IOSR Journal of Business and Management (IOSR-JBM)
e-ISSN:2278-487X, p-ISSN: 2319-7668. Volume 25, Issue 5. Ser. III (May. 2023), PP 41-53
www.iosrjournals.org

FUZZY Methodology Applied IN THE EVALUATION OF THE QUALITY Of Hospital SERVICES. Case Study IN A HOSPITAL In Amazonas.

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Abstract:
Background*: There is currently an important challenge for hospital companies, which is to offer their services with the highest quality to their customers. And meeting this demand requires more efforts from public or private organizations to provide quality services offered to customers who are more demanding and interested not only in cost, but in the quality of the product or service offered. Therefore, if you guarantee in the market, you have an unknown, to evaluate the quality of services to monitor the quality of service according to the expectations of your customers, thereby creating competitive advantages. In this context, the private hospital in Manaus is with an interest in measuring its quality, placing itself as an object of study, in order to know: the quality of the services offered by the Hospital in the view of the clients, identifying the relevant positive and negative aspects for that the Hospital can act more precisely on the points that allow it to achieve excellence in customer service and acquire more competitiveness.*
Materials and Methods: *This reality dictates the need to create effective methods to meet the demand for quality in hospital services. In response, the purpose of this study arises to create a quality assessment model using the Fuzzy inference system, based on the studies by Parasuraman, Zeithaml and Berry, in 1994, who developed the SERVQUAL scale, an efficient instrument to assess the quality of services with evaluative diagnosis of quality that are important and followed until today.*
Results*: For this, a model was developed to evaluate the quality of private hospital services in Manaus. The questionnaire was used as data collection techniques, as determined by the SERVQUAL scale, which generated variables that were used for Fuzzy Inference in the Matlab R16 Student software.*
Conclusion: *The results made it possible to evaluate the quality of customer service, which reached an index of 82.7%, thus identifying the level of customer satisfaction, highlighting the negative points, essential information for managers to implement appropriate improvements.*
Key Word*:*Quality; Servqual; Fuzzy; Methodology; Hospital.

Date of Submission: 08-05-2023 Date of Acceptance: 18-05-2023

I. Introduction

This work presents a summary on how to evaluate the quality of services offered by hospital companies, what is the method for this and its importance in the process of management and support of the institution, mainly in the private area. Economic studies emphasize this theme in the list of first fruits that enable and sustain a company in the current market, as customers are increasingly demanding and interested not only in cost, but in the quality of the product or service offered. This trajectory forces organizations to be continually concerned with improving their production processes and services to achieve quality and minimize the negative impacts that surround them.

This denotes that the quality of services is fundamental for the performance and competitiveness of a company's business and emphasizes that it is important to monitor the quality of the products and services offered according to the needs and expectations of its customers, thereby creating competitive advantages in the face of competition (ANTUNES AND TREVISAN, 2000; VOLPATO et al., 2010; STEFANO et al. 2018).

The management processes of current companies are concerned and demonstrate an evolution in quality over time, trying to keep up with market demands. In this social configuration, it is identified that measuring the quality of products and services offered is essential to have preference in the current competitive scenario. To do

so, it must start from the principle that the efficiency of the activity is linked to a constant focus on observing the basic characteristics of "quality" according to customer satisfaction. Current studies show that 75% of companies consider Customer Service (SAC) a competitive advantage in the market, as it allows listening to customers and directing effective actions (DIMENSION DATA GLOBAL CONTACT CENTER BENCHMARKING REPORT, 2017). Faced with the complexity of the problem, the development and application of this logistics becomes challenging because the current market requires greater efficiency on the part of companies in terms of customer service.

Therefore, measuring customer satisfaction becomes an unknown, since the quality of services includes a composite of several attributes with items, subcriteria or constructs where all must be analyzed (BEZERRA, GOMES, 2015; DHAR, 2015). These attributes include the tangible ones that are easy to assess, and the intangible and subjective ones, which are difficult to assess (STEFANO, et al. 2018). And for that, it is necessary to evaluate the quality of services with instruments that offer managers efficient parameters that permeate quality, so that they can clearly see to the interested parties where to act.

Following this premise, the object of study emerged, a Private Hospital, which aims to offer quality services to its customers. The commitment of the managers of this hospital to achieve excellence in its services and thus increase its competitiveness is notorious. In this bias, it becomes necessary to know and understand the quality of the services provided, through the customer's perception, considering that to achieve quality in customer service, it is essential to meet customer expectations.

It is therefore appropriate to raise the following questions: How is the quality of the services offered by the private hospital under study in the view of its customers? Do the services offered by the hospital need improvements and innovations in the operational dynamics (agility and optimization)? Therefore, in order to respond to the premises discussed, it is necessary to know: the quality of the services offered by the Private Hospital in Manaus in the view of the clients, identifying the relevant positive and negative aspects so that the Hospital can act more precisely in the points that enable it to reach excellence in customer service and become more competitive. Therefore, understanding quality requires an efficient methodology to meet this demand.

To meet this premise and justify this research with the aim of helping service organizations in the evaluated unit, we followed the studies by Juran (1992), Slack et al. (2009), Stefano et al. (2018), Nogueira (2019), Silva et al (2021) and Souza (2019), since their methodology allowed managers to better assess the quality of the service offered, and bring many benefits that added, cost reduction, reduction of material stocks, savings in operating and waiting time, increased confidence in operations, agility in responding to changes in the organizational environment, in addition to operating within the programmed schedule.

In this context, the main objective is to develop a model for assessing private hospital services using the Fuzzy inference system, the Fuzzy logic (ZADEH, 1965) was chosen as tools capable of making the evaluative diagnosis of quality (ZADEH, 1965), together with the SERVQUAL scale, model perfected by Parasuraman, Zeithaml and Berry (1994) creating the work "Delivering Quality Service", with the purpose of measuring the quality of the perception of the services received and the expectations of the customers.

II. Material and Methods

This research in terms of nature has an applied character, as for the approach is qualitative, the data collected on quality are transcribed in numbers and presented in a quantitative approach; the objectives have a descriptive/explanatory character, as they seek to describe the expectations and perception of the studied population and explain the determining factors for the occurrence of the fact/quality; the procedures that involve the entire data collection process are guided by a case study, which seeks to understand the quality of a hospital care service from the customer's point of view. Data collection was guided by bibliographical research and field research, which involved exploratory observational research and the application of questionnaires to customers.

The entire research development process took place in three phases, as shown in Table 1. In Phase 1 – Construction of the Methodological Process, the following items were worked on: 1.1 Area of study, 1.2 Sampling and size, 1.3 Research Instruments, 1.4 Definition of Dimensions in the Servqual scale, 1.5 Criteria, Categories and evaluation scores. In Phase 2 – Modeling of the Fuzzy Logic System, the items were the following: 2.1 Development of the Fuzzy set, 2.2 Development of the "Inference" rules. And in phase 3 - Experiment of the Proposed model, 3.1 Tabulation of data collected in the questionnaire, 3.2 Application of tabulated data in Matlab R16 Student, 3.3 Presentation and discussion of the results of the Fuzzy methodology together with Servqual and 3.4 Conclusion.

In Phase 1, the study area and sampling were described and delimited in order to determine the instruments necessary for the development of the objectives defined for the research. In this phase, the dimensions of the Servqual scale were defined together with the criteria, categories and scores used to evaluate the data collected on perspectives and perceptions of customers. All these items consisted of identifying results for the application to Fuzzy Logic.

Phase 2 exposes the Fuzzy Logic "Inference" System, at that moment all the parts involving the fuzzy set were developed, thus preparing the alignment of the items under a purposeful view of the evaluation model necessary for Fuzzy inference. This whole process was outlined based on the combination of Fuzzy methods and the sequence of rules, necessary for Fuzzy Logic for technical analysis of quality in hospital services, exemplified in Table 1

Table 1: Research development process.

FASE	SEGUIMENTO DOS ITENS
1. Construction of the Methodological Process	1.1 Study area
	1.2 Sampling
	1.3 Research Instruments
	1.4 Definition of Dimensions on the Servqual scale
	1.5 Definition of Criteria, Categories and Assessment Scores
2. Fuzzy Inference System Modeling	12.1 Development of the Fuzzy Inference System
	2.2 Development of the "Inference" rules
3. Proposed model experiment	3.1 Tabulation of data collected in the questionnaire
	3.2 Application of tabulated data in Matlab R16 Student
	3.3 Comparison of Servqual and Fuzzy methodology results for validation
	3.4 Conclusion

Source: Prepared by the author.

Phase 3 and the moment of the final conclusion of the research contemplated the compilation of the results achieved. The results of the questionnaires were applied to the developed Fuzzy inference model, validating the model for evaluating the quality of hospital services, using the Servqual methodology.

Study Area: Private Hospital in the Center of Manaus

The object of this study is a for-profit private hospital whose mission is to be a regional reference in small and medium complexity outpatient and hospital care, providing services to private patients, private and state health insurance.

The hospital has been in the market for about 30 years, is a reference in Obstetrics and adult ICU and has an outpatient unit that serves the following areas: anesthesia, cardiology, general surgery, medical clinic, peripheral vascular clinic, endocrinology, endoscopy, physiotherapy, gastroenterology, geriatrics, gynecology, nutrition, obstetrics, dentistry, orthopedics, otorhinolaryngology, pediatrics, pulmonology, proctology, psychology, radiology, rheumatology, ultrasound, urology and vascular.

Currently, the hospital occupies a usable area of 7,900.00 square meters and around 50 parking spaces for vehicles. The physical installation is equipped with three Receptions (Maternity, Adult and Child Emergency Care). The three receptions have, together, 13 receptionists and each of them has a considerable number of seats and 1 or 2 toilets nearby. In addition, the hospital has: Surgical Center with 5 rooms; Hospitalization Sector; delivery rooms; Imaging Diagnosis; Emergency; Ambulatory with 10 offices; and ICU with 20 beds.

The hospital has 1 administrator, 60 doctors, 67 cleaning assistants and other health professionals. The units of the Inpatient Sector are composed of suites with television, minibar and air conditioning.

The Surgical Clinic comprises several areas such as: general, urological, gynecological, vascular and ophthalmological surgery. The Covenants unit serves patients with Health Plans or Private, and includes several clinics such as: medical clinic, surgical clinic and obstetrics. The Surgical Clinic and Covenants units had their active bed capacity reduced due to a renovation that was being carried out in parts of the hospital at the time of the application of the questionnaires.

Sampling

The Hospital, under study, serves an average of 692 patients per month. Of these patients, an approximate sample of 30% of the patients received monthly was selected, the extract of this research covered 30% of the global population, for the period of 30 days, considering each unit of the Admission Sector as an extract.

Research Instruments

The questionnaire was used as data collection techniques, to identify the customers' view of the process that concerns the services offered by the hospital, focusing on the positive and negative points. Initially, 2 (two) questionnaires were prepared for inpatients (expectations and perceptions), all based on pre-established criteria for comparing expectations and perceptions. All questions aimed to analyze the quality and were defined in a

perspective between Perception and Expectation according to the ideas of Parasuraman et al. (1988), and calculated according to the SERVQUAL scale.

After collection, data were tabulated and statistically analyzed to generate the five input variables for Fuzzy Inference. This procedure was carried out through simulation in the Matlab R16 Student software and the results measured the expectation of quality and the real perception of hospital services and would evaluate the characteristics considered a priority in health services.

Definition of dimensions on the Servqual scale

The dimensions in the Servqual scale were outlined based on the questions in the questionnaire, always in the aspects of the 5th gap. The adapted questionnaire had 22 items to measure Expectations and 22 items to measure Perception, and encompassed the following dimensions: Tangibility, Reliability, Responsiveness, Security and Empathy (PARASURAMAN et al. 1988). These items had the function of measuring the five main dimensions of service quality, following a five-point scale ranging from "I agree" (5) to "I disagree" (1).

One part of the questionnaire was intended to identify the respondent with respect to the name (optional), the second part was concerned with the five dimensions of the SERVQUAL model (tangibility, reliability, responsiveness, security and empathy) through phrases that expressed the meaning of each dimension in the sense of capturing patients' expectations about the quality of the hospital's inpatient service. The 22 items related to the five dimensions were distributed as follows: items 1 to 4 related to the tangible dimension, items 5 to 9 related to the reliability dimension, items 10 to 13 related to the responsiveness dimension, items 14 to 17 related to the dimension security, and items 18 to 22 related to the empathy dimension.

To facilitate the understanding of the respondents, all items are exposed through positive sentences and the answers for each item, followed in Likert format 5 points (instead of 7). The respondent was asked to give a score from 0 to 5 for each dimension according to the importance given to each one of them when evaluating the admission sector of a hospital. Each item of the applied questionnaire was measured on a scale ranging from 1 to 5, as previously explained in order to assess the average value of each item. The overall sample size (n) followed the precision determined for the experiment according to the terms of maximum tolerated sampling error (E0) and the confidence level (γ) to be adopted in the estimation process (BARBETTA et al., 2004). For each element, quality was defined by the difference between Perception and Expectation (Parasuraman et al., 1988), calculated from the following Eq. (1):

$$Qi = \frac{\sum_{j=1}^{ni} (P_{ij} - E_{ij})}{n_i}$$

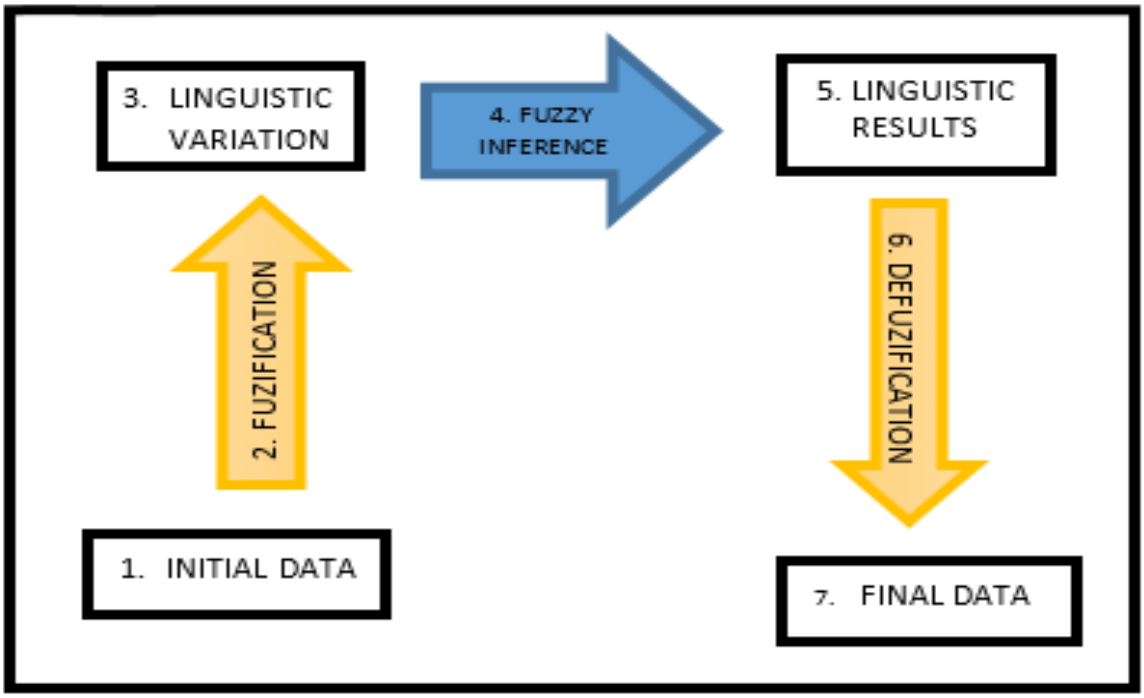
where:
Qi = quality of hospital services in relation to dimension i;
P_ij = perceived quality of hospital services in relation to item j of Dimension i;
E_ij = expectations of hospital services regarding item j of dimension i;
n_i= number of items related to dimension i.
The information obtained by the applied questionnaires were manipulated in three stages of Fuzzy logic: Fuzzyfication, inference and Fuzzyfication.

Fuzzy Inference Model for evaluating Service Quality

The description of Fuzzy logic has two extremes: either it is "completely true" or it is "completely false". Based on this principle, the two extremes used in the logical preposition were: either it is 'Little Relevant', or it is 'Very Relevant'. The fuzzy logic control was executed by imitating a behavior based on rules instead of a control explicitly restricted to mathematical models such as differential equations, with the objective of creating a logic output from a set of inputs that are not precise, carrying noise or even missing paragraphs.

The Fuzzy inference system for assessing service quality occurred in three stages: a (Fuzzyfication, Inference and Defuzzyfication), using as a basis the combination of Fuzzy methods for operations between input variables (linguistic values) and behavior based on sequencing From creating the rules to creating the Fuzzy model used in the technical analysis of quality in hospital services, this process generated numerical values of logical outputs, which made it possible to identify the quality of the hospital under study (Figure 1).

Figure 1: Fuzzy Logic System.



Source: Cox (1995).

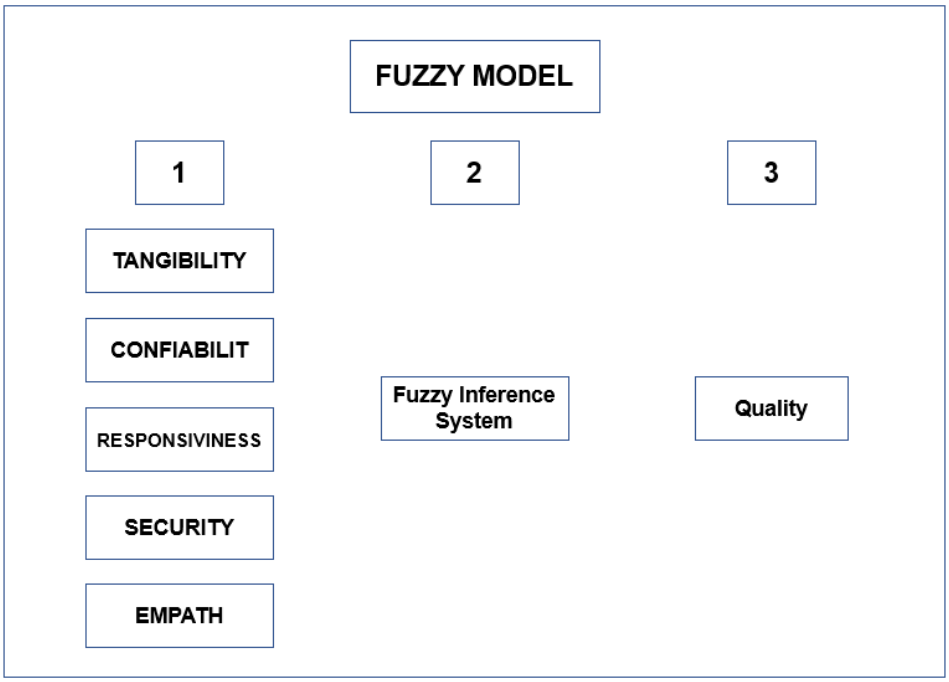
In the first step, there is "fuzzification" (2), in which the initial data (1) is transformed into linguistic variables (3), a phase in which all information related to imprecision or uncertainty associated with these variables must be considered. In the second step, after adjusting the initial values in linguistic variables (3), the Fuzzy inference is the next phase (4), whose purpose is to compare the probable variables with each other through pre-established norms, with the objectives of the algorithm achieved. From the Fuzzy logic system, "defuzification" is the third and last step (6) and comprises, according to Altrock (1996), the interpreted linguistic result (5) of the Fuzzy "inference" methodology in final elements (7), in numerical value (JANÉ, 2004).

Evaluation Process

The data collected in the interviews with the clients of the case study hospital were applied in the Fuzzy "inference" (Figure 2), in order to arrive at the algorithms and followed the main steps of the method, which were:

• Identification of quality factors (linguistic variables) inherent to the hospital service;
• Establishment of criteria and indicators based on linguistic variables;
• Data Processing and Classification – Development and Implementation of the Rules Base and the Fuzzy System;
• Interpretation of linguistic results into results (numerical variables).

Figure 2: Graphic representation of the proposed model.



Source: Prepared by the author.

In this phase, the information collected from the questionnaires was used in order to follow the Input operations, for the transformation of the indicators obtained in the formulas into Fuzzy sets with several analysis variables: “Bad”, “Regular”, “Good”, “Excellent”, “Very Good”, “Great" for each indicator, with triangular and trapezoidal membership functions, which shows the proposed Fuzzy Inference System of one of the defined Inputs. Five input variables were selected with 3 levels of inference each, totaling 243 rules for all combinations of the Fuzzy Interference System. The results found in this process are evidenced in the analysis of variables (Chart 1), and proved to be decisive information in decision making to improve the quality of services.

The Fuzzy Toolbox from MatLab R2016a Student was used to implement the modeling, with standardized Min-Max inference operators from the Mamdani method, with “Defuzzyfication” by centroid.

Criteria Categories and Scores

The Servqual model questionnaire served as the basis for validating the definition criteria of the Fuzzy model exemplified in Chart 1, where the intersection of metric information defined in the Fuzzy inference system can be seen.

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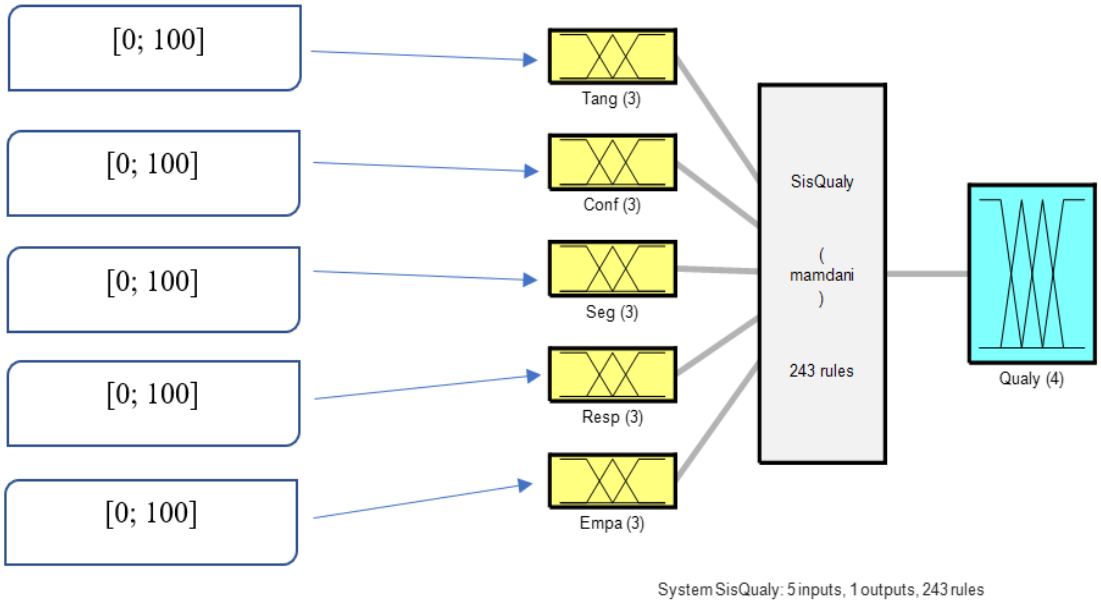
Chart 1: Basis of Analysis between Criteria Categories and Scores.

Dimensions	Assessment Items	Score	Metrics
Tangibility	Questions from 1 to 4	0-100	0 a 50 - Bad 25 a 75 - Regular 50 a 100 - Good
Reliability	Questions from 5 to 9	0-100	0 a 50 - Bad 25 a 75 - Regular 50 a 100 - Good
Responsiveness	Questions from 10 to 13	0-100	0 a 50 - Bad 25 a 75 - Regular 50 a 100 - Good
Security	Questions from 14 to 17	0-100	0 a 50 - Bad 25 a 75 - Regular 50 a 100 - Good
Empathy	Questions from 18 to 22	0-100	0 a 50 - Bad 25 a 75 - Regular 50 a 100 - Good

Source: Prepared by the author.

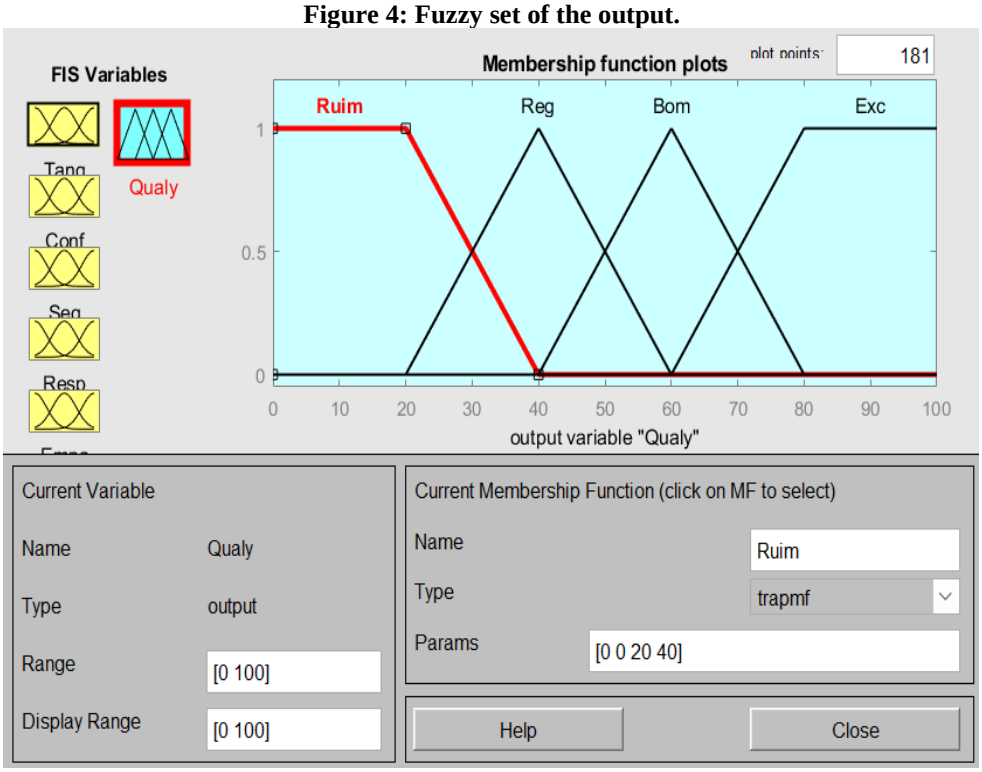
The Fuzzy "Inference" System was intended to aggregate customer expectations and perceptions data to form a Fuzzy Model with the entries (inputs) determining a set of scores for each evaluated criterion, and then aggregate the scores through of the proposed SIF (Fuzzy Inference System). In Figures 3 and 4, the Fuzzy Inference process can be seen in more detail.

Figure 3: Compilation of the Indicator Aggregation Algorithm.



Source: Prepared by the author.

Figure 4: Fuzzy set of the output.



Source: Prepared by the author.

Observing the output (1): it is seen: the performance with range from 0 to 100. The membership functions are triangular and trapezoidal in the tails, with equidistance between the regions of maximum membership to the sets (apexes of the triangular functions), identified by numeral "1" on the ordinate axis. Representing the intersections of the triangular functions is half membership to each adjacent set, with values of "0.5" on the vertical axis.

For the experiment, 243 rules of "inferences" were created, as shown in Table 2, these were individually evaluated in a careful way, in order to make decisions about the performance of the hospital services offered. The choice of the 243 rules was based on observing those with the greatest variation in performance results for better illustration and a more strategic look at the analysis framework.

Table 2: Inference rules. Source: Prepared by the author.

SQ	Tang	Relia	Sec	Resp	Empa	Quality
225	Good	Good	Bad	Good	Good	Regular
226	Good	Good	Regular	Bad	Bad	Regular
227	Good	Good	Regular	Bad	Regular	Regular
228	Good	Good	Regular	Bad	Good	Regular
229	Good	Good	Regular	Regular	Bad	Regular
230	Good	Good	Regular	Regular	Regular	Regular
231	Good	Good	Regular	Regular	Good	Good
232	Good	Good	Regular	Good	Bad	Regular
233	Good	Good	Regular	Good	Regular	Bom
234	Good	Good	Regular	Good	Good	Excellent
235	Good	Good	Good	Bad	Bad	Regular
236	Good	Good	Good	Bad	Regular	Regular
237	Good	Good	Good	Bad	Good	Good
238	Good	Good	Good	Regular	Bad	Regular
239	Good	Good	Good	Regular	Regular	Good
240	Good	Good	Good	Regular	Good	Excellent
241	Good	Good	Good	Good	Bad	Good
242	Good	Good	Good	Good	Regular	Excellent
243	Good	Good	Good	Good	Good	Excellent
	E	E	E	E	E	SO

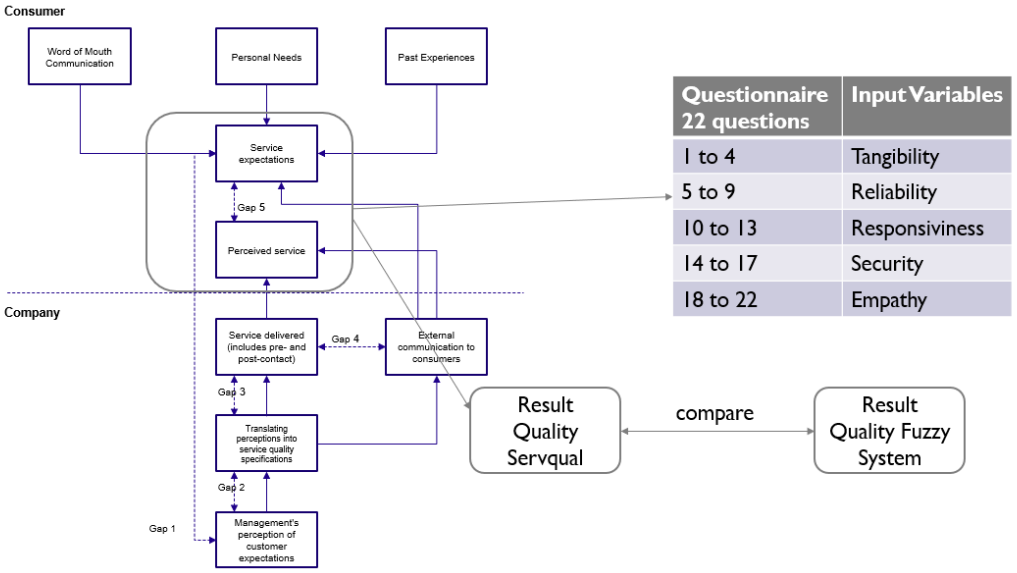
Interference Rules
SQ = Sequential rules;
Tang = Tangibility;
Relia = Reliability;
Sec = Security;
Resp = Responsiveness;
Empa = Empathy.

III. Result

Servqual Model Adaptation

Figure 6 illustrates the scheme used to create the quality assessment model in order to achieve the general objective of this research. The elements composed in the questionnaires following GAP 5 of the Servqual methodology were prerequisites to obtain the input variables established by the Fuzzy inference system. The validation required by the scientific research was carried out by comparing the created model with the existing evaluation methodology of the Servqual model according to Parasuraman and Berry (1992).

Figure 6: Demonstration of the process of building a quality assessment model.



Source: Prepared by the author.

Definition of Dimensions

Following the adaptation of the questionnaires, the Scope of the questions and the respective dimensions of quality were defined (Table 3).

Table 3: Intersection of questions with quality dimensions.

Dimensions	Questions
TANGIBILITY	1- Does the hospital have well-maintained and modern equipment?
	2- Are the hospital's physical facilities visually beautiful and pleasant?
	3 - Do hospital employees have a well-groomed appearance and attire, in accordance with the characteristics of the work environment?
	4 - Are reports and other documents delivered to the patient in the hospital easy to understand and visually attractive?
RELIABILITY	5 - Does the hospital carry out its activities at the scheduled time?
	6 - Does the Hospital demonstrate sincere interest in solving patients' problems?
	7 - Does the hospital perform the services and procedures correctly the first time, not causing rework?
	8- Does the hospital provide its services within the promised deadline?
	9- Does the hospital present reports, documents and information about the patient without errors?
RESPONSIVINESS	10- In the hospital, do the employees inform the patients exactly when the services will be performed?
	11- In the hospital, do the employees promptly attend to their patients?
	12- In the hospital, do employees try to help patients?
	13- At the hospital, are the employees available to respond to the patient's requests?
SECURITY	14- In the hospital, does the behavior of the employees transmit confidence to the patients?
	15- Do hospital patients feel safe using your services?
	16- In the hospital, are the employees polite and courteous to their patients?
	17- In the hospital, do the employees have adequate knowledge to answer patients' questions?
EMPATHY	18- In the hospital, do the employees give individualized attention to the client?
	19- Does the hospital operate at appropriate times for its patients?
	20- Does the hospital have employees who give personal attention to their patients?
	21- Does the hospital prioritize the interests of the patient?
	22- In the hospital, do the employees understand the specific needs of their patients?

Source: Adapted by the author from Parasuraman, Zeithaml and Berry (1994).

Tabulation of information

Observing the sequence, one can see the results of the data tabulation of this research, which highlights the frequency with which the degrees related to each attribute of the service appear. An important characteristic can be seen that denotes the quality of the service offered by the glimpse of the averages obtained in relation to the expectations of the clients and in relation to the service provided by the Hospital (Tables 4 and 5).

Table 4 shows the expectations presented by customers about the service offered by the hospital under study, where it is clear that the evaluated dimensions do not follow a uniform pattern, varying between 60.65% and 71.83%.

Table 4: Tabulation chart of the "Expectation" survey

TABULATION TABLE AND RESULTS "EXPECTATIONS"									
Declaration	1	2	3	4	6	AVERAGE	STANDARD DEVIATION OF THE QUESTIONS	PERCENTAGE OF PERCEPTION OF THE QUESTION	PERCENTAGE OF PERCEPTION OF THE DIMENSION
1- Does the hospital have well-maintained and modern equipment?	2	22	89	90	37	3,575	35,65950084	71,50%	
2- Are the hospital's physical facilities visually beautiful and pleasant?	19	141	36	41	3	2,45	48,39008163	49,00%	
3 - Do hospital employees have a well-groomed appearance and attire, in accordance with the characteristics of the work environment?	8	68	124	36	4	2,833333333	44,39819816	56,67%	
4 - Are reports and other documents delivered to the patient in the hospital easy to understand and visually attractive?	1	47	86	98	8	3,270833333	39,38019807	65,42%	60,65%
5 - Does the hospital carry out its activities at the scheduled time?	4	11	76	142	7	3,570833333	54,0481267	71,42%	
6 - Does the Hospital demonstrate sincere interest in solving patients' problems?	1	22	62	146	9	3,583333333	53,30290799	71,67%	
7 - Does the hospital perform the services and procedures correctly the first time, not causing rework?	3	17	76	127	17	3,575	46,84442336	71,50%	
8- Does the hospital provide its services within the promised deadline?	2	2	104	113	19	3,604166667	49,8678253	72,08%	
9- Does the hospital present reports, documents and information about the patient without errors?	4	25	44	151	16	3,625	53,13002917	72,50%	71,83%
10- In the hospital, do the employees inform the patients exactly when the services will be performed?	4	9	104	109	14	3,5	47,89572006	70,00%	
11- In the hospital, do the employees promptly attend to their patients?	3	17	119	85	16	3,391666667	45,65084884	67,83%	
12- In the hospital, do employees try to help patients?	2	15	72	121	30	3,675	43,43731115	73,50%	
13- At the hospital, are the employees available to respond to the patient's requests?	2	11	52	147	28	3,783333333	52,34882998	75,67%	71,75%
14- In the hospital, does the behavior of the employees transmit confidence to the patients?	2	28	109	60	41	3,458333333	35,86084215	69,17%	
15- Do hospital patients feel safe using your services?	1	14	65	129	31	3,729166667	45,83448483	74,58%	
16- In the hospital, are the employees polite and courteous to their patients?	7	17	48	129	39	3,733333333	43,09060222	74,67%	
17- In the hospital, do the employees have adequate knowledge to answer patients' questions?	15	30	92	69	34	3,320833333	28,23473039	66,42%	71,21%
18- In the hospital, do the employees give individualized attention to the client?	10	41	79	82	28	3,320833333	28,31960452	66,42%	
19- Does the hospital operate at appropriate times for its patients?	3	22	49	143	23	3,670833333	49,70311861	73,42%	
20- Does the hospital have employees who give personal attention to their patients?	1	7	129	76	27	3,504166667	48,32390713	70,08%	
21- Does the hospital prioritize the interests of the patient?	3	30	99	89	19	3,379166667	38,65747017	67,58%	
22- In the hospital, do the employees understand the specific needs of their patients?	6	14	35	151	34	3,804166667	52,71432443	76,08%	70,72%
23- In the hospital, is the general quality of care provided by employees satisfactory?	9	11	49	153	18	3,666666667	54,43528268	73,33%	

Source: Adapted by the author following Parasuraman, Zeithaml and Berry (1994).

In table 5, the analysis referring to the clients' perception of the service offered by the hospital, follows the same pattern of answers of expectations, that is, not showing a single pattern, its variation of answers per question and per dimension is between 61 .83% and 78.42, therefore, it is observed that there is no pattern of answers.

Table 5: Tabulation table of the research "Perception".

TABULATION TABLE AND RESULTS "PERCEPTION"									
Declaration	1	2	3	4	6	AVERAGE	STANDARD DEVIATION OF THE QUESTIONS	PERCENTAGE OF PERCEPTION OF THE QUESTION	PERCENTAGE OF PERCEPTION OF THE DIMENSION
1- Does the hospital have well-maintained and modern equipment?	24	40	120	48	8	2,9	38,53310265	58,00%	
2- Are the hospital's physical facilities visually beautiful and pleasant?	16	88	72	48	16	2,833333333	29,0654434	56,67%	
3 - Do hospital employees have a well-groomed appearance and attire, in accordance with the characteristics of the work environment?	24	32	88	72	24	3,166666667	26,77312085	63,33%	
4 - Are reports and other documents delivered to the patient in the hospital easy to understand and visually attractive?	24	16	72	80	48	3,466666667	25,29822128	69,33%	61,83%
5 - Does the hospital carry out its activities at the scheduled time?	16	16	56	112	40	3,6	35,41750979	72,00%	
6 - Does the Hospital demonstrate sincere interest in solving patients' problems?	14	18	32	72	104	3,975	34,71022904	79,50%	
7 - Does the hospital perform the services and procedures correctly the first time, not causing rework?	24	8	48	89	71	3,729166667	29,61756236	74,58%	
8- Does the hospital provide its services within the promised deadline?	33	16	80	66	45	3,308333333	22,82980508	66,17%	
9- Does the hospital present reports, documents and information about the patient without errors?	3	22	15	80	120	4,216666667	44,71688719	84,33%	75,32%
10- In the hospital, do the employees inform the patients exactly when the services will be performed?	48	39	16	50	87	3,370833333	22,93468988	67,42%	
11- In the hospital, do the employees promptly attend to their patients?	8	25	63	65	47	3,091666667	22,08710031	61,83%	
12- In the hospital, do employees try to help patients?	13	21	72	104	30	3,4875	34,6121366	69,75%	
13- At the hospital, are the employees available to respond to the patient's requests?	7	33	39	129	32	3,608333333	41,96188747	72,17%	67,79%
14- In the hospital, does the behavior of the employees transmit confidence to the patients?	3	5	65	111	56	3,883333333	40,48703496	77,67%	
15- Do hospital patients feel safe using your services?	5	11	70	115	39	3,716666667	40,67431622	74,33%	
16- In the hospital, are the employees polite and courteous to their patients?	20	25	51	99	45	3,516666667	28,04282439	70,33%	
17- In the hospital, do the employees have adequate knowledge to answer patients' questions?	10	29	39	79	83	3,816666667	28,53769437	76,33%	74,67%
18- In the hospital, do the employees give individualized attention to the client?	9	7	51	91	82	3,958333333	35,25904139	79,17%	
19- Does the hospital operate at appropriate times for its patients?	20	28	72	69	51	3,429166667	21,02379604	68,58%	
20- Does the hospital have employees who give personal attention to their patients?	6	9	33	86	106	4,154166667	40,78725291	83,08%	
21- Does the hospital prioritize the interests of the patient?	9	16	14	105	96	4,095833333	43,02092514	81,92%	
22- In the hospital, do the employees understand the specific needs of their patients?	8	12	29	122	69	3,966666667	42,83456548	79,33%	78,42%
23- In the hospital, is the general quality of care provided by employees satisfactory?	11	18	34	106	71	3,866666667	35,65950084	77,33%	

Source: Adapted by the author following Parasuraman, Zeithaml and Berry (1994).

The tabulation of data based on the expectations and perceptions of GAP 5 customers (Difference between Expectation and Perception), showed that only the Responsiveness dimension did not have a positive result, making clear the need for improvements in the delivery of services that covers the items evaluated in the responsiveness dimension, in order to achieve expectations and have full customer satisfaction. This analysis is

in line with the ideas of Parasuraman and Berry (1992), stating that to ensure a good quality of service, it is necessary for the customer's perception to exceed expectations. From this perspective and through the analysis of Table 6, it can be said that the private hospital under analysis has ensured a good quality of service regarding tangibility, reliability, security and empathy, but, regarding the responsiveness dimension, it is necessary to induce an increase in the level of quality, as it is the only one with a negative score, which means that the customer's expectations regarding responsiveness aspects are not being achieved.

Table 6: Gap tabulation model between Expectation and Customer Perception.

QUALITY ISSUES AND DIMENSION		EXPECTATION OF THE DIMENSION IN %	PERCEPTION OF THE DIMENSION IN %	GAP IN %
Questions 1 to 4 refer to the dimension:	TANGIBILITY	60,65%	61,83%	1,19%
Questions 5 to 9 refer to the dimension:	RELIABILITY	71,83%	75,32%	3,48%
Questions 10 to 13 refer to the dimension:	RESPONSIVINESS	71,75%	67,79%	-3,96%
Questions 14 to 17 refer to the dimension:	SECURITY	71,21%	74,67%	3,46%
Questions 18 to 22 refer to the dimension:	EMPATHY	70,72%	78,42%	7,70%

Source: Prepared by the author.

However, the other four dimensions with positive values, show a favorable performance of the hospital, but it is necessary to be attentive to this analysis, checking the details presented by each dimension, because this analysis generalizes the factors and presents a result evaluating the whole and not the parts.

In figure 7, it is possible to see that in the Fuzzy inference system, after manipulating the input variables, the following coefficient was reached: Tangibility- 62, Reliability- 75, Safety- 75, Responsibility-68 and Empathy 78, and that these demonstrate to have achieved the general objective of the work, on the quality of the Hospital, as they showed satisfactory results, since the perception of each dimension presented an average quality index of 82.7%, which indicates positively for 4 of the 5 dimensions.

Figure 7: Result of the Fuzzy inference system.

Source: Prepared by the author.

According to the results obtained in the Fuzzy inference (figure 7), it became clear to the responsible managers which dimension needs special and urgent attention to raise the quality level of this hospital.

IV. Discussion

As already mentioned, measuring service quality is quite complex, as it depends on consumer satisfaction, and this is permeated by intangible and changeable factors over time, some points such as tolerance during waiting, it depends from customer to customer, emergency in attendance is variable as to the suffering of each patient among others. emergency of the sick, for example. Therefore, this problem lacks a management model that can capture all the details that show customer satisfaction through the most reliable linguistic range possible for representing customer preferences, as in Fuzzy Logic, which considers aspects such as subjectivity, imprecision and vagueness. of the human being.

In this sense, the proposed model showed a direction to the hospital in the sense of making viable the guidelines capable of meeting its demand, because from this methodology it clarified the management that in order to better know the quality it is necessary to strengthen the relationship with its patients, because the exchange of information and the knowledge of the real and current expectations, allows to perceive the failures with the patients assisted.

Therefore, the implementation of quality is based on the commitment to search for more efficient hospital techniques, as well as the training of all professionals involved in order to achieve quality based on the opinion of customers.

V. Conclusion

This research materialized positively because the methodology created made it possible to evaluate the quality of customer service; check the level of customer satisfaction; identify the negative points, to propose the implementation of improvements; in addition to proving that the private hospital under study is investing in the pursuit of quality, as it meets more than 80% of customer expectations. That is, the result corroborates that the GAP 5 of the Servqual model was useful for the Fuzzy system to make it possible to manage decisive information in decision making to improve quality and customer satisfaction.

For validation of the method, real information was used, obtained through the Servqual questionnaires applied in the hospital under study, making it possible to quantify a value for the quality of the hospital studied, presenting data that will subsidize the management of the hospital, with information that indicates where to act.

The purpose of this research is then concluded through the development of the model for evaluating the quality of private hospital services using the Fuzzy inference system, proving the importance of the Fuzzy inference system for measuring the quality of services provided by the hospital, because, with the creation of this evaluation model, it was discovered that the perception of the clients in relation to the tangible aspects is lower than the expectation and this becomes extremely important for the actions of the hospital managers.

VI. Acknowledgments

Institute of Technology and Education Galileo of the Amazon (ITEGAM) for supporting this research and the Postgraduate Program in Engineering, Process Management, Systems and Environmental (PGP.EPMSE).

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