Original Article: Error Coverage in Operating Room Processes by Combined RCA and Fuzzy ANP Method

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ABSTRACT

Various studies conducted in the world and Iran have shown that the issue of patient immunity is one of the most important concerns of health care systems. Lack of immunity and errors in the patient care system are the main concerns of the patient when receiving health services. Reducing avoidable injuries to patients should be a major concern of the health system. In this regard, the use of a systemic approach to investigate errors and make appropriate decisions to prevent their occurrence in the field of health and treatment has been approved. The method focused on network analysis of fuzzy process and radical analysis of cause (s) of case type. The data were collected through direct observation, interview and review of documents. Super Decision software was used to analyze the data. In the data analysis section, 14 types of important errors were selected. In the ranking of errors, medical error was selected as the most important errors. The patient's head and neck, spinelectomy during partial nephrectomy and the patient's arest during catheterization were selected as the most important medical errors. Lack of a general protocol for the anesthesia team, non-uniform temperature of the operating room, lack of pre-up room, long shifts for staff and high fatigue and lack of technical specialist (medical engineering) in the operating room are important causes of errors in this operating room.

Introduction

Patient immunity is a major concern in the health care delivery system (1-3). Previous studies have shown that between 3 and 17% of hospital admissions result in unintended harm to the patient, while 30 to 70% of these events are preventable (4). Deaths from medical errors are reported to be the eighth leading cause of death in the United States (5). In addition, accidents lead to additional annual costs of about $ 37 million in the United States and between one and two billion pounds in the United Kingdom (6).

One of the medical departments of the hospital, which is known as one of the most dangerous departments based on organizational, educational-environmental and technological needs, is operating rooms

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(7). About 234 million surgeries are performed worldwide each year, which means that an average of one in 25 people undergo surgery (8).

Evidence shows that in developed countries, nearly 50% of all adverse events in hospitals occur in operating rooms, with postoperative mortality rates reported between 0.4 and 10%. That is, about one million people worldwide die from surgery. The important point is that more than half of all deaths and complications from surgery can be avoided if operating room standards are met, so that health organizations and treatment to be considered as safe centers, an effective system should be designed and implemented to identify systemic defects and improve patient immunity in a preventive manner (9).

In this regard, the use of a systemic approach to investigate errors and make appropriate decisions to prevent their occurrence in the field of health and treatment has been approved. Therefore, considering that the operating room is one of the high-risk areas of the hospital and includes environmental, process and equipment complexities. In this study, the current processes in the operating rooms are first identified and extracted and then drawn. After that, the root analysis of errors and network analysis between errors will be examined and identified, as well as solutions to prevent errors (10-12).

The beginning of attention to the issue of patient immunity goes back to the report of the American Medical Institute Quality of Medical Care Association in 1999, entitled "Man is a sinful creature, creating a healthier system". Numerous reports in this regard have led to the insecurity of the health system (13).

Reducing avoidable injuries to patients should be a major concern of the health system. Studies in the United States, Canada, the United Kingdom, and Australia show that 4 to 16.6% of injuries to patients are due to errors during hospitalization, which according to the results of these studies is significant (about 50%). Injuries are preventable. In other words, one in ten hospitalized patients experiences a medical injury or error during their stay that may result in their death or disability (14-16).

However, even in industrialized countries, error prevention is not done properly. Given that the surgical ward in a hospital is very important, the performance of this ward is very effective in evaluating the performance of inpatient services and their satisfaction. Surgery is an important health care service that accounts for 40% of hospital costs (17).

Studies show that errors can occur in various fields such as human, systemic, technological, etc., each of which has its own errors. If the errors are not only hierarchical (from top to bottom) on each other, but also it is possible to affect the errors at the level related to themselves and other levels, the error communication will be out of the hierarchical mode and will find a network mode (18-20).

Due to the high probability of error in operating rooms and its consequences for patients, this study seeks to identify and correct errors in operating room processes to increase the effectiveness of processes in the relevant department by analyzing the network relationship of errors.

Materials and methods

The research method is quantitative and qualitative and interviews and questionnaires were used. Because the data is related to surgery and medicine in the field of specialization (urology), it required a specialized study in the field of medicine and terms specific to this field, so before entering the operating room, all studies in this field were considered (21-23).

Then, by entering the operating room and getting acquainted with the operating room environment, while getting acquainted with the surgeries, with specialized surgical terms, surgical methods, type and number of surgeries performed in this operating room, operation process, methods Operation planning, number of personnel shifts and number of personnel and number of operations during the day, week and month, patient transfer process from arrival to complete exit were observed and studied, which was a cross-sectional study for 8 months in which the surgery was evaluated directly and covered all morning, evening and night shifts (24-26).

Surgeries included urology, nephrology, general and vascular, which was designed according to the checklist and used in 7 operating rooms of the hospital. During the study and observation, the opinions of doctors and experts in this field were always used, and about 62 errors with different frequencies were identified, which are examined and isolated in the results (27-29).

Due to the fact that there are several methods for categorizing and analyzing errors in different fields, the method chosen in this research was network analysis of the process and root analysis of the cause (causes). (30-33).

Among the qualitative methods root cause analysis was applied after selecting the most effective errors, since other methods had fewer methods for analyzing the causes and less addressed the root causes, and due to the fact that many factors affect the errors that occur in the operating room. Also, the classification of errors in human, medical and systematic in this study was done, which made the analysis of these errors easier (34-36).

Results

In this study, 8 respondents to the questionnaire who met the inclusion criteria entered the project. The demographic characteristics of the questionnaire respondents are shown in Table 1.

Fuzzy network analysis process

As mentioned before, in this study, the collected data were analyzed using the network analysis process (ANP) method. Therefore, the stages of research data analysis can be presented based on the steps of the network analysis process method. According to the collected errors based on the type of medical, human and systemic errors are summarized in Table 2.

Table 1. Demographic characteristics of the questionnaire respondents

	Variables
(Percentage) number	Specialty
4 (50)	Anesthesiologist
4 (50)	Surgeon and urologist
	Level of education
7 (87.5	fellowship
1 (12.5)	Specialist
	Executive position
2 (25)	Associate Professor
4 (50)	Assistant Professor
2 (25)	Treatment staff
	Work experience (years)
3 (37.5)	<10
4 (50)	10 to 20
1 (5/12)	>20

Table 2. Collected errors by type of medical, human and systemic errors

Symbol	Human operating room errors	Symbol	Human operating room errors	Symbol	Human operating room errors
ME1	.1Patient arrest during catheterization	SY1	1 .High temperature fluctuations in operating rooms	HU1	**.1Prep the surgical site less than 2 minutes**
ME2	.2Decreased sensation after patient anesthesia	SY2	2 .Failure to study the suggestions and complaints in the fund from two years ago	HU2	**. 2 Detachment of the patient's dental veneer during anesthesia**
ME3	.3Insert the catheter in the wrong size	SY3	3 .Improper allocation of operating room	HU3	**.3Do not check operating room accessories before surgery**
ME4	.4Severe shortness of breath After RIRS in the operating room	SY4	4 .Improper operating room scheduling	HU4	**.4Not ordering the necessary tests, CT scans and consultations before the patient enters the operating room**
ME5	.5Amphibian in the head and neck area	SY5	5 .Repair of devices during surgery	HU5	**.5Do not control the patient's profile bracelet during the reception in the operating room**
Symbol	Operating room medical errors	Symbol	Operating room system errors	Symbol	**Human operating room errors**
ME6	.6Severe weakness and lethargy then Catheterization for transplant patient	SY6	6 .Delay in transferring the patient from the operating room to recovery	HU6	**.6The presence of a surgical team without a mask**

ME7	.7Patient splenectomy during Partial nephrectomy (spleen removal)	SY7	7 .Improper timing for timely calibration of sensitive devices	HU7	**.7Unreasonable departure of the nurse garlic cooler during surgery**
ME8	.8Installation of a permanent catheter instead of a temporary catheter and CVP	SY8	.8Inadequate equipment in the operating room	HU8	**.8Repair of devices during surgery**
ME9	.9Install a permanent catheter instead of a temporary catheter			HU9	**.9Lack of coordination between staff in two shifts**
ME10	.10Numbness and coldness of the patient's lower extremities Follow the transplant operation 4 hours after the operation			HU10	**.10Delay in transferring the patient from the operating room to recovery**
ME11	.11Superficial burn in the patient's posterior base			HU11	**.11Delay in operating room cleaning**
ME12	.12The patient is looking for a catheter)First jugular catheter that did not work, then femoral(			HU12	**.12Lagaz stays at the patient's surgical site**
ME13	.13Lack of urine			HU13	**.13Do not use masks**

	after transplantation for Receptor and finally diagnosis of thrombosis				**and goggles when using the solution (High Level)**
ME14	.14Cancellation of the patient after surgery From the injection of anesthetic			HU14	**.14Formally report the operation report before the end of the surgery**
ME15	.15Internal bleeding of the patient in surgery Laparotomy and opening of the patient after two days			HU15	**.15Departure of anesthesia nurse during surgery**
ME16	.16Patient bradycardia during prostate surgery and bleeding due to capsule rupture			HU16	**.16Leave the oxygen outlet open after the end of the shift**
ME17	.17Anesthesia of a patient with irregular AF (ECG) problem			HU17	**.17The patient is not aware of her surgical team due to not introducing the team**
Symbol	Operating room medical errors	Symbol	Operating room system errors	Symbol	**Human operating room errors**
ME18	.18Surgical side displacement in urethroscopic surgery			HU18	**.18Not explaining the type of surgery in outpatient procedures to the patient**

In this study, two types of questionnaires were used to collect information in the field research. In order to collect the opinions of experts regarding the identification of medical, human and systemic errors of Shahid Hasheminejad Hospital in Tehran were considered after extracting 52 errors from the literature review, using the Kyosert method and compiling a questionnaire with a survey of university professors and experts to determine the factors. The literature was used as research errors and it was asked to determine whether in their opinion each of the 52 cases was known as errors. Then, the percentage of experts' agreement was calculated for each.

To reach the acceptable index, the level of 65% agreement was considered, which was mentioned by Lee et al. (2005). As a result of the 52 factors evaluated, 14 errors were determined with the agreement of over 65% of the experts, which is shown in table 3 (37-39).

Table 3. Errors obtained from the Kyusert method

Percent comments	Errors Selected human	signs	Percent comments	Errors Selected Systemic	signs	Percent comments	Errors Selected medical	signs
0.88	Prep the surgical site in less than 2 minutes	HU1	0.82	Improper allocation of the operating room	SY3	0.86	Rupture of the intestine during laparoscopic surgery	ME 20
0.85	Delay in transferring the patient from the operating room to recovery	HU 10	0.81	Inadequate equipment in the operating room	SY8	0.82	Patient arrest during catheterization	ME1
0.82	Not ordering tests, CT scan	HU4	0.79	Repair of devices during surgery	SY5	0.80	Amphibian in the head and neck area	ME5
0.76	Lagaz stays at the patient's surgical	HU 12	0.71	Delay in transferring the patient from the	SY6	0.72	Patient spinelectomy during partial nephrectomy (spleen	ME7

	site			operating room to recovery			removal)	
0.68	Repair of devices during surgery	HU8				0.68	Surgical side displacement in urethroscopic surgery	ME 18

Conceptual model of process network analysis

The hierarchical model for network analysis in this research based on purpose, criteria and options is as follows.

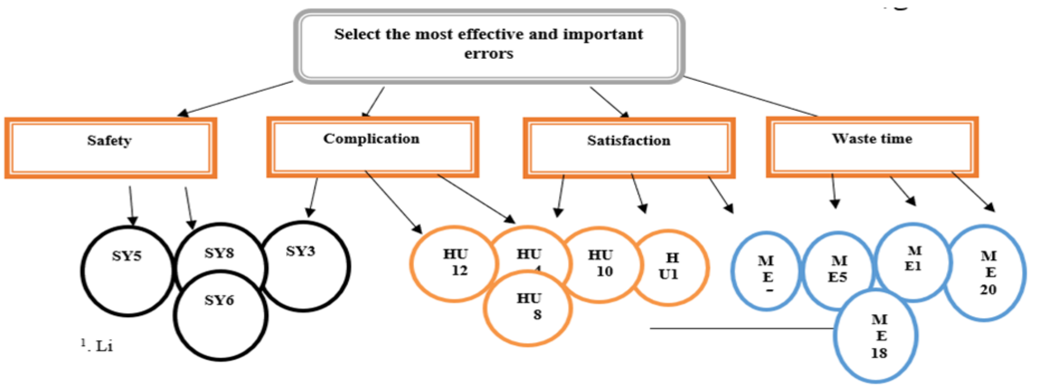


Figure 1. ANP conceptual model

The interpretation of the figure above is summarized in Table 4.

Table 4. Research criteria and options

Options	Criteria	Target
ME20 , ME1 , ME5 , ME7 , ME18 , SY 3, SY 8, SY5, SY6 HU1, HU10, HU4, HU12, HU8	Useless time	Select the most effective and important errors
ME20 , ME1 , ME5 , ME7 , ME18 SY 3, SY 8, SY5, SY6 HU1, HU10, HU4, HU12, HU8	Patient satisfaction	
ME20 , ME1 , ME5 , ME7, ME18 SY 3, SY 8, SY5, SY6 HU1, HU10, HU4, HU12, HU8	Complications of the error	
ME20 , ME1 , ME5 , ME7 , ME18 SY 3, SY 8, SY5, SY6 HU1, HU10, HU4, HU12, HU8	Patient Immunity	

Fuzzy process network analysis method

We used Super Decision software to get the results and analysis in fuzzy and binary comparison. This software helps us to compare the main criteria options in pairs and prioritize them.

Step 1: Form a graphic model:

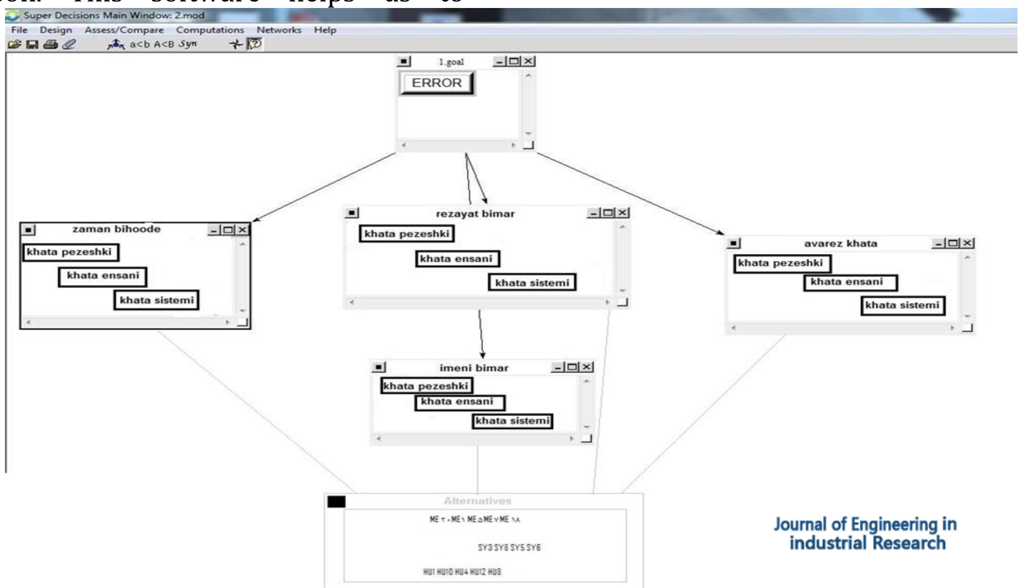


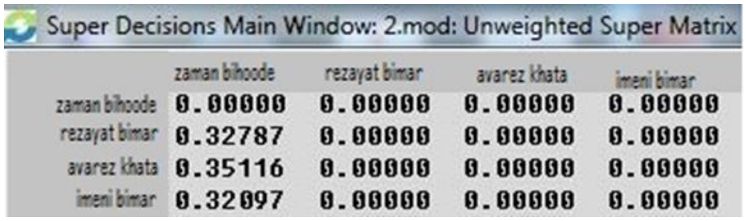
Figure 2. Graphic model

As can be seen, the cluster is targeted at the top. The goal is to select the most effective and important mistakes. In the next step, the index clusters are placed. Zaman bihoode (time of recovery), rezayat bimar (patient consent), avarez khata (side-effect of error) and imeni bimar (patient immunity) indexes are placed and nodes are marked inside them. The next step, marked with alternatives, shows the final part of the decision. The arrows seen in Figure 2 indicate the relationship between the clusters. The goal is linked to all 4 criteria zaman bihoode (time of recovery), rezayat bimar (patient consent), avarez khata (side-effect of error) and imeni bimar (patient immunity), because it is affected by these indicators as well as alternatives. The reason for this is that we want to examine which of the research options ultimately has the highest priority for selection among the main indicators. Finally, this graph tells us, firstly, what the result of the pairwise correlation of the sub-indices is and secondly, the effect of this ranking on the choice of an alternatives. In fact, the result is that by comparing the binaries of each of the indicators, prioritization is done for the same sub-index, and finally, by examining all these prioritizations, the final priority for selecting the most effective and the most important errors in the fields of medicine and health are identified (40-44).

Step 2: Enter the data

Unfortunately, at this time, it was not possible to enter questionnaire data. Therefore, we extracted the values obtained from the pairwise comparison questionnaires and entered these values one by one for each index and option. One can see the result below: As it is clear in the model, each of the indicators has options in which the value of options and indicators must be entered for further calculations. By entering the data, we reach the following results:

1) Super weightless matrix


Super Decisions Main Window: 2.mod: Unweighted Super Matrix

	zaman bihoode	rezayat bimar	avarez khata	imeni bimar
zaman bihoode	0.00000	0.00000	0.00000	0.00000
rezayat bimar	0.32787	0.00000	0.00000	0.00000
avarez khata	0.35116	0.00000	0.00000	0.00000
imeni bimar	0.32097	0.00000	0.00000	0.00000

Figure 3. Weightless supermatrix

Because each of the indicators did not have a separate sub-index, we did not compare the non-identical sub-indices - for example, the sub-indices for useless time and the sub-indices for error effects. The end is zero. Because a one-to-one comparison between these two groups is illogical given that their correlation coefficient is zero

To compute a limit supermatrix, it suffices to bring the random (weightless) supermatrix to infinite power (or a very large number). This is because we want to consider all the effects along all the paths of the supermatrix. The elements of this sup matrix represent the direct effect of each element on the other elements of the system (45).

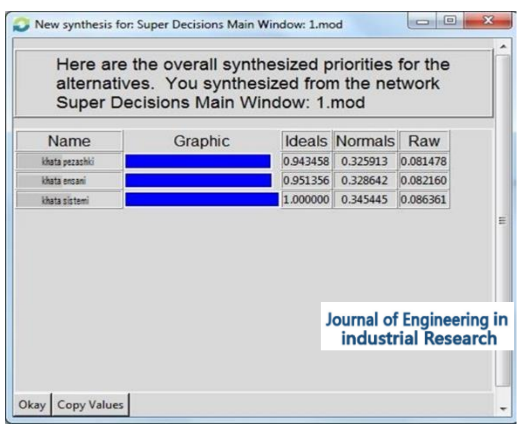
2) Weighted super matrix


Super Decisions Main Window: 2.mod: Weighted Super Matrix

	zaman bihoode	rezayat bimar	avarez khata	imeni bimar
zaman bihoode	0.00000	0.00000	0.00000	0.00000
rezayat bimar	0.08197	0.00000	0.00000	0.00000
avarez khata	0.08779	0.00000	0.00000	0.00000
imeni bimar	0.08024	0.00000	0.00000	0.00000

Figure 4. Weighted super matrix

Ranking of key indicators based on key options


New synthesis for: Super Decisions Main Window: 1.mod

Here are the overall synthesized priorities for the alternatives. You synthesized from the network Super Decisions Main Window: 1.mod

Name	Graphic	Ideals	Normals	Raw
khata pezashki		0.943458	0.325913	0.081478
khata ensani		0.951356	0.328642	0.082160
khata sisteni		1.000000	0.345445	0.086361

Okay Copy Values

Figure 5. Ranking of the main indicators based on shadow options

Assigning the highest number to 1, and then showing how much of the other indicators have the highest score. In fact, the human error index has 95% of the total value of the total errors in the operating room of Shahid Hasheminejad Hospital and the medical error index has 94% of the total value of the operating room of Shahid Hasheminejad Hospital. As it is clear, the normal column shows the weightless matrix values and the Raw column shows the weighted matrix values (42).

Ranking of options based on indicators

Each of the studied indicators had options that were identified at the beginning. The point here is that the values found are very close to each other and have very little difference. One of the reasons for this is that all the indicators used in the design of the model have the highest error detection rate in the operating room of Hasheminejad Hospital. In fact, the researcher has used various studies in order to identify the errors in the operating room of Shahid Hasheminejad Hospital and has entered the most frequent and important errors in the model. Therefore, it can be expected that since these errors are very important for the hospital, the selection of these errors will also improve the performance of human resources, medical personnel and systemic performance. In the general literature, this is explained by the phrase "choosing better than good." (14).

The ranking of the main waste time index options based on system errors are as follows:

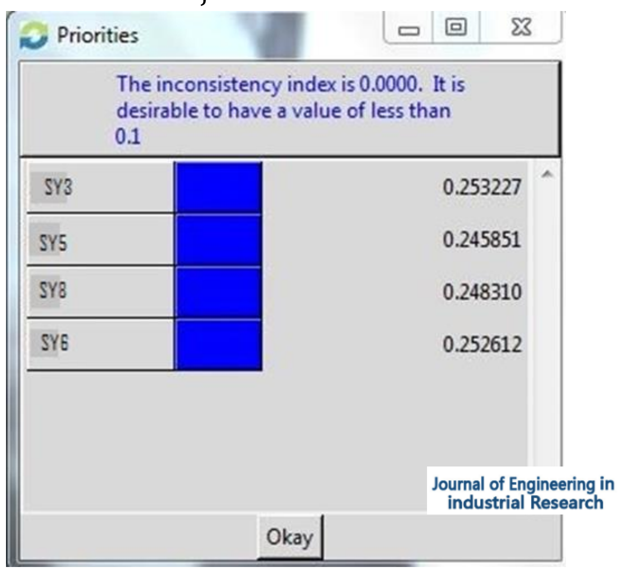


Figure 6. Ranking of waste time index options based on system error components

Table 5. Ranking of useless time components

Rank	Component
1	**Improper allocation of the operating room**
2	**Delay in transferring the patient from the operating room to recovery**
3	**Inadequate equipment in the operating room**
4	**Repair of devices during surgery**

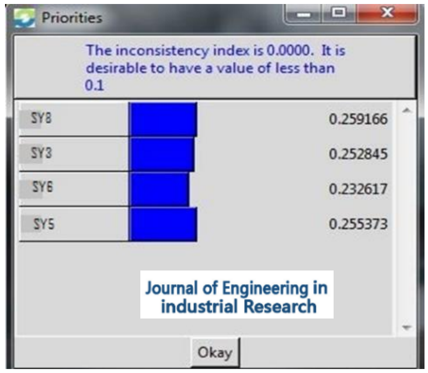


Figure 7. Ranking of patient satisfaction options based on system error

Table 6. Ranking of patient satisfaction options based on system error

Rank	option
1	**Inadequate equipment in the operating room**
2	**Repair of devices during surgery**
3	**Improper allocation of the operating room**
4	**Delay in transferring the patient from the operating room to recovery**

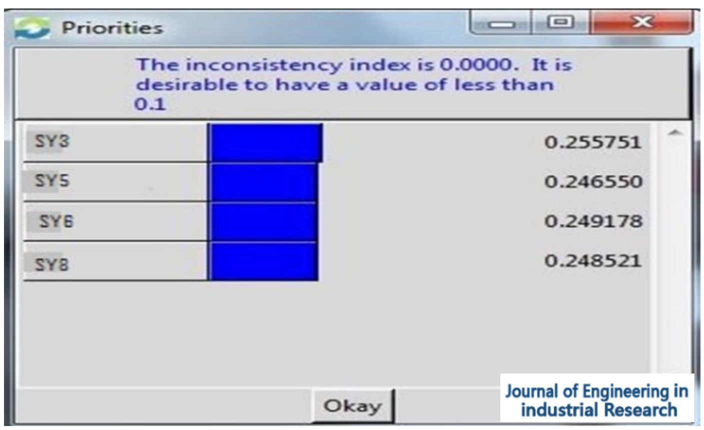


Figure 8. Ranking of error components based on system errors

Table 7. Ranking of error components based on system errors

Rank	Component
1	**Improper allocation of the operating room**
2	**Delay in transferring the patient from the operating room to recovery**
3	**Inadequate equipment in the operating room**
4	**Repair of devices during surgery**

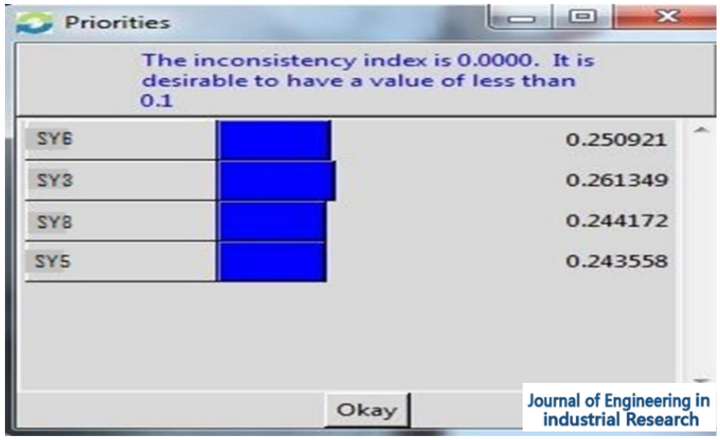


Figure 9. Ranking of patient immunity components based on system errors

Table 8. Ranking of patient immunity components based on system errors

Rank	Component
1	**Improper allocation of the operating room**
2	**Delay in transferring the patient from the operating room to recovery**
3	**Inadequate equipment in the operating room**
4	**Repair of devices during surgery**

Discussion

In this section, where the options of the main indicators, namely wasted time, patient satisfaction, error complications and patient immunity, are ranked based on system error, as can be seen, four errors have been selected from among the errors, which, of course, are ranked in Each of the indicators is different, but there is no new error in the indicators and all four errors are repeated in all four indicators (criteria) and this shows the correct choice and the correct opinion of experts in selecting and scoring errors (5). The main options for wasting time based on medical errors are as follows:

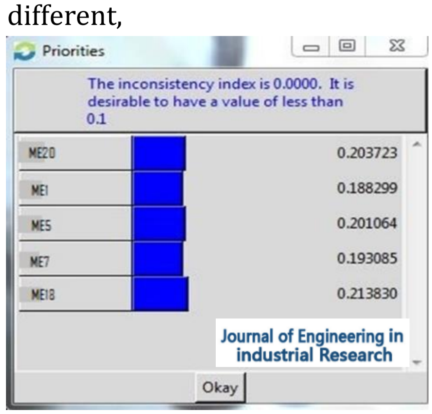


Figure 10. Ranking of useless time components based on medical errors

Table 9. Ranking of waste time components based on medical errors

Rank	Component
1	**Surgical side displacement in urethroscopic surgery**
2	**Rupture of the intestine during laparoscopic surgery**
3	**Amphibian in the head and neck area**
4	**Patient spinelectomy during partial nephrectomy (spleen removal)**
5	**Patient arrest during catheterization**

Table 10. Ranking of patient satisfaction components based on medical errors

Rank	Component
1	**Patient spinelectomy during partial nephrectomy (spleen removal)**
2	**Rupture of the intestine during laparoscopic surgery**
3	**Amphibian in the head and neck area**
4	**Surgical side displacement in urethroscopic surgery**
5	**Patient arrest during catheterization**

Table 11. Ranking the components of error complications based on medical errors

Rank	Component
1	**Amphibian in the head and neck area**
2	**Patient arrest during catheterization**
3	**Patient spinelectomy during partial nephrectomy (spleen removal)**
4	**Surgical side displacement in urethroscopic surgery**
5	**Rupture of the intestine during laparoscopic surgery**

Table 12. Ranking of patient immunity components based on medical errors

Rank	Component
1	**Rupture of the intestine during laparoscopic surgery**
2	**Patient spinelectomy during partial nephrectomy (spleen removal)**
3	**Patient arrest during catheterization**
4	**Amphibian in the head and neck area**
5	**Surgical side displacement in urethroscopic surgery**

In this section, the options of the main indicators are ranked based on medical errors. As can be seen, five errors have been selected from the errors, which are different according to the systematic errors in each of the indicators, but no errors. There is nothing new in the indicators and all five errors are repeated in each of the four indicators.

human mistake

The ranking of the main waste time index options based on human errors is shown in Table 13.

Table 13. Ranking of useless time components based on human errors

Rank	Component
1	**Prep the surgical site in less than 2 minutes**
2	**Delay in transferring the patient from the operating room to recovery**
3	**Not ordering tests, CT scan**
4	**Lagaz stays at the patient's surgical site**
5	**Repair of devices during surgery**

Similarly, the ranking of the main patient satisfaction index options based on human errors is shown in Table 14:

Table 14. Ranking of patient satisfaction components based on human errors

Rank	Component
1	**Repair of devices during surgery**
2	**Not ordering tests, CT scan**
3	**Delay in transferring the patient from the operating room to recovery**
4	**Lagaz stays at the patient's surgical site**
5	**Prep the surgical site in less than 2 minutes**

Similarly, the ranking of the main error index options based on human errors is shown in Table 15:

Table 15. Ranking of error components based on human errors

Rank	Component
1	**Not ordering tests, CT scan**
2	**Prep the surgical site in less than 2 minutes**
3	**Delay in transferring the patient from the operating room to recovery**
4	**Repair of devices during surgery**
5	**Lagaz stays at the patient's surgical site**

Similarly, the ranking of the main patient immunity index options based on human errors is shown in Table 16:

Table 16. Ranking of patient immunity components based on human errors

Rank	Component
1	**Lagaz stays at the patient's surgical site**
2	**Delay in transferring the patient from the operating room to recovery**
3	**Not ordering tests, CT scan**
4	**Prep the surgical site in less than 2 minutes**
5	**Repair of devices during surgery**

In the end, the options of the main indicators are ranked based on human errors. As can be seen, five errors have been selected from the errors. Of course, their ranking is different in each of the indicators, but all five errors are repeated in all four indicators (criteria) and this shows the validity of scoring and correct selection of errors.

Conclusion

Lack of a general protocol for the anesthesia team, non-uniform temperature of the operating room, lack of pre-up room, long shifts for staff and high fatigue and lack of technical specialist (medical engineering) in the operating room are important causes of errors in this operating room.

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