
Identify economic indicators (direct and indirect costs) of occupational accidents

HOSSEIN RAHMANI¹, MOHAMMAD REZA MIRI LAVASANI^{2*}, MAHNAZ MIRZA EBRAHIM TEHRANI³, FARHAD HOSSEINZADEH LOTFI⁴

¹PhD student, Department of Environmental management, Science and Research Branch, Islamic Azad University, Tehran, Iran

²Professor, Department of Environmental management, Science and Research Branch, , Islamic Azad University, Tehran, Iran

³Assistant Professor, Department of Environmental management, Islamic Azad University, Tehran North Branch, Tehran, Iran

⁴Professor, Department of statistics, Science and Research Branch, Islamic Azad University, Tehran, Iran

Abstract: The analysis of HSE events, especially occupational accidents, along with identifying the effective factors on the occurrence of accidents is of crucial importance. The study of events before, during and after their occurrence is one of the requirements of study in accidents field. The present study is aimed to manage direct and indirect accident costs and improve the mechanism of accident management based on critical accident costs in the country. The present study is an analytical study that is a cross-sectional case study in different industries of the country. The statistical population of the research includes experts in oil, gas, petrochemical, cement, steel, power plant and road construction and construction, and university professors related to occupational health, industrial safety, HSE, and finally active professors in crisis management and under emergency conditions. 12 people were selected by theoretical saturation method. This research was conducted during 2018 and 2019 in determining the costs of occupational accidents. The research area is in various upstream industries, oil, gas and petrochemical and steel and cement industries and other industrial and urban areas. The research instrument includes a researcher-made questionnaire. Data analysis was performed using fuzzy Delphi method. In the field studies of the study, 8 important and major groups of indicators in occupational accident costs at workplace were identified. In order to calculate and obtain the amount of each of the mentioned indicators, a number of sub-criteria were determined and by examining economic models and calculation software, accident costs and conventional and valid models that had verified validity and reliability showed that 51 sub-indicators in the above 8 groups were effective on calculating the accidents costs. It was found that out of 51 indicators identified in the direct and indirect costs of accidents, 45 indicators have a greater effect and to calculate and technically and economically investigate the accidents costs, 45 indicators were required to be investigated.

Keywords: economic indicators, direct costs, indirect costs, occupational accidents

INTRODUCTION

Various events and accidents in health, safety and environment (HSE) have more adverse consequences and effects and often have irreversible effects on human beings, capital, environment and industry reputation. Although, information on events in HSE, especially in the field of safety, its effect, and its numerous consequences around the world, especially in developing countries such as Iran is not present systematically due to the lack of appropriate mechanisms and systems of accidental registration and integrated information systems in the accidents fields, all industry statistics in the framework of specific industry and the Ministry of Labor, Welfare and Social Affairs and the Ministry of Health and Medical Education can not be accepted. On the other hand, in economic analysis and planning in health, safety and environment, due to the lack of accident reporting mechanism as the basis, few accidents reported as a basis and lack of economic and financial studies in accident analysis and Lack of statistical database analysis does not result in any financial and economic information and economic analyzes are not used in accidents. According to medical records and research statistics on actual accident statistics, and despite significant technical, managerial and executive efforts to prevent or reduce accidents and their consequences, the available evidence is still worrisome as the important dimension in the analysis of events is the financial dimension. [1]

It seems that the factors identified in previous studies investigating the various dimensions and ranges of accident costs have a complex and interactive effect on each other that this mutual effect can not be easily identified and therefore can not be analyzed and examined. By investigating previous studies in accident costs, there is no study to identify the effective factors on accidents, latent and intervening variables related to accident costs, and estimate and analyze the relationship between internal and external factors and hidden factors using different mathematical and statistical methods. As it was said, this study aims to analyze and predict the effective factors on accident costs, including direct and indirect, insurance and non-insurance in order to provide a model to identify the costs of each accident and improve the mechanism of accident management and use economic and financial studies of accidents in HSE management system in the industry. [2] As it was mentioned, the main question of this research is what are the economic indicators (direct and indirect costs) of occupational accidents?

Theoretical basics and research background

Industrial accidents in industries, especially in industries with high and medium risk levels are one of the most important problems of developed and developing countries. Despite many efforts to reduce accident rates, the statistics over the world are still terrible. Studies in several countries have attributed many adverse consequences to industry. Identifying indicators for analyzing direct and indirect costs of the accident and analyzing the complex relationships between the causes of the accident and the causes before, during and after the accident in different stages of accident management and the mutual relationship between financial indicators of accidents is an important issue in accident analysis and it is considered a method to reduce the accidents cost. The existing approaches in accidents and accident costs issues all consider the relationships between indicators and rates of different accident management activities as independent, and assuming that all financial and economic indicators of accidents are independent, they accident costs have been also investigated. In terms of econometric methods, this is mostly rejected and the outputs of economic studies are not reliable if the indicators are assumed to be independent of each other. Using a comprehensive approach that can initially examine all financial indicators of the accident, including direct and indirect, overt and covert, insurance and non-insurance, and are used in econometrics and studies of the financial and economic dimension of accidents [3]

The central conference of Canada, financed by the public health agency of Canada, in 2015, in a study “injury and accident costs in Canada”, investigated the various costs of injuries and accidents in Canada. The results of this study show that the cost of injuries studied in 2015 has increased by about 35% compared to 2004 and this value will increase to 180% by 2035. [4-5] The hidden costs of accidents will also increase by 6 times more than the various costs of accidents. Alizadeh et al. (2008) [2] showed that the inability of managers in explaining how to develop and enhance their safety management system is one of the causes of accidents. Later, they refer to the reduction of accidents, injuries and diseases, and the reduction of direct (overt) and indirect (covert) costs of accidents arising from the design and implementation of a proper management system in the safety field. Also, the direct and indirect costs of accidents and its impact on productivity and profitability of the organization and how to calculate them are examined. The results of this study indicate that the ratio of indirect costs to direct costs of accidents is high in all case studies and indicates the need for accident management to eliminate factors increasing the financial and economic dimensions of accidents.

Zhang et al. (2016) [10] in their research applied a systematic approach to analyze the mutual relationship of these factors involved in the occurrence of coal mine accidents (unsafe conditions of rules and regulations, unsafe behavior of employees, unsafe conditions of tools and equipment and unsafe conditions of work place).

Arlinghaus et al. (2012) [6] in their research showed that as occupational injuries is associated with multiple occupational and non-occupational risk factors through complex mechanisms that have not yet been truly understood. Structural equation modeling was used as a new approach to investigate direct and indirect risk factors with potential use of occupational injuries. The study data were collected from about 9000 workers and the direct and indirect effects of weekly working hours and normal sleep duration on occupational injuries were modeled using structural equation models. The confounding and mediating effects involved were also analyzed simultaneously. The final model obtained and fitted showed that the structural equation model is a suitable approach to investigate dual results and indirect effects in complex samples and can explain a new and comprehensive model for predicting damage.

Ruhollah (2014) in his research by achieving direct and covert variables and path functions of effective factors on the safety performance of latent and hidden variables that affect the safety climate and safety performance of the country's aviation industry and using structural equation modeling can identify and trace all effective latent and overt variables in the two topics discussed.

METHODOLOGY

The purpose of this research is applied-analytical and descriptive-cross sectional and case-study in terms of type. In this study, the provided criteria to evaluate direct costs whose impact on other variables are examined are considered as independent variables of research and indirect costs of accidents that affect the dimensions of the accident and the type of accident and direct costs of accidents and their changes depend on these criteria are known as dependent variables of research. All independent variables and all formative and dependent variables and their types are described in the following procedure. The statistical population of this research is restricted

to a group of experts - with two separate groups of university professors and senior managers related to HSE activity fields. This group of 12 experts including experts in the oil, gas, petrochemical, cement, steel, power plant, road and construction industries, and university professors related to occupational health, industrial safety, HSE, and finally active professors in crisis and emergency management, in which 12 people were chosen by theoretical saturation method – were selected and by designing a questionnaire, experts' opinions on each of the criteria and the effective indicators on the costs of occupational accidents and diseases were also investigated. The reason for using a combination of academic experts and people working in the industry was that in determining the effective cost indicators, in addition to examining the scientific nature of these criteria, the matching degree and the possibility of using them in the future implementation phase were also considered by which much accuracy is used in determining the criteria and the importance of each of them. The measures of selecting Delphi panel members in this study are work experience related to HSE field, especially event and accident analysis (at least 5 years) and relevant education (senior and higher), as well as the tendency to participate in research and categorize expertise. Data collection instrument in this research is a researcher-made questionnaire. Due to the fact that in this study, the opinion of experts is used to verify the initial indicators by fuzzy Delphi method, so the validity of the questionnaire is confirmed. Statistical analysis is performed using fuzzy Delphi method.

Research findings

In the first stage and after performing library studies and the investigation of conventional and fixed models that are considered worldwide regarding effective indicators in accident costs and by holding 2 different Delphi panels between professors and experts in the field of accident analysis, the effective indicators on the costs of accidents were extracted according to the following table and the it was used as the basis of the study. Table 1 includes the effective indicators and financial elements in cost and economic aspects of accident costs (both direct and indirect). In the first phase, first, macro models, frameworks, guides, software, standards and executive methods related to the calculation and economic analysis of accidents were introduced, and in this section, by selecting suitable keywords such as "Incident costs" , "Direct cost", "Indirect costs", "Incident cost calculator", "Incident cost modeling", "Cost of incidents", individually and in combination , were extracted from the most famous scientific databases such as Science direct, SID, Civilica, Springer and articles, books, thesis, scientific reports and valid standards of records related to the full text or summary of the text. In the second stage, detailed knowledge was identified and a list of basic criteria was determined. Therefore, in order to determine the list of direct and indirect economic indicators and parameters in occupational accidents, at first models, frameworks, guidelines and standards of economic analysis report and calculation of accident costs in all three fields of health, safety and environment that were investigated in macro field and review of existing models in the calculation and extraction of accident costs have been investigated as economic indicators of accident costs and then by reviewing different models to select and investigate the previous research , the best and the most comprehensive model was also selected. Based on the extracted records and studies, three suitable models and samples were selected for examining and designing the checklists and questionnaires as follows, and were also analyzed. These three models are:

- 1- The model and software of calculating OSHA accident cost
- 2- Model and software for calculating the costs of codified and comprehensive widely used accidents in England called HSE UK Incident Cost Calculator
- 3- Official Website of Work Safe BC affiliated with the Canadian HSE Association

Table 1 - Table of indicators identified in the effective field studies on accident costs (indirect and indirect)

1-Emergency action (response to accident / initial costs of the accident)			
Environment safety (fence and risk mark, etc.)	5-1	Time dedicated for first aids	1-1
Fire fighting	6-1	Equipment, tools and procurement of first aids	2-1
Production reduction due to work stopping (workers)	7-1	Transporting and sending the injured to health centers	3-1
The time loss of people involved in emergency actions	8-1	Costs related to taxi and ambulance	4-1
2- Research costs of accidents			
The sessions to discuss the event with managers and employers	6-2	The time given for analysis and investigation of event	1-2
The time loss of people involved in emergency actions	7-2	The time dedicated to complete the initial forms and reports of event	2-2
The sessions about workers accidents	8-2	The time given to research about the accident and completing the additional reports	3-2
Consulting fee of the employees of event analysis center	9-2	The time given to complete the relevant reports	4-2

		The report and accident analysis by the qualified experts	5-2
3-The research costs and accidents investigation			
Pay compensation expenses	9-3	The time dedicated to evaluate and estimate damage	1-3
The repair and improvement time of production-services system	-3 10	Lawyer fee and the expenses of legal prosecution	2-3
The purification time and eliminating risks from the environment	-3 11	The time given by the personnel for corresponding and removing legal problems	3-3
The costs paid to the client and requirements for removing	-3 12	Imposed costs of dealing with legal procedure	4-3
Replacement of the lost sectors, equipment and production	-3 13	Increase of insurance rate and increase the premium of the next year	5-3
The money paid to the treatment and medical equipment of injured	-3 14	The losses of insurance companies in increasing compensation	6-3
Compensation to the contract party (binding money)	-3 15	Pay the compensation costs	7-3
		The coordination time of reform and repair of production/services system	8-3
4-The damage costs of work and accident (alternative costs of people)			
Cost of absorbing and employing (employment and replacing new people)	4-4	The fee of replacing the alternative workers	1-4
Costs and wage of injured in cased of absence	5-4	Planning and replacing other workers	2-4
The cost of replaced person with the injured one	6-4	The education time for new replaced workers	3-4
5-The costs of production (product/service)			
Replacing the lost sectors, equipment and production	4-5	Reduction of production for stopping/reducing the process efficiency	1-5
The lost demand and proposal for product	5-5	The claim and complaining management of damage	2-5
		Reducing of production and efficiency of the damaged worker after returning to work	3-5
6-The restoring activity cost of maintaining work reputation			
Providing the other resources to meet the demands of customers	3-6	Re-acquisition of the customers reputation	1-6
		The costs of advertising for planning	2-6
7-Resuming work activities			
Restoration of normal conditions of activity and working	4-7	Evaluation/re-planning work activity	1-7
Changing and reforming any system defect	5-7	Remodeling product and services activity	2-7
Renting and purchasing tools, equipment, device	6-7	Refining equipment	3-7

4-1 Survey of experts of emergency action variable (dealing accident / initial costs of accidents)

After determining the indicators of the emergency action variable (dealing with the accident / initial costs of accidents), in order to weight the different parameters, survey forms including all parameters were prepared and provided to experts for completion as its initial result is as follows:

Table 2 - General results of the expert survey

Expert/ sub-index	1	2	3	4	5	6	7	8	9	10	11	12
1-1	4	4	4	5	5	4	4	4	4	5	4	4
2-1	4	4	4	5	5	5	4	4	4	4	4	4
3-1	5	4	4	5	5	5	4	4	4	5	3	5
4-1	5	3	4	5	5	4	4	3	5	5	4	5
5-1	5	4	4	5	5	5	4	4	4	5	5	5
6-1	2	3	4	5	5	3	4	4	3	5	4	2
7-1	5	4	4	5	4	5	4	4	4	4	4	5
8-1	4	4	4	4	4	5	4	4	4	5	4	4

2-4- Matrix of pairwise comparison of research experts

In the second stage, according to the preliminary results of the experts' opinions, the pairwise matrix is calculated. It is worth to mention that due to the numerous identified indicators, only the opinion of the first expert is provided.

Table 3- Matrix of pairwise comparisons related to the first expert

Expert 1	1-1	2-1	3-1	4-1	5-1	6-1	7-1	8-1
1-1	1	1	0/8	0/8	0/8	2	0/8	1
2-1	1	1	0/8	0/8	0/8	2	0/8	1
3-1	1/25	1/25	1	1	1	2/5	1	1/25
4-1	1/25	1/25	1	1	1	2/5	1	1/25
5-1	1/25	1/25	1	1	1	2/5	1	1/25
6-1	0/5	0/5	0/4	0/4	0/4	1	0/4	0/5
7-1	1/25	1/25	1	1	1	2/5	1	1/25
8-1	1	1	0/8	0/8	0/8	2	0/8	1

4-3- Finding the weight of the parameters using FDAHP method

After performing the survey and evaluating the results, all the original results have been used to form the main pairwise comparison matrix of the parameters. In the formation of the mentioned matrix, the triangular membership function and fuzzy numbers according to the following mathematical relations have been used. The fuzzy pair comparison matrix between the 51 indices is as follows:

$$a_{ij} = (\alpha_{ij} \cdot \delta_{ij} \cdot \gamma_{ij})$$

$$\alpha_{ij} = \text{Min}(\beta_{ijk}) \quad k = 1 \dots n$$

$$\delta_{ij} = \left(\prod_{k=1}^n \beta_{ijk} \right)^{1/n} \quad k = 1 \dots n$$

$$\gamma_{ij} = \text{Max}(\beta_{ijk}) \quad k = 1 \dots n$$

Table 4: Delphi pair comparison matrix between 8 surveyed indicators

	1-1	2-1	3-1	4-1	5-1	6-1	7-1	8-1
1-1	1/25	1/02	0/80	1/25	0/98	0/80	1/25	1/00
2-1	1/25	1/02	0/80	1/25	0/98	0/80	1/25	1/00
3-1	1/25	1/05	1/75	1/25	1/01	1/75	1/25	1/00
4-1	1/25	1/03	1/75	1/25	1/99	1/75	1/25	1/00
5-1	1/25	1/10	1/00	1/25	1/06	1/00	1/25	1/00
6-1	1/25	1/84	1/50	1/25	1/81	1/40	1/25	1/00
7-1	1/25	1/04	1/80	1/00	1/00	1/00	1/25	1/00
8-1	1/00	1/00	1/00	1/25	1/96	1/80	1/25	1/00

In the next step, using the following equations, the fuzzy numbers \tilde{Z} and \tilde{Z}_i are calculated for different indices, and the result of the calculations is listed in the following table:

$$\tilde{Z} = [\tilde{a}_{1j} * \dots * \tilde{a}_{ij}]$$

$$\tilde{Z}_i = \overline{Z^1/n}$$

Table 5 - Calculation of relative fuzzy weights of indicators

	z			Z _i		
1-1	0/262144	1/076174	7	0/845897	1/009219	1/274103
2-1	0/209715	1/076174	7	0/822628	1/009219	1/274103
3-1	0/106787	1/388066	8	0/756075	1/041841	1/299615
4-1	0/133484	1/145824	10	0/777461	1/017161	1/336376
5-1	0/8	1/951234	14	0/972492	1/087148	1/385307
6-1	0/0032	0/2400233	3	0/48769	0/836718	1/168358
7-1	0/209715	1/248790	9	0/822628	1/028161	1/310142
8-1	0/209715	0/927419	7	0/822628	0/990625	1/274103

According to the following equations, the fuzzy and non-fuzzy weights of the indicators respectively, have been calculated, and the results are as follows:

$$\tilde{W}_i = \tilde{Z}_i * (Z_i * \dots * Z_n)^{-1}$$

$$W_i = \left(\prod_{j=1}^3 W_{ij} \right)^{1/3}$$

4-4- Defuzzification of parameters weighting

In this step, for defuzzification of the weight of the indicators, according to the above equation, the geometric mean of the fuzzy number components, the weight of the parameters is obtained, and thus the weight of the parameters is expressed as a definite number:

Table 6- defuzzification of the weight of variable parameters of emergency action (response to accident / initial costs of accidents)

	Fuzzy weight of indices			Non-fuzzy weight of indices
1-1	0/08195	0/1258	0/210998	0/127713
2-1	0/079696	0/1258	0/201998	0/126531
3-1	0/073248	0/1299	0/206043	0/125158
4-1	0/07532	0/1268	0/211871	0/126492
5-1	0/094215	0/1356	0/219871	0/141028
6-1	0/047247	0/1043	0/185233	0/097013
7-1	0/079696	0/1282	0/207712	0/128507
8-1	0/079696	0/1235	0/201998	0/125749

According to the obtained results, it can be said that question 1-5 (environment safety (fence and danger zone, etc.)) with the weight of 0.141 has the highest weight. In the second rank is question 1-7 (reduction of production due to work stopping) with the weight of 0.1285. The average indices is equal to 0.1248 and it is observed that question 1-6 (fire control) is below the average and should be removed in the continuation of the research process.

4-5 Survey of experts regarding research and investigation costs of accidents

Due to the existing limitation, for other variables, only the final result is presented. In the last step, for defuzzification of the weight of the indicators, according to the above equation, the geometric mean of the fuzzy number components of the weight of the parameters is obtained and thus the weight of the parameters is expressed as a definite number:

Table 7- The Defuzzification of the weight of parameters of research and investigation costs of accidents

	Fuzzy weight of indices			Non-fuzzy weight of indices
1-2	0/065633	0/113311	0/193283	0/112857
2-2	0/065633	0/112426	0/188550	0/111636
3-2	0/073041	0/117947	0/196075	0/119095
4-2	0/074875	0/117947	0/196075	0/120083

5-2	0/067765	0/114536	0/193283	0/114476
6-2	0/067060	0/113032	0/185257	0/111982
7-2	0/066105	0/112326	0/1899907	0/112171
8-2	0/069508	0/111548	0/182021	0/112169
9-2	0/040437	0/086825	0/170301	0/084246

According to the obtained results, it can be seen that question 2-4 (time spent to complete the reports of the legal authorities) with a weight of 0.12008 had the highest weight. In the second rank, question 2-3 (time spent for investigating the accident and completing additional reports) with the weight of 0.11909, the average of the indicators is equal to 0.1097 and it can be observed that question 2-9 (index of the consultation fee of the experts of the accident analysis) are below the average (equal to 0.08425) and should be eliminated in the research process continuation.

6-4- Survey of experts on variable costs related to damages and compensation

In the last step, for defuzzification of the weight of the indicators, according to the above equation, the geometric mean of the fuzzy number components of the weight of the parameters is obtained and thus the weight of the parameters is expressed as a definite number:

Table 8- Defuzzification of the parameters weight of the costs related to damages and compensation

	Fuzzy weight of indices			Non-fuzzy weight of indices
1-3	0/048608	0/073708	0/114238	0/074247
2-3	0/043153	0/071563	0/119280	0/071684
3-3	0/046339	0/072341	0/110656	0/071852
4-3	0/044886	0/073708	0/119831	0/0734620
5-3	0/046339	0/072341	0/110656	0/071852
6-3	0/044886	0/071001	0/119831	0/072552
7-3	0/049388	0/075099	0/119831	0/076315
8-3	0/014770	0/046602	0/092127	0/039887
9-3	0/045607	0/075099	0/119831	0/074315
10-3	0/045607	0/073708	0/119831	0/073853
11-3	0/048608	0/073708	0/114238	0/074247
12-3	0/046339	0/073708	0/121756	0/074642
13-3	0/045607	0/073708	0/119831	0/073853
14-3	0/048608	0/073708	0/114238	0/074247

According to the obtained results, it can be observed that question 3-7 (payment of compensation and demanded costs and indemnity) with a weight of 0.07632 had the highest weight. In the second rank is question 3-12 (replacement of lost sections, equipment and products) with the weight of 0.07464. The mean of the indicators is equal to 0.0712 and it can be observed that question 3-8 (coordination time of repair / improvement of production / service system) are below the average (equal to 0.0399) and should be eliminated in the continuation of the research process.

4-7- Survey of experts of costs of work-related and accident damages (replacement costs of individuals)

The last step, for the defuzzification of the weight of the indicators, according to the above equation, the geometric mean of the fuzzy number components of the weight of the parameters is obtained and thus the weight of the parameters is expressed as a definite number:

Table 9- Defuzzification of the weight of parameters of costs of work-related and accident damages (replacement costs of individuals)

	Fuzzy weight of indices			Non-fuzzy weight of indices
1-4	0/089950	0/164812	0/322200	0/168411
2-4	0/096251	0/170488	0/325700	0/174848
3-4	0/074717	0/146797	0/283900	0/146028
4-4	0/093365	0/171994	0/322200	0/172958
5-4	0/094377	0/169732	0/295900	0/167971
6-4	0/082033	0/176176	0/334400	0/169076

According to the obtained results, it can be seen that question 4-2 (planning and replacement of other workers) with a weight of 0.1748 has the highest weight. In the second rank, there is question 4-4 (employment and hiring costs (employment and contract) of alternative) with the weight of 0.173. The mean of the indicators is equal to 0.16655 and it is observed that question 4-3 (training time for newly replaced workers) is below the average (equal to 0.146) and should be eliminated in the continuation of the research process.

4-8- Survey of experts on variable costs related to the product production / service

In the last step, for defuzzification of the weight of the indicators, according to the above equation, the geometric mean of the fuzzy number components of the weight of the parameters is obtained and thus the weight of the parameters is expressed as a definite number:

Table 10 – Defuzzification of the weight of parameters of the costs related to the production of the product / service variable

	Fuzzy weight of indices			Non-fuzzy weight of indices
1-5	0/126871	0/2	0/315269	0/199997
2-5	0/126871	0/2	0/315269	0/199997
3-5	0/126871	0/2	0/315269	0/199997
4-5	0/128519	0/2	0/311226	0/199997
5-5	0/128519	0/2	0/311226	0/199997

According to the obtained results, it can be observed that all the questions of this dimension have equal weight and there is no need to delete any of the indicators of this variable and all the indicators of this variable are used in the second stage.

4-9- Survey of experts on the restoring activity cost of maintaining work reputation

In the last step, for defuzzification of the weight of the indicators, according to the above equation, the geometric mean of the fuzzy number components of the weight of the parameters is obtained and thus the weight of the parameters is expressed as a definite number:

Table 11- Defuzzification weight of parameters of the restoring activity cost of maintaining work reputation

	Fuzzy weight of indices			Non-fuzzy weight of indices
1-6	0/228013	0/333333	0/487302	0/333333
2-6	0/228013	0/333333	0/487302	0/333333
3-6	0/228013	0/333333	0/487302	0/333333

According to the obtained results, it can be observed that all the questions of this dimension have equal weight and there is no need to eliminate any of the indicators of this variable and all the indicators of this variable are used in the second stage.

4-10- Survey of experts of resuming work activities variable

In the last step, for defuzzification of the weight of the indicators, according to the above equation, the geometric mean of the fuzzy number components of the weight of the parameters is obtained and thus the weight of the parameters is expressed as a definite number:

Table 12 - Defuzzification of the weight of parameters of resuming work activities

	Fuzzy weight of indices			Non-fuzzy weight of indices
1-7	0/101796	0/184415	0/321600	0/182093
2-7	0/093472	0/164427	0/309900	0/168245
3-7	0/106281	0/172095	0/301800	0/176724
4-7	0/064189	0/147538	0/256200	0/134369
5-7	0/097021	0/166209	0/298500	0/168850
6-7	0/093472	0/165316	0/309900	0/168547

According to the obtained results, it can be observed that question 7-1 (evaluation / re-planning of work activity) with the weight of 0.1821 has the highest weight. In the second rank, question 7-3 (place cleaning, garbage disposal, equipment transfer, etc.) has the weight of 0.1767. The mean of the indices is equal to 0.1665 and it is observed that question 7-4 (returning the work to normal and standard conditions) is below the average (equal to 0.1344) and should be eliminated in the continuation of the research process.

DISCUSSION

The present study was aimed to identify economic indicators (direct and indirect costs) of occupational accidents. With initial surveys, three emergency action questionnaires (dealing with accidents / initial costs of accidents), Model and software for calculating the costs of codified and comprehensive widely used accidents in England called HSE UK Incident Cost Calculator and the official website Work Safe BC. Affiliated to Canadian HSE association was identified. 106 indicators were identified, which by deleting common indicators in the questionnaires, 55 common indicators were eliminated, and finally 51 primary indicators in seven components of the category were obtained. Among the seven variables identified, which include emergency action (response to accident / initial costs of accidents), costs of investigating accidents, costs related to damages and compensation, costs of damages related to work and accidents (costs of replacing individuals), costs related to the production of products / services, the cost of restoring activities (maintain) reputation and resumption of work activities were also identified.

After investigating the findings of the fuzzy Delphi method between the indicators of these variables, a total of 46 indicators were verified. According to the research background, it was observed that in none of the researches in Iran and abroad, economic indicators (direct and indirect costs) of occupational accidents have been identified and the majority of these researches have presented a model using structural equation software. Seo (2005) in his study showed that the variables of safety climate perceived by individuals are the best exploratory factor and the reason for unsafe behavior among the effective factors and is effective on the path of unsafe behaviors, which is most consistent with the findings of this study. Zhang et al. (2016) [10] showed in their research that they classified the factors involved in the occurrence of coal mine accidents. In this study, using a systematic approach, analyzing the mutual relationship between the factors involved in the occurrence of coal mine accidents (unsafe conditions of the rules and regulations, unsafe behavior of employees, unsafe conditions of tools and equipment and unsafe working environment conditions) were also examined, which are consistent with the components of costs related to damages and compensation, costs related to the production of product / service and costs of investigation of accidents. Gholamnia et al. in their research indicated that the average lost working days was 49.57 days and the hidden causes of safety training, risk control and risk assessment are very effective as hidden variables to reduce lost working days and these are consistent with the components of costs related to damages and emergency action (response to accident / initial costs of accidents). Among the indicators identified for the emergency action variable (response to accident / initial costs of accidents), the firefighting index was not verified and the rest of the indicators, which include time spent for first aid, equipment, tools and related supplies of the first aid, transportation of the injured to medical centers, costs related to taxi and ambulances, safety of the environment (fence and danger zone, etc.), reduction of production due to work stopping (workers) and lost time of people involved in emergency actions were approved by experts. For the accident investigation costs variable, 9 primary indicators were identified, among which the consultation fee of the experts of the accident analysis was not approved and the rest of the indicators, which include the time spent to analyze and investigate the accident, the time spent to complete the form and initial reports of the accident, the time spent for accident investigation and complete the additional reports, the time spent to complete the reports related to legal authorities, reporting and analyzing the accident by qualified experts, discussion sessions about the accident with managers and employers, the lost time of people involved in emergency actions and accident discussions with workers were also confirmed. For the variable of costs of damages and compensation, only the index of coordination time of repair / improvement of production / service system was not approved by experts and the indicators of time spent to evaluate and estimate damages, attorney's fees and legal and prosecution costs, time spent by staff to correspond and resolve legal issues, costs imposed in litigation and procedure, increase in insurance rates and increase in premiums next year, losses of insurance companies in increasing compensation, payment of compensation and the required costs, the amount of compensation, the time of repair and improvement of the production / service system, the time of cleaning, disposal and collection of hazards from the environment, the cost paid to the contractor and the requirements for cleaning, replacement of parts, equipment and the lost products, the cost paid for the treatment and medical equipment of the injured one and the damage to the contract (obligation fee) were also verified. For the costs of work-related and accident damages (replacement costs of individuals), only the index of recruitment and employment costs (employment and contract) of alternatives were not approved by experts, and the indicators of wages for moving and transfer of alternative workers, planning and replacement of other workers, training time for newly replaced workers, cost and salary of the injured one (injured) were confirmed in the absence and cost of salary of the replaced person with the injured person. For the variable of costs related to the production of product / service, all indicators of production reduction due to stopping / reduction of process efficiency, management of claims and complaining, reduction of production and productivity of the injured worker after returning from work, replacement of parts, equipment and lost products and the lost proposal for the product were also approved. For the variable of the cost of restoring activities of the maintenance of reputation, all the indicators of regaining customers' credit, advertising costs for planning and providing other resources to meet

the needs of customers were also confirmed. For the variable of resumption of work activities, only the indicators of returning to normal and standard conditions at work were not approved by experts, and the indicators of evaluation / re-planning of work activity, product improvement and service satisfaction, site cleaning, garbage disposal, equipment transfer, etc. repair and reformation of any damage and rent and purchase of tools, equipment, devices and tools, etc. were approved.

According to the applied results of the present study, the following recommendations are presented:

- Among the variables of emergency action (response to the accident / initial costs of accidents) the highest weight is dedicated to the environmental safety index (fence and danger zone, etc.), so it is recommended to create the equipment for the occurrence of the accident and making these devices available can be used in the shortest time in case of occurrence of any problem to minimize the consequences of the accident.
- Among the indicators of accident investigation costs variable, the highest weight was the index of time spent to complete the reports related to legal authorities, so it is recommended that by creating a legal process, steps of administrative work related to accident investigation and combining the experiences and tacit knowledge of employees of this field, we can structure the process of this task for new entrants to be automated and it has the lowest cost.
- Among the indices of costs related to damages and indemnities variable, the highest weight was the index of payment of compensation and the requested costs of damages and indemnities, so it is recommended to create a legal and experienced staff in the process of payment of compensation for stakeholders, and these steps should be reduced as minimum.
- Among the indicators of work-related and accident compensation costs variable (replacement costs of individuals), the highest weight is dedicated to planning and replacement of other workers, so it is suggested that by creating long-term planning for workers, if any person is injured, the necessary predictions can be made for the succession system and the necessary action can be taken in the shortest time to solve the problems.
- Among the indicators of costs related to the production of products / services, the highest weight is dedicated to the management index of claims and injuries complaining, so it is suggested to establish the system of customer complaints in order to solve the existing problem. In the second stage, with appropriate response to customers, the satisfaction is increased to returning to the previous level.
- Among the indicators of the cost of restoring activities (maintaining) reputation and work credit, the highest weight is dedicated to the index of restoring customers' credit, so it is recommended that with a continuous increase in service quality and solving existing problems, the reduced credibility from the perspective of customers can be increased.
- Among the indicators of resumption of work activities variable, the highest weight is dedicated to the index of evaluation / re-planning of work activity, so it is recommended that by re-planning in the process of providing products and services, we can identify the methods with high efficiency and productivity and take the necessary actions for its continuous improvement.

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