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Comprehensive Causal Analysis of Occupational Accidents' Severity in the Chemical Industries; a Field Study Based on Feature Selection and Multiple Linear Regression Techniques

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ABSTRACT

Introduction: The causal analysis of occupational accidents' severity in the chemical industries may improve safety design programs in these industries. This comprehensive study was implemented to analyze the factors affecting occupational accidents' severity in the chemical industries.

Material and Methods: An analytical study was conducted in 22 chemical industries during 2016-2017. The study data included 41 independent factors and 872 accidents in a ten-year period (2006-2015) as a dependent variable. Feature selection algorithm and multiplied linear regression techniques were used to analyze this study.

Results: Accident severity rate mean was calculated 214.63 ± 145.12. The results of feature selection showed that 30 factors had high impacts on the severity of accidents. In addition, based on regression analysis, the severity of accidents in the chemical industries was affected by 22 individuals, organizational, HSE training, risk management, unsafe conditions and unsafe acts, as well as accident types ($p<0.05$).

Conclusion: The findings of this study confirmed that accidents' severity in the chemical industry followed the multi-factorial theory. In addition, the main finding of this study indicated that the combination of features selection algorithm and multiple linear regression methods can be useful and applicable for comprehensive analysis of accidents and other HSE data.

Keywords: Chemical Industry, Accidents, Accident Severity Rate (ASR), Multiple Linear Regression.

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1.Introduction

Despite many efforts made in various industrial fields to reduce occupational accidents, the statistics continue to be catastrophic. Mohammadfam et. al., studies have shown that the incidence of accidents is high in sectors such as chemical, petrochemical, steel, aluminum and construction industries [1, 2]. Although, occupational accidents-related data in developing countries such as Iran does not provide reliable information due to the lack of proper registration and report systems. But these reported accidents have been using as a basis for safety activities in industries, so far [3, 4].

Accident analysis and forecasting models are one of the most important tools in the accident prevention. These tools have been explained and developed in various studies to understand the effective and contributing factors in the incidence of occupational accidents [5,6]. Therefore, the aim of present study was comprehensive causal analysis of traumatic occupational accidents occurring during a ten-year period (2005-2015) in 22 chemical industries using two data analysis approaches including feature selection and multiple linear regression analysis.

2.Material and Methods

This study was implemented as a retrospective descriptive-analytical study to analyze the factors contributing to the occurrence of occupational accidents in the chemical industries in 2015-2016. The statistical population was included all occupational accidents that occurred in the 22 chemical industries during the 10 years leading up to the study (2005-2015).

The statistical sample were included traumatic occupational accidents. Initial survey showed that 908 reported accidents were included to present study. It should be noted that only accidents were remained in the study which have all inclusion criteria. For example, accidents that had incomplete report, were excluded. Finally, 872 accidents were selected as the final sample for the study.

Based on the objectives, the study factors were classified as independent and dependent factors that met criteria such as different literatures review, past accidents analyze and logical relationships between factors in 7 independent factor groups (including individual, organizational, training, risk management, unsafe conditions, unsafe actions, and type of accidents factors) and a dependent factor including the Accident Severity Rate (ASR). Determination and analysis of pollution is very important factor for occupational accidents in air [7].

Data analysis were implemented based on feature selection using IBM SPSS Modeler 2.14 and multiple linear regression analysis using IBM SPSS V. 23.0. It should be noted that the significance level was less than 0.05 and the cut-off point for feature selection was considered 0.95 [8].

3.Results and Discussion

Based on 872 reported accidents, mean and standard deviation of accident severity rates were calculated 214.63±145.12. The mean and standard deviation of age and occupational experience of the injured workers were 38.05±5.85 and 9.34±6.32 years, respectively. 61.7% of accidents was related to contractors. Time limitation contributed to 36.5% of accidents, and 79.7% of accidents occurred for shift workers. Among the training factors, desirability of pre-employment training and personal protective equipment (PPE) training were 35.6% and 24.7%, respectively.

The results of risk management factor analysis showed that the low desirability was related to specific risk assessment factor and risk control (technical and engineering measures) (0.8% and 8.3%, respectively).

The frequency and percentage of unsafe conditions , unsafe acts and type of accident are presented in Table 1.

According to table 2, the findings of analytical modeling of occupational accidents in the 22 chemical industries showed that 22 factors remained in the final model and had significant relationship with accident severity Rate (ASR) ($p < 0.005$). It should be noted that the calculation of

Table 1. Descriptive findings of Accident factors

Unsafe condition factors	Frequency (%)
Working Inappropriate and dangerous	252 (% 29)
Insufficient protection systems	327 (% 37.6)
Inadequate safety protection	227 (% 26)
Structural defects	325 (% 37.3)
Working with electrical device	157 (% 44)
Materials and chemicals	388 (% 44.5)
Unsafe action factors	Frequency (%)
No use or improper use of PPE	283 (% 32.3)
Lack of knowledge of the dangers	340 (% 39)
All sorts of inappropriate gestures and jokes	196 (% 22.5)
Exposure to unsafe situations	303 (% 37.3)
Working without permit	65 (% 7.5)
Accident incidence Type Factor	Frequency (%)
Spraying chemicals	325 (% 37.3)
Contact with electrical objects	148 (% 17)
Accidents caused by the displacement of materials	105 (% 12)
Fire	397 (% 45.5)

According to table 2, the findings of analytical modeling of occupational accidents in the 22 chemical industries showed that 22 factors remained in the final model and had significant relationship with accident severity Rate (ASR) ($p < 0.005$). It should be noted that the calculation of R^2 coefficient showed that among the analyzed factors, organizational factor ($R^2=0.879$), unsafe conditions ($R^2=0.829$) and unsafe acts ($R^2=0.805$) have had the most correlation with ASR (Table 2).

Table 2. Results of regression modeling of Accident Severity Rate (n=872)

The remaining variable in the model	†p-value	$CI_{95\%}$	R^2
Age	0.012	(-3.12)-(-1.63)	0.677
Education	0.001	(-5.94)-(-3.46)	
Shift Work	0.001	(1.45)-(3.64)	0.879
Time	0.002	(1.78)-(7.72)	
Type of Employment	0.001	(4.13)-(11.34)	
Periodic education	0.039	(-58.29)-(-1.53)	0.703
Post-accident training	0.002	(-18.21)-(-11.49)	
Training in the use of PPE	0.009	(-27.12)-(-3.93)	
Quality of education	0.001	(-31.32)-(-8.82)	
HAZID	0.001	(-40.11)-(-13.96)	0.683
General risk assessment	0.002	(-28.12)-(-6.56)	
Accident analysis	0.005	(-35.86)-(-6.56)	
Engineering measures	0.009	(-29.26)-(-4.28)	
PPE	0.001	(-35.94)-(-8.61)	
Insufficient protection systems	0.001	(4.13)-(11.34)	0.829
Inadequate safety protection	0.001	(1.44)-(3.64)	
Materials and chemicals	0.012	(3.2)-(26.07)	
Not using or PPE	0.001	(2.28)-(8.83)	0.805
Lack of knowledge and awareness of workplace hazards	0.001	(9.13)-(13.85)	
unsafe situations	0.001	(6.04)-(11.86)	
Spraying chemicals	0.006	(4.75)-(28.29)	0.79
Fire	0.011	(4.12)-(31.73)	

R2 coefficient showed that among the analyzed factors, organizational factor ($R^2=0.879$), unsafe conditions ($R^2=0.829$) and unsafe acts ($R^2=0.805$) have had the most correlation with ASR (Table 2).

4.Conclusion

The findings showed that the severity of accidents is high in the chemical industry. In addition, the severity of accidents in the chemical industry follows a multivariate theory of accidents. combined application of two analytical method of feature selection and multiple linear regression which may provide a comprehensive analysis of accidents and other health, safety and environment challenges, can be as a main finding of the currently study.

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