Identification of Service Elements Affecting Customer Satisfaction in Hospital Inpatient Unit Using Fault Tree Analysis and Kano Model

Talitha Ulima Sofiana, Isti Surjandari, and Dwi Bagus Yulianto

***Abstract*—** Inpatient unit is considered as one of the important units in a hospital where improvement in its services may be needed by the hospital to remain competitive. This study represents an attempt to identify elements that may affect inpatients satisfaction. Fault Tree Analysis (FTA) and Kano Model were performed on answers to survey questions posed to several respondents in some units of hospital. The result showed that there were 14 service elements affecting 60% of overall customer satisfaction. Based on FTA, a systematic structure and influence of elements to overall inpatients satisfaction could be determined, while using Kano model, the customer needs could be identified. This study also indicates whether determining the most influencing elements to improve hospital as a distinct example of service industry based on customer satisfaction is no longer impossible.

***Keywords*—** customer satisfaction, Fault Tree Analysis (FTA), hospital, Kano Model.

I. Introduction

THE rising of consumer demand on hospital service quality causes people involved in this business keep creating continuous of improvement. In delivering services, inpatient unit is considered as one of the important units in a hospital where improvement in its services may be needed by the hospital to remain competitive.

In service management, it is important to get customers involvement in service operations. Customer needs must be able to be translated in the service process. On the other hand, service companies are faced with the limitations of quantitative analysis tools used to systematically describe the service process. Moreover, it is necessary to use an analytical tool which can translate customer perspectives into a systematic structure, so the management could know the service elements giving great influence in the company service system that can be used as consideration to improve the quality of service and gain customer satisfaction. In this case, FTA and Kano model were performed to identify them.

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II. Methods

A. Fault Tree Analysis

FTA is a method to analyze system failures from combination of several subsystems and sublevels and also the failure of its components. The fault tree illustrates the relationship between basic event (the root of the incident that cause the top event occurs) and top event (event that occur). Basic event could have environmental conditions, human error, or the specific component failure. The results of this analysis are:

1. list of possible failures; and
2. the probability of events that will occur within a certain time.

FTA symbols commonly used can be seen in Figure 1. Here are the steps commonly performed in FTA:

1. defining failure / risk occurred;
2. constructing the fault tree;
3. identifying *minimal cut set* (MCS);
4. performing qualitative analysis; and
5. performing quantitative analysis. Critical event that will be analyzed is usually called the *top event*.

There are two kinds of analysis in FTA, i.e.: qualitative and quantitative analysis. *Qualitative analysis* is the analysis which is done by making the formation of *logic expressions series* where *the top event is coupled with basic events*. Logic expressions series will form *MCSs* as output of the qualitative analysis. *Quantitative analysis* is the analysis of event probability that occurred. By the existence of the cut set (a series of basic events that cause the top event occurs), the probability of top event can be calculated based on the probability of each event which is obtained by using historical data or engineering judgments when there is no historical data. [1]

In *OR gate*, if event A and B are the inputs of the output Q, then:

$$Pr(Q) = Pr(A) + Pr(B) - Pr(A \cap B) = Pr(A) + Pr(B) - Pr(A)Pr(B|A) = Pr(A)Pr(B) - Pr(B)Pr(A|B) \quad (1)$$

In this condition, note that if A and B are independent then

$$Pr(B|A) = Pr(B) \quad (2)$$

$$Pr(Q) = Pr(A)+Pr(B)-Pr(A)Pr(B) \quad (3)$$

If B is dependent with A, then

$$Pr(B|A)=1 \quad (4)$$

$$Pr(Q)=Pr(B) \quad (5)$$

In *AND gate*, if events A and B are the inputs of Q, then:

$$Pr(Q) = Pr(A)Pr(B|A) = Pr(B)Pr(A|B) \quad (6)$$

Note that if A and B are independent, then equation (2) is applied and

$$Pr(A|B)= Pr(A) \quad (7)$$

$$Pr(Q) = Pr(A)Pr(B) \quad (8)$$

If A and B dependent, then equation (4) is applied and

$$Pr(Q) = Pr(A) \quad (9)$$

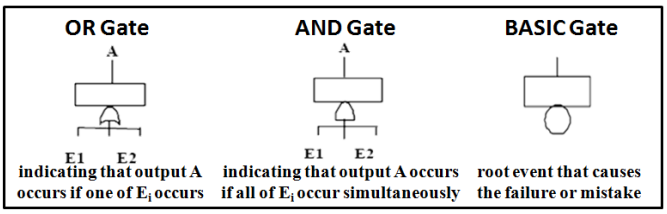

Fig. 1 Symbols Used in FTA

In this case, FTA is used to analyze the service process. First, the Boolean logic gates could explain the choice of customers for each element of service in the service system; whether the customer has to go through all elements of the service or undergo some elements of service only. Second, FTA could find a critical element in the failure of the system in service process. [2]

B. Kano Model

Kano Model is one of the quality methods referring to customer satisfaction in creating products. [5] It can also be used as an effective tool to determine the characteristics of consumer requirements based on consumers responses to given company product features. Characteristics of consumer requirements can be classified as follow:

1. *must be*, i.e.: something that must exist in the current product, so the inability to provide it could cause to high consumer dissatisfaction;
2. *one-dimensional*, consumer satisfaction is achieved when the product is more functional and customer requirements can be met by the company;
3. *attractive*, i.e.: a requirement to increase customer satisfaction by making the product more functional (usually not expected by customer), however, when the variables are not available, consumers do not become dissatisfied;
4. *indifferent*, i.e.: showing the normal features when displayed on the product;
5. *questionable*, i.e. condition where respondent is indicated "like" (or sometimes "dislike") when product is functional and dysfunctional; and
6. *reversal*, i.e.: the opposite of one-dimensional because there are several additional variables that it is not desired by consumers. [3]

The process used for Kano Model is by holding survey (questionnaire). Questionnaires that will be distributed have some questions which contain the same answer choices components shown in table 2, i.e.:

1. like;
2. must be;
3. neutral;
4. may; and
5. dislike.

The calculation of Kano model was done based on Kano Evaluation as can be seen in Table 1 below.

TABLE I
KANO EVALUATION TABLE

Customer needs		Dysfunctional question (negative)				
		1. Like	2. Must be	3. Neutral	4. May	5. Dislike
Functional question (positive)	1. Like	Q	A	A	A	O
	2. Must be	R	I	I	I	M
	3. Neutral	R	I	I	I	M
	4. May	R	I	I	I	M
	5. Dislike	R	R	R	R	Q

Note:
Q = Questionable; R = Reverse; A = Attractive; I = Indifferent; O = One-dimensional; M = Must be [4]

III. RESULT AND ANALYSIS

To arrange the service elements into FTA structure, an observations and interviews about the process of inpatient care to some respondents in each service unit was done. The FTA structure can be seen in Figure 2.

To get the core and peripheral service of FTA, it depends on whether the customer has to go through all elements of the service or not. Core service is defined as something that is really needed by the customer in the service process. Peripheral service is divided into two: supporting service and optional service. Supporting service is service that is not directly related to the main function but help core service runs well. Optional service is defined as additional service which is not connected directly to the main function but could make customers more satisfied.

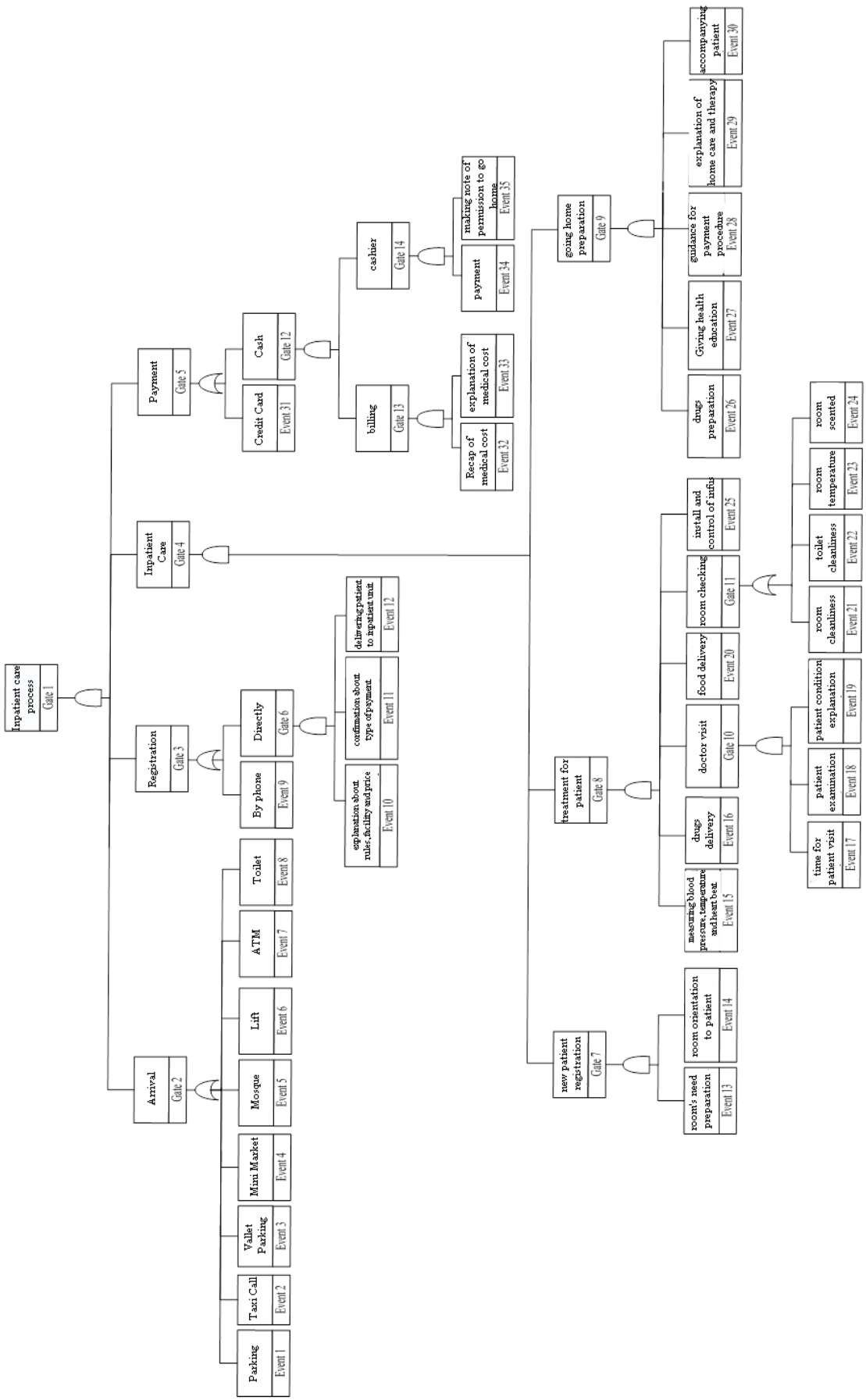

Fig.2 The Structure of the FTA process Inpatient Hospital Services

Following is the procedure of identifying core and peripheral service:

1. determining MCS by using traditional methods of FTA;
2. determining the Minimal Service Cut Sets (MSCS, element which is always traversed by customer), i.e.: E13, E14, E15, E16, E17, E18, E19, E20, E25, E26, E27, E28, E29, and E30;
3. defining core services, i.e.: elements of MSCS;
4. determining the supporting service (E21, E22, E23, E24) and optional service (E1, E2, E3, E4, E5, E6, E7, E8, E9, E10, E11, E12, E31, E32, E33, E34, E35).

The results of qualitative analysis in the service process of hospital can be seen in Table 2.

TABLE II
CLASSIFICATION OF SERVICE ELEMENTS

Type of Service	Service Element (Ei)		
Core Service	preparation of room needed	doctor's examination	health education
	room orientation for patient	explanation of patient condition	guidance of payment procedure
	measuring blood pressure, temperature and heart beat	delivering meal	explanation of home therapy and care
	purchasing medicine	installing and controlling of infuse	accompanying patient
	doctor's visit	medicine preparation	
Supporting service	room cleanliness	room temperature	room scented
	toilet cleanliness		
Optional service	leisure in a hospital parking lot	ATM Center	credit card
	taxi call service	condition of toilet in hospital	recap data of medical cost
	valet parking service	patient registration via phone	explanation of expenses
	mini market	mosque	payment
	a description of the discipline, facilities, and price	confirmation the type of payment to the patient	making note of permission to go home
	Lift	bring patients into inpatient unit	

Quantitative analysis in this study consists of 2 steps: (1) determining the weights of each element of service by deciding coefficient satisfaction levels ranging from 0 to 1, the closer value to 1, the bigger influence to consumer satisfaction, vice versa (see Table 3.); and (2) measuring the effect of each service element to customer satisfaction. To measure the sensitivity of the service element, service quality is improved from 50% (obtained from the average coefficient of customer satisfaction) to 80%. The table 4 shows changes in increasing customer satisfaction for each service element.

The result shows that there are 14 service elements categorized as core services both from class 1, class 2 and class 3 (affect as much as 60% of overall customer satisfaction). This indicates that the increasing of core services is more affecting to increase customer satisfaction rather than increasing the other ones. Results of the analysis explained that there was no significant difference between increasing of satisfaction in all classes.

TABLE III
CUSTOMER SATISFACTION COEFFICIENT CALCULATION RESULTS

	SERVICE ELEMENT	Customer Satisfaction Coefficient		
		Class 1	Class 2	Class 3
1	Leisure in a hospital parking lot	0.33	0.27	0.26
2	Taxi call service	0.39	0.18	0.21
3	Valet parking service	0.24	0.21	0.09
4	Mini market	0.39	0.36	0.38
5	Mosque	0.64	0.55	0.65
6	Lift	0.67	0.52	0.55
7	ATM Center	0.55	0.52	0.48
8	Condition of toilet in hospital	0.76	0.76	0.76
9	Patient registration via phone	0.52	0.58	0.42
10	A description of the discipline, facilities, and price	0.33	0.42	0.32
11	Confirmation the type of payment to the patient	0.52	0.48	0.47
12	Bring patients into inpatient	0.48	0.42	0.44
13	Preparation purpose room	0.64	0.55	0.62
14	Introduction and orientation to the patient's room	0.27	0.3	0.29
15	Measuring blood pressure, body temperature and heart rate	0.61	0.55	0.62
16	Drug delivery	0.73	0.7	0.59
17	Visiting the patient by a doctor	0.64	0.7	0.68
18	Check the condition of patients by doctors	0.79	0.79	0.68
19	A description of the condition of the patient	0.67	0.58	0.82
20	Delivery meals	0.52	0.64	0.5
21	Hygiene room	0.79	0.82	0.85
22	Cleaning the toilet room	0.76	0.76	0.79
23	Room temperature	0.3	0.21	0.12
24	Smells of room	0.39	0.39	0.47
25	Installation and supervision infusion	0.52	0.64	0.53
26	Preparation of drugs	0.48	0.55	0.5
27	Giving health education	0.36	0.27	0.35
28	Directing payment procedure	0.36	0.36	0.29
29	Explanation of the therapy and treatment at home	0.39	0.36	0.5
30	Bring patients home	0.3	0.27	0.26
31	Credit card	0.39	0.42	0.38
32	Recap treatment cost data	0.61	0.7	0.68
33	Explanation of medical expenses	0.52	0.55	0.56
34	Payment	0.58	0.58	0.41
35	Making note of permission to go home	0.48	0.45	0.56

TABLE IV
SATISFACTION IMPROVEMENT

	SERVICE ELEMENT	Satisfaction Improvement (%)		
		Class 1	Class 2	Class 3
1	Leisure in a hospital parking lot	1.28	1.57	1.49
2	Taxi call service	1.57	0.99	1.15
3	Valet parking service	0.89	1.19	0.45
4	Mini market	1.57	2.22	2.29
5	Mosque	3	3.73	4.62
6	Lift	3.22	3.45	3.66
7	ATM Center	2.4	3.45	3.1
8	Condition of toilet in hospital	3.92	6.09	5.89
9	Patient registration via phone	57.65	57.79	57.7
10	A description of the discipline, facilities, and price	1.75	1.58	1.81
11	Confirmation the type of payment to the patient	1.75	1.58	1.81
12	Bring patients into inpatient	1.75	1.58	1.81
13	Preparation purpose room	60	60	60
14	Introduction and orientation to the patient's room	60	60	60
15	Measuring blood pressure, body temperature and heart rate	60	60	60
16	Drug delivery	60	60	60
17	Visiting the patient by a doctor	60	60	60
18	Check the condition of patients by doctors	60	60	60
19	A description of the condition of the patient	60	60	60
20	Delivery meals	60	60	60
21	Hygiene room	13.46	14.86	14.75
22	Cleaning the toilet room	12.62	13.09	13.06
23	Room temperature	3.7	2.55	1.28
24	Smells of room	5.08	5.27	6.1
25	Installation and supervision infusion	60	60	60
26	Preparation of drugs	60	60	60
27	Giving health education	60	60	60
28	Directing payment procedure	60	60	60
29	Explanation of the therapy and treatment at home	60	60	60
30	Bring patients home	60	60	60
31	Credit card	58.38	58.28	58.33
32	Recap treatment cost data	1.3	1.35	1.35
33	Explanation of medical expenses	1.3	1.35	1.35
34	Payment	1.3	1.35	1.35
35	Making note of permission to go home	1.3	1.35	1.35

IV. CONCLUSION

FTA could be used to identify critical events that exist in the system of hospital services. Based on qualitative analysis of the FTA, the characteristics of each service element could be categorized into core, supporting, and optional service. Based on quantitative analysis of FTA, how much influence of each element to overall inpatients satisfaction could be determined. Kano model, as the next relevant method of analysis, could be performed to identify the customer needs. This study also indicates whether determining the most influencing elements to improve hospital as a distinct example of service industry based on customer satisfaction is no longer impossible.

ACKNOWLEDGMENT

The authors would like to gratefully acknowledge all of personnel at Statistics and Quality Engineering Laboratory (SQE Lab), University of Indonesia who had helped us by providing services and facilities related to data processing of this research.

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