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An Unsafe Practice Analysis considering Potential Risk to Foreign Construction Laborers in Korea

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Abstract

Recently, the number of accidents reported involving foreign laborers has risen, and the need to prevent accidents at construction sites has become more urgent. It has been found that 90 percent of construction accidents are caused by unsafe work practices, and various studies have been conducted on these practices with the aim of preventing accidents at construction sites. However, the tendency with previous studies was to average the results of survey responses, and as a result it is impossible to consider the potential risk of how many foreign laborers feel unsafe in relation with the unsafe practices. Therefore, in this study, importance-performance analysis (IPA) was improved in order to assess the potential risk of the unsafe practices of foreign laborers at construction sites in Korea. To verify the applicability of the improved IPA, a survey was carried out, and then the results were compared with those of the IPA. Through the use of the improved IPA, unsafe practices that were not found in the previous IPA but have potential risk were identified. The method proposed in this study is expected to contribute to the prevention of construction accidents of foreign workers by enabling a more efficient management.

Keywords : potential risk, unsafe practice, foreign laborer, importance-performance analysis (IPA)

1. Introduction

With Korea lacking construction laborers due to a shortage of construction workers and a rapid increase in labor costs, large numbers of foreign laborers have entered the country. As of the end of 2010, it was estimated that there were 1.2 million foreign laborers in Korea, of which an estimated 80,000 were foreign construction laborers, both legal and illegal, representing about 6.6 percent of the total construction work force[1].

As the number of foreign construction workers in Korea has increased, the number of construction accidents related with foreign laborers has grown to represent a large portion of all construction accidents. Looking at the current state of local and foreign laborers at construction sites in Korea, the number of foreign construction laborers involved in accidents stood at 5,195 people or 4.7 percent over the past five years (2008-2012), while the death toll of foreign laborers in accidents stood at 210 people or 7.34 percent, showing that the death toll of foreign laborers is relatively high as a portion of the number of victims of construction accidents[2].

In general, 90 percent of industrial disasters involve unsafe practices[3]. In the construction industry, unsafe practices are also one of the main causes of construction accidents[4]. Therefore, it is important to prevent construction accidents by monitoring and managing unsafe practices.

Previous studies on the causes of industrial disasters have tended to clarify the relationship

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between the factors triggering an industrial disaster and the personal characteristics (i.e., social, physical, and psychological factors, etc.) of the workers, breaking away from the conventional stance that unsafe physical working conditions may cause an industrial disaster[5]. A variety of studies have been conducted and an analysis was performed using Analysis of Variance (ANOVA), Factor Analysis (FA), Structural Equation Model, Analytic Hierarchy Process (AHP), and Importance-Performance Analysis (IPA). Significantly, IPA has the advantage of enabling an urgent problem to be grasped easily and rapidly, without a complicated statistical approach[6]. However, as in an analysis of a general survey, since an average of the response results has a significant meaning in these analysis methods, it is impossible to assess the potential risk of the unsafe practice. That is, the average is the same both when all 100 respondents gave an answer of 3 points on the 5-point scale and when 50 of 100 respondents gave 1 point on the 5-point scale while the rest of the respondents gave a 5 on the 5-point scale. However, in the assessment on the risk of unsafe practices, the case in which 50 people gave a response of 5 points on the 5-point scale should be noted rather than what the average is. The potential risk can be considered as high because 50 people evaluated that it is risky compared with the former.

Thus, this study aims to propose an improved IPA to assess the potential risk of the unsafe practices of foreign construction laborers. The method proposed in this study is expected to contribute to the prevention of construction accidents involving foreign construction laborers, by supporting a more efficient management and an analysis of the unsafe practices of foreign construction laborers.

In the next section, a theoretical review, i.e. of construction disasters related with foreign laborers, IPA, and previous studies, was performed. And in the third section, the improved IPA was described according to each step. In the fourth section, the improved IPA was applied to an actual case and its performance was evaluated. Finally, in the last section, some conclusions were drawn and a direction for further study was described.

2. Theoretical review

2.1 Current state of construction disasters related with foreign laborers

The construction industry in Korea suffers from a serious shortage of laborers due to the aging of construction workers and the tendency among the younger generation to avoid the so-called 3D(Dirty, Difficult, Dangerous) jobs. For this reason, the number of foreign laborers continues to increase because of their relatively low wages and availability for hiring, and as such the number of industrial disasters involving foreign laborers has been increasing annually.

As indicated in Table 1, which examines of the current state of disasters involving construction workers over the past five years (2008-2012), 5,195 foreign laborers were injured, accounting for 4.7 percent of all victims of construction disasters, and 210 foreign laborers were killed, accounting for 7.34 percent[2]. This shows that foreign laborers represent a relatively large portion of all victims of construction disasters.

Table 1. Comparison of the current state of accidents of local and foreign construction workers (Unit: people)

Division	Construction workers(Total)		Foreign workers	
	Injured	Dead	Injured	Dead
2008~2012	110,468	2,861	5,195	210
2012	23,349	557	1,237	38
2011	22,782	577	1,149	34
2010	22,504	556	950	39
2009	20,998	559	901	37
2008	20,835	612	958	62

2.2 IPA method

IPA (Importance Performance Analysis) method is a marketing analysis method that first became known to the world when Martilla & James (1977)[7] published a paper titled 'Importance Performance Analysis' in the Journal of Marketing, and is used to analyze the awareness of importance of and satisfaction with the important attributes that a product or service has, with a view to determining the priority for improvement. IPA is generally utilized by expressing the values of importance and performance (current competency) of the items evaluated on the coordinate plane, and it is very useful to understand the important management competencies quickly and easily by utilizing the averages of the performance and importance of the competency evaluated, without using any complicated statistical method[6]. In this study, an evaluation of unsafe practices was performed by applying a more comprehensive criteria obtained through the improved IPA.

Using the result values of importance and performance, the quadrant was divided (X axis: average of performance, Y axis; average of importance), and the quadrant of the IPA model was defined and explained in Figure 1[8].

Quadrant 1: The evaluated importance is considered to be high, and the performance is currently evaluated as relatively satisfactory, a condition which is desirable to maintain.

Quadrant 2: The evaluated importance is considered to be high, but the performance is currently evaluated as unsatisfactory and urgently needs to be improved.

Quadrant 3: The evaluated importance is considered to be low, and the performance is currently evaluated as low, but it is not necessary to make any further effort.

Quadrant 4: The evaluated importance is considered to be low, but the performance is currently evaluated as relatively high, so that some of the efforts currently made should be put into other items evaluated.

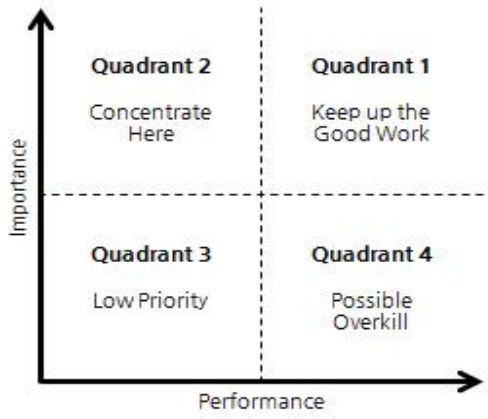

Figure 1. Importance-performance analysis model

2.3 Previous studies related to unsafe practices

Previous studies on the factors that may cause construction disasters at construction sites in Korea have examined the unsafe practices of individual construction laborers in Table 2[1,9,10,11,12,13,14]. This implies that individual psychology and practice are important factors to be managed in construction disasters at construction sites. While these studies have been ongoing, few studies have been carried out on foreign laborers, who were more likely to be victims of the disasters; moreover, almost no studies have been conducted that considered the potential risk. Therefore, in this study the potential risk for foreign laborers working at construction sites in Korea was taken into account.

Table 2. Previous studies on unsafe acts in Korea

Authors(Year)	Research description
Choi & Kim[11] (2006)	The study identified the safety environment factors and examined the relationships of the safety climate and safe acts on a construction site
Ryu & Her[9] (2009)	This study was about developing a checklist to evaluate the occurrence possibility of individual laborers' unsafe acts.
Lee et al.[12] (2009)	The study was about the extent to which safety activity could be improved through the safety consciousness of construction laborers
Lee[13] (2011)	This research analyzed improved safety awareness
Park et al.[1] (2011)	The study suggested a prevention plan based on an analysis of industrial accidents of foreign construction laborers.
Shin & Lee[10] (2013)	The study identified some factors which have powerful direct effects on safety acts of construction workers.
Han et al.[14] (2014)	The study analyzed unstable behavior of construction laborers working at construction sites in Korea using an IPA method.

3. Improved IPA

The potential risk analysis method for unsafe practices by construction laborers proposed in this study was a benchmarking of the 6-step methodology proposed by Strading et al.[15]. The research proposed a more detailed analysis method compared with the IPA method, one of the existing analysis methods used to assess customer dissatisfaction. That is, it did not simply analyze the average of response results from the existing IPA, but deduced a new measure called 'disgruntlement' based on the rate of the respondents who answered 'disagree or strongly disagree' on the performance of a specific item, while highlighting the same item as 'quite important or very important' through the cross-tabulation process. By weighting performance ratings according to importance ratings in this manner, disgruntlement provides a more plausible measure on which to base remedial actions to improve user satisfaction with service than performance alone. Rather than dealing in aggregate mean scores and discrepancies between them, this method identifies 'how many' and, potentially, 'which' respondents believe an aspect of a service is important to them and is not being delivered well[15]. In terms of unsafe practices, it is more meaningful in safety management to consider 'how much' certain laborers think an unsafe practice is risky rather than 'how much' the laborers think an unsafe practice is risky on average. Therefore, this study adopts 'potential risk,' which is similar to the measure of 'disgruntlement' in the previous research[15]. The improved IPA method proposed in this study is as follows:

Step 1. Select unsafe practice items through literature review and statistical data on construction disasters (i.e. KOSHA).

Step 2. Survey present construction laborers to rate the importance of (I) and performance on (P) each element.

Step 3. Cross-tabulate importance and performance ratings to calculate percentage of potential risk (R).

Step 4. Plot potential risk against importance for all elements.

Step 5. Prioritize by dividing plot into four zones.

Step 6. Identify elements in urgent need of attention.

4. Application and evaluation of the improved IPA

4.1 Application and results of the improved IPA

4.1.1 Selection of the items of unsafe practices

Table 3. Classification of unsafe behavior

No.	Main Item	No.	Sub Item
A	Inadequate use of Equipment machineries, and materials	A-1	Inadequate use of protection management
		A-2	Inadequate use of vehicle
		A-3	Cleaning and repairing of working machines
		A-4	Inadequate handling of toxic substance
B	Neglect of dangerous structure	B-1	Neglect of dangerous structures
		B-2	Obstacles left alone on the ground
		B-3	Use of defective tools and materials
		B-4	Bad state of load
		B-5	Incognizance of obstacles at bottom
C	Careless working and breaking the procedure	C-1	Inappropriate method and procedure
		C-2	Inadequate supervision and management
D	Unsafe working posture	D-1	Unsafe working posture
E	Mistakes at working	E-1	Equipment malfunction
		E-2	Wrong handling of hand tools
		E-3	Miss of footing on the stairs
F	The reckless and unnecessary acts	F-1	Reckless acts
		F-2	Unnecessary acts
		F-3	Approach hazardous locations
G	Inadequate use of protective equipment	G-1	Inadequate use of protective equipment

In the 1st step, the unsafe practice items were selected as shown in Table 3. In order to select the unsafe practice items, 19 items were selected by referring to the unsafe practices in industrial accident statistics. Next, 2 managers with 10 years of work experience in safety management at construction sites were interviewed to evaluate the appropriateness of the selected items. Finally, the questionnaire was composed as shown in Table 2. Each item was evaluated on the 5-point Likert scale (from 1= 'strongly disagree' to 5='strongly agree') by adjusting the importance(I) and performance(P) measured in the existing IPA to the importance(I) and performance of management(P) suitable for this research.

4.1.2 Questionnaire survey

Table 4. The summary of questionnaire survey

Factor	Category	The Number	Ratio (%)
Sex	Male	130	97
	Female	4	3
Age	~29	5	4
	30-39	13	9
	40-49	62	46
	50~	54	41
Work	Steel-frame	38	29
	Bricklayers	2	1
	Plastering	9	7
	Heating system	1	1
	Waterproof	10	7
	Carpenter	15	12
	Metal	0	0
	Windows and doors	2	1
	Masonry mason's	3	2
	Painting	2	1
	Insulation	4	3
	Interior finishing	3	2
	Frame	45	34
Career	~1year	7	5
	1-5years	60	45
	5-10years	44	33
	10years~	23	17

In the 2nd step, a questionnaire survey was conducted on a total of 150 laborers working at construction sites of 5 construction companies from March 15 to April 20, 2014 (about one month). 150 questionnaires were collected, but 16 of them were considered inadequate and thus excluded. The general information of the respondents is indicated in Table 4.

To validate the reliability of the survey results, the reliability was analyzed using the SPSS 19.0 software package using the Cronbach's alpha coefficient. In general, when the Cronbach's alpha coefficient is higher than 0.6, it is reliable[16]. In this study, the Cronbach's alpha coefficient for the survey results is identified as higher than 0.6 in all the items as shown in Table 5, and the statistical analysis using the survey results was determined appropriate.

Table 5. Cronbach alpha coefficient

Main Category	No. of questions	Cronbach's Alpha	
		Importance	Performance
A	4	0.888	0.738
B	5	0.872	0.799
C,D	3	0.883	0.826
E	3	0.882	0.730
F,G	4	0.905	0.848

Tables 6 and 7 are the ratings of the people who responded "Agree" or "Strongly Agree" in the 19 unsafe practice items, Performance and Importance, respectively.

Table 6. Performance ratings of unsafe behavior

No.	Sub Item	Performance(%): % strongly agree +% agree
B-2	Obstacles left alone on the ground	51
E-1	Equipment malfunction	55
F-2	Unnecessary acts	55
G-1	Inadequate use of protective equipment	56
B-3	Use of defective tools and materials	56
E-3	Missing footing on the stairs	58
D-1	Unsafe working posture	58
E-2	Wrong handling of hand tools	58
A-4	Inadequate handling of toxic substance	58
B-1	Neglect of dangerous structures	59
B-4	Bad state of load	60
F-3	Approach to hazardous locations	61
C-1	Inappropriate method and procedure	62
C-2	Inadequate supervision and management	63
A-3	Cleaning and repairing of working machines	63
F-1	Reckless acts	64
A-2	Inadequate use of vehicle	64
B-5	Incognizance of obstacles at bottom	67
A-1	Inadequate use of protection management	68

Table 7. Importance ratings of unsafe behavior

No.	Sub Item	Importance(%): % strongly agree + % agree
D-1	Unsafe working posture	57
G-1	Inadequate use of protective equipment	58
B-2	Obstacles left alone on the ground	59
F-2	Unnecessary acts	60
A-3	Cleaning and repair of working machines	62
F-3	Approach hazardous locations	62
A-4	Inadequate handling of toxic substance	63
B-1	Neglect of dangerous structures	63
A-2	Inadequate use of vehicle	64
C-1	Inappropriate method and procedure	66
C-2	Inadequate supervision and management	66
B-4	Bad state of load	67
E-1	Equipment malfunction	67
E-3	Missing footing on the stairs	67
B-3	Use of defective tools and materials	69
E-2	Wrong handling of hand tools	69
F-1	Reckless acts	69
B-5	Incognizance of obstacles at bottom	70
A-1	Inadequate use of protection management	73

4.1.3 Risk evaluation by item

Table 8. Cross-tabulation of performance(P) and importance(I) ratings for 'B-5'

P \ I	strongly disagree	disagree	Neutral	agree	strongly agree	total
strongly disagree	0	0	0	0	2	2
disagree	0	2	1	10	2	15
Neutral	0	2	8	11	6	27
agree	1	8	10	18	20	57
strongly agree	0	3	5	7	18	33
total	1	15	24	46	48	134

In the 3rd Step, the risk evaluation by item was performed. In the risk evaluation, Importance for each item was calculated using the cross-tabulation. For example, Table 8 indicates the results of the cross-tabulation for Item 'B-5.' In this result, 10 percent of all respondents responded that Importance was high while Management of Performance was low for 'B-5.' Through this process, the risk of 19 unsafe practice items was enumerated in descending order in Table 8. As shown in Table 6, Item 'B-5' was evaluated as good in Management of Performance.

Table 9. Potential risk measures of unsafe behavior

No.	Sub Item	Potential risk (%): % strongly agree + % agree
B-5	Incognizance of obstacles at bottom	10
B-4	Bad state of load	9
C-2	Inadequate supervision and management	8
B-1	Neglect of dangerous structures	7
E-1	Equipment malfunction	7
C-1	Neglect of dangerous structures	6
F-3	Approach hazardous locations	6
B-2	Obstacles left alone on the ground	5
B-3	Use of defective tools and materials	5
B-4	Inadequate handling of toxic substance	4
D-1	Unsafe working posture	4
E-2	Wrong handling of hand tools	4
G-1	Inadequate use of protective equipment	4
A-1	Inadequate use of protection management	3
A-3	Cleaning and repair of working machines	3
E-3	Missing footing on the stairs	3
F-1	Reckless acts	3
A-2	Inadequate use of vehicle	2
F-2	Unnecessary acts	2

However, the potential risk was shown to be considerably risky in Table 9, unlike the result of performance. This item can be said to have high potential risk. In addition, as indicated in Table 10, for the four items of B-4, B-5, C-1, and C-2, where the rating of potential risk rose compared with the rating of performance, it can be considered that their potential risk is high.

Table 10. Potential risks items (in Step 3)

No.	Performance		Potential risk		
1	B-2	51%	B-5		10%
2	E-1	55%	B-4		9%
3	F-2	55%	C-2		8%
4	G-1	56%	B-1	7%	
5	B-3	56%	E-1	7%	
6	E-3	58%	C-1		6%
7	D-1	58%	F-3	6%	
8	E-2	58%	B-2	5%	
9	A-4	58%	B-3	5%	
10	B-1	59%	A-4	4%	
11	B-4	60%	D-1		4%
12	F-3	61%	E-2	4%	
13	C-1	62%	G-1		4%
14	C-2	63%	A-1		3%
15	A-3	63%	A-3	3%	
16	F-1	64%	E-3	3%	
17	A-2	64%	F-1	3%	
18	B-5	67%	A-2		2%
19	A-1	68%	F-2	2%	

4.1.4 Mapping

In the 4th Step, it is clarified whether the items that have high risk are to have high importance, and the results are shown in Figure 2.

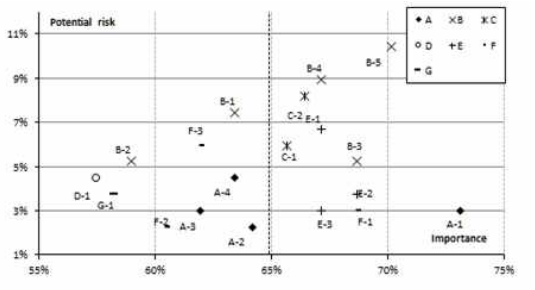

Figure 2. Scatter graph of potential risk vs. importance (Improved IPA)

4.1.5 Division by zone and deduction of main management items

Finally, in the 5th and 6th Steps, it was divided into four Zones as indicated in Table 11 on the basis of the average of the data in order to enable easy identification of the items that need to be urgently improved.

Table 11. Definition of Zones 1~4

Zone 2 High potential risk but low importance	Zone 1 High potential risk + High importance
Zone 3 Low potential risk + Low importance	Zone 4 High importance but low potential risk

Zone 1 is the area where both potential risk and importance are high. The items of unsafe practices in this area urgently need to be improved. 6 items, including B-3, B-4, and C-5, are included in this area. Zone 2 is the area in which potential risk is high while importance is low. The items in this area need to be continuously monitored considering that they are not as important as those in Zone 1 but are potentially risky. There are three items in this area: B-1, B-2, and F-3. Zone 3 is the area in which both potential risk and importance are low. The items of unsafe practice in this area are last in terms of priority in order to perform efficient management. There are 6 items in this area, including A-2, A-3, A-4, etc. Zone 4 is the area in which potential risk is low while importance is high. The items of unsafe practice in this area are well managed and are considered as not risky compared with the items in other areas, and efforts should be made to maintain the status quo. There are four items in this area, including A-1, E-2, and E-3.

4.2 Result analysis

In this study, to evaluate the potential risk of 19 unsafe practice items of construction laborers, an improved IPA method was proposed, and its applicability was assessed using the results of the questionnaire survey. As a result, it was found that the IPA method newly proposed in this study has advantages compared with the existing IPA in terms of identifying potential risk. That is, in the results of Step 2, the items of B-4, B-5, C-1, and C-2 were evaluated to be relatively good in terms of management of performance. However, in terms of the results of the potential risk evaluation, Step 3 was evaluated to be comparatively risky. The items evaluated to be managed effectively were evaluated to actually have potential risk. This result could not have been obtained using the IPA that only uses an average.

This characteristic is shown through an analysis by Zone. The analysis results obtained using the existing IPA are shown in Figure 3.

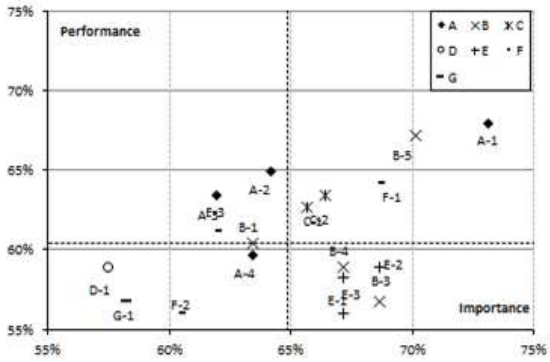

Figure 3. Scatter graph of performance vs. importance (IPA)

The five items included in the 4th quadrant, the area deemed important but poorly managed in the IPA, are B-3, B-4, E-1, E-2, and E-3. The six items included in the 1st quadrant, the area deemed important and risky in the IPA, are B-3, B-4, B-5, C-1, C-2, and E-1. There is an urgent need for improvement and action related to these items. Table 12 indicates the items included in the existing IPA and the improved IPA.

In particular, items B-5, C-1 and C-2 were evaluated as being managed effectively in the existing IPA. However, through the improved IPA, they were evaluated to be included in Zone 1 and highly risky. From the average perspective, the items of B-5, C-1 and C-2 were managed fairly well, but there was a relatively high number of respondents who thought they were not managed well.

Compared with other management tasks in a construction project (i.e. cost management, quality management, scheduling, etc.), a lack of management in the area of risk to the workers may be lethal, as it can cause both financial damage and casualties. Therefore, a more appropriate criterion to evaluate the risk is to consider how many people perceive a risk related to the unsafe practice item evaluated rather than to consider how risky an unsafe practice item is considered on average. In conclusion, the improved IPA method proposed in this study would aid the safe execution of a construction project by ensuring the safety managers' understanding of the items that have potential risk.

Table 12. Comparison of results of IPA and improved IPA

Methodology	No.	Sub Item
Improved IPA	B-3	Use of defective tools and materials
	B-4	Bad state of load
	B-5	Incognizance of obstacles at bottom
	C-1	Inappropriate method and procedure
	C-2	Inadequate supervision and management
IPA	E-1	Equipment malfunction
	B-3	Use of defective tools and materials
	B-4	Bad state of load
	E-1	Equipment malfunction
	E-2	Wrong handling of hand tools
	E-3	Missing footing on the stairs

5. Conclusion

As the number of foreign laborers has been increasing in recent years, the number of construction disasters that occur has also been on the rise. The most influential factor among direct causes of a construction disaster is unsafe practices. While previous studies have been performed on unsafe practices, most of them employed an analysis approach by averaging the survey results conducted. However, this method does not allow the researcher to consider how many people feel unsafe in terms of an unsafe practice. Therefore, in this study an improved IPA method was proposed to evaluate the potential risk of unsafe practices for construction laborers working at construction sites. In order to verify the applicability of the proposed method, a questionnaire survey was conducted and applied, and the results were compared with those of the existing IPA method. As a result, it was found that unsafe practice items could be identified with the improved IPA method that were not found with the existing IPA, as well as unsafe practices requiring urgent measures. In conclusion, it is expected that the improved IPA proposed in this study will help safety managers successfully perform safety management by identifying the items that have the potential risk of unsafe practices.

An improved IPA analysis method was proposed to determine the potential risk of unsafe practice of construction workers in this study. However, the object of analysis for this study was restricted only to unsafe practices, and it is difficult to identify any potential risk of other areas using the proposed method. As such, to verify the applicability of the improved IPA, future studies should be conducted on diverse research targets, including job stress and evaluation of the field safety management level.

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