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DEA STUDY ON GOVERNMENT HOSPITAL PERFORMANCE IN TELANGANA STATE FOR THE YEAR 2018

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Abstract:
In this paper we studied the performance of the hospitals in 31 districts in Telangana to infer which district performs well in terms of various infrastructural / doctors/lab facilities etc. Data is considered for the new districts and the old ones for the year 2018 by Data Envelopment Analysis (DEA) for computing the efficiency of these districts by evaluating the technical efficiency. The peer district's performance is studied and compared with two models, CCR and BCC, for the performance evaluation.

Key words: BCC model, CCR model, data envelopment analysis, health services, hospital efficiency, Telangana State.

1.Introduction:

With an emphasis on preventive and promotive mechanisms of health care, India's health care system was designed to offer an integrated restorative and preventive health care to the public. Integrating Health & Family Welfare Programs, making the best use of resources and infrastructure, and strengthening public healthcare facilities are some of the ways that hospitals can be strengthened for effective curative care.

Today Health care industry is facing challenges and health care reforms, has gone transition period in the last 2 decades, is an important aspect of study for patients, practitioners, academicians and policy makers. Hospital industry is making huge revenue contributing for development of state/ nation. Measuring the efficiency of an organization/institution/industry is an important aspect to know the effective utilization of resources. The growth of an organization depends on effective use of existing resources, and evaluating continuously about public healthcare facilities.

After the formation of 31 new districts of the Telangana state, the government has taken measures to improve the efficiency of public healthcare facilities but to detect the drawbacks of the service facilities in public hospitals, we need the indicators to understand the efficiency of public hospitals/services.

Population Study:

To study efficiency in terms of performance of all the 31 districts of Telangana state were considered. A dataset of 2018 from January to December containing Allopathy patients' information collected from a secondary source, from the department of Telangana State and Ministry of Health and Family Welfare, Government of India.

Selection of Variables:

The main objective of assessing hospital efficiency is to check that, the health care services provided, are ensuring the quality of patient care and services done by doctors/paediatricians are reachable to the society. Also, the funds provided by the government is sufficient according to the needs of the society. Hospital efficiency is a critical indicator for ensuring quality in the service/performance by the authorities by observing the input and output variables. The input/output variables available from the data source are presented in the following table.

 ISSN: 2278-4632
Vol-13, Issue-02, No.01, February 2023

Table.1 The input / output variables are presented in the following table.

	Name of the Variables
Inputs	No. of Hospitals No. of Doctors No. of Beds
Outputs	No. of Male patients treated for Communicable Diseases No. of Female patients treated for Communicable Diseases No. of Male patients treated for Non- Communicable Diseases No. of Female patients treated for Non-Communicable Diseases

Date Envelopment Analysis has proven to be an efficient and well-known method to assess the efficiency of decision-making units (DMU's) in multiple sectors. The DEA is a non-parametric linear programming technique of measuring the efficiency of a decision-making unit (DMU), such as a firm or a public -sector agency or an organisation/institution etc., stated differently, a technical efficiency. Abraham Charnes (1978), who first introduced this method into the Operations Research (OR) literature, used the term Decision Making Unit (DMU) to evaluate the efficiency of scores.

2.Methodology:

Data Envelopment Analysis:

The most widely used to evaluate the DMU's is the CCR model and BCC model as one of the extensions of the CCR model have been proposed here. The CCR model was initially proposed by Charnes, Cooper and Rhodes in 1978 is a basic DEA model. To measure the efficiency and evaluations of the activities of organisations such as hospitals, we commonly use the measure of Efficiency

E=Output/Input

The two basic models are CCR model, and BCC model based on different assumptions. The performance and evaluation of DMU depends on Return to Scale (RTS). There are two types of return to scale techniques in DEA. They are Constant Returns to Scale and Variable Returns to Scale. The CCR model is based on Constant Returns to Scale and the BCC model is based on Variable Return to Scale.

Constant Returns to Scale

An increase in all the inputs by the same proportion results in an increase in all the outputs by the same proportion is known as Constant Returns to Scale (CRS).

Consider DMUs A, B, C, &D

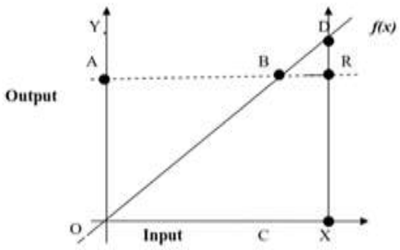


Fig.1 Constant returns to scale.

From the Fig. 1 The production of a single output is examined graphically. We observe that Constant Returns to Scale (CRS) represented by a function f***(x)*** is a straight line and has a single slope. Every unit increase in the input that goes into the process, the output produced increases by a constant proportional quantity. We observe that R is projected onto the frontier either under an input- reducing or an output –increasing consideration. By comparison, B and D points are projected on the frontier.

Variable Return to Scale

The variable returns to scale (VRS) result in a non-proportionate change (increase and decrease) in the outputs. If the non-proportionate change shows an increase in the outputs, then it is known as increasing return to scale (IRS) and non-proportionate change shows a decrease in the outputs then it is known as decreasing return to scale (DRS).

ISSN: 2278-4632
Vol-13, Issue-02, No.01, February 2023

Fig. 2, represents the increasing returns to scale IRS, the function ***f(x)*** has an increasing slope. For every unit increase in the input, the output increases by a more than proportionate quantity.

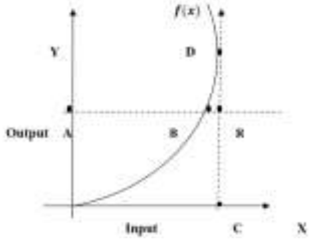


Fig. 2 Increasing returns to scale.

In Fig. 3, Decreasing returns to scale (DRS) the function ***f(x)*** has a decreasing slope. For every unit decrease in the input, the output decreases by a more than proportionate quantity. It is clear that it lies below the efficient status. For this, R could be projected onto the frontier either under an input reducing or an output–increasing consideration. Where B and D points are projected on the frontier. The input reducing efficiency is obtained by $\frac{CR}{CD}$.

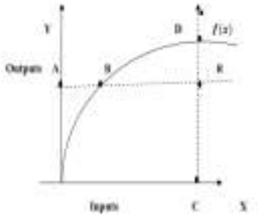


Fig.3 Decreasing returns to scale.

Potential Improvement (P.I):

Potential Improvement is the efficiency performance study. This study provides the information about which area an inefficient unit needs to improve in order to be efficient. This information can help inefficient unit needs to be improved.

Reference Comparison (R C):

The number of units was found inefficient status then it's felt to be justified. This information can be used for setting targets for the inefficient units. The inefficient units should be compared with the units in its reference set (R. S)

Peer group or Reference Set:

DEA identifies for each inefficient unit a set of excellent units, called Peer Groups, which includes those units which are efficient if evaluated with the optimal weights of inefficient.

Most Productive Scale Size (MPSS):

The CCR and BCC models are used to find which DMU is under Most Productive Scale Size. A Decision-Making Units found to be efficient in a CCR Model will also found an efficient DMU in BCC model and constant returns to scale (CRS) prevails.

CCR model:

Terminology/Notations in CCR model:

Let DMU1, DMU2, DMU3…………DMUn be the decision-making units contain inputs/outputs

Let x_{ij}: the i^{th} input of the j^{th} DMU x_{1j}, x_{2j}, x_{3j} …………x_{mj}

y_{rj}: the r^{th} output of the j^{th} DMU y_{1j}, y_{2j}, y_{3j} ……y_{sj}

v_i: the weight of the ith input i= 1,2,3………….m

u_r: the weight of the rth output r=1,2,3………..s

To evaluate the n DMU's we use the Fractional Programming Problem (FPP) technique. It is the problem of maximising or minimising the ratio of two functions over a convex region. The objective function of FPP estimates the efficiency of the DMU's.

The Fractional Programming Problem (FPP_o) is as follows:

$$\text{Max } \Theta = u_1y_{1o}+u_2y_{2o}+\ldots\ldots+u_sy_{so}/v_1x_{1o}+v_2x_{2o}+\ldots\ldots+v_mx_{mo} \quad (1)$$

subject to

$$u_1y_{1j}+u_2y_{2j}+\ldots\ldots+u_sy_{sj}/v_1x_{1j}+v_2x_{2j}+\ldots\ldots+v_mx_{mj} \leq 1 \ (= 1\ldots\ldots, n) \quad (2)$$

$$v_1, v_2, \ldots\ldots\ldots\ldots v_m \geq 0 \quad (3)$$

$$u_1, u_2, \ldots\ldots\ldots\ldots u_s \geq 0 \quad (4)$$

The constraint ratio of input and output ratio should not exceed for every DMU. The objective is to obtain weights(v_i) and (u_i)that maximise the ratio of DMU$_o$, when the DMU is being evaluated. Mathematically, the non-negativity constraint (3) is not sufficient for the fractional terms in (2) to have a positive value. To achieve this, we replace the Fractional Program (FP) by the linear program (LP$_o$) as

$$\text{Max}_{(u,v)}\ \Theta = u_1y_{1o} + \ldots\ldots\ldots\ldots + u_sy_{so} \quad (5)$$

$$\text{Subject to } v_1x_{1o}+v_2x_{2o}+ \ldots\ldots\ldots + v_mx_{mo} = 1 \quad (6)$$

$$u_1y_{1j}+u_2y_{2j}+\ldots\ldots\ldots+u_sy_{sj} \leq v_1x_{1j}+v_2x_{2j}+ \ldots\ldots\ldots + v_mx_{mj}\ (j=1\ldots\ldots n) \quad (7)$$

$$v_1, v_2, \ldots\ldots\ldots\ldots v_m \geq 0 \quad (8)$$

$$u_1, u_2, \ldots\ldots\ldots\ldots u_s \geq 0 \quad (9)$$

Let the optimum solution (OS) assumed as: (Θ^*, v^*, u^*)

The Reference set

$$R_o = \{\ j:\ \textstyle\sum_{r=1}^{s} u_r^* y_{rj} = \sum_{i=1}^{m} v_i^* x_{ij}\ \} \qquad j = 1,2,3\ldots\ldots\ldots n \quad (10)$$

The subset R_o composed of CCR-efficient DMUs is called the reference set or the peer group to the DMUo

The reference set R_o is the Primal Problem in terms of duality principle.

The Primal Problem is

Objective function Maximize $\Theta^*(u^*, v^*) = \sum_{r=1}^{s} u_x^* y_{ro}$ (11)

Subject to constraints: $\sum_{r=1}^{s} u_r^* y_{rj} - \sum_{i=1}^{m} v_i^* x_{ij} \leq 0$ (12)

$\sum_{i=1}^{m} v_i x_{io} = 1$ (13)

non -negative restriction $v_i \geq 0, \quad u_r \geq 0$

The above LPP produce yield the Optimum Solution Θ^*. This optimal solution efficiency score is known as Technical Efficiency (T.E) or CCR efficiency for the particular DMU$_o$. This Technical Efficiency scores were obtained by repeating for each DMU.

The optimal values of $\Theta^* \leq 1$. If optimal value of $\Theta^* < 1$ shows DMUs are inefficient and $\Theta^* = 1$ indicates relatively efficient, having its virtual inputs and outputs combination points on the frontier.

The objective of the CCR model is to minimize the input which satisfy at least the given output level and maximize the output without significant level of observed input values.

The CCR model is extended by Banker, R.D., Charnes R.F and Cooper W.W. used in efficiency analysis and a variable return to scale (VRS) relationship is assumed between input variables and output variables. Banker, Charnes and Cooper (BCC) who first introduced it in [5]. If the total constraints equal to one is adjoined, which is known as Banker, Charnes R.F and Cooper BCC model. Added a constraint as an additional variable into multiplier problem. This extra variable is makes it possible to affect returns to scale VRS evaluation. This scale is constant or decreasing or increasing. This BCC model is also referred to as the Variable Returns to Scale (VRS)model. The convexity constraints in this model formulation make sure that composite units of similar scale size units being calculated.

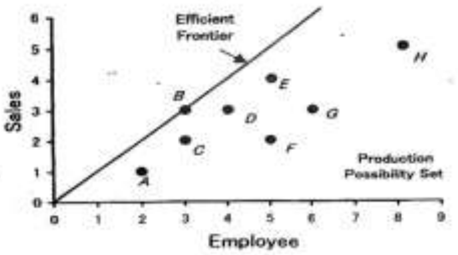


Fig4: Production Possibility Set

Let us consider A, B, C and D are DMUs exhibited in Fig5 each with one input and one output.

ISSN: 2278-4632
Vol-13, Issue-02, No.01, February 2023

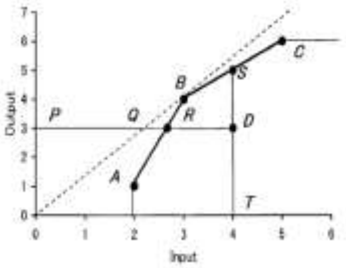


Fig 5 BCC & CCR models

The efficient frontier of the CCR model is the dotted line that passes through B from the origin and the frontiers BCC model consists the bold lines connecting A, B and C. The production possibility set is the area consisting of the efficient frontier. From the above figure it is clear that BCC efficient frontiers are A, B and C. The points on the solid lines connected between A & B, B & C. However, only B is CCR Model efficient DMU.

The Production Possibility Set (P.P.S) of the BCC Model is defined below:

$$P_B = \{(x, y)/x \geq X\lambda,\ y \leq Y\lambda,\ e\lambda = 1,\ \lambda \geq 0\} \qquad (14)$$

Where $X=(x_j) \in R^{mxn}$ and $Y=(y_j) \in R^{sxn}$ are a given data set, $\lambda \in R^n$ and e is a row vector with all elements equal to 1.The BCC model differs from the CCR model only in the adjunction of the condition $\sum_{j=}^{n} \lambda_j = 1$ equal to $e\lambda=1$ where e is a row vector with all elements unity and λ

The input-oriented BCC Model calculate the pure technical efficiency of DMUo (o= 1,2 ………n) by solving envelopment form of linear programming problem:

Objective function (BCC_o)

$$\text{Min}_{(\Theta B, \lambda)}\ \Theta_B \qquad (15)$$

$$\text{Subject to } \Theta_B X_o - X\lambda \geq 0 \qquad (16)$$

$$Y\lambda \geq y_o \qquad (17)$$

$$e\lambda = 1 \qquad (18)$$

$$\lambda \geq 0 \qquad (19)$$

where Θ_B is a scalar.

The dual multiplier form of this linear program (BCCo) is expressed as

$$\text{Max, } Z(v, u, u_o) = uy_o - u_o \qquad (20)$$

$$\text{Subject to } \quad vx_o = 1 \qquad (21)$$

$$-vX + uY - u_o e \leq 0 \qquad (22)$$

$$v \geq 0, u \geq 0\text{ , } u_o \text{ is free in sign} \qquad (23)$$

where u, v are vectors and z and u_o are scalars

The equivalent BCC Fractional Programming is found from the dual problem as:

$$\text{Max } \frac{uy_{o-u_o}}{vx_o} \qquad (24)$$

$$\text{Subject to } \frac{uy_{j-u_o}}{vx_j} \leq 1 \qquad (25)$$

$$v \geq 0, u \geq 0 \quad u_o \text{ is free} \qquad (26)$$

The difference between CCR and BCC models is present in the free variable u_o, which the dual variable associated with the constraint $e\lambda = 1$ in the envelopment model that does not appear in the CCR model. The primal problem (BCC_o) is solved using a two-phase procedure similar to CCR model.

An optimum solution for (BCC_o) is represented by (Θ_b^*, λ^*, s^{-*} ,s^{+*}) $where\ s^{+*}$ and s^{-*} represents the maximul input excesses and output shortfalls respectively.

4.Analysis:

In understanding /visualizing, our computation for the data, a descriptive statistic of input and output variables for communicable diseases and non-communicable diseases is listed in table1. The mean, standard deviation, minimum and maximum values are presented for the year 2018-2019.

ISSN: 2278-4632
Vol-13, Issue-02, No.01, February 2023

Table.2 Descriptive statistics of input and output variables of public hospitals of Telangana State for the year 2018

Variable Under Study		Mean	S.D	Minimum	Maximum
Inputs	No. of Hospital	192.19	66.03	106	318
	No. of Beds	744.09	1443.31	178	8316
	No. of Doctors	181.19	303.57	51	1762
Outputs	No of Male patients treated for Communicable Diseases	20360.84	13789.75	2665	53976
	No of Female patients treated for Communicable Diseases	21277.81	14970.203	1727	55800
	No of Male patients treated for Non-Communicable Diseases	37288.03	23969.90	5901	119934
	No of Female patients treated for Non-Communicable Diseases	32639.58	22107.47	3678	107103

From the above table, we observe that, for input variables, no. of beds has more variation between districts as compared to Hospitals and Doctors, also for output variable, no of patients treated are more for males for non-Communicable diseases. To study the efficiency in hospital performance of various districts, we evaluated the CCR model & BCC model for the input /output variables for the data of the year 2018, for Communicable and comparison is done between the models.

Table.3 CCR technical efficiency of district hospitals for the communicable diseases in the year 2018

S.NO	DMU(District)	Technical Efficiency (CCR)	References	Ranks	Peers	Name of the Peers (in codes)
1	Adilabad	0.22	0	18	1	DW
2	Bhadradri - Kothagudem	1	4	3	0	DBK
3	Gadwal	0.734	0	18	1	DW
4	Hyderabad	0.937	0	18	1	DW
5	Jagityal	0.872	0	18	2	DBK, DW
6	Jangaon	0.662	0	18	1	DW
7	Jaya Shankar -Bhupalapally	0.874	0	18	1	DW
8	Kamareddy	0.377	0	18	1	DW
9	Karimnagar	0.604	0	18	1	DW
10	Khammam	1	1	4	0	DKH
11	Komram Bheem - Asifabad	0.397	0	18	2	DBK, DW
12	Mahabubabad	0.72	0	18	2	DNK, DW

ISSN: 2278-4632
Vol-13, Issue-02, No.01, February 2023

13	Mahbubnagar	0.793	0	18	1	DW
14	Manchiryal	0.239	0	18	2	DNK, DW
15	Medak	0.552	0	18	1	DW
16	Medchal	0.929	0	18	1	DNK
17	Nagarkurnool	1	6	2	0	DNK
18	Nalgonda	0.624	0	18	1	DW
19	Nirmal	0.151	0	18	1	DW
20	Nizamabad	0.127	0	18	1	DW
21	Peddapally	0.698	0	18	1	DW
22	Rangareddy	0.592	0	18	1	DW
23	Sangareddy	0.35	0	18	1	DW
24	Siddipet	0.446	0	18	1	DW
25	Siricilla	0.38	0	18	2	DNK, DW
26	Suryapet	0.248	0	18	2	DBK, DW
27	Vikarabad	0.508	0	18	1	DW
28	Wanaparthy	1	27	1	0	DW
29	Warangal	0.116	0	18	1	DW
30	Warangal Rural	0.136	0	18	2	DNK, DW
31	Yadadri	0.112	0	18	1	DW

Note: District code abbreviations- DW for Wanaparthy district. etc.

Efficiency scores for 31 district hospitals are presented in table 3. Compared with Nizamabad district hospital, Karimnagar district hospital, for example could produce the same output level (or activities) with only 60.40 % of its current resources. It is also noticed that, there are significant variations in efficiency scores between hospitals i.e. 0.11< ϴ*(CCR)< 1.00.

For example, the most efficient district hospitals are over 9 times as efficient as the least efficient. The most inefficient district hospitals (Yadadri) have an efficiency score of only 11.2%, hence Yadadri district hospitals are technical inefficient. If return to scale is constant it could have produced its current outputs 0.1120 or 11.2 of outputs. Therefore, removal of inefficiencies is achieved by reducing all inputs by 0.888 or approximately 88.8% of their observed values. To bring Adilabad district hospitals into efficient status is done based on reference set and peer weight ƛ by relating inputs /outputs to make the inefficient unit into an efficient frontier.

It is evidence from the table out of 31 district hospitals only 4 district hospitals have performed better based on technical efficiency of CCR model namely Bhadradri –Kothagudem district hospitals, Khammam district hospitals, Nagarkurnool district hospitals and Wanaparthy district hospitals and the remaining inefficiency district hospitals has to be improved in their performance.

Distribution Score graph of Government hospitals in 31 districts of Telangana State

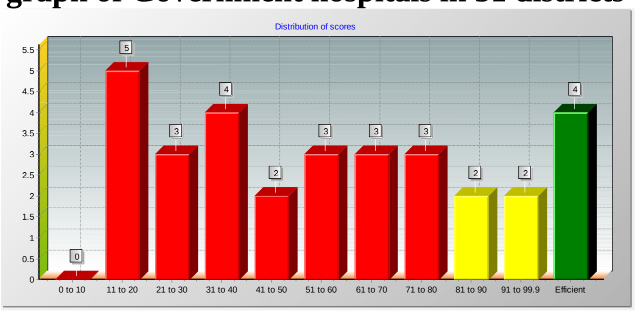


Figure 6. Distribution Score graph of Government hospital in 31 districts of Telangana State

From the above table, it is observed that, there are only 4 model district hospitals namely, Bhadradri - Kothagudem Khammam, Nagarkurnool and Wanaparthy due to their highest technical efficiency 1.000. District hospitals in Wanaparthy has highest references (27). Peer contribution of Wanaparthy hospitals is more analogous to others hospitals.

In DEA every inefficient DMU(District) have more than one role model and efficient DMUs (District), they themselves are the role models.

For example, Nagar Kurnool (DNK) and Wanaparthy (DW) districts are the role models for Siricilla (DS) district, Warangal Rural district, Manchiryal district, Mahabubabad district and Nagar Kurnool district is efficient, because its technical efficiency is 1.000 and district by itself is a role model.

The reference graph of Government hospital in 31 districts of Telangana State are presented below.

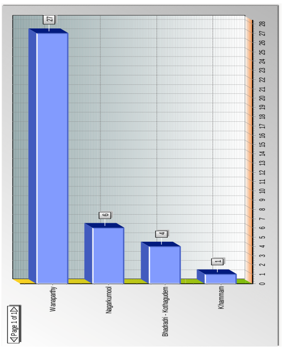


Fig.7 Reference graph of District Hospitals in Telangana State

We now evaluate ranking of districts shown below.

Here we assign the ranks based on the references. Highest reference district should get first position if two or more district's references are same then average of that position will be considered.

For example, the total number of references of Wanaparthy is 27, as it appears in the references list for maximum number of times, hence it is considered as role model for 27 inefficient districts, and ranked as 1. The next rank 2 given to Nagarkurnool as the number of references are 6.And this process is repeated until all the ranks are assigned for each of the district.

With this pattern, we can say that 4 districts are performing well, while the remaining 27 inefficient districts needs potential improvement to improve their performance.

Table 4: The BCC Model results of 2018 for the Communicable diseases are shown below

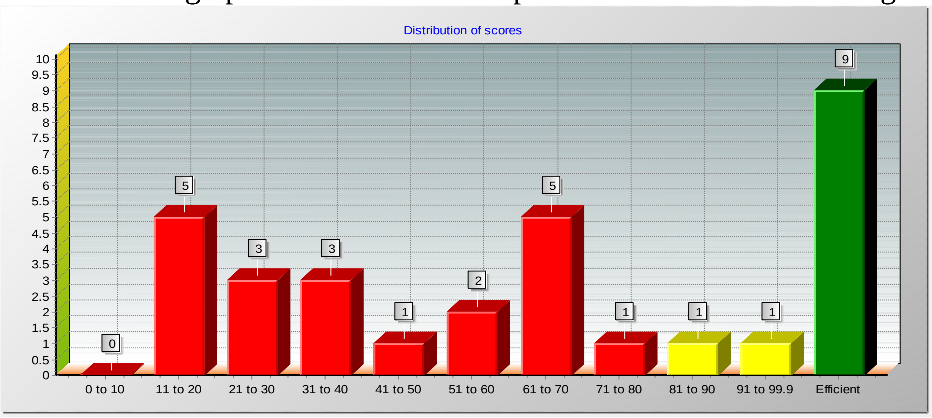
S.NO	DMU(District)	Technical Efficiency (BCC)	References	Ranks	Peers	Name of the Peers (District code)
1	Adilabad	0.2274	0	20.5	3	DW, DH, DNK
2	Bhadradri - Kothagudem	1.000	14	3	0	DBK
3	Gadwal	1.000	1	8	0	DW
4	Hyderabad	1.000	11	4	0	DH
5	Jagityal	0.8980	0	20.5	3	DBK, DW, DNK
6	Jangaon	0.6695	0	20.5	3	DW, DH, DNK
7	Jayshankar-Bhupalapally	1.000	2	5.5	0	DJB
8	Kamareddy	0.3944	0	20.5	2	DW, DNK
9	Karimnagar	0.6299	0	20.5	3	DW, DH, DNK
10	Khammam	1.000	2	5.5	0	DKH
11	Komram Bheem - Asifabad	0.3991	0	20.5	2	DKH, DW
12	Mahabubabad	0.7259	0	20.5	3	DBK, DW, DNK
13	Mahbubnagar	0.9120	0	20.5	3	DBK, DH, DNK
14	Manchiryal	0.2436	0	20.5	3	DBK, DW, DNK
15	Medak	0.5862	0	20.5	3	DBK, DW, DNK
16	Medchal	1.000	1	8	0	DM
17	Nagar Kurnool	1.000	20	1	0	DNK
18	Nalgonda	0.7091	0	20.5	3	DBK, DH, DNK

ISSN: 2278-4632
Vol-13, Issue-02, No.01, February 2023

19	Nirmal	0.1518	0	20.5	3	DW, DH, DNK
20	Nizamabad	0.1418	0	20.5	3	DBK, DH, DNK
21	Peddapally	0.7047	0	20.5	2	DW, DNK
22	Rangareddy	0.699	0	20.5	1	DBK
23	Sangareddy	0.4051	0	20.5	3	DBK, DH, DNK
24	Siddipet	0.4837	0	20.5	3	DBK, DH, DNK
25	Siricilla	1.000	1	8	0	DS
26	Suryapet	0.258	0	20.5	3	DBK, DW, DNK
27	Vikarabad	0.5373	0	20.5	3	DBK, DW, DNK
28	Wanaparthy	1.000	17	2	0	DW
29	Warangal	0.1222	0	20.5	2	DW, DJB
30	Warangal Rural	0.1458	0	20.5	3	DBK, DW, DNK
31	Yadadri	0.1152	0	20.5	3	DH, DW, DNK

We observe that using BCC model 9 district hospitals are performing well as per Pure Technical Efficiency and the remaining 22 districts which are inefficient units need potential improvement in their performance. It is also noticed that, there are significant variations in Pure Technical efficiency scores between DMU's (hospitals) i.e. 0.1152< ϴ*(CCR)< 1.00. It is evident from the table, out of 31 district hospitals only 9 district hospitals have performed better based on Pure Technical efficiency. District hospitals in Jagityal & Mahbubnagar are closed to efficiency status.

Figure 8: Distribution Score graph of Government hospitals in 31 districts of Telangana State



The district wise Scale Efficiency and Returns to Scale and cause of inefficiency of 2018 are presented below:

TABLE 5: SCALE EFFICIENCY AND RETURNS TO SCALE of districts for the year 2017

S.NO	**Name of district**	**CCR**	**BCC**	**Scale Efficiency (S.E)**	**Cause of Inefficiency**		**Return to scale**	**Efficient /Inefficient**
					PTE	**S. E**		
1	Adilabad	0.22	0.227	0.967		S. E	IRS	Inefficient
2	Bhadradri - Kothagudem	1.000	1.000	1.000		-	CRS	Efficient
3	Gadwal	0.734	1.000	0.734		S. E	IRS	Inefficient
4	Hyderabad	0.937	1.000	0.937		S. E	IRS	Efficient
5	Jagityal	0.872	0.898	0.971		S. E	IRS	Inefficient
6	Jangaon	0.662	0.670	0.989		S. E	IRS	Inefficient
7	Jaya Shankar - Bhupalapally	0.874	1.000	0.874		S. E	IRS	Inefficient
8	Kamareddy	0.377	0.394	0.956		S. E	IRS	Inefficient
9	Karimnagar	0.604	0.630	0.959		S. E	IRS	Inefficient

ISSN: 2278-4632
Vol-13, Issue-02, No.01, February 2023

10	Khammam	1.000	1.000	1.000		-	CRS	Efficient
11	Komrambeem - Asifabad	0.397	0.399	0.995		S. E	IRS	Inefficient
12	Mahabubabad	0.72	0.726	0.992		S. E	IRS	Inefficient
13	Mahbubnagar	0.793	0.912	0.870		S. E	IRS	Inefficient
14	Manchiryal	0.239	0.244	0.981		S. E	IRS	Inefficient
15	Medak	0.552	0.586	0.942		S. E	IRS	Inefficient
16	Medchal	0.929	1.000	0.929		S. E	IRS	Inefficient
17	Nagarkurnool	1.000	1.000	1.000		-	CRS	Efficient
18	Nalgonda	0.624	0.709	0.880		S. E	IRS	Inefficient
19	Nirmal	0.151	0.152	0.995		S. E	IRS	Inefficient
20	Nizamabad	0.127	0.142	0.896		S. E	IRS	Inefficient
21	Peddapally	0.698	0.705	0.990		S. E	IRS	Inefficient
22	Rangareddy	0.592	0.699	0.847		S. E	IRS	Inefficient
23	Sangareddy	0.35	0.405	0.864		S. E	IRS	Inefficient
24	Siddipet	0.446	0.484	0.922		S. E	IRS	Inefficient
25	Siricilla	0.38	1.000	0.380		S. E	IRS	Inefficient
26	Suryapet	0.248	0.258	0.961		S. E	IRS	Inefficient
27	Vikarabad	0.508	0.537	0.945		S. E	IRS	Inefficient
28	Wanaparthy	1.000	1.000	1.000		-	CRS	Efficient
29	Warangal	0.116	0.122	0.949		S. E	IRS	Inefficient
30	Warangal Rural	0.136	0.146	0.933		S. E	IRS	Inefficient
31	Yadadri	0.112	0.115	0.972		S. E	IRS	Inefficient
		0.56	0.618	0.924				

The CCR Technical Efficient Model provides the efficiency evaluation based on scale under Constant Return to Scale. Using the CCR model, 15 out of 31 districts are below average.

The BCC Pure Technical Efficient Model provides efficiency evaluation based on scale under variable return to scale. Using the BCC model, 5 out of 31 districts are on the efficient frontier, in addition to the 4 districts that are efficient in the CCR model, which holds its previous efficient frontier. Jagityal and Mahbubnagar are almost efficient district hospitals.

The BCC Model score reveals that 13 out of 31 districts are below average. Under the Scale Efficiency (S.E.) indicator, six out of 31 districts were below average.

From the above, it is clear that Bhadradri- Kothagudem, Khammam, Nagarkurnool, and Wanaparthy districts are efficient in both models. These districts' performance is showing consistency in both models' Most Productive Scale Size (MPSS) status, whereas the remaining 27 of them are showing increasing returns to scale.

TABLE 6: SUMMARY OF CCR AND BCC MODEL

	CCR Model	BCC Model
Mean Efficiency	0.56122	0.61806
S.D of Efficiency	0.3052	0.330
C.V of Efficiency	54.5%	53.3%
Min. Efficiency	0.112	0.115
Max. Efficiency	1.000	1.000
Number of Efficient Districts	4	9

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Vol-13, Issue-02, No.01, February 2023

5.Results and Discussions:

The main findings of this paper are to identify and study the district hospital performance after formation of new districts in Telangana State.

DEA provides a path to health industry, as the model can define the levels of inputs and outputs required to be considered efficient (targets) districts. We considered resources related to no of beds, no of doctors, no of hospitals as inputs and no of male patients, no of female patients treated for communicable diseases as output variables to analyse different perspectives.

We performed DEA analysis to distinguish between efficient and inefficient Decision-Making units (Districts) on 31districts of Telangana State for the year 2018-19 by using CCR and BCC models.

The efficiency levels of hospital performance according to CCR model vary from 11%to 100% and 4 districts namely Nagarkurnool, Wanaparthy, Bhadradri - Kothagudem and Khammam are efficient out of 31districts, assuming constant return to scale (CRS) relationship between input variables and output variables. The remaining 27 inefficient districts need potential improvement to improve their performance. Ranking is done to all the districts by using reference set.

Similarly BCC model is studied to identify efficiency districts and the evaluation is based on variable return to scale (VRS). 9 districts namely Gadwal, Hyderabad, Bhadradri- Kothagudem, Khammam, Nagar Kurnool, Wanaparthy, Jaishankar -Bhupalapally, Medchal, and Siricilla are in efficient status and remaining districts needs to be improved and ranking is done to all the districts by using reference set. Critical care has to be taken on inefficient and to improve their performance by comparing with efficient set.

In our analysis, our models identify districts which are closed to efficient status. BCC model out performed CCR.Our results of this study will serve as a point of reference for future studies on the efficiency and performance of the hospital industry. Furthermore, our study provides a useful framework for health officials to assess the current resources by evaluating continuously for strengthening public health care facilities.

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