



A Two-phased Study to Rank the Hazards in the Healthcare System: A Case Study of the Operating Rooms of Farabi Hospital in Tehran, Iran

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ABSTRACT

Background: Healthcare systems are exposed to various occupational hazards (e.g., infectious diseases), which threaten the health and safety of the employees. This study, conducted in September 2017 aimed to outline a two-phased approach for the identification of the most important hazards accurately and rapidly and better decision-making in the next step of risk management.

Methods: This two-phased study aimed to rank the most important hazards in the operating room of a hospital and identify the hazards using two methods (HAZID and ANP) consecutively. Data management was performed in the Super Decisions software.

Results: In total, 44 hazards were analyzed in three categories, and five hazards (occupational stress, formaldehyde exposure, shift work, poor posture, and exposure to anesthetic gases) had the highest priority. The normalized values of the alternatives obtained from a limit super matrix were 0.33, 0.251, 0.258, 0.096, and 0.06. Occupational stress was the most weighted hazard, while formaldehyde exposure was the least weighted hazard.

Conclusion: Using the two approaches of hazard identification helped us conduct new, rapid hazard identification activities and increased the accuracy of the process as well. As a result, the time-consuming risk assessment phase was focused on the most important hazards.

1. Introduction

According to the statistics of the International Labor Organization (ILO), approximately 2.3 million workers die each year due to accidents or diseases worldwide. Furthermore, workplace accident costs have been estimated at US\$ 2.8 trillion [1]. Every accident or illness stems from the disagreeable events that occur in workplaces [2]. To manage these issues, various approaches have been proposed to identify and rank hazards, rendering hazard identification methods critical to the operation of any systems as a tool in a definite time of any activity to distinguish similar unsafe measures [3].

A comprehensive literature is available on the health hazards in the healthcare industry. Although health care is supposed to be a safe practice [4], these professionals are exposed to various occupational hazards (e.g., infectious diseases) [5], which threaten their health and safety [6]. Several hospital studies have reported operating rooms to be a fundamental unit associated with the challenge of various physical, chemical, biological (e.g., infectious agents), ergonomic, and psychological hazards (e.g., stress and depression), as well as fire, explosion, electricity, and falls. In general, it has been established that hospitals rely on various skilled personnel for the provision of high-quality services, and their first priority is to protect the personnel.



However, occupational hazards cause extensive damage to these organizations, such as the loss of experienced workforce and adverse effects on patient safety [4,7-8].

Recent development in risk management have led to the use of the analytic network process (ANP) approach as the initial tool for this process [9], which has become more applicable lately [10]. In addition, several studies have been focused on hazard identification (HAZID), and extensive research has been conducted regarding HAZID for safety design in risk assessment [8]. HAZID has been performed for the safety issues of liquefaction in the storage and transportation of liquid hydrogen [11]. Ample evidence attests to the potential of the ANP approach; such examples are asset maintenance decision-making [12], risk assessment in enterprise resource planning and system implementation [13], risk prioritization in megaprojects [14], and several other cases for which the ANP approach has proven potent in network analysis for optimal decision-making.

There are a few closely related studies that used two techniques to rank the hazards consequently in the field of healthcare and this recently developed study aimed to outline a two-phased approach for the identification of the most important hazards accurately and rapidly and better decision-making in the next step of risk management.

2. Materials and Methods

This cross-sectional study was conducted in September 2017 in the operating rooms of Farabi Hospital, which is an old governmental hospital in Tehran, Iran specialized in ophthalmology. The hospital has five operating rooms in which more visible hazards are present, and adequate documents are available to investigate the health, safety, and environmental aspects.

In the present study, the HAZID method was selected considering that it is a familiar technique to identify all hazards in detail based on possible consequences within a short period [15]. In addition, the HAZID method could recognize the importance of all risks due to their advantages; therefore, it was considered optimal for our research prior to the ANP approach in order to achieve accurate results. The number of the HAZID team members had to be small, while they were required to have adequate knowledge to carry out the process. The team members were selected during the initial stages of the process and included the administrator of the facility, HSE manager, occupational health officer, and two experienced operating room nurses.

After the classification of the hazards into three categories and 44 hazards, the team members investigated

these items in accordance with the HAZID guidelines [15].

Table 1 shows the category of the health hazards. As can be seen, anesthetic gases were classified as carcinogenic agents and regarded as the potential hazards, effects, and threats.

Several measures were taken to control these effects using a risk matrix, and the team scoured the hazards considering the likelihood and severity of the events.

In 1996, Saaty introduced a new applicable method known as the ANP, which is a network modeling approach to solving complicated issues. As is depicted in Figure 1, there are dependencies and interaction between the elements in the ANP, while the analytic hierarchy process (AHP) is a linear process.

The ANP was used in the current research for several reasons. The approach has the capability to analyze both feedback and dependence [13], while it is also applied for problem-solving as a systematic, efficient approach [13]. In addition, the ANP could conceivably analyze complicated systems and has the potential to identify the interdependencies between various elements [14,16].

In the first phase of the study, the problem was explained, and the dependencies of the distinguished elements were specified based on the interrelations of the clusters and nodes [17,18], which were obtained in the Super Decisions software 2.4.0-RC1 version as a specialized tool for the analysis of the ANP method. In the second phase, the pairwise comparison matrix was conducted, and the criteria had to be weighted in accordance with Saaty's fundamental scale (Table 2) [19]. With the completion of this step, the pairwise comparison was carried out.

As is shown in Table 3, a questionnaire was used to compare the alternatives, and the decision-makers decided to dominate one element over another with respect to a criterion by selecting a scale [19]. For instance, in the first row of Table 3, two alternatives with respect to health consequences were compared, and the team selected three alternatives for occupational stress, which indicated that occupational stress was moderately more important than formaldehyde exposure in terms of health consequences. To evaluate the inconsistency of the judgments associated with weights, the consistency ratio was defined and had to be less than or equal to 0.10 [20].

When the steps were completed, the software was ready to build the unweighted super matrix based on the pairwise comparisons. By multiplying the corresponding elements of the unweighted super matrix, the weighted super matrix was obtained [21].

Table 1: Classified operating room hazards of health hazard category

Guide word	Potential hazards and effects	Threats	Controls	Development phase	Priority	Number
Carcinogenic Toxic	The presence of waste anesthetic gases and vapors from devices which is resulted from anesthesia devices which are inhaled by the operating room personal and cause damages to several organs.	Depending on kind of anesthetic gases they can cause variety of occupational disease like congenital and cancer	Existing good ventilation system, continuous monitoring, periodic examinations	In operation phase	High	6
Physical	Various bad postures during work can cause back pain in all operating room workers	Back pain and absence from work or losing experienced workers	Observe the correct posture, instructions for prevention, not bending a lot during work, using chair if possible	In operation phase	High	2

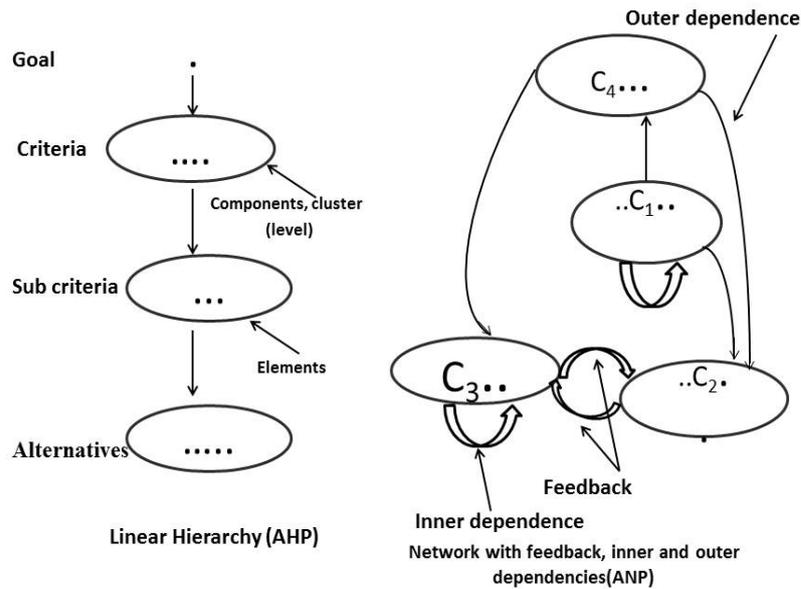


Figure 1: Differences between AHP and ANP

At this point, the final weight of the alternatives and criteria was computed, and the limited super matrix could be calculated, in which the weighted super matrix was raised to power, and all the limits were summed in one for each cluster (Table 4). Finally, the ratio scale priority of the elements was synthesized from the limit super matrix.

3. Results and Discussion

The main objective of the current research was to prioritize the hazards of operating rooms using the ANP approach. In addition, the identified hazards were screened using the HAZID method in advance. As described earlier in the HAZID process, 44 hazards were identified in three categories of fire and explosion (17 items), health hazards (19 items), and environmental hazards (8 items) and analyzed; as a result, five items achieved high scores in the health hazard category.

The first set of the analysis using the ANP method confirmed that the CR values in all the comparisons were calculated to be less than 0.10. Further analysis (Table 4) also indicated that with the limit super matrix, the most remarkable result to emerge from the data was the final weight of each alternative (Figure 2). The normalized values of the alternatives obtained from the limit super matrix were 0.33, 0.251, 0.258, 0.096, and 0.06, which were obtained using the Super Decisions software. As is depicted in Figure 2, occupational stress had the highest priority in decision-making, while formaldehyde exposure had the lowest priority compared to the other alternatives.

In the present study, occupational stress scored the highest weight (0.33) compared to the other alternatives. In a study in this regard, Yang et al. (2017) reported that healthcare professionals (e.g., operating room staff) showed high occupational stress, which could be due to their long working hours and significant stress [22]. On the other hand, Elshaer et al. (2018) investigated occupational stress among critical care staff, observing that the majority of

surgical nurses and technicians at the intensive care unit (ICU) of the critical care department experienced high levels of occupational stress [23]. According to the findings of the current research, the operating room staff of the hospital constantly experienced high levels of stress due to heavy workload, shift work, and long working hours.

According to the results of the present study, poor posture was weighed to be 0.258 and had the second priority. In another research, Valipour et al. (2016) investigated the posture of military hospital staff while working, reporting that they were subject to the high risk of musculoskeletal disorders [24].

Table 2: Saaty's fundamental scale

Intensity of importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
2	Weak or slight	
3	Moderate importance	Experience and judgment slightly favor one activity over another
4	Moderate plus	
5	Strong importance	Experience and judgment strongly favor one activity over another
6	Strong plus	
7	Very strong or demonstrated importance	An activity is favored very strongly over another; its dominance demonstrated in practice
8	Very, very strong	
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation
Reciprocals of above	If activity <i>i</i> has one of the above non-zero numbers assigned to it when compared with activity <i>j</i> , then <i>j</i> has the reciprocal value when compared with <i>i</i>	A reasonable assumption

Table 3: Comparison of super decisions main window in operating room

Node comparison with respect to health consequence																		
Job stress	9	8	7	6	5	4	3*	2	1	2	3	4	5	6	7	8	9	Formaldehyde
Job stress	9	8	7	6	5	4	3	2	1	2	3**	4	5	6	7	8	9	Shift work

*Priority of Job stress comparing to Formaldehyde exposure
 **Priority of shift work comparing to Job Stress

Operating room staff have many wrong postures due to different duties, heavy workload, and urgent activities.

In the present study, shift work scored as the third priority (weight: 0.251). Operating room and ICU nurses had a heavier workload compared to clinical nurses due to their shift work, which could lead to physiological, physiological, and social complications [25]. According to the findings of Portoghese *et al.* (2014), workload causes exhaustion and low job control, which in turn lead to the low efficiency of the system [26]. In addition, De Araujo *et al.* (2013) denoted the risk of exposure to anesthetic gases in operating room personnel as shown by a micronucleus test, requiring the installation of sufficient ventilation. Moreover, the periodical examination of personnel is essential with respect to this hazard score in the present study [27]. Considering the observed deleterious effects, it is recommended that all the possible measures be taken to control or mitigate this issue [7].

According to the study by Lyapina *et al.* (2012), healthcare professionals are more frequently affected by formaldehyde compared to other occupations [28]. In the current research, formaldehyde exposure had the lowest priority;

formaldehyde is a stabilizing chemical, which is used in operating rooms and exerts acute and chronic health effects. Therefore, operating room personnel must follow the safety instructions regarding the handling and use of this hazardous material [29].

Few studies have addressed the issue of overall hazard identification in healthcare systems, and previous research has only been focused on specific hazards. The findings of the current research have important implications for the ranking of important hazards prior to risk assessment and are consistent with the previous studies using the ANP (Liu, 2012; Lo, 2012) [30,31]. However, it is suggested that further investigations be conducted regarding the new combinations of other models (e.g., MCDM methods) with the ANP method [32]. In this respect, Zammori *et al.* (2012) have proposed the integration of the FMECA and ANP methods to evaluate risk priorities [33]. In contrast, we did not combine methods and only performed the study in two phases. Further assessments should be focused on the current subject matter in order to attain more accurate results using the Fuzzy method, which may improve the ambiguous human judgments in this regard [34].

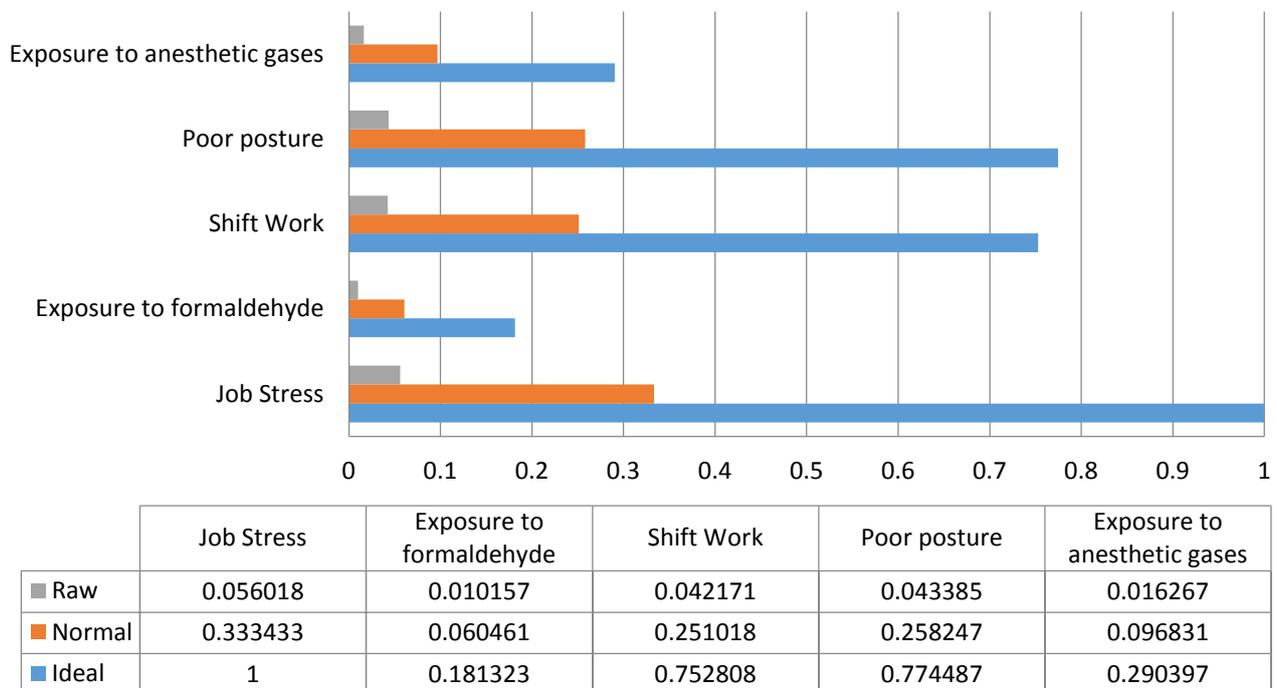


Figure 2: Priorities of alternatives for operating room

Table 4: Limit super matrix of decision making model of operating room

goal	HSE top risk	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	probability	0.179772	0.179772	0.179772	0.179772	0.179772	0.179772	0.179772	0.179772	0.179772	0.179772	0.179772	0.179772	0.179772	0.179772	0.179772	0.179772	0.179772
severity	Environmental consequence	0.132845	0.132845	0.132845	0.132845	0.132845	0.132845	0.132845	0.132845	0.132845	0.132845	0.132845	0.132845	0.132845	0.132845	0.132845	0.132845	0.132845
	Financial consequence	0.137246	0.137246	0.137246	0.137246	0.137246	0.137246	0.137246	0.137246	0.137246	0.137246	0.137246	0.137246	0.137246	0.137246	0.137246	0.137246	0.137246
	Health consequence	0.302425	0.302425	0.302425	0.302425	0.302425	0.302425	0.302425	0.302425	0.302425	0.302425	0.302425	0.302425	0.302425	0.302425	0.302425	0.302425	0.302425
	Reputation consequence	0.079714	0.079714	0.079714	0.079714	0.079714	0.079714	0.079714	0.079714	0.079714	0.079714	0.079714	0.079714	0.079714	0.079714	0.079714	0.079714	0.079714
alternatives	Job stress	0.056018	0.056018	0.056018	0.056018	0.056018	0.056018	0.056018	0.056018	0.056018	0.056018	0.056018	0.056018	0.056018	0.056018	0.056018	0.056018	0.056018
	Exposure to formaldehyde	0.010157	0.010157	0.010157	0.010157	0.010157	0.010157	0.010157	0.010157	0.010157	0.010157	0.010157	0.010157	0.010157	0.010157	0.010157	0.010157	0.010157
	Shift work	0.042171	0.042171	0.042171	0.042171	0.042171	0.042171	0.042171	0.042171	0.042171	0.042171	0.042171	0.042171	0.042171	0.042171	0.042171	0.042171	0.042171
	Poor posture	0.043385	0.043385	0.043385	0.043385	0.043385	0.043385	0.043385	0.043385	0.043385	0.043385	0.043385	0.043385	0.043385	0.043385	0.043385	0.043385	0.043385
	Exposure to anesthetic gases	0.016267	0.016267	0.016267	0.016267	0.016267	0.016267	0.016267	0.016267	0.016267	0.016267	0.016267	0.016267	0.016267	0.016267	0.016267	0.016267	0.016267

4. Conclusion

According to the results, using the two approaches resulted in a new, rapid hazard identification activity and increased the accuracy of the process as well. In addition, all the important hazards could be ranked in order of importance, and the next step of risk assessment requires expert procedures and might be more time-consuming (e.g., FTA approaches to find probability) so as to be focused on the most important hazards.

Authors' Contributions

M.B., designed the study, performed the statistical analysis, drafted the manuscript, directed the analyses of the study, and was responsible for the analysis and management of the literature search.

Conflict of Interest

The Authors declare that there is no conflict of interest.

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