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AN ANALYTIC HIERARCHY PROCESS FOR A DECISION TO IMPLEMENT MODERN INFORMATION SYSTEMS IN A HOSPITAL

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Abstract Discussed in this paper is the application of Operations Research/Management Science (OR/MS) method of Analytic Hierarchy Process (AHP) in the decision to implement modern information Systems in Gal-Bose Hospital, Yola. It was a pre-study undertaken to assist the decision maker, the Chief Medical Director, to make a decision that reflects his judgment. The study demonstrates practically the application of Operations Research in multi-criteria decision process by showing that, principal decision makers can make decisions which are holistic in view, unambiguous, free of doubts and with reduced risks.

The Problem Situation

The wife of the researcher urgently needed to see a medical doctor and was rushed to Gal-Bose Hospital, Yola (Nigeria). While waiting at the Card Room, the researcher observed huge piles of files on the shelves and the floor. He began wandering in his heart why the hospital management has not thought of modern information systems. In the process of wandering, a regular patient came in. As the usual duty of the Card Room staff, the attendant needed to retrieve the patient's file before any process of treatment could commence. The researcher watched with amazement how long it took her (the Card Room staff) - over 20 minutes - to locate the file. As a masters student in the Department of Operations Research, Federal University of Technology, Yola, the researcher thought of picking up a project to introduce Modern Information Systems to the Hospital.

Though the Medical Director, who is the principal decision maker welcomed the idea, certain criteria needed to be observed in order to clear his doubts about the desirability or otherwise of alternative. The researcher also gained understanding of how important the study is to the Director. In this way, the researcher hoped to also establish the probability of implementation of the system to be designed.

Gal-Bose Hospital

Gal-Bose Hospital, a subsidiary of Gal-Bose Nigeria Ltd, was conceived and located in Jada, a town in Jadavernment Area of Adamawa State, Nigeria in 1998. At the time of this study, the Hospital has relocated to its purpose built facility at No. 22 Atiku Abubakar Road, Jimeta Yola.

The hospital runs both Out-patient and In-patient clinics in all specialties of medicine such as Internal Medicine, Surgery, Pediatrics, Obst./Gynaecology, Dentistry and Physiotherapy. It has an in-house licensed registered Pharmacist, in accordance with the NHIS requirements. It has a state of the art Laboratory Department and conducts Ultrasound scan in addition to other contrast studies. The hospital has two incubators in its Pediatric department and also a functional mortuary. Its KIA ambulance is well equipped with comprehensive emergency gadgets. The Hospital is on retainer ship with a large number of private and corporate organizations. It also enjoys large NHIS enrollment.

The Model

"The Analytic Hierarchy Process (AHP) is a structured technique for helping people deal with complex decisions. Rather than prescribing a "correct" decision, the AHP helps people to determine one based on mathematics and human psychology. It was developed by Thomas L. Saaty in the 1970s and has been extensively studied and refined since then. The AHP provides a comprehensive and rational framework for structuring a problem, for representing and quantifying its elements, for relating those elements to overall goals, and for evaluating alternative solutions. It is used throughout the world in a wide variety of decision situations, in fields such as government, business, industry, healthcare, and education." (www.wikipedia.org.).

The output of Analytic Hierarchy Process (AHP) is a prioritized ranking of the decision alternative based on the overall preferences expressed by the decision maker.

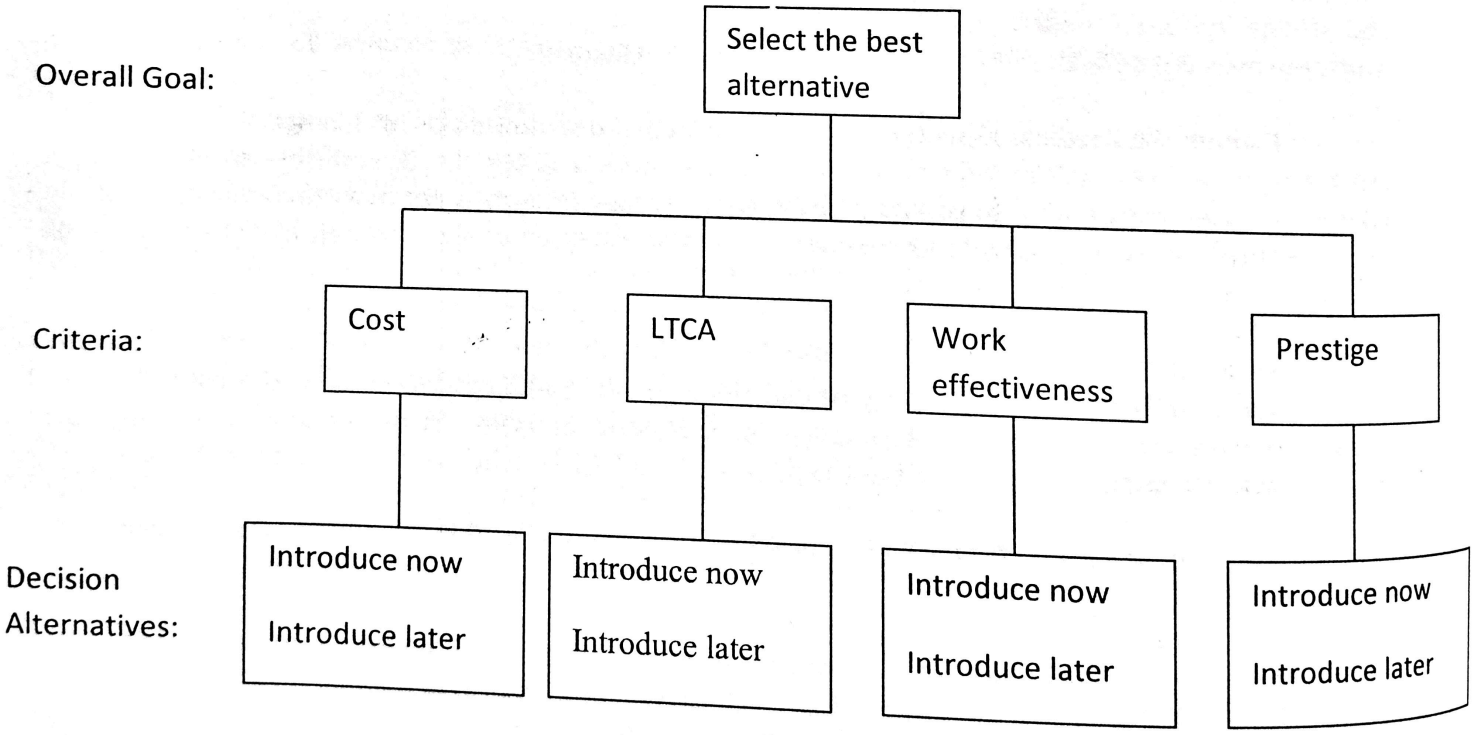
i) **Decision Alternative**: The researchers modeled the problem of the decision maker of Gal-Bose Hospital – The chief Medical Director, Dr. Jala Saleh to 3 decision alternatives (See Appendix I).

- Introduce Information Systems Now
- Introduce Information Systems later on, say, in five years or more
- Not to introduce Information Systems

ii) **Decision criteria:** Dr. Jala agreed that the following criteria were relevant for his decision selection process:

- **Cost**: This is the present cost of introducing the information system. It is worthy of note that there will be no immediate cost advantage.
- **Long Term Cost Advantage (LTCA)**: In the long run, there will be accumulated savings from stoppage of printing of record materials, construction of shelves, purchase of file cabinets and building of store rooms.
- **Work Effectiveness**: Information systems will save time and energy for both staff and patients. The Hospital would have a more efficient business.
- **Prestige**: Introduction of information systems will command respect for the hospital and give it a good image. Customers will be impressed and employees will be happier and work more proudly because there will be improvement in the business processes..

Figure 1: Hierarchy for the Selection Problem



Establishing Priorities

AHP uses pair-wise comparisons expressed by the decision maker to establish priorities for the criteria and priorities for the decision alternative based on each criterion. Pair-wise comparisons form the fundamental building blocks of AHP. With the four criteria, Dr. Jalal must make the following pair-wise comparisons:

- Cost compared to LTCA
- Cost compared to work effectiveness
- Cost compared to prestige
- LTCA compared to work effectiveness
- LTCA compared to prestige
- Work effectiveness compared to prestige.

Pair-wise comparison for the decision Alternatives:

- Introduce now compared to introduce later
- Introduce now compared to not to introduce
- Introduce later compared to not to introduce.

Comparison Scale for the Importance of Criteria

In establishing the priorities for the four criteria, AHP will require Dr. Jalal to state how important each criterion is relative to each other criterion when the criteria are compared two at a time (pair-wise). Table 1 shows the decision maker's verbal descriptions of the relative importance between the two criteria are converted into a numerical rating. Because the Doctor is too busy to complete a questionnaire, the research took the "verbal description" approach.

Table 1: Judgment Ranking

Verbal Judgment	Numerical Rating
Extremely more important	8 (Very Strongly to Extremely More Important)
Very strongly more important	7 (Strongly to Very Strongly More Important)
Strongly more important	4 (Moderately to Strongly More Important)
Moderately more important	2 (Equally to Moderately More Important)
Equally more important	

Data Collection and Analysis

Criteria Pair-Wise Comparism

Table 2 Summary of Dr. Jalal's Pair-wise Comparism of the four Criteria for the Decision to Implement Modern Information System in Gal-Bcse Hospital

Pair-wise Comparism	More Important Criteria	How Much More Important	Dr. Jalal's Numerical Rating
Cost – LTCA	LTCA	Very strongly to Extremely	8
Cost – Work Effectiveness	Work Effectiveness	Very Strongly	7
Cost – Prestige	Prestige	Very Strongly	7
LTCA – Work Effectiveness	LTCA	Strongly to Very Strongly	6
LTCA – Prestige	LTCA	Strongly to Very Strongly	6
Work Effectiveness - Prestige	Work Effectiveness	Very Strongly	7

Source: Researcher Interview 2009

LTCA: Long Term Cost Advantage.

Table 3: Matrix of Dr. Jalal's Criteria Pair-wise Comparism.

	Cost	LTCA	Prestige	Work Effectiveness
Cost	1	1/8	1/7	1/7
LTCA	8	1	6	6
Prestige	7	1/6	1	1/7
Work Effectiveness	7	1/6	7	1
Column Total	23.000	1.458	14.143	7.286

Source: Researcher Interview 2009

Table 4: Dividing each element of the matrix in Table 3 above by its column total

	Cost	LTCA	Prestige	Work Effectiveness	Averages
Cost	0.043	0.086	0.010	0.020	0.0398
LTCA	0.348	0.686	0.424	0.823	0.5703
Prestige	0.304	0.114	0.071	0.020	0.1273
Work Effectiveness	0.304	0.114	0.495	0.137	0.2625

Source: Researcher Interview 2009

Synthesization

The Averages Column in Table 4 shows the priority of each criterion. Using Dr. Jalal's Criteria Pair-wise comparism, the AHP determines that Long Term Cost Advantage (LTCA) with a priority of 0.5703. this is the most important criterion in the Information System Implementation process. Work Effectiveness (WE) with a priority of 0.2625 ranks second in importance, followed by Prestige with a priority of 0.1273. The present cost of implementing Information Systems (Cost) is the least important criterion with a priority of 0.0398. (See Table 4; Average Column)

Alternatives Pair-Wise Comparism

Summary of Dr Jalal's Pair-wise comparism of the three Narrowed Alternatives

Table 5: In terms of cost

Pair-wise Comparism	More Important Criteria	How Much More Important	Dr. Jalal's Numerical Ranking
Introduce Now – Introduce Later	Introduce Later	Moderately to Strongly	4
Introduce Now – Not to Introduce	Not to Introduce	Strongly	5
Introduce Later – Not to Introduce	Not to Introduce	Strongly	5

Table 6: Matrix of the Alternative Pair-wise Comparism in Terms of Cost

	Introduce Now	Introduce Later	Not to Introduce
Introduce Now	1	¼	1/5
Introduce Later	4	1	1/5
Not to Introduce	5	5	1
Column Total	10.00	6.25	1.40

Table 7: Dividing each Element of the Column in Table 6 by its Column Total

	Introduce Now	Introduce Later	Not to Introduce	Averages
Introduce Now	0.1000	0.0400	0.1429	0.0943
Introduce Later	0.4000	0.1600	0.1429	0.2343
Not to Introduce	0.5000	0.8000	0.7143	0.6714

Table 8: In Terms of LTCA

Pair-wise Comparism	More Important Criteria	How Much More Important	Dr. Jalal's Numerical Ranking
Introduce Now – Introduce Later	Introduce Now	Strongly Very	7
Introduce Now – Not to Introduce	Introduce Now	Strongly Very	7
Introduce Later – Not to Introduce	Introduce Later	Strongly	5

Table 9: Matrix of the alternative Pair-wise Comparism in Terms of LTCA

	Introduce Now	Introduce Later	Not to Introduce
Introduce Now	1	7	7
Introduce Later	1/7	1	5
Not to Introduce	1/7	1/5	1
Column Total	1.29	8.20	13.00

Table 10: Dividing Each Element of the Column in Table 9 by its Column Total

	Introduce Now	Introduce Later	Not to Introduce	Averages
Introduce Now	0.7752	0.8537	0.5385	0.7225
Introduce Later	0.1107	0.1220	0.3846	0.2058
Not to Introduce	0.1107	0.0244	0.0769	0.0707

Table 11: In Terms of Work Effectiveness

Pair-wise Comparism	More Important Criteria	How Much More Important	Dr. Jalal's Numerical Ranking
Introduce Now – Introduce Later	Introduce Now	Strongly	5
Introduce Now – Not to Introduce	Introduce Now	Moderately	3
Introduce Later – Not to Introduce	Introduce Later	Equally to Moderately	2

Table 12: Matrix of the Alternative Pair-Wise Comparism in Terms of Work Effectiveness

	Introduce Now	Introduce Later	Not to Introduce
Introduce Now	1	5	3
Introduce Later	1/5	1	2
Not to Introduce	1/3	1/2	1
Column Total	1.53	6.50	6.00

Table 13: Dividing Each Element of the Column in Table 12 by its Column Total

	Introduce Now	Introduce Later	Not to Introduce	Averages
Introduce Now	0.6536	0.7692	0.5000	0.6409
Introduce Later	0.1307	0.1538	0.3333	0.2059
Not to Introduce	0.2179	0.0769	0.1667	0.1538

Table 14: In Terms of Prestige

Pair-wise Comparism	More Important Criteria	How Much More Important	Dr. Jalal's Numerical Ranking
Introduce Now – Introduce Later	Introduce Later	Strongly	5
Introduce Now – Not to Introduce	Introduce Now	Moderately	3
Introduce Later – Not to Introduce	Introduce Later	Equally	1

Table 15: Matrix of the Alternative Pair-Wise Comparism in Terms of Prestige

	Introduce Now	Introduce Later	Not to Introduce
Introduce Now	1	1/5	3
Introduce Later	5	1	1
Not to Introduce	1/3	1	1
Column Total	6.30	2.20	5.00

Table 16: Dividing Each Element of the Column in Table 15 By its Column Total

	Introduce Now	Introduce Later	Not to Introduce	Averages
Introduce Now	0.1587	0.0909	0.6000	0.2832
Introduce Later	0.7937	0.4545	0.2000	0.4827
Not to Introduce	0.0529	0.4545	0.2000	0.2358

Overall Priority Ranking

Overall priority of Introducing Now

$0.0398(0.0943) + 0.5703(0.7225) + 0.1273(0.6409) + 0.2625(0.2832) = 0.5717$

Overall priority of Introducing Later

$0.0398(0.2343) + 0.5703(0.2058) + 0.1273(0.2059) + 0.2625(0.4827) = 0.2796$

Overall priority of Not to Introduce

$0.0398(0.7143) + 5703(0.0707) + 0.1273(0.1538) + 0.2625(0.2358) = 0.1502$

Summary

Ranking the priorities of the criteria with the alternatives, we have the AHP ranking of the decision alternatives as shown in Table 17.

Table 17. Decision Alternatives Vs Priority Values

Decision Alternatives	Priorities
• Introduce Modern Information Systems Now	0.5717
• Introduce Modern Information Systems Later	0.2796
• Not to Introduce Modern Information Systems at all	0.1502

Conclusion

AHP as a potent OR/MS tool can provide scientific basis – that which is based on data or facts - for even more complex decisions than the one demonstrated in this study and quantitatively guide decision makers to gain better understanding of the trade offs in a decision making process. Decision makers in government, educational institutions, public and private establishments, social organizations, groups and associations can make use of Operations Research tools in their decision making processes. This will give them more confidence in implementing their decisions and have their costs and risks reduced.

Recommendations

The results of the study as seen in the summary (Table 17) provide scientific basis for Dr. Jalal to make a decision regarding introducing Modern Information Systems in Gal-Bose Hospital. As long as Dr. Jalal believes that his judgments regarding the importance of the criteria and his preferences are valid, the AHP priorities recommend that Dr. Jalal should introduce Modern Information Systems in Gal-Bose Hospital Now.

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