



## Research Paper

# Quantitative and Qualitative Assessment of Safety Status in a Medical Centre: Experience from Implementing Safety System



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## ABSTRACT

**Background:** An accident is an unforeseen occurrence that happens in all organs, including medical centers, due to unsafe conditions and practices which cause damage and sometimes irreparable injuries. Establishing safety system in the medical center seek to prevent harm to both patients and health care professionals.

**Objectives:** The aim of this study was to assess safety status in a medical center before and after implementing standard safety system.

**Materials & Methods:** This case-study was carried out among the staff of a hospital in Guilan province, Iran in 2018-2019. The information was collected through observation and interview with staff and checking the observance of instructions and safety tips. Then, the possibility of needle stick injury was identified by calculating accident indices. human errors were assessed using risk assessment using Systematic human error reduction and prediction approach (SHERPA).

**Results:** A total of 9 departments of a selected hospital were studied and the accident and human errors were identified. The recurrence rate of the accident in 2019 compared to 2018 had a decreasing rate from 11.36 to 4.09 (safe\_T\_score=-3.14). Risk assessment using SHERPA method in the gynecology ward revealed 4 important types of errors in this department.

**Conclusion:** There was considerable reduction in frequency and severity of needle stick injuries after establishment of safety system in the hospital. The SHERPA method, detailed the task errors and specific remedial measure to correct the task. The results of this study can be helpful for medical staff, managers, employers, and safety experts in identifying and preventing the causes of the accident.

**Keywords:** Hospital, Accident indices, Risk assessment, Human errors, standard safety

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## 1. Introduction

The advancement of industry and scientific growth from the past to the present has brought comfort and well-being to all human societies. Although the expansion of industry employed more labors, but it significantly increased the number of occupational accidents [1].

Accident is an unforeseen occurrence and far from the expectation [2] that threatens the body and mind of people working in workshops, organizations, and institutions. The occurrence of accidents causes compensable or even irreparable injuries which is the worst consequence of the premature death of the labor force [3].

According to statistics from the International Labor Organization in 2020, 2.78 million deaths occur from work-related accidents or work-related diseases per year. Additionally, there are also 374 million non-fatal injuries that result in more than 4 days of absence from work [4].

A 2017 study by Hämäläinen et al. found that occupational mortality accounted for 5% of the world's fatalities. So that 86.3% (4.2 million) of occupational fatalities are due to occupational diseases and the remaining 13.7% are due to occupational accidents. Asia, meanwhile, accounts for two-thirds of occupational fatalities from occupational diseases which is equal to six times of Africa and Europe. China and India also have the highest mortality rates based on population, as expected [5].

The damage rate of health center staff is equal or even more than that of employees working in the industry so that occupational health has negative effects on treatment staff and patients under their supervision [6].

The research of Çelikkalp et al. in a sample of Turkish nurses in 2019 shows that 68.5% of nurses have experienced at least one occupational accident during their professional life. Among them, only one-third (1.35%) of nurses who experienced occupational accidents reported them [7]. Unfortunately, countries have calculated only occupational accidents caused by the national compensation system, which represents a small proportion of work-related mortality [8]. For this reason, data on occupational accidents is not available in all countries of the world [9].

Needle stick injuries was reported as one of the most likely accidents in medical centers and hospitals and one of the most common sources of contamination with

hepatitis B, C virus and immune deficiency virus (AIDS / HIV) in medical staff [10].

Several factors contribute to the occurrence of occupational hazards; Including biological, ergonomic, environmental, and psychological factors [11-13]. Review and analysis of occupational accident statistics determine why and for what reason the accident occurred [14].

Safety system is a method for identifying, evaluating, and deciding how to manage risks to improve the level of safety of work environment. Establishing safety system in the medical center seek to prevent harm to both patients and health care professionals [15].

The establishment of the safety system in a selected hospital in Guilan province was carried out in 2018 with the aim of reducing the risks of the work environment and securing medical centers. The components of the safety system were iterative process of continuous improvement of products, people and services and implementing Plan-Do-Check-Act cycle including testing solutions, analyzing the results, and improving the work process.

With the aim of evaluating the role of safety system on occurrence of human errors, this study was conducted to measures safety indices and human errors before and after implementing safety system. Quantitative assessment was performed for needle stick injury and human errors were assessed using systematic human error reduction and prediction approach (SHERPA) [16] in one of the hazardous departments of the hospital.

## 2. Materials and Methods

This case study was performed among the staff of a selected general hospital in Guilan province, North of Iran, in 2018-2019. All departments of hospital, including the emergency room, operating room, ICU, gastrointestinal, dialysis, pediatrics, men's ward, gynecology and maternity ward were evaluated. Data was collected through observation and interview with staff and checking the observance of instructions and safety tips.

In the first step, accident indices were examined. Accident Frequency Rate (AFR) index is the frequency of the number of accidents at a given time (usually one year). Since the consequences and losses resulting from accidents are different from each other, we use the Accident Severity Rate (ASR) to calculate the number of days lost by the accident victims and should also be clarified the severity of the consequences of accidents,

but the coefficients of the accident frequency rate and accident severity rate alone are not sufficient to compare the performance of occupational safety and health. So, in a comparative assessment, Frequency Severity Index (FSI) is used which is the result of a combination of accident frequency rate and accident severity rate. According to the standards of the Occupational Safety and Health Administration (OSHA), accident indices are calculated as follows:

$$AFR = \frac{1000000 \times N}{T}$$

$$1. ASR = \frac{1000000 \times n}{T}$$

$$FSI = \sqrt{\frac{AFR \times ASR}{1000}}$$

Where, N is the number of accidents in a specified time, n is the number of lost workdays due to accidents in a specified time, and T is the total efficient working hours of the workers in that specified time. According to industrial safety and protection guideline, if the AFR in the workplace gets less than 10, and FSI gets less than 0.1, that work environment is good in terms of safety principles that working environment is very good in terms of safety principles [17].

A factor of 200000 working hours is used for organizations with 100 or fewer employees, but the International Labour Organization (ILO) standard offers a factor of one million for organizations with more than 500 employees.

Then, according to the following formula, Safe\_T\_Score was calculated to compare AFR in two years of 2018 and 2019;

$$2. safe.T.score = \frac{AFR_{new} - AFR_{old}}{\sqrt{\frac{AFR_{old}}{\frac{t}{200000}}}}$$

Where, t is the total efficient working hours of the workers in the new year. The score has no dimension.

If the Safe\_T\_Score is between +3 and -3, the AFR changes are not significantly different and the deviation is due to chance. If it is more than +3, the current AFR is significantly worse than the previous year's AFR and it is necessary to check for changes. If it is less than -3, the current AFR is significantly better than the last AFR, and events are significantly less reported.

In the second step to identify and evaluate errors, risk assessment is performed. In this study, the SHERPA method (systematic human error and reduction prediction approach) has been used to examine the potential of human errors. There are 9 levels to perform and implement the SHERPA technique (Table 1).

All of the above information was entered in the SHERPA worksheet to identify and analyse human errors. This worksheet contains information about Task, Error type, Description of error, Error consequences, risk level, Recovery, and Control measures. Finally, after categorizing the errors, using the risk assessment

Table 1. Steps of SHERPA technique

Steps	Titles	Descriptions
One	Hierarchical task analysis	Task/sub-tasks analysis by interviews and observation
Two	Task classification	Dividing tasks based on the behavior taxonomy a
Three	Human error identification	Using error code
Four	Consequence analysis	Examining the consequences of each error
Five	Recovery analysis	Which action is necessary to error prevention
Six	Ordinal probability analysis	The probability of the error is determined
Seven	Criticality analysis	The severity of damage caused by error is determined
Eight	Remedy analysis	Practical ways to control and prevent error
Nine	Tabulation	SHERPA's worksheets

**Table 2.** Risk assessment matrix (risk level)

Risk	Catastrophic (1)	Critical (2)	Marginal (3)	Insignificant (4)
Frequent (A)	1A	2A	3A	4A
Probable (B)	1B	2B	3B	4B
Occasional (C)	1C	2C	3C	4C
Remote (D)	1D	2D	3D	4D
Improbable (E)	1E	2E	3E	4E



matrix, we evaluated the identified risks and calculate their level of risk as shown in [table 2](#).

### 3. Results

A total of 9 departments was assessed for needle stick injuries. In 2018, needle stick injuries occurred among 24% of male employees and 76% of female employees; the respective values in 2019 were 22.2% and 77.8%. Regarding to the type of occupation, 60% of human errors for needle stick injury were occurred among nurses, 44.4% among trainee students, 20% among service labours, 8% among midwives, and 4% among operating room expert. [Table 3](#) shows the frequency of needle stick injuries according to hospital departments in 2018 and 2019.

The number of accidents in the Emergency department was more than other departments; followed by gynaecology and surgery department. However, according to the training and control measures in the field of accident prevention, this statistic in other parts in 2019 reached zero percent.

[Table 4](#) illustrates quantitative indices of needle stick injuries in 2018-2019. AFR in 2019 has a decreasing rate compared to 2018. According to industrial safety and protection guideline, the value of AFR and FSI in 2019 shows the favourable trend of safety conditions. The Safe\_T\_Score was obtained negative and is less than -3, indicating that AFR is significantly better than before and accidents are considerably less reported ([Table 4](#)). To analyse human errors in the gynaecology ward, the existing errors were matched with 5 catego-

**Table 3.** Frequency of needle stick injuries reported in 2018-2019

Departments	2018		2019	
	Frequency	Percent	Frequency	Percent
Paediatrics	2	8.0	-	-
Dialysis	2	8.0	-	-
Gastrointestinal	1	4.0	-	-
ICU	1	4.0	-	-
Men's ward	1	4.0	-	-
Emergency	8	32.0	4	44.4
Surgery room	4	16.0	-	-
Gynaecology	4	16.0	4	44.4
Maternity	2	8.0	1	11.1
Total	25	100	9	100



**Table 4.** Quantitative indices of needle stick injuries in 2018-2019

Indices	Year	
	2018	2019
Number of accidents	25	9
Number of lost workdays	25	9
AFR	11.36	4.09
ASR	11.36	4.09
FSI	0.35	0.13
Safe_T_Score	-3.14	

AFR: Accident Frequency Rate; ASR: Accident Severity Rate; FSI: Frequency Severity Index.



ries of errors by the SHERPA method. **Table 5** presents SHERPA worksheet for risk assessment among nurses in the gynaecology ward.

Evaluation of human errors among nurses in the gynaecology ward identified 4 different types of errors which are action errors with error codes A7 and A9. Error performing incorrect catheterization process with level 2B intensity (critical probability), Error performing ECG process with level 2C intensity (occasional critical), Error in suction operation with level 3C intensity (occasional marginal), and Reporting errors that can cause irreparable consequences, even death, are recorded with

a level of 1C (occasionally catastrophic); The risk level of error in the ECG and suction process (3C, 2C) is undesirable and the risk level of the sounding and reporting process (1C, 2B) is unacceptable. The SHERPA worksheet provides information on the consequences of error, recovery, and in particular control measures to prevent the recurrence of these errors.

#### 4. Discussions

Human error is the result of deviation from the human performance from the specified rules and tasks, which if the system exceeds the acceptable limit can

**Table 5.** Risk assessment of human errors in Gynaecology ward using SHERPA method in 2019

SHERPA Worksheet						
Tasks	Error Type	Description of error	Errors Consequence	Risk level	Recovery	Control Measures
Catheterization	A7	Wrong operation on Catheterization	Delay in treatment of urinary tract infection	2A	Injury and infection	Preparation of catheterization instructions and installation on the wall - Treatment in case of infection with antimicrobial drugs (antibiotics)
ECG	A7	Wrong operation on ECG	Receiving incorrect information from the doctor about the patient's condition	2A	Lack of recovery and diagnosis	Supervision of the head nurse - Training of new nurses - Training in working with medical equipment
Suction	A9	incomplete Suction operation	Possibility of infection and duct damage	3C	Injury and infection	Checking for patient symptoms - Sterilizing tools and using gloves
Report submission	A9	incomplete submission operation Report	The required information is not recorded, the course of treatment is prolonged - There is a possibility of death	1C	Lack of recovery	Editing the checklist and completing it by the nurse - Controlling by the supervisor and shift manager



harm system performance. On the other hand, human tasks in the workplace are associated with increased psychological burden and complexity of work, which increases the likelihood of error.

The findings of current study showed a remarkable decrease in frequency of accident and human errors after implementing safety system in the hospital. According to literature searched by the author there was no previous studies evaluating the impact of establishing safety system in a medical or health care centers on occurrence of human errors and patients and staff safety. The role of safety system on reducing accidents costs has been evaluated in construction industry [18]. Considering the potential highly hazardous environment in the medical and health care centers, the privilege of establishment of safety system in the medical centers should be considered by health care authorities.

The results of this study showed that several factors such as work experience duration, age, gender, and type of occupation can contribute to occurrence of human errors. In this study, 44% of needle sticks have occurred by trainees. The trainees are at young age and have low experience and do not have the necessary training and skills to use the equipment and devices and the danger of accidents threatens them greatly, so it is better for trainees to work with people with experience or in departments that have less risk of doing the job. According to the previous studies, increasing age and work experience [19, 20] and literacy level [21] were associated with a significant reduction in accidents. This finding was consistent with the results of Hasoumi [22]. However, Leggit and Smith [23] in their studies on needle stick injuries and collision with sharp objects violated the existence of gender difference for needle stick injuries. In accordance with previous studies, nurses had the highest rate of accidents, especially the needle stick injuries [24-26]. The type of jobs, work load and job-related shifts can influence the concentration of people [20].

The results obtained from risk assessment by the SHERPA method indicated that the main errors in medical centers are action errors; In particular, the errors of category A7 (Right operation on the wrong object) and A9 (wrong operation on the wrong object). These types of errors are in line with the findings of Shanooli et al. in 2019 to identify and analyze human errors in the cardiac intensive care unit of Tehran Petroleum Hospital and Daštaran et al. in 2016 to identify and evaluate human errors in the specialized assistants of the endodontics department of Dental School of Kerman Medical science using the SHERPA. More accurate and detailed assess-

ments on a larger scale using standard methods makes it easier to access statistics that are close to reality [27, 28]. Many accurate statistics or standard methods have not been evaluated and identified, and this challenge can have a detrimental effect on the process of identifying and controlling errors and accidents [27, 29]. Therefore, to record accidents and identify errors, it is recommended to use a checklist and instructions to using checklists to examine the share of occurrence of each error or accident, and control strategies to correct the error [29]. Establishing a safety standard will reduce the incidence of accidents and human errors and increase the level of safety in medical centers [30].

## 5. Conclusion

The finding of current study revealed a considerable reduction in frequency and severity of needle stick injuries after establishment of safety system in the hospital. The SHERPA method, detailed the task errors and specific remedial measure to correct the task. The results of this study can be helpful for medical staff, managers, employers, and safety experts in identifying and preventing the causes of the accident. According to the findings of this study, human errors are created by various causes that can be reduced by employing a more experienced workforce and providing a safer work environment, as well as training control strategies. On the other hand, there are no accurate and standard statistics of many accidents in the medical center. Therefore, the use of a checklist in the field of recording and recording events is recommended.

## Ethical Considerations

### Compliance with ethical guidelines

This study was approved by the Vice Chancellor for Research and Technology of Guilan University of Medical Sciences (Code: IR.GUMS.REC.2018.535).

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### Authors' contributions

All authors contributed in preparing this article.

### Conflict of interest

The authors declared no conflict of interest.

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