ORIGINAL ARTICLE

Assessment of Health and Safety Hazards in Hospitals using five methods and comparing the results with the FMEA method

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ABSTRACT

Background: Observation of safety and health condition at hospitals helps controlling and decreasing the hazards. Due to the wide range of incidents and the notable financial load, safety management is highly important for hospitals. Through systematic assessment of potential hazard, we can take effective measures to protect workforces' heath and assets.
Aim: To compare ETBA, HEMP, HOSHRA, and AHP for assessing hazards at Iran-based hospitals using the FMEA method in 2019.
Methods: The study was carried out as a descriptive and cross-sectional study in 2019 at 12 wards of Imam Hospital, Ardabil-Iran. Data gathering was done by the experts and using the checklists of ETBA, HEMP, HOSHRA, FMEA, and AHP and the results were compared.
Results: The comparison of the methods was done using FMEA and the results showed that the hazard risks identified by ETBA were different from FMEA and those identified by HEMP were similar to FMEA. In addition, the result of the FMEA method was identical to HOSHRA in terms of chemical, biological, and ergonomic hazards and identical to the AHP method in terms of biological, needle stick, and chemical agents.
Conclusion: As the results showed, FMEA revealed the highest number of risks. Along with FMEA method, ETBA can be also used in hospitals for risk assessment and to have a comprehensive view of the risks.
Keywords: Hospital, occupational safety, health, risk assessment

INTRODUCTION

Accidents are unwanted events that create damages to assets and the organization in general. An accident highlights a defect in the system and after an accident the defect and ways to create the optimum situation should be assessed[1]. Every organization needs an updated and proper system that is a balanced mixture of management, engineering, and educational methods to control hazards and accidents[2]. The main problem in the way of safety and health managers is to identify and eliminate the hazards that cause damage to individuals and equipment. If the hazards cannot be eliminated completely, the experts need to introduce recommendations to control and decrease the risk of hazards as much as possible[3]. Lack of physical activity in patients and their dependence on stationary equipment highlights the importance of safety at hospitals. Observance of safety at hospitals helps controlling and attenuating hazards to some extent. Given the extensive accidents and the financial load, safety management at hospitals is highly imperative[4]. In general, risk assessment consists of three steps, including hazard identification, risk calculation, and control measures[5]. Implementation of safety system based on management, monitoring and risk assessment principle is important[6,7]. In addition to unwanted consequence, work accidents in health sectors cause extensive economic damages and casualties[8]. According to the World Labor Organization (WLO), observation of safety standards by the government, managed, and employees can prevent the damages of work accident[9]. The damages sustained by employees and equipment by accident are predictable using hazard assessment methods and control measures[10]. Alleviation of risks depends on our perception of the nature of risk and the level of acceptable risk [11]. Hazard assessment is a part of the hazard assessment process. Results of hazard assessment help us in prioritizing, finding control solution, and convince managers to dedicate budget to preventive measures[12-14]. Through systematic assessment of potential risks, we can protect workforce' health and the assets by taking effective measures[15]. There are different scientific hazard assessment methods available like PHA (primary hazard assessment),FMEA (Failure Mode and Effects Analysis), FTA (failure tree analysis), HAZOP (hazard and operation assessment),ETBA (Energy Trace Barrier Analysis), HEMP (hazards and effects management process), HOSHRA (Hospital Occupational Safety and Health Risk Assessment), and AHP (Analytic hierarchy process)[16,17]. The FMEA method has been one of the widely used risk assessment methods in all industries and hospitals since 2000. The method identifies and eliminates errors, problems, and potential mistakes using engineering methods and analyzes the results semi-quantitatiively so that the potential risk, causes, and effects are identified and ranked[18,19]. Currently, FMEA method is commonly used for risk assessment at hospitals. The ETBA method is one of the most straightforward methods that is an advanced version of energy model for risk assessment. This method was designed for fundamental assessment of the causes of incidents and risk assessment. Accident is represented as an unwanted current of energy that is rooted in a failure in the design or operational obstacles[20]. The ETBA method gives a deep perception of resources, nature, and type of unwanted currents of energy that may lead to accidental damages. The method was extracted from management oversight and risk tree (MORT) method by Hadon in 1973[21]. The HEMP method is a framework for HSE risk management. Salter explained how to use the process[22]. The HEMP process is implemented in four stages to control risk in an acceptable level. The tools used in this method

are valuable parts of a safety program in research and development process[23,25]. Another notable method is HOSHRA, which was introduced by Jahangiri et al. (2015) to assess safety and occupational health risk at hospitals [26]. The final method used in this study is AHP method, which is a multi-indices decision making model introduced by Saaty in 1988. This method combines opinions and assessments by experts and coverts a complicated decision-making system into a simple hierarchical system. Afterwards, the assessment method based on a scale is used to assess the relative importance of pair wise comparison among the measures[27,30].

There have been several studies on hazard assessments using, ETBA, HEMP, HOSHRA, and AHP, while there is a paucity of studies on comparing the results of these methods using the FMEA method in hospitals. Therefore, the present study is an attempt to compare ETBA, HEMP, HOSHRA, and AHP uses FMEA in terms of hazard assessment on Iran-based hospitals in 2019.

MATERIALS AND METHODS

A descriptive cross-sectional study was conducted in 2019 in 12 wards of Imam Hospital, Ardabil-Iran. The study is an attempt to compare risk assessment results by ETBA, HEMP, HOSHRA, and AHP uses FMEA. The required information was collected by attending the wards, observing, interviewing the personnel, and filling out the worksheets of the assessment method. An assessment was done by five occupational hygiene experts. The experts were identical in terms of the experience and each expert independently worked with one of the assessment methods. The steps of risk assessment using FMEA, HOSHRA, ETBA, HELP, and AHP are discussed in the following sections.

FMEA: At first, a specific ward and the work description of the personnel were determined. Then, the potential hazard modes, causes of errors, and available controls were determined and assessed. As the third step, severity of the error, probability of occurrence, and probability of detection were determined using a five-point scale. These three parameters were multiplied to obtain the risk priority number (RPN) and then control measures for each hazard was proposed [18, 19].

ETBA: At first, different types of potential risks and all the available hazardous energies (mechanical, pressure, chemical, electrical, radiation, heat, biological, and the like) were identified. Then, the probable risks of these energies were described. Afterwards, the potential subjects exposed to the risk and available protections on the path of the energy were determined. Finally, the risk level of each hazard was determined and control measures were recommended [20, 21].

HEMP: At first, activities, hazards, and outcomes of each ward were determined based on resources like physical inspections, interviewing the personnel, and examining instructions and standards checklists. Afterwards, the probability and severity of each hazard and the risk level were determined. Finally, the measures for recovery were determined. The recovery measures are those activities that must be done after an incident to minimize the potential effects [22, 25].

HOSHRA: This method was implemented based on a question checklist in chemical, biological, ergonomic, mental, electrical shock, fire, explosion, slipping risk, falling, and exposure to radiation fields. Each question was first given a score and to compute the final score, each question was answered as 'safe' and 'unsafe.' Possible scores for each question were 0 (negligence of safety codes), 1 (incomplete safety), and 2 (complete safety). The final score for each field was calculated and prioritized[26].

AHP: The safety and occupational hygiene officials and supervisors of different wards were interviewed to collect information about the probable hazards. The hazards were compared using pair wise comparison. The officials were asked to compare the risk of each hazard with other hazards and rank them in terms of importance. The hazards were compared as completely more important (9), very more important (7), more important (5), slightly more important (3), and identical (1). Prioritizing the risk of hazards were done using hierarchical analysis in Expert Choice 11[27, 30].

RESULTS

Using the FMEA method, 84 activities were determined in different hospital wards and each activity was assessed based on 10types of risk models. Hazards with the highest risk priority score were musculoskeletal disorder hazard in repair and maintenance, needle stick hazard in medical activity, biological factors risk in hospitalization wards, exposure to chemical materials in the clinical lab, and therapeutic and care errors in medical and nursing activities (Table 1).

Based on ETBA, seven energies and 34 hazards were identified and their risk factors were determined. The hazards with the highest risk level where mechanical energy that may injure personnel at laundry and operation room; pressure energy with breakage and explosion of steam tank; chemical energy with chemical reactions or fire hazard in the lab, and electrical energy with electrical shock risk.

The HEMP yielded 76 activities with potential hazards. The risk number of hazards was determined by multiplying severity and probability of occurrence. The identified hazards with the highest risk number where biological agent hazard in medical activities (lab, operating room, and intensive care ward), musculoskeletal disorder hazard in repair and maintenance, needle stick hazard in medical activities, exposure to chemical compounds in clinical lab, and therapeutic and care errors in medical and nursing activities.

The HOSHRA method resulted in eight types of chemical, biological, ergonomic, mental, electrical shock, fire and explosion, slipping, falling, and radiation hazards. All the identified hazards had a moderate risk level (need for modification in the near future). The majority of the identified hazards were mental, chemical, slipping and falling, electric shock, and ergonomic hazards.

Finally, the AHP method showed that the highest priority was with biological contamination caused by ineffective ventilation, needle stick injuries in medical procedure, electrical shock caused by working with electrical equipment, and fire at the hospital.

Table 1- Comparison of ETBA, HEMP, HOSHRA, and AHP methods using the FMEA method

Priority of hazard risk	FMEA			ETBA			HEMP			HOSHRA		AHP	
	Description	Potential risk	RPN	Type of energy	Hazard description	Risk level	Activity	Hazards	Risk number	Hazards	Safety (%)	Hazard risk, according to experts	Weight
1	Repair and maintenance activities	Musculoskeletal disorders hazard	147	Mechanical energy	Damages by equipment in laundry and operation rooms	2C	Mental measures	Exposure to biological agents	54	Mental	70.9	Biological contamination caused by ineffective ventilation	0.1350
2	Medical measures	Needlestick injury hazards	126	Pressure energy	Fracture and explosion of steam tank	2D	Repair and maintenance	Heavy works	49	Chemical	71.43	Needlestick injuries	0.1180
3	Medical measures in risky areas (operation room, lab, clinical setting, etc.)	Exposure to chemical agents	108	Chemical energy	Chemical reactions or fire hazards at lab	3C	Medic measures	Needlestick	42	Slipping and falling	72.5	Electrical shock	0.0964
4	Clinical lab activities	Exposure to chemical agents	106	Electricity	Electrical shock	3D	Clinical lab activities	Exposure to chemical material	36	Electrical shock	73.43	Fire	0.0932
5	Medical and nursing activities	Therapeutic and care errors	105	Radiation	X Ray exposure at radiology and by portable devices- UV radiation	3D	Medical and nursing measures	Therapeutic and care hazards	35	Ergonomic	80	Explosion of oxygen capsule	0.0882
6	Repair and maintenance activities	Falling, cutting, and mechanical damages	105	Heat	Fire	3D	Carrying oxygen capsule	Explosion	27	Fire and explosion	81.81	Explosion of steam tank	0.0826
7	Washing and disinfection	Respiratory damages caused by exposure to detergents	90	Biological	Virus and bacterium	3D	Steam tanks	Explosion	18	Biological	87.5	Chemical and detergent agents, hazards	0.0789

DISCUSSION

The FMEA method showed that musculoskeletal disorders, needlestick injuries, biological agents, and chemicals had the highest hazard risks. This finding is consistent with Attar et al. (2015) and Omidvari et al. (2016) [31,32]. Based on this method, performing heavy workload using mechanized equipment, using safety box, using special containers for sharp and pointy wastes, and using more efficient ventilation equipment was recommended as control measures.

The ETBA method indicated that among the identified hazards, the highest risk levels were with personal injuries by mechanic energy, explosion and breakage of steam tank by pressure energy, chemical energy (chemical reactions and spontaneous fire), and electrical energy (electrical shock). Sarsangi et al (2015) used EBTA method in a hospital and reported that the highest level of risk was with chemical and electrical energies[33]. Control measures recommended by this method were procuring new equipment with automatic safety microswitches, moving the powerhouse to a separate building, and improving ventilation facilities.

Chamberlain et al. (2006) noted that HEMP was a valuable method to predict all the major hazards. This method uses a hierarchy modeling tool and assess the safety level with high accuracy [34]. Nkwocah et al. (2018) argued that HEMP was an important element in safety, health, and environment management. This method is a process to identify the hazards in an HSE critical activity and it can be used to eliminate or control hazards [35]. The results obtained by HEMP were more similar to those by FMEA. The proposed controls by this method were the same as those proposed by FMEA.

The major hazards identified by HOSHRA method were mental hazards, chemical hazards, and slipping and falling hazards. Jahangiri et al. (2015) reported consistent results in their study titled “assessment of safety situation using the audit method at the hospital.” They showed that

safety condition in the hospitals under study was at a relatively low level in areas like safety management, response plan for emergency situations, and fire safety[24].

Based on AHP method, the top hazard risks where biological contamination, needle stick injuries, electrical shock, and fire. Zarezade et al (2016) conducted a study on prioritizing hazard risk of patients in treatment wards of educational hospitals using AHP model. They showed that needlestick injuries of personnel had the highest priority[36].

CONCLUSION

The assessment methods were compared using the FMEA method. The risk priorities according to ETBA was completely different from the FMEA. The top risks identified in HEMP were biological hazards, musculoskeletal disorders, needle stick injuries, and exposure to chemicals, which were similar to FEMA. The results of HOSHRA were similar to FMEA only in terms of chemical and biological agents and ergonomic factors as the top risk hazards. The AHP method was similar to FMEA in terms of top risk, hazard biological contamination, needle stick, and chemicals. Our comparison also showed that FMEA found more risks. To have comprehensive results, ETBA method is recommended along with FMEA to identify risks in hospitals.

In terms of limitations, the small sample size is notable. Future studies may focus on several hospitals and wards.

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