EQUALHI: A neural networks-based ergonomic evaluation of service quality in the hospital industry

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Abstract— An approach for ergonomic evaluation of hospital service quality (EQUALHI) is proposed. It is based on a checklist tool using a neural networks-based evaluation model. This approach enables the determination of the most important ergonomic criteria and the generation of recommendations for improving the hospital service quality. EQUALHI is illustrated and validated by a study in 50 small- and medium-sized hospitals in Istanbul. Data from hospital managers were collected by the checklist tool. Then ergonomic evaluations were calculated using EQUALHI. Based on the approach the most important ergonomic criteria that affect service quality in the hospital industry in Istanbul were determined. Relevant recommendations and measures for improving the hospital service were proposed.

Keywords—Ergonomic evaluation, hospital service quality, neural networks.

I. INTRODUCTION

In the health care industry, the rising level of technological developments as well as of quality standards have had an important impact on medical care, surgical techniques, drugs, equipment, and the organization and delivery of health care. Specifically, quality management has become an important issue in the healthcare sector after 1980 [4], [1], [5], [11], [6]. Based on these studies, a wide range of management issues, techniques, approaches, and systematic empirical investigation have been generated.

Recently many Artificial Neural Networks (ANN) applications in health care industry use ANN models as a better alternative to multivariate statistical methods, e.g. for predicting mortality rate in intensive care units [3], for evaluation of survival prediction accuracy in the intensive care units [2], and for measuring hospital performance or predicting health care costs [7].

There are many methods for hospital service quality (HSQ) evaluation. Their drawback is that they do not provide recommendations for improving HSQ. Here we propose a neural-network-based method for ergonomic quality evaluation of hospital services (EQUALHI). Based on a case study, EQUALHI is found to provide a better understanding of managers’ perceptions of hospital service quality and its improvement.

II. DESCRIPTION OF EQUALHI

The individual steps of the EQUALHI method are shown in Figure I. Principal purposes of this method are: 1) aggregating the hospital service data for quantitative ergonomic evaluations; 2) selecting important HSQ evaluation criteria for the generation of ergonomic recommendations and measures for HSQ improvements.

A. Step1: Knowledge base design

For ergonomic evaluation and design of HSQ, a knowledge base including 9 evaluation criteria (cf. Annex) can be developed.

 EQUALHI is based on the adapted checklist instrument of Saraph, Benson & Schroder, [9] (cf. Appendix) developed
with the purpose of identifying critical factors (areas) of total quality management in a business unit and further adapted by Raju, Lonial for use in the hospital industry [8].

The EQUALHI checklist tool consists of two parts. The first input part contains 21 questions that identify HSQ evaluation criteria for role of top management, training of employees and managers, process management, quality data and reporting, employee relations, managers’ knowledge, corporate support for quality, past quality performance. These questions are asked to managers of the hospital for measuring their perceptions of the service quality performance of the hospital. In the second output part of the checklist tool, a single question regarding manager’s overall evaluation of financial performance is asked. For the above criteria, a criteria hierarchy is defined (see Fig. II). To each criterion, a weight is associated by expert estimates.

B. Step 2: Data collection

During this step the managers’ evaluations of the single criteria at the lowest first layer of the criteria hierarchy are determined.

C. Step 3: Criteria hierarchy learning

During this step of the EQUALHI method the initial weights of criteria hierarchy are trained. Because of the strong nonlinear correlation between evaluation criteria we chose a nonlinear evaluation model: the backpropagation (BP) algorithm [10]. It carries out supervised learning of neural network weights using training data as inputs and known output minimizing the mean square error. In this study, managers’ perception related to pre-specified HSQ criterion is paired with overall HSQ evaluation. The hierarchy is coded in a hierarchical neural network, where each neuron corresponds to a criterion. We consider a neural network with 21 inputs (single criteria), nine hidden neurons (complex criteria) and an output neuron (financial performance) (cf. Fig. II).

D. Step 4: Lack analysis

A goal of EQUALHI method is to support the lack analysis. This is accomplished by determining the most important single criteria at input layer whose improvement will lead to the most significant increase of the financial performance.

The lack analysis consists in sequential computation of HSQ indices for the criteria of each network layer shown on Fig. 5 and relevant decisions.

E. Step 5: Improvement/redesign recommendations

A team of experts discusses the results at the previous step. Thus, improvement/redesign recommendations are generated by the EQUALHI software tool (cf. Fig. III).

III. CASE STUDY

For the empirical research, we selected as our universe the private and state hospitals in Turkey. Data for this study was collected using a questionnaire that was distributed to 150 chief executive officers of healthcare institutions in Turkey. 70 useable questionnaires were returned giving a response rate of 47 percent, which was considered satisfactory for subsequent analysis. Each checklist item was rated on a seven-point Likert scale anchored at the verbal statement “Strongly Disagree” to which is associated a value of 1 and the verbal statement “Strongly Agree” valued at 7.

The current service quality of the hospital industry in Istanbul was analyzed according to EQUALHI steps 4 and 5. The evaluation of current service quality was carried out in the two stages. At the first stage complex criteria was evaluated and ranked from most important to less important given in Table I. At the second stage considering the complex criteria, single criterion scores were calculated as shown in Table II. Subsequently, improvement plans were developed.

In the first step, according to the evaluation of the complex criteria, the past quality performance with a score of 2.39 was found to be the most important criterion (cf. Table I). According to Table II, perceived customer satisfaction with quality (21) was determined as the most important single criterion related to past quality performance with a score of 2.55. To improve the quality performance of the hospital, the most significant effort must be devoted to the perceived customer satisfaction. Corporate support for quality, the
second criterion, also has a strong impact on hospital performance.

<table>
<thead>
<tr>
<th>Number of factor</th>
<th>Complex criteria</th>
<th>Evaluation</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Past Quality Performance</td>
<td>2.39</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>Corporate Support For Quality</td>
<td>2.36</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>Training Of Employees and Managers</td>
<td>2.32</td>
<td>3</td>
</tr>
<tr>
<td>1</td>
<td>Role Of Top Management</td>
<td>1.93</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>Process Management</td>
<td>1.72</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>Quality Data And Reporting</td>
<td>1.17</td>
<td>6</td>
</tr>
<tr>
<td>6</td>
<td>Managers Knowledge</td>
<td>0.75</td>
<td>7</td>
</tr>
<tr>
<td>5</td>
<td>Employee Relations</td>
<td>0.38</td>
<td>8</td>
</tr>
</tbody>
</table>

According to Table I, corporate support for quality was found to be the second important complex criteria with a score of 2.36. As it is shown in Table 2, two single criteria (19 and 17) related to corporate support for quality are the most important criteria. These variables are denoted as single criterion. Single criterion 19 is defined as “quality is emphasized throughout the hospital by the senior management”. Single criterion 17 is defined as the “extent to which senior management has set goals in the area of quality”. In healthcare industry, successes of TQM applications depend on a strong leadership that must be initiated by the top management. Quality improvement plans proposed by several gurus emphasize primarily the commitment of top management. The top management of the hospitals determines an appropriate organization culture, vision, and quality policy. Managers of healthcare organizations should determine objectives, and set specific measurable goals to satisfy customer expectations and improve their organizations’ performance. On the other hand, the top managements must provide adequate resources to the implementation of quality efforts. This model implies that the managers’ role has a direct impact on the financial performance of the hospitals. In order to increase net profit and revenue, and to reduce cost of quality, hospital managers must convey their priorities and expectations to their employees. The training of employees and managers was found to be a third important criterion improving hospital performance (score 2.32). According to Table II, training has two important single criteria. These are labeled as single criterion 5 and single criterion 7. Their scores were computed as 1.08 and 1.04, respectively.
After determining important complex and related single criteria one needs to develop an improvement plan to increase total quality management performance and consequently improve the financial performance of the hospital. If the performance of the above mentioned single criteria (21, 19, 17, 5 and 7) is enhanced, the overall financial performance of the hospital will be improved.

IV. CONCLUSIONS

An approach for ergonomic evaluation of hospital service quality (EQUALHI) is proposed. It is based on a checklist tool using a neural networks-based evaluation model. By EQUALHI, the most important ergonomic criteria can be determined and recommendations for improving the hospital service quality can be generated.

A. Advantages

- This method enables the determination of the most important ergonomic criteria and of the generation of recommendations for improving the hospital service quality.
- Hospital managers can measure by EQUALHI their hospitals’ service quality from their manager’s viewpoint.

B. Disadvantages

- The costs of improvement and redesign activities and their impact on hospital profitability are not considered.
- Service quality improvement and redesigning activities were carried out under non-restricted constraints.
- The study was carried out considering only financial performance as an output.

C. Further Development

- EQUALHI conceptual domain can be extended by measuring the service quality from patient’s viewpoint.
- The evaluation of current service quality was carried out according to the service recipients’ perception. It will be very valuable to add physicians’ perception of service quality when designing and improving the health care delivery system.
- EQUALHI did not consider expectations of patients. It could be further developed so as to consider expectations of patients and measure how expectation effects overall service quality.

APPENDIX

Checklist of patient’s perception of the service quality of the hospital.

A. Input

Role of top management
1. Extent to which top executives assume responsibility for quality performance (current practice)
2. Acceptance of responsibility for quality by major department heads
3. Degree to which top management is evaluated for quality performance
4. Extent to which top management supports a long term quality improvement process

Training of employees and managers

5. Specific work skills training given to hourly employees
6. Training in statistical techniques in the hospital as a whole
7. Extent to which quality improvement teams are trained in problem solving approach

Process management
8. Amount of preventive equipment maintenance
9. Amount of inspection, review, or checking of work

Quality data and reporting
10. Availability of cost of quality data in the hospital
11. Availability of quality data (mortality, morbidity)

Employee relations
12. Extent to which employee involvement type programs are implemented in the hospital
13. Effectiveness of quality teams or employee involvement type program in the hospital
14. Extent to which the employees are responsible for error free output

Managers knowledge
15. My experience with quality and its role in the hospital
16. Extent to which I have read books in the quality area
17. Corporate support for quality
18. Extent to which senior management has set goals in the area of quality
19. Extent to which quality is considered as a key strategic opportunity by the senior management
20. In general, our hospital’s quality performance rates for the past three years
21. Perceived customer satisfaction with quality for the past three years

B. Output

Financial performance

REFERENCES