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Original Article

A Causal Model to Design more Effective Policies and Practices in Error Management in the Healthcare Industry

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Abstract

Background: Identification of the factors contributing to the errors of medical staff and examining the causal relationships among those factors can help better manage and design more effective policies and practices.
Objectives: This study aimed to identify the causes and factors affecting medical error management and determine a model for better management of such errors.
Methods: This descriptive-analytical study was conducted in two qualitative and quantitative phases. In the quantitative part of the study, the factors related to medical error management were identified and validated through reviewing previous studies and interviewing some specialists. Following that, the fuzzy decision-making trial and evaluation method was used for structural modeling of the factors and investigating the causal relationships among them in the quantitative part.
Results: In this study, the results showed that the "education and learning from error" subfactor had the most significant impact on the system. The second highly effective subfactors in the management of medical errors were "organizational communication and improved information access", "safety culture and climate", and "policies, procedures, and guidelines". In addition, the "safety culture and climate" was the most important factor that had the most critical impact on the system. Moreover, the "handoff conversations and communication" subfactor was mostly influenced by the other factors, followed by the "incident reporting system", "error prevention and corrective measures", "safety culture and climate", and "individuals' participation".
Conclusion: According to the results of this study, the health care industry should take into consideration both organizational and individual factors in error management. In order to achieve better planning and higher performance in error management, increase patient safety, and ultimately improve the quality of hospital services, it is suggested to consider the causes and factors affecting the system.

Keywords: Health care, Hospital, Medical errors

1. Background

Medical errors (MEs) are a chief cause of fatality and injury in patients worldwide (1). More than 400,000 deaths per year occur due to MEs (2). The MEs have increased concerns about patient safety events (3) occurring all over the healthcare industry (4). As a high-risk system, the healthcare industry needs preventive procedures (5), and medication error prevention is the main program in any hospital (6). There is no general agreement toward the definition of a medication error (7). The United States National Coordinating Council for Medication Error Reporting and Prevention defined a medication error as "any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the health care professional, patient, or consumer. Such events may be related to professional practice, health care products, procedures, and systems, such as medication prescription, order communication, product labelling, packaging and nomenclature, compounding, dispensing, distribution, administration, education, monitoring, and use" (8).

A variety of factors is involved in error occurrence, and events occur when there is a combination of active and hidden errors. Active errors are related to human factors, while hidden errors are associated with the management of health systems and organizations (9). Various studies have reported several factors to prevent errors; however, none of them addressed a systemic approach and the causal relationship among the factors contributing to medical error management.

Identification of the factors contributing to the errors of medical staff and examining the causal relationships among those factors can help better manage and design more effective policies and measures. Therefore, the present study aimed to identify the causes and factors affecting the management of MEs and determine a model for the better management of such errors. In the present study, the fuzzy DEMATEL model was used for structural modeling of the identified effective factors (10). It evaluates the intensity of communications through a scoring method, examines the feedbacks and their importance, and determines their interrelationships (11, 12). Some studies used the DEMATEL technique to identify and evaluate the factors affecting the implementation of safety programs (13) in production resources (14). Moreover, it evaluates the dynamic risks in offshore industries (15). In those studies, the DEMATEL method transformed the causal relationship between the effective factors into an understandable structural model of the system. On the other hand, due to the ambiguity in the answers provided by the respondents when completing the questionnaire, and given the updating of many concepts of the DEMATEL technique to be used in industrial analyses, the use of multi-criteria decision making in fuzzy environments seems necessary.

Lee et al. combined the DEMATEL technique and fuzzy theory in 2007 to identify and examine the factors influencing the promotion of the competency of managers of internationally accredited corporations (16). Considering the hospital setting, Afsharkazemi et al. (2012) utilized the fuzzy logic and DEMATEL method to identify the factors affecting hospital performance and determine their causal relationships (17). In addition, Lin and Wu (2008) analyzed complex causal relationships in a fuzzy environment by developing the fuzzy DEMATEL method (11). In this study, a decision-making framework was proposed based on the fuzzy DEMATEL method as a powerful decision-making model for establishing structural relationships between the factors and sub-factors affecting ME management.

2. Objectives

The present study could determine the causal relationship among the factors in situations where it was difficult and sometimes impossible to measure their effects.

3. Methods

This descriptive-analytical study was carried out in two qualitative and quantitative phases in Tehran, Iran. In the qualitative part of the study (phases 1-3), the factors related to ME management were identified and validated through reviewing previous studies and interviewing some specialists. Following that, the fuzzy DEMATEL method was used for structural modeling of the factors and investigating the causal relationships among them in the quantitative part of the study.

2.1. Research process

Figure 1 illustrates the research process in this study.

2.1.1. Phase 1: Factor Identification

Previous studies and interviews with experts were used in this phase. Initially, the information on management and control of medical staff errors was extracted through a review of related studies. Afterward, a list of influential factors was prepared, and the subjects were interviewed to investigate the influential extracted factors and sub-factors related to the main factors. The study population consisted of 10 specialists working in a hospital and a research center affiliated to Baqiyatallah Hospital, Iran University of Medical Sciences, Tehran, Iran.

The specialists had over five years of work experience. As in various studies, semi-structured interviews were employed in the present study (16-18). The first interviews were performed with

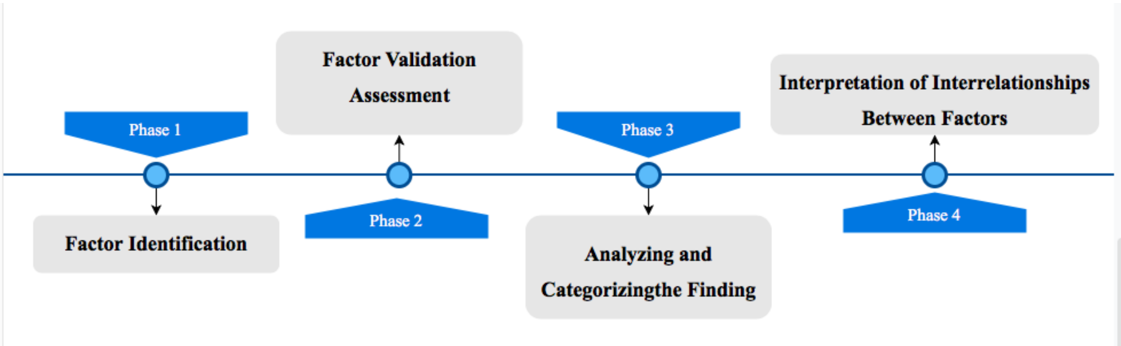

Figure 1. Research process

the specialists working in the research center during which the specialists mentioned the factors related to error management based on their personal experiences. Considering the studies conducted, the researcher collected the data after each face-to-face interview. After successive interviews, the information overlaps increased gradually, and no new factor was mentioned after 10 interviews. Each interview lasted about 1 to 5 min, and a list of factors was prepared after the interview process. A list of 26 factors was prepared after combining the factors with the ones collected from previous studies and deleting the duplicate codes.

2.1.2. Phase 2: Factor Validation Assessment

After identifying the factors, a pilot study was conducted to assess the face and content validity of the factors. To this end, a questionnaire was designed and sent to 15 specialists in this field. The respondents were selected through purposeful sampling using such inclusion criteria as expertise or experience, organization position, and skill in the subject studied. All the specialists had over five years of experience in different hospitals. The mean±SD of the respondents' work experience and age were obtained at 10±3.5 and 45±6.4 years, respectively. The content validity ratio (CVR) and content validity index (CVI) were applied to check the content validity. For this purpose, a questionnaire was designed and the specialists were asked to classify the factors' necessity based on the research objective using a 3-point Likert scale of "The factor is necessary", "The factor is useful but not necessary", and "The factor is not necessary".

Subsequently, the CVR was calculated using a formula. Waltz and Bausell's method was also utilized to examine the CVI (19). To this end, the specialists identified the "relevance", "clarity", and "simplicity" of each index based on a 4-point Likert scale. The minimum acceptable value for the CVI was obtained at 0.79, and if the index value was less than 0.79, it would be omitted. To quantify the face validity, the impact score was calculated for each factor. A 5-point Likert scale of 5=strongly agree, 4=agree, 3=no comment, 2=disagree, and 1=strongly disagree was also employed for each of the 26 factors. The specialists were then provided with the questionnaire to determine its validity. Once the questionnaire was completed by the target group, its face validity was quantitatively calculated using the item impact formula. After examining the face and content validity of the factors, a re-test was used to determine the reliability. The questionnaires were distributed among the statistical population in two different times with at least a two-week interval. In the next stage, the correlation coefficient between the results of the first and second periods were calculated using the Spearman correlation coefficient. The confidence coefficient (reliability) of 0.60 or more was considered sufficient. Table 1 tabulates the identified effective factors and their reliability scores for the study.

2.1.3 Phase 3: Analyzing and Categorizing the Findings

In this phase, after eliminating six factors with unacceptable validity, the remaining ones were classified into three main factors and 20 sub-factors (Table 1).

Table 1. Identified factors and sub-factors

Main factors	Code	Sub-factors	Impact Score	CVI	CVR	Researchers/ Sources
Organizational factors	F1	Policy, procedures, and instructions regarding medical errors and reduce reliance on memory	4.067	0.867	0.867	(9, 40)
	F2	Resource management (material, financial, and human resource) and organizational processes	4.267	0.889	0.733	(41)
	F3	Event-reporting systems	4.067	0.889	0.867	(42-44)
	F4	Performance measurement of high-risk processes and review EMP	4.000	0.822	0.600	(9, 45)
	F5	Root cause analysis of critical incidents	4.133	0.844	0.867	
	F6	Medication error prevention(design mistake-proof processes or high reliable processes, reduce the number of handoffs) and corrective actions	4.200	0.911	0.733	(9)
	F7	Documentation and classifying medical errors	3.733	0.844	0.600	(46-49)
	F8	Valid and up-to-date training and learning from errors	4.133	0.844	1.000	(42, 43)
	F9	Organization communication and improvement of information access	4.133	0.911	0.733	(50-52)
	F10	Strong and supportive organizational safety culture and climate	4.333	0.844	0.867	(9)
Physical work environment factors	F11	Hospital environment and condition (noise levels, air quality, lighting levels, facility design)	4.267	0.889	0.600	(53)
Human factors	F12	Handoff conversations and communication	4.267	0.867	0.733	(54-56)
	F13	Individual participation	4.067	0.867	0.867	(57, 58)
	F14	Fear of blame and shame or punishment	4.400	0.867	0.733	(43, 59)
	F15	Situational awareness	4.133	0.844	0.600	(60-63)
	F16	Building teamwork	4.067	0.889	0.733	(64-68)
	F17	Patient participation	4.267	0.867	0.600	(58, 69, 70)
	F18	Personnel responsibilities and commitment to patient safety	4.200	0.911	0.733	(71-73)
	F19	Knowledge, competency, and skills	4.000	0.800	0.600	(74)
	F20	Patient safety attitudes	4.400	0.822	0.867	(74, 75)

2.1.4. Phase 4: Interpretation of the Interrelationships among Factors

In this study, the fuzzy DEMATEL technique was used for structural modeling of the identified effective factors. This technique is one of the decision-making methods based on paired comparisons using expert judgment. The DEMATEL technique is an approach for identifying cause-and-effect relationships among multiple factors in order to properly understand problems (20, 21). In general, it is very difficult to estimate experts' opinions with accurate numerical values, especially in uncertain situations since the decisions are strongly dependent on imprecise and ambiguous mental judgments.

Such uncertainties have led to the introduction of fuzzy logic in the DEMATEL technique. Therefore, the fuzzy DEMATEL technique uses fuzzy linguistic variables and facilitates decision making in environmental uncertainty (22). After examining the validity and reliability of the collected factors, the paired comparison questionnaire was developed based on the fuzzy DEMATEL method and was sent to the specialists. They were then asked to determine the direct impact or influence of each factor by selecting a linguistic variable of "no influence", "low influence", "moderate influence", "high influence", and "very high influence''. In the next stage, the results provided by each specialist were entered into separate matrices, and finally, to apply the fuzzy logic to the study of linguistic options, they were replaced by fuzzy numbers (Table 2) in which the proposed fuzzy linguistic options were compared with those introduced by Lee. After collecting the specialists' comments, the fuzzy mean method was used to aggregate them (23). The data were then collected and analyzed in this study. In total, three steps were used to implement this technique in the present study. It is worth mentioning that Wu and Lee also conducted a study on the DEMATEL techniques (16).

2.2. Step 1: Direct Relationship Matrix Calculation

After obtaining the experts' comments, the fuzzy direct relation matrix $\tilde{x}$ was formed, and the fuzzy mean method was used to integrate the comments. Suppose that n specialists commented on the relationships among the indices. Each element of the fuzzy direct matrix was represented by $\tilde{x}_{ij}$ and calculated using the following Equation (1):

Table 2. Linguistic variable scales

Linguistic terms	Crisp values	Linguistic values
Very high influence (VH)	4	(0.75 , 1 , 1)
High influence (H)	3	(0.5 , 0.75 , 1)
Moderate influence (M)	2	(0.25 , 0.5 , 0.75)
Low influence (L)	1	(0 , 0.25 , 0.5)
No influence (N)	0	(0 , 0 , 0.25)

$$\tilde{x}_{ij} = \left({\textstyle\sum l_{ij}}/_{n} + {\textstyle\sum m_{ij}}/_{n} + {\textstyle\sum u_{ij}}/_{n} \right) \quad Eq1$$

2.3. Step 2: Normalization of Direct Relation Matrix

To normalize the values, $\sum u_{ij}$ of each row required to be calculated, and the fuzzy normal matrix $\tilde{N}$ was obtained by dividing the elements of the $\tilde{x}$ matrix by the maximum values of the $\sum u_{ij}$ matrix using Equation 2:

$$\mathrm{K} = max\left(\textstyle\sum_{j=1}^{n} u_{ij}\right), \tilde{N} = {}^{1}/_{K} \times \tilde{x} \quad Eq2$$

2.4. Step Three: Total-Relation Matrix Calculation

To calculate the fuzzy total-relation matrix, the fuzzy normalized matrix was subdivided into three definite ones as follows:

$$N_u = \begin{pmatrix} . & u_{12} & \dots & u_{1n} \\ u_{21} & . & \dots & u_{2n} \\ . & \vdots & & \\ u_{n1} & u_{n2} & \dots & . \end{pmatrix}$$

$$N_m = \begin{pmatrix} . & m_{12} & \dots & m_{1n} \\ m_{21} & . & \dots & m_{2n} \\ & & & . \\ m_{n1} & m_{n2} & \dots & . \end{pmatrix}$$

$$N_l = \begin{pmatrix} . & l_{12} & \dots & l_{1n} \\ l_{21} & . & \dots & l_{2n} \\ & & & . \\ l_{n1} & l_{n2} & \dots & . \end{pmatrix}$$

Subsequently, the identity matrix I_{n*n} was formed, and the following operations were performed:

$$T_l = N_l \times (I - N_l)^{-1} \quad Eq3$$

$$T_m = N_m \times (I - N_m)^{-1} \quad Eq4$$

$$T_u = N_u \times (I - N_u)^{-1} \quad Eq5$$

In the next stage, the fuzzy total-relation matrix was calculated using Equation 6, and the values of $\tilde{D}_i, \tilde{R}_i$, $(\tilde{D}_i + \tilde{R}_i)$, and $(\tilde{D}_i - \tilde{R}_i)$ were defuzzified using

Equation 7.

$$\tilde{t}_{ij} = \left(t^{l}_{ij}, t^{m}_{ij}, t^{u}_{ij}\right) \quad Eq6$$

$$B = {(l + u + 2 \times m)}/{4} \quad Eq7$$

The defuzzified B was the triangular fuzzy number

$\tilde{A} = (l, m, u)$.

4. Results

In this study, the fuzzy DEMATEL technique and the viewpoints of 15 specialists were used for structural modeling of 20 effective factors in error management. Initially, using the viewpoints of 15 specialists including patient safety experts, health and safety managers, and accreditation authorities, the direct impact of each factor on the other ones was identified using linguistic variable scales (Table 2). The first viewpoints of the experts are shown in Table 3 with linguistic variable scales. After obtaining the experts' viewpoints, the linguistic variables were replaced with their corresponding fuzzy numbers, and a fuzzy direct relation matrix was formed for each expert. Subsequently, using formula 1, the fuzzy mean method was utilized to obtain the experts' viewpoints. Following that, the obtained matrix was normalized using Equation 2, and Equation 6 was then employed to create a structural model and determine the fuzzy total-relation matrix. After obtaining the experts' viewpoints, the verbal variables were replaced with their corresponding fuzzy numbers, and a fuzzy direct relation matrix was formed for each expert. Equation 3 was then used to create a structural model and determine the matrix of the total fuzzy relations. In the next stage, the values of $\tilde{D}_i$, $\tilde{R}_i$, $(\tilde{D}_i + \tilde{R}_i)$, and $(\tilde{D}_i - \tilde{R}_i)$ were determined (Table 4). Equation 7 was also used for the

Table 3. Linguistic assessment data of the first expert

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20
F1	N	N	H	H	H	H	H	H	VH	H	M	H	H	VH	M	H	H	N	N	M
F2	M	N	H	H	L	VH	L	VH	H	VH	H	M	N	N	L	L	L	N	H	N
F3	N	N	N	VH	M	VH	L	H	N	VH	N	N	N	N	N	N	N	N	N	N
F4	N	N	N	N	L	H	L	M	L	M	M	M	N	N	N	L	N	N	L	N
F5	N	N	N	N	N	VH	N	VH	L	N	L	N	N	N	N	N	N	N	L	N
F6	N	N	N	N	N	N	N	N	N	L	N	N	N	N	N	N	N	N	N	N
F7	N	N	N	H	H	H	N	M	N	N	N	N	N	N	N	N	N	N	N	N
F8	N	N	VH	H	VH	H	H	N	H	VH	L	VH	VH	N	H	VH	VH	M	H	VH
F9	N	N	VH	N	H	L	H	VH	N	VH	N	H	H	L	H	VH	H	L	H	H
F10	N	N	VH	H	VH	H	M	VH	VH	N	H	VH	VH	VH	H	VH	H	L	L	L
F11	N	N	N	N	N	L	N	N	N	L	N	N	N	N	N	N	N	N	N	N
F12	N	N	L	N	N	N	N	N	N	N	N	N	N	N	H	N	N	N	N	N
F13	N	N	VH	N	VH	N	H	N	H	VH	N	VH	N	N	H	VH	N	N	M	N
F14	N	N	VH	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
F15	N	N	H	N	N	N	N	N	M	L	N	H	M	N	N	H	N	L	L	N
F16	N	N	L	N	H	N	N	H	N	M	N	H	H	N	H	N	N	N	N	N
F17	N	N	N	N	M	N	N	N	N	M	N	H	N	N	N	N	N	N	N	N
F18	N	N	VH	N	L	N	M	N	N	H	N	H	H	N	N	H	N	N	N	H
F19	N	N	L	N	N	N	N	N	L	L	N	H	H	N	M	M	N	L	N	VH
F20	N	N	VH	N	N	N	N	L	N	H	N	H	VH	N	M	H	N	N	N	N

Table 4. Values of $\tilde{D}_i$, $\tilde{R}_i$, $(\tilde{D}_i + \tilde{R}_i(76)\tilde{D}_i - \tilde{R}_i)$

	$\tilde{D}_i$	$\tilde{R}_i$	$(\tilde{D}_i + \tilde{R}_i)$	$(\tilde{D}_i - \tilde{R}_i)$
F1	(0.522, 0.988, 2.516)	(0.019, 0.044, 0.890)	(0.542, 1.032, 3.406)	(0.503, 0.943, 1.626)
F2	(0.450, 0.938, 2.360)	(0.000, 0.000, 0.815)	(0.450, 0.938, 3.174)	(0.450, 0.938, 1.545)
F3	(0.309, 0.580, 1.735)	(0.539, 0.945, 2.152)	(0.849, 1.525, 3.887)	(-0.230, -0.365, -0.417)
F4	(0.116, 0.399, 1.563)	(0.301, 0.530, 1.656)	(0.417, 0.929, 3.219)	(-0.185, -0.131, -0.093)
F5	(0.135, 0.295, 1.307)	(0.353, 0.683, 1.841)	(0.488, 0.978, 3.149)	(-0.219, -0.388, -0.534)
F6	(0.061, 0.128, 1.115)	(0.437, 0.785, 1.992)	(0.498, 0.914, 3.108)	(-0.376, -0.657, -0.877)
F7	(0.130, 0.245, 1.289)	(0.171, 0.379, 1.449)	(0.301, 0.624, 2.738)	(-0.041, -0.135, -0.160)
F8	(0.721, 1.262, 2.801)	(0.398, 0.755, 1.932)	(1.119, 2.017, 4.733)	(0.324, 0.506, 0.869)
F9	(0.619, 1.151, 2.643)	(0.134, 0.305, 1.297)	(0.753, 1.455, 3.940)	(0.485, 0.846, 1.346)
F10	(0.624, 1.107, 2.549)	(0.436, 0.841, 2.090)	(1.060, 1.948, 4.638)	(0.188, 0.266, 0.459)
F11	(0.013, 0.060, 0.994)	(0.104, 0.252, 1.230)	(0.117, 0.312, 2.224)	(-0.091, -0.192, -0.236)
F12	(0.038, 0.099, 1.068)	(0.559, 0.977, 2.326)	(0.597, 1.076, 3.394)	(-0.521, -0.878, -1.259)
F13	(0.539, 0.899, 2.176)	(0.434, 0.771, 1.975)	(0.973, 1.670, 4.151)	(0.104, 0.128, 0.201)
F14	(0.088, 0.148, 1.098)	(0.218, 0.412, 1.439)	(0.306, 0.560, 2.537)	(-0.129, -0.264, -0.340)
F15	(0.185, 0.428, 1.635)	(0.343, 0.653, 1.915)	(0.527, 1.082, 3.550)	(-0.158, -0.225, -0.280)
F16	(0.266, 0.515, 1.756)	(0.410, 0.743, 1.940)	(0.676, 1.258, 3.696)	(-0.144, -0.227, -0.184)
F17	(0.090, 0.199, 1.238)	(0.172, 0.318, 1.330)	(0.262, 0.517, 2.568)	(-0.082, -0.119, -0.091)
F18	(0.345, 0.630, 1.871)	(0.096, 0.270, 1.270)	(0.442, 0.900, 3.141)	(0.249, 0.361, 0.601)
F19	(0.244, 0.518, 1.751)	(0.137, 0.362, 1.427)	(0.381, 0.879, 3.179)	(0.107, 0.156, 0.324)
F20	(0.301, 0.553, 1.764)	(0.192, 0.358, 1.366)	(0.492, 0.911, 3.130)	(0.109, 0.195, 0.398)

Table 5. Values of D, R, (D+R), and (D-R)

	D	R	$(D-R)^{defuzzy}$	$(D+R)^{defuzzy}$
F1	1.156	0.250	0.906	1.405
F2	1.095	0.204	0.891	1.298
F3	0.708	1.145	-0.438	1.853
F4	0.576	0.754	-0.179	1.330
F5	0.477	0.890	-0.413	1.367
F6	0.335	1.000	-0.665	1.335
F7	0.456	0.595	-0.138	1.051
F8	1.367	0.960	0.407	2.327
F9	1.277	0.510	0.767	1.787
F10	1.264	1.052	0.212	2.315
F11	0.260	0.460	-0.199	0.720
F12	0.303	1.210	-0.906	1.513
F13	0.996	0.988	0.008	1.983
F14	0.343	0.620	-0.277	0.963
F15	0.632	0.891	-0.259	1.523
F16	0.722	0.959	-0.237	1.681
F17	0.405	0.534	-0.130	0.939
F18	0.799	0.476	0.322	1.275
F19	0.719	0.572	0.147	1.291
F20	0.751	0.569	0.182	1.320

defuzzification of the total-relation matrix and $\tilde{D}_i$, $\tilde{R}_i$, $(\tilde{D}_i + \tilde{R}_i)$ as well as $(\tilde{D}_i - \tilde{R}_i)$ values. The D and R values in Table 5 show the extent of impact and impressibility of each factor in the system. According to the DEMATEL method, if D-R is positive, the variable is considered causal; however, if it is negative, it is regarded as the effect. The D+R values in this method indicate the impact and impressibility of the intended factors in the system. In other words, the higher values of the D+R factor indicate more interaction with other elements of the system; accordingly, it is more critical in the system.

In this study, the D values presented in Table 5 showed that the "education and learning from error" subfactor had the most impact on the system, followed by "safety culture and climate" that obtained the largest D value. These subfactors were the most important and had the most impact on the system. The "education and learning form error" are not separate from a strong "safety culture"; moreover, they can have a good effect on improving the patient's safety culture. The other highly effective subfactors in the management of MEs were "organizational communication and improved information access" and "policies, procedures, and guidelines". In addition, the "safety culture and climate" subfactor received the highest D+R value indicating that it was the most important factor and had the most significant impact on the system. Based on the R values, the "handoff conversations and communication" subfactor was mostly influenced by the other factors, followed by the "incident reporting system", "error prevention and corrective measures", "safety culture and climate", and "individuals' participation" (Table 5).

According to Table 5 and Figure 2, "policies, procedures, and guidelines", "resource management", "education and learning from errors", "organizational communication and improved information access", and "safety culture and climate" were among the organizational factors affecting the system. Among the individual factors, "participation, responsibility, and commitment to patient safety", "patient safety attitude", as well as "knowledge, skill, and competence of the individuals" were the causal factors influencing the error management system. According to the results, "responsibility and commitment to patient safety" had the greatest impact on ME management. Figure 3 illustrates the cause and effect relationships among the factors. The factors above the coordinate axis are causal factors, and the farther factors from the horizontal axis indicate the greater effect on the system. The horizontal and vertical axes show the importance of the factors as well as the degree of influence and impressibility, respectively.

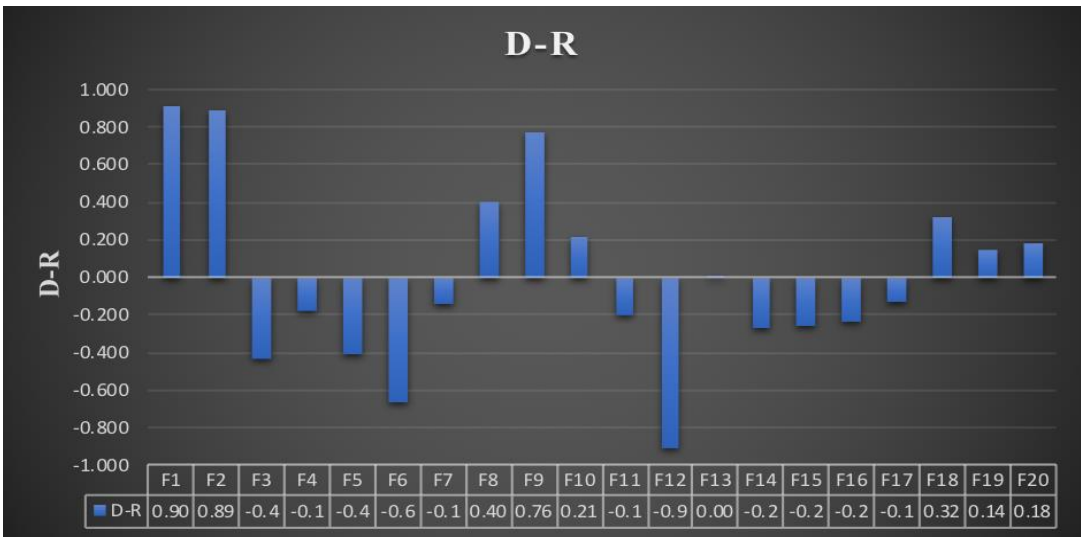

Figure 2. Net cause/effect graph

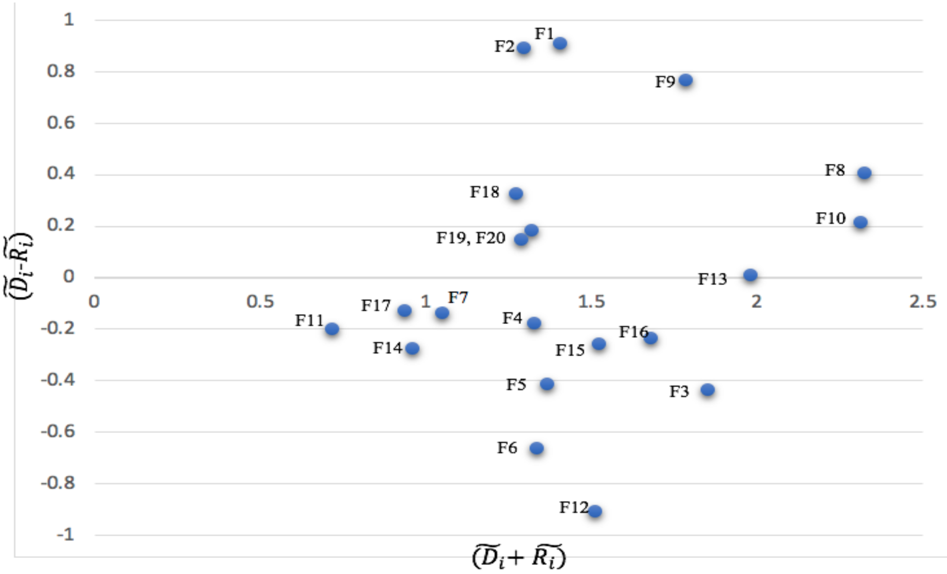

Figure 3. Causal diagram

5. Discussion

The results of this study showed that organizational factors had the most influence on other factors and the error management system. The results of a study conducted by Afsharkazemi et al. using the DEMATEL technique showed that organizational factors had the greatest impact on the overall performance of hospitals (17). The factors affecting error control and management vary from the perspectives of different researchers. In this study, different organizational and individual factors were identified, and their relationships were extracted and discussed, the most influential of which in the error management system are discussed below.

5.1. Education and Learning from Errors

Among the organizational factors investigated in this study, "education and learning from errors" had the greatest influence on error management and individual factors. In this regard, instead of reacting to the occurrence of errors, the management of the organization should be involved in learning from them and teaching error reduction strategies. The results of a study conducted by Cynthia et al. showed that educational interventions had the greatest impact on error management (24). In the same line, Doshmangir et al. performed a study in Iran to identify the challenges and strategies related to MEs and showed that human resource education played an effective role in error control and management (25).

The results of a study performed by Pazokian et al. showed that the factors affecting medical error management in nurses were influenced by individual, organizational, and situational factors. It should be noted that a comprehensive educational program and its implementation was an important and influential factor in error management (26).

5.2. Organizational Communication and Improved Information Access

Communication systems have a significant effect on patient safety in organizations (27). An organization should develop creative and effective solutions to facilitate information provision and access, and the information must be provided at the required time and place. Collaborations in error prevention will be poor without effective communications. Through communications, the management will be allowed to disseminate information when executing prevention programs. Additionally, human resources will get aware of the management's demands, and by interacting, they can communicate their demands and suggestions to the managers. In order to improve communications within the organization, the management can set executive instructions based on the tasks of various units and provide related information. The organization can also organize various sessions on error management in order to establish communication, disseminate information, receive feedback or analyze the problems, and make decisions.

5.3. Safety Culture as well as Positive and Supportive Safety Climate

The biggest challenge to move toward the health system is to change the culture of healthcare providing organizations (28). In the present study, it was shown that "safety culture and climate" was an important factor affecting error management. In a study carried out by Nabilah et al., "safety culture" was regarded as an important and effective factor in error management (29). These results are in line with those of the present study. Managers in the organization should try to investigate the errors rather than blame the staff for making mistakes. Such an approach would improve the system, prevent errors, and ultimately create a safety culture (28).

5.4. Policies, Procedures, and Guidelines

An effective response to events aimed at reducing the risk of errors should be based on valid risk management policies. The results of a study conducted by Pietra et al. revealed that health care providers were required to define and enforce policies and procedures for error reduction and management (30). In the present study, "policies, procedures, and guidelines" sub-factor was also found to be a key factor in error management. In order to improve error management programs, the issues that should be considered by any organization include the establishment of checklists, protocols, computerized decision aids, teamwork coaching, and surgical procedures, as well as procedures to ensure the maintenance of team structures over shift changes, guide employees in crowded areas for better performance, and develop facility policy regarding patient identification.

5.5. Handoff Conversations and Communication

In this study, this individual factor was mostly influenced by organizational factors. Poor communication during shift delivery was one of the major causes of adverse events (31). Patient safety experts have also suggested that communication and other teamwork skills are a key factor in preventing and managing medical errors. Leonard et al. analyzed 2455 errors and revealed that in 70% of the cases, the causes of errors were communication problems. To understand the significance of these errors, it should be noted that 70% of errors caused by communication problems resulted in the death of 75% of the patients (32). In the present causal model, organizational factors, such as "policies, procedures, and guidelines", "resource management", "performance measurement and program review", "error prevention with emphasis on designing anti-error processes and reducing handoff", "education and learning from errors", and a "positive and supportive safety culture and climate" influenced and interacted with the "handoff conversation and communication" subfactor. The results also showed that among the individual factors, "team formation", "individuals' participation", "situational awareness", "commitment and responsibility for patient safety", "knowledge, competence, and skill", and "patient safety attitudes" were related to and influenced the handoff factor.

5.6. Event Reporting System

In the present study, this organizational factor was mostly influenced by individual factors and other organizational ones. The downside of the reporting system is the elimination of a valuable source of information to prevent subsequent errors and facilitate the re-occurrence of previous ones. Other studies also considered the effective role of error reporting (33-35) and recording in preventing and managing errors (36-38). The results of this study showed that individuals' participation and fear of reprimand and punishment were the individual factors with the greatest impact on the event reporting system. The results of a study carried out by Fein et al. showed that fear of punishment and reprimand was the most important reason for not reporting errors by the medical staff, which is in line with the findings of the present study (39).

6. Conclusion

According to the results of this study, the health care industry should take into consideration both organizational and individual factors in error management. This industry can also provide strategies to improve the error management process and fix its deficiencies with regard to the causes and factors affecting the system, thereby reducing and managing errors with the greatest effectiveness and efficiency. In order to achieve better planning and higher performance in error management, increase patient safety, and ultimately improve the quality of hospital services, it is suggested to consider the causes and factors affecting the system.

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Footnotes

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References

1. Khan A, Spector ND, Baird JD, Ashland M, Starmer AJ, Rosenbluth G, et al. Patient safety after implementation of a coproduced family centered communication programme: multicenter before and after intervention study. *BMJ*. 2018;**363**:k4764. doi: 10.1136/bmj.k4764. [PubMed: 30518517].
2. Welsh D, Zephyr D, Pfeifle AL, Carr DE, Fink JL 3rd, Jones M. Development of the barriers to error disclosure assessment tool. *J Patient Saf*. 2017;**30**:1-22. doi: 10.1097/PTS.0000000000000331. [PubMed: 28671908].
3. Valley M, Stallones L. A thematic analysis of health care workers' adoption of mindfulness practices. *Workplace Health Saf*. 2018;**66**(11):538-44. doi: 10.1177/2165079918771991. [PubMed: 29806801].
4. Ravindran S, Thomas-Gibson S, Murray S, Wood E. Improving safety and reducing error in endoscopy: simulation training in human factors. *Frontline Gastroenterol*. 2019;**10**(2):160-6. doi: 10.1136/flgastro-2018-101078. [PubMed: 31205657].
5. Saravi BM, Mardanshahi A, Ranjbar M, Siamian H, Azar MS, Asghari Z, et al. Rate of medical errors in affiliated hospitals of Mazandaran university of medical sciences. *Mater Sociomed*. 2015;**27**(1):31-4. doi: 10.5455/msm.2014.27.31-34. [PubMed: 25870528].
6. Sarfati L, Ranchon F, Vantard N, Schwiertz V, Larbre V, Parat S, et al. Human-simulation-based learning to prevent medication error: a systematic review. *J Eval Clin Pract*. 2019;**25**(1):11-20. doi: 10.1111/jep.12883. [PubMed: 29383867].
7. Lisby M, Nielsen LP, Brock B, Mainz J. How are medication errors defined? A systematic literature review of definitions and characteristics. *Int J Qual Health Care*. 2010;**22**(6):507-18. doi: 10.1093/intqhc/mzq059. [PubMed: 20956285].
8. Cousins DD, Heath WM. The national coordinating council for medication error reporting and prevention: promoting patient safety and quality through innovation and leadership. *Joint Commission J Qual Patient Saf*. 2008;**34**(12):700-2. doi: 10.1016/S1553-7250(08)34091-4.
9. Spath PL. Error reduction in health care: a systems approach to improving patient safety. *J Nurs Regulat*. 2012;**2**(4):60. doi: 10.1016/S2155-8256(15)30255-6.
10. Fontela E, Gabus A. The dematel observer, battelle geneva research center, geneva, switzerland. *Modern Econ*. 1976; **7**(9):16-3287.
11. Lin CJ, Wu WW. A causal analytical method for group decision-making under fuzzy environment. *Exp Syst Appl*. 2008; **34**(1):205-13. doi: 10.1016/j.eswa.2006.08.012.
12. Vosoughi S, Chalak MH, Rostamzadeh S, Taheri F, Farshad AA, Motallebi Ghayen M. A cause and effect decision making model of factors influencing falling from height accidents in construction projects using Fuzzy-DEMATEL technique. *Iran Occup Health J*. 2019;**16**(2):79-93.
13. Bavafaa A, Mahdiyarb A, Marsonoa AK. Identifying and assessing the critical factors for effective implementation of safety programs in construction projects. *Saf Sci*. 2018;**106**:47-56. doi: 10.1016/j.ssci.2018.02.025.
14. Wang L, Cao Q, Zhou L. Research on the influencing factors in coal mine production safety based on the combination of DEMATEL and ISM. *Saf Sci*. 2018;**103**:51-61. doi: 10.1016/j.ssci.2017.11.007.
15. Meng X, Chen G, Zhu G, Zhu Y. Dynamic quantitative risk assessment of accidents induced by leakage on offshore platforms using DEMATEL-BN. *Int J Naval Arch Ocean Eng*. 2019;**11**(1):22-32. doi: 10.1016/j.ijnaoe.2017.12.001.
16. Wu WW, Lee YT. Developing global managers' competencies using the fuzzy DEMATEL method. *Exp Syst Appl*. 2007;**32**(2):499-507. doi: 10.1016/j.eswa.2005.12.005.
17. Afsharkazemi MA, Manouchehri J, Salarifar M, Nasiripour AA. Key factors affecting the hospital performance: a qualitative study using fuzzy logic. *Qual Quant*. 2013;**47**(6):3559-73. doi: 10.1007/s11135-012-9739-7.
18. Hudson M, Smart A, Bourne M. Theory and practice in SME performance measurement systems. *Int J Operat Prod Manag*. 2001;**21**(8):1096-115. doi: 10.1108/EUM0000000005587.
19. Waltz CF, Bausell BR. Nursing research: design statistics and computer analysis. Philadelphia: Davis FA; 1981.
20. Bacudio LR, Benjamin MF, Eusebio RC, Holaysan SA, Promentilla MA, Yu KD, et al. Analyzing barriers to implementing industrial symbiosis networks using DEMATEL. *Sustainable Prod Consumpt*. 2016;**7**:57-65. doi: 10.1016/j.spc.2016.03.001.
21. Gandhi S, Mangla SK, Kumar P, Kumar D. A combined approach using AHP and DEMATEL for evaluating success factors in implementation of green supply chain management in Indian manufacturing industries. *Int J Logist Res Appl*. 2016;**19**(6):537-61. doi: 10.1080/13675567.2016.1164126.
22. Patil SK, Kant R. A fuzzy AHP-TOPSIS framework for ranking the solutions of knowledge management adoption in supply chain to overcome its barriers. *Exp Syst Appl*. 2014;**41**(2):679-93. doi: 10.1016/j.eswa.2013.07.093.
23. Li R-J. Fuzzy method in group decision making. *Comput Mathem Appl*. 1999;**38**(1):91-101. doi: 10.1016/S0898-1221(99)00172-8.
24. Beckett CD, Kipnis G. Collaborative communication: integrating SBAR to improve quality/patient safety outcomes. *J Healthc Qual*. 2009;**31**(5):19-28. doi: 10.1111/j.1945-1474.2009.00043.x. [PubMed: 19813557].
25. Doshmangir L, Ravaghi H, Akbari Sari A, Mostafavi H. Challenges and solutions facing medical errors and adverse events in Iran: a qualitative study. *J Hosp*. 2016;**15**(1):31-40.
26. Pazokian M, Zagheri Tafreshi M, Rassouli M. Factors affecting medication errors from nurses' perspective: lessons learned. *Iran J Med Educ*. 2013;**13**(2):98-113.
27. Chiu CH, Pan WH, Wei CJ. Does organizational culture impact patient safety management? *Asian J Health Informat Sci*. 2008;**3**(1-4):88-100. doi: 10.6412/AJHIS.200812.0088.
28. Nieva V, Sorra J. Safety culture assessment: a tool for improving patient safety in healthcare organizations. *Qual Saf Health Care*. 2003;**12**(Suppl 2):ii17-23. doi: 10.1136/qhc.12.suppl_2.ii17. [PubMed: 14645891].
29. Nabilah H, Idris O, Eliana M, Roslinah A, Aishah A, Noriah B. Do we communicate openly in healthcare delivery. *Int J Curr Res Acad Rev*. 2014;**1**:30-7.
30. La Pietra L, Calligaris L, Molendini L, Quattrin R, Brusaferro S. Medical errors and clinical risk management: state of the art. *Acta Otorhinolaryngol Ital*. 2005;**25**(6):339-46. [PubMed: 16749601].
31. Salas E, King HB, Rosen M. Improving teamwork and safety: toward a practical systems approach, a commentary on Deneckere et al. *Soc Sci Med*. 2012;**75**(6):986-9. doi: 10.1016/j.socscimed.2012.02.055. [PubMed: 22627017].
32. Leonard M, Graham S, Bonacum D. The human factor: the critical importance of effective teamwork and communication in providing safe care. *Qual Saf Health Care*. 2004;**13**(Suppl 1):i85-90. doi: 10.1136/qhc.13.suppl_1.i85. [PubMed: 15465961].
33. Walston SL, Al-Omar BA, Al-Mutari FA. Factors affecting the climate of hospital patient safety: a study of hospitals in Saudi Arabia. *Int J Health Care Qual Assur*. 2010;**23**(1):35-50. doi: 10.1108/09526861011010668. [PubMed: 21387862].
34. Bell SK, Delbanco T, Anderson-Shaw L, McDonald TB, Gallagher TH. Accountability for medical error: moving beyond blame to advocacy. *Chest*. 2011;**140**(2):519-26. doi: 10.1378/chest.10-2533. [PubMed: 21813531].
35. Vozikis A. Information management of medical errors in Greece: The MERIS proposal. *Int J Informat Manag*. 2009;**29**(1):15-26. doi: 10.1016/j.ijinfomgt.2008.04.012.
36. Pukk Härenstam K, Elg M, Svensson C, Brommels M, Øvretveit J. Patient safety as perceived by Swedish leaders. *Int J Health Care Qual Assur*. 2009;**22**(2):168-82. doi: 10.1108/09526860910944656. [PubMed: 19536967].
37. Marcatto F, Colautti L, Filon FL, Luis O, Di Blas L, Cavallero C, et al. Work-related stress risk factors and health outcomes in

public sector employees. *Saf Sci*. 2016;**89**:274-8. doi: 10.1016/j.ssci.2016.07.003.
38. Moumtzoglou A. Reporting adverse events: Greek doctor and nurse attitudes. *Int J Health Care Qual Assur*. 2010;**23**(7):680-7. doi: 10.1108/09526861011071607. [PubMed: 21125963].
39. Fein S, Hilborne L, Kagawa-Singer M, Spiritus E, Keenan C, Seymann G, et al. A conceptual model for disclosure of medical errors. Rockville (MD): Agency for Healthcare Research and Quality; 2005. [PubMed: 21249826].
40. Kline TJ, Willness C, Ghali WA. Determinants of adverse events in hospitals--the potential role of patient safety culture. *J Healthc Qual*. 2008;**30**(1):11-7. doi: 10.1111/j.1945-1474.2008.tb01122.x. [PubMed: 18257452].
41. Pizzi L, Goldfarb NI, Nash DB. Crew resource management and its applications in medicine. *Making Health Care Safer*. 2001;**44**:511-9.
42. Kalra J. Medical errors: overcoming the challenges. *Clin Biochem*. 2004;**37**(12):1063-71. doi: 10.1016/j.clinbiochem.2004.08.008. [PubMed: 15589811].
43. Caty MG. Complications in pediatric surgery. Florida: CRC Press; 2008. P. 19-27.
44. Kim J, An K, Kim MK, Yoon SH. Nurses' perception of error reporting and patient safety culture in Korea. *West J Nurs Res*. 2007;**29**(7):827-44. doi: 10.1177/0193945906297370. [PubMed: 17636243].
45. Helmreich RL. On error management: lessons from aviation. *BMJ*. 2000;**320**(7237):781-5. doi: 10.1136/bmj.320.7237.781. [PubMed: 10720367].
46. Haghighi MH, Dehghani M, Teshnizi SH, Mahmoodi H. Impact of documentation errors on accuracy of cause of death coding in an educational hospital in Southern Iran. *Health Inf Manag*. 2014;**43**(2):35-42. [PubMed: 24948664].
47. Tran DT, Johnson M. Classifying nursing errors in clinical management within an Australian hospital. *Int Nurs Rev*. 2010;**57**(4):454-62. doi: 10.1111/j.1466-7657.2010.00846.x. [PubMed: 21050197].
48. Keselman A, Smith CA. A classification of errors in lay comprehension of medical documents. *J Biomed Inform*. 2012;**45**(6):1151-63. doi: 10.1016/j.jbi.2012.07.012. [PubMed: 22925723].
49. Farhan J, Al-Jummaa S, Alrajhi AA, Al-Rayes H, Al-Nasser A. Documentation and coding of medical records in a tertiary care center: a pilot study. *Ann Saudi Med*. 2005;**25**(1):46-9. doi: 10.5144/0256-4947.2005.46. [PubMed: 15822494].
50. Sutcliffe KM, Lewton E, Rosenthal MM. Communication failures: an insidious contributor to medical mishaps. *Acad Med*. 2004;**79**(2):186-94. doi: 10.1097/00001888-200402000-00019. [PubMed: 14744724].
51. Pirnejad H, Niazkhani Z, Berg M, Bal R. Intra-organizational communication in healthcare--considerations for standardization and ICT application. *Methods Inf Med*. 2008;**47**(4):336-45. [PubMed: 18690367].
52. Choo J, Hutchinson A, Bucknall T. Nurses' role in medication safety. *J Nurs Manag*. 2010;**18**(7):853-61. doi: 10.1111/j.1365-2834.2010.01164.x. [PubMed: 20946221].
53. Fennigkoh L, Haro D. Human factors and the control of medical device-related error. It's making the world a smarter place. New Jersey: Lawrence Erlbaum Associates; 2010. P. 39.
54. Carroll JS, Williams M, Gallivan TM. The ins and outs of change of shift handoffs between nurses: a communication challenge. *BMJ Qual Saf*. 2012;**21**(7):586-93. doi: 10.1136/bmjqs-2011-000614. [PubMed: 22328456].
55. Abraham J, Kannampallil T, Brenner C, Lopez KD, Almoosa KF, Patel B, et al. Characterizing the structure and content of nurse handoffs: a sequential conversational analysis approach. *J Biomed Inform*. 2016;**59**:76-88. doi: 10.1016/j.jbi.2015.11.009. [PubMed: 26625846].
56. Amato-Vealey EJ, Barba MP, Vealey RJ. Hand-off communication: a requisite for perioperative patient safety. *AORN J*. 2008;**88**(5):763-74. doi: 10.1016/j.aorn.2008.07.022. [PubMed: 19024783].
57. Scarsi KK, Fotis MA, Noskin GA. Pharmacist participation in medical rounds reduces medication errors. *Am J Health Syst Pharm*. 2002;**59**(21):2089-92. doi: 10.1093/ajhp/59.21.2089. [PubMed: 12434722].
58. Longtin Y, Sax H, Leape LL, Sheridan SE, Donaldson L, Pittet D. Patient participation: current knowledge and applicability to patient safety. *Mayo Clin Proc*; 2010;**85**(1):53-62. doi: 10.4065/mcp.2009.0248. [PubMed: 20042562].
59. Zabari ML, Southern NL. Effects of shame and guilt on error reporting among obstetric clinicians. *J Obstet Gynecol Neonatal Nurs*. 2018;**47**(4):468-78. doi: 10.1016/j.jogn.2018.03.002. [PubMed: 29678432].
60. Wilson KA, Burke CS, Priest HA, Salas E. Promoting health care safety through training high reliability teams. *Qual Saf Health Care*. 2005;**14**(4):303-9. doi: 10.1136/qshc.2004.010090. [PubMed: 16076797].
61. Bleetman A, Sanusi S, Dale T, Brace S. Human factors and error prevention in emergency medicine. *Emerg Med J*. 2012;**29**(5):389-93. doi: 10.1136/emj.2010.107698. [PubMed: 21565880].
62. McIlvaine WB. Situational awareness in the operating room: a primer for the anesthesiologist. *Semin Anesth Perioperat Med Pain*. 2007;**26**(3):167-72. doi: 10.1053/j.sane.2007.06.001.
63. Singh H, Giardina TD, Petersen LA, Smith MW, Paul LW, Dismukes K, et al. Exploring situational awareness in diagnostic errors in primary care. *BMJ Qual Saf*. 2012; **21**(1):30-8. doi: 10.1136/bmjqs-2011-000310. [PubMed: 21890757].
64. Risser DT, Rice MM, Salisbury ML, Simon R, Jay GD, Berns SD, et al. The potential for improved teamwork to reduce medical errors in the emergency department. *Ann Emerg Med*. 1999;**34**(3):373-83. doi: 10.1016/s0196-0644(99)70134-4. [PubMed: 10459096].
65. Sun R, Marshall DC, Sykes MC, Maruthappu M, Shalhoub J. The impact of improving teamwork on patient outcomes in surgery: a systematic review. *Int J Surg*. 2018;**53**:171-7. doi: 10.1016/j.ijsu.2018.03.044. [PubMed: 29578095].
66. Ramaswamy RS, Tiwari T, Ramaswamy HF, Akinwande O. Teamwork and communication in interventional radiology. *J Radiol Nurs*. 2017;**36**(4):261-4. doi: 10.1016/j.jradnu.2017.10.003.
67. Hwang JI, Ahn J. Teamwork and clinical error reporting among nurses in Korean hospitals. *Asian Nurs Res (Korean Soc Nurs Sci)*. 2015;**9**(1):14-20. doi: 10.1016/j.anr.2014.09.002. [PubMed: 25829205].
68. Motycka C, Egelund EF, Gannon J, Genuardi F, Gautam S, Stittsworth S, et al. Using interprofessional medication management simulations to impact student attitudes toward teamwork to prevent medication errors. *Curr Pharm Teach Learn*. 2018;**10**(7):982-9. doi: 10.1016/j.cptl.2018.04.010. [PubMed: 30236437].
69. Weingart SN, Zhu J, Chiappetta L, Stuver SO, Schneider EC, Epstein AM, et al. Hospitalized patients' participation and its impact on quality of care and patient safety. *Int J Qual Health Care*. 2011;**23**(3):269-77. doi: 10.1093/intqhc/mzr002. [PubMed: 21307118].
70. Schwappach DL. Review: engaging patients as vigilant partners in safety: a systematic review. *Med Care Res Rev*. 2010; **67**(2):119-48. doi: 10.1177/1077558709342254. [PubMed: 19671916].
71. Hashemi F, Nasrabadi AN, Asghari F. Factors associated with reporting nursing errors in Iran: a qualitative study. *BMC Nurs*. 2012;**11**:20. doi: 10.1186/1472-6955-11-20. [PubMed: 23078517].
72. Kagan I, Barnoy S. Organizational safety culture and medical error reporting by Israeli nurses. *J Nurs Scholarsh*. 2013; **45**(3):273-80. doi: 10.1111/jnu.12026. [PubMed: 23574516].
73. Spath PL. Error reduction in health care: a systems approach to improving patient safety. *J Nurs Regulat*. 2012;**2**(4):60. doi: 10.1016/S2155-8256(15)30255-6.
74. Safarpour H, Tofighi M, Malekyan L, Bazyar J, Varasteh S, Anvary R. Patient safety attitudes, skills, knowledge and barriers related to reporting medical errors by nursing students. *Int J Clin Med*. 2017;**8**(1):11. doi: 10.4236/ijcm.2017.81001.
75. Bognár A, Barach P, Johnson JK, Duncan RC, Birnbach D, Woods D, et al. Errors and the burden of errors: attitudes, perceptions, and the culture of safety in pediatric cardiac surgical teams.

Ann Thorac Surg. 2008;**85**(4):1374-81. doi: 10.1016/j.athoracsur.2007.11.024. [PubMed: 18355531].

76. Landberg HE, Berg P, Andersson L, Bergendorf U, Karlsson JE, Westberg H, et al. Comparison and evaluation of multiple users' usage of the exposure and risk tool: stoffenmanager 5.1. *Ann Occup Hyg*. 2015;**59**(7):821-35. doi: 10.1093/annhyg/mev027. [PubMed: 25858432].