May. 2014. Vol. 6, No.1 ISSN 2305-1493
International Journal of Scientific Knowledge
Computing and Information Technology

www.ijsk.org/ijsk

APPLICATION OF FUZZY LOGIC FOR PRIORITIZING SERVICE QUALITY IMPROVEMENT IN HEALTHCARE A SURVEY

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ABSTRACT

Service activities are multifaceted and have distinctive behavior of being simultaneous with their delivery and consumption. This makes them intricate and of problematic nature. It is also common to hear customers' complaints in service areas. In healthcare centers, the complaints are high and need immediate solution as the activities in the healthcare consist a work of life perpetuation that should be delivered as fast as possible. Thus, improving the service quality of healthcare centers is a determinant issue. In addition, customer needs are different in nature and difficult to understand. Prioritizing service quality improvement in healthcare is usually uncertain and vague. From the existing methods, there is no single method which fully handles the uncertainties. This paper proposes a fuzzy logic integrated with analytical hierarchy process (AHP) (fuzzy extended AHP) in order to consider the uncertainties to prioritize service quality improvement in healthcare and solve the pitfalls with the exiting methods. As a result, service quality dimensions: Tangibles, Reliability, Responsiveness, Assurance and Empathy are found to be critical factors to prioritize the existing service quality level. In this paper, linguistic values are used to assess the ratings and weights of the factors. Then, AHP model based on fuzzy-sets theory is proposed in dealing with prioritizing service quality improvement in healthcare problems. Finally, Tikur Anbessa Specialized Hospital in Ethiopia is taken to prove and validate the procedure of the proposed method. A sensitivity analysis is also performed to justify the results.

Keywords: ***Fuzzy Logic, AHP, healthcare, service quality, improvement***

1. INTRODUCTION

In most of the developed countries, service sector has a considerable portion in employment and this portion is increasing day to day. This increment is also accepted as a sign of being full-grown and the high quality of the life standards. In addition, service sectors are the main drivers of the economy. As a result; without service sector, development of other sectors are not probable. By the meaning, the quality of the services should be prioritized. Companies also realized that, with the similarity of products and services, service quality is the key role for success in differentiating the products/services. Therefore, enhancing the service quality became vital issue in recent times. Service quality of healthcare sector is fairly variable and healthcare quality is important because human health is in subject and it is crucial to provide healthcare service that meets or exceeds patients' expectations. It also gives us the reason to choose this sector for implementation in such an increasing population and developing country [16]. This paper focused on prioritizing the need of customers in the major services of healthcare sector to improve quality in the sector by the application of fuzzy extended AHP.

The paper is organized as follows: Section 2 explores the literature review; Section 3 presents proposed methodology. Section 4 presents results and discussions. Finally, Section 5 presents the conclusion and future work.

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2. LITERATURE REVIEW

2.1 Service Quality Improvement Approaches

The provision of quality healthcare is an important issue because its twin consequences are relief from suffering and improved health status in humans [2]. But, without measuring the level of priority given for each service dimension by different customers in different healthcare departments, intended improvement cannot be achieved easily. Thus, prioritization of improvement needs should be the first step for service quality improvement especially in healthcare. Measurement based improvements have been applied in healthcare having their own contributions as well as drawbacks in bringing the intended improvement.

The improvement approaches have tried to address the improvement areas by following a general attitude of quality improvement. Different research works were reviewed on how to measure service quality and work for improvement [3], [10], [12], [13], and [16]. In the reviewed research works, service and the accompanying service quality are chosen for research and analysis. Ways to measure the service quality were also proposed as statistical methods, benchmarking, SERVQUAL (service quality methodology), etc. One of the approaches used for analysis in most of previous studies was the use of Likert Scale which was originally introduced by Rensis Likert in 1932[10].In addition to the commonly used Likert scale; other advanced approaches have been studied to improve quality in healthcare. By the use of SERVQUAL as a methodology in an effort to measure service quality and by the use of fuzzy extended AHP to evaluate proposed service quality framework was done to assess hospital performance in Turkey [3].The study prioritized the dimensions after developing a model to measure the relative healthcare performance. A study aimed at integrating the five dimensions of SERVQUAL and fuzzy theory was done by using the five dimensions of SERVQUAL and adopted a fuzzy set theory based research design [16]. A study aimed at identifying the patients' perceived values toward hospitals [12]. The study adopted the fuzzy logic, a method that had been developed to reflect the fuzzy nature of human mind.

The studies discussed above and other studies referred for this research have contributed a lot to improve service quality in healthcare but have also got drawbacks. For the case of using Likert Scale in gathering data, it doesn't give value for the in-between values. As a result, a significant amount of information is lost and/or distorted due to the built-in limitations of the Likert method. The other studies have a drawback of following a general improvement approach without prioritizing the need of the customers in major cases in healthcare departments. This is creating a difficulty in how to prioritize the improvement needs in the sector.

From the existing methods, there is no single method which fully handles the uncertainty through the integrated use of tools to handle vagueness. This paper proposes a fuzzy extended AHP to prioritize the need of customers in the major services of healthcare sector and solve the pitfalls with the exiting methods. However, up to now, research has not been conducted on fuzzy extended AHP to prioritize the need of customers in the major services of healthcare sector.

2.2 Service Quality Improvement through Fuzzy Extended AHP

2.2.1 Fuzzy extended AHP

In this paper, the Fuzzy extended AHP is preferred to be a good approach to work on the identified gap of prioritizing the need of customers in major cases of healthcare departments. Because, fuzzy logic is primarily concerned with quantifying and reasoning using linguistic expression in which words can have ambiguous meaning. Supporting and extending it with AHP helps to give a reasonable weightage in the study to prioritize customer needs in different healthcare departments. In many practical cases, the linguistic assessment of human feelings and perceptions are vague and it is not reasonable to represent it in terms of precise numbers. It feels more confident to give interval judgments than fixed value judgments [5]. Also as the service quality concept is an intangible phenomenon because of criteria, it makes people more difficult to evaluate it. Thus, the case of fuzzy extended AHP approach adequately handles the uncertainty of the human preferences; this method is more desirable and helpful for evaluation. The fuzzy extended AHP methodology extends Saaty's AHP by combining it with the fuzzy set theory pioneered by Zadeh (1965) [3]. As the paper focused on using this approach for prioritizing customer needs in major cases of healthcare departments, some terminologies and operations of fuzzy logic are defined and explained in following sections.

May. 2014. Vol. 6, No.1 ISSN 2305-1493
International Journal of Scientific Knowledge
Computing and Information Technology

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2.2.2 Fuzzy sets

A membership function in fuzzy sets assigns to each object a grade of membership in [0, 1]. A tilde is placed above a symbol if the symbol represents a fuzzy set. A triangular fuzzy number (TFN), M is shown in the figure below. A TFN is denoted simply as (l, m, u). The parameters l, m, and u denote the smallest possible value, the most promising value and the largest possible value that describe a fuzzy event [8]. When l=m=u, it is a non-fuzzy number by convention [5]. As shown in equation (1), and each TFN has linear representations on its left and right side such that its membership function can be defined as:

$$\mu_{\tilde{M}} = \begin{cases} 0, & x < 1 \\ (x - 1)/(m-l), & l \le x \le m, \\ (u- x)/(u- m), & m \le x \le u, \\ 0, & x > u \end{cases} \quad (1)$$

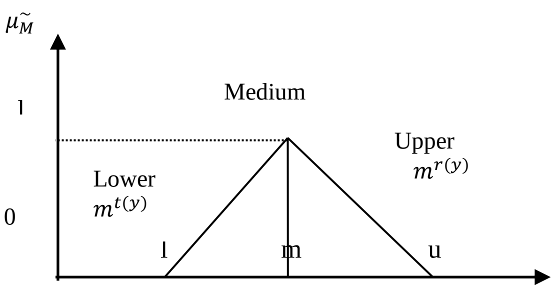

Fig.1. A triangular membership function of fuzzy number

A fuzzy number can always be given by its corresponding left and right representation of each degree of membership [8]:

$\tilde{M} = M^{l(y)}, M^{r(y)} = (l + (m - l)y, u + (m - u)y, y \in [0,1)$ ……………………(2)

Where $M^{l(y)}$ and $M^{r(y)}$ denote the left side representation and the right side representation of a fuzzy number, respectively.

According to the method of [6], the extent analysis method is used to consider the extent of an object to be satisfied for the goal, that is, satisfied extent. In the method, the ''extent'' is quantified by using a fuzzy number. On the basis of the fuzzy values for the extent analysis of each object, a fuzzy synthetic degree value can be obtained. As an example, in a supplier selection problem, let X= $\{x_1, ., x_n\}$ represent the elements of the alternatives as an object set and let U= $\{u_1, ., ., u_m\}$ represent the elements of the supplier selection criteria as a goal set. Each object is taken and extent analysis for each goal g_i is performed respectively. Therefore, m extent analysis values for each object can be obtained, with the following signs:

$M^1_{gi}, M^2_{gi}, ..., M^m_{gi}$ i=1,2..n …………………………………………………(3)

Where all the M^j_{gi} (j=2,.,.,n) are TFNs.

2.2.3 Computational procedure of Fuzzy extended AHP

Step 1. The value of fuzzy synthetic extent with respect to i^{th} object is defined as:

$S_i = \sum_{j=1}^{m} M j_{gi} * 1/\sum_{i=1}^{n}\sum_{j=1}^{m} M j_{gi}$ ……………(4)

To obtain $\sum_{j=1}^{m} M j_{gi}$, the fuzzy addition operation of m extent analysis values for a particular matrix is performed such that:

$\sum_{j=1}^{m} M^j_{gi} = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j\right), i = 1,2, n$ ………………………….(5)

And to obtain $\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M^j_{gi}\right]^{-i}$ perform the fuzzy addition operation $M^j_{gi}(j = 1,2, \dots, n)$ values such that:

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M^j_{gi}\right]^{-1} = M\left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i}\right) \dots (6)$$

Step 2. The degree of possibility of $M_2 = (l_2, m_2, u_2) \ge M_1 = (l_1, m_1, u_1)$ is defined as:

$V(M_2 \ge M_1) = \sup_{y \ge x}[\min(\mu_{M1}(x), \mu_{M2}(y))]$ .. …..(7)

And can be equivalently expressed as:

$V(M_2 \ge M_1) = hgt(M_1 \cap M_2) = \mu_{M2}(d)$ … ……… (8)

Where the value is expected to be:

$$\begin{cases} 1, & \text{if } m_2 \ge m_1, \\ 0, & \text{if } l_1 \ge u_2, \\ l_1\text{-}u_2/(m_2 - u_2) - (m_1 - l_1) & \text{otherwise} \end{cases} \quad \dots(9)$$

Where d is the ordinate of the highest intersection point D between μm_1 and μm_2. Fig.3 below shows the intersection point between M_1 and M_2. To compare M_1 and M_2, the values of $V(M_1 \ge M_2)$ and $V(M_2 \ge M_1)$ are needed.

 ISSN 2305-1493

International Journal of Scientific Knowledge

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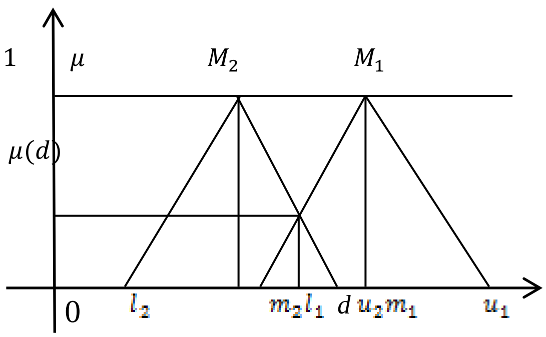

Fig.2. *The intersection between* M_1 *and* M_2 *[6].*

Step 3. The degree of possibility for convex fuzzy number to be greater than k convex fuzzy numbers M; (i = *1* , *2* ,. . ., k) can be defined by:

$V(M \geq M_1 M_2, \ldots, M_k) = V[(M \geq M_1 \text{ and } (M \geq M_2) \text{ and } \ldots \text{ and } (M \geq M_k)] = \min V(M \geq M_i), i = 1,2,3,\ldots,k)$ ……………………………(10)

Assume that $d'(A_1 = \min V(S_i \geq S_k)$ …………………………………………(11)

For K=1,2…n; K≠i, then the weight vector is given

by $W' ((d'(A_1), (d'(A_2) \ldots (d'(A_n))^T$ ……………………………………………….(12)

Where A_i $(i = 1, 2, \ldots, n)$ are n elements.

Through normalization, the normalized weight vectors are

$W = (d(A_1), d(A_2), \ldots, d(A_n))^T$ …(13)

3. RESEARCH METHODOLOGY

The main aim of this paper is to apply the fuzzy extended AHP approach to prioritize the need of customers in the major services of healthcare sector to solve the pitfalls with the exiting methods. Prioritizing the need of customers in the major services of healthcare consists of five main steps:

1. Identifying the common service quality dimensions
2. Prioritizing the service quality dimensions based on fuzzy extended AHP
3. Select case study and develop alternative
4. Prioritize and Rank the Alternatives
5. Sensitivity Analysis

4. RESULTS AND DISCUSSIONS

4.1 Service Quality Dimensions

Before focusing on prioritization of immediate improvement needs, there should be a measuring means for the need of the customer and the existing service quality level. Because, service quality is essential to obtain and retain customers, through the function of customer satisfaction and repurchase [4]. It is the primary contributor to the firm's competitive strength [7], [9]. Literatures have identified that, the major and common service quality dimensions are; Tangibles(physical facilities, equipment, and appearance of contact personnel), Reliability (ability to perform the promised service reliably and accurately), Responsiveness (willingness to help customers and provide prompt service), Assurance (knowledge and courtesy of employees and their ability to inspire trust) and Empathy (provision of caring, individualized attention to consumers)[13].These five dimensions are identified as per their expressive content of service quality.

4.2 Pair-wise Comparison

After identifying the service quality dimensions, different priority weights of each service quality dimensions were calculated using the fuzzy extended AHP approach. The comparison on the importance of one service quality dimension over another was achieved by the help of the questionnaire. The questionnaire facilitates the answering of pair-wise comparison questions. The preference of one measure over another was decided by the experience of the experts.

Experts used the linguistic variables to compare the criteria with respect to the main goal. Then the linguistic variables were converted to fuzzy numbers. Table 1 shows the linguistic variables and their corresponding fuzzy numbers.

After the pair-wise comparison matrices were formed, the consistency of the pair-wise judgment of each comparison matrix was checked, using the calculation method of consistency index and consistency ratios in crisp AHP.

May. 2014. Vol. 6, No.1 ISSN 2305-1493
International Journal of Scientific Knowledge
Computing and Information Technology

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	T	Rel	Res	A	E
T	(1,1,1)	(0.17,0.2,0.25)	(0.13,0.14,0.17)	(0.25,0.33,0.5)	(0.5,1,1)
Rel	(4,5,6)	(1,1,1)	(2,3,4)	(0.5,1,1)	(0.25,0.33,0.5)
Res	(6,7,8)	(0.25,0.33,0.5)	(1,1,1)	(1,1,2)	(0.5,1,1)
A	(2,3,4)	(1,1,2)	(0.5,1,1)	(1,1,1)	(0.5,1,1)
E	(1,1,2)	(2,3,4)	(1,1,2)	(1,1,2)	(1,1,1)

Each fuzzy number, *M = (l, m, u)* in the pair-wise comparison matrix was converted to a crisp number using M-crisp= *(4* m + l + u)/6*. After the fuzzy comparison matrices were converted into crisp matrices; the consistency of each matrix was checked by the method in crisp AHP.

After calculating the consistency ratios of the entire matrix and making it below 0.1, the next step is to calculate the weight vector for each factor lying at different levels of the hierarchy using fuzzy extended AHP approach.

***Table1**. Definition and Membership Function of Fuzzy Scale [14].*

Intensity ofImportance	Fuzzy Number	Definition	Membership Function
9	$\tilde{9}$	Extremely more importance(EMI)	(8,9,10)
7	$\tilde{7}$	Very strong importance(VSI)	(6,7,8)
5	$\tilde{5}$	Strong importance(SI)	(4,5,6)
3	$\tilde{3}$	Moderate importance(MI)	(2,3,4)
1	$\tilde{1}$	Equal importance(EI)	1,1,2)

Step 1. Comparison of the relative strength of each dimension in the same hierarchy

Before going further, there should be the relative weightage of each service quality dimension: Tangibles (T), Reliability (Rel), Responsiveness (Res), Assurance (A) and Empathy (E) with respect to the other as shown in Table 2 by using the saaty's fuzzy scale. A linguistic evaluation with respect to each dimension is taken. The base for giving this weightage is a discussion with experts having more than ten years work experience in the hospital.

- Reliability is strongly important than tangibles.
- Responsiveness is very strongly important than tangibles.
- Assurance is moderately important than tangibles.
- Empathy is equality important as tangibles, responsiveness, and assurance etc.

***Table 2.** The Fuzzy Evaluation Matrix With Respect to The Service Quality Dimensions*

the detail computation, the row sum and the column sum of each dimensions is needed to know weightage for each dimensions and to further proceed in calculating the degree of possibility in step 2. And finally the total column sum should also be computed. The result of these summations is represented in Table 3. Then further calculations of the weightage for each dimension can be easily done as explained next to table 3.

***Table 3**. The Row and Column Sum of each Dimension*

	Row Sums	Column sums
Tangibles	(2.05,2.67,2.92)	(14,17,21)
Reliability	(7.75,10.33,12.5)	(4.42,5.53,7.75)
Responsiveness	(8.75,10.33,12.5)	(4.63,6.14,8.17)
Assurance	(5,7,9)	(3.75,4.33,6.5)
Empathy	(6,7,11)	(2.75,4.33,4.5)
Column Sum		**(29.55,37.33,47.92)**

s_1= (2.05,2.67,2.92)*(1/47.9,1/37.33,1/29.55)= (0.04,0.07,0.10)

s_2 = (7.75,10.33,12.5) *(1/47.9,1/37.33,1/29.55)= (0.16,0.28,0.42)

s_3 = (8.75,10.33,12.5) *(1/47.9,1/37.33,1/29.55)= (0.18,0.28,0.42)

s_4= (5,7,9)*(1/47.9,1/37.33,1/29.55)=(0.10,0.19,0.30)

s_5=(6,7,11)*(1/47.9,1/37.33,1/29.55)= (0.13,0.19,0.37).

Step 2: To calculate the degree of possibility of Si over Si (i – j) , equation (7) and (8) are used.

$V(S_1 \geq S_2) = l_1 \geq u_2$ =0
$V(S_1 \geq S_3) = l_1 \geq u_2$ =0
$V(S_1 \geq S_4) = l_1 \geq u_2$ =0
$V(S_1 \geq S_5) = l_1 \geq u_2$ =0
$V(S_2 \geq S_1) = m_2 \geq m_1$=1
$V(S_2 \geq S_3)= m_2 \geq m_1$=1
$V(S_2 \geq S_4) = m_2 \geq m_1$=1
$V(S_2 \geq S_5) = m_2 \geq m_1$=1
$V(S_3 \geq S_1)= m_2 \geq m_1$=1
$V(S_3 \geq S_2) = m_2 \geq m_1$=1
$V(S_3 \geq S_4)= m_2 \geq m_1$=1
$V(S_3 \geq S_5) = m_2 \geq m_1$=1
$V(S_4 \geq S_1) = m_2 \geq m_1$=1
$V(S_4 \geq S_2)=\frac{0.16-0.30}{(0.19-0.30)-(0.28-0.16)}$=0.61 $V(S_4 \geq S_3) = \frac{0.18-0.42}{(0.28-0.42)-(0.28-0.18)}$ =1
$V(S_4 \geq S_5)= m_2 \geq m_1$=1
$V(S_5 \geq S_1) = m_2 \geq m_1$=1

May. 2014. Vol. 6, No.1 ISSN 2305-1493
International Journal of Scientific Knowledge
Computing and Information Technology

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Step 3. The degree of possibility for a convex fuzzy number to be greater than k convex fuzzy numbers $M_i(i = 1,2, \dots, k)$ can be defined by equation(11):

$d(A_t) = \min V(S_i \geq S_k)$

$V(M \geq M_1, M_2, \dots, M_k) = V[(M \geq M_1) and\ (M \geq M_2) and \dots and\ (M \geq M_k)] = min V(M \geq M_i), i = 1,2,3, \dots, k\ W' = ((d'(A_1), d'(A_2), \dots, d'(A_n))^T$

Where A_i $(i = 1,2, \dots, n)$ are n elements. Via normalization, the normalized weight vectors are:

$W = (d(A_1), d(A_2), \dots, d(A_n))^T$

Where W is a non-fuzzy number. This gives the priority weights of one alternative over another.

d′(C1) = V($S_1 \geq S_2, S_3, S_4, S_5$) = min(0,0,0,0,) = 0
d′(C2) = V($S_2, \geq S_1, S_3, S_4, S_5$) = min(1,1,1,1) = 1
d′(C3) = V($S_3 \geq S_1, S_2, S_4, S_5$) = min(1,1,1,1) = 1
d′(C4) = V($S_4, \geq S_1, S_2, S_3, S_5$) = min(1,0.61,1,1) = 0.61
d′ (C5) = V ($S_5 \geq S_1\ S_2, S_3, S_4,$) = min (1, 0.7, 0.75,1) = 0.7
W′ = (0, 1, 1, 0.61, 0.7)

Through normalization, the weight vectors are obtained with respect to the decision criteria C1, C2, C3, C4 and C5 :W = (0,0.30,0.30,0.18,0.21). The final weights for Tangibles (T), Reliability (Rel), Responsiveness (Res), Assurance (A) and Empathy (E) were found to be 0, 0.3, 0.3, 0.18, and 0.21, respectively. It is concluded that the most important quality dimensions per the need of the customer to be prioritized in the major services of healthcare sector are Reliability (Rel) and Responsiveness (Res) as they have the highest and equal priority weight. Empathy (E) is the next preferred dimensions.

4.3 Prioritizing Service Quality Improvement Needs in Tikur Anbessa Specialized Hospital

The healthcare sector in Ethiopia is having aggravated customer complain. To minimize this complain, different activities that focus on improving the existing service delivery mechanism in the sector have been done. Among them, the use of a reform cycle for controlling quality in the hospital having similarity with the Deming's PDCA(Plan, Do, Check, Act) was used as a blueprint to improve the overall service quality in the hospital. BPR (Business Process Re-engineering) was also implemented in 2010 to help in facilitating the service quality in the highest referral hospital of the country (Tikur Anbessa Specialized Hospital). But the results achieved were not as expected. Implementation of TQM (total Quality Management) was also proposed to be implemented by integrating with business process re-engineering [15]. These improvement activities were not successful because they lack a focus of prioritizing customer needs in the major cases of healthcare departments of the sector. Though the need of customers in healthcare sector can be generalized as to get fast and good service of life perpetuation, the major priority of the service dimensions in major cases of healthcare departments is not clearly stated in the hospital rather than following a general approach of service quality improvement. This study deals with how to prioritize customer needs in different cases of healthcare departments by measuring the dominant service quality dimensions using the fuzzy extended AHP concept and by taking the case of Tikur Anbessa Specialized Hospital.

Tikur Anbessa Specialized Hospital is the highest referral hospital in Ethiopia. The number of patients weekly served is around 25,000.This number includes all the cases coming to the hospital with and without referral (for urgent cases).The major departments are: Emergency department, Outpatient department, Referral department, Gynecology and Obstetrics department, Surgical department, Pediatric department and Inpatient department for different medical cases. But in all departments, there are Emergency cases, referral cases and outpatient cases. Thus, this study focused on these three representative cases throughout the hospital and on measuring the major service dimensions (tangibles, reliability, responsiveness, assurance and empathy) in each case as the level of complain is different in all cases. This indicates the priority of different quality needs is different in all the departments. And for an ease of identifying the improvement needs, the level of the priorities needed in each departments should be studied. To assess this, the SERVQUAL approach is used supported with the Fuzzy extended AHP concept. By this approach, the major dimensions of service quality are prioritized in the three representative cases of the services in the hospital. Fig. 4 represents the overall objective, the basic criteria to consider for selection (service quality dimensions) and the major case in healthcare departments that is selected as a result of the measurement and analysis by fuzzy extended AHP.

May. 2014. Vol. 6, No.1 ISSN 2305-1493
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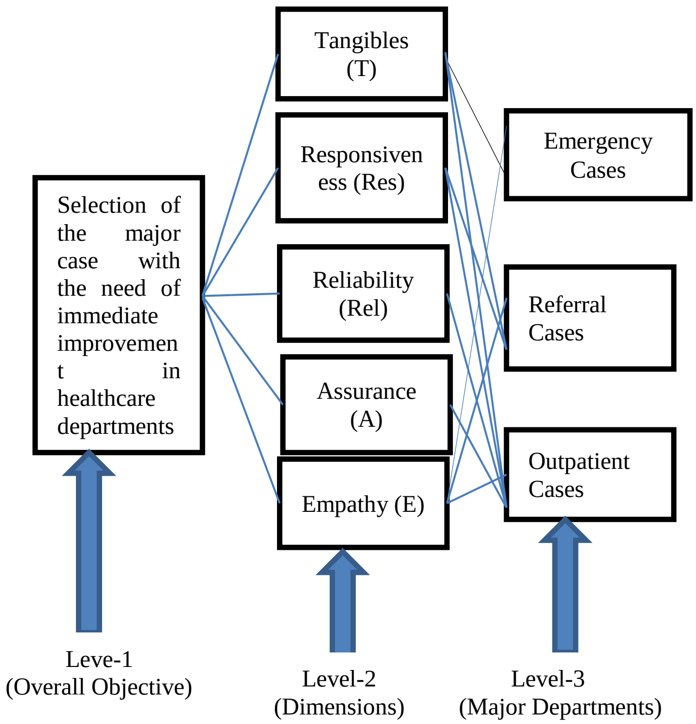

Figure 3. *Evaluation Framework to select specific healthcare department*

By applying the fuzzy extended AHP concept with fuzzy numbers and hierarchical analysis to find preference weights through a step by step pair wise comparison in a reasonable way, the major case in need of immediate quality improvement is selected as explained in the next topics.

Similarly, relative weightages are given for the five dimensions with respect to each case as represented in tables;, 4,5,6,7 and 8.By using the weightages given in the tables, raw sum and column sum calculations and finding the total column sum, the priority weights of the five dimensions in the three major cases in the hospital are computed and represented in each table.

Table 4. *Pririty of each case in major departments with respect to Tangibles*

T	Emergency case	Referral case	Outpatient case	Priority weight
Emergency case	(1,1,1)	(0.13,0.14,0.17)	(0.25,0.33, 0.5)	0
Referral case	(6,7,8)	(1,1,1)	(2,3,4)	1
Outpatient case	(2,3,4)	(0.25,0.33,0.5)	(1,1,1)	0

Table 5. *Pririty of Each Case in Major Departments With Respect to Reliability*

Rel	Emerge-ncy case	Referral case	Outpatient case	Priority weight
Emergency case	(1,1,1)	(6,7,8)	(0.5,1,1)	0.42
Referral case	(0.13,0.14, 0.17)	(1,1,1)	(4,5,6)	0.16
Outpatient case	(1,1,2)	(0.17,0.2 ,0.25)	(1,1,1)	0.42

Table 6. *Pririty of Each Case in Major Departments with Respect to Responsiveness*

Res	Emerge-ncy case	Refer-ral case	Outpatient case	Priority weight
Emergency case	(1,1,1)	(8,9,10)	(6,7,8)	0.66
Referral case	(0.1,0.11,0.13)	(1,1,1)	(0.5,1,1)	0.17
Outpatient case	(0.13,0.14, 0.17)	(1,1,2)	(1,1,1)	0.17

Table 7. *Pririty of Each Case in Major Departments with Respect to Empathy*

Empathy	Emergency case	Referral case	Outpatient case	Priority weight
Emergency case	(1,1,1)	(0.5,1,1)	(2,3,4)	0.52
Referral case	(1,1,2)	(1,1,1)	(0.5,1,1)	0.28
Outpatient case	(1,1,2)	(1,1,2)	(0.5,1,1)	0.30

Table 8. *Pririty of Each Case in Major Departments with Respect to Assurance*

A	Emergency case	Referral case	Outpatient case	Priority weight
Emergency case	(1,1,1)	(1,1,2)	(2,3,4)	0.52
Referral case	(0.5,1,1)	(1,1,1)	(0.25,0.33,0.5)	0.04
Outpatient case	(0.25,0.33,0.5)	(2,3,4)	(1,1,1)	0.44

May. 2014. Vol. 6, No.1 ISSN 2305-1493
International Journal of Scientific Knowledge
Computing and Information Technology

www.ijsk.org/ijsk

After having the priority weights of the five dimensions in the three cases, all the weights are collected in one table as shown in Table 9.

4.4 Prioritize and Rank the Alternatives

The same calculations were applied to the other pair-wise comparison matrices and the priority weights in the three cases with respect to the five dimensions; Tangibles (T), Reliability (Rel), Responsiveness (Res), Assurance (A) and Empathy (E). Results of these pair-wise comparison matrices are shown in Table 9.
By taking the average of each of the priority weights, the final weight that should be given in the major cases of the departments is determined. From the result found and represented in the last column of this table, the case that needs immediate quality improvement is known. The priority weights for the alternatives were found to be (0.42, 0.33, 0.25). According to the result, healthcare service in emergency cases should be first improved to minimize customer complain then the referral cases and Outpatient cases should be assessed accordingly.

Table 9. *Pririty of Each Department With Respect to the Overall Service Quality Dimensions*

Cases	T	Rel	Res	E	A	Weight
Emergency case	0	0.42	0.66	0.52	0.52	0.42
Referral case	1	0.16	0.17	0.28	0.04	0.33
Outpatient case	0	0.42	0.17	0.20	0.44	0.25

4.5 Sensitivity Analysis

A sensitivity analysis is conducted in order to monitor the robustness of the preference ranking among the alternative cases by changing the priority weights of the quality dimensions. Five trials have been done to justify the results. As shown in fig.4 in most trial cases the ranking among the alternatives stayed the same. In case 1 when Tangibles (T) quality dimension significantly higher than the others and in Case 4 Tangibles (T) and Empathy (E) quality dimensions higher than the others, the ranking between emergency cases and referral case are exchanged. In case 2 when Empathy (E) quality dimension increases, and in case 5 when all quality dimensions have equal weight the rank of emergency cases referral case and outpatient case stayed the same. Generally, sensitivity analysis shows that the ranking among the cases is not sensitive to the changes in the weights of the quality dimensions.

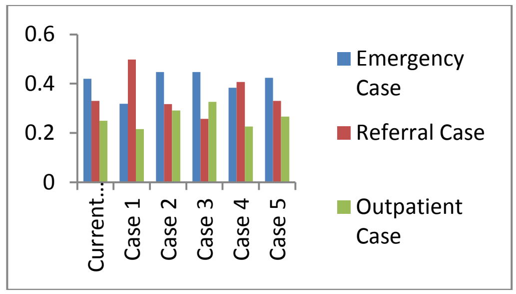

Figure 4. Sensitivity Analysis

CONCLUSION AND FUTURE WORK

In this study, fuzzy extended AHP was used as a methodology to prioritize the need of immediate quality improvement solutions in core cases of healthcare departments. Using fuzzy extended AHP helps in clarifying the fuzziness in human needs which is difficult to measure especially in service sector. Healthcare sector was selected as a case specifically Tikur Anbessa Specialized Hospital in Ethiopia to implement this methodology and come up with solution proposal for the sector to minimize customer complaints. Accordingly ,the result of this study showed improvement plans in the sector should first focus on emergency cases, then on referral cases and finally on outpatient cases. Sensitivity analysis is also performed to discuss and explain the results. As a future study, the authors planned plan to use other methods to measure and prioritize the need of customers in the major services of healthcare sector and to compare fuzzy extended AHP with the other methods.

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