

ORIGINAL ARTICLE

Errors Evaluation Using Barrier Analysis- A Case Study in Laboratory Unit

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ABSTRACT

The laboratory unit is one of the most dangerous work environments in which the occurrence of errors can lead to severe injuries to patients, psychological damages to the service providers, degradation of the unit, and legal consequences. This descriptive cross-sectional study was conducted in the laboratory unit of Akhtar Hospital in Tehran. The current study was organized as follow: literature review based on previous studies and scientific resources, interview with laboratory staffs, design the methodology of research, studying the instructions, observing activities and practices. A Hierarchal Task Analyze (HTA) method was applied to evaluate tasks, thereafter errors and obstacles were identified based on Barrier Analysis instruction. Finally appropriate control strategies were proposed to reduce the risk of errors. A total of 552 errors were identified of which 86 barriers were in the laboratory unit including 12 administrative barriers, 15 statutory barriers, 9 humanitarian action barriers, 18 supervision and cooperation barriers, 8 educational barriers, 0 natural barriers, 9 physical barriers and Finally 15 environmental design barriers. The results and risk assessment showed that functional errors (maximum frequency) and errors in this area should be given priority to be controlled and reduced. This is possible through the development of instructions, training courses, close supervision on officials and frequent inspections, record the errors and disclosure.

KEYWORDS: Barrier Analysis, Human Error, Laboratory Unit

INTRODUCTION

To perform a work, various tasks should to be done in which errors and mistakes may occur and result in irreversible risks and complications. A free of danger life is a primary goal and dream for people [1]. On average, it was expected that each person makes 15

mistakes per working day. Of course, this estimate is only true in stress-free working conditions. If workload and stress increase, the number of errors increases to one error every half minute [2]. The "human error" factor is still responsible for 75% of all accidents in advanced conditions and generally, 88%

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of accidents are occurred due to unsafe actions [3]. In the American Medical Institute annual report, a significant role of the workforce proved in mistake and error occurrence [4]. Human error among different jobs regardless of their profession is inevitable. Considering a sensitive nature of physicians and nurses, they must be minimize error occurrence [5].

The quality of medical care is important in the health system. In a report of world Health Organization (WHO) one of ten patients suffer while receiving health care services [6]. The results of a study showed that 50 to 96% of medical errors never being reported, 96% of these errors are not being evaluated, and their recurrences could not be prevented [7]. Many studies have confirmed that a major part of injuries happened due to physician negligence. Each year 44,000 to 98,000 people death reported because of medical errors [8] and the third cause of mortality in the US are motorcycle accidents and Breast Cancer [9-10]. The Swedish National Health and Welfare Association stated that each year about 3,000 deaths occur per 100,000 error-related accidents for patients in Sweden. In United States, United Kingdom and Australia, 4 to 16.6 percent of hospitalized patients die from permanent injuries or permanent disabilities, half of which are preventable.

The laboratory environment itself has potential risks due to the presence of hazardous chemicals, complex devices, equipment, and special working methods, which can lead to accidents and financial-life losses if the safety and health of laboratories are take into account. Therefore, it can be said that the laboratory is a very sensitive and important work environment regarding the diversity of activities and the fact that the specialized workforces in different fields are working in laboratories, so it needs more attention and accuracy [11].

METHODS AND MATERIALS

In this study, Barrier Analysis (BA) method was used. The complexity of the processes in the laboratory unit is such that there is a possibility of error at any stage of the process and the treatment staff has an important role in identifying and preventing errors. The purpose of this study is to identify and analyze the errors of the medical staff working in the laboratory

unit and to find the causes in order to reduce the possibility of these errors in the future. Having considered all abovementioned issues, it seems that the role of human errors in the field of health and treatment is very important. However, a study that examines the errors of medical staff in the laboratory with standard methods directly and comprehensively has not been done yet. The errors of the medical staff in the laboratory using a systematic method of predicting and reducing human errors were investigated, identified, and evaluated. Then, control strategies were provided to prevent and reduce various types of errors.

The BA method can be used in the error prevention stage as a situation analyzer where there is a possibility of error also, in the treatment stage to understand the nature of the human function and examine the errors to reduce them. In the laboratory or hospital's staffs are even more likely to make mistakes. Moreover, the errors may negatively affect the treatment of patients, making mistakes in this area is extremely dangerous. For this reason, the laboratory unit of one hospital was selected for this study.

The selected unit had 2,500 patients every month. The BA method is a well-known method in terms of accurate estimation of human errors. This technique was initially used by the nuclear industry and the chemical process to reduce errors due to barriers used in some places to protect vulnerable objects from the risk of harmful energy transmission. Other techniques with the same framework included: Barrier Safety Performance Analysis 1994, Event Development Barrier Performance, Energy Barrier Analysis, and Protection Analysis which was renamed for the healthcare sector.

This technique can be used in health services as placing a barrier to protect the patient from the risks of health care treatment. The term barrier can be replaced with control, defense or protection. It should be noted that a barrier analysis is also provided by the NPSA. Therefore, the BA method can play a major role in reducing errors in future health care.

Step 1.

Hierarchical Task Analysis (HTA): The hierarchical analysis of tasks was performed by the HTA method to identify sub-tasks. A description of these tasks was provided in HTA format. The ability

to breaking downs a task into small parts is the most important advantage of HTA. In addition, the tasks and sub-tasks were performed in consultation with and under the supervision of the medical staff of the laboratory department.

The HTA procedure has been shown in Figure 1.

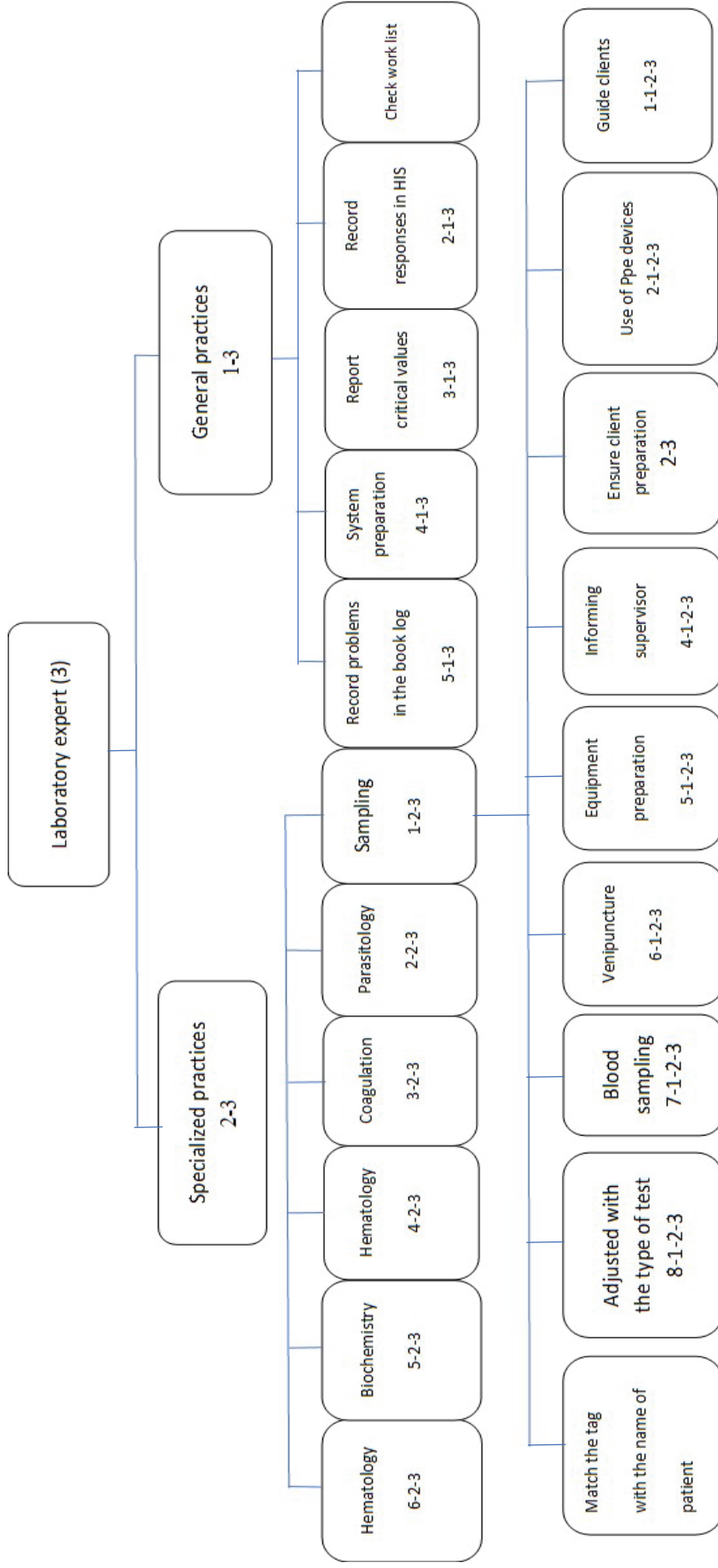


Fig 1. Hierarchical Task Analysis

Step 2.

Determine protective barriers: The BA considers behavioral determinants in a process so that more protective behavior and less harmful actions. In an organizational context, these barriers are defined such as physical, natural, barrier to human action, administrative or executive barriers.

Step 3.

Determine the strength of protective barriers: The amount of protection that each barrier provides against damages to vulnerable components. This protection force should consider the effectiveness: do these barriers break easily? Where the barriers are located and whether they always work or only whenever they run.

Step 4.

Determine barrier breakers: Barrier breakers means that the requirements prevent the effectiveness of the barriers or reduce their level of efficiency. Laws and regulations are constantly being violated by people who are unaware of the laws and people who seek the benefits of not following them. Therefore, it is necessary to study the capability of the breakers.

Step 5.

Determine remedial measures: Once the barriers, breakers, and their related capabilities are

assessed, it becomes possible to determine which improvements are necessary. These modifications can reinforce existing barriers, reduce the impacts of breakers or they may be entirely creative ways to reduce the risk of injuries/damages. From this point of view, it is essential to pay attention to the cost and feasibility of the modifications and also to identify the responsible people to start them.

Step 6.

Fuzzification of the power of obstacles and breakers: The triangular fuzzy method was used to convert the qualitative values of the power of obstacles and breakers into quantitative (numerical) values and, to prioritize obstacles in terms of power. To convert qualitative options into fuzzy numbers, appropriate fuzzy scales are often used and usually the appropriate scale is selected according to the number and nature of the options. For the present study, according to the number and nature of options, the most appropriate scale, namely triangular fuzzy numbers, has been used. The fuzzy interval has been presented in Figure 2.

Step 7.

Convert fuzzy numbers into definitive value using equations 1 and 2:

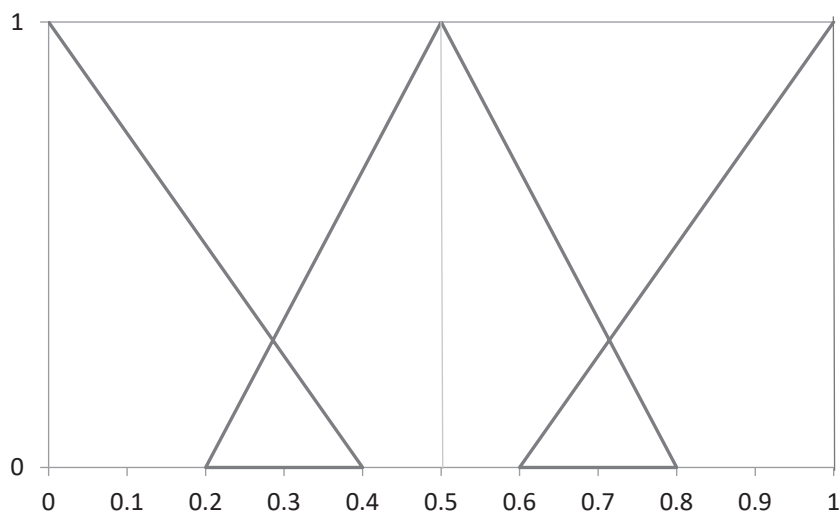
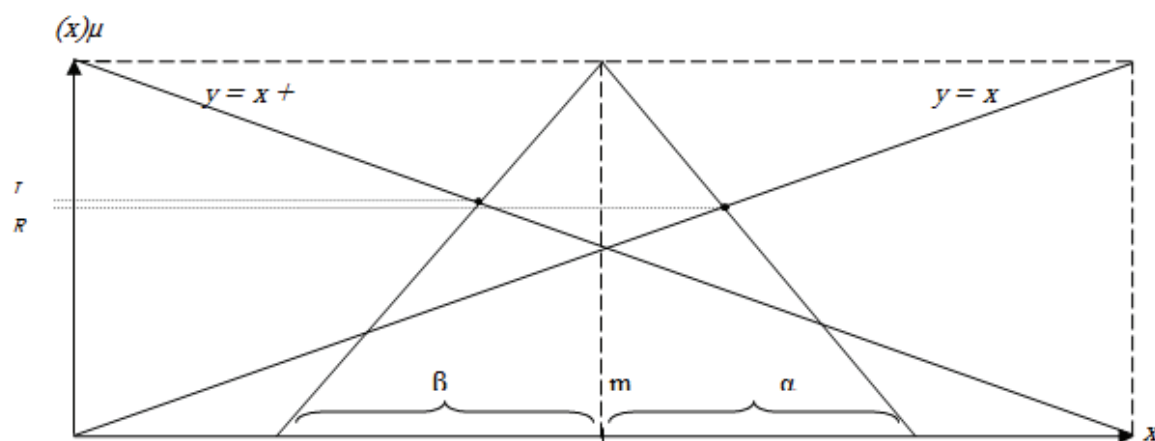


Fig 2. Fuzzy interval

$$\mu \text{Max}(x) = \begin{cases} x & 0 \leq x \leq 1 \\ 0 & \text{Otherwise} \end{cases}$$

$$\mu \text{Min}(x) = \begin{cases} 1-x & 0 \leq x \leq 1 \\ 0 & \text{Otherwise} \end{cases} \quad (2)$$



Different working shifts and tasks were observed to get a comprehensive view of activities, interviewing the treatment staff of the ward about the different stages of research, studying the objectives and justifying them, reading the instructions of the ward, reviewing client statistics, and recorded errors.

FINDINGS

According to the results of BA method Table 2, the identified barriers were classified into 8 groups including; 4 Executive barriers, 0 Regulatory barriers, 8 Humanitarian actions barriers, 1 Supervision and cooperation barriers, 7 Training barriers, 4 Natural barriers, 5 Physical barriers and

8 Environmental design barriers. In total, in the laboratory unit, 86 barriers were detected such as 12 administrative barriers, 15 regulatory barriers, 9 humanitarian action barriers, 18 supervision and cooperation barriers, 8. Training barriers, 0 natural barriers, 9 physical barriers, and finally 15 environmental design barriers. Also 52 barrier breakers were found included 17 organizational and managerial factors, 8 working environment factors, 3 team factors, 10 individual factors, 11 task factors and 3 client factors. Finally, 54 corrective measures were identified including 8 educational and training plans, 20 supervision and control plans, 6 software design plans, 5 feedbacks 8 resources and 7 plans to change the organizational culture.

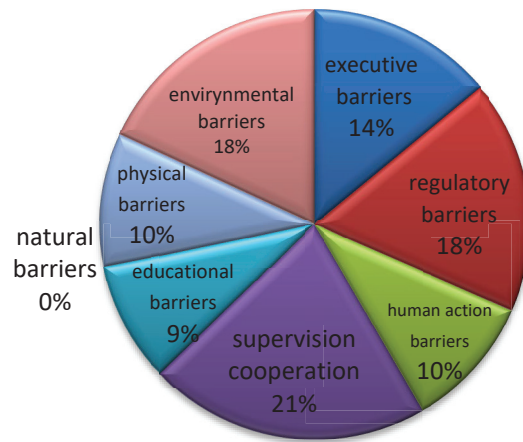


Table 1. Analysis of technical assistant and supervisor barriers in BA approach

Measures /barriers identified by technical assistant	Barrier strengths			Weak	Quantification
	Number	Strong	Moderate		
Executive barriers	2	**			0.86
Cheklis development	2	**			0/86
Checklist implementation	2	*	*		0.68
System establishment	2	*	*		0.68
Efficient force recruitment	2		**		0.5
Use experienced force	2		**		0.5

Table 2. Controlling approaches offered by BA method

Official's control strategies	Supervisor control strategies	Laboratory expert control strategies
Supervise the preparation of instructions	Conduct training classes for laboratory expert (TBM)	Establish system 5s
Supervise the preparation of monitoring form	Hold training classes on a regular and periodic basis	Participate in training classes
Develop an evaluation form for supervisor	Train recruits	Full cooperation with technical manager
Compile evaluation form for laboratory expert	Supervise trainee training	Complete report presentation
Compile evaluation form for laboratory secretary	Prepare instructions	Provide complete statistics within the department
Culturalization	Prepare a monitoring form	Correct use of equipment
Attend meetings and committees	Prepare executive method	Measure client satisfactions
Monitor unit satisfaction	Tag equipment	Incomplete performance report
Supervise equipment repairs	Online records	Report faulty equipment
Supervise calibration of equipment	Purchase equipment based on standard	Active attendance in meetings
Yolk head presence in evening and night shifts	Timely calibration of equipment	Use of control sample
Implement punishment and encourage system	Purchase standard consumables	Use of automation system
Use of office automation for correspondence	Prepare periodic statistics	Daily quality control

DISCUSSION

According to the outcomes of previous studies, work-related injuries are more likely to occur in medical centers than in the industrial centers and they aren't considered as safe environments for personnel (Bucknall 13). 80.5% of medical accidents are considered undesirable, of which 36.2% are preventable (near miss) and 13% are fatal (sentinel event). Safety standards in the hospital include: 1. patient safety, 2. staff and clients safety, 3. equipment safety, 4. safety of repairs and facilities. Ignoring these standards leads to major human and financial losses. The aim of this study was to evaluate the safety of staff and patients but the results include and support two other cases.

The purpose of identifying barriers is to increase the reliability of personnel performance. For this reason, 8 classifications were used. In addition, the relative importance of each group of obstacles was determined using fuzzy technique, based on which the barriers to monitoring and cooperation group gained the highest importance. In the next step, barrier breakers were investigated as the factors which can inactivate the barriers, for which 4 classifications were used. The relative importance of each group was also revealed.

So far, several methods have been proposed to assess human reliability, which have been divided into 8 generations including techniques such as the systematic approach of predicting and reducing human error (SHERPA), a technique to analyze Human error (ATHEANA), evaluation and mitigation technique to reduce human errors (HEART) etc. [14]. However, there are very few techniques which have discussed the analysis of obstacles after human error. One of the efficient examples of these techniques is the BA method, which has been used in the present study. Reasons for the effectiveness of this technique include identifying barriers, analyzing barriers and identifying corrective measures.

In addition, this technique uses both retrospective and prospective approaches simultaneously. So far, BA technique has not been used to identify human errors in the laboratory process. Therefore, the results of the present study could not be compared with other studies. However,

errors are the results of the interaction of several factors. In a study conducted by Lisa [15] workload, skill level, work experience and the number and characteristics of patients are among the factors influencing the increase in errors identified. In this study, the role of the treatment staff was noticeable due to the high number of errors and control strategies. Similarly, other factors were proposed to investigate like reporting systems, monitoring systems, training, and review the number due to the high volume of work.

Computer-generated medical instructions and patient tests eliminated many errors during treatment in the study by Velde et al. [16] and this innovative strategy is used to minimize errors in treatment.

In this research, the arrangement of errors for all tasks is completely the same. This is due to the importance of similar tasks in complex processes in the laboratory unit and the general practitioner has an important task to communicate with the patient during the examination and with the nurse during emergencies. Medical errors can occur anywhere during the care and treatment process. Managerial and organizational factors, complexity of tasks, environmental conditions, work instructions are considered as the causes of human errors.

In the treatment staff of laboratory ward also the history of severe mental pressures, a lot of working shifts, irregular biological rhythms, inadequate rest and sleep, lack of social support, lack of experience, fatigue, low number of medical staff compared to a large number of patients, can be seen. Due to the undeniable impact of working conditions on the occurrence of errors, working conditions and environment should be updated based on ergonomic and safety standards and principles.

CONCLUSION

This study is one of the few studies in Iran which has investigated errors in the field of treatment and for the first time in the laboratory ward, human errors were estimated by systematic methods. Unfortunately, there is no real estimate of the amount of errors that occur in medical centers in the country and its importance and benefits are felt systematically. Establishing a safety culture in the hospital that encourages staff to report errors is an effective approach to reduce mistakes and help people learn from mistakes and correct them. Development of detailed work instructions, train the treatment staff, design special equipment, compilation of checklists, regular training, evaluation of staff by patients, setting work shifts and the ability to manage workload, increase the number of staff due to the increase in patients and finally encourage staff to follow safety principles, all of these can lead to a safe and satisfying atmosphere. The findings of this study showed that in a systematic way, human errors by medical staff can be identified and analyzed. Finally, in order to prevent and reduce the occurrence of each of the identified human errors, solutions were proposed in the form of practical strategies.

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CONFLICT OF INTERESTS

The authors declare that there is no conflict of interest in this study.

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