

Occupational Health and Safety Management System Development: A Qualitative System Dynamics Approach

Leila Azizi Baraftabi^a, Mahdi Bastan^b, Alimohamamd Ahamdvand^a

^a Department of Industrial Engineering
Eyvanekey University, Garmsar, Iran
E-mail: Leila.azizi@eyc.ac.ir, am.ahmadvand@eyc.ac.ir

^b Department of Industrial Engineering and Management Systems
Amirkabir University of Technology, Tehran, Iran
E-mail: bastan@aut.ac.ir

Abstract

There are exist unacceptably high of occupational accidents and injuries despite the obvious benefits of legal, moral and financial, maintenance through occupational health and safety management systems for employers as well as improvements in occupational health and safety in recent years. Should be developed and implemented the occupational health and safety management system to make a work environment health and safety situation. This system is composed of other subsystems that the design and proper functioning require a comprehensive and holistic understanding of its function. This study is deal with the development occupational health and safety management system aimed at reducing occupational accidents. The results of this study show how an organization can improve occupational health and safety performance by identifying occupational health and safety hazards and risk assessment. As well as are done the proper implementation of these subsystems by factors such as human resource empowerment, commitment to the policy of occupational health and safety, occupational health and safety improvement programs, and infrastructure development, culture and analysis of the accidents, control contractors, emergency response and audits. Thus, can be provided by understanding gained from this learning system, efforts by providing a suitable decision support system, admitted efficient and effective policies to improve the safety and performance.

Keywords:

Accidents, Hazard, Risk, Occupational Health and Safety System Management, System Dynamics.

Introduction

Organizational accidents are rare but catastrophic events [1]. In comparison to individual accidents, organizational accidents involve complex organizational behavior typically beyond the control of accident victims. One of the recent organizational accidents occurred in 2005 in BP Texas City Refinery. The fire and explosion killed 15 people, injured 180 and caused financial losses exceeding US\$1.5 billion [۲],[۳]. Other examples of organizational accidents include the Westray coal mine explosion in Canada [۴], the Nicoll Highway collapse in Singapore [۵], the Columbia and Challenger space shuttle tragedies [6] and the Moura mine explosion in Queensland, Australia [7]. As in the case of BP Texas fire and explosion, not only do these organizational accidents cause loss of precious lives, they lead to huge commercial impacts on the organizations involved and society as a whole. The studies in the case of industrial accidents show that there is still great potential for accidents despite the use of all factors engineering and high protection, high-risk industries. The important point is that these errors do not appear only as an individual error, but often in the form of a truncated form behavioral culture in general. Therefore, considering the importance of behavioral and cultural aspects of safety management in organizations largely increased and should be sought to strengthen and increase the level of safety culture, which is the mental model and shared values of an organization, work safety is used to create more safe behaviors. Many managers and safety professionals in organizations have not been considered a clear understanding of the economic benefits that may directly or indirectly result in increased costs for occupational health and safety in

the work environment. However, researchers considered the benefits of a good management of occupational health and safety, particularly in reducing the costs associated with accidents in the work environment: as much as accidents occur less frequently encountered expenses that the organization has to be also reduced [8]. Models and theories about causes and effects of accidents have been proposed that accident prevention and safety development are required occupational health and safety management. The important note is not enough to create a system of occupational health and safety alone, but also should be considered the mechanisms to measuring the effectiveness of measures taken in the organization. The theories in relation to industrial accidents expressed that defects in the management system of an organization predispose accidents. hence in order to maintain and improve safety and health in the organization, founding an occupational health and safety management system are necessary [9].

In this research, have tried using the systemic approach, provide a model to analyze the dynamics of the development of occupational health and safety management system, Because despite available research on health and safety and the importance of its implementation has been realized, even as accidents and their consequences, occur with high intensity or some accidents or recurring incidents still to be seen in organizations. The investigation of immediate and initial causes of accidents to be held accountable and effective in short-term, but it cannot specify the factors would ensuring the execution of occupational health and safety standards for the organization's goals. Therefore, in this research at the first by identification affecting factors available in literature and considering processes associated with structural of occupational health and safety management system development, a systemic model of the problem will be presented.

Background and literature

In most studies, safety implementation importance can be seen of over time, but not been discussed the integration and development of a management system. One of these studies realized the role of safety by analyzing the accidents, some studies with the doing of the safety rules and comply with it and also with finding the reasons of accidents that caused by unsafe acts or conditions, have a system approach to safety issues. Huchler and Sauer [10] the issue of safety in the work environment and its economic impact is particularly taken into account in some specific economic sectors, where there is a strong feeling that accidents will have a more serious downfall than in other sectors. Serious downfall than in other sectors. In this context, there are studies proving that the implementation of safety actions and standardized procedures leads to a reduction of business costs. Stringfellow [11] Cooke and Rohleder [12] underline

the leverage of informal aspects: general perception, social and cultural processes. Shin, Lee [13] the importance of subjective factors (perceived risk and acceptable risk) is pointed out. Goh, Love [14] in the field of occupational safety or occupational hazards prevention there is research that with a general review and a selection of the most important contributions, analyzing many accidents with details. Cook [12] suggested that offers a generic vision of risk and occupational accidents based on the opinions of subject matter experts. Moizer [15] Contemporary United Kingdom health and safety legislation encourages more self-regulation and active management of health and safety at work. Employers are responsible for managing the risks in the work environment that they create, rather than simply seeking to comply with specific health and safety regulations. In particular, they are required to develop and document their occupational safety management systems. The onus now is on the employer to take practicable action to secure safe and healthy work environment, along with maintenance of the systems to ensure their continuation. There are several studies where researchers applied System Dynamics modeling techniques to help mitigate risk in various industries. Lyneis and Madnick [16] developed a model that focused on the effect of task backlog and adherence to rules and procedures and showed that making safety a high priority by limiting production pressure is by far the highest leverage policy available to managers seeking to prevent accidents. Shin, Lee [13] Safety management parts can be classified into Environment-based Safety Management (ESM) and Human-based Safety Management (HSM). To attain the desired safety level, improving both parts is required. The current safety management, however, is conducted focusing mainly on the ESM, not on the HSM. In order to conduct balanced safety management, a mental process model to support the HSM is a requisite. Thus, this study presents a mental process model which explicates how a worker makes a decision on safe behaviors. Donald and Young [17] In order to develop a worker's mental process model, a basic framework is needed to be identified first. In order to develop a worker's mental process model, a basic framework is needed to be identified first. Behaviors which lead to accidents are intentional. Ajzen [18] attitudes are one of the key factors to predict intentions on behaviors. Smith, Desvousges [19] Moreover, attitudes depend on how people perceive risks. Feola, Gallati [20] a traumatic event may make people perceive a loss of safety or increased risk and previous experience of accidents influences attitudes towards accidents. Nasirzadeh, Afshar [21] despite the risks and uncertainties inherent in the development and implementation of projects play an important role in weakening the performance of the project. Therefore, there is a significant need for effective risk analysis approach to assess the impact of various risks on project objectives. A strong risk analysis possible



consider the dynamic nature risks during the project life cycle, as well as the effect on the effects of feedback loops that generally risk. Bastan and Azizi Baraftabi [22] showed that waste of time due to lack of safety and exorbitant costs can be avoided by an effective planning and funding. Also, can be avoided in a significant amount of damages and accidents by the training and recruitment of human resources familiar with safety issues.

It can be said that all of these studies only considered at some of the factors affecting safety and reduce accidents and have not been a system approaches to safety and health analyzing (most of them focused on the immediate and initial causes of accidents) while in order to reach a desired level of safety and health Should be developed health and safety system. In this study, we will address to create an integrated safety and health management system.

Methods

Research methodology is based on the qualitative system dynamics. This method is one of the Appropriate methods to simulate complex systems that it is based on causal relationships which enabling the system to provide appropriate learning by providing an environment for testing various scenarios. System dynamics can be used in three modes: qualitative, quantitative and semi-quantitative. In the qualitative approach to analyze the dynamics of the system, try to identify feedback structure and reinforcing and balancing loops and then according to generated perception, will also be provided feedback solutions. In the quantitative approach by using stock and flow model allows the simulation of the consequence of policies as model scenarios. there are some applications of this methodology in social and economic complex problem modeling such as mobile banking adoption simulation[23], Banking Risk Management[24], Banking paradox[25], Sustainable development[26], Organizational demographics[27], Brain drain[28], dust emission[29], Waste management[30], Crisis management[31], Inflation rate[32], Housing Cost[33], User satisfaction in Healthcare services[34] and Public health[35].

Modeling

Dynamic Hypothesis

According to studies based on theories that were extracted from the literature, dynamic hypothesis describing the system structure is as feedbacks which interacting into some subsystems according to **Figure 1**.

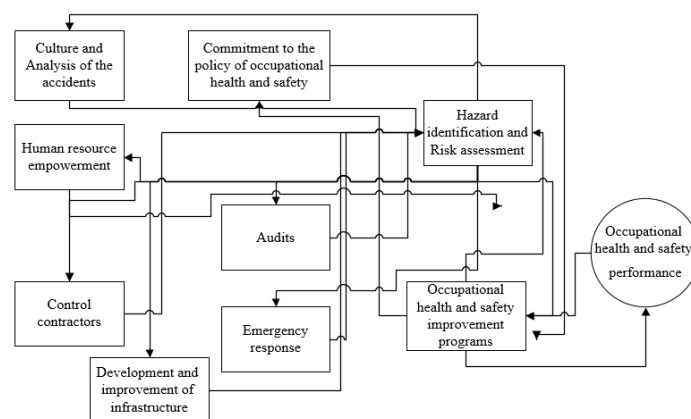


Figure 1 - Subsystem Diagram of occupational health and safety performance

In **Table 1** the loops of each sub-system and a brief description of them have been mentioned.

Table 1 - Subsystems and their feedback loops

| Subsystem | Loop | Loop Description |
|---|------|---|
| Human Resource Empowerment | B1 | The effect of education and human resources empowerment on behavior and unsafe acts that lead to accidents. |
| | R1 | The effect of education on people's motivation and consultation, participation and awareness and learning of the subjects of occupational health and safety |
| Development and Improvement of Infrastructure | B2 | The effect of Development in the infrastructure situation on the conditions unsafe that lead to accidents. |
| | R2 | The effect of Development in the infrastructure situation, the awareness of infrastructure Situation, periodic visits and removing errors and defects |
| Control Contractors | B3 | The effect of contactor control on the conditions unsafe that lead to accidents. |
| | B4 | The effect of the contactor controls on the behavior and unsafe acts that lead to accidents. |
| Culture and Analysis of the Accidents | B11 | The effect on the analysis of the accidents on the behavior and unsafe acts that lead to accidents. |
| | B12 | The effect on the analysis of the accidents on the conditions unsafe that lead to accidents. |
| | R7 | The effect of culture on the analysis of the accidents and individual motivation and morale |

| Subsystem | Loop | Loop Description |
|---|------|--|
| Hazard Identification and Risk Assessment | B10 | The effect of hazard identification, risk assessment, hazard perception and risk control on the behaviors and unsafe acts that lead to accidents. |
| | R6 | The effect of awareness of occupational health and safety situation and risk control on the occupational health and safety improvement programs |
| Occupational Health and Safety Improvement Programs | B13 | The effect of occupational health and safety improvement programs with the interface between reality and the utility level, which lead to improved occupational safety and health performance. |



| Subsystem | Loop | Loop Description |
|--|------|--|
| Emergency Response | B5 | The effect of risk rate and safety alerts on the occupational health and safety resources and manager's interests |
| | B6 | The effect of costs of resources on the manager's interest to occupational health and safety |
| | R3 | The effect of occupational health and safety alerts on its manager's interest and related resources |
| | B7 | The effect of practice and exercise on learning and education and motivating individuals to decrease their risk rate and increase interest and accuracy in reporting minor accidents |
| | B8 | The effect of reporting minor accidents with the resources needed for occupational health and safety to importance perceived by the employees from occupational health and safety |
| | R4 | The positive effect of reporting minor accidents with the resources needed and occupational health and safety resources to importance perceived by the employees from occupational health and safety and motivating them |
| | B9 | The effect of identifying crises and doing exercises and maneuvers on the risk rate that lead to accidents. |
| | R5 | The effect of education and learning and motivation of the maneuvers and identify crises |
| | B15 | The effect of identifying crises and maneuvers on the risk rate that lead to accidents. |
| Commitment to the Policy of Occupational Health and Safety | R8 | The positive effect of commitment to occupational health and safety policies and responding to legal liability |
| Audits | B14 | The effect of audits and risk control on the risk rate, which leads to accidents. |
| | R9 | The positive effect of monitoring and audits and risk control on the occupational health and safety improvement programs |

To have an occupational health and safety desired performance should be above all sub-systems to run correctly.

Figure 2, the loop is describing the effect of empowering human resources subsystem on occupational health and safety performance. By training, we can raise the people information, motivation and counseling and their awareness and knowledge. As well as communication and participation of people in learning and interested individuals have a positive impact. So, the unsafe behaviors and acts that controlled by an awareness and interests. This is effecting on hazard identification and risk assessment variable. This effect is ultimately contingent on the occupational health and safety improvement programs and finally occupational health and safety performance.

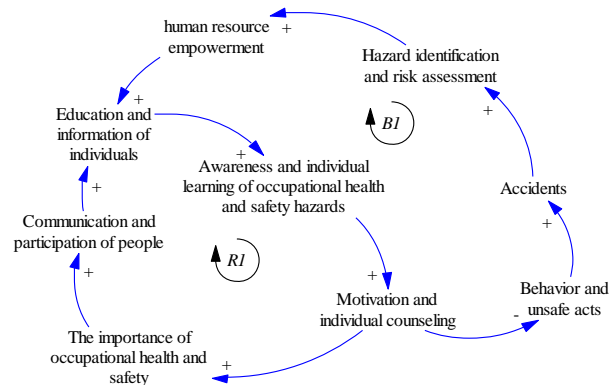


Figure 2 - Human resource empowerment subsystem

In **Figure 3**, the loop is describing the effect of development and improvement of infrastructure subsystem is on occupational health and safety performance. To infrastructure improvement and development must be aware of its status that realized with Periodic visits. So the defects and errors and unsafe conditions influence on stress, discomfort and ensure the work environment. This is the effect on the hazard identification and risk assessment variable. This effect is ultimately contingent on the occupational health and safety improvement programs and finally occupational health and safety performance.

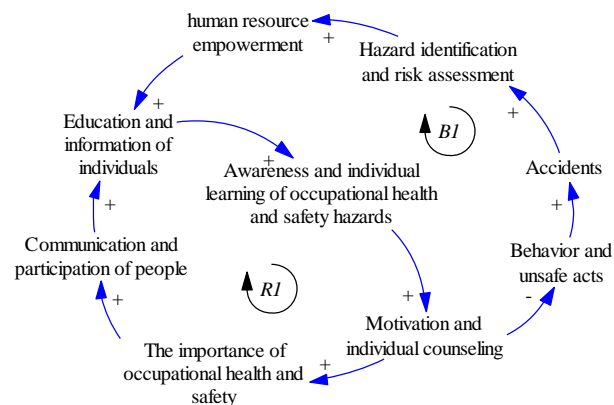


Figure 3 - Development and improvement of infrastructure subsystem effects loop

Figure 4, shows subsystem which related to the effect of contractors controls on occupational health and safety performance. By identifying and control the activities of routine and non-routine can increase controls on which contractors that doing non-routine activities. By controlling contractors can affect unsafe acts, behaviors and conditions. The impact of these variables and their relationships leads to accidents is unusual activities that effect on the hazard identification and risk assessment. This positive impact will ultimately result in occupational health and safety improvement programs and finally occupational health and safety performance.

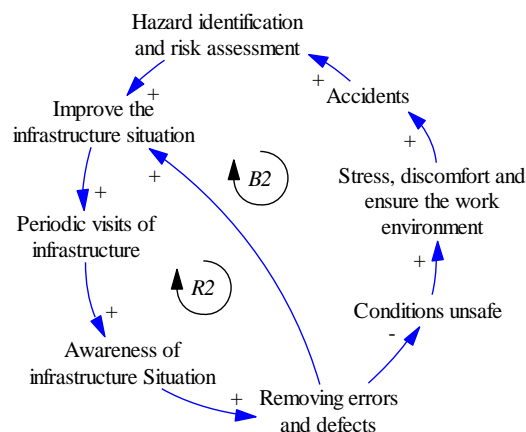


Figure 4 - Contractors control subsystem effects loop



Figure 9 which include four section shows the effect of emergency response subsystem (Figures 5 to 8). It Also Shows how the risk rate related to the sources of occupational health and safety and interest of managers and this relationship effect between the variables occupational health and safety improvement programs. **Figure 5**, shows the relationship between interest in occupational health and safety managers according to the risk rate and safety alerts as well as resource requirements of health and safety that is costly. **Figure 6**, shows the relationship between education and motivation to the employee after the maneuver running that shows reporting minor accidents more likely. **Figure 7**, shows that the tendency to report minor accidents increases after exercise. This happens because the interest of the employees in safety topics increases, and they are much more careful before any accident occurs - even if the accident would be negligible. This is in spite of the fact that the risk rate has diminished because after the exercise the resources allocated for safety have increased. **Figure 8**, shows the relationship between education, information, and awareness, motivation and counseling of individuals to identify crises that will result from identified hazards and risk assessment. It also shows that identifying crises and doing disasters maneuver had an impact on the risk rate. This variable effect on hazard identification and risk assessment. This effect results in improving occupational health and safety programs and then occupational health and safety performance.

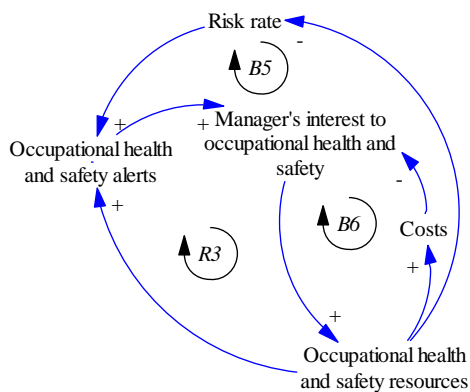


Figure 5 - (B5, B6, R3) part of the emergency response subsystem effect loop



Figure 6 - (B7) part of the emergency response subsystem effect loop

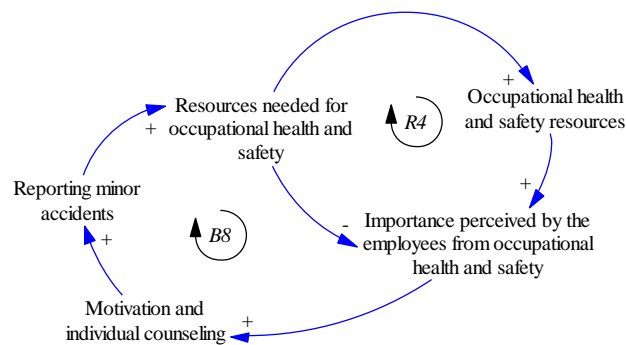


Figure 7 - (B8, R4) part of the emergency response subsystem effect loop

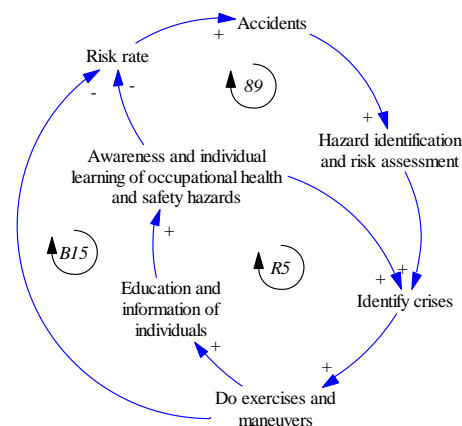


Figure 8 - (B9, B15, R5) part of the emergency response subsystem effect loop

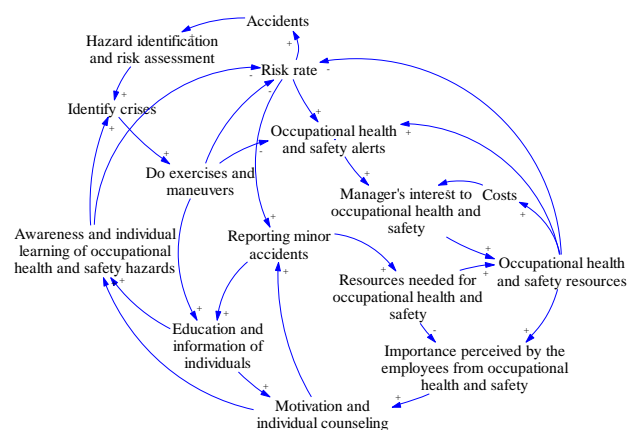


Figure 9 - Emergency response subsystem effect loop

Figure 10, shows the effect subsystem hazard identification and risk assessment of occupational Health and safety performance. Understanding of occupational health and safety status and hazard identification and risk control, the effect on unsafe acts and behaviors as well as accidents. This is the effect on occupational health and safety improvement programs variable. This effect Results in the occupational health and safety performance.

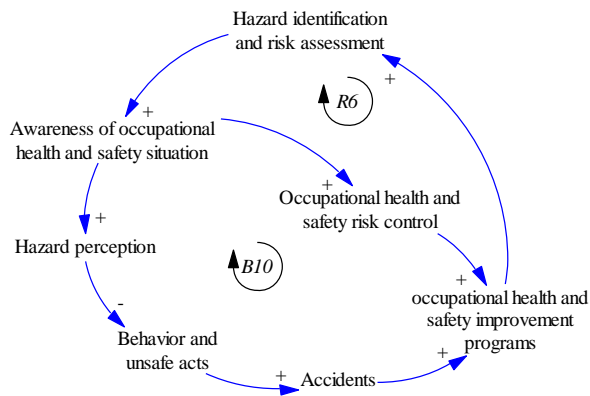


Figure 10 - Hazard identification and risk assessment subsystem effect loop

Figure 11, shows the effect loop audit subsystem is on occupational health and safety performance. This relationship shows that with monitoring and audits, can control risks and improve occupational health and safety programs. This relationship has an impact on the accidents and risk rate. This is the effect on hazard identification and risk assessment variable. This effect Results in the occupational health and safety improvement programs and finally occupational health and safety performance.

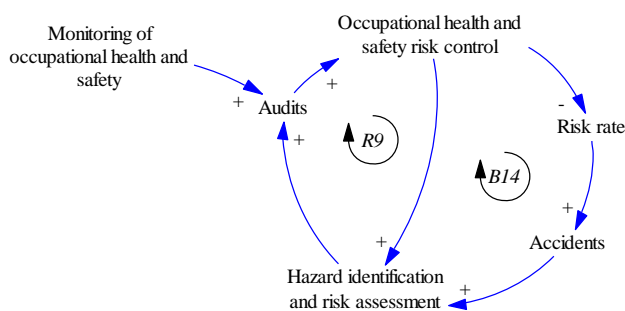


Figure 11 - Audits subsystem effect loop

In **Figure 12** a reinforcing loop of occupational health and safety culture by analyzing accidents and unsafe behaviors can be applied to the variables, have an impact on unsafe conditions, the occurrence of repetitive and similar accidents and the satisfaction of stakeholders. By analyzing the accidents can be prevented the accidents. This is the effect on hazard identification and risk assessment variable. This effect Results in the occupational health and safety improvement programs and finally occupational health and safety performance.

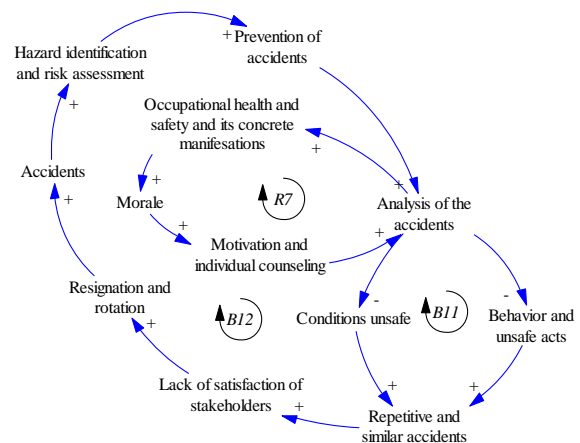


Figure 12 - Culture and analysis of the accidents subsystem effect loop

Figure 13, shows the gap between the desired level of occupational health and safety performance and the level of current occupational health and safety, the impact on occupation health and safety improvement programs and the impact will ultimately result in occupational health and safety performance.

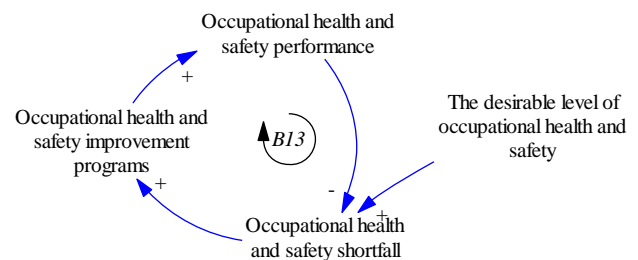


Figure 13 - Occupational health and safety improvement programs subsystem effect loop

Figure 14, shows the relationship between commitment to occupational health and safety policy and meet the legal responsibilities (implementation of rules and standards) as well as occupational health and safety improvement programs show.

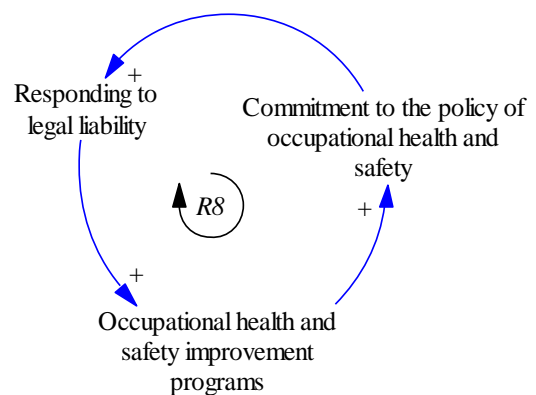


Figure 14 - Commitment to occupational health and safety policy subsystem effect loop



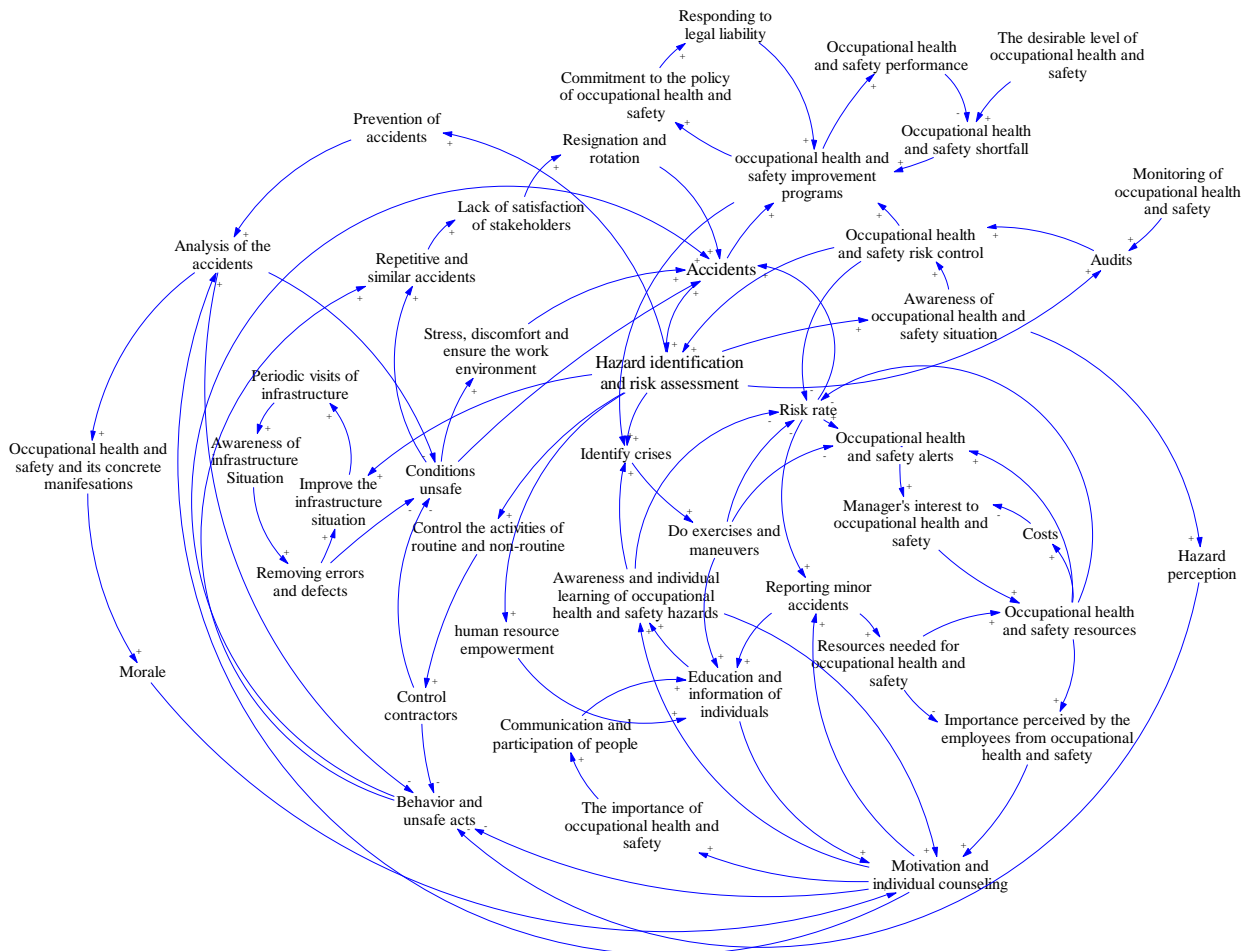


Figure 15 - Causal Loop Diagram

Figure 15, shows the causal diagram of the whole system with interactions between the all involved components.

Results and Conclusion

A safe place to work is hardly accessible. Because there is almost always some risks remain. In addition to the work to be done whether operational or maintenance - in turn, inevitably will create more risks. Therefore it is necessary to be run a set of safety systems. Can never be 100% safe conditions because it is impossible to eliminate all risks. Is not conclusive the border between dangerous and harmless. Based on these reasons, all of the efforts are in order to improve conditions and reduce risks. This effort must be made by all components of a system and all levels of the organization. In this regard, should be taken the problem quite seriously to identify risks and converting them to prevent the accident.

In this study, we try to show that can reduce risk facing as well as accidents, by monitoring and improvement of each of the subsystem are defined in system, as well as through occupational health and safety improvements program, commitment to safety and health policy, control occupational health and safety risks, can achieve to

occupational health and safety performance and can reduce the gap of between desired and current occupational health and safety level.

If each of the presented subsystems is applied properly and continuously, then the occupational health and safety improvement programs will implement. By The realization of programs can be said that occupational health and safety performance achieved. Was determined according to cause and effect diagrams will improve the occupational health and safety performance that with improving and control the sub-systems of hazard identification, risk assessment the input can also be other subsystems. This relationship shows that occur with the hazard identification and risk assessment of the state of the infrastructure by controlling unsafe conditions, the status of human resource empowerment through control unsafe acts and behaviors, state of control the routine and non-routine operations by controlling contractors, emergency response situation with the exercises that can be done, implementing and improving occupational health and safety culture by analyzing accidents and in the monitoring of health and safety audits. For future research, it is recommended to develop the mathematical and simulation model, present the stock and flow structure of this system which can provide a context to test various scenarios and report some effective solutions.



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