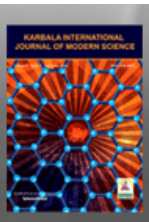

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A Fuzzy Assessment Model for Hospitals Services Quality based on Patient Experience

mohamed khodyer Alkafaji
University of Babylon, mohamed_alkafaji@outlook.com

Eman Salih Al-Shamery
university of Babylon, emanalshamery@itnet.uobabylon.edu.iq

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A Fuzzy Assessment Model for Hospitals Services Quality based on Patient Experience

Abstract

The patient's experience is a lens for services assessment that provide from healthcare institutions because the patient is the first and the last recipient for the service. The patient's experience carries a lot of uncertainty and an ultimate decision cannot be taken from the patient about the services, but it carries the partial truth. Many artificial intelligence technologies deal with the concept of partial truth, such as genetic algorithms and neural networks, but the fuzzy logic remains pioneering to deal with uncertainty. This paper aims to develop an assessment model by using fuzzy inference that is able to assess the quality of services in a similar way to the human experts of healthcare. The fuzzy assessment model applied to measure the patient satisfaction rate for health services for more 4500 hospitals in the United States and two hospitals in Iraq. The services are assessed by the questionnaire and its design according to the questionnaire of the assessment of healthcare providers and systems (HCAHPS) for all hospitals in the United State. The population study in Iraq consisted of 1,000 patients divided between 500 patients from Al-Hillah general teaching hospital and 500 patients from Al-Kafil private hospital. Depending on the patients' answers, the degrees of membership are calculated among the fuzzy sets. The results show a clear difference between the services provided by private hospitals compared to public hospitals.

Keywords

Assessment; Fuzzy set theory; Healthcare; Hospital service quality; Patient's experience; Private Hospital; Public Hospital.

1. Introduction

Nowadays, improving health services quality is a big problem for all countries in the world. The countries seek through their various policies to develop economic and strategic plans to rise the service level and improve health status. The concept of quality and control of quality has become one of the topics that most discussed and most interested by researchers, administrators, consumers, and services funders [1]. Despite the many measures and efforts made to improve the quality of services, it remains open always to question [2,3].

Quality in health services is the clinical quality (technical) and non-clinical quality (functional) quality. Technical quality indicates the procedure's accuracy, care staff skills, and medical diagnosis. Functional quality indicates the way that services are provided to patients [4]. The patient is the basis in the health sector and the main goal is patient satisfaction. Therefore, the patient experience is an important measure of quality [5].

The health sector in Iraq suffers from many dilemmas in technical services and functional services, which leads to preventable deaths and unplanned readmission to the hospital. Poor health services lead to the patient's lack of confidence in the hospital, also it leads to the migration of patients outside Iraq for treatment. In a time, health care has become a tourist destination for many countries that receive patients. Hospitals in Iraq divided into two types are private hospitals and public hospitals. The quality of services provided by private hospitals different from public hospitals. Some researchers discuss health care provided by private hospitals is better than public hospitals [6,7]. In contrast, others discuss the opposite [8,9]. This paper adopted a fuzzy assessment model to measure the patients' satisfaction with the services provided by public hospitals compared to private hospitals.

After this section, which presents a general introduction, the paper discusses in section tow, the most related works that discuss the assessment of the hospitals' services. In section three reviews an extensive description of the main concepts of hospital services, the quality of services, and the machine-learning algorithm that is used in the paper. In section four the research methodology. Section five discussed the experimental results and lastly the conclusion.

2. Relate work

The patient experience attracted many researchers such as:

Kwateng and Lumor compared private hospitals and public hospitals. They adopted a mixed approach to measuring patients' perceptions. The study applied on 400 patients form 30 hospitals in Ghana, it was used the SERVQUAL model to measure five dimensions of service quality. The results indicated that private hospitals provide better services than public hospitals [10].

Al-Neyadi, Abdallah, and Malik proposed a study to assess the healthcare services quality by investigating the factors affect patient satisfaction hospitals. The study included 127 patients from UAE hospitals. It was concluded there is no gap between private hospitals and public hospitals in services [11].

Teshnizi, Hosseini, and others assessed the health services' quality with the SERVQUAL model in Iran. The study showed all dimensions of quality were negative, there is a gap between the patient's satisfaction and the services' quality [12].

Behdioglu, Sema, and others suggested a fuzzy model to evaluate service quality in Yoncalı physiotherapy and rehabilitation hospital in Turkey. The study was included 262 patients and it showed a general dissatisfaction from the provided services [13].

Meesala and Paul introduced a study to assess service quality, consumer satisfaction and loyalty in hospitals. The study was conducted on 180 patients in 40 different hospitals in Hyderabad and it was concluded the patient's loyalty is directly related to the patient's satisfaction with the service [14].

The patient's experience carries a large amount of ambiguity and it contains the partial truth and the partial error. Therefore, the sample size is important to reach the full truth. Through the previous studies, it can be noted the small size of the sample patients adopted by researchers, this does not give a clear impression of the services. In addition to the fact that most data mining technique needs a large sample to give the correct decision.

3. Theoretical background

This section discusses the concept of service and quality, assessing health services, and the concept of fuzzy logic.

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3.1. Service and quality

Many researchers addressed the concept of service, the service definitions are differed according to the researchers' opinions. In Ref. [15] the service was defined, meeting the customer needs from the first moment and at any time. In Ref. [16] the service was defined, interactions or activities between service staff and customers where solutions are provided by service staff to meet the needs of the customers. In Refs. [17] the service was defined, the performance that customers expect. In Ref. [18] the service was defined, intangible activities that benefit the customer. The most common definition of service is the compatibility between the service provided and what the customer expects [19]. Quality is an accompanying concept for all services activities. Any development of the service without looking at the customer's opinion is not an improvement. Therefore, adaptive service according to the customer's opinion is important [20].

3.2. Service quality assessment in healthcare

Health services are different from other services and improve it has become the utmost importance because of it direct connection with the patient's health. Many studies adopted different criteria for measuring service quality. In Ref. [21,22], and [23] the patient's experience was measured by the "SERVQUAL" questionnaire, it set five quality parameters were empathy, tangibility, responsiveness, reliability, and assurance. Another approach to measuring services quality and patient experience is the hospital consumer assessment of healthcare providers and systems (HCAHPS) [24]. HCAHPS is a questionnaire for the patient after leaving the hospital. It developed by the Centers for Medicare & Medicaid Services (CMS) for all hospitals in the United States. HCAHPS includes a set of measures such as communicate doctors, nurses, and healthcare staff with patients; communicate about medications with the patients; Quietness; cleanliness; communicate after patient discharge.

To verify that health services are effective not only from the expert's viewpoint (technical quality), patient expectations are crucial to assessing services (functional quality). The service is considered excellent if it is more than the expectations of the patients, it is considered acceptable if it matches the expectations of the patients, and it is considered bad if it is less than the expectations of the patients [25].

3.3. Fuzzy theory

The fuzzy logic was introduced by Lotfi Zadeh in 1965 [26]. Fuzzy logic is employed to handle the concept of partial truth, when the truth value ranges between true and false [27]. In contrast to Boolean logic, it is part of fuzzy logic. In classical theory, if x an object is a member or not a member of (Z). Equation (1) represented it:

$$\mu_Z(x) = \begin{cases} 1 \text{ if } x \in Z \\ 0 \text{ if } x \notin Z \end{cases} \quad (1)$$

Many forms of membership in fuzzy logic, for example, the quality can take multi fuzzy set forms such as excellent, very good, good, medium, acceptable, and bad. A fuzzy set Z in a sample space of object X is described by a membership function $\mu_Z(x)$ that associates with each element x in the sample space X [28], as in equation (2).

$$Z = \{[x.\mu_Z(x) | x \in X]\} \quad (2)$$

where $\mu_Z\ (x)$ has a value between (0, 1), represents the membership degree of element x. Membership degree of any element among the fuzzy set it determines by the membership function. There are several types of membership function, as shown in Fig. 1. Many researchers focused on the assessment of different aspects of healthcare by using fuzzy logic such as [29,30], and [31].

4. Research methodology

The methodology consists of three stages. The first stage is questionnaire design, collecting questionnaire, and data preprocessing. The second stage is the fuzzy assessment model. The third stage is the evaluation of the results and recommendations of the hospital to improve quality services. Fig. 2 illustrates the proposed methodology.

4.1. Design of the questionnaire

The questionnaire designed after benefiting from the literature and previous studies, it consists of two parts. The first includes general information about the patient (age, gender, and educational qualification). The second includes a quality measure according to the measure in the HCAHPS questionnaire. The questionnaire consists of eight questions. Each question includes different levels for an answer are acceptable, medium, good, very good, and excellent.

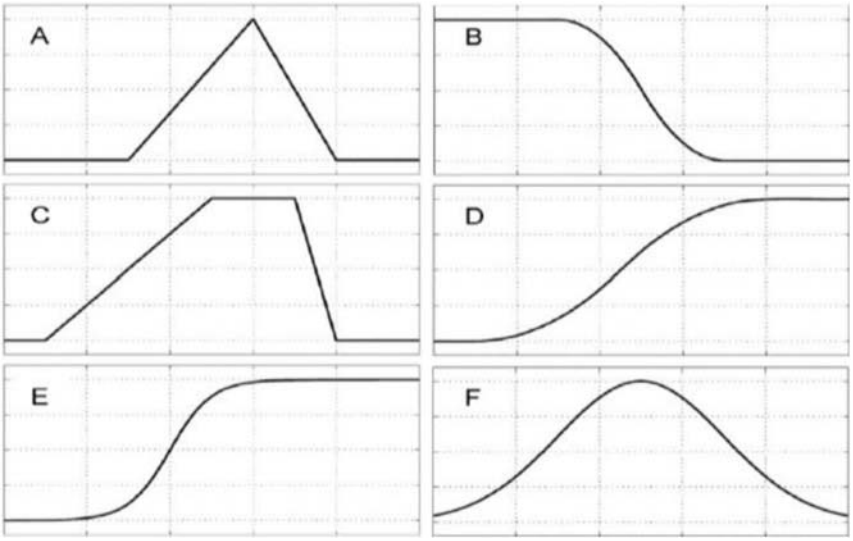


Fig. 1. (A) triangular (B) z-shape (C) trapezoidal (D) s-shape (E) sigmoid, and (F) Gaussian [32].

4.2. Collecting the questionnaires

The questionnaire is circulated to several Iraqi hospitals, but there is no good sample from most hospitals. Comparing to the United States hospitals where the questionnaire is conducted through the hospital and electronically.

The study consists of two types of hospital, Al-Hillah general teaching hospital in Babil Governorate, Al-Kafil private hospital in Karbala Governorate, for the period from October 2019 to February 2020. The population of the study consists of 1000 different patients' questionnaires of males and females, immediately after their discharge from the hospital. It was planned to obtain 750 questionnaires for each hospital, but it is obtained 500 questionnaires. The justifications for choosing two hospitals from two different governors, to find the real level of services within a large geographical area, because both hospitals serve a wide society segment. In addition, getting a different sample of patients. A good sample is obtained from the respondents to the questionnaire. Despite the presence of many obstacles during the questionnaire collection period such as the difficulty of moving between two governors. Moreover, many patients do not prefer questionnaires, because it is directly after the patient discharge from the hospital. Furthermore, patients complain about poor services, thus is reflect negatively on the patient's interest in the questionnaire.

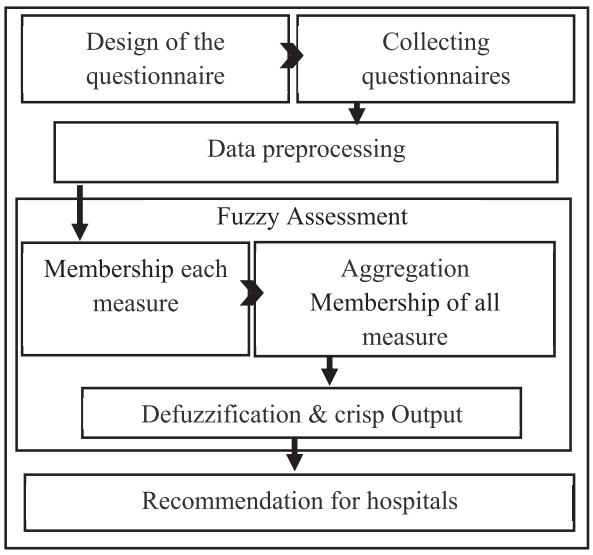


Fig. 2. The architecture of the proposed methodology.

4.3. Data preprocessing

Data preprocessing very necessary before data analysis and sent across the model. In this step, the data are cleaned and standardized. It is observed during the data collection, some patients do not answer all questions and some patients choose more than one answer. Therefore, an unqualified questionnaire and containing missing data are excluded.

The model applies data preprocessing automatically. Where input new questionnaires the model isolates the questionnaires containing more than one answer to the single question, or that contains missing data. After this step, the number of questionnaires

became 446 for Al-Kafil private hospital and 487 for Al-Hillah general teaching hospital.

4.4. Fuzzy assessment model

After collecting and data preprocessing, a fuzzy assessment model consists of three steps, as shown in Fig. 3.

In the first step, converting the real value into a fuzzy value (Fuzzyfication). Each measure from the questionnaire has different memberships among the five fuzzy sets that represent the patient experience for this measure. Memberships are calculated as in equation (6).

Let $x \in X$ where $X = \{\text{Acceptable, Medium, Good, Verygood, Excellent}\}$ (3)

Let $q \in Q$ where Q *is* questionnaire questions. (4)

Let N is Questionnaire Sample space. (5)

$$\mu_{x\in X}\ (\ q\ \in\ Q) = \frac{number\ of\ x\ chosen\ in\ q}{N} \tag{6}$$

$$\mu_{x\in X}:\ q \in Q \rightarrow [0,1] \tag{7}$$

$$\sum \mu_{x\in X}(q) = 1 \tag{8}$$

In the second step, aggregation the membership of all measures to produce unified membership among the fuzzy set. As in equation (9).

$$\mu_{x\in X}(h) = \frac{\sum \mu_x(q \in Q)}{Number\ of\ (Q)} \tag{9}$$

where h is aggregation membership.

In the third step, changing the fuzzy set value to crisp output (Defuzzyfication) by using the rule base to make a decision. R1 represents the rule base, as in equation 10

$$R1: If(\mu_{(x\ U\ X)}\ (h)\ = \mu_{(x\ \in X)}\ (h)) \rightarrow x \tag{10}$$

Algorithm 1, explains the fuzzy assessment model steps.

Algorithm 1. Fuzzy assessment model

```
1   N= Number of patient questionnaires
2   Let X is {Acceptable, Medium, Good, Very good, Excellent}
3   Let q ∈ Q is question of questionnaire
4   Begin
5   for all questionnaires
6   for each q ∈ Q
7   Add one to each x that chosen in q and set in C_x(q)
    // C_x is count the number of x in q for all N
8   End for
9   End for
10  For each q x ∈ Q
11  μ_{x∈X} (q ∈ Q) = C(x)/N
12  End for
13  μ_{x∈X}(h) = Σ μ_x(q∈Q) / Number of (Q)
    // h is aggregation membership
14  If (μ_{(x U X)} (h) = μ_{(x ∈ X)} (h)) then
15  crisp_output = x
16  End if
17  Return crisp_output
18  End
```

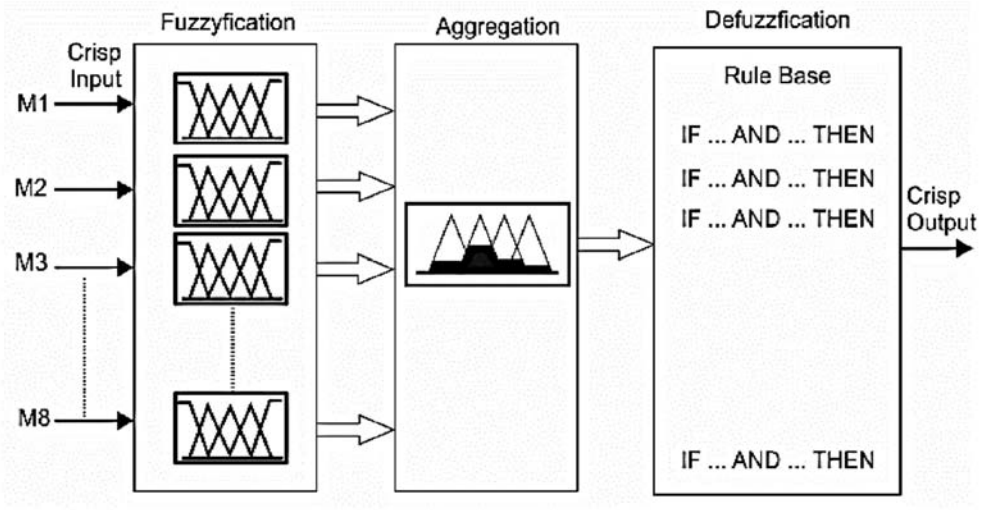


Fig. 3. Fuzzy assessment model.

5. Experimental results and discussion

When applying the first step from fuzzy assessment model to patients' experiences in Al-Kafil private hospital and Al-Hillah general teaching hospital, the results show as in Table 1 and Table 2. Each measure has a different membership degree among fuzzy sets according to the opinion of the patients after their discharge from the hospital by using equation (6). The justifications for using the fuzzy assessment are many such as giving the patient more space to express an experience inside the hospital. Besides, most patients' perceptions contain a high percentage of uncertainty. Therefore, the fuzzy assessment model has a great ability to overcome uncertainty.

The results show a great variation in services between two hospitals. No patient gives an excellent degree for any service in Al-Hillah general teaching hospital, while a small percentage of patients give an acceptable degree to services in Al-Kafil private hospital. It can be seen the services range from the acceptable to the good in Al-Hillah general teaching hospital, while the services range from the medium to the excellent in Al- Kafil hospital, as shown in Fig. 4.

After applying the second step of the fuzzy assessment model, the results aggregation between the fuzzy sets, it is noted that the fuzzy set very good and good are the highest membership ranks among the five fuzzy sets in the Al-Kafil private hospital. Whereas, the fuzzy set acceptable and medium are the highest membership ranks among the five fuzzy sets in Al-Hillah general teaching hospital. Fig. 5 shows the aggregation membership.

After applying the third step from fuzzy assessment model, Fig. 6 shown the crisp output for each hospital.

Through the results, it is evident there are shortcomings in providing functional services in Al-Hillah general teaching hospital comparing to Al-Kafil private hospital. Functional services do not need financial resources or huge infrastructure, there is a clear deficiency in providing services such as cleanliness, quietness, and continuous care for the patient and this is evident through the patient's experience in Al-Hillah general teaching hospital. There are several reasons for shortcomings some of them administrative reasons, poor follow-up by the manager to his staff in the performance of their duties. On the other hand, the employees in the government sector receive a fixed salary. There is no motivation for the employees to provide the best as long as the monthly salary will not change. Moreover, the government health sector suffers from a lack of infrastructure and a lack of resources.

Table 1
Al-Hillah general teaching hospital.

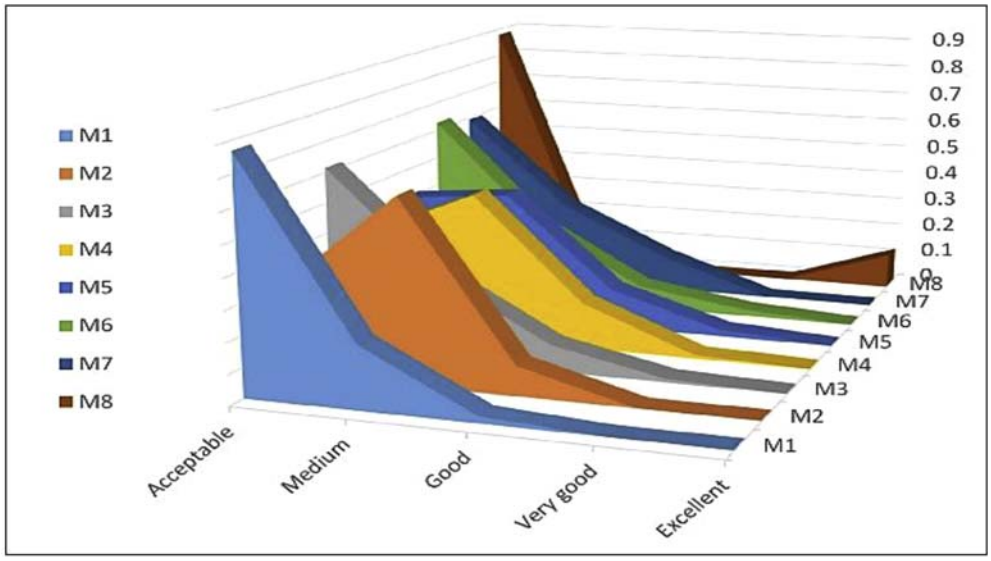
	Acceptable	Medium	Good	Very good	Excellent
M1	0.769	0.209	0.022	0	0
M2	0.297	0.604	0.099	0	0
M3	0.615	0.286	0.088	0.011	0
M4	0.341	0.495	0.154	0.011	0
M5	0.407	0.44	0.132	0.022	0
M6	0.627	0.275	0.077	0.022	0
M7	0.594	0.286	0.121	0	0
M8	0.879	0	0	0	0.121

Table 2
Al-Kafil private hospital.

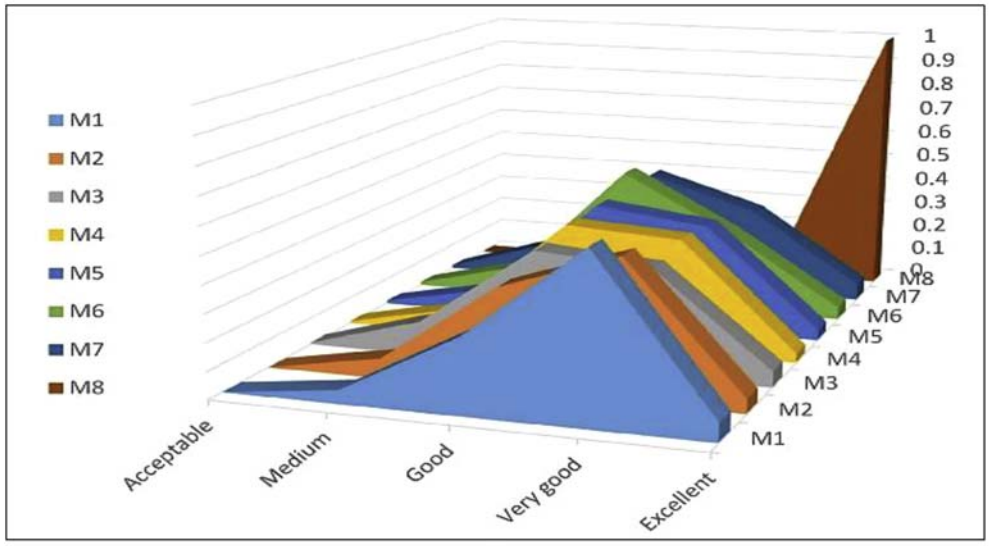
	Acceptable	Medium	Good	Very good	Excellent
M1	0	0.05	0.275	0.606	0.069
M2	0	0.074	0.366	0.505	0.054
M3	0.007	0.124	0.421	0.389	0.059
M4	0.007	0.092	0.446	0.421	0.035
M5	0.01	0.092	0.455	0.403	0.04
M6	0.012	0.111	0.522	0.307	0.047
M7	0.01	0.136	0.455	0.334	0.064
M8	0	0	0	0	1

On the other side, the model is experimented on different data to determine its ability for rapprochement with the human experts' assessment. The same methodology is used on patients' experiences (HCAHPS) for more 4500 hospitals in United State published by CMS in April 2019. In the preprocessing stage, the hospitals that did not report all the questions of the questionnaire are isolated. The number of hospitals became 3413 hospitals. After applying The fuzzy assessment model with the Gaussian membership function, the score of patient satisfaction ranged between good and very good levels, the highest percentage is to a good level, where got 1544 hospitals good level, 1065 hospitals very good level, 515 hospitals medium level, 215 hospitals excellent score, and 74 hospitals acceptable level. While Al-Kafil private hospital got a good level and Al-Hillah general teaching hospital got an acceptable level. The results are shown in Fig. 7.

The strengths of the proposed model compared with the traditional services' assessment models. First, the model works on identifying the weaknesses in the hospitals' services. Second, analyze the results and sends recommendations about the poor services to the



(a)



(b)

Fig. 4. Patient experience, (a) Al-Hillah general teaching hospital, (b) Al- Kafil private hospital.

hospitals to raise its level in the assessment process, thus leads to improve services' quality. Third, it shows a high convergence with human experts' assessment in health care, as well as high adaptability with different data.

6. Conclusion

The services assessment process is important to determine the level of the hospitals compared to other hospitals in the assessment process, which leads the hospital to discover weaknesses in services and work to improve them. The target of healthcare is to provide the best services to the patients at any time. Therefore, improving quality according to patients' perceptions is very important to win patient satisfaction. This paper presented an assessment model using fuzzy inference to measure the degree of patient satisfaction with the services provided by hospitals for more 4500 hospitals in the United States and two hospitals in Iraq. The

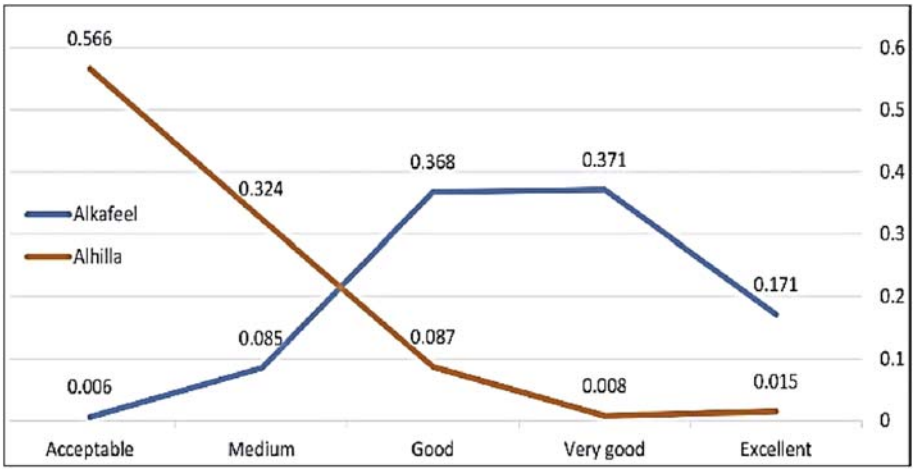


Fig. 5. The difference between the patient's experiences in Al-Hillah general teaching hospital and Al-Kafil private hospital.

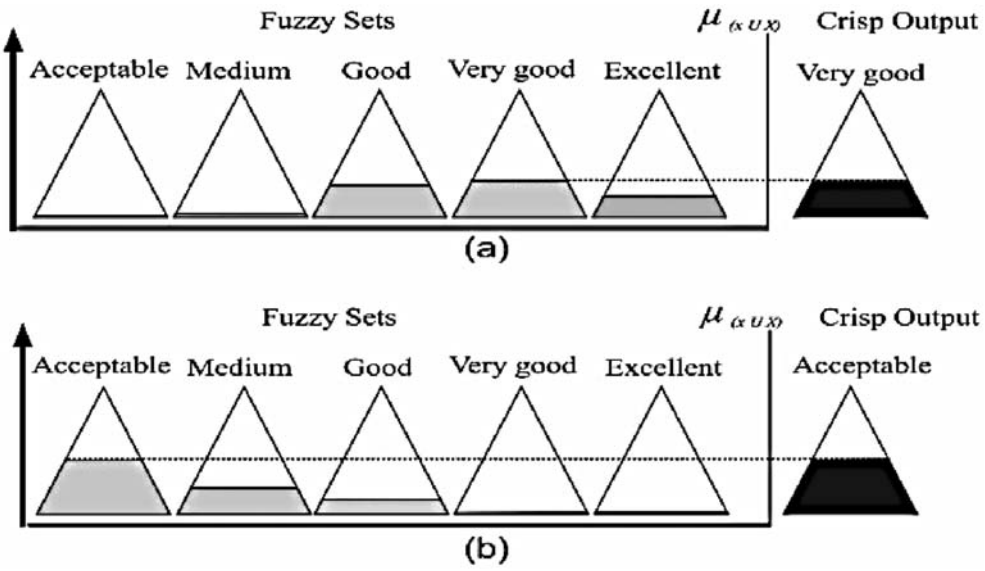


Fig. 6. Crisp output (defuzzification), (a) Al-Kafil private hospital (b) Al-Hillah general teaching hospital.

results showed that more than half of the United States hospitals fall between good level and very good level out of five assessment levels (acceptable, medium, good, very good, and excellent). The study employs fuzzy inference to deal with uncertainty in the patient's experience. The fuzzy inference shows high potential in extracting the correct decision from uncertainty. Membership behavior changes with changing the data, the model gave Al-Kafil hospital in Iraq a very good level in the local domain, while the model gave it a good level compared to the United States hospitals. The study found there are shortcomings in providing functional services in Al-Hillah general teaching hospital comparing to Al-Kafil private hospital such as cleanliness, quietness, and continuous care for the patient. On the other hand, the model recommended improving the services such as continuous communication with the patient and following up on the patient's

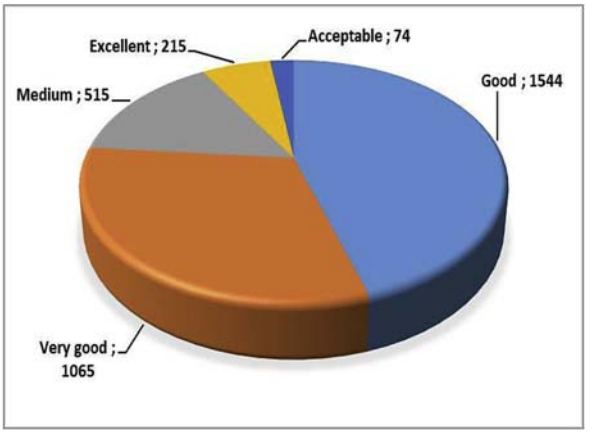


Fig. 7. Frequency of United States hospitals among fuzzy sets according to the fuzzy assessment model based on patient's satisfaction.

health after discharge from the hospital will raise the level of Al-Kafil private hospital assessment from good to very good compared to hospitals in the United States.

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