

# Modeling the Factors Affecting Unsafe Behaviors using Fuzzy Logic in an Iranian Steel Industry

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## Abstract

**Aim:** Unsafe behaviors (UBs) are the most important cause of accidents, so there is a need to identify the factors effective on it. The purpose of this study was to identify the factors affecting the occurrence of UBs and also to build a strong theoretical model with fuzzy logic. **Materials and Methods:** This study was conducted among 270 participants in the steel industry in Iran. The factors, such as work-family conflict, job stress, and general health were investigated using relevant questionnaires, and the prevalence of UBs was investigated with the safety behavior sampling technique. Finally, the results were analyzed with SPSS 21.0 and MATLAB software. **Findings:** The results showed that out of 1310 samples of observed behavior, 531 UBs were observed (39.81%). There were 202 cases of nonuse or inappropriate use of personal protective equipment. General health, job stress in the supervisor, and colleagues' support were significantly associated with UBs ( $P < 0.05$ ). In addition, general health, work-family conflict, job stress and were significantly correlated with each other ( $P < 0.001$ ). Diffuse results using fuzzy logic predicted 56% of the behavioral conditions. **Conclusions:** This study showed that managing UBs is possible by controlling factors such as the support of supervisors and the way of management, as well as the reduction of social stresses such as work-family conflict, in addition to being able to increase people's health, also reducing accidents and UBs. Finally, using fuzzy logic, it is able to predict reality, and by knowing several behaviors, better models can be obtained.

**Keywords:** Fuzzy logic, job stress, occupational accidents, unsafe behaviors

## INTRODUCTION

One of the most important adverse effects of industrial revolution is the incident of occupational accidents, which is more significant in developing countries.<sup>[1,2]</sup> According to the International Labor Organization, 2.3 million people die each year as a result of a work-related accident,<sup>[3]</sup> and in 2009, there were more than 2.8 million serious accidents and 3,806 fatal accidents in Europe.<sup>[4]</sup> Accident injuries are also estimated to be the second leading cause of disability in developing countries by 2020 and the third leading cause of death and disability in the world by 2020. Therefore, the prevention of industrial accidents has become the most important safety concern in industry today.<sup>[5]</sup>

According to Henrich in industrialized countries, about 90% of occupational accidents are caused by humans.<sup>[6]</sup> Shoyaku points out that lack of concentration, fatigue, forgetfulness, slow reaction time are the reasons why depressed workers are unsafe.<sup>[7]</sup> Furthermore, in many studies, the effect of mental health and depression on unsafe behaviors (UBs) has been studied and low mental health is considered as one of the causes of UBs.<sup>[8]</sup> Job stress also causes problems and harms people's mental health.<sup>[3]</sup> It can also affect a person's behavior

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Received: 28-Sep-2021

Revised: 25-Jan-2022

Accepted: 25-Jan-2022

Published: 10-Apr-2023

### Access this article online

Quick Response Code:



Website:  
<http://iahs.kaums.ac.ir>

DOI:  
10.4103/iahs.iahs\_192\_21

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**How to cite this article:** Rabiei H, Malakoutikhah M, Beyrami S, Zare A, Saberi HR, Karimi A. Modeling the factors affecting unsafe behaviors using fuzzy logic in an Iranian steel industry. *Int Arch Health Sci* 2022;9:89-93.

at work. High-stress work environments can negatively affect people's safety and safe behavior and increase the risk of injury.<sup>[9]</sup> Ling Chen *et al.* investigated the effect of stress on the safe behavior of construction workers in Hong Kong and concluded that occupational injuries were strongly related to their psychological and physical stress.<sup>[10,11]</sup>

In addition, studies by Griffin and Neil in 2000 developed an effective framework that shows that social factors in the workplace also affect safety outputs.<sup>[12]</sup> One of these social factors, which is called a factor in creating and intensifying stress, is work-family conflict. Work-family conflict is a type of role conflict. This means that it becomes difficult to play job or family roles.<sup>[13,14]</sup> Mazerlow *et al.* believe that work-family conflict is caused by inconsistencies between job demands and family or family life demands. In their view, this phenomenon occurs when the expectations and time constraints of a person's professional and personal life are incompatible, which makes it difficult to manage the two.<sup>[15]</sup>

Due to the importance of the steel industry in the occurrence of accidents and also the review of studies, so far, no study has been conducted on the study of occupational accidents with a full view on the Domino Henrich model. This study aimed to investigate the prevalence of UBs and the general health as an individual factor, job stress as a psychosocial factor of work, and work-family conflict as a social factor as the factors affecting UBs using fuzzy logic in the steel industry.

## MATERIALS AND METHODS

The present study was conducted in one of the steel industries. This study was conducted in three phases, the first phase was to investigate the prevalence of UBs using the safety behavior sampling (SBS) method and the second phase was to assess general health, job stress, and work-family conflict as factors affecting UBs using questionnaire and the third phase was modeling the effective factors using fuzzy logic.

The prevalence of UBs was assessed using the SBS method using the Tarant UBs checklist.<sup>[16]</sup> In the present study, based on this checklist, statistics and causes of past accidents as well as defined UBs in the studied industry, an UBs checklist was designed. This work requires a pilot study and after conducting this study, knowing the number of UBs in the pilot sample, the sample number formula was obtained by considering the 95% confidence interval and 5% accuracy of the total number of observations.<sup>[17]</sup> After investigating the pilot study of 200 behavior samples, the final sample size was 1310 behavioral samples were observed for more certainty.

The second part included a 3-part questionnaire of information on the work-family conflict,<sup>[18]</sup> the UK Health and Safety Executive (HSE) job stress,<sup>[19,20]</sup> and general health questionnaire.<sup>[21]</sup>

The fuzzy system has four parts: Inputs, rules, decision-making system, and defuzzification. The input part means the conversion of real information into linguistic variables. The decision-making system uses operators between rules to better

relate them. Finally, the final results of the defuzzification system are always fuzzy, but the final information required must be in the form of difuzzy primary information. In this study, the rules of Mamdani fuzzy system were used.<sup>[22]</sup> All construction and analysis of the fuzzy system of this study were performed by MATLAB (MATrix LABORatory) software.

## RESULTS

The first part of the results of this study is related to the frequency and percentage of UBs among the participants. Out of 1310 observed behavior, 531 UBs were observed that mean standard deviation was (14.923) 39.81%. The most UBs observed are related to nonuse or inappropriate use of personal protective equipment (PPE) with a frequency of (38%) 202 cases, the second unsafe action with a high percentage is related to awkward posture (20.2%).

Table 1 shows that only general health had a significant correlation with UBs ( $P < 0.05$ ). In addition, general health, work-family conflict, and job stress were significantly correlated with each other ( $P < 0.001$ ).

The statistical relationship between the questionnaires as the factors affecting UBs is shown in Table 2. As Table 2 shows, job stress in the subscriber supervisor and colleagues support scale and general health are parameters that are significantly associated with UBs ( $P < 0.05$ ), and these factors can be considered as fuzzy inputs. The effect of all factors is the same and directly. Other parameters do not show a significant relationship with UBs. The fuzzy numbers in the language variables for job stress was Low (0, 0, 1.25), Medium (0, 1.25, 2.5), High (1.25, 2.5, 3.75), Very high (2.5, 3.75, 5, 5), general health was Low, (0, 0, 22, 45) Medium, (22, 45, 65) High, (45, 65, 84) Very high, (65, 84, 84) and UBs was Low (0, 0, 19.5), Medium (0, 19.5, 39), High (19.5, 39, 52), Very high (39, 52, 100, 100).

The range of variables was job stress from 0 to 5, general health from 0 to 84, and behavior. Unsafe was 0–100. These language variables are shown as fuzzy diagrams in MATLAB software in [Figure 1] (this figure was drawn by Excel software according to MATLAB fuzzy logic output). The variables “b and c” are the inputs of the model and the variable “a” is the output of the model. The variables affecting UBs included job stress and general health, which were considered as input variables and UBs as output variables.

The results show that there is a significant correlation between the actual data of UBs and the Defuzzification data of behavior in fuzzy logic with correlation 0.181 ( $P < 0.01$ ). Furthermore, the correlation between real and fuzzy data is 0.56, which indicates that the obtained fuzzy data, according to the input variables, can predict 56% of the real UBs variable.

## DISCUSSION

The results of UBs sampling show that the most UBs are related to nonuse or inappropriate use of PPE and then awkward

**Table 1: Correlations between general health, work-family conflict, job stress, and unsafe behaviors**

Variables	Job stress	Work-family conflict	General health	UBs
Job stress	-			
Work-family conflict	0.515**	-		
General health	0.387**	0.477**	-	
UBs	0.363**	0.419**	0.479**	-

\*Significant relationship at the level below 0.05, \*\*Significant relationship at the level below 0.001. UBs: Unsafe behaviors

**Table 2: Linear regression between all studied variables and unsafe behaviors**

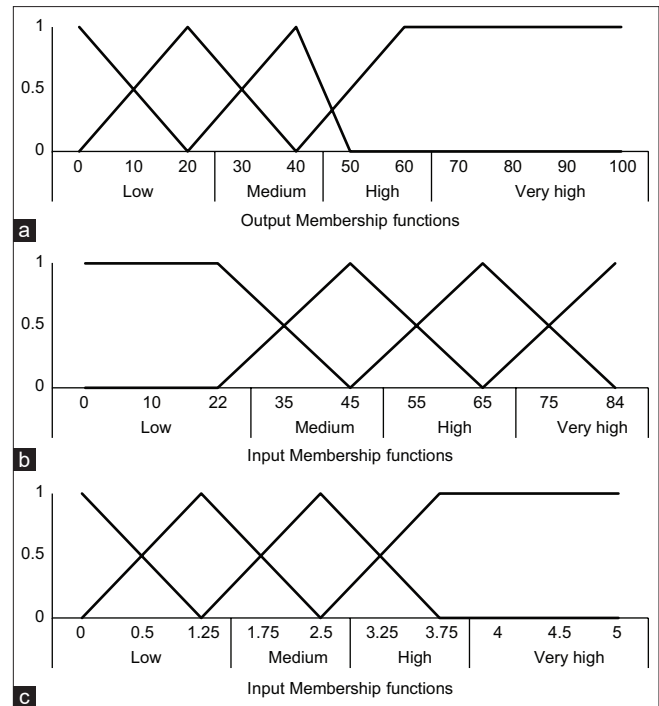
Variables	Categories	P
Job stress	Role	0.784
	Communication	0.412
	Supervisor support	0.043*
	Colleague support	0.022*
	Control	0.956
	Demand	0.651
	Changes	0.115
Work-family conflict	Total	0.150
	Time-based (work-family)	0.670
	Pressure-based (work-family)	0.611
	Behavior-based (work-family)	0.39
	Total	0.699
General health	Physical	0.047*
	Anxiety and sleep disorders	0.231
	Social function	0.103
	Depression	0.716
	Total	0.042*

\*Statistically significant  $P < 0.05$

postures at work. According to Table 1, the observed UBs for all observations were 39.81%.

The results of the prevalence of UBs showed that nonuse of PPE was the most common UBs. This type of behavior is also considered as one of the six main causes of occupational accidents.<sup>[21]</sup> There are several factors on the prevalence of this type of behavior in the industry, including the role of the organization in providing PPE appropriate to the type of work and appropriate to employees, appropriate training on how to properly use and the importance of using this type of equipment and inspection during the work can be called. Furthermore, awkward posture at work is the main cause of musculoskeletal disorders related to work, which are considered as a factor for occupational diseases, absence from work, and loss of labor.

Based on various studies, the percentage of UBs observed in the present study is the average of other studies,<sup>[23]</sup> so that Anderson *et al.* in the electrical industry also shows that 45% of all observed acts are unsafe and the most unsafe practice observed is not using PPE. They also found that



**Figure 1:** Linguistic variables and triangular and trapezoidal fuzzy numbers in MATLAB® software (a) Unsafe behavior, (b) General health, (c) Job stress

there was a significant relationship between the two groups of accident victims and nonaccident victims.<sup>[24]</sup> Mohammadfam *et al.* in a study investigating UBs in the Iranian gas industry concluded that 37% of the behaviors observed in this industry are unsafe and the highest prevalence of UBs is related to inappropriate body condition and then not using PPE has become more common. These results are similar to the present study.<sup>[14]</sup> The cause of UBs depends on several factors such as the type of job, organizational climate, and the type of industry. Since the steel industry is one of the large industries of the country and also has very difficult working conditions, in addition to being affected by individual differences, unsafe practice is also affected by organizational factors.

Mohammadfam *et al.* in a study examined the relationship between job stress and UBs, whose results show that these two parameters are directly and significantly related.<sup>[25]</sup> This result contradicts the present study and the reason for this can be said that the present study is directly related to other factors that one (work-family conflict) affects stress and the other (general health) is affected by stress. It does not show between UBs and stress, but despite the significant relationship that UBs have with general health, it can be said that the effect of job stress on his health has affected his health and has caused UBs. In a study of the relationship between general health and UBs in the printing industry, Khandan *et al.* found that although occupational accidents increase with decreasing general health, they did not find a significant relationship between UBs and general health.<sup>[26]</sup> This study is not similar to the present study, the reason for this may be that the present study has considered other underlying factors for general health and by affecting

these factors on general health, this parameter has a significant relationship with behavior.

The ultimate goal of this study was to model the factors affecting UBs using fuzzy logic. By diffusing the variables, which provide the actual score of each person in the input variables and receive the score obtained becomes fuzzy for UBs, the percentage of predicted UBs of each person was extracted. Combining the results of fuzzy UBs and the percentage of real UBs of each person can be concluded that fuzzy logic with the expressed input variables can predict 56% of the real state. The results showed that the percentage of fuzzy UBs has a significant correlation with the percentage of real UBs, and this shows that fuzzy logic has been able to make an acceptable prediction. To investigate the safety performance using fuzzy logic in Indian industries, Friaiah *et al.* Used fuzzy logic as a tool to predict and judge conventional evaluations. They also found that fuzzy logic can predict up to 90% of the actual state, noting that accident prediction and safety performance require consideration of various variables.<sup>[27]</sup> Dimitriou *et al.* also found a good correlation between the predicted fuzzy logic information and risk assessment information.<sup>[28]</sup>

## CONCLUSIONS

The results indicate that the fuzzy logic and their correlation with the percentage of real UBs, we concluded that the fuzzy model of this study can only predict 56% of the real state. Also, it can be concluded that other factors also contribute to the development of UBs. As we have stated, factors such as organizational climate, safety climate and culture, and training on the use of PPE can be considered as factors that affect the goals and safety policies of the organization as well as increasing employee support and increasing motivation and awareness to perform job duties safely, affect UBs in the workplace. Of course, considering that the percentage of behavior obtained from fuzzy logic is significantly and closely related to real data, the model obtained in the present study can be considered an acceptable model, but future studies will expand the input variables. Furthermore, this logic can be used as a predictor of factor affecting UBs and future studies can use fuzzy ANFIS or system dynamics or other statistical models to increase predictive power of the modeling of the factors affecting UBs.

## Acknowledgment

The authors would like to thank Health, Safety, and Environment (HSE) sector of the studied steel company and Tehran University of Medical Sciences for ethical approval (No.IR.TUMS.SPH.REC.1397.265) and financial support.

## Financial support and sponsorship

Nil.

## Conflicts of interest

There are no conflicts of interest.

## REFERENCES

- Mehrdad R, Seifmanesh S, Chavoshi F, Aminian O, Izadi N. Epidemiology of occupational accidents in Iran based on social security organization database. *Iran Red Crescent Med J* 2014;16:e10359.
- Khoshakhlagh AH, Yazdanirad S, Hatamnejad Y, Khatooni E, Kabir S, Tajpoor A. The relations of job stress dimensions to safety climate and accidents occurrence among the workers. *Heliyon* 2021;7:e08082.
- Barkhordari A, Malmir B, Malakoutikhah M. An analysis of individual and social factors affecting occupational accidents. *Saf Health Work* 2019;10:205-12.
- DeNorre B. 8.6% of workers in the EU experienced work related health problems. *Eurostat* 2009;10:1-10.
- Izadi N, Aminian O, Esmaceli B. Occupational accidents in Iran: Risk factors and long term trend (2007-2016). *J Res Health Sci* 2019;19:e00448.
- Fleming M, Lardner R. Strategies to Promote Safe Behaviour as Part of a Health and Safety Management System. London, UK: HSE Books; 2002.
- Sheviakov AV. Psychophysiological characteristics of nuclear power station operator activity as a factor in accident rate. *Human Physiology* 2005;31:135-41.
- Malakoutikhah M, Karimi A, Hosseini M, Rastgarkhaled A. Modeling of relationship between work-family conflict and occupational accident in a steel manufacturing industry. *Health Saf Work* 2017;7:77-84.
- Hoggan BL, Dollard MF. Effort-reward imbalance at work and driving anger in an Australian community sample: Is there a link between work stress and road rage? *Accid Anal Prev* 2007;39:1286-95.
- Leung MY, Chan IY, Yu J. Preventing construction worker injury incidents through the management of personal stress and organizational stressors. *Accid Anal Prev* 2012;48:156-66.
- Fallah Madvari R, Malakoutikhah M, Rabiei H, Jalali Ardekani M. The relationship between occupational noise exposure and worker's communication skills in miners in Iran: A cross-sectional study. *J Occup Hyg Eng* 2020;7:8-15.
- Neal A, Griffin MA, Hart PM. The impact of organizational climate on safety climate and individual behavior. *Saf Sci* 2000;34:99-109.
- Manoukian A, Pedram RS, Monjamed Z, Faghilzadeh S. Comparison between oncology and labor delivery nurse's job satisfaction. 2007;13:49-55.
- Fam IM, Azadeh A, Faridan M, Mahjub H. Safety behaviors assessment in process industry: A case study in gas refinery. *J Chin Inst Ind Eng* 2008;25:298-305.
- Mazerolle SM, Bruening JE, Casa DJ. Work-family conflict, part I: Antecedents of work-family conflict in national collegiate athletic association division I-A certified athletic trainers. *J Athl Train* 2008;43:505-12.
- Akbari H, Motalebi Kashani M, Asadi Z, Kaveh M, Hannani M. The correlation between occupational unsafe acts and job burnout among workers in kashan metal melting industries 2017. *Int Arch Health Sci* 2019;6:148-53.
- Ghasemi F, Kalatpour O, Moghimbeigi A, Mohammadfam I. Selecting strategies to reduce high-risk unsafe work behaviors using the safety behavior sampling technique and Bayesian network analysis. *J Res Health Sci* 2017;17:e00372.
- Carlson DS, Kacmar KM, Williams LJ. Construction and initial validation of a multidimensional measure of work-family conflict. *J Vocat Behav* 2000;56:249-76.
- Azad ME, Gholami FM. Reliability and validity assessment for the HSE job stress questionnaire. *Int J Behav Sci* 2011;4:291-7.
- Goldberg DP, Hillier VF. A scaled version of the general health questionnaire. *Psychol Med* 1979;9:139-45.
- Arshi S, Sadeghi-Bazargani H, Mohammadi R, Ekman R, Hudson D, Djafarzadeh H, *et al.* Prevention oriented epidemiologic study of accidental burns in rural areas of Ardabil, Iran. *Burns* 2006;32:366-71.
- Liu P. Mamdani fuzzy system: Universal approximator to a class of random processes. *IEEE Trans Fuzzy Syst* 2002;10:756-66.
- Azadeh MA. Creating highly reliable manufacturing systems: An integrated approach. *Int J Reliab Qual Saf Eng* 2000;7:205-22.
- Anderson SE, Coffey BS, Byerly RT. Formal organizational initiatives

- and informal workplace practices: Links to work-family conflict and job-related outcomes. *J Manag* 2002;28:787-810.
25. Mohammadfam I, Bahrami A, Fatemi F, Golmohammadi R, Mahjub H. Evaluation of the relationship between job stress and unsafe acts with occupational accidents in a vehicle manufacturing plant. *Avicenna J Clin Med* 2008;15:60-6.
  26. Khandan M, Koohpaei A. Survey the relationship between mental health statuses with safety behavior, occupational accident and demographic variables among workers: A case study in publication industry. *J Occup Hyg Eng* 2015;2:17-28.
  27. Beriha G, Patnaik B, Mahapatra S, Padhee S. Assessment of safety performance in Indian industries using fuzzy approach. *Expert Syst Appl* 2012;39:3311-23.
  28. Dimitriou L, Vlahogianni EI. Fuzzy modeling of freeway accident duration with rainfall and traffic flow interactions. *Anal Methods Accid Res* 2015;5:59-71.