

Modeling Factors Affecting the Susceptibility of Construction Workers to Accidents using Structural Equation Model

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Abstract

Aim: Identifying the factors affecting the susceptibility to accident aiming to reach a better understanding of this phenomenon and review preventive strategies is of the utmost consequence. The present study was carried out with the aim to model the factors affecting the susceptibility of construction workers to an accident using the structural equation model. **Materials and Methods:** This research was of cross-sectional type which was conducted on 200 people in one of the construction sectors in one of the oil refineries from 2020 to 2021. Participants were divided into accident and nonaccident groups. Data were collected using demographic questions contained in 11 questionnaires in three individual, organizational, and social areas. SPSS and PLS-SEM software were also used for statistical analysis and modeling. **Results:** There was a significant relationship between the two groups in the final score of accident susceptibility, individual personality in the field of openness, and safety culture in the field of work environment ($P < 0.05$). The findings showed that job stress has a direct relationship with accident proneness and individual factors and social factors have an inverse relationship with accident proneness. **Conclusion:** After juxtaposing the data, in addition to identifying people with higher accident susceptibility, it can be concluded that industry managers should take into account the background and influencing factors which affect this variable to lessen the accidents. The managers are also requested to improve working conditions, provide the workers with more training, and examine individual and social factors in addition to taking safety measures.

Keywords: Accident proneness, accident, job stress, safety management

INTRODUCTION

The development and expansion of industries have given rise to a surfeit of consequences, one of the most important negative consequences of which is the occurrence of accidents in the workplace. An accident is an unexpected or unplanned event occurring as a consequence of a series of different causes leading to injury (or illness), property damage, work stoppage, or a combination of these effects.^[1] According to the International Labor Organization, 2.3 million people die each year as a result of work-related accidents.^[2] Studies indicate that accidents occur for two pivotal reasons: unsafe conditions and unsafe behavior^[3] Roger L Brauer has introduced human error as the cause of 70%–90% of accidents.^[4]

For as long as anyone can remember, researchers have been trying to identify the psychological factors contributing to accidents, which is called accident potentiality or susceptibility to accidents. This theory has now been modified to the theory of disaster preparedness. According

to this theory, a set of characteristics makes a person commit unsafe behaviors more than others. Of course, the continuity of such characteristics is not constant over time and may decrease with higher levels of experience, skill, and awareness of accident susceptibility.^[5] Studies show that people's risk-taking can be predicted and their behaviors can be modified by changing their attitudes because people's attitudes are changeable. Paying attention to safety issues is an attitude that is effective in promoting safe behaviors and reducing accidents.^[6]

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The concept of susceptibility to accidents as one of the causes of industrial insecurity was first introduced by Greenwood *et al.* Analyzing the records of most workers who were exposed to similar job positions, Greenwood *et al.* found that a small percentage of workers were responsible for occupational accidents. Accordingly, the issue of the accident was introduced as an inherent and integrated trait in occupational accidents.^[7] They also stated that the distribution of accidents among people is not based on chance (Poisson distribution) and there are people whose recurrence of the accident is more than what is expected by chance and these people frequently use medical services.^[8] Studies show that several factors affect the phenomenon of accident-prone talent.^[6] For example, some researchers have concluded that job stress has the potential to harm individual performance. Similarly, the researchers suggest ways in which negative emotional conditions can affect attention to detail or impede the process of information processing in decision-making.^[9] Shevyakov points out that lack of concentration, fatigue, forgetfulness, and slow reaction time are the reasons proving that depressed workers are insecure.^[10]

Furthermore, in many studies, the effect of mental health and depression on accident has been investigated and low mental health is considered one of the causes of accident.^[11] Job stress as a condition of restlessness and anxiety is related to work which affects a person's mental and physical health.^[12]

Since the factors influencing this phenomenon are on a large scale some which are still not properly understood, modeling approaches are used to better identify them. One of these methods is the structural equation modeling approach. Structural equation model can reveal complex relationships between variables. This model is able to use and implement simultaneous communication between internal and external factors. Moreover, it can include hidden factors and variables in the model. Using structural equation modeling to understand the complex relationships between various variables and factors which are directly and indirectly, covertly and explicitly involved in the occurrence of events is highly useful. Structural equation modeling is one of the strongest and most appropriate methods of analysis in behavioral and social sciences research and multivariate analysis.^[13]

The question that arises is whether all people are equally affected by the accident and what are the factors that cause people to behave differently in the same situation.

Taking into account the theoretical and empirical background of occupational accidents, the existing studies fails to properly cover the gaps in this area. Accordingly, it is necessary to conduct further studies in this area to reveal its hidden aspects. The results of previous studies indicate the important role of individual factors, psychological and social factors in the occurrence of occupational accidents. Summarizing the studies indicates that the factors affecting occupational accidents can be classified into three individual, psychosocial, and social categories. The present study focuses on the three

mentioned factors, to study and model the factors affecting the susceptibility of workers to an accident in a construction industry using structural equation modeling.

MATERIALS AND METHODS

Research setting

This research was of cross-sectional type which was conducted on 200 people in one of the construction sectors in one of the oil refineries from 2020 to 2021.

The statistical population studied in the present article comprises the entire staff of the construction department of oil refineries who worked in that department and company during the timespan from 2020 to 2021. The individuals were divided into accident and nonaccident groups. The statistical population of the victims consisted of people who had at least one accident registered in the accident log of the safety, health, and environment department of the organization during the mentioned period. The second group was selected randomly from the same industry sector on the condition that they had no occupational accidents during this period.

Inclusion and exclusion criteria

The inclusion criterion of the accident victims in the study includes cases in which the participants of the accident victims were from work who had referred to the safety, health, and environment management of the organization within 1 year (2020) and were registered in the list of accidents. They had a work accident. Finally, participants were reassured that the information in the questionnaire would be confidential and that the information would only be used for research purposes. A written letter of consent was obtained from the participants and the researcher instructed the participant how to complete the questionnaire. Furthermore, the priority was to select the victims based on the recurrence of the accident. In this way, people who had a higher recurrence rate were preferred to those who had fewer accidents to evaluate the study. The inclusion criterion for nonaccident group in the study also included random selection of other staff who did not have a job accident in 2020 and their minimum work experience is more than 1 year.

Dissatisfaction with the participants to continue the study, having a history of mental illness and drug use, disability due to occupational accident, changing the job of the person due to occupational accident, work experience of <1 year and current job, and incomplete completion of one of the questionnaires, were the exclusion criteria.

Sampling method, tools, and data analysis methods

Due to the modeling nature of this study, 10 random samples were selected for each variable. The total of the variables used in this study is 10 variables consequently, random sampling was performed among the workers of the accident group (100 people) and nonaccident group (100 people) in a construction industry in 2020. According to the study of Kock *et al.*,^[14] when the maximum number of independent variables in the measurement

and structural model is 3, 124 observations are needed to achieve a statistical power of 85% and obtain a minimum value of $R^2 = 0.01$ (with 5% error probability). Due to the fact that a higher sample size increases the accuracy (compatibility) of PLS-SEM estimates,^[15] therefore, the sample size was considered to be 200 people, which included accident victims and nonaccident victims. In addition, the demographic characteristics of the ten selected people in both the nonaccident group and the victim group were considered similar. These characteristics include age, level of education, marital status, shift work, type of employment, and being the head of the household.

The data collection tool includes the following items: demographic information questions, questionnaires related to individual factors including general health questionnaire (GHQ),^[16] NEO personality questionnaire,^[17] questionnaires related to psychological factors including Standard questionnaire of job involvement based on the Kanongo model,^[18] Minnesota job satisfaction questionnaire,^[19] and Herzberg Job Motivation questionnaire.^[20] Also, questionnaires related to social risk were used, including the Carlson and Kakmar Family Work Conflict Questionnaire,^[21] the Yadgarfar Effort-Reward Balance Questionnaire,^[22] the Supplemental Safety Culture Questionnaire,^[23] the UK HSE Job Stress Questionnaire,^[24] and the Accident Susceptibility Questionnaire.^[25] Descriptive statistics including mean, standard deviation, frequency, percentage were used to describe how the variables of demographic factors (age, work experience, marital status, educational status, etc.) were distributed. Mann-Whitney statistical test, Chi-square test and Spearman non-parametric correlation analysis were used to determine the relationship between variables affecting accident susceptibility. PLS-SEM software with partial least squares approach was used for modeling in the present study.

Descriptive statistics including mean, standard deviation, frequency, and percentage were used to describe how the variables of demographic factors (age, work experience, marital status, and educational status) were distributed. Mann-Whitney statistical test, Chi-square test, and Spearman nonparametric correlation analysis were used to determine the relationship between variables affecting accident proneness. PLS-SEM software with partial least squares approach was used for modeling in the present study.

RESULTS

Table 1 shows the distribution of participants' demographic characteristics, including age, work experience, level of education, marital status, type of employment, head of household, and work shift. In both groups, most people are between 30 and 40 years old and have 11–20 years of work experience. There is no significant relationship between the two groups in any of the variables.

Table 2 shows the final score of the participants by completed questionnaires. All questionnaires were analyzed based on the desired areas and only two questionnaires on personality and job motivation were reported separately due to a lack of final score. The results suggested that there was a significant relationship between the final score of accident susceptibility, individual personality in the field of openness, and safety culture in the field of work environment. In other questionnaires, there was no significant relationship between the two groups by different areas and also the final score. Also, the final score was not a significant relationship between the two groups.

The results of correlation among all variables between the two groups showed that neo-personality and job motivation were

Table 1: Frequency distribution of participant's demographic characteristics by accident and nonaccident groups

Variables	Classification of variables	Accident victim (n)	Not accident victims (n)	P
Age group	<30-year	18	16	0.827*
	Between 31 and 40 years old	67	58	
	>41-year	15	26	
Work experience	<10-year	45	23	0.827*
	Between 11 and 20 years old	46	56	
	>21-year	9	21	
Level of education	High school	13	12	0.832*
	Diploma	52	54	
	Associate degree	21	20	
	Bachelors	12	12	
Marital status	Master's degree and higher	2	2	0.261**
	Married	87	89	
	Single	13	11	
Type of employment	Contractual	59	44	0.261**
	Official	41	56	
Head of household	Yes	85	89	0.261**
	No	15	11	
Shift work	Working day	25	21	0.261**
	Regular shifts	75	79	

*Mann-Whitney test, **Chi-square test

Table 2: Mean (standard deviation) of the final score of the studied variables in the two groups of accident and nonaccident

Classification	Mean±SD		P*
	Accident	Not accident victim	
General health	19.47±12.05	17.97±9.81	0.686
Work-family conflict	60.32±11.97	58.47±10.70	0.497
Effort-reward imbalance questionnaire	1.03±0.20	0.97±0.21	0.178
Safety culture	201.40±20.10	204.72±19.71	0.544
Job stress	2.72±0.40	2.62±0.52	0.519
Job satisfaction	56.42±10.34	57.27±11.95	0.333
Job conflict	29.30±8.70	29.10±8.00	0.593
Accidental talent	119.47±10.27	114.35±12.00	0.037**
Locus of control	9.85±3.21	10.12±3.27	0.783
Individual personality neo			
Psychiatry	26.70±4.15	24/87±4.43	0.098
Extraversion	21.65±48.20	20.95±4.45	0.315
Openness	23.35±3.94	21.42±4.18	0.013**
Agree	21.97±4.94	21.80±3.38	0.820
Conscientiousness	21/10±4/97	19/77±3/60	0.323
Job motivation			
Salary	10.52±1.81	10.75±1.91	0.391
Environmental policy	9.22±2.53	10.10±1.97	0.125
Relationship	13.15±3.85	13.90±4.14	0.285
Job security	11.97±2.97	12.15±3.03	0.684
Workplace conditions	9.95±28.58	10.22±1.72	0.855
Supervise and monitor method	15.70±2.94	15.20±3.72	0.850
Recognition and appreciation	13.87±4.60	14.07±4.05	0.885
Career advancement and advancement	11.87±2.57	10.92±2.95	0.234
The nature of work	7.70±2.68	7.65±2.38	0.977
Job responsibility	8/42±2/34	8.35±2.19	0.942
Job position	4.07±2.00	4.27±1.85	0.525

**Significance level, P-value <0.05. SD: Standard deviation

excluded from the correlation section because they did not have a final score. As can be seen, there is a significant and direct relationship between public health and the source of control, effort-reward imbalance, and a significant inverse relationship between public health and accident susceptibility, job stress, and job conflict. The analysis of the data indicates that there is a significant direct relationship between work-family conflict and job stress and conflict; significant inverse relationship between work-family conflict and safety culture and job satisfaction; significant inverse relationship between effort-reward imbalance and safety culture; significant direct relationship between safety culture and job satisfaction; significant inverse relationship between safety culture and job conflict and stress; significant direct relationship between job stress and conflict; significant inverse relationship between job stress and job satisfaction; and last but not least, significant inverse relationship between job satisfaction and job conflict [Table 3].

Figure 1a shows the final model of the structural equations of the factors affecting the susceptibility to accident-mediated job stress, taking into account the three general factors of individual, cognitive, and social factors. As it can be seen, job stress is directly related to accident susceptibility and individual and social factors are inversely related to accident susceptibility and directly to job stress, and safety culture is directly related to job stress and accident susceptibility. Inversely and cognitive factors are directly related to accident susceptibility and inversely related to job stress.

Figure 1b shows the final model of structural equations for the factors affecting accident susceptibility mediated by job stress separately for all questionnaires. As it can be seen, public health, source of control, effort-reward imbalance, safety culture, and job conflict are inversely related to accident susceptibility and of these five variables, two variables of public health and source of control are directly related to job stress.

DISCUSSION

The present study aimed to investigate to investigate some of the most important factors affecting accident susceptibility and their relationship with accident detection to model the relationship between factors affecting accident susceptibility of workers in a construction industry using structural equation modeling. The results of nonparametric statistical tests showed that there was a significant relationship between safety culture (work environment), personality (openness), and susceptibility to accidents between two groups of nonaccident victims and accident victims. Furthermore, the correlation of factors showed that there is a significant and directional relationship between public health and the source of control, effort-reward imbalance and there is a significant inverse relationship between public health and accident susceptibility, job stress, and job conflict. Finally, public health, source of control, effort-reward imbalance, safety culture, and job conflict are inversely related to accident susceptibility and of these 5 variables, two variables of public health and source of control were directly related to job stress.

Workers' behavior and performance are a reflection of individual characteristics such as personality, attitudes and motivations, perceptual-motor abilities, and information processing.^[26] Studies have shown that employees who cause accidents are more prone to accidents.^[27] In other words, being prone to accidents is due to the presence of some personal characteristics in people prone to accidents, which causes this group to suffer more accidents.

Abbasi *et al.* showed in their study that not only do some psychosocial risk items have a significant direct effect on cognitive impairments, but also can indirectly affect cognitive impairments through accident susceptibility. Work-family conflict and social support by caregivers had the most direct impact with coefficients of 0.188 and -0.187, respectively.^[16] Visser *et al.* also after reviewing and studying 79 articles,

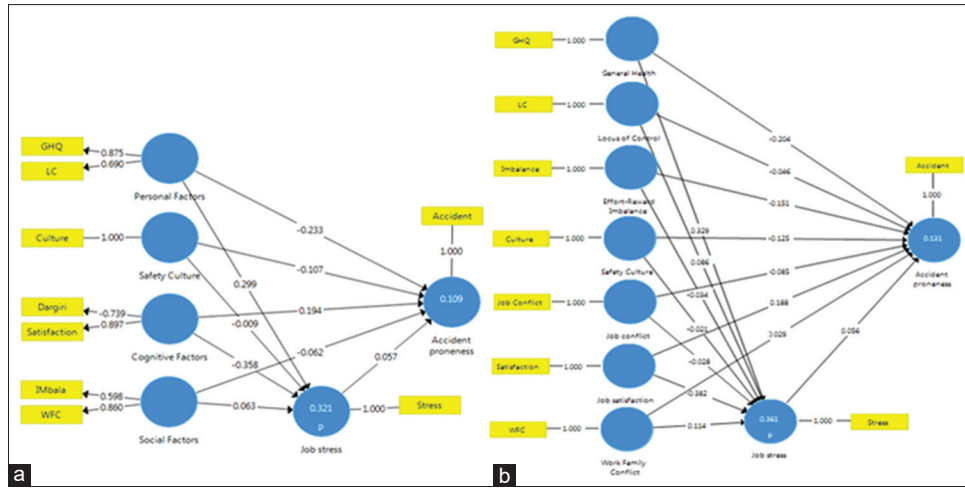


Figure 1: (a) Structural equation model of the studied questionnaires based on individual, cognitive and social factors, (b) structural equation model of the studied questionnaires

Table 3: Correlation between the studied questionnaires

Variables	General health	Source of control	Work-family conflict	Effort-reward imbalance	Accident susceptibility	Safety culture	Job stress	Job conflict	Job satisfaction
General health	-								
Source of control	0.232*	-							
Work-family conflict	0.136	0.203	-						
Effort-reward imbalance	0.263*	0.263*	0.113	-					
Accident susceptibility	-0.257*	0.257*	-0.102	-0.157	-				
Safety culture	-0.212	-0.154	0.259*	-0.233	-0.015	-			
Job stress	-0.360**	0.360**	0.363**	0.129	0.113	-0.267*	-		
Job conflict	-0.257*	0.257*	0.392**	0.041	-0.140	0.236*	0.263*	-	
Job satisfaction	-0.178	-0.253	-0.363**	0.100	0.256	0.276	0.535	0.251*	-

*Significant relationship with $P < 0.05$. **Significant relationship with $P < 0.001$

showed that the number of people observed with frequent accidents is higher than expected. As a result, there is a possibility of accidents and the potential for accident, but more study is needed.^[17] Dorn and Wählberg also examined the susceptibility of bus drivers. They stated that the reason why the previous evidence did not seem to confirm the hypothesis of accidental susceptibility was the inappropriate methodology and misinterpretations of the results. The correlation between driving accident history periods actually shows significant stability over time for which the variance limit is controlled. As a result, in this study, the correlation between accident records between time periods and comparing full-time and part-time bus drivers was analyzed. The correlation between accident time periods was weaker for part-time drivers than for full-time drivers. Correlation increased with increasing variance in the data. The present results support the concept of the tendency to cause traffic accidents as a sustainable feature in individuals.^[18]

The results of the correlation and structural equation model of the present study showed that there is a significant and directional relationship between public health and the source of control, effort-reward imbalance; and, there is a significant inverse relationship between public health and accident

susceptibility, job stress and job involvement. There is a significant direct relationship between work-family conflict and job stress and job conflict as well as there is a significant inverse relationship between work-family conflict and safety culture and job satisfaction; a significant inverse relationship between effort-reward imbalance and safety culture, a significant direct relationship between safety culture and job satisfaction; and, significant inverse relationship between safety culture and job involvement and job stress; a significant direct relationship between job stress and job involvement and significant inverse relationship between job stress and job satisfaction and significant inverse relationship between job satisfaction and job involvement. The structural model also showed that there was a direct relationship between general health and the source of control with job stress and there was an inverse relationship with accident susceptibility, and there was an inverse relationship between effort-reward imbalance, job conflict and safety culture with job stress.

Furthermore, during a study examining the effect of work-family conflict on mental health and job satisfaction, considering the effect of job stress, the researchers found that work-family conflict has a direct and significant relationship

with job stress. Another conclusion of this study was that work-family conflict is not related to mental health alone, but with the effect of mediating the role of job stress, these two factors are significantly related to each other.^[19] This finding is similar to a study carried out by Anderson *et al.* and Gaither *et al.* which shows a direct and significant relationship between work-family conflict and stress.^[20,28] The reason for this can be said that work-family conflict is a kind of ambiguity in creating a role and this leads to pressure on the person and stress, as well as the consequences of stress or disturbance in understanding and it upsets a person's balance, in other words, stress upsets the balance of the person's external and internal conditions, and this disorder disrupts and endangers the person's health. Another study examined the relationship between job stress and accident susceptibility, whose findings show that these two parameters are directly and significantly interrelated.^[21] This result contradicts the results of this study and the reason can be said that the present study, considering other factors that one (work-family conflict) affects stress and the other (general health) is affected by stress, a direct relationship between it does not indicate unsafe behavior and stress, but despite the significant relationship that unsafe behavior has with public health, it can be said that a person's exposure to job stress has affected his health and has caused unsafe behavior.

Also, safety culture in the field of work environment was significantly associated with occupational accidents in the industry. According to the research results, the safety culture of people who have had an accident at work is in a more unfavorable condition than the other group. Safety culture in an organization reflects the general attitude of the organization towards safety. Optimal safety culture is the factor by which all employees, from the CEO to ordinary workers, commit to making a major contribution to their own safety and that of other co-workers.^[22] The results of previous studies show that by increasing the positive safety culture in workers, we can reduce the accident.^[23] One of the areas that had a significant relationship between the two groups was the work environment. It can be said that with the increase of safety culture in the workplace, the incidence of accidents decreases. One reason is that they do not know why they should follow these rules, and the second is that they do not know how to do their job properly. In an organization where there is a strong supportive environment and the person feels that there is sufficient and necessary support for the person and his work by the supervisor and management, he continues to work with more enthusiasm and also tries to be motivated and apply most of the necessary safety tips.^[24]

In general, there was no significant relationship between the personality of the two groups and only the area of openness had a significant relationship. This finding is consistent with the findings of Khoshnevis *et al.*,^[25] Khani *et al.*^[29] and Mohammadfam *et al.*^[30] In explaining this finding, it is highly important to mention that in most of the cited researches, neuroticism (emotional instability) is mentioned as a common finding of most of the researches that is related to the incident.

This finding is also confirmed by the fact that the rate of neurosis is higher in people who have had an accident at work compared to those who have not had an accident. However, the difference between the two groups is not significant. The most important point that has not been considered in most researches in Iran is unsafe work environments in Iranian industries. In other words, the findings related to the relationship between the accident and personality traits, have, to a large extent, attracted the attention of industry owners and officials through external documents (the culprit of the accident is the person who has had an accident), from continuous control of working conditions. In other words, when the environment is unsafe, the accident is out of people's control. Another reason for not observing the correlation between the five personality traits and the number of incidents is the limitation of the number of recorded incidents.

CONCLUSION

Among the studied factors, there was a significant relationship between workplace subscale and openness of the two factors of safety culture and personality, as well as the susceptibility of accident and accident, and the other factors did not show a significant relationship. Findings showed that factors such as general health, personality, safety culture and job satisfaction can affect the susceptibility of individuals to accident. Therefore, in addition to identifying people with higher accident susceptibility, it can be concluded that industry managers should take into account the background and influencing factors which affect this variable to decrease the accidents. The managers are also requested to improve working conditions, provide the workers with more training, and examine individual and social factors in addition to taking safety measures. The managers should also examine factors such as job stress, work-family conflict, general health, job satisfaction, and the correct choice of individuals in terms of their personality relationship with the job.

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Ethics code

The study was also approved by the Ethics Committee of Isfahan University of Medical Sciences, No. IR.MUI.RESEARCH.REC.1399.703.

Conflicts of interest

There are no conflicts of interest.

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