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Risk Assessment by Job Safety Analysis and William Fine Method and Comparison with Workers' Risk Perception Results

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ABSTRACT

Background: Job analysis, detecting hazards, and measuring their relationship with risk perception in workers are efficient ways of preventing accidents. Therefore, the present study is an attempt to identify and assess the risk of job accidents in steel industry in the south of Iran in 2020 using job safety analysis and the William Fine method. The results are also compared with the workers' perception of risk. **Methods**: The study population consisted of workers in the supplementary section of the studied steel industry(N=169). All the collected data were analyzed in SPSS using frequency and percentage for description and simple/multivariate logistic regression for analysis with sig. equal to 0.05. To determine the risks, JSA was used. Risk assessment was also performed using William Fine method, and then risk scores were obtained. Afterwards, Risk Perception Questionnaire was used to collect information about risk perception in the workers. **Results:**In total, 265 job activities along with 2684 risks were identified and evaluated in 7 units of sections in the steel industry. **Conclusion**: The results of risk assessment and risk perception in this study indicate that when safety risk is properly perceived by workers, the chance of observing safety codes and better detection of risks increases. Therefore, in the face of an unsafe condition at work, workers will be abed to make the right decision and control the risk and prevent work accidents by taking corrective measures and making safe and efficient decisions.

Keywords: Job safety Analysis; Risk assessment; Risk perception; Steel industry; William Fine

Introduction

Numerous machineries and tools found in industrial environments create various safety risks for workers. Technological advances and the increase in the role of technology in production lines have increased the risk of different hazards and accidents in such an environment. Accidents in industries mostly lead to mutilation or death. [1] Many of the injuries caused by such accidents are irreversible, and the organization might lose skilled workers and the time and money spent on educating them. [2] According to international organizations, 250 million job accidents happen in work every year, and the mortality rate of these accidents is 14 out of each 100 thousand cases. [3] According to estimates in Iran, three deaths happen every hour due to a variety of accidents. The costs incurred due to failure to observe safety codes and regulations are equal to

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Iran's income from oil export. [4] Statistics published in Sweden show that metal industries workers had experienced a higher number of accidents compared to other jobs between 2006 and 2010. [5] Metal industries are considered as one the most hazardous industries in the world. It is notable that the steel industry is a metal industry and one of the most hazardous industries. [6]

One of the causes of accidents is the wrong perception of the risk at work. Risk perception is an internal judgment about the specifications and severity of risks. [7, 8] In addition, workers under the same risks might have a different perception of the risks, leading to different attitudes and behaviors. [9] According to Randmo, a proper perception of risk affects workers' perception of risk management and workers' safety in return. In other words, a wrong perception of risk leads to risky and unsafe behaviors. [10, 11] Perlman et al. found that workers' perception of risk is lower than it should be, leading to incidents. [12]

On the other hand, Rodriguez et al. argued that when workers perceive the risk as high, the chance of taking preventive actions and having a safer behavior at work increases. [13] Given that perception of risk is highly important in the field of safety and professional hygiene,it is important to assess individuals' perception of risk at work. There are various methods to measure individuals' perceptions of job risk, and one of them is using questionnaires. Therefore, to estimate risk perception, Risk Perception Inventory was used in this study. [14]

Taking into account that risk perception indicates the level of perception in workers about work environment risks, to compare risk perception and actual risk, we also need to assess risks at work environment. This comparison shows the extent of consistency between individuals' perceptions of risk and actual risks. In addition, risk assessment is one of the main priorities, and researchers believe that risk assessment is the centerpiece of safety management and professional hygiene systems. The objective is to assess and control the risk factors that affect workers' safety and health. [15, 16] The main part of any safety and health program is to identify the risks. One of the systematic methods to detect risks is job safety analysis, and its results can improve worker's perception about risk level and their adherence to safety codes. [17, 18]

On the other hand, risk assessment is one of the main factors in health and safety management. In this regard, one of the common methods is the William Fine method, which is a method to make a required decision and justify the costs of removing the risk of hazards. [19] Since detection of risk and perception of the safety risk are essential factors in safety management and prevention of accidents, the risk of accidences increases when the risks are not detected accurately or underestimated. In addition, workers might demonstrate risky behaviors. [20] Therefore, the present study aims to detect and assess job hazard risks in the steel industry in the south of Iran using job safety analysis and William Fine method and compare the findings with workers' risk perception.

Methods

A cross-sectional study was carried out at a steel industry in the south of Iran in 2020. The study population consisted of workers in supplementary sections, and all the workers (N=169) participated in this study. First, workers' perception of their job was measured using risk perception inventory with Cronbach's alpha equal to 92.8% and content and face validity supported by three experts. [14] The inventory contains two sections of general information and risk perception. Section one asks questions about demographics, job activities (type of work, work record, education, age, marital status, witnessed accidents, and the cases, if any). Section two (perception of risk) contains five questions (Yes =2, to some extent =1, and No =0). The sum of scores about risk perception gives risk perception at three levels of low (1-2), moderate (3-5), and high (6-10). Seven units in the supplementary section were included,

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namely industrial services, operation, hydraulic and lubrication, quality control, roof crane, cold section, and roof crane mechanics. After selecting the units, the author made the arrangement with officials and visited the units to brief the candidates about the objectives and the questionnaire. Inclusion criteria were at least six months of work record and desire to participate in the study. The exclusion criterion was reluctance to participate. It is notable that all units had rotating work schedules, and to minimize disrupting factors, data gathering was limited to the morning shift.

Then, to determine the risks, a job safety method was used. First, supervisors of each unit checked their unit and examined the available processes and activities in each unit. Afterwards, the jobs in each unit were disintegrated into their constituent parts, and actual and potential risks were examined. To do risk assessment based on William Fine method [1], the severity of the damage, probability of an accident, and risk exposure were determined based on the pertinent tables for each activity. Then, the risk score was obtained by multiplying risk severity by the probability of accident and exposure to risk. The obtained score was categorized at three levels of severe, moderate, and trivial. Eventually, perceived risk by workers was compared with the risk level determined by William Fine method.

Data were analyzed using a logistic regression model in SPSS software (version 22). The significant level was set at 0.05. In observance of ethical consideration, the respondents were reminded in the questionnaire that their personal information would remain confidential, and no name was mentioned in the study.

Results

The study was carried out at a steel industry in the south of Iran in 2020. From seven units in the supplementary section, 265 job activities and 2684 risks were identified and assessed. The results of risk assessment for the seven units in the supplementary section are listed in Table 1.

As listed, mechanics, hydraulics & lubrication, and overhead cranes mechanists had the highest number of detected hazards with 785, 691, and 444 hazards, respectively. In addition, overhead cranes, quality control, and the operation had the highest risk levels equal to 51%, 45%, and 40%, respectively (Table 1). Data analysis of the frequency of high and moderate level risks showed that overhead cranes, quality control, and the operation had high and moderate levels of risk equal to 81%, 68%, and 61%, respectively. These risks need modifications to lower their level to an acceptable level.

Table 1. Results of supplementary area risk assessment by units

Work unit in the supplementary area	High risk level		Moderate risk level		Low risk level		Total	
	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent
Overhead cranes	58	51	34	30	22	19	114	4
Quality Control(QC)	66	45	34	23	46	32	146	6
Operation	80	40	44	21	79	39	203	8
Industrial services	27	9	89	30	185	61	301	11
Hydraulics & Lubrication	44	6	99	14	548	80	691	26
Mechanics	14	2	111	14	660	84	785	29
Overhead cranes mechanist	10	2	85	19	349	79	444	17
Total	299	11	496	19	1889	70	2684	100

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Table 2. Results of supplementary area risk assessment by units

Work unit in the supplementary area	High and moderate risk level		Low risk level		Total	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Overhead cranes	92	81	22	19	114	4
Quality Control(QC)	100	68	46	32	146	5
Operation	124	61	79	39	203	8
Industrial services	116	39	185	61	301	11
Hydraulics & Lubrication	143	20	548	80	691	26
Mechanics	125	16	660	84	785	29
Overhead cranes mechanist	95	21	349	79	444	17
Total	795	30	1889	70	2684	100

Table 3. Demographic characteristics of the subjects

Variable		Frequency	Percent
Unit	Quality Control(QC)	23	13.6
	Production	38	22.5
	Hydraulics & Lubrication	17	10
	Production mechanics	12	7.1
	Overhead cranes	51	30.2
	Overhead cranes mechanist	6	3.6
	Industrial services	22	13
Work experience(year)	<5	33	19.5
	10-5	62	36.7
	10-15	66	39
	15-20	5	3
	>20	3	1.8
Education	Junior high school diploma	3	1.8
	High school diploma	60	35.5
	Associate degree	31	18.3
	Bachelor's degree	71	42
	Master's degree	4	2.4
Age(year)	18-25	5	3
	25-35	90	53.2
	35-45	68	40.2
	45-60	6	3.6
Marital status	Single	31	18.3
	Married	138	81.7
Get safety Training	Yes	161	95.3
	No	8	4.7
Witness the Incident	Yes	144	85.2
	No	25	14.8

As illustrated in Table 2, among the hazards under examination in the supplementary wards, 70% of the risks were at a low level, 91% were at a moderate level, and 11% were at a high level.

Table 3 lists the demographical information of the participants. All the participants were male, of Iranian nationality, and in the 18-60 years age range. Four age categories were devised; the largest category was 25-35 years (52.7%), and the smallest category was 18-25 years (3%). In addition, 31 participants (18.3%) were unmarried, and 138 (81.7%) were married. The work record of 33 participants (19.5%) was less than five years, 62 participants (36.7%) between five to ten years, 66 participants (39.1%) between 10 to 15 years, five participants (3%) between 15 to 20 years, and three participants (1.8%) more than 20 years.

As to education level, 1.8% had junior high school diplomas, 35.5% had high school diplomas, 18.3% had associates' degree, 42% had bachelor's degree, and 2.4% had masters' degree. Among the participants, 95.3% had received safety education, and 85.2% had witnessed accidents that happened to others.

Table 4 lists the frequency distribution of perception of risk by the workers in the supplementary section of the steel industry. 3% of the participants perceived risks at a low level, 24.2% perceived risks at a moderate level, and 72.8% perceived risks at a high level.

Table 5 lists the frequency distribution of risk perception based on different units in the supplementary section. Production line mechanics, crane mechanics, and overhead crane mechanics had the highest levels of perceived risk, equal to 83.3%, 83.3%, and 82.4%, respectively (risk perception =>6). On the other hand, the lowest percentage in the high-risk category of perceived risk was equal to 54.5% in the industrial services unit (risk perception =>6).

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Table 4. Frequency distribution of Workers' Risk Perception

Variable			Frequency	Percent
Workers' Risk Perception	Low risk perception level	<3	5	3
	Medium risk perception level	3-6	41	24.2
	High risk perception level	≥6	123	72.8

Table 5. Frequency distribution of Workers' Risk Perception by units

Unit	Workers' Risk Perception		
	<3	3-6	≥6
Mechanics	1(8.3)	1(8.3)	10(83.3)
Overhead cranes mechanist	0(0)	1(16.7)	5(83.3)
Overhead cranes	0(0)	9(17.6)	42(82.4)
Quality Control(QC)	0(0)	5(21.7)	18(78.3)
Operation	1(2.6)	12(31.6)	25(65.8)
Hydraulics & Lubrication	0(0)	6(35.3)	11(64.7)
Industrial services	3(13.6)	7(31.8)	12(54.5)

Table 6 indicates the relationship between risk perception and other variables under study. There was no significant relationship between work record and perceived risk (p=0/445,0/494). The probability of perceiving a higher level of risk in individuals with 5-10 years and more than ten years of work experience was 1.64 (p=0.285) and 1.78 (p=0.203) times more than those with less than five years of work record, respectively. There was no significant relationship between age and perceived risk(p=0/419), while younger participants had a higher perceived risk. There was a negative relationship between safety education and risk perception, so that the workers who had passed educational courses had a lower perceived risk (p=0/602).

There was a positive and significant relationship between education and perception of safety risk(p=0/039), In terms of education level, 43 workers with high school diplomas (68.3%), 27 workers with an associates' degree (87.1%), 53 workers with a postgraduate degree (70.7%) perceived the risk at a high level. In addition, the chance of perceiving a high level of risk in workers with associates' degrees and postgraduate degree was 3.14 and 1.12 times higher than those with a lower education level.

The findings indicated that married individuals perceived a higher risk level than unmarried workers (p=0/645). There was a positive and significant relationship between witnessing an accident and perception of safety risk(p=0/0203). That is, those who had witnessed an accident at work perceived a higher level of risk and demonstrated more protective behaviors compared to those who had not witnessed an accident.

Risk assessment results in mechanics units, rook crane mechanics, hydraulics, and lubrication indicated that these units had a lower level of risk, while workers in these wards perceived a higher level of risk. Risk assessment and perceived level of risk in the operation unit showed a high level of risks in work processes, while the perceived level of risk in the workers was low.

Discussion

Detecting and assessing risks and perception of the safety risk are essential elements for safety management and prevention of job accidents. However, many hazards in steel industries remain unidentified, and the safety risks are widely underestimated or not perceived accurately. This leads to risky behaviors in workers and increases the rate of accidents at work. To control this rate, we need a thorough perception of the factors that lead to the wrong perception of safety, failure to detect risks, and decrease of safe behaviors in workers. There have been a few studies on risk assessment and comparing the results with Workers' Risk Perception in Iranian. As noted, the steel industry, among different industries, is one of the most hazardous industries with a high rate of work accidents compared to other industries. [21] In the present case study, mechanics, hydraulics, lubrication, and roof crane mechanics had the highest number of detected hazards, and the roof crate, quality control, and operation units had the highest level of hazards.

Risk assessment is an imperative issue, and an efficient risk assessment is important to control risk.

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Risk assessment includes identifying risks at work, assessing risk level, deciding to control risks, and implementing a risk strategy. [22] Perceived risk level and risk assessment result in operator, quality control, and roof crane units indicated that when workers properly perceive safety risk, the chance of observing safety codes and better detection of risks increases. Therefore, in the face of an unsafe condition at work, workers will be abed to make the right decision and control the risk and prevent work accidents by taking corrective measures and making safe and efficient decisions. There are two key methods for risk assessment, including qualitative and quantitative risk assessment. [23] Among the hazards understudy in the supplementary section, 70% had a low level of risk, 19% had a moderate level of risk, and 11% had a high level of risk. Alipour Nilash et al. used William Fine method to detect and assess hazards and reported that 4.4% of hazards were at an urgent level (urgent need to take corrective measures), 40% were at an abnormal level (need attention and assessment in the short term), 55.6% were at a normal level (should be removed). [24] Hafezi et al. detected 100 safety and hygiene risks using William Fine method, out of which 2% were urgent risks, 31% were moderate level risks, and 67% were lowest level risks. [25] The results of these two studies are consistent with the present study.

Xia et al. found that a reasonable perception of risk had a notable effect on workers' direct perception of risk. [26] Risk perception analyses showed that many workers (72.8%) perceived a high level of risk. Jahangiri et al. calculated risk perception levels in construction workers in Shiraz City and reported that they perceived a high level of risk (77.6%). [14] Khajavi and Ebrahimi also reported that perceived risk by the workers in privately owned gas stations in Ahvaz City was high (72.8%) and in an acceptable range. [27] Considering that the perceived risk level in their study was 72.8%, being directly engaged with job processes in workers explains the high level of perceived risk in them compared to other groups of employees. These results are consistent with the present study.

Table 6. Results of fitting logistic regression model to determine the factors influencing Workers' Risk Perception

Dependent variable / Independent variable		Workers' Risk Perception <6	Workers' Risk Perception ≥6	Multivariate logistic regression OR(95% CI)	Multivariate logistic regression P-value	Simple logistic regression OR(95% CI)	Simple logistic regression P-value
Work experience(year)	<5	12(36/4)	21(63/6)	Reference		Reference	
	5-10	16(25/8)	46(74/2)	1/45(0/56,3/80)	0/445	1/64(0/66,4/08)	0/285
	>10	18(24/3)	56(75/7)	1/44(0/51,4/08)	0/494	1/78(0/73,4/31)	0/203
Education	High school diploma≤	20(31/7)	43(68/3)	Reference		Reference	
	Associate degree	4(12/9)	27(87/1)	3/65(1/07,12/44)	*0/039	3/14(0/97,10/18)	*0/057
	Bachelor's degree >	22(29/3)	53(70/7)	1/21(0/56,2/64)	0/628	1/12(0/54,2/32)	0/759
Age(year)	<35	30(31/9)	64(68/1)	Reference		Reference	
	>35	16(21/9)	57(78/1)	1/43(0/60,3/43)	0/419	1/67(0/83,3/38)	0/153
Marital status	Single	9(29)	22(71)	Reference		Reference	
	Married	37(28/8)	101(73/2)	0/80(0/31,2/08)	0/645	1/12(0/47,2/65)	0/802
Get safety Training	Yes	44(27/3)	117(72/7)	Reference		Reference	
	No	2(25)	6(75)	1/58 (0/28,8/82)	0/602	1/13 (0/22,5/80)	0/885
Witness the incident	No	12(48)	13(52)	Reference		Reference	
	Yes	34(23/6)	110(76/4)	2/93(1/16,7/40)	*0/023	2/99(1/25,7/16)	*0/014

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Among the factors that might affect the perception of risk are the demographical variables. The relationship of demographical variables and perception of risk was examined from different viewpoints. These variables are work record, age, education, marital status, education, and occurrence of an accident. Mohamed argued that the work experience of a worker affects their perception of risk. [28] In addition, risk perception might change over time, and different individuals have a different perception of risk. [29] There was no significant relationship between work record and perceived risk. Jazayeri et al. also reported that the relationship between work record and skills to diagnose and perceive risk was not high (eta = 0.129 and 0.152 respectively). [30] This means a weak correlation and that work record does not have a notable effect on safety skills. It also highlights the opportunity to improve safety skills through quality and highly engaging education.

Although there was no significant relationship between marital status and perception of risk in the present study and OaH [31], the married participants had a higher perceived risk than unmarried participants.

There was a negative relationship between safety education and risk perception, so that the workers who had passed educational courses had a lower perceived risk. Safety education programs can have shortages in terms of content, the number of sessions, or other factors. Therefore, the necessity of quality educational programs to improve workers' familiarity with the risk of accidents at their unit was highlighted. Lack of knowledge about the risks at works prepares the ground for perceiving a lower level of risk, and this delays diagnosing the risk and eliminates the chance of taking timely measures, which in turn causes unwanted consequences. Amiri showed in their study that education did not have a significant effect on perceived risk. [32]Namian et al. reported that workers who had an extensive education were able to diagnose more hazards to have a higher perceived risk. [33] Khajavi and Ebrahimi reported that education had a positive effect on the perceived risk in workers, which is inconsistent with our finding. [27]

This study showed no significant relationship between age and perceived risk, while the younger participants had a higher perceived risk. This finding is consistent with Ian Savage, who showed that younger individuals had a higher perceived risk because of their fears. [34] On the contrary, Sanaei Nasab et al. reported that the older individuals had higher perceived risks. [35] Several studies have shown that having an experience of accident and the consequences (the injuries and pain) changes workers' perception of risk. [36, 37] According to risk assessment and perception results, the workers in lower risk levels had a higher perceived risk. The positive and significant effects of hazard detection and diagnosis and perception of the safety risk are consistent with previous studies. [28, 38, 39] Among the limitations of this research is that some workers were not adequate accuracy and clarity in completing the questionnaires, and as a result, some of the information related to that questionnaire was incomplete, and the lack of similar studies in this field. One of the strengths of the present study is that due to workers' misunderstanding about the dangers in occupational activities and the consequences that can result, so modify safety training classes and hold retraining courses with priority to recognize and understand the occupational hazards. Itself and consequently the reduction of injuries and possible accidents can be very helpful; Also, using the cooperation of supervisors and experienced experts to familiarize the researcher with job activities in each unit and obtain the proper results in identifying risks and risk assessment are other strengths of the research.

Conclusion

Risk assessment results in mechanics units, rook crane mechanics, hydraulics, and lubrication indicated that these units had a lower level of risk, while workers in these wards perceived a higher level of risk.

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Perceiving something as inevitable has a negative and inverse effect on safety behavior. That is, the wrong perception of risk may lead workers to do unsafe behaviors. Risk assessment and perceived level of risk in the operation unit showed a high level of risks in work processes, while the perceived level of risk in the workers was low. When workers underestimate the risks -i.e. wrong perception of risk- the chance of taking safety measure in the face or risks decreases, and the rate of work accidents lead to unwanted outcomes increases.

Education has a notable role in the improvement of detecting and identifying hazards, and the skill of perceiving risk is important to improve the perception of risk. Quality safety education can also have a positive effect on workers' perception of safety issues and increase their motivation to adhere to safety protocols. Adaptation to safety codes in practice has a direct effect on the perception of risk. In addition, safety behavior of supervisors such as frequent checks, rewarding and recognizing correct safety behaviors, providing correctional feedbacks to safety behaviors, providing simple, efficient, and applied education of safety at work, and other safety and risks related education all affect workers' perception of risk.

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Conflict of interest

The authors reported no potential conflict of interest.

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Authors contribution

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