An Integrated Approach for Performance Evaluation of Healthcare Industry with Proposed Leagile Policy Framework

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Abstract - During the pandemic outbreak, the healthcare sector is at the forefront to face the unforeseen crisis with its' different wings including doctors, nursing staff, clinical and diagnostic services with diversified applications of medical electronics. Healthcare services are characterized by the changing demand for products and services due to the changing dimensions of the pandemic day by day. Hence the varying demand for healthcare services in these pandemic times should be monitored by a suitably structured framework so that the right product and service should reach the patient at right time and place. The objective of the present study is to analyze the performance of Indian healthcare by identifying the healthcare performance indictors by means of BSC perspectives, which are responsible to improve the quality of health care service, ranking of healthcare units based on those key factors to validate the same, zone wise analysis for child healthcare performance, which leads to constitute a suitable strategy to improve nationwide child health care and propose a healthcare strategy framework to obtain the balance between patient demand and supply. The proposed Leagile Strategy with Patient Order Decoupling Point (PODP) leads to a balanced Leagile framework to meet the patient demand variations.

Keywords: Balanced Score Card, Data Envelopment Analysis, Fuzzy TOPSIS, PODP, Leagile Strategy

1. Introduction

Indian healthcare is characterized by patient-centric care, functional through the hospitals, and health care units all over India. The objective if Indian healthcare industry is to sustain a user-friendly ambiance to achieve maximum patient satisfaction by providing the right care to the right patient at right time. However perfect synchronization between the patients and related service providers definitely results in accurate treatment, timely recovery, and discharge of patients with a smiling face, which results in the long-term reputation of the hospital. In the present study, two different secondary data sources have taken into consideration. In the first approach, based on patient feedback data obtained from eight tertiary healthcare units, eleven key performance indicators identified in the context of four perspectives of a Balanced Scorecard. Based on patient feedback data, net weighted average for each performance indicator determined based on a total 100 score and five-point scale. The net weighted score shows the patient focus on financial implications and the recommendation for further improvement of interdepartmental functions. Further, in the same study, the Data Envelopment Analysis approach with a single input and single output focussed on patient satisfaction and the best degree of service to be provided to the patients. In the subsequent approach, based on these key performance indicators, three healthcare units have ranked. In the next study, the district wise child health data for a state, obtained from the Ministry of Health and Family Welfare, Government of India has taken into consideration. Three different infant immunization data have been considered as inputs and infant survival rates with three common diseases as outputs. Applying online DEA Solver, the efficient DMUs (districts) are determined. Also with constant input and two outputs and vice versa, Efficient Frontiers are drawn to determine the most efficient districts leads to minimizing the output, i.e. least number of affected children, and maximize the input, i.e. maximum number of infants have immunized. The study concluded with proposed Leagile Strategy with Patient Order Decoupling Point (PODP), that leads to a balanced Leagile framework.

Rest of the paper is organized as follows. The second section explained the objective of the study, third section elaborated the literature review, fourth section represents the identified problem and decision algorithm, fifth section deliberated on results and discussion, the proposed model with different components is discussed in the sixth section and the conclusion, limitation and future scope of the study in last section.

2. Objective

- Identify significant factors responsible to maximize patient satisfaction and validate the same by ranking healthcare units.
- Analyse regional child healthcare and formulate child healthcare strategy
- To propose Leagile Policy Framework to obtain balance between production lead time and delivery lead time

3. Literature Review

As per the data provided by the Central Bureau of Health Intelligence, Government of India in National Health Profile, 2018, India has contributed significantly to the national health progress that includes enhanced life expectancy at birth, reduced infant mortality rate and crude death rates, as a result of improved immunization, growing health consciousness, necessary health care provisions for newborns, conducting national health programs all over India. Gupta et al, 2017, conducted a qualitative study to assess the degree of implementation of maternal and child health (MCH) plan and subsequent exploration of perceptions and beliefs of stakeholders regarding the extent and effectiveness of National Rural Health Mission (NRHM).

3.1 Fuzzy TOPSIS Multi Criteria Decision Making

As stated by Wang and Lee, 2009, MCDM provides the most effective framework for comparison based on the evaluation of multiple conflict criteria. The authors earlier discussed the selection of material handling equipment through MCDM processes (Sen et al, 2015, 2017 & 2019]). Now there are some critical attributes, determined by subjective perceptions when Fuzzy MCDM can explain more appropriately the evaluation of available alternatives to select the optimum one. Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), a well known classical Multi criteria Decision Making Approach (MCDM), was first introduced by Hwang and Woon,1981. TOPSIS refers to the concept that the chosen alternative should have the shortest distance from the positive ideal solution and the farthest from a negative ideal solution. In this process, the fuzziness in decision data and group decision-making process are taken into consideration and linguistic variables are used to assess the weights of all criteria and the ratings of each alternative with respect to each criterion (Chen 2000). After converting the decision matrix into a fuzzy decision matrix, a weighted normalized fuzzy decision matrix is constituted and the Fuzzy Positive Ideal Solution (FPIS) and Fuzzy Negative Ideal Solution (FNIS) is determined. Finally, a Closeness coefficient of each alternative is determined to obtain the ranking order of the alternatives. The higher value of the Closeness coefficient indicates that an alternative is closer to FPIS and far from FNIS simultaneously. The Fuzzy TOPSIS algorithm represented as follows. (Sarkar, 2011)

Step 1: Constitution of Fuzzy Decision Matrix with m alternatives and n criterion.

	Criteria			
	C_1	C_2	C_j	C_n
A_1	$\tilde{\tilde{\theta}}_{11}$	$\tilde{\tilde{\theta}}_{12}$	$\ldots\ \tilde{\tilde{\theta}}_{1i}$	$\ldots\ \tilde{\tilde{\theta}}_{1n}$
A_2	$\tilde{\tilde{\theta}}_{21}$	$\tilde{\tilde{\theta}}_{22}$	$\ldots\ \tilde{\tilde{\theta}}_{2j}$	$\ldots\ \tilde{\tilde{\theta}}_{2n}$
	…	…	…	…
A_i	$\tilde{\tilde{\theta}}_{i1}$	$\tilde{\tilde{\theta}}_{i2}$	$\ldots\ \tilde{\tilde{\theta}}_{ij}$	$\tilde{\tilde{\theta}}_{in}$
A_m	$\tilde{\tilde{\theta}}_{ml}$	$\tilde{\tilde{\theta}}_{m2}$	$\ldots\ \tilde{\tilde{\theta}}_{mj}$	$\ldots\ \tilde{\tilde{\theta}}_{mn}$

Where A_i = ith alternative, i = 1,2 ...... m; C_j = jth criterion/attribute, j =1,2 --- n; $\tilde{\tilde{\theta}}_{ij}$ = Performance rating of alternative A_i wrt criterion C_j, also represents the linguistic variables described by triangular fuzzy numbers (a_{ij}, b_{ij}, c_{ij})

$$\tilde{\tilde{W}} = [\tilde{\tilde{w}}_1, \tilde{\tilde{w}}_2 \ldots \tilde{\tilde{w}}_j \ldots \tilde{\tilde{w}}_n]$$

$\tilde{\tilde{w}}_j = [\tilde{\tilde{w}}_{j1}, \tilde{\tilde{w}}_{j2}, \tilde{\tilde{w}}_{j3}]$ denotes weight of criterion C_j

Step 2 : Computation of normalized Fuzzy Decision matrix denoted by *R* as

$R = [r_{ij}]_{m \times n}, i = 1,2, \ldots, m, j = 1,2, \ldots n$

When $r_{ij} = \left[\frac{a_{ij}}{c_j^+}, \frac{b_{ij}}{c_j^+}, \frac{c_{ij}}{c_j^+}\right]$, j € B: $r_{ij} = \left[\frac{a_j^-}{c_{ij}}, \frac{a_j^-}{b_{ij}}, \frac{a_j^-}{a_{ij}}\right]$, j € C when B = benefit criterion, C = cost criterion

$c_j^+ = \max c_{ij}$ if j € B, $a_j^- =$ minimum a_{ij} if j € C

Step 3 : Determination of weighted normalised fuzzy decision matrix

$\tilde{\tilde{V}} = [\tilde{\tilde{v}}_{ij}]_{m \times n}$, I = 1,2,…..,n, where $\tilde{\tilde{v}}_{ij} = \tilde{\tilde{r}}_{ij}\tilde{\tilde{w}}_j$

Step 4: Determination of Fuzzy Positive Ideal solution (FPIS, A^+) and Fuzzy Negative Ideal Solution (FNIS, A^-)

$A^+ = (v_1^{\sim+}, v_2^{\sim+}, \ldots. v_n^{\sim+})$; $A^+ = (v_1^{\sim-}, v_2^{\sim-}, \ldots. v_n^{\sim-})$

Where $v_j^{\sim+}$=(1,1,1) and $v_j^{\sim-}$ = (0,0,0)

Step 5: Determination of separation distance of each alternative from A^+ and A^-

$$d_i^+ = \sum_{j=1}^{n} d(v_{ij}, v_j^+), i = 1,2,\ldots\ldots m, j = 1,2,\ldots\ldots n \qquad d_i^- = \sum_{j=1}^{n} d(v_{ij}, v_j^-), i = 1,2,\ldots\ldots, m, j = 1,2,\ldots.., n$$

when *d* (....,....,)= the distance measured between two fuzzy numbers; d_i^+ = the distance of alternative A_i from FPIS; d_i^- = the distance of alternative A_i from FNIS

Step 6: Computation of Closeness Coefficient (cc_i) of each alternative (A_i) as follows.

$$cc_i = \frac{d_i^-}{d_i^+ + d_i^-}, i = 1,2,\ldots.., m$$

Step 7: Ranking the order of alternatives and selection of the best alternative

Chou *et al,* 2012 proposed a Fuzzy TOPSIS approach for selection of medical service provider and subsequent evaluation process.

3.2 Balanced Score Card

Kaplan and Norton, 1996 stated that Balanced Score Card translates the business unit's mission and strategy into tangible objectives and measures. The application of Balanced Score Card as a strategic management tool is shown in Figure 1**.** The four perspectives of Balanced Score Card are

Customer Perspective: This perspective focuses particularly on core measures of customer satisfaction, customer retention, new customer acquisition, customer profitability, market, and account share in targeted segment etc.

Financial Perspective: Financial measures related to the financial planning and implementation strategy with the objective of long term profitability.

Internal Business Process Perspective: The objective of this perspective is to identify critical internal processes to deliver the value proposition, that will attract and retain customers in targeted market segments and also to satisfy shareholder expectations with excellent financial returns.

Learning and Growth Perspective: The fourth perspective of BSC identifies the infrastructure that the organization must build to create long term growth and improvement. Three principal sources namely people, system, and organizational procedure help to accelerate organizational learning and growth.

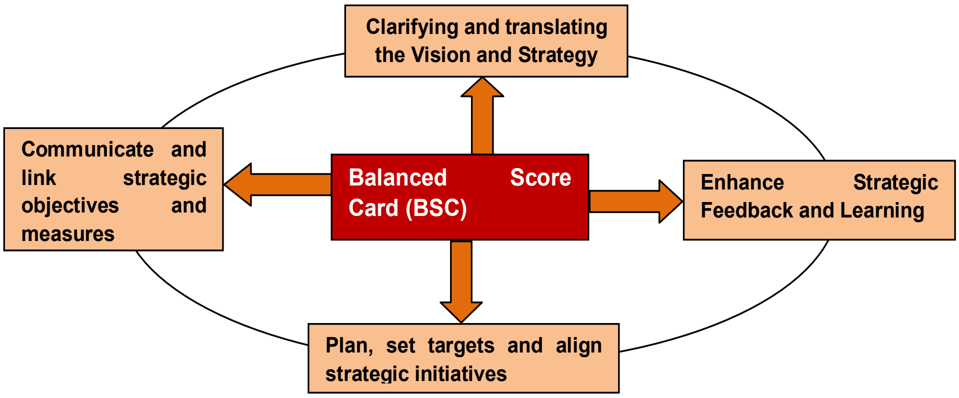


Figure 1 Balanced Score Card as a Strategic Frame Work

Punniyamoorthy and Murali, 2008 described Balanced Score Card as an objective benchmarking indicator for evaluating the achievement of the strategic goals of the organization. Aly *et al*, 2013 proposed balanced scorecard as a performance evaluation model for engineering education systems. A review of the application of BSC in healthcare was carried out by McDonald, 2012. Mavlutova and Babauska, 2013 carried out a performance analysis of private healthcare companies through BSC strategy. Bisbe and Barrubes, 2012 stated that BSC strategy has the potential to contribute to the implementation of strategies through the strategically oriented performance measurement system embedded within it. Lin *et al* 2013 explore the use of a Balanced Score Card that facilitates managers to meet multiple strategic goals and fuzzy linguistic methods to evaluate the performance of operating rooms of hospitals.

The Mountain Sates Group Inc, Department of Health and Human Sciences, USA, 2005 discussed the application of Balanced Score Cards for small rural hospitals and described Balanced Scorecard as an integrated management system with three principle components namely strategic management, communication, and measurement and analysis of the status of rural hospital employee turnover, patient turn over etc. Koncitikova *et al*, 2014 too discussed the application of BSC perspectives in healthcare organizations.

3.3 Data Envelopment Analysis

Data Envelopment Analysis (DEA) is a fractional linear programming based technique used to measure the efficiency of peer decision-making units that employ multiple inputs to produce multiple outputs. The nonparametric method was developed by Charnes et al, 1978. DEA is applied to measure performance and evaluating different organizational activities. The individual unit is termed as Decision Making Unit (DMU), which contains a number of inputs to produce different outputs (Cooper *et al*, 2007). DEA is employed to measure the performance and evaluate the organizational activities including healthcare services in terms of operational efficiency and productivity as a ratio of output to input. The simplest application of Data Envelopment Analysis refers to application of single input to single output to obtain the highest slope attained through the points joining through the origin, termed as Efficient Frontier. All other points used to stay below the said frontier when the Frontier Line envelops all other points. For multiple inputs and outputs, the generalized DEA ratio (Cooper et al, 2007), expressed as

$$\frac{\sum_{r=1}^{s} u_r y_r}{\sum_{i=1}^{m} v_i x_i} \quad \frac{u_1 y_1 + u_2 y_2 + \ldots\ldots\ldots u_s y_s}{v_1 x_1 + v_2 x_2 + \ldots\ldots\ldots v_m x_m} \quad \text{----------------------------------} \ (1)$$

When y_r = Quantum of output r; u_r = Assigned weightage to r ; x_i = Quantum of input i ; and v_i = Assigned weightage to i.

There are two types of DEA models, namely constant return to scale (CRS) or CCR model (Charnes et al, 1978) and variable return to a scale model (VRS) or BCC model, introduced by Bankers et al, 1984. Charnes et al,1978 introduced the term DMU (Decision-making Unit) and proposed the methodology to measure the efficiency of DMU through CCR model as the maximum the ratio of weighted output to input, when for all DMUs, the ratios are less than or equal to 1 and expressed as

$$\text{Max}_{h_0} = \frac{\sum_{r=1}^{s} u_r y_{ro}}{\sum_{i=1}^{m} v_i x_{i0}} \quad \text{Subjected to} \quad \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \le 1 \quad j = 1, 2, \text{--------} n \text{ -- (2)}$$

$$v_r, v_i \ge 0 \quad r = 1 \text{ ------- } s,\ i = 1 \text{ ------- } m$$

$y_{rj}, x_{ij} > 0$ represents the outputs and inputs of DMU_j and $u_r, v_i \ge 0$ represents the variable weights to be determined. Banker et al, 1984 further proposed an Input-Output Configuration Model, when *DMUs* are X_j, Y_j, $j = 1 .... n$, and $X_j = (x_{ij}, ... x_{ij}, ..., x_{mj})$; $Y_j = (y_{1j}, ..., y_{rj}, ..., y_{sj})$. It is assumed that at least one input and one output is positive and every DMU is assumed to use identical inputs and produce same outputs in varying amounts.

3.4 Agility, Leanness and Leagile Strategy

Agility is defined as the ongoing exploration and development of decision making capabilities under changed circumstances that lead to sustainable competitive advantage for the organization. The basic criteria for Agile thinking is transparent and well defined organizational objectives, meaningful communications in all directions, multidirectional dynamic leadership, opportunities for continuous learning and growth and the provision to generate and explore new ideas.

Leanness refers to the method that is applied to identify and remove redundant activities and waste and thereby improve the process velocity. The objective to apply Lean strategy in process control is to maximize the values obtained from products and services and thereby reduce the inactive process components. The Lean concept was generated from the 5S Quality Tool which provides the proven guideline to keep the workstation clean, safe, uncluttered, and properly organized. Naylor et al, 1999 proposed the application of Lean and Agile Strategy in manufacturing and stated that Agility is suitable to satisfy fluctuating demand of products in terms of volume and variety, whereas Lean strategy is suitable for reduced demand variation, when only the supply chain optimized, simplified, and streamlined. Mishra et al, 2018 while studied Lean and Agile strategy in healthcare, mentioned that Lean strategy is most appropriate with low variety products with predictable demand and longer product life cycle. On the other hand, the Agile strategy is suitable for a high variety of products with volatile demand and shorter product life cycles. At the same point in time, the objective to achieve a Lean and Agile strategy simultaneously leads to introducing a hybrid strategy, known as the Leagile strategy. Rahimnia and Moghadasian, 2010 explained supply chain leagility in healthcare services, where Lean and Agile paradigms separated by means of a strategic stocking point known as Customer Order Decoupling Point (CODP). Wikner and Johansson, 2015 classified Decoupling Point as Operational, Tactical, and Strategic. Operational Decoupling Points are used to interconnect the points of transformation during the flow of resources. Tactical Decoupling Points facilitate material code-enabled material management and Strategic Decoupling Point plays a key role in the supply chain interface and referred to as a subset of Tactical Decoupling Point. Neylor et al, 1999 explained Decoupling Point as a Buffer Point of strategic stock, that maintains the balance between fluctuating customer demand and product variety. The study explains the positional strategy of Decoupling Point highlighting five distinct supply chain classifications as follows when the stock holding Decoupling Point shifts gradually from manufacturers end to customer end.

Engineer to Order (ETO): Product and services in this category are unique with larger lead time, variable demand, and different raw materials.

Make to Order (MTO)/Buy to Order (BTO): This supply chain is characterized by greater product variety with the same raw material and comparatively reduced lead time.

Assembly to Order (ATO): In this stage, the stock holding Decoupling Point moves more towards customer ends, which is characterized by greater product variety with further reduced lead time.

Make to Stock (MTS): MTS supply chain is principally dominated by price and accurate forecast demand of a standard product with the correct level of stocks. This stage of the supply chain implies the delivery of products and services in predetermined locations, that nullifies under stock or overstock.

Ship to Stock (STS): This supply chain implies delivery of standard products to fixed locations.

Different supply chain strategies with stock holding Decoupling Point, as stated by Neylor et al is shown in Figure 2.

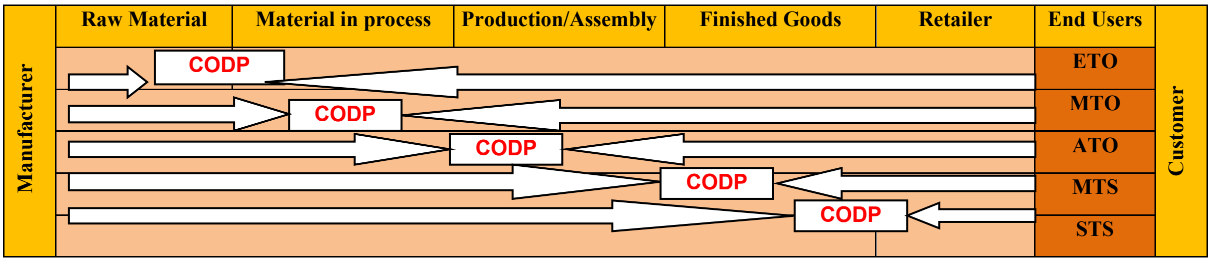


Figure 2 Operational Positions of Decoupling Points wrt manufacturers and Customers End

4. Problem Identification and Decision Algorithm

The literature survey indicates that a number of researches have obtained on enhancement of healthcare efficiency from different points of view, which include the application of different MCDM tools, Balanced Score Card strategy, Data Envelopment Analysis, Lean and Agile Approach, etc. For the present study, the research gap is identified as the approach to determine the key factors to enhance the healthcare performance, which is based on patient viewpoint in the context of Balanced Score Card perspective, application of MCDM and Optimization method to prioritize those key factors and validate the factors through the ranking of healthcare units based on the expert responses obtained. The study also emphasized on another important key result area in the national domain, child health care and applied Data Envelopment Analysis to determine the best performing districts in a state in child health care with the objective that other districts would follow the strategy of those identified districts. The study concluded with a proposed Leagile Framework with dynamic Decoupling Point methodology, that results a holistic approach for fulfilment of changing demands of the patients as per the situation, place, time, the patient condition is concerned, that leads to a sustainable healthcare service to the patients. The proposed Algorithm with Flowchart is shown in Figure 3.

5. Results and Discussion

5.1 Determination of Key Factors to improve Healthcare Performance

The constituted Balanced Score Card Framework based on the associated Performance Indicators with its' net weighted average (NWA) is shown in Figure 4. The net weighted score reveals a greater patient's focus towards financial procedures and norms to avail the healthcare service. The net weighted score also shows that there are numerous scope to improve and explore the interdepartmental functions. Nextly**,** Data Envelopment Analysis is applied with single input and single output with constant Return to Scale assumption and the Efficient Frontier is shown in Figure 5. The graph shows the efficient frontier line joining I2 and I3 with maximum efficiency. Thus the DEA study proposed the highest degree of importance to patient satisfaction in healthcare service providers and best services to be provided to the patients in the shortest possible time. Further, based on eleven identified BSC KRA, Fuzzy TOPSIS method has been applied, when three healthcare units have given the importance rating based on fuzzy linguistic weighing variables (Table 1) as represented in Table 2. Based on the identified key result areas (KRA), all responses are now categorised and subsequent net weighted average of all eleven performance indicators have determined.

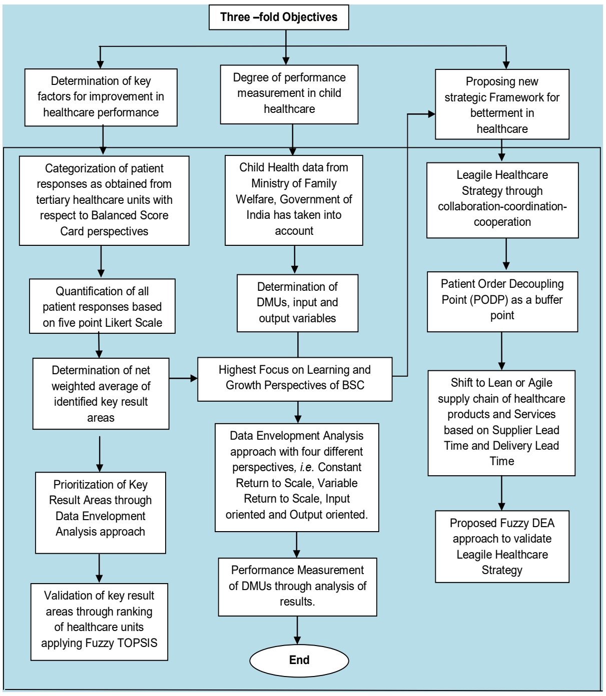
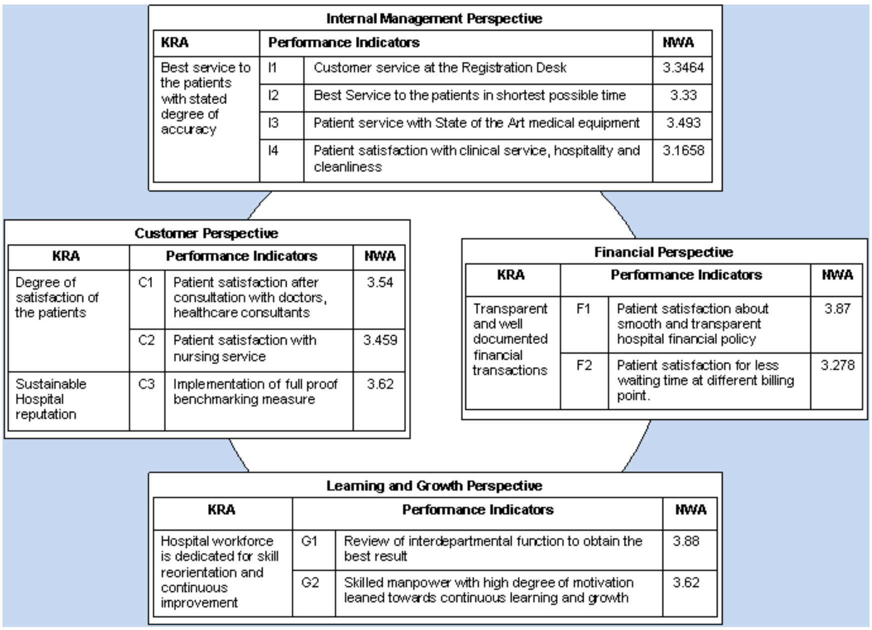


Figure 3 Stepwise Representation of Decision Algorithm through Flow Chart



Internal Management Perspective

KRA	Performance Indicators		NWA
Best service to the patients with stated degree of accuracy	I1	Customer service at the Registration Desk	3.3464
	I2	Best Service to the patients in shortest possible time	3.33
	I3	Patient service with State of the Art medical equipment	3.493
	I4	Patient satisfaction with clinical service, hospitality and cleanliness	3.1658

Customer Perspective

KRA	Performance Indicators		NWA
Degree of satisfaction of the patients	C1	Patient satisfaction after consultation with doctors, healthcare consultants	3.54
	C2	Patient satisfaction with nursing service	3.459
Sustainable Hospital reputation	C3	Implementation of full proof benchmarking measure	3.62

Financial Perspective

KRA	Performance Indicators		NWA
Transparent and well documented financial transactions	F1	Patient satisfaction about smooth and transparent hospital financial policy	3.87
	F2	Patient satisfaction for less waiting time at different billing point.	3.278

Learning and Growth Perspective

KRA	Performance Indicators		NWA
Hospital workforce is dedicated for skill reorientation and continuous improvement	G1	Review of interdepartmental function to obtain the best result	3.88
	G2	Skilled manpower with high degree of motivation leaned towards continuous learning and growth	3.62

Figure 4 BSC KRA with weighted performance

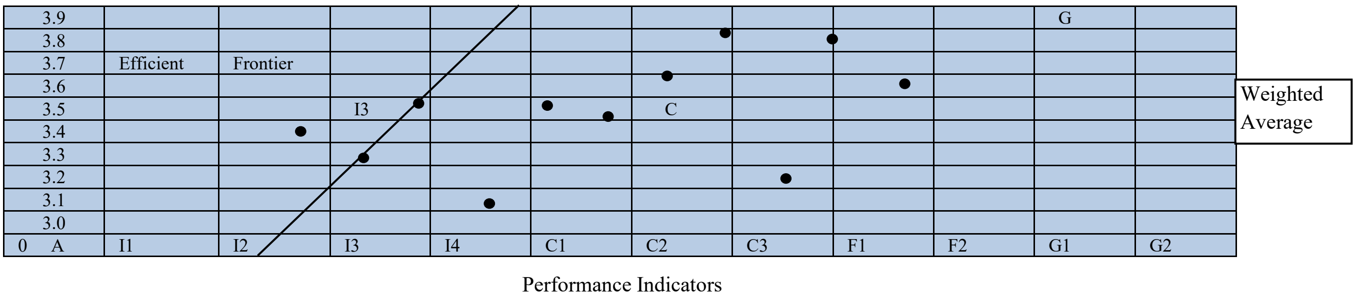


Fig 5 DEA Efficient Frontier with Single Input and Single Output

Table 1 Fuzzy Linguistic Scales for Importance Weight of Criteria

Linguistic Variables	Corresponding Trangular Fuzzy Numbers
Very Low (VL)	(0.0.1,0.3)
Low (L)	(0.1,0.3,0.5)
Medium (M)	(0.3,0.5,0.7)
High (H)	(0.5,0.7,0.9)
Very High (VH)	(0.7,0.9,1.0)

Table 2 Relative Importance of Eleven Criteria

Performance Indicators	DM1	DM2	DM3	Corresponding values			Fuzzy Weightage
				DM1	DM2	DM3	
I1	H	M	H	0.5, 0.7,0.9	0.3,0.5,0.7	0.5, 0.7,0.9	0.43,0.63,0.83
I2	H	H	H	0.5, 0.7,0.9	0.5, 0.7,0.9	0.5, 0.7,0.9	0.5, 0.7,0.9
I3	M	M	H	0.3,0.5,0.7	0.3,0.5,0.7	0.5, 0.7,0.9	0.36,0.56,0.76
I4	H	M	H	0.5, 0.7,0.9	0.3,0.5,0.7	0.5, 0.7,0.9	0.43,0.63,0.83
C1	H	VH	H	0.5, 0.7,0.9	0.7,0.9,1.0	0.5, 0.7,0.9	0.56,0.76,0.93
C2	VH	H	H	0.7,0.9,1.0	0.5, 0.7,0.9	0.5, 0.7,0.9	0.56,0.76,0.93
C3	M	M	M	0.3,0.5,0.7	0.3,0.5,0.7	0.3,0.5,0.7	0.3,0.5,0.7
F1	M	M	H	0.3,0.5,0.7	0.3,0.5,0.7	0.5, 0.7,0.9	0.36,0.56,0.76
F2	H	M	M	0.5, 0.7,0.9	0.3,0.5,0.7	0.3,0.5,0.7	0.36,0.56,0.76
G1	H	M	M	0.5, 0.7,0.9	0.3,0.5,0.7	0.3,0.5,0.7	0.36,0.56,0.76
G2	VH	VH	VH	0.7,0.9,1.0	0.7,0.9,1.0	0.7,0.9,1.0	0.7,0.9,1.0

Table 3 Linguistic Scale for rating of Healthcare Units

Linguistic Scale	Corresponding Trangular Fuzzy Numbers
Very Poor (VP)	0,1,3
Poor (P)	1,3,5
Fair (F)	3,5,7
Good (G)	5,7,9
Very Good (VG)	7,9,10

Now, the ranking of three health care units for each of the eleven key result areas based on Fuzzy Linguistic scale (Table 3) are shown through Table 4 and Table 5.

5.2 Degree of Performance Measure in Child Healthcare

In the second study, the Child Health Data of Ministry of Health and Family Welfare, Govt of India for the year 2018-19 is taken into consideration. All 23 districts in West Bengal, India are considered as DMUs and vaccine provided to the infants are considered as inputs and three diseases occurred among the infants as outputs (Table 6). Let us consider three input and one output and three outputs with one input with constant Return to Scale assumption. For 23 DMUs, the input and output data are analyzed through online DEA Solver based on four assumptions, namely Constant Return to Scale, Variable Return to Scale, Input oriented and Output oriented. For all approaches, DMUs 3, 4, 9,10,21,22 are found to be most efficient (Figure 6-9). The DEA Solver tool is applied in four different approaches namely output-oriented, input-oriented, constant return to scale, and variable return to scale. From all four graphical representations, six districts are showing the highest performance out of twenty-three.

Table 4 Fuzzy Weighted Normalised Decision Matrix

Alternatives	Criteria										
	I1 0.43,0.63, 0.83	I2 0.5,0.7,0.9	I3 0.36,0.56,0.76	I4 0.43,0.63, 0.93	C1 0.56,0.76,0.93	C2 0.56,0.76, 0.93	C3 0.3,0.5,0.7	F1 0.36,0.56. 0.76	F2 0.36,0.56.0.76	G1 0.36,0.56. 0.76	G2 0.7,0.9,1.0
H1	0.28,0.4,0.83	0.26,0.504, 0.837	0.22,0.46,0.76	0.245,0.51,0.93	0.34,0.62,0.93	0.34,0.623,0.93	0.18,0.41, 0.7	0.22,0.46, 0.76	0.167,0.38, 0.677	0.218,0.46,0.76	0.41,0.71, 0.96
H2	0.22,0.45, 0.772	0.325,0.602,0.9	0.2,0.42,0.706	0.215,0.46,0.89	0.34,0.62,0.93	0.257,0.51,0.83	0.16,0.375,0.65	0.2,0.42,0.7	0.22,0.46,0.76	0.165,0.38,0.68	0.46,0.774,1
H3	0.25,0.504,0.79	0.29,0.56,0.864	0.144,0.38, 0.623	0.245,0.51,0.93	0.25,0.51,0.0.83	0.3,0.57,0.863	0.18,0.41, 0.7	0.22,0.46, 0.76	0.22,0.46,0.76	0.22,0.46, 0.76	0.41,0.713,0.96
FPIS: A^+	(1,1,1)	(1,1,1)	(1,1,1)	(1,1,1)	(1,1,1)	(1,1,1)	(1,1,1)	(1,1,1)	(1,1,1)	(1,1,1)	(1,1,1)
FNIS: A^-	(0,0,0)	(0,0,0)	(0,0,0)	(0,0,0)	(0,0,0)	(0,0,0)	(0,0,0)	(0,0,0)	(0,0,0)	(0,0,0)	(0,0,0)

Table 5 Score of Healthcare Units and their Relative Ranking

Alternatives	**d_i^+**	**d_i^-**	**cc_i**	**Ranking**
Health Care 1	6.1247	5.819	0.4849	3
Health Care 2	6.172	5.98	0.492	2
Health Care 3	5.9385	5.75	0.5	1

Table 6 Database with 23 DMUs, three inputs and three output variables

DMUs	**Input 1**	**Input 2**	**Input 3**	**Output 1**	**Output 2**	**Output 3**
	In 1000	In 1000	In 1000	In 1000	In 1000	In 1000
	882.05	1.039	185.6	6.8	19.5	243.6
DMU 1	13.074	16.289	2.303	0.046	0.241	6.075
DMU 2	32.622	39.585	4.964	0.323	0.553	14.121
DMU 3	42.678	47.771	9.702	0.749	1.146	8.768
DMU 4	16.912	17.378	2.085	0.231	0.171	4.528
DMU 5	17.140	20.007	5.123	0.16	0.297	4.985
DMU 6	33.448	40.958	8.756	0.366	0.45	8.526
DMU 7	41.863	47.999	5.513	0.28	1.512	14.606
DMU 8	20.146	21.146	4.241	0.093	0.235	7.381
DMU 9	12.621	13.112	2.844	0.12	0.583	7.112
DMU 10	1.233	1.269	0.279	0.016	0.023	1.35
DMU 11	27.594	33.189	5.235	0.159	0.644	11.617
DMU 12	63.588	66.998	6.585	0.113	1.384	1.78
DMU 13	54.571	65.282	15.371	0.313	0.961	15.527
DMU 14	98.905	109.682	15.815	0.692	0.978	21.589
DMU 15	48.537	57.748	11.729	0.18	0.381	10.339
DMU 16	53.272	73.494	19.246	0.263	0.394	11.537
DMU 17	15.969	30.67	7.813	0.041	0.489	2.385
DMU 18	42.113	48.87	10.48	0.518	0.593	9.992
DMU 19	47.525	52.36	10.47	0.636	1.258	12.746
DMU 20	50.101	59.787	9.165	0.65	0.45	8.737
DMU 21	33.995	36.435	7.829	0.164	1.745	16.854
DMU 22	79.879	97.377	12.874	0.574	4.828	32.468
DMU 23	34.273	42.508	7.213	0.196	0.216	10.645

Source: Ministry of Health and Family Welfare, Government of India

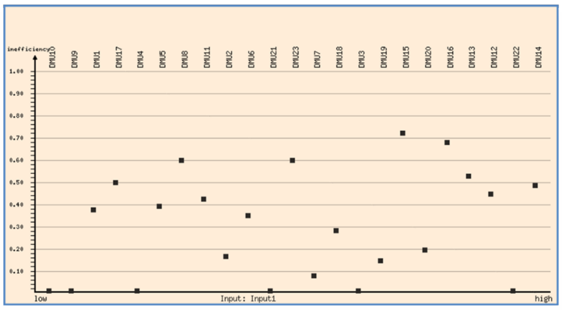


Figure 6 DMU Ranking Input Oriented

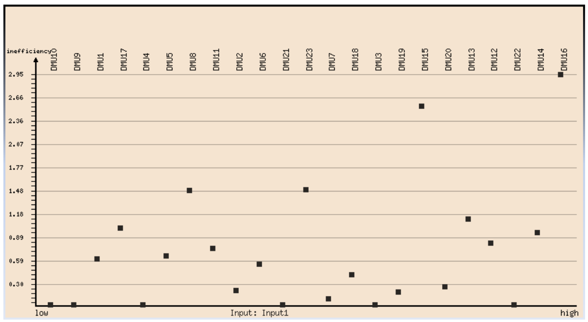


Figure 7 DMU Ranking Output oriented

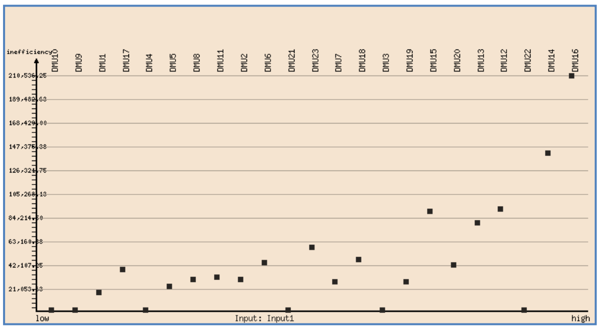


Figure 8 DMU Ranking Constant Return to Scale

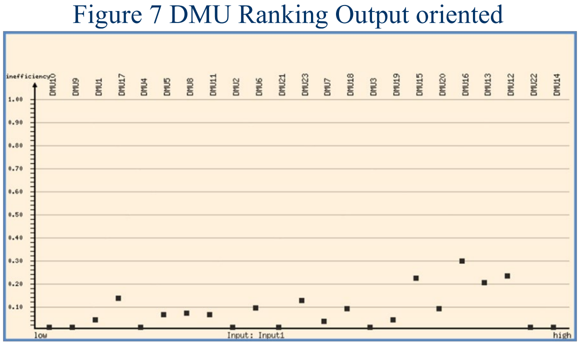


Figure 9 DMU Ranking Variable Return to Scale

5.3 Proposing New Strategic Framework for Betterment in Healthcare

As already mentioned, the net weighted score of the Performance Indicators shows the highest focus on Learning and Growth perspective of Balanced Score Card through exploring new methods for improvement of interdepartmental functions. At the outset, a Leagile Supply Chain Strategy with Patient Order Decoupling Point (PODP) is proposed, that acts as a buffer to determine the upstream and downstream of the supply chain of healthcare products and services, which results in the synergy between the healthcare service provider and patient through collaboration-co-ordination-cooperation as shown in Figure 10. As stated by Nath and Sarkar, 2017, Production Lead Time and Delivery Lead Time plays the pivotal role in supply chain. As per the intensity of patient demand for healthcare products and services, the ratio of Production and Delivery Lead Time (P/D ratio) varies and the PODP be shifted accordingly from product and service end to the customer end. According to the volatility of demand of patients, the PODP shifted from Lean to Agile and the Leagile shift of patient demand is explained in Figure 11. Further, as per the urgency of patient demand is concerned, it is understood that comparatively higher Production Lead Time may be approved for healthcare products and Delivery Lead Time is always higher for healthcare services. The PODP shift and associated parameters are shown in Figure 12.

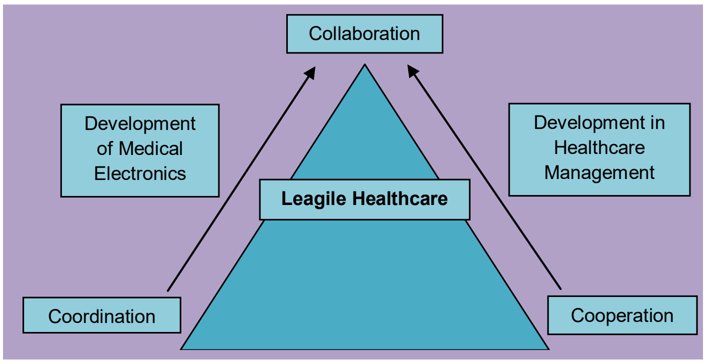


Figure 10 Proposed Leagile Healthcare Strategy

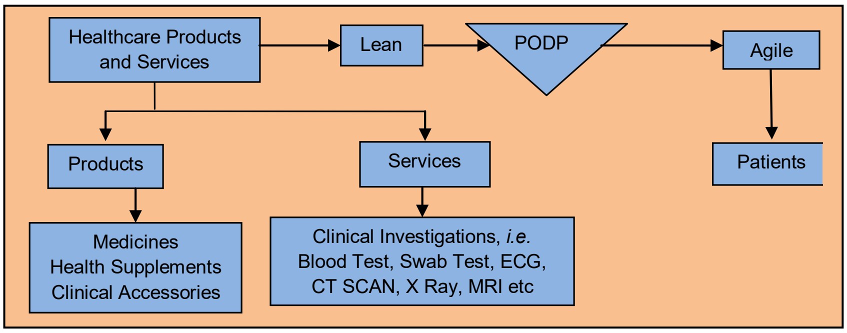


Figure 11 Volatility in Patient Demand

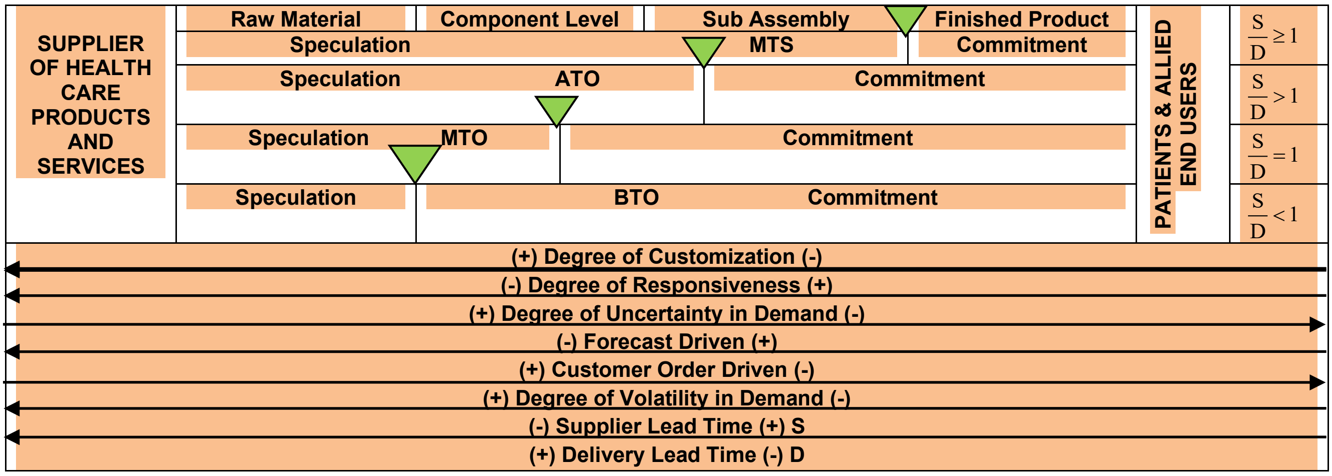


Figure 12 PODP Shift in Leagile Healthcare

6. Conclusion, Limitation and Future Scope

On growing complexity in patient demand to avail the opportunities and new avenues in modern healthcare services, increased interdependencies in healthcare service delivery and unpredictable variation in patient demand leads to more complicated demand-supply structure in healthcare services.

Moreover, the pandemic era accelerate the complexity further when healthcare service providers are implementing a suitable strategy to ensure adequate infection resistant measures for the patients. Technology has revolutionized the delivery of healthcare models by improving the quality of service being offered to the patients by reducing various cost components and turnaround time of workflow. In the present two-fold analysis, an effort has been made to find out the most important key factors for ultimate patient satisfaction and value-added patient service. The study also helped to determine the best performing districts in a state for child healthcare, one of the most important factor to move forward the national health indicator.

The study can be explored further with Fuzzy DEA methodology with the objective to overcome the inadequate robustness of DEA Efficiency Frontier and the probabilistic feasibility of the DEA inequality constraints. The Leagile Strategy may be validated with suitable data through the Fuzzy DEA approach. The study can also be explored further with more input and output variables of Child Health Care Data with Fuzzy DEA approach to obtain more precise results.

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