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Nursing Errors in Intensive Care Unit by Human Error Identification in Systems Tool: A Case Study

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Abstract

Background: Although health services are designed and implemented to improve human health, the errors in health services are a very common phenomenon and even sometimes fatal in this field. Medical errors and their cost are global issues with serious consequences for the patients' community that are preventable and require serious attention.

Objectives: The current study aimed to identify possible nursing errors applying human error identification in systems tool (HEIST) in the intensive care units (ICUs) of hospitals.

Patients and Methods: This descriptive research was conducted in the intensive care unit of a hospital in Khuzestan province in 2013. Data were collected through observation and interview by nine nurses in this section in a period of four months. Human error classification was based on Rose and Rose and Swain and Guttmann models. According to HEIST work sheets the guide questions were answered and error causes were identified after the determination of the type of errors.

Results: In total 527 errors were detected. The performing operation on the wrong path had the highest frequency which was 150, and the second rate with a frequency of 136 was doing the tasks later than the deadline. Management causes with a frequency of 451 were the first rank among identified errors. Errors mostly occurred in the system observation stage and among the performance shaping factors (PSFs), time was the most influencing factor in occurrence of human errors.

Conclusions: Finally, in order to prevent the occurrence and reduce the consequences of identified errors the following suggestions were proposed : appropriate training courses, applying work guidelines and monitoring their implementation, increasing the number of work shifts, hiring professional workforce, equipping work space with appropriate facilities and equipment.

Keywords: Intensive Care, Human Error, HEIST, Medical Errors

1. Background

Human errors contribute to the majority of incidents within complex systems (1). Many researches conducted in the field of industrial accidents, show that human error is a major contributor to the risks and reliability of many systems (2): over 90% in nuclear industry (3), over 80% in chemical and petro-chemical industries (4), over 75% of marine casualties (5) and over 70% of aviation accidents (6, 7) and a large number of accidents resulting in many injuries occurred due to human errors (1, 2, 8).

Human errors, in general, can be defined as the failure to perform a specific task that could lead to disruption of scheduled operation or result in damages to property and equipment (9). Human errors in the medicine filed are crucial since they may result fetal outcomes.

Despite many advances achieved in all fields of medicine, medical errors remain as a fact of life-threatening and a global problem (10). According to the studies, approximately 100,000 patients are killed due to preventable medical errors, in the US annually. Medical errors are approximately the eighth cause of death in this country (11). The number of people who die due to medical errors each year is even greater than those of motor accidents, breast cancer or AIDS in the US (12). Medical errors are also one of the most important causes of diseases following treatment in hospitalized patients (13).

Medical errors have a fundamental difference with errors in other fields. For example, in industry, errors cause more damage in the system or they rise from individuals rather than humans who are patients. While in medical errors the patient is hurt, that is, one of the factors that cause these errors is less visible (14). According to statistics provided by the American board of medical sciences, 98,000 Americans die every year due to medical errors, and thousands of people are seriously injured (15).

When medical errors are heard, medication errors are often remembered. However, medical errors have a very wide definition including errors of the health care team,

errors of personnel even the defect in health equipment. The safety of patients in hospitals, especially in intensive care units (ICUs), is a global health concern since patient's safety can influence all health services in the developed and developing countries.

The role of nurses in the care services is undeniable. They are doing different activities such as promotion of healing, early diagnosis, and prevention of mortality. In some cases, the nurses as a person may make mistakes in their job, but sometimes this mistake cannot be compensated at any price. A study by the school of nursing in Pennsylvania university was conducted over a period of 28 days, 30% of nurses reported that they had committed at least one error per day (16).

Between the various parts of hospitals, ICU has a considerable concern for all experts (17-19). ICU is a unit where the most critically ill patients are under the intensive care and treatment with the best nurses, by the most modern equipment (20). Among a variety of tasks of nurses in ICU, securing patients who are connected to the ventilator and positioning them are the most sensitive tasks. Any errors in these therapeutic procedures may lead to irreversible complications. Statistics show that a high percentage of abnormalities in hand and foot neural networks are caused by improper care during connection to a ventilator and non-standard positions (21).

In Iran, there are not accurate statistics to show nursing errors especially in ICU. The first step to develop the control and decrease errors in nursing care is to investigate the causes of these errors. Various methods are proposed to detect and analyze human errors. Human error identification in systems tool (HEIST) proposed by Barry Kirwan (22) is a useful method to study the human errors in terms of causes. It provides enough guidelines to categorize tasks (22, 23). In addition, it is a comprehensive method for error assessment which proposes guidelines to reduce the errors (24). According to the capabilities of this technique to identify and evaluate the human errors, the method was used in this study.

2. Objectives

The current study aimed to identify and analyze the probable nursing errors using HEIST and provide appropriate control strategies to prevent and reduce errors or at least limit their consequences. Given the undeniable importance of the ICU, this section of a hospital in Khuzestan province, Iran, was selected as the research site. Furthermore, since ventilator is the most important and the most sensitive instrument to improve treatment in patients with respiratory problems, this task was considered as a major task of nurses in this unit and was studied in the current research.

3. Patients and Methods

The current descriptive study identified the types and the causes of nursing errors. The study was conducted in the intensive care unit of a hospital in Khuzestan province, Iran, in 2013. The studied group was nurses who worked in ICU, particularly responsible for the care of patients connected to the ventilators. The nine nurses working in three shifts in circulation were studied. Data were collected through observation and interview with the nine nurses in this section over a period of four months.

In this study, HEIST was used to analyze predictive nursing errors. The types of errors and different causes of their occurrence were identified based on the structure of the HEIST method by the researcher, according to the following steps:

3.1. Identification and Analysis of Nurses' Tasks

The critical tasks were identified by observation and interview with the supervisor of nurses. The critical identified task resulting from observation and interview was taking care of patients who were connected to the ventilators. This task itself can be divided into three subtasks: 1, connecting patients to the ventilator; 2, taking care of patients when the patient is connected to the ventilator; 3, weaning from the ventilator.

3.2. Identification and Analysis of Human Errors

The main task was determined and all probable nursing errors were identified and predicted using a series of questions guidelines in the HEIST method. The technique was as follows: each task was assessed in one, some or all of the six stages of the Rose and Rose decision-making model. These steps include: system observation, hypothesis selection, hypothesis testing, target selection, strategy selection and implementation of strategy. In this model, the influencing factors which are called PSF can be assessed at every stage of the decision-making. They include time, training and experience, interaction with signs and monitors, instructions, task complexity and task organization.

Then, the error type can be determined based on one of the classification error methods. Two models were used to classify the types of errors, which were Rose and Rose error classification model and Swain and Guttmann model. Finally, causes of possible errors were identified and control methods were recommended. Six stages of decision–making in one task of nurse staff are shown in after mentioned example.

3.2.1. Stage 1 System Observation

At this stage, the nurse should recognize the warning signs of the ventilator. The alarm may be due to the technical malfunction or worsening of the patient's condition. Both conditions can cause worsening respiratory status and increase the risk of death.

3.2.2. Stage 2 Hypothesis Selection

To consider the patient's condition and the potential causes of deterioration, the nurses should identify the main cause of this problem from possible causes based on their experiences and the instructions.

3.2.3. Stage 3 Hypothesis Testing

At this stage, the nurses should assess the selected hypothesis about the causes of the critical conditions according to the data and the records, as well as instructions, training and experience.

3.2.4. Stage 4 Target Selection

Nurses are well aware of the patient's condition. Their main goal is to restore the patient to normal condition or prevent deterioration of the condition by considering all the available options.

3.2.5. Stage 5 Strategy Selection

Nurses try to select the best approach according to the patient's condition, time, the number of nurses in the ICU and the available facilities to improve patient's condition and restore it to the normal.

3.2.6. Stage 6 Implementation of Strategy

In the last stage, the nurse tries to run the selected approach to take care of the patient.

4. Results

The critical task and the probable nurse errors were determined. An illustration of a HEIST sheet format is shown in Table 1. Totally, 545 human errors were detected in this task. These errors were classified based on the decision-making process and PSFs (Table 2). As Table 2 shows the errors mostly occurred at the system observation stage and among the PSFs, time was the most influencing factor in occurrence of human errors.

Errors were classified into 16 categories based on the Rose and Rose model. The most important categories were: 1, performing the operation later than the deadline, with a frequency of 154; 2, carrying the activity in the wrong direction (137 cases); 3, not performing the task (113 cases). The complete list of these errors is shown in Table 3.

Table 1. A Human Error Identification in Systems Tool Work Sheet[a]

Performance Shaping Factor	Guide Question	Error Type	Cause of Error
Time	Is it a warning sign appears on time?	Not performing the task, performing the operation later than the deadline	Device failure to timely replace the filters
Signs and monitors	If dose not set the ventilator heater, alarms appear?	Not performing the task	Defects in design

[a]System observation: At this stage, the nurse must recognize the warning signs of the ventilator. Sounded the alarm may be due to the technical malfunction or worsening of the patient's condition. These factors can cause worsening respiratory status and increase the risk of death.

Swain and Guttmann classification model was another model for error classification used in the current study, in which errors were classified into four categories: omission errors, scheduling errors, sequencing errors and performing errors. The list of these errors is presented in Table 4. Scheduling errors had the highest frequency (205).

After assessment of the HEIST work sheets, 29 causes (with frequency of 704) were identified and categorized into four groups containing human causes, management causes, human-management causes and structure-hardware causes. Table 5 shows the frequencies of each group. Management had the highest rank in the cause of errors (64.063%). Totally, the obligation to have high workload and consequently fatigue had the highest responsibility (21.448%) to cause human errors in this task. Then, lack of training for nurses and inadequate knowledge (with frequency of 101) and the lack of supervisors' commitment (with frequency of 69) were the other major causes of nursing errors. All these potential errors by type (management, human, structure-hardware and human-management) are shown in Table 6.

5. Discussion

Evaluation of human errors by decision-making process model shows that about 65% of errors occurred in three stages, namely, observation, target selection, and strategy implementation. Most of the errors occurred during the system observation. 29% of total errors that is the most primary and critical step in decision-making process. Time is the most influential performance shaping factor on nurses, with a share of 50% following interaction with signs and monitors by 14%.

Target selection stage had the second rank and strategy implementation stage had the third rank in human errors

Table 2. Distribution of Detected Errors Separated Based on the Decision-Making Process and Performance Shaping Factors[a]

Decision-Making Vs. PSF_S	Observation	Hypothesis Selection	Hypothesis Testing	Target Selection	Strategy Selection	Strategy Implementation	Total
Interaction with signs and monitors	30.45 (166)	22.34 (21)	27.39 (20)	30.61 (30)	10.63 (5)	14.66 (11)	50 (79)
Training and experience	17.43 (95)	21.27 (20)	19.17 (14)	18.36 (18)	21.27 (10)	14.66 (11)	13.92 (22)
Instructions	12.47 (68)	17.02 (16)	15.06 (11)	13.26 (13)	8.51 (4)	13.36 (10)	8.94 (14)
Organization	12.69 (69)	8.53 (8)	9.58 (7)	21.42 (21)	19.18 (9)	18.66 (14)	6.32 (10)
Task complexity	12.84 (70)	17.02 (16)	12.32 (9)	6.15 (6)	10.63 (5)	17.33 (13)	13.23 (21)
Time	14.12 (77)	13.82 (13)	16.48 (12)	10.20 (10)	29.78 (14)	7.59 (16)	7.59 (12)

[a]Values are expressed as No (%).

Table 3. Distribution of Identified Errors in the Rose and Rose Model

Error Type	No. (%)
Performing the operation later than the deadline	154 (28.256)
Activity carried out in the wrong direction	137 (25.137)
Not performing the job	113 (20.734)
Excessive long-term performance	22 (4.036)
Do not be visited correctly	18 (3.302)
Action done sooner	16 (2.935)
The required information will not be received or sent	15 (2.752)
Action to be performed less than the required	14 (2.568)
Visit is not performed at the deadline	14 (2.568)
Visit step is not performed	12 (2.201)
Proper action is performed on the error case	9 (1.651)
Incorrect action is performed on the right case	8 (1.467)
Information received or sent incorrectly	5 (0.917)
Step visit done on the wrong case	4 (0.733)
Excessive short-term performance	3 (0.550)
Excessive need to be performed	1 (0.183)
Total	545 (100)

Table 4. Distribution of Identified Errors in the Swain and Guttmann Model

Error Type	No. (%)
Scheduling	205 (37.615)
Performing	198 (36.330)
Omission	142 (26.055)
Sequencing	0 (0)
Total	545 (100)

Table 5. Classification and Distribution of Error Causes

Cause	No. (%)
Management	451 (64.063)
Human	144 (20.454)
Human-management	99 (14.063)
Structure-hardware	10 (1.420)
Total	704 (100)

frequency 17.982% and 17.248% respectively. In strategy implementation stage, the time factor (22.340%) and then interaction with signs and monitors (21.277%) were the most influential factors. These results reflect the importance of these stages in task performance. In the study by Zaranejad et al., the implementation of the strategy and observation had the highest rate in human error types which included a large share of errors (73%) (25).

The distribution of detected human errors according to the PSFS shows that time factor alone was effective in the occurrence of 30.458% of errors and then interaction with signs and monitors (17.432%) and task complexity (14.128%) followed. Three influencing factors that are training, instructions and organization had almost the same share in the distribution of human errors (each with about 12%). It indicates the contribution and importance of time factor in human errors. Many studies emphasized the essential influence of time in human errors (26-29).

The result of technique implementation which focuses on the main tasks of ICU nurses shows that according to the Rose and Rose model, among the total number of detected errors (545), performing the operation later than the deadline (28.256%), performance in the wrong direction (25.137%), and not performing the task (20.734%) were

Table 6. Distribution of Error Causes

Row	Error Cause	Error Type	No. (%)
1	Nurse fatigue and commitment to high workload	Management	151 (21.448)
2	Lack of educational programs, inadequate knowledge	Management	101 (14.346)
3	Weakness supervisor on work commitment, injection of weakness to the staff	Management	69 (9.801)
4	Mental, psychological and personal problems of nurse	Human	58 (8.238)
5	Manpower shortage	Management	54 (7.670)
6	A mismatch between jobs and man, low-skill	Management	35 (4.971)
7	low attention to nurse	Human	33 (4.687)
8	Low work motivation	Human-management	26 (3.693)
9	Stress	Human-management	25 (3.551)
10	Forgetfulness	Human-management	22 (3.125)
11	The absence on time, physician	management	20 (2.840)
12	Ethical problems nurse	Human	17 (2.414)
13	Understanding and incorrect view of nurse to patient situation	Human	11 (1.563)
14	too much reliance nurse to ventilator	Human	9 (1.278)
15	Transmission and review of inappropriate information and reports patient	Human-management	9 (1.278)
16	Impatience	Human	8 (1.136)
17	Lack of facilities and defects of equipment	Management	7 (0.994)
18	Manipulating the ventilator by nurses	Human	7 (0.994)
19	Design defects ventilator	Structure-hardware	6 (0.852)
20	Fear of decisions in times of crisis	Human-management	6 (0.852)
21	Slow performance	Human-management	6 (0.852)
22	Neglecting nurse	Management	5 (0.710)
23	Monitoring weakness expert of equipment	Management	5 (0.710)
24	Repair and maintenance	Management	4 (0.568)
25	Routine work	Human-management	3 (0.426)
26	Lack of educational spaces for apprentices	Structure-hardware	3 (0.426)
27	Inappropriate physical environment because voice of persons	Human-management	2 (0.284)
28	High cost	Structure-hardware	1 (0.142)
29	Bad mood patients	Human	1 (0.142)
Total			704 (100)

the most frequent errors (26-29). According to Swain and Guttmann, scheduling errors by 37.62% had the highest rank. Comparison results of Swain and Guttmann and Rose and Rose classification models show that time plays a key role in the occurrence of human errors in both models. Errors in performing the tasks (36.330%) and omission errors (26.055%) ranked the second and the third level.

As presented in Table 5, the main causes of nursing errors were the management errors by frequency of 451 (64.063%). In the study conducted by Mohammadfam et al., to identify human errors in the surgery room in a hospital in Hamadan, the management errors were considered as the main causes of errors (30), in the study by Baghaii et al., management errors were mentioned as one of the main causes of errors in ICU (31).

The results show that mandatory high workload consequently fatigue has allocated the highest rate (21.448%) between management causes for human errors. High workload and fatigue are factors that can be created due to labor shortage. Based on the results of some studies, labor short-

age is the most basic managerial factor responsible for human errors (27, 28, 32-39).

There are many factors that cause nurse's fatigue such as: unrelated tasks, very ill patients, long shifts and high workload. The results of the study by Anderson et al. showed that giving each patient to a nurse was associated with 7% increase in the risk of patient death within 30 days after hospitalization (39). Other studies also showed that high workload and working for long hours are mentioned as important risk factors in the occurrence of nurses' errors (32, 33, 38). In a study by Olds and Clarke, the correlation between working more than 40 hours a week for nurses and nursing errors was mentioned (33). In another study, Rogers et al. referred to the direct relationship between the rate of occurrence of nursing errors and increase in work hours over the 12 hours of their shifts (32). In the research by Saremi and Fallah, the relationship between fatigue and intensity of nursing errors in a teaching hospital were examined and the critical role of fatigue in increasing the nurses' error rate was emphasized (36).

Lack of adequate training and enough nursing skills in ICU environment (14.346%) are the second cause of errors, which was included in managerial causes. In some cases, insufficient training can cause errors which put the patients in unsafe conditions. Lack of education and knowledge in operators, are respectively, 34% and 41% of the causes of industrial accidents (40). In the studies by Adl et al., Qasemi et al., and Mohammadfam et al., deficiencies in education were determined as the main reasons for the occurrence of human errors ; therefore, the training courses are proposed (27, 28, 35, 37).

Human causes are rated as the second cause (20.454%), after management reasons. Result of the study by Adl et al. showed that human causes were the first cause of human errors (41). In the study by Horton et al., human causes, as well as device failures were named as the factors causing the accidents (42).

Among the human causes, personal and psychological attitudes of nurses (8.238%) have the highest frequency. Personal problems include: family matters, excessively high or low self-esteem, economic issues and their indifference toward work that provide the background to make a mistake.

Management-human errors have the third rank among all categories of error causes by 14.063%. These errors cannot be considered in management or human causes category because both of these factors are responsible for these errors. In this category, low motivation (3.693%) is in the first place. Factors such as: emotional problems, indifference toward job, poor working relationships between management and nurses and not enough encouragement by management are raised as the main causes of nursing low motivation.

Second place in this group is allocated to the stress of the job (43-45). Several factors are causing stress such as: not on-time presence of the physician, inadequate skills, the critical condition of the patient, low self-esteem of nurses, lack of action plan and inappropriate guidelines (27-29).

Among the identified errors, fourth grade is allocated to structural-hardware errors. According to the survey, defect in ventilator (the lack of separation of sound alarms, not clear screen, lack of specific alarms to harmer defect) is introduced as the most important reasons in this group (29).

5.1. Conclusion

Determination of human errors plays a key role in the prevention of medical errors followed by reducing the cost of care (46-48). Nurses in the intensive care units have critical roles to save the patient's life. HEIST method is selected for systemic and psychological rigorous examination of human errors in ICU (24, 49). This method can identify and analyze the human errors in very critical tasks, in which the occurrence of human errors can lead to unpleasant consequences. It also provides control solutions to prevent errors.

Although the issues and problems that lead to human errors are often unavoidable, but there are many ways to prevent and reduce errors or limit the consequences. Methods such as awards or bonus for personnel who report their errors, proper training programs, proper guidelines, monitoring their implementation, decreasing the working hours and encouraging the nurses can prevent or reduce the frequency of errors.

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