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Reducing chronic medical complications due to failure of patient safety using Standardized Plant Analysis Risk-Human Reliability Analysis (SPAR-H) method

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Original Article

Abstract

BACKGROUND: Human errors in the medical profession can lead to irreparable errors in people's lives, damage, and heavy costs. Among health care workers, nurses spend more time with patients compared to other personnel; hence, they are more prone to human error. Therefore, the purpose of this study was to identify and evaluate human errors using the Standardized Plant Analysis Risk-Human Reliability Analysis (SPAR-H) method in nursing staff of a general hospital in Qazvin Province, Iran.

METHODS: This cross-sectional study was conducted in a general hospital in Qazvin during last 6 months of 2016 and first 6 months of 2017. The target population in the present study was nursing groups based on their highest work experience, from each section in hospital. The SPAR-H method was used to investigate human error in the population and the collected data were analyzed using SPSS software.

RESULTS: The highest error related to inappropriate venipuncture with probability of 0.7, and the least probable error related to error in entering the numbers of vital signs with the probability of 0.0045.

CONCLUSION: Due to the sensitivity of the role of nurses in hospitals, the need for increased workforce, the use of people with higher work experience in sensitive sectors, reducing overtime even for those who volunteered to work overtime, scientific scheduling of the personnel's work shifts, and providing practical training such as stress control methods in case of emergencies can be effective in reducing the probability of an error.

KEYWORDS: Medical Error, Risk, Analysis, Nursing, Iran

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Introduction

Human errors are one of the topics that in today's theoretical and practical management world account for a considerable part of the time, budget, and attention of the experts and managers. The organizational structure of the staff of an organization is one of the factors that plays an effective role in reducing human error.[1] The damages caused by human error in different professions have different consequences and small mistakes can lead to catastrophic dimensions in important and sensitive jobs.[2,3]

Human error called medical error in the medical profession is the failure to act correctly or to commit a mistake in planning or execution that inactivates or potentially causes an unwanted event that results in death, prolongation of hospitalization, or disability when discharged.

These include diagnostic errors, errors in drug administration and treatment, errors in surgical procedures, errors in the use of

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technology and equipment, errors in the interpretation of paraclinical tests, etc.[4]

The review of resources shows that the mistakes of medical professions are less studied than other occupations in Iran and other countries. Various studies globally suggest that human error in these occupations has imposed heavy costs on patients by imposing additional costs of health care due to error, disability, and income reduction. In addition, errors lead to a reduction in patient's trust in the therapeutic care system, as well as a decrease in the patient satisfaction.[5]

According to the Starfield Institute of the American Academy Institute of Medicine (IOM), medical error in the United States (US) hospitals and healthcare institutions (including drug errors, laboratory errors, errors in diagnosis, surgical errors, radiological errors, etc.) after cardiovascular diseases (CVDs) and cancers is the third most common cause of death, and nearly 98000 deaths occur each year due to these errors; in 2008, 17.1 billion dollars were spent on measurable errors in US hospitals.[6,7]

Among the medical staff, nurses spend more time with patients than other personnel; hence, they are more prone to human error.[8] This could be created or increased due to factors such as mental and physical exhaustion, unusual work hours, occupational stress, weakness in personnel communication, information processing deficits, inexperience and deficit in standardization of nursing orders.[9-12]

Since some of these unwanted events are unavoidable and can be repeated under the same conditions, by sharing their experience of errors, they can be prevented from happening again.[13] In this regard, different methods have been proposed to evaluate human error capabilities such as Human Error Assessment and Reduction Technique (HEART), Technique for Human Error Rate Prediction (THERP), A Technique for Human Error Analysis (ATHENA), Standardized Plant Analysis Risk Human Reliability Analysis (SPAR-H), Systematic Human Error Reduction and Prediction Approach (SHERPA), etc. Among these methods, SPAR-H was first proposed by the US Nuclear Regulatory Commission (NRC) and the Idaho National Laboratory (INL) to develop nuclear power plant safety models and then completed by Gertman et al. in 2004 and was published in 2005.[14]

The SPAR-H is based on revisions to the first and second-generation techniques of Human Reliability Assessment (HRA) process, which divides human activities into two types of practical and diagnostic activities, which can be used to classify errors and quantify the contribution of human beings to error. In this method, the factors affecting human performance are divided into eight categories: available time, stress/stressors and environmental factors causing stress, experience/training, work complexity, ergonomics of the work environment including human-machine interfaces, functional procedures, suitability of tasks, and work processes. As a result, managers make decisions easier and with the knowledge of the probability of occurring mistakes.[15,16]

In a study using SPAR-H method, it was concluded that the most probable error was error in injecting blood products with a 78% and the least probable error was in the serum device with a 55% error probability.[17] In the study of Khandan et al., the rate of performance error has been reported 46.8%, inspection 25.6%, recovery 8.5%, communication 12.1%, and selective error 7.0%.[18]

Considering the importance of nurses' role in patient safety and providing safe services to patients, this study was aimed to identify and evaluate human errors using SPAR-H method in nursing staff of one of the general hospitals in Qazvin Province, Iran.

Materials and Methods

This cross-sectional study was conducted in a

general hospital in Qazvin during last six months of 2016 and first six months of 2017. The hospital was divided into 10 sections [emergency, women internal, men internal, women surgery, men surgery, urology, hematology, general surgery, intensive care unit (ICU), coronary care unit (CCU)]. The target population in this study was nursing groups based on their highest work experience. In each section, three people (one morning shift, one noon shift, one night shift) were enrolled. The SPAR-H method was used to investigate human error in the population, which was performed in the following steps, respectively:

1- In the first step, task analysis was performed using Hierarchical Task Analysis (HTA)[19] independently for both groups of diagnostic and practical activities related to the nursing profession.

2- In this step, the probability of human error was determined, thus providing an effective diagnostic and practical form for the nursing profession after entering basic error-affecting information including age, sex, history, education. The worksheets were completed with the presence of the researcher and after providing the required information to the subjects.

This step of the study took the form of the following steps:

A) Evaluation of each Performance Shaping Factors (PSFs) from the diagnostic or performance dimension:

At this stage, each of the factors shaping performance for diagnosis or performance was evaluated. These factors include available time, stress/stressors, complexity, experience/training, operational procedures, ergonomics, task suitability, and work processes.[14,20] Each of these shaping factors has specific coefficients.

B) The calculation of the probability of error in diagnostic or performance errors was calculated as follows:

(1) If all PSF values are sufficient, the diagnostic and functional failure probability is 1.0E-2 (one to the power of -2) and 1.0E-3 (one to the power of -3), respectively.

(2) Otherwise, the probability of a diagnostic and performance error is:

-The probability of diagnostic error = 1.OE-2 × available time × stress and stressors × work complexity × training and experience × operating methods × ergonomics × fitness with task × working process

-The probability of a performance error = 1.OE-3 × available time × stress and stressors × work complexity × training and experience × operating procedures × ergonomics × fitness with task × working process

C) Calculation of the regulatory factor when there are several (three or more) negative factors for the PSF: When three or more PSFs with a negative effect are present, instead of the above equations, another equation is used in which the regulatory factor is also calculated. Negative PSF means that the coefficient of choice is greater than 1. Nominal human error probability (NHEP) for diagnostic error is 1.OE-2 and for the performance error is 1.0E-3. The PSF score used in this mode is the result of the coefficient of all the specified values of the PSF. Therefore, the regulatory factor is used to calculate HEP in this way:

HEP = NHEP.PSF/NHEP(PSF-1) + 1

Where HEP is a human error.

D) The final HEP is recorded by diagnosis or performance: If the regulatory agent was not used, the final diagnosis HEP would be recorded using section B, and if the regulatory agent was used, the amount of section C would be calculated and recorded.

E) Calculating error occurrence without dependence equation [Task Failure Probability without Formal Dependence (Pw/od)]: The probability of the task failure without the dependence equation is actually the sum of the probability of failure of the diagnosis with the probability of failure of the performance.

(3) Determination of the amount of

dependency share (Pw/d) available between tasks: The table of dependency conditions was used, which includes the change in the person being analyzed, the open or closed time range, the analyzed person's displacement, and the presence or absence of additional indications to guide the individual to make or not to make an error.

In this case, the dependence of the negative effect of a human error on the subsequent errors is calculated as the general error. Dependency can be in full, high, moderate, low, or zero modes. After determining the dependence, the probability of the final probability of the error was calculated.[17]

Pw/od = The probability of failure without the dependence relation (calculated in section E): For a complete dependence, the probability of failure = 1; for a high dependence, the probability of failure equals to 2 (Pw/od + 1); for the average dependence, the probability of error equals to 7 (Pw/od × 6 + 1); for a low dependence, the probability of failure is equal to 20 (Pw/od × 19 + 1); and for zero dependence, the probability of failure is equal to Pw/od.

D) Risk level assessment was performed using the probability and severity of the risk.

Results

Analysis of the results of demographic information showed that 64% of the participants in the study were women with an average age of 34 years and 36% of them were men with an average age of 38 years, of which 12% were apprentices, 75% were undergraduates, and 13% were masters. Their work experience was 12 years. Based on the results, there was no significant relationship between the probability of error and sex, age, and educational status (P > 0.05). But there was a meaningful relationship with the average of working experience.

The findings of the study indicate that in the nursing activities, in the diagnostic errors, the most probable error belonged to patient's diagnosis mismatch with record and incorrect injection because of nominal or physical resemblance (0.4%), and the least probable error rate related to the probability of entering the incorrect code in the system and entering the incorrect patient in the system for laboratory and paraclinical services (0.0016%). Among the performance errors, the most probable error rate belonged to the patient bedsore (0.005%) and the least probable error was error in entering vital signs' numbers (0.000125). Among the combined errors, the most probable error belonged to inappropriate venipuncture with probability of 1 and the lowest probable failure belonged to the probability of failure in entering at least one of the drugs because of the nominal similarity with the probability of 0.0045 (Table 1).

Probable errors were ranked as the percentage of error probability in table 2.

The highest probable failure belonged to inappropriate venipuncture with a probability of 0.7, and the lowest probability error related to the probability of mistake in entering numbers related to vital signs with the probability of 0.0045.

Discussion

In the present study, the human errors of nurses in a general hospital were identified and evaluated via the SPAR-H method. There was not a significant relationship between gender, age, educational status and the probability of error, which was in line with the results of the study by Shamsaii et al.[21] With increased work experience, stress decreases in emergency situations, and knowing error-prone bottlenecks can overcome the likelihood of an error in such situations and prevent the occurrence of errors and increase patient safety.

In this study, the most probable incidence of errors belonged to inappropriate venipuncture with the probability of 0.7. Therefore, the nurses are trained to do appropriate venipuncture to reduce the chance of such an error.

Table 1. The probability of human error (nursing)

Row	Task list	Probable error	The probability of the diagnostic error	The probability of the performance error	Error probability without dependency factor	Error probability with coefficient of dependency
1	Admission	Wrong registration request	-	0.0002	0.0002	0.0002
		Failure to match patient's diagnosis with the record	0.4000	-	0.4000	0.0400
		Mistake in closing the patient's bracelet and error in identifying the patient	-	0.0025	0.0025	0.0025
2	Entering the doctor's orders at the card	Probability of not entering at least one order in the card	-	0.0025	0.0025	0.0025
		Mistake in entering at least one case of drugs due to nominal similarity	0.0040	0.0005	0.0045	0.0045
3	Controlling the patient's vital signs	Error in entering numbers related to vital signs	-	0.0001	0.0012	0.0012
4	Monitoring the patients	Falling from bed	-	0.0025	0.0025	0.0025
		Patient's bedsore	-	0.0050	0.0050	0.0050
5	Attaching the peripheral venous catheter	Inappropriate venipuncture	0.1000	0.6000	0.7000	0.7000
6	Serving drug to the patient	Wrong injection due to nominal or apparent similarity	0.4000	-	0.4000	0.4000
		Giving a wrong oral medicine	0.1000	-	0.1000	0.1000
		Needle stick when injecting medication or sampling	0.0160	0.0010	0.0170	0.0170
7	Blood injection	Injecting wrong blood products to the patient	0.0500	-	0.0500	0.0975
8	Entering paraclinical tests and services in the system	Probability of entering the wrong code in the system	0.0016	0.0001	0.0017	0.0017
		Probability of entering the wrong patient's name in the system	0.0016	0.0001	0.0017	0.0017
9	Delivering patients to the next shift	Uncertainty about the correctness of patient connections	0.0080	0.0010	0.0090	0.0090

In hospitals, one of the most common in the hospitals is the similarity error in the patient's name and the inconsistency of the patient's profile with their records, which are Because of the change of shift and high work pressure on nurses. Color labels on the records and their identification bracelets are used to reduce the likelihood of error due to nominal similarity. Another common mistake in the hospital is giving and injecting a wrong medication due to a mistake in the form or appearance of the drug; the probability of this error in this hospital was 0.4 and 0.1, respectively. In a study done in hospitals affiliated to Mazandaran University of Medical Sciences, Sari, Iran, incorrect dose administration was one of the major causes of medical errors.[22] The results of some studies indicated that most of the drug failures occurred because of the high workload, drug interactions, delivery

problems, incomplete and inappropriate communication of personnel when delivering shifts, and unreadable prescriptions.[23,24] Hence, the hospital's proposed solution, i.e., using labels for similar drugs and listing these medications and sticking them to the wards in front of the nurses, was done to reduce the chance of error.

Table 2. Prioritizing the error rate

Probable error	Probable total error
Inappropriate venipuncture	0.7000
Failure to match patient's diagnosis with the record	0.4000
Wrong injection due to nominal or apparent similarity	
Giving a wrong oral medicine	0.1000
Injecting wrong blood products to the patient	0.0975
Needle stick when injecting medication or sampling	0.0170
Uncertainty about the correctness of patient connections	0.0090
Patient's bedsore	0.0050
Mistake in entering at least one case of drugs due to nominal similarity	0.0045
Probability of not entering at least one order in the card	0.0025
Falling of patient from bed	
Probability of entering the wrong code in the system	0.0017
Probability of entering the wrong patient in the system	
Mistake in entering the patient name	0.0002
Mistake in closing the patient's bracelet and error in identifying the patient	
Error in entering numbers related to vital signs	0.0001

Another detected mistake is that errors can occur in the hospital was injecting wrong blood products to the patient prone to error 0.0975. In a study that investigated the human error in emergency department, it was found that the most likely error in the nursing group was blood and blood products transfusion with a probability of 0.78.[17] In a study by Hewitt, one of the common mistakes of nurses was error in blood transfusion,[25] which is matched with this study. The strategy provided by the hospital included double check-ups of blood requests by the two nurses, sending separate samples for wrist application and blood products, scientific-practical empowerment of all new personnel by the blood bank, and assessment of information provided to the personnel by the head nurse, informing signs and symptoms of unhealthy blood products, control of patients' vital signs and clinical status in the first 51 minutes that blood transfusion was started.

Conclusion

The probability of error as well as the role of different situations can affect the performance of personnel in their duties; therefore, by using the ergonomic interventions the risk of human errors can be reduced. Also, the findings of this study suggest the need for increased workforce, the use of people with a higher work experience in sensitive wards, reducing overtime even for volunteers who want overtime, scientific scheduling of personnel's working shifts, and providing practical training such as stress control techniques in case of emergencies in high-risk situations.

Conflict of Interests

Authors have no conflict of interests.

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