Analytic hierarchy process helps measure performance of hospitals

Prasanta K Dey Ph.D\textsuperscript{1} and Seetharaman Hariharan MD\textsuperscript{2},

1. Lecturer, Department of Management Studies, Cave Hill Campus, University of West Indies, Bridgetown, BARBADOS, West Indies

2. Senior Registrar, School of Clinical Medicine and Research, University of West Indies, Queen Elizabeth Hospital, Bridgetown, BARBADOS, West Indies

Correspondence to:
Prasanta K Dey
Email: pdey@uwichill.edu.bb
Measuring Health Care Service Performance using Multi-attribute Decision-making Technique: A Case study

Abstract

Measuring health care service performance is a complex task as it has multiple-functions, which contribute in aggregate towards achieving overall goals. There has been an increasing need of a tool for the process-based performance measurement of multispecialty tertiary care hospitals to identify the deficiencies in services and suggest recommendations for their improvement. Analytic Hierarchy Process (AHP), a multiple attribute decision-making technique, is utilized in this study to evolve a model to effectively measure the performance of the processes involved in the healthcare delivery of a hospital. Each step in the model was derived by group-discussions and brainstorming sessions among clinicians and managers with more than twenty years service in healthcare system. This tool was applied to a 600-bed tertiary care teaching hospital in Barbados, and another similar bed-strength tertiary care teaching hospital in South India. The cumulative performance rating of the Barbados hospital was 0.38 when compared to the cumulative performance rating of the Indian hospital which was 0.27. Gap analysis showed that the Indian hospital performed at 71% with respect to Barbados hospital. The model enabled identification of specific areas where either hospital did not perform very well, and helped to suggest recommendations to improvise those areas. We recommend analytic hierarchy process as a valuable tool to measure the process-based performance of a multispecialty tertiary care hospital.

Keywords:
Hospital performance measurement, quality of service, analytic hierarchy process
Introduction

Health services sector is a complex area that is unique in all its characteristics. It has too many dimensions to be fitted into a simple singular unit and it is therefore essentially very difficult to approach the measurement of the performance of healthcare services by using one method or another. Traditionally hospital performance measurement is done by measuring certain specific metrics that are thought to be the important indicators of the overall performance. Broadly healthcare delivery is evaluated by three categories of measurement namely structure, process and outcome (Donabedian 1980). The progress report “America’s Best Hospitals” released annually by the US News and World Report since 1990, incorporates all the three quality measures in attempting to rate the best hospitals nationwide in United States of America (US News and World Report, 1990). The structure of the hospitals is assessed by the human and material resources available in each hospital. Outcomes are usually evaluated by the standardized mortality ratio which is the ratio of the observed to expected mortality rate in each hospital. Process of hospitals has been difficult to measure by specific metrics. The authors of the annual progress report have acknowledged that there is inherent difficulty in measuring the process of care in hospitals (The Editors of US News and World Report, 1996). Hence they relied upon a survey involving physicians for the evaluation of the process of healthcare delivery in hospitals. They selected a cross section of physicians from the American Medical Association’s master-file and asked them to name five “best” hospitals in their respective field. Obviously this is a highly subjective assessment because the physicians were not given any criteria to rate the hospitals. Although process was considered as the primary aspect of assessment among all the three measures of
quality, there have been few methods developed so far to reliably measure the process of care in a healthcare institution.

Therefore, in an attempt to measure the performance of a multi-specialty tertiary care hospital with regards to its processes of healthcare delivery, we devised a model using the Analytic Hierarchy Process (AHP), a multiple criteria decision-making technique developed initially by Saaty (Saaty, 1980). We applied this model to evaluate the performance of two hospitals in developing countries namely Barbados and India and compared the results. Both the hospitals are university teaching hospitals with public sector role, with similar bed-numbers and are referral centres catering to populations of about 250,000.

While there have been many applications of AHP in the medical field (Weingarten MS, 1997; Carter KJ, 1999; Hummel JM, 2000; Sloane EB, 2003), we have been unable find an instance where it has been applied so far as performance measurement tool for a hospital.
Methodology

In developing the performance measurement model of hospital services, a consensus opinion method was adopted following an initial questionnaire survey with active involvement of the managers and clinicians of the hospitals in both India and Barbados. An AHP-based approach to measure the performance of a tertiary-care hospital involved the following steps:

1. Identification of critical success factors
2. Identification of sub-factors, their ratings and constructing the hierarchical model
3. Comparison of critical success factors and sub-factors in a pair-wise fashion to derive their importance and assigning weights for the individual ratings
4. Derivation of the weights of ratings for the two hospitals individually
5. Gap analysis by comparing the ratings individually as well as by cumulative ratings

Why AHP?

The analytic hierarchy process (AHP) developed by Saaty, (1980) provides a flexible and easily understood way of analyzing complicated problems. It is a multiple criteria decision-making technique that allows subjective as well as objective factors to be considered in decision making process. The AHP allows the active participation of decision-makers in reaching agreement, and gives managers a rational basis on which to make decisions. AHP is based on the following three principles: decomposition, comparative judgement, and synthesis of priorities.
The AHP is a theory of measurement for dealing with quantifiable and intangible criteria that has been applied to numerous areas, such as decision theory and conflict resolution (Vargas, 1990). AHP is a problem-solving framework and a systematic procedure for representing the elements of any problem (Saaty, 1983).

Formulating the decision problem in the form of a hierarchical structure is the first step of AHP. In a typical hierarchy, the top level reflects the overall objective (focus) of the decision problem. The elements affecting the decision are represented in intermediate levels. The lowest level comprises the decision options. Once a hierarchy is constructed, the decision-maker begins a prioritization procedure to determine the relative importance of the elements in each level of the hierarchy. The elements in each level are compared as pairs with respect to their importance in making the decision under consideration. A verbal scale is used in AHP that enables the decision-maker to incorporate subjectivity, experience, and knowledge in an intuitive and natural way. After comparison matrices are created, relative weights are derived for the various elements. The relative weights of the elements of each level with respect to an element in the adjacent upper level are computed as the components of the normalized eigenvector associated with the largest eigenvalue of their comparison matrix. Composite weights are then determined by aggregating the weights through the hierarchy. This is done by following a path from the top of the hierarchy to each alternative at the lowest level, and multiplying the weights along each segment of the path. The outcome of this aggregation is a normalized vector of the overall weights of the options. The mathematical basis for determining the weights was established by Saaty, 1980.
Risk management is usually a team effort, and the AHP is one available method for forming a systematic framework for group interaction and group decision-making (Saaty, 1982). Dyer and Forman, 1992 describe the advantages of AHP in a group setting as follows: 1) both tangibles and intangibles, individual values and shared values can be included in an AHP-based group decision process, 2) the discussion in a group can be focused on objectives rather than alternatives, 3) the discussion can be structured so that every factor relevant to the discussion is considered in turn, and 4) in a structured analysis, the discussion continues until all relevant information from each individual member in a group has been considered and a consensus choice of the decision alternative is achieved. A detailed discussion on conducting AHP-based group decision making sessions including suggestions for assembling the group, constructing the hierarchy, getting the group to agree, inequalities of power, concealed or distorted preferences, and implementing the results can be found in Saaty, 1982 and Golden et. al. 1989. For problems with using AHP in group decision making, see Islie, et. al. 1991.

Researchers use AHP in various industrial applications. Partovi et. al., 1990 used it for operations management decision-making. Mian and Christine, 1999 and Dey, 2001 used AHP for evaluation and selection of projects. Meredith and Mantel, 2000 described AHP as an effective tool for project selection. Dey and Gupta, 1999 used AHP for cross-country petroleum pipeline route selection. Dey, 2002 applied AHP for environmental impact assessment of a cross-country petroleum pipeline in India. Mustafa and Al-Bahar, 1991 have applied the AHP in risk analysis for the assessment of risk in a construction
project from the evaluation perspective and Dey, et. al. 1994 for cost risk analysis of construction project.

**Step 1: Identifying the critical success factors**

The first step was to identify the critical success factors for the “process” of healthcare delivery of a tertiary care multi-specialty hospital. Critical success factors, by definition, are the characteristics, conditions, or variables that when properly sustained, maintained, or managed can have a significant impact on the successful management of an organization (Leidecker JK, 1984)

In the present study, an initial questionnaire survey was conducted to find what clinicians and managers think as the most important factors for the optimal functioning of a hospital. Later, extensive brainstorming sessions were undertaken within clinicians and managers all of whom have more than twenty years service experience in the healthcare system and the critical success factors were identified.

Accordingly, three main areas were identified as the most important sections whose processes could be measured and used as indicators of the performance of healthcare delivery process in a hospital:

1. Patient care sector
2. Establishment sector
3. Administrative sector

**Step 2: Identifying sub-factors, ratings and constructing the hierarchical model**

All the critical success factors were sub-divided into sub-critical success factors again with the active involvement and discussions among the clinicians and managers in the hospital environment. Patient care sector was further classified into acute-care areas and
chronic-care areas. The acute-care areas comprised of Accident & Emergency (A&E), Operating Rooms, Intensive Care Units, Labor and Dialysis units. Chronic-care areas included Out-patient clinics, General wards and Physical therapy unit. The establishment sector was subdivided into the following: Management of pharmacy, laboratory sciences including microbiology, pathology and hematology and blood bank, radiology including radiotherapy, central sterilization and infection control management, patient nutrition, hospital ethics committee, communication systems and library/academic activities. The administrative sector was classified into the following subdivisions: Human relations and personal management of staff including medical, nursing, paramedical and support staff, overall supply-chain management, financial management, clinical engineering and housekeeping management and medical records management.

For all the sub-factors in the patient care sector three common ratings (attributes) were identified, namely patient turnover, patient comfort and adverse patient occurrences (APO). These three ratings were again qualified by three characteristics namely High/good, Average and Low/poor. For the sub-factors in the establishment sector the ratings were Good/state-of-art technology, Average/semi-automated technology, Poor/outdated technology. For the sub-factors in the administrative sector, the ratings were whether the management of each sub-division was Good, Average or Poor. The next step was to assign the weights for the ratings of each sub-factor. For the “best” rating in each category the weight was 0.6, for the “average” rating the weight was 0.3 and for the “worst” rating in each category a weight of 0.1 was assigned. For example a high incidence of APO in a unit will get a weight of 0.1, a moderate incidence will receive a weight of 0.3 and a low incidence of APO will get a weight of 0.6. The definitions of the
ratings and the weight they should receive were decided following extensive brainstorming sessions and discussions.

Figure 1 shows the entire hierarchical model in AHP framework consisting of the critical success factors and sub-factors identified as the most important for the optimal performance of a hospital. The goal for the analysis is located on the highest level of the hierarchy, the critical success factors on the second level and the critical sub-factors on the third level and their ratings on the fourth level.

**Step 3: Pair-wise comparison of critical success factors and sub-factors**

The next step was determining the importance of each critical success factor by pair-wise comparison. Multiple brainstorming sessions were held among the clinicians and the comparisons were derived for each critical success factor and then the sub-factors. The priorities were derived by comparing each set of elements in a pair-wise fashion with respect to each of the element in higher stratum. A nine-point numerical scale was used for the comparison. The intensity and the definitions of the pair-wise comparison used for prioritization is given in Table.1

In a common objectives context where all members of the group have the same objectives, there are four ways that could be used for setting the priorities: 1) consensus, 2) vote or compromise, 3) geometric mean of the individuals’ judgments, and 4) separate models or players (Dyer RF, 1992). Although initial brainstorming sessions had many conflicting opinions, these were later resolved by way of discussions and ultimately all the clinicians and managers arrived at a consensus after being adequately satisfied regarding the priority of each level in the hierarchy. The prioritization of each critical success factor was then constructed into a normalized matrix which gave the overall
weight of each critical success factor (Table 2). Similarly the normalized matrices for the
importance levels of each sub-factor gave the weights of each sub-factor which is known
as the local percentage (LP).

**Step 4: Deriving the weights of ratings for the hospitals**

The next step was to derive the ratings for each sub-factor for a hospital in Barbados and
also for a hospital in India. The hospital clinicians in each unit as well as the managers
were interviewed regarding the ratings of each sub-factor. Ratings of each sub-factor
were allocated to each unit in the given hospital according to the clinician or managers’
view of where the particular unit stands according to the attribute. For example, in a
given hospital, if the A&E department had a high patient turnover, a weight of 0.6 was
assigned, if the mean waiting time for patients in the A&E was long (e.g., 3-6 hours), the
patient comfort was considered to be average with a weight of 0.3, (if longer than 6 hours
the rating would have been poor with a weight of 0.1); if the incidence of adverse patient
occurrences were low, again the unit was assigned a weight of 0.6. Weights for each and
every unit and section of the hospitals were derived in a similar fashion by explaining the
criteria and characteristics of each attribute to the clinicians and managers. The weights
of all the factors and the sub-factors along with the weights assigned to each attribute in
the AHP framework are given in Figure 2.

**Step 5: Calculating and comparing cumulative performance between the hospitals**

By multiplying the overall weight of each critical success factor with those of the sub-
factors (Local Percentage) (LP), the Global Percentage (GP) of individual sub-factor was
derived. The product of the weight of the rating of each sub-factor with the GP is the
factor level performance of each sub-factor and the sum of these gave the overall factor
level performance of the sub-factors of each critical success factor. (Tables 3a through 5)

This method was employed to calculate the performance ratings of both the hospitals. The sum of performance ratings of all the critical success factors will give the overall performance rating of the given hospital. The comparison of performance ratings at the sub-factor level as well as the overall cumulative performance of each hospital and enabled the gap analysis.
Summary of derivation of cumulative performance

- Pair-wise comparison of critical success factors and normalization:
  Overall weight of critical success factor…… [1]

- Pair-wise comparison of sub-factors and normalization:
  Weight of individual sub-factor (Local Percentage)……… [2]

- Product of 1 and 2: Global Percentage of each sub-factor…… [3]

- Derivation of weight of each sub-factor according to its rating for either hospital…. [4]

- Product of 3 and 4: Performance rating of each sub-factor for either hospital.. [5]

- Sum of all the sub-factor performance ratings: Performance rating for each critical success factor…… [6]

- Sum of performance ratings of all the three critical success factors: Cumulative performance rating of either hospital…… [7]

Although dedicated software for AHP is available (ExpertChoice™), we did our calculations using Microsoft Excel™ software.
Results

By pair-wise comparison of the critical success factors, “Patient care” factor received the highest weight followed by the “Establishment sector”, and “Administrative sector”.

(Table 2) The consistency ratios which were calculated for the normalized matrices of all the pair-wise comparisons both in the critical factor and sub-factor levels were found to be less than 0.1 which is in the acceptable limits.

There were many differences between the two hospitals in many areas of patient care. Most of the attributes in many patient care areas received only “Average” and “Poor” ratings in both the hospitals. The Indian hospital received “Poor” rating for more number of attributes for different units, however the patient turnover was always high in India, which increased the overall performance rating. (Tables 3a, 3b) The Indian hospital performed at 85% of the performance of Barbados hospital with respect to the patient care sector.

In the establishment section, Barbados hospital surpassed the Indian hospital thanks to the state-of-art technology being employed in many areas. Many areas in Barbados hospital received the highest rating compared to Indian hospital which received only “Average” and “Poor” ratings (Table 4). The gap analysis for this sector showed that the Indian hospital performed only 50% of Barbados hospital.

In the administrative section, there were not many areas which grossly differed between the two hospitals. Both hospitals received “Average to “Poor” ratings for most of the sub-factors (Table 5) and the Indian hospital performed almost equal (90%) to the hospital in Barbados with respect to the “Administrative sector”.
When all the performance ratings were summed, the cumulative rating of performance of Barbados hospital was 0.38 and that of the Indian hospital was 0.27. The overall percentage of performance of Indian hospital with respect to the Barbados hospital was 71%.

The comparison between Barbados hospital and the Indian hospital with respect to the critical success factors is illustrated in Figure.3.
Discussion

Quality of healthcare delivery is a very difficult paradigm to measure quantitatively and it was thought it might be impossible to measure it at all. Donabedian outlined the classical three categories of measurement of quality of healthcare delivery namely structure of the healthcare institution, process of care and outcome of the patient (Donabedian, 1988).

The structure-based quality measure should ideally evaluate the human, physical and financial resources that are needed to provide care. The clinical and technological expertise with respect to all the specialties in medical field forms the skeleton of this assessment, although the exact evaluation methodology is known to have many disadvantages. For this type of measurement, the progress report “America’s Best Hospitals” used American Hospital Association’s coding of hospitals such as board-certified physicians to number of beds, although there were many ambiguities in the method of coding. The expertise of healthcare providers is also a difficult area to measure.

Process is defined as what is actually done in giving and receiving care while outcome is defined as a change in the patient’s current health status that can be attributed to antecedent healthcare. However a quality measure based on process may not be able to predict the outcome of a patient and an outcome-based quality measure may not adequately consider the factors which are not under the control of the physicians (Brook RH, 1996). Mortality rates are the usual endpoints of outcome-based models of quality measurement. Risk adjusted mortality rate as a measure of quality is highly controversial, because of its inability to appropriately adapt to different case-mixes of different hospitals. Many factors such as socio-economic and cultural factors may influence
outcomes in a given setting. Many patients may not seek immediate medical attention
due to their cultural beliefs and also due to inaccessibility to modern medical care in
many developing countries. Thus despite adequate delivery of healthcare, there can still
be poor outcomes in certain hospitals depending on the case-mix of the hospitals. Hence
there have been many dissident opinions for the use of mortality rates to evaluate quality
of healthcare delivery (Sherck JP, 1996; Normand ST 1996). Our earlier research for
evaluating the outcome of a surgical ICU in Barbados used a mortality-based model and
assessed the ICU’s performance to be excellent because our observed mortality rate was
lower than the predicted rate (Hariharan S, 2002). However, when we later evaluated the
performance of the same ICU with a model based on the AHP, we could exactly delineate
the areas of weakness in our ICU (Hariharan S, 2003). Hence in a situation where
majority of the healthcare organizations qualify with honors when evaluated according to
the mortality-based models, it is difficult to distinguish between genuine quality and
grade inflation (Popovich MJ, 2002). The Health Care Financing Administration
(HCFA) in USA even discontinued the public release of the risk-adjusted mortality rates
of hospitals because of the skeptical opinions regarding the value of mortality-based
models as a reliable quality measure (Associated Press, 1993).

Thus there can be a no single measure that can assess the overall quality of a hospital and
this is why the US News and World Report incorporates all the three factors to rate
America’s Best Hospitals. By combining all three factors, an Index of Hospital Quality
(IHQ) was devised with scores distributed along a scale ranging from 0 through 100 (Hill
CA, 1995). Although process of healthcare delivery is considered as the most important
factor of quality measure, this has been identified as the “weakest link” in the IHQ chain
by the authors of America’s Best Hospitals (The Editors of US News and World Report, 1996). This is because of the non-availability of a method to effectively measure the process of healthcare delivery. The current method of physician survey is completely subjective, because the survey asked the physicians to choose the “best” hospitals without even defining the factors that they have to consider before arriving at such a conclusion. The reputation of the hospital was the predominant factor used in deciding this attribute as “best”. The reputation of the hospitals further went up since these hospitals quoted their ratings as part of public relation exercises, although the method of rating was known to be highly controversial (Mod Health Care, 1995). Thus proxies such as reputation of a hospital are not sufficient as a measure of the process and it is only through a clear understanding of the complete process of healthcare that the other two quality measures namely the outcome and structure can be understood and measures for quality improvement and remedies for deficiencies can be implemented (Green J, 1997).

Palmer has suggested ways of constructing process-based methods to measure quality of healthcare (Palmer RH, 1997). The ratio of the number of patients who are treated according to evidence-based guidelines to those who are eligible to receive such a management has been suggested by this author as a process-based measure. The biggest disadvantage of this method is that it is difficult to apply this as a measure of the process of healthcare delivery in a tertiary care hospital. A patient who attends a tertiary care hospital will be most often managed by evidence-based guidelines and hence it may not be easy to find those patients who have not been treated according to such guidelines. The variability in the management of patients who have had similar diagnoses may be attributed to either different schools of thoughts within the standard guidelines or
individual variations in the clinical presentation of each patient. A general practitioner who has not updated his or her knowledge for a longer period of time may be unaware of the recently established guidelines and hence may treat patients by an outdated therapeutic guideline. Therefore this method might be applicable in a situation when performance of an individual is being assessed rather than assessing the process of a system at the organizational level.

Nowadays, with the explosive growth of information technology (IT), patients are frequently well informed from the world-wide-web regarding the standard guidelines for the management of their illnesses. Therefore it is difficult to exactly pin-point a situation where a patient will be managed not in accordance with the standard guidelines. This is especially true in this era of managed care and litigations. Therefore non-evidence based treatment situations will always be the rare and exceptional cases in a tertiary care hospital and hence the ratio of “inappropriately” treated patients to those who were eligible to receive such treatment (if this denominator is accurately quantifiable) will be always close to “one”. The consequence of this again is that most of the hospitals will qualify with honors if this method is used to rate their performance. In a tertiary level hospital, assessment of the processes in every sector of the hospital which sequentially leads to overall better patient care, is a better option than assessing the quality of individual healthcare provider.

The Accreditation Manual for Hospitals (AMH) released by the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) in USA describes the need for not only knowing whether things are done the right way, but also to know whether things done the right way are being done well. Therefore, it has emphasized for a shift of focus
in evaluating the quality of process of healthcare delivery from the individual level performance to performance of the systems and processes in an organizational level (JCAHO, 1993). Measurements such as infection surveillance, review of resource utilization are suggested as methods for measuring the quality at an organizational level (Slovensky DJ, 1996). Although these methods assess certain specific processes of a hospital, there is no method currently available to evaluate all the important processes of a healthcare institution in a global way. Hence we developed this model using AHP so that multiple criteria could be used to evaluate the overall performance of the hospital as an organization.

Although at the first sight, our method may appear to be one that evaluates the structure and resources of a hospital, it is the attribute we have assigned for each sector that exactly defines the process of healthcare rather than the availability of resources. For example, the patient turnover in a unit will reveal whether the scheduling and allocation of resources are done in the proper way, patient comfort will reveal if a patient-focused care is delivered properly and the incidence of adverse patient occurrences will indirectly reveal if the patient received management according to the established standards and without negligence. The performance of the different sections in the establishment sector such as radiology and laboratory with a state-of-art technology will identify if the care given is faster and conforms to an updated good quality method, rather than just evaluating if the service is available or not. As another example, a blood bank which has the state-of-art facilities to separate components will invariably supply only components, and this will serve to decide if the quality of the process of blood bank operation conforms to high standards. Similarly, a hospital pharmacy, which is not developed by an
IT based system management, will have time-consuming and inferior quality methods of dispensing medications which will eventually lead to more patient discomfort and poor performance.

Thus the present method clearly defines all the processes of healthcare delivery in a given hospital and by asking the hospital managers to assign their weights for the ratings of the critical success factors and sub-factors, it will be possible to evaluate the performance of the hospital which in turn enables comparison between different hospitals. This can be easily done relatively, because attributes such as patient turnover can be accessed from records, patient comfort can be assessed by data such as waiting time in areas such as A&E and out-patient clinics, cancellations and postponements in the OR etc., and APOs can be assessed by the audit in each patient-care unit and data such as successful lawsuits against those patient care sectors.

Another advantage of the method is that it clearly demarcates the areas where one hospital is doing well and where it is deficient. Thus applying this methodology, it is possible for a hospital manager to identify all the rectifiable areas where the hospital is weak which helps to enable improvisation of that specific area and in turn improve the overall function of the hospital. A sensitivity analysis may also done by which it is possible to know the impact of improvisation of that area and prioritizations can be done.

The method we have used is not without pitfalls. Although the weights and ratings for each sub-factor were allocated by detailed discussions and brainstorming sessions, it may be argued that these are still subjective. However, the consistency ratios for the pair-wise comparison were in the acceptable limits and additionally the mathematical basis of AHP itself has allowances for these subjective components in the hierarchy. When compared
to the absolutely subjective nature of asking the physicians to select “best” hospitals, the present way of asking the hospital managers to uniformly allocate specific weights to the different areas of their hospitals will minimize the subjective component. Certain attributes may not exactly reflect the quality accurately in some circumstances. For example, patient turnover is considered to be one of the important criteria in the all the patient-care areas of the hospital. However this may be influenced by the geographical location of the hospital, demographics of the area and the pattern of hospital outpatient appointments. For example, a hospital in a developing country like India, where there are frequently no regulated appointment systems for patients to attend outpatient clinics, the patient turnover may be very relatively high in many hospitals. This does not necessarily mean that the quality of care given is good in the hospital; on the contrary it may be even low. This is the main drawback of considering patient turnover alone as a measure of the quality of performance of a hospital. However, if it is either known or assumed that a hospital is adequately equipped to handle a high patient turnover, it will be useful to consider this factor as a metric of hospital performance. Hence we included patient turnover as an attribute to the sub-factors in areas of patient care.

We suggest that the model may be applied with minimal modifications for every hospital tailoring to the local needs. Managers may also identify their own critical success factors, sub-factors by questionnaire evaluation and/or brainstorming sessions and identify their respective weights to the various factors and sub-factors. This is one of the benefits of applying AHP as a tool of healthcare quality measurement. Healthcare delivery is highly complex and the patterns are different in every region in accordance with the social, cultural, economic and political setting of the particular region. When different factors
take priority in different settings, and there are trade-offs between decision criteria, AHP is one of the most appropriate tools for the successful application in multiple criteria decision-making situations (Sloane EB, 2002). It allows application of the different perspectives of managers according to their own context.

In summary, there are many advantages of using AHP in the performance measurement of a hospital.

- Healthcare service is multifactorial and the factors are both objective and subjective in nature and measurement of the performance of such a system can be easily modeled using AHP.
- Performance measurement is also a group-decision-making process, and AHP allows the same.
- AHP has a sound mathematical basis, and its application is user-friendly.
- AHP enables to identify the deficiencies in the specific areas of the hospital.
- AHP allows carrying out a sensitivity analysis that may help hospital managers understanding the effect of their decisions, and prioritize the areas requiring improvement.
- Software is available and can be utilized for easy measurement.

AHP suffers from the following shortcomings:

- A limitation of AHP is its inability to indicate those judgements that need to be revised. Expert Choice gives a recommended revision regardless of whether the recommended value fits within the 9-point scale of AHP. An additional approach is recommended. The study of Genest and Zang (1996) can be a first instigator for a surveyable approach.
The choice of the scale and whether or not to use normalizations, are important issues which should be seen as practical procedural choices whose consequences need to be understood. Although discretized ratio scales such as the 1-9 scale of the AHP can be very helpful in preference elicitation, they are nevertheless problematic as they severely restrict the range and distribution of possible priority vectors. The balanced scale proposed by Salo and Hamalainen, (1997) provide an essential improvement in this matter. Even so, the assumption that verbal expressions can be mapped onto numbers in the same way, no matter who is responding and in what context, must be regarded with due caution. The implication of scale selections must be considered explicitly, especially if the results to be used in a normative sense. Risks associated with scale selection can be mitigated through software tools, which allow the practitioner to compare results based on different scales.

The real problem with AHP is the way it aggregates over levels of the hierarchy. This has been well documented in the work of Barzilai (1998), Finan and Hurley (2002), and Belton and Gear (1983). Belton and Gear (1983) introduced rank reverse phenomenon and most researchers agree that it poses a serious challenge to the AHP.

Nevertheless, on the whole, AHP has been a useful tool in dealing with multiple factors on different qualitative domain.
Conclusions

With the focus of performance measurement in healthcare shifting from individual practitioner’s level to the organizational level, there is an increasing need for an easily applicable tool to evaluate the existing level of performance of all the systems and processes of a hospital for improvement in quality. The present study has established AHP as a very useful tool for a process-based performance measurement of a tertiary care hospital and comparing its performance with another.
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Table 1 Nine point scale for pair-wise comparison

<table>
<thead>
<tr>
<th>Intensity of pair-wise comparison</th>
<th>Importance</th>
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<tbody>
<tr>
<td>1</td>
<td>Equal importance, two activities contribute equally to the object</td>
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<tr>
<td>3</td>
<td>Moderate importance, slightly favors one over another</td>
</tr>
<tr>
<td>5</td>
<td>Essential or strong importance, strongly favors one over another</td>
</tr>
<tr>
<td>7</td>
<td>Demonstrated importance, dominance of the demonstrated importance in practice</td>
</tr>
<tr>
<td>9</td>
<td>Extreme importance, evidence favoring one over another of highest possible order of affirmation</td>
</tr>
<tr>
<td>2, 4, 6, 8</td>
<td>Intermediate values, when compromise is needed</td>
</tr>
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### Table 2. Pair-wise comparison in factor level

<table>
<thead>
<tr>
<th>Factor</th>
<th>Patient Care</th>
<th>Establishment</th>
<th>Administration</th>
<th>Overall weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient Care</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>0.55</td>
</tr>
<tr>
<td>Establishment</td>
<td>1/2</td>
<td>1</td>
<td>1</td>
<td>0.25</td>
</tr>
<tr>
<td>Administration</td>
<td>1/3</td>
<td>1</td>
<td>1</td>
<td>0.20</td>
</tr>
<tr>
<td>Sub-factors</td>
<td>Ratings</td>
<td>Barbados hospital Performance*</td>
<td>Indian Hospital Performance*</td>
<td></td>
</tr>
<tr>
<td>-------------</td>
<td>---------</td>
<td>--------------------------------</td>
<td>----------------------------</td>
<td></td>
</tr>
<tr>
<td>A&amp;E</td>
<td>Patient turnover</td>
<td>Average</td>
<td>0.005</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Patient Comfort</td>
<td>Poor</td>
<td>0.0011</td>
<td>Poor</td>
</tr>
<tr>
<td></td>
<td>APO</td>
<td>Average</td>
<td>0.0083</td>
<td>Average</td>
</tr>
<tr>
<td>OR</td>
<td>Patient turnover</td>
<td>Average</td>
<td>0.0087</td>
<td>Poor</td>
</tr>
<tr>
<td></td>
<td>Patient Comfort</td>
<td>Poor</td>
<td>0.0029</td>
<td>Poor</td>
</tr>
<tr>
<td></td>
<td>APO</td>
<td>Low</td>
<td>0.0149</td>
<td>Poor</td>
</tr>
<tr>
<td>ICU</td>
<td>Patient turnover</td>
<td>Average</td>
<td>0.005</td>
<td>Average</td>
</tr>
<tr>
<td></td>
<td>Patient Comfort</td>
<td>Average</td>
<td>0.0058</td>
<td>Poor</td>
</tr>
<tr>
<td></td>
<td>APO</td>
<td>Average</td>
<td>0.0058</td>
<td>Average</td>
</tr>
<tr>
<td>Dialysis unit</td>
<td>Patient turnover</td>
<td>Average</td>
<td>0.0041</td>
<td>Average</td>
</tr>
<tr>
<td></td>
<td>Patient Comfort</td>
<td>Average</td>
<td>0.0017</td>
<td>Average</td>
</tr>
<tr>
<td></td>
<td>APO</td>
<td>Low</td>
<td>0.005</td>
<td>Average</td>
</tr>
<tr>
<td>Labor ward</td>
<td>Patient turnover</td>
<td>Average</td>
<td>0.0083</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Patient Comfort</td>
<td>Good</td>
<td>0.01</td>
<td>Average</td>
</tr>
<tr>
<td></td>
<td>APO</td>
<td>Low</td>
<td>0.007</td>
<td>Low</td>
</tr>
<tr>
<td>Cumulative performance</td>
<td>0.093</td>
<td>0.076</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A&E: Accident & Emergency  
ICU: Intensive Care Units  
OR: Operating Rooms

APO: Adverse Patient Occurrences

* Performance as calculated by the AHP steps
**Table 3b** Weights and performance ratings for Chronic Care areas in “Patient Care”

<table>
<thead>
<tr>
<th>Sub-factors</th>
<th>Ratings</th>
<th>Barbados hospital</th>
<th>Indian Hospital</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General wards</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patient turnover</td>
<td>Average</td>
<td>0.0083</td>
<td></td>
</tr>
<tr>
<td>Patient Comfort</td>
<td>Average</td>
<td>0.017</td>
<td>Average</td>
</tr>
<tr>
<td>APO</td>
<td>Average</td>
<td>0.005</td>
<td>High</td>
</tr>
<tr>
<td><strong>Outpatient clinics</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patient turnover</td>
<td>Average</td>
<td>0.0083</td>
<td></td>
</tr>
<tr>
<td>Patient Comfort</td>
<td>Average</td>
<td>0.017</td>
<td>Poor</td>
</tr>
<tr>
<td>APO</td>
<td>Average</td>
<td>0.0083</td>
<td>High</td>
</tr>
<tr>
<td><strong>Physical therapy unit</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patient turnover</td>
<td>Average</td>
<td>0.007</td>
<td>Average</td>
</tr>
<tr>
<td>Patient Comfort</td>
<td>Average</td>
<td>0.005</td>
<td>Poor</td>
</tr>
<tr>
<td>APO</td>
<td>Average</td>
<td>0.0083</td>
<td>Average</td>
</tr>
</tbody>
</table>

**Cumulative performance**

Barbados hospital: 0.086  
Indian Hospital: 0.075

APO: Adverse Patient Occurrences

* Performance as calculated by the AHP steps
Table 4 Weights and performance ratings for “Establishment” factor and its sub-factors

<table>
<thead>
<tr>
<th>Sub-factors</th>
<th>Barbados Hospital</th>
<th>Indian Hospital</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Weights</td>
<td>Performance*</td>
</tr>
<tr>
<td>Laboratories</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laboratories</td>
<td></td>
<td>State-of-art</td>
</tr>
<tr>
<td>Pharmacy</td>
<td></td>
<td>Average</td>
</tr>
<tr>
<td>Radiology/radiotherapy</td>
<td></td>
<td>State-of-art</td>
</tr>
<tr>
<td>Central Sterilization/</td>
<td></td>
<td>Good</td>
</tr>
<tr>
<td>Infection Control</td>
<td></td>
<td>Good</td>
</tr>
<tr>
<td>Dietetics and nutrition</td>
<td></td>
<td>Average</td>
</tr>
<tr>
<td>Ethical Committee</td>
<td></td>
<td>Good</td>
</tr>
<tr>
<td>Communication systems</td>
<td></td>
<td>Average</td>
</tr>
<tr>
<td>Library/academic activities</td>
<td></td>
<td>Average</td>
</tr>
<tr>
<td>Cumulative performance</td>
<td>0.146</td>
<td></td>
</tr>
</tbody>
</table>

* Performance as calculated by the AHP steps
Table 5 Weights and performance ratings for “Administration” factor and its sub-factors

<table>
<thead>
<tr>
<th>Sub-factors</th>
<th>Barbados hospital</th>
<th>Indian Hospital</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Weights</td>
<td>Performance*</td>
</tr>
<tr>
<td>Staff Management</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medical</td>
<td>Average</td>
<td>0.0053</td>
</tr>
<tr>
<td>Nursing</td>
<td>Average</td>
<td>0.0038</td>
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<tr>
<td>Paramedical</td>
<td>Poor</td>
<td>0.0013</td>
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<tr>
<td>Support</td>
<td>Average</td>
<td>0.0023</td>
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<tr>
<td>Supply chain management</td>
<td>Average</td>
<td>0.015</td>
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<tr>
<td>Clinical Engineering</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maintenance</td>
<td>Average</td>
<td>0.008</td>
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<tr>
<td>Housekeeping</td>
<td>Average</td>
<td>0.0036</td>
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<tr>
<td>Financial Management</td>
<td>Average</td>
<td>0.012</td>
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<tr>
<td>Medical Records Management</td>
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<td>0.006</td>
</tr>
<tr>
<td>Cumulative performance</td>
<td>0.0575</td>
<td></td>
</tr>
</tbody>
</table>

* Performance as calculated by the AHP steps
Measuring performance of a hospital

Patient care

Establishment

Acute Care

Chronic Care

General wards

Outpatient Clinics

Physical therapy unit

Laboratories

Pharmacy

Radiology

Central sterilization & Infection control

Nutrition/dietetics

Ethics committee

Communication

Library/academic activities

Labor Wards

Outpatient Clinics

Physical therapy unit

Labor Wards

Goal

Critical success factors

Administration

Medical

Nursing

Paramedical

Support staff

Sub-factors

1. Good
2. Average
3. Poor

Ratings

1. State-of-art/ Good
2. Semi-automated/ Average
3. Outdated/ poor

(APO: Adverse patient occurrences)

Figure. 1 Entire hospital processes in AHP framework
Measuring performance of a hospital

Goal

Critical success factors

Establishment (0.25)

Administrative (0.2)

Patient care (0.55)

Acute Care (0.5)

Chronic Care (0.5)

Laboratory (0.3)

Pharmacy (0.3)

Operating Rooms (0.2)

Radiology (0.2)

Outpatient Clinics (0.4)

Central sterilization & Infection control (0.05)

General wards (0.4)

Nutrition (0.05)

Physical therapy unit (0.2)

Ethics committee (0.025)

Sub-factors

1. Patient turnover [High (0.6), Average (0.3), Low (0.1)]
2. Patient comfort [Good (0.6), Average (0.3), Poor (0.1)]
3. APO [High (0.1), Average (0.3), Low (0.6)]

1. State-of-art/ Good (0.6)
2. Semi-automated/ Average (0.3)
3. Outdated/ poor (0.1)

(APO: Adverse patient occurrences)

Figure 2 AHP framework with prioritizations
Figure 3 Overall comparisons between Barbados and Indian hospitals