohar (1980), explained safety climate in terms of three factors: workers' perception of risk, managers' concern for workers, and managers' behavior.

3.2.3 Safety Motivation

Motivation is a trigger that causes a person to do something or behave in a certain way; it sets an individual's mind to something or moves them in a certain direction to achieve a goal. Motivation can be viewed as a concept to explain why a behavior occurs, and if a person is highly motivated to engage in a particular behavior, exerts selective

effort in performing that behavior, and persists in that behavior, then they are highly motivated to perform that behavior (Steers et al., 2004). Here, if the motivation is to achieve a safety goal, it can be referred to as safety motivation. Neal and Griffin (2006) defined safety motivation as an individual's willingness to make an effort to comply with safety behaviors or safety-related matters. Thus, safety motivation is the state of an individual's commitment to behave safely and the importance they attach to safety behaviors in order to achieve organizational safety goals (Neal et al., 2000). Safety motivation determines the willingness to be safe, the direction, extent, and duration of behavior (Campbell et al., 1993), and is a continuous effort to achieve safety goals under any circumstances. In addition, Ahn (2014) viewed safety motivation as a sustained effort to achieve a goal or task on a safety issue, even in the presence of other constraints or obstacles. Safety motivation means caring about the issue of safety, and the intensity of motivation can be said to be an employee's passion and commitment to safety in terms of the energy and vigor they devote to performing goal-oriented tasks (Woo, 2014). Deci (1971) categorized motivation into intrinsic motivation and extrinsic motivation. Intrinsic motivation is a motivation that induces a person to have a sense of reward for a task through a sense of satisfaction or accomplishment in performing a task without any other special reward. In other words, intrinsic motivation means that when a worker receives a task from a manager and uses creative judgment to achieve it, the worker achieves the task given by the manager or achieves more than the task, the reward in the process of performing the task, and the sense of accomplishment when the task is completed. Extrinsic motivation refers to drivers such as rewards provided by factors outside of the job, such as money, rewards, and punishments, and is concerned only with the outcome of a task rather than the activity or process of

performing it.

3.2.4 Safety Behavior

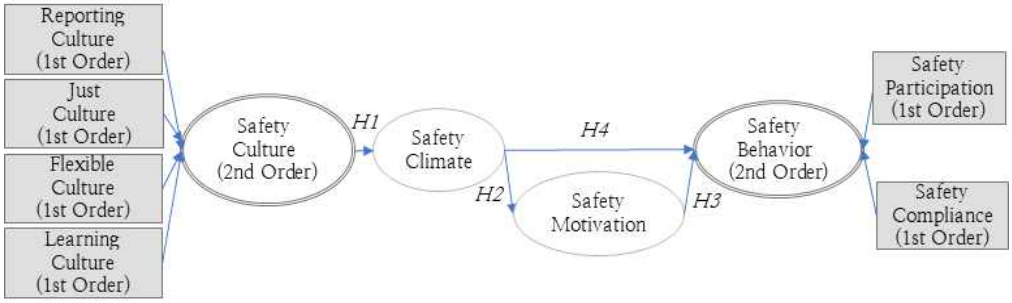
Several studies have proposed indicators of safety performance, including participation in safety activities (Cheyne et al., 1998), minor accidents (Zohar, 2000), observation of safety behaviors (Glendon & Litherland, 2001), and workers' compliance with safety rules and procedures (Marchand et al., 1998). Burke et al. (2002) defined safety performance as job-wide behaviors that promote the safety and well-being of organizational stakeholder groups and extended groups. Neal and Griffin (2006) stated that the safety behavior of organizational members is a fundamental factor in safety performance, where safety behavior refers to all actions performed to ensure safety. Wu et al. (2008) stated that safety behavior is an essential element of safety performance and is influenced by various factors. Neal et al. (2000) stated that safety behavior in organizations refers to behaviors such as complying with safety procedures and regulations set by the organization, wearing safety equipment, etc., in the process of performing their job duties. In other words, safety behavior can be seen as the behavior of workers to eliminate, control, and isolate dangerous factors during work. Garavan and O'Brien (2001) stated that safety behavior is the implementation of procedures to reduce exposure to potentially hazardous risk variables and injuries as behaviors that cause workers to avoid risk while performing their jobs. Neal and Griffin (1997) divided safety behaviors into two types: safety participation and safety compliance. Where safety participation refers to behaviors such as active efforts to make safe changes in the workplace environment or promote safety, such as safety-related training and meetings, establishing safety goals, and making safety-related suggestions, and safety compliance refers to the

implementation of safety procedures to prevent hazards as a key activity that individuals should perform to prevent safety accidents or maintain safety in the workplace. Safety participation behaviors are active and proactive safety activities that do not have a direct and immediate impact on safety, while safety compliance behaviors are basic and core activities but passive safety behaviors (Kim, 2015). Lee and Cho (2014) conducted a statistical analysis of the survey and found that five factors were the main factors affecting safety behavior: safety training and training and safety organization system, safety importance perception, top management's valuation of safety, safety knowledge, and safety-related communication. A study by Terry (2003) found that about 76% of accidents are caused by behavior, and when the indirect part of environment and behavior is included, nearly 96% of accidents are caused by behavior. Therefore, safety behavior is an important factor in preventing safety accidents.

3.3 Research Design and Methodology

3.3.1 Research Model

This study aims to determine the effect of safety culture on safety climate. Second, this study aims to determine the effect of safety climate on safety motivation. Third, we want to find out the effect of safety motivation on safety behavior. Fourth, we want to understand the effect of safety climate on safety behavior. Fifth, we want to determine whether safety climate mediates the relationship between safety culture and safety motivation. Sixth, we want to determine if safety climate mediates the relationship between safety culture and safety behavior. Seventh, we want to see if safety motivation mediates the relationship between safety climate and safety behavior.



〈Figure 3-1〉 Research Model

3.3.2 Hypothesis Formulation

3.3.2.1 Safety Culture and Safety Climate

Flin et al. (2000) argued that the concept of safety culture predates the extensive research on organizational culture and organizational climate and that culture is concerned with values and beliefs, while climate can be viewed as a measure that reflects members' perceptions of organizational climate. Mohamed (2003) argued that the two concepts cannot be used interchangeably because safety culture is primarily concerned with an organization's safety management, and safety climate is concerned with workers' perceptions of the role of safety in the workplace. Cox and Flin (1998) also stated that safety climate is a surface feature of safety culture that can be identified from workers' attitudes and perceptions at a particular point in time. In other words, safety culture influences safety climate. Safety culture is considered to be an enduring characteristic of an organization, as reflected in a consistent way of dealing with important safety issues. In contrast, safety climate is considered to be a temporary state of an organization that is susceptible to change due to a particular work environment or economic environment, so it is generally accepted that safety culture is a

subconcept of organizational culture and safety climate is a subconcept of organizational climate (Kim, 2015). Organizational climate can be conceptualized according to four perspectives: structural, perceptual, interactive, and cultural. Among them, the role of organizational culture in shaping the climate is important because the climate is formed due to the interaction between individuals (Tak, 2020). Therefore, organizational culture is a value system and behavior that affects the unique social and psychological environment of an organization, which is likely to affect the safety climate and safety behavior of a particular organization (Kim, 2015). Hofmann and Morgeson (1999) found that employees who work in companies with a safety-first environment, i.e., a safety culture, ensure a safety climate through compliance with safety procedures. Therefore, based on these previous studies, the following hypotheses were developed.

H1: Safety culture will have a positive effect on safety climate.

3.3.2.2 Safety Climate and Safety Motivation

The relationship between safety climate and safety motivation can be explained by the Expectancy theory (Vroom, 1964) and Social Exchange theory (Blau, 1964). According to the Expectancy theory, people are highly motivated when they believe that their behavior will result in a valued outcome, and when applied to safety, a good safety climate indicates that safety is perceived as valuable and important, so safety motivation is triggered by believing that their safety behavior will result in a valued outcome (Jung et al., 2015). Social exchange theory suggests that when employees perceive that an organization cares about their well-being, they will act in ways that benefit the organization in return, and this relationship also applies to safety. When an organization creates an atmosphere in which safety is valued for the safety and well-being of individuals, and employees perceive this, they are voluntarily motivated to

engage in safety behaviors in return (Jung et al., 2015). Neal et al. (2000) addressed safety climate as an important antecedent of safety motivation, stating that safety climate is an individual's willingness to comply with safety-related behaviors, and when a positive safety climate is created in the workplace, safety motivation to comply with safety tasks or engage in safety-related behaviors occurs. Payne et al. (2009) confirmed that the better the safety climate, the higher the safety motivation in their study of manufacturing and mining workers. Zohar (2000) stated that organizational safety climate affects safety motivation because safety climate provides employees with information that enables them to engage in desirable role behaviors, which in turn affects their safety motivation to decide whether to engage in safe or unsafe behaviors. In a study titled Determinants of Safety Motivation and Relationship with Safety Behavior among Air Force Pilots, Woo (2014) found that among the factors of safety climate, safety support, safety training, and communication from managers have a positive effect on safety motivation, while reprimands from supervisors or confirmation of flight briefings have a negative effect. Based on these previous studies, we set the following hypotheses.

H2: Safety climate will have a positive effect on safety motivation.

3.3.2.3 Safety Motivation and Safety Behavior

Sulistiobudi and Kadiyono (2017) found that motivation plays an important role in goal achievement. They discuss motivational climate, which is described as an individual's perception of their expectations regarding a motivational situation. The idea is that a motivating situation will orient and engage the individual in working towards achieving the goal. Ahn (2013) found that a high level of motivation leads to increased self-efficacy and higher performance, and motivation positively affects the

performance of a given task. The importance of safety motivation for workers' safety behaviors is that during the motivation process, they specifically strive to satisfy their personal needs and achieve organizational goals. This can be viewed as channeling the energy into purposeful behavior for the individual and performance-oriented behavior for the organization. Neal et al. (2000) stated that worker safety behavior requires knowledge and skills, and a lack of worker safety knowledge leads to a lack of motivation to comply with safety regulations or engage in safety behaviors, which negatively affects safety behavior. This shows that motivation is an important factor in determining employees' safety behavior. Kim and Park (2002) tested Neal et al.'s (2000) safety climate-safety behavior model on Korean workers. They found that safety climate influences safety knowledge and safety motivation, and safety knowledge and safety motivation significantly influence safety compliance behavior, which is following safety instructions in the process of performing work. Campbell et al. (1993) explained that motivation is a key factor in job performance through the job performance model theory, arguing that motivation determines the direction, scope, and duration of behavior and depends on motivational features. This means that motivation is a very important in inducing voluntary safety behavior among employees. Based on these previous studies, we formulated the following hypotheses.

H3: Safety motivation will have a positive effect on safety behavior.

3.3.2.4 Safety Climate and Safety Behavior

A number of studies have demonstrated that perceptions of safety climate are positively related to safety behavior as measured by self-assessment and that safety climate and safety behavior are negatively related to safety accidents (Neal et al., 2000; Hofmann & Stetzer, 1996; Neal & Griffin, 2006). In other words, a negative safety climate leads to

unsafe behaviors, such as ignoring safety procedures, which increases the likelihood of subsequent safety accidents. Zohar (2002) demonstrated that perceptions of safety climate, which reflect workers' beliefs about prioritizing safety, influence behavioral outcome expectations: if workers perceive a safety climate that values safety, they have a higher expectation that acting safely will lead to a valued outcome. Wu et al. (2008) analyzed the relationship between safety climate and safety behavior using previously developed safety climate indicators and safety behavior indicators and found a highly significant relationship between safety climate and safety behavior. Clarke (2006), in his paper, The Relationship Between Safety Climate and Safety Behavior, demonstrated a positive relationship between safety climate and safety behavior. Hofmann and Morgeson (1999) stated that safety culture or safety climate is not easily changed and takes time, but its effect can be considered comprehensive and long-term, and the perception of this safety climate directly affects safety behavior. Neal et al. (2000) found a positive relationship between safety climate and safety behavior in a study of 525 employees, and Mohamed (2003) also found that a significant positive relationship between safety climate and safety behavior was demonstrated. Based on Mohamed's (2003) research model, Jung and Kim (2008) investigated the effects of 10 safety climate factors on safety behavior by surveying engineers in the semiconductor manufacturing industry and semiconductor equipment service industry and found that safety climate had a significant positive effect on safety behavior. Based on these previous studies, we set the following hypotheses.

H4: Safety climate will have a positive effect on safety behavior.

3.3.2.5 Mediating Effects

According to Schein (1985), culture ultimately leads to explicit

behavior. Clarke (2003) suggests that worker behavior reflects an organization's safety culture and that worker behavior is an indicator of safety culture, meaning that worker behavior is influenced by the safety climate when a strong safety culture exists. Williamson et al. (1997) found that safety culture predicts safety-related employee behavior. Research on safety culture, safety climate, and safety behavior has been conducted in three main streams: what constitutes the safety climate of a workplace, the safety climate as perceived by workers, and the outcomes of the safety climate, such as safety behaviors and reduced accidents. Neal et al. (2000) discuss the role of safety climate as a predictor of the determinants and components of safety performance. Cooper (1998) stated that individual behavior is influenced by the culture and climate of an organization, which in turn is influenced by the preferred attitudes and behaviors of its members, its mission, and its management style. In addition, Glendon and Clarke (2015) found that safety climate is a determinant factor in predicting workers' safety behaviors and the likelihood of accidents. This means that higher levels of safety climate are associated with fewer safety incidents. In addition, safety climate has been defined in various ways in many studies. However, studies on safety climate have assumed that safe work behavior is a result of an organization's safety culture that has already been formed. By identifying the factors that create the safety climate, they have tried to create a positive work climate to elicit workers' safety behavior and prevent workplace accidents (Kwon, 2019). In the field of safety, safety motivation is a determinant of safety behavior, which directly affects safety compliance behavior and safety engagement behavior, and antecedents such as safety climate can affect safety behavior, which is an outcome through the mediation of safety motivation, which is a determinant (Neal & Griffin, 2006). In addition, Christian et al. (2009)

confirmed that safety knowledge and safety motivation mediate the relationship between safety climate and safety behavior. Based on these previous studies, the following hypotheses were developed.

H5: Safety climate will mediate the relationship between safety culture and safety motivation.

H6: Safety climate will mediate the relationship between safety culture and safety behavior.

H7: Safety motivation will mediate the relationship between safety climate and safety behavior.

3.4 Construct Definition and Questionnaires

3.4.1 Definition of Constructs

The measurement tool was constructed based on survey questions from existing studies that were validated based on previous research. The questionnaire was administered to employees currently working at a manufacturing site. All survey items were measured on a 5-point Likert scale, and the survey was conducted online through an internet survey. The operational definitions of the variables, related literature, and survey questions are summarized in 〈Table 3-1〉.

〈Table 3-1〉 Operational Definitions and Related Literature of Variables

Variable		Operational Definitions	Related Literature
Safety Culture	Reporting Culture	Core values and actions resulting from the total commitment of management and employees who prioritize safety over any	Reason (1998)
	Just Culture		

Variable		Operational Definitions	Related Literature
	Flexible Culture	competing goals to protect humans and the environment	Ek et al. (2003)
	Learning Culture		
Safety Climate		Shared perceptions of organizational members regarding safety-related policies, procedures, and practices within the organization	Zohar & Luria(2005)
Safety Motivation		Motivating individuals to make efforts and engage in safe behavior to achieve safety goals or safety outcomes	Neal & Griffin (2006)
Safety Behavior	Safety Participation	Behavior that don't directly impact safety but help make the workplace safer	Neal et al. (2000)
	Safety Compliance	Key safety behavior required of individuals to stay safe	

3.4.2 Questionnaires of Constructs

Safety culture was measured with a total of 19 items, which were adapted from Reason (1998) and Ek et al. (2003) by selecting the co-components of safety culture: reporting culture, just culture, flexible culture, and learning culture. Safety climate was measured with nine items, and the scale developed by Zohar and Luria (2005) was used. Safety motivation was measured using a scale developed by Neal and Griffin (2006), comprising 6 items. Safety behavior was measured with a total of 11 items, with six items related to safety participation and five items related to safety compliance developed by Neal et al. (2000). The measurement variables and survey questions are summarized as shown in 〈Table 3-2〉.

〈Table 3-2〉 Measurement Variables and Questionnaires

Variable	Measurement Variable	Questionnaires	Source

Variable	Measurement Variable		Questionnaires	Source
Independent Variable	Reporting Culture	Core values and actions of management and workers who prioritize safety	5(3)	Reason (1998)
	Just Culture		5(4)	
	Flexible Culture		5(4)	
	Learning Culture		4(4)	
Mediating Variable	Safety Climate	Workers' shared perceptions of safety-related practices	9(6)	Zohar & Luria(2005)
	Safety Motivation	Motivating safety behavior	6(5)	Neal & Griffin (2006)
Dependent Variable	Safety Participation	Helpful behavior to keep your workplace safe	6(4)	Neal et al. (2000)
	Safety Compliance	safety behavior to stay safe	5(2)	
Demographic questions			12	
Total number of questionnaires			57(44)	

* Number of final adopted survey questions in parentheses

3.5 Data Collection and Sample Characteristics

3.5.1 Data Collection

To validate the research model, a survey was conducted among workers in both skilled and clerical positions at manufacturing sites across the country. A total of 271 out of 300 copies of the online survey were used in the final analysis.

3.5.2 General Characteristics of the Sample

The demographic characteristics of the survey participants are shown in 〈Table 3-3〉 below.

〈Table 3-3〉 General Characteristics of the Sample

Description		Frequency(people)	Rate(%)
Gender	Male	222	81.9%
	Female	49	18.1%
	Sum	271	100%
Age	20-29 years old	13	4.8%
	30-39 years old	87	32.1%
	40-49 years old	106	39.1%
	50-59 years old	53	19.6%
	Age 60 and older	12	4.4%
	Sum	271	100%
Workplace location	Seoul, Gyeonggi	112	41.3%
	Chungcheong-do	49	18.1%
	Gyeongsang-do	86	31.7%
	Jeolla-do	20	7.4%
	Gangwon & Jeju-do	4	1.5%
	Sum	271	100%

3.6 Analysis and Results

3.6.1 Evaluation of the Measurement Model

SmartPLS Ver.4.0 based on PLS (Partial Least Square) was used to analyze reliability, convergent validity, and discriminant validity. According

to the proposed method, variables with factor loadings of 0.7 or less were removed one by one. Among the measured items, two items of reporting culture, one item of process culture, and one item of flexible culture were removed from the safety culture item due to low factor loadings. In the safety climate item, three items were removed due to low factor loadings. One item was removed from the safety motivation scale due to low factor loadings, and the fourth item in the safety motivation scale was measured with a reverse scale, which was used to check for potentially dishonest responses from respondents. Two items from the first factor of safety behavior, safety participation, and three items from safety compliance were removed due to low factor loadings. The Cronbach's alpha value was examined for reliability analysis and was deemed adequate as it met the recommended level of 0.7 or higher (Hair Jr. et al., 2014). Discriminant validity was determined by comparing the square root value of the mean variance extracted for the factor with the correlation coefficient with other factors, and the significance was confirmed as the square root value of the mean variance extracted for the factor indicated in the diagonal column of the table exceeded the value to the left or right of the variable, as shown in 〈Table 3-5〉, and the discriminant validity was evaluated as significant according to the analysis results (Fornell & Larcker, 1981).

3.6.2 Evaluation of Structural Model: Hypothesis Testing

Here's a quick summary of the study's findings. First, safety culture had a positive effect on the safety climate. Second, safety climate had a positive impact on safety motivation. Third, safety motivation had a positive effect on safety behavior. Fourth, safety climate had a positive impact on safety behavior. Fifth, safety climate mediated the relationship between safety culture and safety motivation. Sixth, safety climate mediated the relationship between safety culture and safety behavior.

Seventh, safety motivation mediated the relationship between safety climate and safety behavior. Safety culture is composed of reporting culture, process culture, flexible culture, and learning culture, and safety behavior is a second-order factor composed of safety participation and safety compliance the analysis was conducted using latent variable scores according to the two-stage analysis (Hair et al., 2017), and the determination coefficient value of the model for the dependent variable, R^2 is 0.506, and 〈Table 3-6〉 summarizes the results of the hypothesis test.

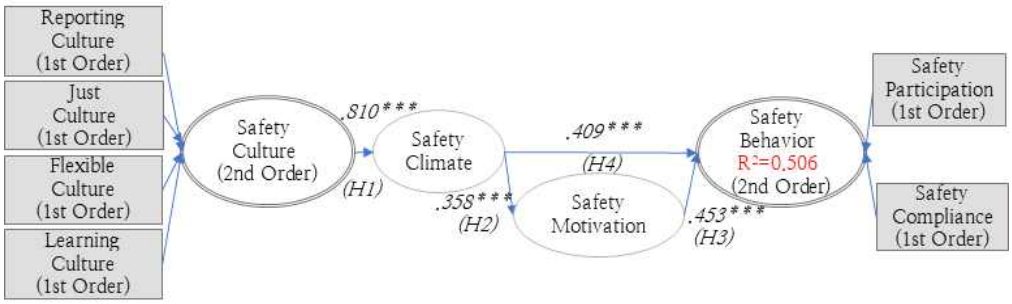
〈Table 3-4〉 Convergent Validity and Reliability Analysis Results

Variable		Indicator	Factor Loading	Cronbach's Alpha	CR	AVE
Safety Culture	Reporting Culture	reporting culture_3	0.856	0.866	0.875	0.788
		reporting culture_4	0.910			
		reporting culture_5	0.897			
	Just Culture	just culture_1	0.837	0.837	0.845	0.673
		just culture_2	0.811			
		just culture_4	0.744			
		just culture_5	0.882			
	Flexible Culture	flexible culture_2	0.772	0.846	0.857	0.684
		flexible culture_3	0.855			
		flexible culture_4	0.834			
		flexible culture_5	0.843			
	Learning Culture	learning culture_1	0.857	0.894	0.896	0.759
		learning culture_2	0.902			
		learning culture_3	0.883			
		learning	0.842			

Variable		Indicator	Factor Loading	Cronbach's Alpha	CR	AVE
		culture 4				
Safety Climate		safety climate 1	0.791	0.896	0.901	0.659
		safety climate 2	0.775			
		safety climate 4	0.844			
		safety climate 5	0.754			
		safety climate 6	0.867			
		safety climate 8	0.834			
Safety Motivation		safety motivation 1	0.849	0.905	0.907	0.724
		safety motivation 2	0.870			
		safety motivation 3	0.855			
		safety motivation 5	0.855			
		safety motivation 6	0.823			
safety behavior	Safety Participation	safety participation 3	0.753	0.844	0.880	0.678
		safety participation 4	0.793			
		safety participation 5	0.877			
		safety participation 6	0.864			
	Safety Compliance	safety compliance 3	0.913	0.779	0.782	0.818
		safety compliance 5	0.897			

〈Table 3-5〉 Discriminant Validity Analysis Results

Variable	Safety Climate	Safety Compliance	Reporting Culture	Learning Culture	Just Culture	Flexible Culture	Safety Motivation	Safety Participation
Safety Climate	0.812							
Safety Compliance	0.413	0.905						
Reporting Culture	0.696	0.213	0.888					
Learning Culture	0.756	0.229	0.729	0.871				
Just Culture	0.742	0.283	0.823	0.754	0.820			
Flexible Culture	0.691	0.276	0.633	0.708	0.709	0.827		
Safety Motivation	0.357	0.689	0.168	0.200	0.275	0.202	0.851	
Safety Participation	0.560	0.570	0.446	0.497	0.443	0.504	0.476	0.823



〈Figure 3-2〉 Research Model Analysis Results(***p〈0.01,**p〈0.05,*p〈0.1)

〈Table 3-6〉 Summary of Hypothesis Testing Results

No.	Hypothesis	Results
H1	Safety culture will have a positive effect on safety climate.	Accept
H2	Safety climate will have a positive effect on safety motivation.	Accept
H3	Safety motivation will have a positive effect on safety behavior.	Accept
H4	Safety climate will have a positive effect on safety behavior.	Accept
H5	Safety climate will mediate the relationship between safety culture and safety motivation.	Accept
H6	Safety climate will mediate the relationship between safety culture and safety behavior.	Accept
H7	Safety motivation will mediate the relationship between safety climate and safety behavior.	Accept

Each of the seven hypotheses was accepted, and it was found that safety culture has a positive effect on safety behavior through safety climate and safety motivation. The mediation analysis of this study is shown in Tables 3-7, and all mediating effects are significant. The mediating effects and serial multiple mediating effects were tested according to the methodology of Baron and Kenny (1986) and Hayes (2009). In addition, after confirming the existence of mediating effects according to the mediation analysis procedure of Baron and Kenny

(1986), the Sobel test was conducted to identify the mediating effects, and the results are shown in 〈Table 3-8〉, and the formula is as follows.

Formula 1 : $Z=\frac{a\times b}{\sqrt{a^2\times SE_b^2+b^2\times SE_a^2}}$ (a: The unstandardized regression coefficient from Step 2, b: the unstandardized regression coefficient from Step 3, SEa: The standard error value of the unstandardized coefficient from Step 2, SEb: unstandardized coefficient standard error value from Step 3).

In order for there to be a mediating effect, the independent variable must have a significant effect on the dependent variable in Step 1, the independent variable must have a significant effect on the mediator in Step 2, and the independent variable and mediator must have a significant effect on the dependent variable at the same time in Step 3. If the parameter is significant and the independent variable is not significant in Step 3, there is a full mediating effect; if both the independent variable and the parameter are significant, look at the regression coefficient, and if the regression coefficient of the independent variable in Step 3 is smaller than the regression coefficient of the independent variable in Step 1, there is a partial mediating effect.

〈Table 3-7〉 Mediating Effects

Path	Path coefficient	T Statistic	P Value
Safety Culture → Safety Climate → Safety Behavior	0.332	5.096	0.000
Safety Culture → Safety Climate → Safety Motivation	0.290	6.210	0.000
Safety Climate → Safety Motivation → Safety Behavior	0.162	5.233	0.000

〈Table 3-8〉 Sobel Test Z Value

Path	Z Value
Safety Climate → Safety Behavior	5.505***

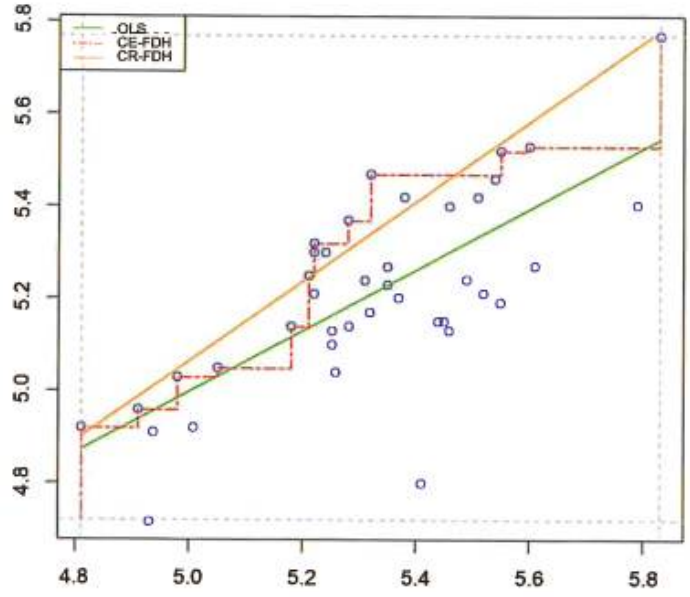
(***: p〈0.01; **: p〈0.05; *: p〈0.1)

Based on the results in 〈Table 3-7〉 and 〈Table 3-8〉 and following the methodology of Baron & Kenny (1986), we can see that the absolute values of the Z values in the Sobel test are all significant at the 0.01 level of significance and that safety climate has a partial mediating effect through safety motivation on safety behavior.

3.6.3 Necessary Condition Analysis(NCA)

NCA is a research methodology utilized to identify the minimum necessary conditions that must be met for a particular event or outcome to occur. NCA is based on Necessity logic, which states that some causal factor must be present for the dependent variable to occur. A necessity condition can be defined as a causal condition that must exist for an outcome to occur, and a necessity logic is a structured argument related to this necessity condition. NCA can be used to identify which causal factors are important for an outcome to occur and to what extent they are necessary. Thus, NCA can improve the quality and value of strategic decisions by providing information on requirements. Dul (2016) suggests that NCA analysis can complement the analytical techniques of regression and structural equation modeling. NCA is an emerging methodology in the field of organizational science and is particularly useful in situations of multi-causality, where multiple known determinants (e.g., events, characteristics, resources, effort) contribute to a desired outcome (e.g., good performance) but no single one is sufficient (Dul, 2016). The NCA methodology consists of two components: determining the ceiling line and

the corresponding bottleneck table and calculating the accuracy of the ceiling line, the effect size of the necessary condition, and necessity inefficiency (Dul, 2016). To determine whether a requirement is met in NCA, four things must be measured. The first is to draw an X.Y. scatter plot to visually confirm the presence or absence of empty space in the upper left corner of the scatter plot. Second, measure the effect size of the empty space on the outcome (Y) of the causal condition (X). Third, perform a statistical test of the effect size by measuring the empty space effect size's significance level (p-value). Fourth, analyze the information about how much of the causal condition (X) is required to achieve a certain level of outcome (Y) by creating a bottleneck table to measure the quantitative degree of the necessary condition. After plotting an X.Y. scatter plot in NCA, the ceiling line and ceiling zone are needed to identify empty spaces. The ceiling line consists of the CE-FDH (Ceiling envelopment-free disposal hull), which is a stepped connecting line, and the CR-FDH (Ceiling regression-free disposal hull), which is a trend line passing straight through the left upward points. Once the NCA has plotted the X.Y. scatterplot to determine the presence of empty space, the next step is to measure and interpret the size of the ceiling region. Here, the effect size (d-value) of the ceiling area is a concept that measures the impact of the empty space, which indicates the degree of constraint of the requirement on the effect (Y) of the causal condition (X). In general, the larger the effect size of the ceiling area, the more the outcome (Y) is constrained by the causal condition (X). Dul (2016) states that an effect size of $0<d<0.1$ is a small effect, $0.1 \leq d \leq 0.3$ is a medium effect, $0.3 \leq d<0.5$ is a large effect, and $0.5 \leq d \leq 1$ is a very large ceiling effect.

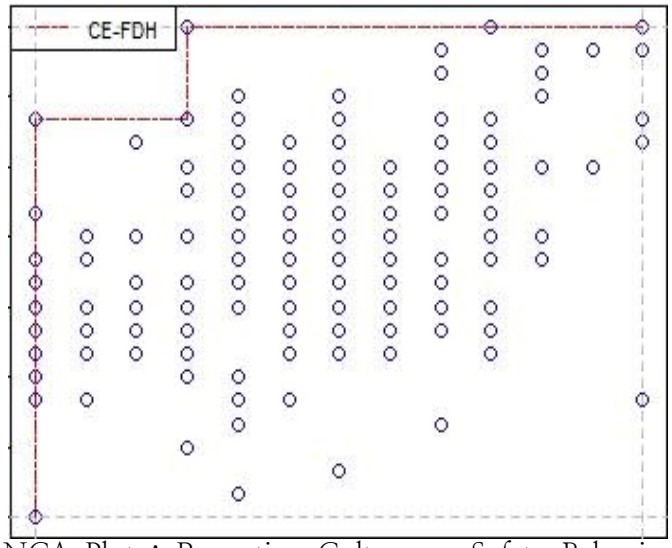


〈Figure 3-3〉 Scatter Plot with OLS and Ceiling Lines

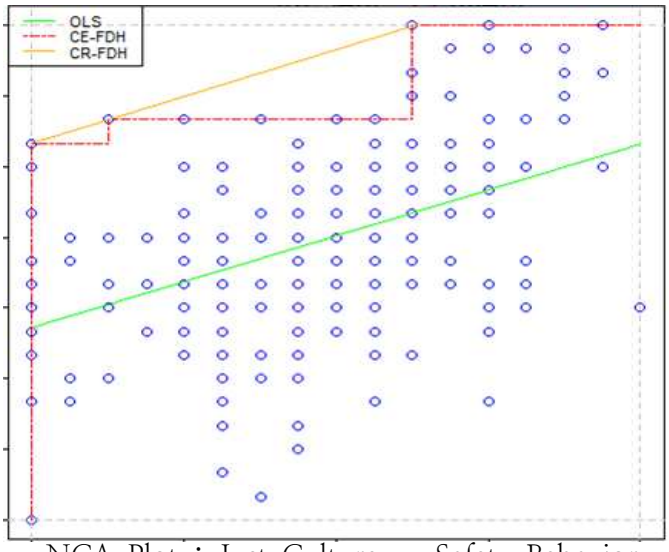
3.6.3.1 NCA Plot

To further explore the relationship between safety culture and workers' safety behaviors, we complemented PLS-SEM with a necessary conditions analysis (NCA). The latent variable scores for safety culture, safety climate, safety motivation, and safety behavior obtained using PLS-SEM were used as a starting point for conducting NCA. After importing these scores into R software, I followed the steps outlined in the Quick Start Guide for Conducting NCA (Dul et al., 2020). To ensure that the analysis did not infer additional linear assumptions between the predictor and outcome variables, I used the CE-FDH line and CR-FDH line. These ceiling lines represent the minimum level of safety culture attributes required to achieve a given workers' safety behavior (see Figure 2-5). Figure 2-5 also shows the CR-FDH, which can be used when many levels exist in the data and can be considered to be continuous. 〈Figure 2-5〉 shows the OLS regression line through the center of the

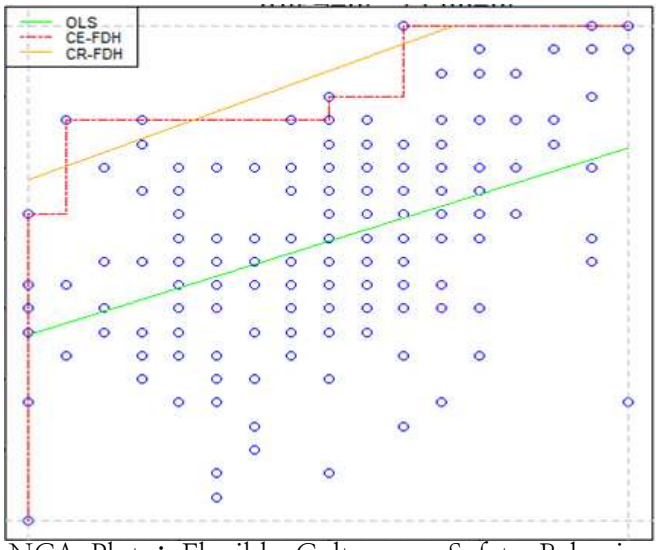
data as a reference point.



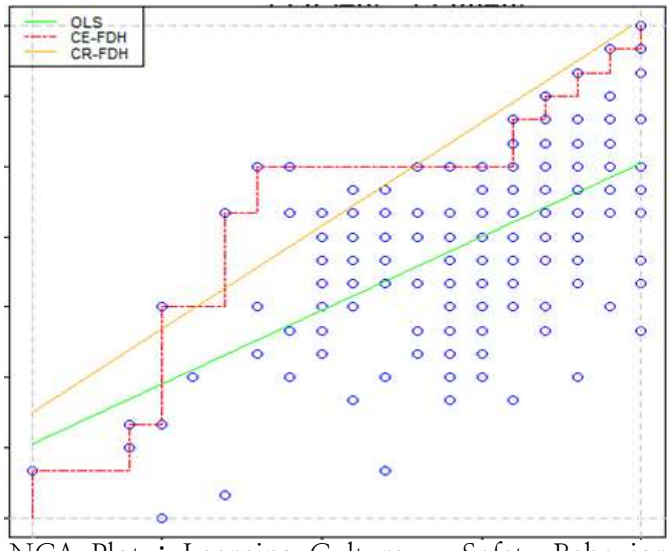
NCA Plot : Reporting Culture – Safety Behavior



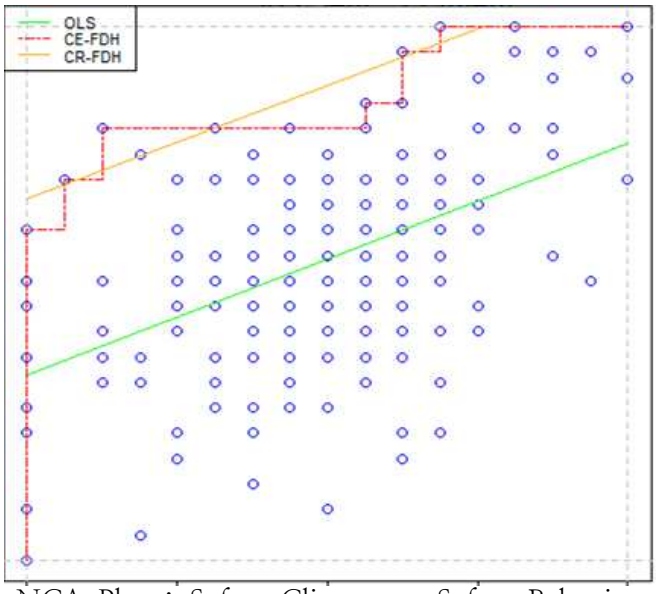
NCA Plot : Just Culture – Safety Behavior



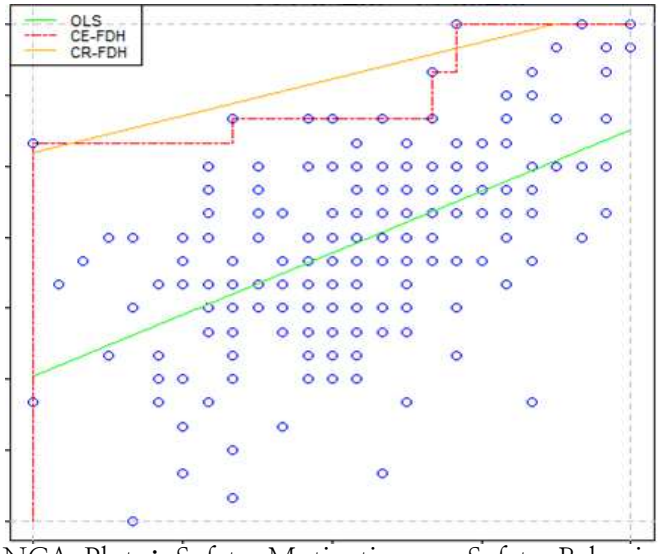
NCA Plot : Flexible Culture – Safety Behavior



NCA Plot : Learning Culture – Safety Behavior



NCA Plot : Safety Climate – Safety Behavior



NCA Plot : Safety Motivation – Safety Behavior

〈Figure 3-4〉 NCA Plot

3.6.3.2 Effect Size and Significance Testing

We examined the effect size (d) of the latent variable scores while testing for significance using the random sample size of 10,000 recommended by Hesterberg (2015). According to Dul et al. (2020), for a condition to be considered necessary, it must meet three criteria: first, it must have a theoretical justification; second, the effect size must be d > 0; and third, the CE-FDH p-value must be less than 0.05. The NCA results (see <Table 3-9>) show that justice culture, flexible culture, learning culture among safety culture, and safety motivation are essential conditions for safety behavior. More specifically, learning culture has a small effect, process culture, and flexible culture have a medium effect, and safety motivation has a large effect, which is statistically significant (p < 0.01) (Dul, 2016). In addition, safety climate had a medium effect, which was statistically significant at p < 0.05.

<Table 3-9> Ceiling Line Effect

Safety Behavior	CE-FDH		CR-FDH	
	d	p	d	p
Reporting Culture	0.05	0.279	0.02	0.404
Just Culture	0.13	0.001	0.11	0.000
Flexible Culture	0.14	0.000	0.12	0.000
Learning Culture	0.13	0.000	0.07	0.010
Safety Climate	0.15	0.004	0.11	0.028
Safety Motivation	0.41	0.000	0.38	0.000

3.6.3.3 Bottleneck Analysis

Next, a bottleneck analysis was performed to analyze information about how much of the causal condition (X) is needed to achieve a certain level of outcome (Y) by creating a bottleneck table to measure

the quantitative degree of the requirement (see 〈Table 3-10〉). According to 〈Table 3-10〉, in order to reach an upper-middle level of safety behavior (50%), at least 31.6% of the safety motivation must be met. The high level of safety behavior (100%) requires six necessary conditions to be met: reporting culture of at least 25.0%, just culture of at least 62.5%, flexible culture of at least 68.8%, learning culture of at least 62.5%, safety climate of at least 70.8%, and safety motivation of 100%.

〈Table 3-10〉 Bottleneck Table (Percentage)

Safety Behavior	Reporting Culture	Just Culture	Flexible Culture	Learning Culture	Safety Climate	Safety Motivation
0%	NN	NN	NN	NN	NN	NN
10%	NN	NN	NN	NN	NN	15.8
20%	NN	NN	NN	NN	NN	21.1
30%	NN	NN	NN	NN	NN	21.1
40%	NN	NN	NN	NN	NN	21.1
50%	NN	NN	NN	NN	NN	31.6
60%	NN	NN	NN	NN	NN	31.6
70%	NN	6.2	6.2	NN	NN	36.8
80%	NN	6.2	12.5	12.5	33.3	78.9
90%	25.0	62.5	62.5	62.5	66.7	89.5
100%	25.0	62.5	68.8	62.5	70.8	100.0

3.7 Conclusions

3.7.1 Summary

In this study, we examined the effects of safety culture on safety climate and safety motivation by conducting a study on field workers in the manufacturing industry. In addition, the effect of safety climate and safety motivation on safety behavior was examined, and the mediating

effect of safety climate and safety motivation on the relationship between safety culture and safety behavior was examined. Based on the results of this study, it was confirmed that safety culture affects safety climate and safety motivation, and safety climate and safety motivation affect safety behavior. Furthermore, it was verified that safety climate and safety motivation mediate the relationship between safety culture and safety behavior. Therefore, based on the efforts to establish a safety culture, companies should improve workers' safety climate and safety motivation to lead to safety behavior. The significance of this study is that it identified the effects of safety culture on safety behavior through the mediation of safety climate and safety motivation in the manufacturing industry, as well as the positive effect of safety culture on safety behavior.

3.7.2 Implications

The theoretical implications are as follows. First, the establishment of a safety culture in the firm is a key determinant of safety behavior among workers in the field. In turn, the establishment of a safety culture in a company has a positive impact on safety behavior through the improvement of workers' safety climate and safety motivation. Second, the verification of the relationship between various variables that can affect safety behavior provides a perspective on safety behavior from the perspective of mediating effects, which are not only direct effects but also indirect effects. The theoretical implication is that the positive effect of safety culture on safety behavior was verified not only through the relationship between the independent variable of safety culture and safety behavior but also through the mediating variables of safety climate and safety motivation.

The practical implications are as follows. First, this study provides direction for the prevention of major accidents by studying the factors

that can lead to the safety behavior of workers necessary to reduce industrial accidents in the manufacturing industry, which has recently been experiencing an increase in social interest in safety and the importance of safety. Second, it is meaningful in that it confirms how safety climate and safety motivation are related to safety behavior through research. Third, by confirming that safety climate and safety motivation have a positive effect on safety behavior, this study provides evidence that corporate safety managers should incorporate more policies into their safety and health management systems to improve workers' safety climate and safety motivation.

3.7.3 Limitations and Suggestions

Despite these implications, there are some limitations to this study. First, cross-sectional surveys collect data from a single point in time, which limits our ability to observe changes and trends over time, and second, due to the time constraints of the study being conducted during a specific time period, the results may not be representative of long-term trends or changes in safety behavior. Second, it is inevitable that there will be limitations in accounting for all the external factors that can influence safety behavior, such as economic conditions, technological changes, changes in industry regulations, etc. Third, it is difficult to rule out the possibility that respondents may respond differently to surveys than they actually do due to social desirability bias, whereby respondents try to provide answers that they think are socially desirable rather than reflect their actual attitudes or behaviors, especially on safety-related issues. In future research, it is necessary to theoretically examine the differences between positions by conducting a multi-group analysis to determine which differences in safety behaviors are influenced by perceptions of safety climate and safety motivation by position and which of the differences between positions on safety are influential.

Conclusion

According to data on the status and analysis of industrial accidents in Korea, construction and manufacturing are the industries with the most frequent industrial accidents. Looking at the industrial accident fatality rate in 2022, the construction industry is at 46%, and the manufacturing industry is at 21%, showing a 67% industrial accident fatality rate in these two industries. The transportation, warehousing, and communication industries followed with a 17% industrial accident fatality rate. The construction industry, which has the highest industrial accident fatality rate, has received a lot of safety-related research. Still, the manufacturing industry is subdivided into 11 industries, including textiles, chemicals, pharmaceuticals, and machinery and equipment. It has a large scope, so safety-related research is relatively inactive compared to the construction industry. The different nature and characteristics of the construction and manufacturing industries also lead to differences in the types of industrial accident fatality. In the construction industry, falling accidents are the leading cause of death, while in the manufacturing industry, being caught in machinery is the leading cause of death. In a study on the situation of disasters and characters of technical construction firms, Jung et al. (2009) stated that the construction industry has low safety consciousness compared to the manufacturing industry because most of the workers are day laborers and lack a sense of belonging to the company, so the effectiveness of safety education is small, and there are irregular working conditions and fatigue accumulation due to the lack of regular holidays. In accordance with previous studies that safety consciousness affects safety behavior, I conducted this study to empirically examine the differences in the relationship between safety behavior and variables that affect safety

behavior between the construction industry and the manufacturing industry.

In the construction industry, Ahn's (2013) study, The mediating effect of safety motivation on the relationship between transformational leadership and safety participation, and Kim's (2017) study, An Empirical Study on the Effects of Safety Culture for Safety Performance, safety leadership and safety management practices had a positive effect on safety behavior. However, reporting culture and flexible culture among safety cultures were found to have no effect on safety behavior (see 〈Table 4-1〉, 〈Table 4-2〉, 〈Figure 4-1〉, 〈Figure 4-2〉).

This is slightly different from my study in the manufacturing industry. The PLS-SEM analysis confirmed that safety leadership, safety management practices, and all subcomponents of safety culture, including reporting culture and flexible culture, had a positive effect on safety behavior in the manufacturing industry.

To further explore the relationship between sub-components of safety culture and workers' safety behaviors that differ between construction and manufacturing industries, Necessary Condition Analysis (NCA) was conducted in Chapter 3. The NCA results showed that just culture, flexible culture, and learning culture among safety culture were necessary conditions for safety behavior, with learning culture having a small effect and process culture and flexible culture having a medium effect ($p < 0.01$). On the other hand, reporting culture was not statistically significant ($p > 0.1$). The PLS-SEM analysis and NCA confirmed that the variable that showed a difference between the construction industry and the manufacturing industry was a flexible culture among the subcomponents of safety culture.

What these results show is that a flexible safety culture does not drive workers' safety behavior in the construction industry, whereas in the

manufacturing industry, a flexible safety culture has a positive impact on workers' safety behavior.

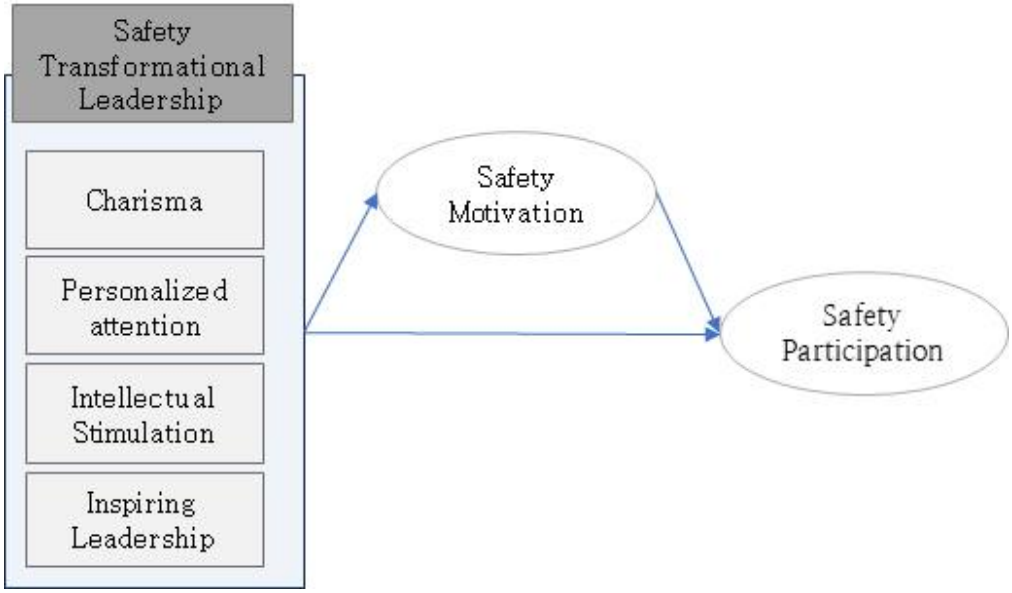
The coefficient of determination (R^2) of the independent variables on the dependent variable, safety behavior, in the three research models, was 0.582 for the safety management practices model, 0.517 for the safety leadership model, and 0.506 for the safety culture model, and the adjusted R^2 considering the degrees of freedom was 0.577 for the safety management practices model, 0.514 for the safety leadership model, and 0.502 for the safety culture model.

The main contribution of this study is the empirical validation of which variables of safety management are influential in driving workers' safety behavior among manufacturing workers. More specifically, the contributions are as follows.

First, until now, safety research has been conducted only in the construction, aviation, military, medical, and school fields. However, through this study, the manufacturing industry, which has the second highest number of industrial accidents after construction, was studied. It is an under-researched manufacturing field. This contributes to the revitalization of safety research in the manufacturing industry.

Second, this study confirms to safety managers the importance of managing worker's involvement, safety knowledge, safety climate, and safety motivation as mediators in driving workers' safety behavior.

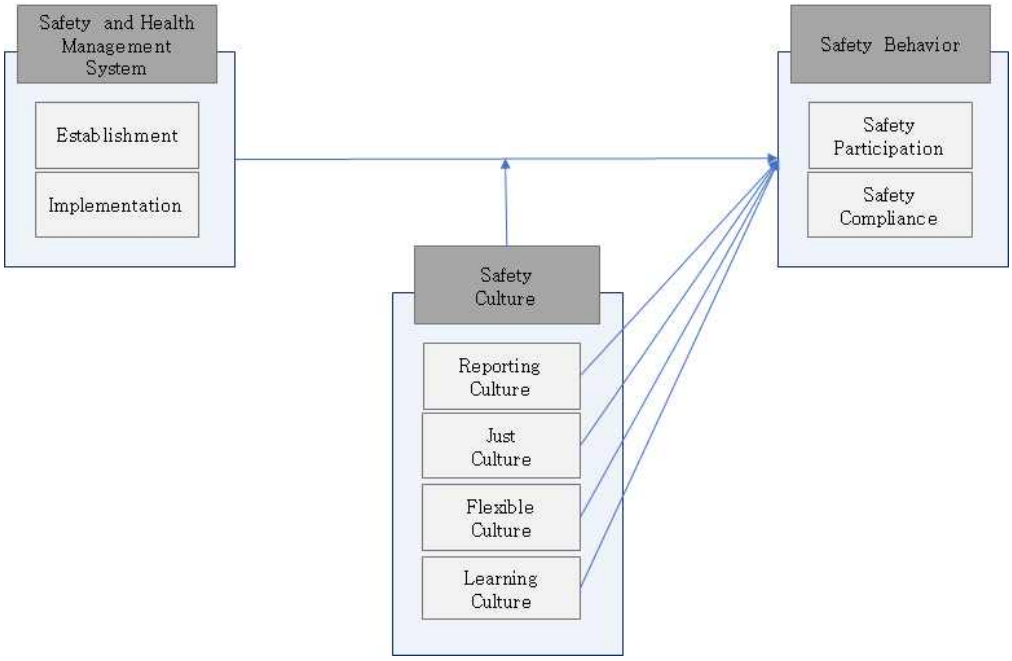
Third, the empirical study confirms the correlation between the variables that can be used as a reference for the operation of a company's safety and health management system.



〈Figure 4-1〉 Safety Transformational Leadership-Safety Participation Research Model

〈Table 4-1〉 Summary of Hypothesis Testing Results

No.	Hypothesis	Results
H1	Safety transformational leadership will have a positive effect on safety motivation.	Accept
H2	Safety motivation will have a positive effect on safety participation.	Accept
H3	Safety motivation will mediate the relationship between safety transformational leadership and safety motivation.	Accept



〈Figure 4-2〉 Safety Transformational Leadership-Safety Participation Research Model

〈Table 4-2〉 Summary of Hypothesis Testing Results

No.	Hypothesis	Results
H1	Safety and health management system will have a positive effect on safety behavior.	Accept
H2	Reporting culture will have a positive effect on safety behavior.	Dismiss
H3	Just culture will have a positive effect on safety behavior.	Accept
H4	Flexible culture will have a positive effect on safety behavior.	Dismiss
H5	Learning culture will have a positive effect on safety behavior.	Accept

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Appendix : Questionnaires

Questionnaires_Chapter 1

Variable	Questionnaires
Safety Leadership	1. My supervisor shows satisfaction when I perform my job safely.
	2. My supervisor assures me that I will be appropriately rewarded for meeting safety goals.
	3. My supervisor consistently encourages my subordinates to perform their jobs safely.
	4. My supervisor demonstrates a commitment to maintaining a safe work environment.
	5. My supervisor suggests new ways to perform my job more safely.
	6. My supervisor encourages me to express thoughts or opinions related to safety.
	7. My supervisor communicates his or her beliefs and values about the importance of safety.
	8. My supervisor demonstrates a commitment to creating a safe workplace.
	9. My supervisor takes the time to show me the safest way to do my job.
	10. My supervisor listens to my concerns about safety.
Trust in Leader	1. I trust my supervisor to handle safety-related tasks correctly.
	2. I trust my supervisor's judgment about safety.
	3. I trust my supervisor's ability to provide leadership to ensure work is done safely.
Workers' Involvement	1. Management is open to hearing from employees before making final decisions on safety-related matters.
	2. My company has a safety committee that includes management and employee representatives.
	3. My company's management encourages employees to participate in safety-related issues.
	4. Management regularly consults with employees or employee representatives on safety and health issues in the workplace.
	5. My company's employees participate diligently in recognizing and identifying safety issues.
Safety Knowledge	1. I know how to do my job safely.
	2. I am familiar with how to wear protective

Variable		Questionnaires
		equipment and standard work procedures.
		3. I know how to maintain or promote safety and health in the workplace.
		4. I know how to reduce the risk of accidents and incidents in the workplace.
		5. I am aware of the hazards associated with my job and the necessary precautions to take when performing my job.
		6. I know what to do and who to report to if I see a potential hazard in the workplace.
Safety Behavior	Safety Participation	1. I actively participate in on-the-job safety activities at my workplace.
		2. I make voluntary efforts to prevent safety incidents in my workplace.
		3. I am willing to present ideas and opinions to my supervisor to improve safety.
		4. I voluntarily attend safety-related discussions, trainings, etc.
		5. I try to improve my work environment to improve safety.
		6. I am interested in and try to prevent safety accidents of my coworkers.
	Safety Compliance	1. I perform my work in a safe and secure manner, such as wearing a seat belt and a hard hat when working at heights.
		2. I always follow all necessary regulations and procedures in the workplace.
		3. I emphasize the importance of accomplishing the mission, including following safety procedures and regulations.
		4. I am not willing to violate safety rules and procedures to accomplish my mission.
		5. I make an effort to maintain safety in the workplace.

Questionnaires_Chapter 2

Variable		Questionnaires
Safety Management Practices	Safety Training	1. My company implements safety training equitably for all members of the organization, regardless of position.
		2. My company observes or tracks individual risk-prone behaviors for employee and worker safety training.
		3. My organization assesses structural hazards in the organization for employee and worker safety training.
		4. My company provides effective and creative training programs for employee and worker safety training.
		5. My organization uses safety-related exercises and tests for employee and worker safety training.
	Workers' Involvement	1. Management is open to hearing from employees before making final decisions on safety-related matters.
		2. My company has a safety committee that includes management and employee representatives.
		3. My company's management encourages employees to participate in safety-related issues.
		4. Management regularly consults with employees or employee representatives on safety and health issues in the workplace.
		5. My company's employees participate diligently in recognizing and identifying safety issues.
	Safety Rules & Procedures	1. My organization's safety rules and procedures are sufficient to prevent accidents from occurring.
		2. My organization's safety-related facilities are sufficient to meet the safety-related needs of my department.
		3. My supervisor always tries to follow safe work procedures.
		4. My company conducts regular safety inspections.
		5. I believe my company's safety rules and procedures are useful and effective.
	Safety Leadership	1. My supervisor shows satisfaction when I perform my job safely.
		2. My supervisor assures me that I will be appropriately rewarded for meeting safety goals.
		3. My supervisor consistently encourages my

Variable		Questionnaires
		subordinates to perform their jobs safely.
		4. My supervisor demonstrates a commitment to maintaining a safe work environment.
		5. My supervisor suggests new ways to perform my job more safely.
		6. My supervisor encourages me to express thoughts or opinions related to safety.
		7. My supervisor communicates his or her beliefs and values about the importance of safety.
		8. My supervisor demonstrates a commitment to creating a safe workplace.
		9. My supervisor takes the time to show me the safest way to do my job.
		10. My supervisor listens to my concerns about safety.
Safety Knowledge		1. I know how to do my job safely.
		2. I am familiar with how to wear protective equipment and standard work procedures.
		3. I know how to maintain or promote safety and health in the workplace.
		4. I know how to reduce the risk of accidents and incidents in the workplace.
		5. I am aware of the hazards associated with my job and the necessary precautions to take when performing my job.
		6. I know what to do and who to report to if I see a potential hazard in the workplace.
Safety Motivation		1. I see value in working to maintain or improve my personal safety.
		2. I believe it is important to stay safe at all times.
		3. I believe it is important to reduce the risk of accidents in the workplace.
		4. I believe it is acceptable to sacrifice safety for increased productivity (Reverse item)
		5. I believe it is important to encourage others to work safely.
		6. I think it is important that safety-related programs are well publicized so that workers are aware of them.
Safety Behavior	Safety Participation	1. I actively participate in on-the-job safety activities at my workplace.
		2. I make voluntary efforts to prevent safety incidents in my workplace.
		3. I am willing to present ideas and opinions to my supervisor to improve safety.
		4. I voluntarily attend safety-related discussions, trainings, etc.
		5. I try to improve my work environment to

Variable		Questionnaires
		improve safety.
		6. I am interested in and try to prevent safety accidents of my coworkers.
	Safety Compliance	1. I perform my work in a safe and secure manner, such as wearing a seat belt and a hard hat when working at heights.
		2. I always follow all necessary regulations and procedures in the workplace.
		3. I emphasize the importance of accomplishing the mission, including following safety procedures and regulations.
		4. I am not willing to violate safety rules and procedures to accomplish my mission.
		5. I make an effort to maintain safety in the workplace.

Questionnaires_Chapter 3

Variable		Questionnaires
Safety Culture	Reporting Culture	1. My company provides immunity from disciplinary proceedings to the extent possible, even if at fault, for prompt reporting of accidents and other incidents.
		2. My company will take measures to ensure confidentiality or anonymity for reporters and the contents of their reports about accidents.
		3. My company separates the organization or department in charge of acquiring and analyzing data about accidents from the department that imposes disciplinary procedures and sanctions.
		4. My company has a prompt, useful, accessible, and understandable feedback system with relevant departments and organizations that need to report incidents.
		5. My company has an easy reporting system for incidents.
	Just Culture	1. My company has fair principles of acceptable and unacceptable behavior.
		2. My company implements safety training fairly for all organization members, regardless of position.
		3. My company assumes that even the best people can cause the worst accidents.
		4. In fairness, my company considers the organization, rather than the individual, to be mostly responsible for accidents.
		5. My organization has a fair disciplinary system for safety incidents.
	Flexible Culture	1. My company has the flexibility to take safety actions that do not follow rules and procedures when there is an imminent danger.
		2. In my company, there is a mutual trust among different members that allows for flexible action under urgent circumstances.
		3. There is a widespread culture in my organization that encourages flexible communication.
		4. In my company, decision-making authority is flexibly adjusted as needed during risky situations.
		5. My company has the flexibility to change organizational priorities in the event of an incident, with safety as the primary goal.
	Learning Culture	1. My company observes or tracks individual risk-prone behaviors for safety training of employees and workers.
		2. My company diagnoses and educates employees

Variable		Questionnaires
		and workers on structural risk factors in the organization for safety training.
		3. My company provides effective and creative training programs for employee and worker safety training.
		4. My company conducts safety-related exercises and tests for employee and worker safety training.
Safety Climate		1. My company strives to provide all necessary equipment for safety.
		2. My company requires employees to report any near misses or unsafe behavior to their supervisor.
		3. My company ensures that temporary workers receive the same safety training as full-time employees.
		4. My company frequently checks that workers are following safety rules.
		5. My organization emphasizes wearing protective equipment even if it is uncomfortable.
		6. My organization responds quickly when workers report safety concerns.
		7. In my company, workers act safely on their own without supervision.
		8. My company is open to suggestions for improving safety.
		9. In my company, people don't feel uncomfortable talking to each other about safety.
Safety Motivation		1. I believe it is worthwhile to work to maintain or improve personal safety.
		2. I think it is important to stay safe at all times.
		3. I believe it is important to reduce the risk of accidents in the workplace.
		4. I think it is acceptable to sacrifice safety for increased productivity (Reverse item)
		5. I believe it is important to encourage others to work safely.
		6. I think it is important that safety-related programs are well publicized so that workers are aware of them.
Safety Behavior	Safety Participation	1. I actively participate in on-the-job safety activities at my workplace.
		2. I make voluntary efforts to prevent safety incidents in my workplace.
		3. I am willing to present ideas and opinions to my supervisor to improve safety.
		4. I voluntarily attend safety-related discussions, trainings, etc.
		5. I try to improve my work environment to improve safety.
		6. I am interested in and try to prevent safety accidents of my coworkers.

Variable		Questionnaires
	Safety Compliance	1. I perform my work in a safe and secure manner, such as wearing a seat belt and a hard hat when working at heights.
		2. I always follow all necessary regulations and procedures in the workplace.
		3. I emphasize the importance of accomplishing the mission, including following safety procedures and regulations.
		4. I am not willing to violate safety rules and procedures to accomplish my mission.
		5. I make an effort to maintain safety in the workplace.

국 문 초 록

기업의 안전관리와 근로자의 안전 행동에 관한 세 가지 소논문

한 성 대 학 교 대 학 원
지 식 서 비 스 & 컨 설 팅 학 과
매 니 지 먼 트 컨 설 팅 전 공
임 정 훈

본 학위논문은 기업의 안전관리 측면의 3가지 관점에서 바라본 안전관리 및 근로자의 안전 행동에 대하여 다루고 있다. 즉, 안전 리더십 관점, 안전관리 실행 관점, 안전 문화 관점에 관한 3편의 소논문으로 구성되어 있다.

첫 번째 소논문은 안전 리더십과 리더에 대한 신뢰가 근로자의 안전 행동에 미치는 영향을 살펴본 논문으로서, 건설업 다음으로 산업재해가 많은 제조업을 대상으로 하여 리더의 안전 리더십과 리더에 대한 신뢰가 근로자 참여와 안전 지식의 제고를 통해 근로자의 안전 행동에 영향을 주는지를 연구하였고, 안전 리더십과 리더 신뢰가 근로자의 안전 행동에 정(+)의 영향을 준다는 것을 확인하였다. 두 번째 소논문은 안전관리 실행 요소들이 근로자의 안전 행동에 미치는 영향을 살펴본 논문으로서, 안전 교육, 근로자 참여, 안전 규칙 및 절차, 안전 리더십과 같은 안전관리 실행 요소들이 근로자의 안전 지식과 안전 동기를 향상시켜 근로자의 안전 행동에 정(+)의 영향을 주는 것을 확인하였다. 세 번째 소논문은 안전 문화가 근로자의 안전 행동에 미치는 영

향을 살펴본 논문으로서, 보고 문화, 공정 문화, 유연 문화, 학습 문화로 이루어진 기업 내 안전 문화가 안전 분위기와 안전 동기를 향상시켜 근로자의 안전 행동을 이끌어 낸다는 것을 검증하였다.

종속변수인 안전 행동에 대한 세 가지 연구모형의 설명력(R^2)을 보면 안전관리 실행 모형이 0.582, 안전 리더십 모형이 0.517, 안전 문화 모형이 0.506으로 안전관리 실행 모형의 설명력이 가장 높았다.

본 논문의 기여점은 다음과 같다. 첫째, 지금까지는 건설, 항공, 군대, 학교 분야에 대한 안전 관련 연구 위주로만 안전 분야 연구가 이루어졌지만 이번 연구를 통해 건설업 다음으로 산업재해가 많은 제조업 근로자를 대상으로 연구를 함으로써 연구가 미진한 제조업 분야 안전 연구의 활성화에 기여한 점이다. 둘째, 근로자의 안전 행동을 이끌어내는 데에 있어 매개 역할을 하는 근로자 참여, 안전 지식, 안전 분위기, 안전 동기에 대한 관리의 중요성을 기업의 안전 관리자에게 확인시켜 주었다는 점이다. 셋째, 실증 연구를 통해 기업의 안전보건관리 체계 운영에 참고할 만한 변수들 간의 상관 관계를 확인하였다는 점이다.

【주요어】 안전 리더십, 리더 신뢰, 근로자 참여, 안전 지식, 안전관리 실행, 안전 문화, 안전 분위기, 안전 동기, 안전 행동