ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue VII July 2025

Efficiency of Healthcare System in India: A Data Envelopment Analysis

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DOI: https://doi.org/10.51244/IJRSI.2025.120700231

Received: 22 July 2025; Accepted: 28 July 2025; Published: 26 August 2025

ABSTRACT

Efficiency plays a crucial role in Indian healthcare systems, where limited resources present notable obstacles. This research employs Data Envelopment Analysis to assess healthcare system efficiency across 29 states in India. By utilizing data from the National Health Profile, Rural Health Statistics, and National Family Health Survey, various input variables (per capita health expenditure, nurses per 1000 population, hospitals per 1000 population) and output variables (percentage of inpatients to outpatients, percentage of mothers with four or more antenatal visits, and infant survival rate) were examined.

The findings indicate significant disparities in healthcare resource distribution and service outcomes among the states. While some states exhibit effective healthcare provision, a majority fall below desirable efficiency levels due to resource inadequacy or misallocation. States such as Bihar, Goa, Kerala, Madhya Pradesh, Maharashtra, Telangana, Uttar Pradesh, and West Bengal are identified as efficient, while others show inefficiencies that could be rectified through adjustments in resource allocation and service delivery strategies.

This study not only provides insights into the current healthcare efficiency status across Indian states but also presents practical recommendations for policymakers and stakeholders to enhance healthcare system effectiveness, ultimately leading to improved health outcomes.

Key words: Efficiency, healthcare system, DEA, health infrastructure, India.

INTRODUCTION

Accessibility to healthcare is by the public in a country or in a region largely depends on availability of the healthcare resources in terms of healthcare infrastructure such as number of PHCs, CHCs, hospitals, hospital beds, and in terms of human resources like doctors, nurses, technical staff, etc. India is a vast country with high density of population and with variation in geographical location. As we have already observed interstate or inter regional variation in the availability of healthcare infrastructure in the last chapter. There is huge shortage of health infrastructure in almost all states. Similarly, public expenditure on health continued to be remain low. Per capital health spending in India was merely Rs. 3,516 in 2019-20, which was only 1.35% as compared to 1.13% in 2014-15 (National Health accounts, NHA, 2019-20)[1]. At this situation of acute shortage of financial and human resource, and infrastructure in healthcare system in India, it is vital for healthcare centres to perform efficiently in order to produce maximum healthcare given the infrastructural constraints. Shortage in number of healthcare centres and manpower impose burden excess to their capacity. Thus, healthcare systems in all the states in India have to increase their efficiency in order to maximize their healthcare output.

India has recently emerged as giant economy in terms of GDP growth rate (5th in world's GDP rankings). It has succeeded to achieve handsome annual GDP growth rate of 5%[2]. The benefit of this economic growth could be observed in healthcare sector in the country with increased life expectancy, reduced infant and child mortality rates. Maternal deaths have also decreased significantly. Various reports of National family Health Survey (NFHS) have shown decreased infant and child mortality rates. Maternal health services such as ANC, institutional deliveries and PNC have also improved overtime. National Health Policy, 2017 have implemented various programs to improve overall health status of the population.

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India since adoption of National Rural Health Mission (2005) has been able to increase health infrastructure and manpower in these health centres with an aim to have better or improvement of the public health condition. India's more than 60% of population reside in rural areas and solely depend on public health centres for healthcare needs. Measuring the efficiency of the healthcare system in India is crucial at this stage when demand for healthcare in rising due to growing population. Various reports from Rural Health Statistics (RHS) reveled that there is shortage of manpower and health centres in most of the states and running with resources much below the requirement of Indian Public Health Standards (IPHS). Indian healthcare system, on an average, running with 30% shortage of PHCs, 35% and 15% shortage of doctors in CHCs and DHs respectively and 15% shortage of nurses in hospitals[3]. The average population covered by SC, PHC and CHC are 5729, 3570 and 171779 respectively[3] which are much higher than IPHS norms. Thus assessment of efficiency of healthcare centres is necessary that can guide decision makers to utilize available resources optimally.

The importance of efficient utilization of resources in healthcare sector has been identified globally by all the countries. Many researchers have attempted to assess efficiency in healthcare system throughout the world. But measuring health efficiency is a complicated process due to its dependence on several external factors. Several methods are used to assess the efficiency of healthcare system, Data Envelopment Analysis (DEA) has been used extensively by most of the researchers.

Study on health system efficiency in OECD countries by Gavurova et al. (2021)[4] found that overall average efficiency of health systems was 0.8693 during 2000 to 2016. According to Malmquist Index results, the OECD countries improved the efficiency over the years. Alatawi et al. (2020)[5] assessed the performance of public hospitals in Saudi Arabia and found that 69 out of 91 (75.8%) of public hospitals were technically efficient with an average efficiency score was 0.76 indicating hospitals could have reduced their inputs by 24% without reduction in provision of health services. A study by Barpanda and Sreekumar (2020)[6] on performance analysis of hospitals in Kerala, found that the technical efficient hospitals were performing well as far as quality measures were concerned. Kocisova and Sopko (2019)[7] analyzed the technical efficiency and change in the efficiency of the healthcare systems in 23 European Union (EU) countries between 2008 and 2016 and found that medical care systems of France, Hungary, Ireland, Lithuania, Poland, Portugal, Spain and United Kingdom were more efficient and efficiency have improved in this country between 2008 and 2016. Ibrahim and Daneswar (2018)[8] analyzed efficiency of healthcare system in Lebanon and found improved efficiency of the healthcare system in Lebanon after health system reform in 2005. Mitrovic et al. (2016)[9] attempted to measure and evaluate the efficiency of healthcare system of Serbia in comparison with countries of in the European regions and found that 19 out of 42 countries are efficient in providing health services but Serbia's health system ranked 15th out of 21 analyzed systems. Akazili et al (2008)[10] analyzed the efficiency of the health sector in Ghana and found that 65% of health centres were technically inefficient and so were using unnecessary resources, meaning that significant amount of resources could be saved if measures were taken to proper channelization of resources. Similarly, Mirmirani and Ilacqua (2008)[11] analyzed healthcare efficiency in transition economies for the period 1997-200 found that the most efficient systems were OECD countries, Albania and Armenia. Russia and Belarus were the least efficient systems over the same period. They also found that consumption of tobacco and alcohol being the important factors in determining efficiency except input and output variables. Kirgia et al. (2004)[12] found in their study of efficiency of health centres in Kenya that 44% of Kenyan health centres are technically inefficient.

In Indian context, limited studies have been carried out assessing the efficiency of healthcare systems. Chitnis and Mishra (2019)[13] analyzed the performance efficiency of private hospitals in India taking a sample of 25 private hospitals and found that seven were efficient, Fortis Hospital Ltd being the super-efficient. Goverdhan et al. (2016)[14] analyzed the efficiency of Indian hospitals found that hospitals of only 18 states were found to be efficient. Among these states, Andhra Pradesh, Arunachal Pradesh Assam, Bihar and Gujarat are top performers. Purohit (2016)[15] attempted to measure district level health system efficiency in Gujarat, India and found that there was a mix of both inefficiency and inadequacy of inputs. Study by Tigga and Mishra (2015)[16] on measuring technical efficiency of the health system in India and found that only 6 out of 27 states were technically efficient and the remaining states were technically inefficient using more than required resources to produce current healthcare services. Jat and Sebastian (2013)[17] evaluated the technical efficiency of public district hospitals and found that half of the district hospitals were operating inefficiently. Satyanarayana et al. (2012)[18] evaluated rural

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healthcare programs in India with reference to data of Chikmagalur district, Karnataka, India and found that 16 out of 27 programs were efficient. All these studies are based on Data Envelopment technique.

Among above studies only one study has attempted to assess efficiency of healthcare system taking 27 states with two inputs and two outputs. All other studies have either taken single state or district. Here, we have attempted to analyze the technical efficiency of healthcare system in India taking 29 states of India using data envelopment technique using latest data. The aim of our study is to identify the efficient and laggard states, and make some suggestions to improve the inefficient healthcare systems of the states.

Data and Methodology

Data

The data used in the study are purely from the secondary sources: National Health Profile (NHP, 2019), Rural Health Statistics (RHS, 2019-20) and National Family Health survey (NFHS 5, 2019-21)[19(p5)]. Due to unavailability of reliable data, data on public health sector have been used.

Input and output variables

As we know two kinds of variables are required to run Data Envelopment Analysis (DEA): inputs and outputs. We should choose the variables in such a way that they could influence the efficiency of healthcare system. Review of existing literatures have been helpful in choosing the input and output variables in this study. Most of the studies have used life expectancy and infant mortality rates as output variable. Few studies of used hospital mortality rate, outpatient visits, discharged patients, laboratory tests, surgical operation performed. Similarly most of the studies have taken input variables as no. of hospitals, no. of physicians and nurses[5], no. of trained medical staff, no. of services offered[6], no. of health workers per 1000 population and no. of health centres per 1000 population[16].

Table I

Input and Output variables

Input Variable	**Description**
Per capita health expenditure (X_1)	Per capita Health expenditure (in Rs) is the spending by the government on healthcare services.
No. of Nurses per 1000 population (X_2)	Number of nurses includes ANM and female health workers.
No. of Hospitals per thousand population (X_3)	Hospitals include PHC, CHCs and District Hospitals.
Output Variable	**Description**
IPD to OPD (Y_1)	Percentage of Indoor patients to Outdoor patients. It shows how much outpatients are getting admitted for medical treatment.
Antenatal Care (Y_2)	Percentage of mothers getting 4 or more antenatal visits.

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Infant Survival Rate (Y_3)	Number of infants survived per 1000 live births. Derived from IMR.

The variables used in the present study are presented in Table I Input variables taken are: Per Capita Health expenditure (PCHE), Nurses per 1000 population, Hospitals per 1000 population. The output variables taken are: percentage of IPD to OPD, Antenatal Care (ANC) and Infant Survival Rate. Infant Survival rate is derived from infant mortality rate (IMR). IMR is negative health indicator and hence cannot be directly used as measure of health efficiency as it is undesirable output (in DEA literature). Infant survival rate is calculated using following formula:

Infant Survival Rate= $\frac{1000-IMR}{IMR}$ ……..…… (1)

Method

As the objective of our study is to measure the efficiency of the health system in India, we have used well known technique: Data Envelopment Analysis (DEA) technique. The Data Envelopment Analysis (DEA) is a widely used technique to measure the efficiency of the healthcare sector. It was first used in the work of Charnes, Cooper and Rhodes (1978)[20]. DEA is a linear programming based non-parametric method used to measure relative efficiency of similar decision making units at to produce similar outputs using similar inputs. In this method, the best decision making unit that produces the most output composition by using the least input composition is determined. This best decision making unit sets the efficient frontier. This is considered as reference and the efficiency of other ineffective DMUs is determined by proportionally measuring distance from this frontier [21].

The DEA model, proposed by Charnes, Cooper and Rhodes, named as DEA-CCR has an input orientation and assumed constant returns to scale in production. Another DEA model named as DEA-BCR (named for Banker, Charnes and Cooper, 1984) assumes variable returns to scale.

The DEA-CCR Model

In DEA-CCR models, technical efficiency of DMU is the maximum of ratio of weighted outputs to weighted inputs subject to the condition that similar ratios for each DMU be less than equal to unity. This can be done by solving following fractional programming problem:

$$Max\ h_0 = \sum_{r=1}^{s} (u_r y_{rj0}) / \sum_{i=1}^{m} (v_i y_{ij0}) \quad \text{…….. (2)}$$

Subject to:

$$\sum_{r=1}^{s} (u_r y_{rj}) / \sum_{i=1}^{m} (v_i x_{ij}) \leq 1,\ \text{j=1,2, ……j0,….n}$$

$$u_r \geq 0,\ \text{r=1,2,…..s and}\ v_i \geq 0,\ \text{i=1,2,……..,m} \quad \text{……(3)}$$

The terms $y_{r\,j0}$ and x_{rj0} denotes the amount of output r and input i for DMU j_0. Optimal values of weights (u_r, v_i) and efficiency ho is obtained solving the above problem. The values of u_r and v_i are chosen, as a result, a DMU that is superior to all others on any single output-input ratio will be efficient.

In our study, we will adopt input oriented CCR model because DMU in health sector have better control over inputs than outputs. As we know, CCR model is a constant returns to scale (CRS) model. CRS model assumes a production process in which the optimal xi of inputs and outputs does not depend on the scale of operation.

Table II

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State wise Healthcare Inputs and Outputs in India

State	Input Variables			Output Variables		
	PCHE	Nurses per 1000 population	Hospitals per 1000 population	Percentage of Inpatients to Outpatients	Percentage of mothers with 4 or more ANC visits	Infant Survival Rate
Andhra Pradesh	1013	7.10	0.25	4.60	46.80	32.11
Arunachal Pradesh	5177	3.35	1.43	4.30	14.40	76.52
Assam	1546	1.46	0.36	4.40	26.90	30.35
Bihar	491	0.15	0.17	5.20	7.60	20.37
Chhattisgarh	1354	0.95	0.08	6.30	29.70	21.62
Goa	3643	0.40	0.28	4.40	81.30	177.57
Gujarat	1189	2.48	0.32	7.90	49.00	31.05
Haryana	1119	1.98	0.23	3.30	35.30	29.03
Himachal Pradesh	2667	4.50	1.12	4.60	45.30	38.06
Jammu & Kashmir	2359	0.36	0.96	4.30	23.40	60.35
Jharkhand	866	0.22	1.17	4.70	14.90	25.39
Karnataka	1124	4.40	0.43	7.20	34.00	38.37
Kerala	1463	8.90	0.36	2.60	69.30	226.27
Madhya Pradesh	716	1.91	0.06	7.90	32.90	23.21
Maharashtra	1011	1.71	0.04	5.40	37.90	42.10
Manipur	2061	4.03	0.38	7.00	46.10	39.00
Meghalaya	2223	2.66	0.47	6.60	26.40	29.96
Mizoram	5862	5.19	0.82	5.60	37.30	45.95
Nagaland	2450	0.56	0.81	8.10	5.30	41.74

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Odisha	927	3.03	0.40	5.30	49.80	26.55
Punjab	1173	3.39	0.27	3.80	34.40	34.71
Rajasthan	1360	3.96	0.36	4.30	21.70	32.11
Sikkim	5126	2.02	0.49	3.00	34.90	88.29
Tamil Nadu	1235	4.76	0.33	3.60	71.30	52.76
Telangana	1322	0.41	0.18	4.40	38.00	36.88
Tripura	2183	1.61	0.38	9.20	15.40	25.60
Uttarakhand	733	12.18	4.14	4.60	11.90	18.84
Uttar Pradesh	1765	0.02	0.03	4.20	31.40	24.58
West Bengal	778	1.52	0.16	5.00	48.20	44.45

Source: NFHS 5 & NHP 2019-20

The CRS model which measures overall technical efficiency for each DMU (state here), ca be written as

$$Max\ h_0 = \sum_{r=1}^{s} (u_r y_{rj0}) \quad \text{.......................................} (4)$$

Subject to: $$\sum_{i=1}^{m} (v_i x_{ij0}) = 1$$

$$\sum_{r=1}^{s} (u_r y_{rj}) - \sum_{i=1}^{m} (v_i x_{ij}) \leq 0 \quad j=1,2,\ldots,n$$

$$u_r v_i \geq 0 \quad \text{.................................} (5)$$

The solution to equation (4) will give the efficiency level of each DMU. Any particular DMU is said to be efficient if and only if h_0=1[20].

To run DEA, Efficiency Management System (EMS) software, developed by Holger Scheel, Dortmund University[22] was used.

RESULTS AND DISCUSSIONS

Table II presents the data on inputs and outputs used in the efficiency analysis of 29 states of India. Table III presents the descriptive statistics for all inputs and outputs used in the study. Wide variations in all the variables can be seen looking at minimum and maximum values of the variables. On average, each state spends Rs.1894 per head on health. A state has less than 3 nurses per thousand population and only 0.57 hospitals per 1000 population. Percentage of IPD to OPD is 5.23 meaning that on an average 5.23% of OPD patients get admission to the hospital. On an average, each state have 35.20 % mothers having 4 or more ANC visits and 48.75 child per 1000 live births survive.

Table III

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Summary Statistics

Variables	Observations	Mean	Standard Deviation	Min	Max
PCHE	29	1894.35	1398.21	491.00	5862.00
Nurses per 1000 population	29	2.94	2.79	0.02	12.18
Hospitals per 1000 population	29	0.57	0.77	0.03	4.14
Percentage of Inpatients to Outpatients	29	5.23	1.65	2.60	9.20
Percentage of mothers with 4 or more ANC visits	29	35.20	18.41	5.30	81.30
Infant Survival Rate	29	48.75	45.73	18.84	226.27

Source: Author's own calculation

The efficiency score for output-oriented DEA was computed using EMS version 1.3 developed by Holger Scheel. In output-oriented approach, for given inputs levels, outputs are maximized or attempts are made to improve the levels of output. In input-oriented model, inputs are minimized to achieve desired level of output and thus maximize the efficiency. Table III presents the score of each DMUs which is actually efficiency of concerned DMUs. The DMus having score 100% or more are considered as efficient. We can

Table IV

Efficiency Scores of Input-oriented Approach

Sl. No.	DMU	Score	X1	X2	X3	Y1	Y2	Y3	Benchmarks
1	Andhra Pradesh	74.57%	1	0	0	0	0.75	0	29 (0.97)
2	Arunachal Pradesh	26.35%	0.81	0.19	0	0.02	0	0.25	4 (0.56) 6 (0.27) 13 (0.08)
3	Assam	45.58%	0.56	0.44	0	0.07	0.31	0.07	4 (0.35) 6 (0.01) 25 (0.18) 29 (0.35)
4	Bihar	270.17%	0.59	0.25	0.16	2.7	0	0	15
5	Chhattisgarh	88.58%	0.55	0.34	0.11	0.44	0.44	0	4 (0.22) 14 (0.41) 28 (0.45) 29 (0.01)
6	Goa	246.18%	0.64	0.12	0.24	0	0	2.46	7
7	Gujarat	78.67%	0.71	0.29	0	0.37	0.41	0	4 (0.15) 14 (0.48) 29 (0.67)

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8	Haryana	54.32%	0.39	0.61	0	0	0.54	0	25 (0.05) 29 (0.69)
9	Himachal Pradesh	30.08%	0.4	0.6	0	0	0.3	0	25 (0.10) 29 (0.86)
10	Jammu & Kashmir	54.92%	0.38	0.62	0	0.18	0	0.37	4 (0.59) 6 (0.27) 28 (0.01)
11	Jharkhand	84.64%	0.66	0.34	0	0.28	0.52	0.05	4 (0.71) 6 (0.02) 25 (0.16) 28 (0.06)
12	Karnataka	66.62%	1	0	0	0.46	0.02	0.19	4 (0.04) 13 (0.08) 14 (0.86)
13	Kerala	270.68%	1	0	0	0	0	2.71	6
14	Madhya Pradesh	185.49%	0.78	0	0.22	1.85	0	0	12
15	Maharashtra	155.89%	0.4	0	0.6	0	0.72	0.84	0
16	Manipur	42.64%	0.3	0.52	0.18	0.18	0.25	0	4 (0.17) 14 (0.33) 28 (0.01) 29 (0.70)
17	Meghalaya	34.83%	0.37	0.39	0.25	0.19	0.16	0	4 (0.62) 14 (0.24) 28 (0.06) 29 (0.25)
18	Mizoram	18.71%	0.43	0.32	0.25	0.07	0.08	0.04	4 (0.30) 6 (0.09) 14 (0.15) 28 (0.12) 29(0.40)
19	Nagaland	43.69%	0.29	0.71	0	0.25	0	0.19	4 (1.44) 6 (0.06) 28 (0.09)
20	Odisha	87.31%	1	0	0	0.24	0.64	0	14 (0.03) 29 (1.01)
21	Punjab	49.13%	1	0	0	0.15	0.24	0.1	13 (0.02) 14 (0.07) 29 (0.63)
22	Rajasthan	37.41%	0.85	0.15	0	0.17	0.08	0.13	4 (0.18) 13 (0.08) 14 (0.35) 29 (0.07)
23	Sikkim	32.80%	0.69	0.09	0.22	0.05	0	0.28	4 (0.16) 6 (0.42) 13 (0.05) 14 (0.03)
24	Tamil Nadu	93.19%	1	0	0	0	0.93	0	29 (1.48)
25	Telangana	114.32%	0.73	0.27	0	0.15	1	0	4
26	Tripura	53.66%	0.26	0.26	0.49	0.54	0	0	4 (1.02) 14 (0.37) 28 (0.23)
27	Uttarakhand	60.28%	1	0	0	0.45	0.01	0.14	4 (0.56) 13 (0.01) 14 (0.21)

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28	Uttar Pradesh	975.10%	0	1	0	4.59	5.16	0	8
29	West Bengal	150.64%	0.65	0.35	0	0.05	1.22	0.23	13

Source: Calculated using EMS.

see that 8 out of 29 states are efficient as their score is more than 100%. The efficient states are Uttar Pradesh, Kerala, Bihar, Goa, Madhya Pradesh, Maharashtra, Telangana and West Bengal. Rest of 21 states are inefficient. Arunachal Pradesh is the least efficient state, followed by Himachal Pradesh. All the efficient states lie on the frontier whereas the inefficient lie farther from the frontier.

The last column of the table IV shows benchmarks or peer groups for each in efficient DMUs. Peer are a set of potential role model whom a unit can imitate to become efficient. In other words peer DMUs are closest efficient units to inefficient units. On a production frontier, each DMU tries to move either horizontally or vertically by increasing its outputs or decreasing inputs to follow the closest DMU to become inefficient. From Table 4, we can see that Bihar has emerged to be the best efficient state to be emulated by 15 inefficient states, followed by west Bengal which is followed by 13 inefficient states. Madhya Pradesh and Uttar Pradesh are emulated by 12 and 8 states respectively. Goa, Kerala and Telangana are emulated by 7, 6 and 4 inefficient states. Maharashtra state is emulated by none of the states.

Table V

Input and Output Slacks in Input-oriented Approach

DMU	X1	X2	X3	Y1	Y2	Y3
Andhra Pradesh	0	3.82	0.03	0.25	0	11.05
Arunachal Pradesh	0	0	0.18	0	17	0
Assam	0	0	0.01	0	0	0
Bihar						
Chhattisgarh	0	0	0	0	0	3.81
Goa						
Gujarat	0	0	0.09	0	0	12.76
Haryana	0	0	0	0.39	0	3.63
Himachal Pradesh	0	0	0.18	0.15	0	3.9
Jammu & Kashmir	0	0	0.35	0	3.44	0
Jharkhand	0	0	0.83	0	0	0
Karnataka	0	0.59	0.2	0	0	0
Kerala						
Madhya Pradesh						
Maharashtra						

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Manipur	0	0	0	0	0	3.33
Meghalaya	0	0	0	0	0	0.76
Mizoram	0	0	0	0	0	0
Nagaland	0	0	0.09	0	13.06	0
Odisha	0	1.05	0.18	0	0	19.17
Punjab	0	0.37	0.02	0	0	0
Rajasthan	0	0	0.05	0	0	0
Sikkim	0	0	0	0	4.32	0
Tamil Nadu	0	2.18	0.07	3.8	0	13
Telangana						
Tripura	0	0	0	0	11.71	9.45
Uttarakhand	0	6.76	2.38	0	0	0
Uttar Pradesh						
West Bengal						

Source: Calculated using EMS.

The efficiency scores further indicate how the inefficient units can be made efficient by identifying input and output slacks. Slack refers to excess input or missing output that exists even after the proportional change in the input or the outputs[23]. The slacks are estimated only for inefficient units and amount is specifies by which inputs or outputs could be increased or decreased to make the concerned DMU efficient. From the Table V, we can easily conclude that all the inefficient units have to either increase output or decrease any of inputs to make themselves efficient. Andhra Pradesh, one of the inefficient states, have to decrease input X2 (nurses per 1000 population) and X3 (number of hospitals per 1000 population) by 3.82 and 0.03 per thousand population. Similarly, it has to increase the outputs Y1 (percentage of IPD/OPD) and Y3 (infant survival rate) by 0.25 percent and 11.05 per 1000 live births. The states of Chhattisgarh, Manipur and Meghalaya have to increase only output Y3 (infant survival rate). Similarly rest of the states have to make changes in both input and output levels to make themselves efficient.

CONCLUSION

Data Envelopment Analysis (DEA) technique provides understanding of the performance of the units the improvements to be made in the units which are not performing up to the mark. We have used here the DEA technique to measure the performance efficiency of the healthcare system taking states as DMUs. Our assessment of efficiency of healthcare system of each state revealed that most of the states are using more than required inputs to achieve the current level of output (healthcare services).

The analysis found that out of 29 states only 8 states' healthcare system is efficient. These states are Bihar, Goa, Kerala, Madhya Pradesh, Maharashtra, Telangana, Uttar Pradesh and West Bengal and lying on the frontier. Rest of the states are found inefficient and hence lying farther away from the frontiers. Given the inputs, the efficient states are considered to be the best achievable. However these states can further be improved if more information on inputs or outputs are provided. The process of benchmarking also revealed that state of Bihar is

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the most efficient as 15 of inefficient states can emulate it to become efficient states. Second best efficient state is west Bengal emulated by 13 inefficient states. The efficiency scores further indicate how the inefficient units can be made efficient by identifying input and output slacks. All the inefficient units have to either increase output or decrease any of inputs to make themselves efficient. The states of Chhattisgarh, Manipur and Meghalaya have to increase only output Y3 (infant survival rate). Rest of the states have to make changes in both input and output levels to make themselves efficient.

Thus, the healthcare system in India is performing inefficiently as majority of the states are inefficient in providing healthcare to its population. The DEA technique has been proved to be suitable in assessing the healthcare system in India. However, the scenario of the efficiency could be different if we employ different inputs or/and outputs other than used in this study. At the same time, increase in sample size may also change the scenario. Small sample size (here 29) causes the number of higher states to lie on frontier, thereby making them efficient. This can be treated as limitation in using DEA in small sample size. However, the present result have some policy implications that more inputs mainly nurses and hospitals to be increased in all inefficient states to make the healthcare system efficient and to achieve better healthcare outputs.

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