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DEA TECHNIQUE BASED ASSESSMENT OF EFFICIENCIES OF THE GOVERNMENT HOSPITALS OF UTTARANCHAL (INDIA)

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ABSTRACT

This paper measures technical and scale efficiencies of 29 government hospitals of Uttaranchal State in India for the years 2001 to 2004 through DEA technique. Number of beds, paramedical staff and doctors are taken as input variables and number of outpatients and indoor patients as outputs variables. Two case-mix outputs, namely, number of minor and major surgery received are also considered. The paper concludes that performance of the hospitals has improved over the years but it is still far from the optimal level. Region-wise comparison of efficiency scores evinces that the hospitals of Garhwal region have performed relatively better than their counterparts in Kumaon region. Further, district male hospitals have experienced relatively higher improvement in the efficiency.

Key Words: Data Envelopment Analysis, Efficiency, and Hospitals.

INTRODUCTION

India as a developing country seems to be riding on the information economy with the potential of being a developed nation in decades to come. However, much progress remains to be achieved in increasing literacy and public awareness, and providing accessible and quality healthcare to the general masses. Education and health, being vital components of human development, play significant role not only in the well being of the people but also contribute substantially to the economic development of a country. Economists have found a strong correlation between better health and faster economic growth (Tyson, 2002).

Like many other developing countries, Indian government is under increasing pressure to improve the efficiency of healthcare delivery system. The increasing resource crunch, coupled with the declining efficiency and effectiveness of public investment, has put the public sector in a position of comparative disadvantage. It is observed that public health investment over the years has been comparatively low as

its per centage in terms of the gross domestic product (GDP) has declined from 1.3 in 1990 to 0.9 in 1999. The aggregate expenditure on the health sector in India is 5.2% of the GDP of which public sector constitutes only 17% (Government of India, 2002).

The scarcity of resources, coupled with structural reform programmes, has forced the policy-makers to search for alternative ways of achieving maximum return from the given public healthcare services. One approach towards this end has been to examine the performance status of public hospitals on the basis of which policy-decisions on the future course of action could be taken. Keeping this in view, the present study is undertaken to examine the relative performance of public hospitals of Uttaranchal State of India which, being thinly populated hill state, does not have significant stake of private sector in the healthcare services.

HEALTHCARE INFRASTRUCTURE OF THE STATE

Uttaranchal, a 27th State of India, attained its statehood on November 9, 2000. It consists of thirteen districts and culturally divided into two regions: Garhwal and Kumaon. Out of thirteen districts, two districts (Haridwar and Udham Singh Nagar) lie in the plain region and two districts (Dehradun and Nainital) are partly covered by plain areas while the rest of them are completely hilly. More than 80% of the land in the state is mountainous. Uttaranchal has a population of 8.5 million. The state is the most sparsely populated with an average population density of 159 per sq. kms. More than 50% of its population lives in villages of population less than 200 people and over 80% of population lives in villages of population less than 500. Further, 62% of villages are not connected by pucca road. So extending public health facilities to such scattered population is a big challenge.

Uttaranchal has an extensive network of public health institutions. It has 1525 sub centers, 84 main centers, 173 additional primary health centers (PHCs), 84 block level PHCs, 30 community health centers (CHCs) upgraded from block level PHCs, 326 allopathic dispensaries, 3 mobile dispensaries, 38 rural female hospitals and 33 district/base/ combined hospitals. To cater to specific diseases, the State owns 14 T.B. Hospital, 3 Leprosy Hospitals, 9 Urban Leprosy Centers (ULCs), 5 Infectious Disease Hospitals (IDH), 9 Revamped Health Posts (RHP) and 7 Urban Family Welfare Centers (UFWCs). In regard to other systems of medicine, it holds 385 Ayurvedic Dispensaries, 60 Homeopathic Dispensaries and only 3 Unani Dispensaries. There are two Regional Family Planning Training Centers (RFWTC) and 7 Auxiliary Nurse Midwives Training Centers (ANMTC). Only one private medical college and 2 government ayurvedic medical colleges are positioned in the state. However, there exists a wide disparity in the public healthcare infrastructure across districts and regions. For instance, 60% of government hospitals' beds are situated only in four districts, namely, Pauri, Almora, Dehradun and Nainital. The State also faces shortage of training institutions and public health management experts. It also suffers from insufficiency of medical and paramedical staff and their willingness to work in the inaccessible areas.

Out of total 6379 sanctioned positions, 1602 are vacant (Government of Uttaranchal, 2002a).

Health Status of the State

The health status of Uttaranchal in terms of many indicators is better than its parent state (Uttar Pradesh) and the national average but still the status is far from satisfactory, as is evident from the figures given in Table 1.

Table 1
Comparative Statement of Uttaranchal State's Health Indicators with its Parent State (U.P.) and India (in %)

Item	*Uttaranchal*	*U. P.*	*India*	*Item*	*Uttaranchal*	*U. P.*	*India*
Decadal Growth of population	19.2	25.8	21.34	Female Ratio	964	879	933
Literacy Rate	72.28	57.36	65.38	Couple Protection Rate	43.1	38.2	44.0
(a) Male	84.01	70.23	75.85	Complete Immunized Children	40.9	21.2	42.0
(b) Female	60.26	42.98	54.16	Safe Delivery	51.2	20.8	40.2
Crude Birth Rate	26.0	32.80	26.0	Unmet Need for Family Planning	21.0	25.1	15.8
Crude Death Rate	6.50	10.5	8.7	Women with Children 3 and above	51.1	59.9	45.8
Infant Mortality Rate	52.00	84.00	70.0	RTI among Women	41.2	38.1	34.0
Total Fertility Rate	3.06	3.99	2.85	Institutional Delivery	18.1	16.2	34.0

Source: http://populationcommission.nic.in/cont-en-ut.htm accessed on November 2005.

Only forty one per cent children are fully immunized; eighteen per cent mothers received the full complement of three antenatal check-ups; twenty one per cent of births are delivered under medical care. Among the births delivered at home, only seventeen per cent are assisted by a health professional. Forty one per cent of married women have reproductive health problems and 69% of them have not sought any advice or treatment. Twenty one per cent of women have an unmet need for family planning. Forty two per cent of children of age up to three years are underweight, twenty seven per cent are physically handicapped, and 8% are mentally disabled (Government of Uttaranchal, 2002b, 2002c). Many of these problems, of course, have their roots in the big problem of access. The poor road connectivity, difficult hilly terrain, small-scattered settlements, lack of infrastructure and manpower contribute to problems of access to health service delivery. Given the poor paying capacity and scattered location of settlements in hilly districts, the population is almost entirely dependent on the public health delivery system while the presence of the private sector tends to be concentrated in the plains. About 80% of private Hospital beds are situated in Dehradun and Haridwar districts (Government of Uttaranchal, 2002a).

Thus, with the increasing pressure to improve the public health delivery system, the government focuses on the issue of assessment and improvement in the performance of public hospitals (Government of Uttaranchal, 2002a). In healthcare systems, efficiency measurement is the first step in the evaluation of individual performance of hospitals. This study is an attempt in this direction to assess the relative efficiency of public hospitals of Uttaranchal State of India.

A BRIEF REVIEW OF LITERATURE

DEA has been successfully used by researchers to measure the relative efficiency of healthcare entities of different countries. Banker *et al.* (1986) and Chang (1998) apply econometric analysis and DEA to obtain the relative efficiency of hospitals. Lynch and Ozean (1994) use DEA and logistic regression to determine technical efficiency which is related to rural hospitals closure. Chilingerian (1995) presents an empirical illustration of the use of DEA to analyze the efficiency of American Physician and to identify key factors associated with the efficient use of clinical resources in the provision of hospital services. Thanassoulis et al (1995) assess units providing prenatal care in England through DEA. Ozean (1995) applies DEA to provide a preliminary assessment of hospital delivery performance at the local market level. Borden (1990) assesses the impact of DRG (Diagnostic Related Groups) based reimbursement on the technical efficiency of New Jersey hospitals using DEA. Giokas (2001) uses two different efficiency estimation techniques, namely DEA and OLS (Ordinary Least Square Method) as a means of ascertaining specific estimates of the marginal costs of hospital services of public, general, and teaching hospitals in Greece. Kleinsorge and Karney (1992) demonstrate how DEA can assist in the management of a chain of Nursing Homes and also compare the results from DEA to more traditional results from financial ratios, occupancy rates and unit cost measures. Shammari (1999) measures the productive efficiency of Ministry of Health hospitals in Jordan by multicriteria DEA. McKillop et al (1999) examine the technical, scale and size efficiency of larger and smaller acute hospitals in Northern Ireland over the six-year period (1986-1992) by applying DEA. Chang *et al.* (2004) evaluate the impact of a National Health Insurance (NHI) Program on the operating efficiency of district hospitals in Taiwan through DEA. Bhatt et al (2001) attempt to provide an overview of the general status of the healthcare services provided by hospitals in the State of Gujarat in India in terms of their technical and allocative efficiency by using DEA technique.

The DEA-based studies overviewed above indicate that there is no dearth of studies on the subject; however, studies on Indian hospitals are, of course, scant. This paper is an attempt in this direction. The paper estimates OTE and SE of district/base/ combined public hospitals of Uttaranchal state for the period from the year 2001 to 2004 and also suggests policy interventions for improving the performance of healthcare infrastructure of the State.

DEA APPROACH AND METHODOLOGY

This paper measures the overall technical efficiency (OTE) and scale efficiency (SE) of the public hospitals. Since the mathematical relationship between hospital inputs and outputs is not known clearly, hospital efficiency is operationalized using a non-parametric linear programming model known as Data Envelopment Analysis (DEA), initially proposed by Charnes, Cooper and Rhodes (1978) and extended by Banker, Charnes and Cooper (1984). It measures the relative technical efficiency of a group of decision-making units (DMUs) by simultaneously evaluating multiple inputs and outputs common to each unit. It is a family of fractional linear programs; each linear program measures the relative efficiency of a particular DMU. Even though the modeling is nonlinear but under appropriate transformations the efficiency rating can be derived from an equivalent linear program (Charnes and Cooper, 1962).

DEA is chosen over other methods because it handles multiple inputs and outputs; does not require a prior weights (as in index numbers); emphasizes individual observations rather than statistical estimates (as in regression analysis); is a dynamic analytical decision-making tool that not only provides a "snapshot" of the current efficiency of the DMU compared with the group, but also indicates possibilities for improving relative efficiency; and uses benchmarking approach to measure hospital efficiency relative to others in their group. Hence, it can assist in identifying best-practice or efficient hospitals and inefficient hospitals within the group. The results obtained can then allow policy makers to develop policies that can assist the relatively inefficient hospitals to improve their performance.

Step-wise methodology used to compute the technical and scale efficiencies of the hospitals are described as:

First Step: Selection of the Homogeneous DMUs

We have selected government hospitals of the State that have bed strength more than or equal to 30. According to data availability and bed strength criteria, out of 33 district/ base/ combined hospitals, only 29 hospitals are selected. Data for the study have been collected from the Directorate of Medical Health and Family Welfare, Government of Uttaranchal, for the calendar years 2001 to 2004.

Second Step: Selection of Input and Output Variables

To evaluate the relative efficiencies of the hospitals, three inputs, viz., number of beds, doctors and paramedical staff (PMS) and four outputs, namely, number of outpatients, indoor patients, minor surgery and major surgery are considered. In the literature, several case-mix indexes based on the concept of Diagnosis Related Groups (DRGs) are used as important output measures in healthcare system (Borden, 1990; Kleinsorge *et al.*, 1992; Steering Committee, 1997). In our sample hospitals, some departments are not common, for example, all district male hospitals don't have maternity department and all district female hospitals don't have dental, orthopedic and eye departments.

So, to maintain the homogeneity of output measures, we consider only number of minor and major surgery received as the case-mix output measures as the surgical department is common in all the hospitals.

Descriptive statistics of the input-output variables are shown in Table 2. There is a perceptible variation in the inputs and the outputs across hospitals, evidenced by standard deviation, minimum and maximum values. The capital input used is in some cases seven times larger than that used by other hospital, whereas variations in labour inputs are around eight to thirteen times. The variation in output produced is very high across hospitals as well as across years.

Table 2
Descriptive Statistics of Inputs and Outputs

Years		*Inputs*			*Outputs*			
		Beds	*Doctors*	*PMS*	*Out-Patients*	*Indoor Patients*	*Minor Surgery*	*Major Surgery*
2001	Min	30	3	9	5044	520	59	6
	Max	212	40	111	390762	9413	3969	2180
	Mean	79.34	14.45	38.93	63004.21	3787.45	617.69	392.28
	S.D.	43.37	8.46	25.27	73143.39	2425.15	933.56	449.61
	Sum	2301	419	1129	1827122	109836	17913	11376
2002	Min	30	4	10	5500	545	20	5
	Max	212	41	114	352749	22898	3269	2095
	Mean	79.34	15.45	39.90	64324.97	4448.103	564.03	388.48
	S.D.	43.37	8.46	25.46	65125.57	4280.86	745.51	492.74
	Sum	2301	448	1129	1865424	128995	16357	11266
2003	Min	30	5	8	5198	515	10	4
	Max	212	42	108	265140	12614	3776	2503
	Mean	79.34	17.86	38.79	66973.86	4411.07	536.03	398.69
	S.D.	43.37	9.06	25.01	54584.4	3081.54	756.93	541.33
	Sum	2301	518	1125	1942242	127921	15545	11562
2004	Min	30	5	10	10866	659	1	2
	Max	212	42	112	265864	12660	4304	2390
	Mean	79.34	17.86	39.93	75351.79	4739.31	632.10	419.72
	S.D.	43.37	9.06	25.27	59369.08	3239.68	837.19	547.32
	Sum	2301	518	1158	2185202	137440	18331	12172

Third Step: Selection of the Models

In general, hospital management and healthcare service providers anticipate demand and invest in inputs necessary to support the expected level of demand. For public hospitals, it is not so easy to adjust (reduce) input levels, as number of beds is a fixed input in the short run. As mentioned earlier, there is inadequacy of medical and paramedical manpower in the public hospitals and more recruitment is required to cater to the requirement of healthcare services. Hence, in this situation, it is not admirable to assume that labour inputs (doctors and paramedical staff) have to be adjusted. From practical point of view, it is more sensible to consider output-based efficiency measure. Therefore, we apply CCR output-oriented model i.e. the relative

efficiency of sample hospitals is measured on their potential to increase outputs (given their existing level of inputs) relative to the best practice (Chen, 2005; Steering Committee, 1997). To decompose OTE into PTE and SE, BCC output-oriented model is also applied. Descriptive statistics of the results are given in Table 3.

RESULTS AND DISCUSSIONS

Table 3 presents the information on descriptive statistics of OTE and SE for the years 2001 to 2004. The OTE scores indicate that the hospitals having value of the efficiency score equal to 1.00 are on the efficient frontier under CRS technology assumption and those having the value less than 1.00 are less efficient relative to the hospitals on the frontier. The lower the efficiency score, higher the scope for the potential increase in outputs (while maintaining inputs) relative to the best practice.

Some points emerge from the perusal of Table 3. In the first instance, it is clear that the efficiency measures show a much greater spread, as evidenced by the standard deviations and minimum and maximum values. This implies that there is significant variation in each of the efficiency measure and the efficiency scores are falling within very large efficiency range across sample hospitals. Secondly, each of the efficiency measure (OTE and SE) shows the same trend, as the average efficiency scores for OTE and SE have steadily increased over the sample periods. During the year 2001, on average, sample hospitals could have produced 34.8% more outputs than they actually produced with the same level of inputs, this potential efficiency gain has reduced, by the year 2004, to a mere 24.1%. This implies that average performance of the hospitals has improved between the years 2001 and 2004.

Table 3
Descriptive Statistics of OTE, SE and RTS for the years from 2001 to 2004

	Overall Technical Efficiency				*Scale Efficiency*			
	2001	*2002*	*2003*	*2004*	*2001*	*2002*	*2003*	*2004*
Min	0.211	0.232	0.259	0.308	0.223	0.232	0.328	0.385
Max	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Mean	0.652	0.725	0.759	0.759	0.845	0.905	0.927	0.927
S.D.	0.239	0.245	0.231	0.229	0.169	0.160	0.136	0.127
No. of efficient	5	8	9	9	5	8	9	9
hospitals	(17.24%)	(27.59%)	(31.03%)	(31.03%)	(17.24%)	(27.59%)	(31.03%)	(31.03%)
No. of hospitals	29	29	29	29	29	29	29	29
	Returns to Scale							
CRS	5	8	9	9				
IRS	15	16	15	4				
DRS	9	5	5	16				

The third point is related to the scale efficiency scores. The DEA analysis evinces the steadily increment in scale efficiency scores over the sample time period. The average scale efficiency score was 0.845 in 2001 which indicates that 15.5%

proportionate expansion in all outputs beyond what was achieved by eliminating pure technical inefficiency would be feasible if the input and output bundles are suitably altered. For the year 2004, the SE score has risen to 0.927, revealing that the scale inefficiency has fallen from 15.5% in 2001 to 7.3 % in 2004.

Fourthly, it is evident from Table 3 that both pure technical inefficiency and scale inefficiency are responsible for overall technical inefficiency. The information on returns to scale (RTS) in Table 3 reveals that in the year 2001 about 17.24% hospitals were operating at the Most Productive Scale size (MPSS) i.e. these hospitals operated at constant returns to scale (CRS). The number of hospitals at MPSS has reached to 31% in the year 2004. It clearly indicates that hospitals are moving towards the optimal scale size but still they are far from the MPSS. The remaining hospitals don't show the clear trend of RTS. In the year 2001, the majority of the scale-inefficient hospitals (62.5%) were operating under increasing returns to scale (IRS) and the remaining (37.5%) hospitals under decreasing returns to scale (DRS). The former are small hospitals that need to increase their size, whereas the latter are larger hospitals which would be better off by reducing their size so that they can operate at optimal scale size. In 2003, about 75% scale-inefficient hospitals were operating under IRS and remaining 25% hospitals under DRS. But in the year 2004, only 20% scale-inefficient hospitals are operating under IRS and remaining 80% hospitals under DRS.

Finally, the DEA analysis also evaluates the set of hospitals which construct the production frontier. The detailed results of OTE and SE (CCR and BCC output models) for the year 2001 reveal that out of 29 hospitals, only 5 (17.24%) hospitals were operating at MPSS i.e. these hospitals were overall technical and scale efficient (OTE and SE Score = 1). These hospitals were H1, H8, H21, H22 and H27. Base hospital Almora (H14) was the most technical inefficient hospital whereas GB Pant hospital Nainital (H15) was the most scale inefficient hospital. The mean technical efficiency of the sample hospitals implies that on average, the hospitals may be able to increase all their outputs by 34.8% using the same amount of inputs. Mean scale efficiency was 0.845, implying that the average size of hospitals was not far from the optimal size, although an additional 15.5% productivity gain would be feasible assuming no other constraining factors, provided they adjusted their hospitals operation to an optimal scale.

In 2002, number of the overall technical and scale efficient hospitals has increased to 8. Three new hospitals (H13, H16 and H26) joined the set of efficient hospitals. The most overall technical and scale inefficient hospital was H15. This indicates that the overall technical inefficiency of the hospital was due to the disadvantageous scale-size. The mean OTE and SE scores of the sample clearly evinces that, on average, hospitals have been improving their performance.

In 2003, 9 hospitals were operating at MPSS. Three new hospitals (H7, H9 and H12) joined the set of efficient hospitals while two earlier efficient hospitals (H21 and H26) turned out to be inefficient in the year. H15 was again rated as the most overall

technical and scale inefficient hospital. The mean values of OTE and SE scores imply that hospitals have improved their performance for the last two years.

In 2004, yet again the set of overall technical and scale efficient hospitals constitutes 9 hospitals. Two new hospitals (H18 and H29) joined the set of efficient hospitals whereas two previously efficient hospitals (H9 and H16) turn out to be inefficient in the year. District Female Hospital Almora (H24) is found the worst performer in terms of OTE. Again H15 is rated as the most scale inefficient hospital even though the SE of this hospital has gradually increased over the whole study period. This hospital is operating under IRS which clearly indicates that this hospital has to increase its scale size if it wants to operate at optimal scale.

The comparative distribution of hospitals according to OTE and SE scores across years is shown by Figure 1 and Figure 2, respectively. Figure 1 shows that number of hospitals, whose OTE scores are falling in the range from 80 to 99 per cent, have increased from 3 (10%) in 2001 to 6 (20.7%) in 2004.These hospitals may be able to expand their outputs by up to 20 % while maintaining the same input level if they want to operate as the best practice hospitals, whereas the numbers of hospitals with OTE scores falling in the range from 40 to 60 % have decreased from 9 (31%) in 2001 to 3 (10%) in 2004. Similarly Figure 2 exhibits that only one hospital has increased in the range from 80 to 99 % SE scores across years. Contrary to this, the number of hospitals has decreased up to only 2 in 2004 as compared to 7 in 2001 in the range from 60 to 79 per cent which clearly indicates that across years hospitals are moving from optimal

Figure 1: Distribution of OTE Scores Across Years

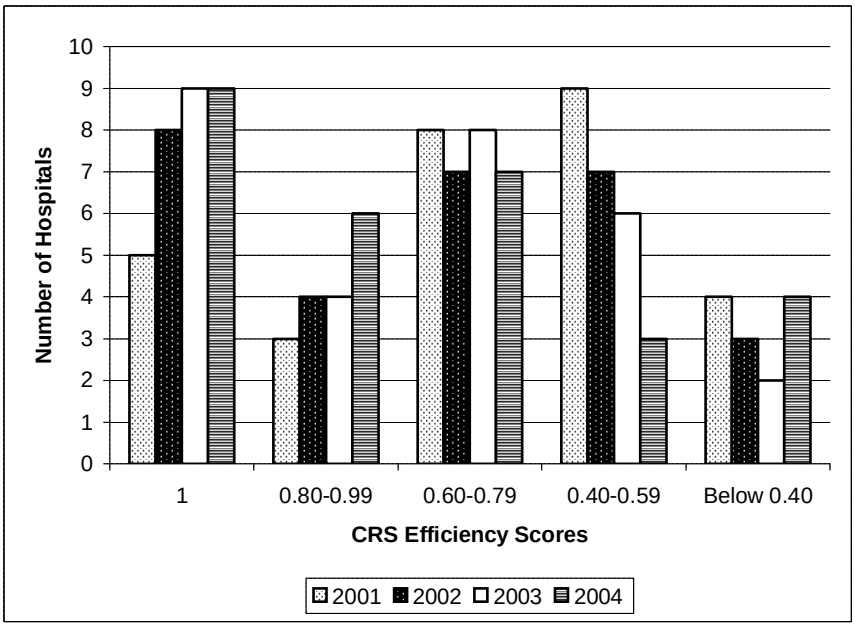
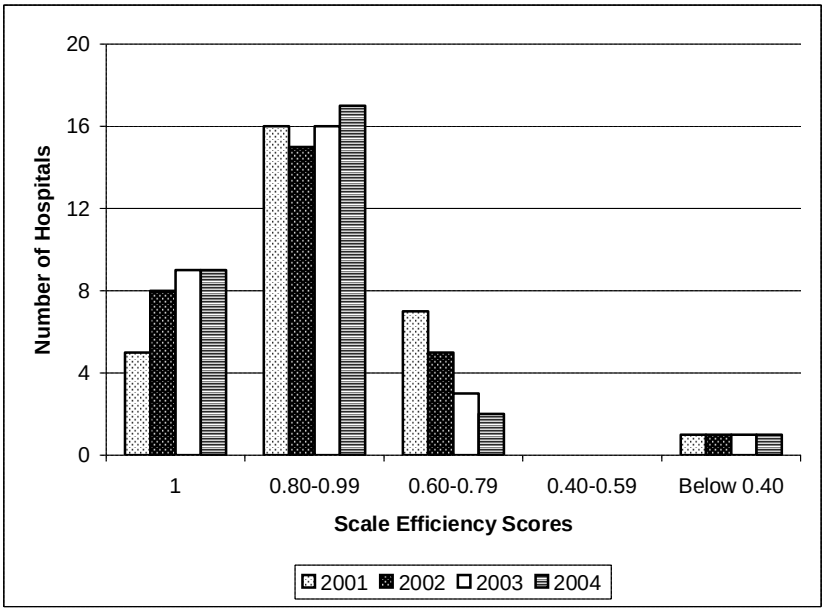


Figure 2: Distribution of SE Scores Across Years



level. Only 1 hospital i.e. H15 is found whose SE has remained below 40 % during the entire study period.

The results show that through out the study period, only four hospitals (H1, H8, H22 and H27) have remained relatively efficient. These hospitals are efficient with respect to a large number of factors and are probably good example of "global leader" or hospitals with a high robustness. Hence, these hospitals can be considered the best-practice hospitals to be followed by the inefficient hospitals to improve their performance.

Input/Output Targets for Inefficient Hospitals

Each of the inefficient hospital can become overall efficient by adjusting its operation to the associated target point determined by the efficient hospitals that define its reference frontier. Table 4 presents the mean target values of all inputs and outputs of inefficient hospitals along with per centage reduction in inputs and per centage expansion in outputs for the sample period in terms of CCR output model. It can be observed from the table that an average hospital has a significant scope to expand the outputs, relative to the best practice hospital during the study period. It is also revealed from the results that an average hospital is moving towards achieving its target but it is very far from the best practice hospital. The differences in the targets are in positive direction except PMS. On average, inefficient hospitals have expanded their outpatients 41.24%, indoor patients 27.18%, minor surgery 103.45% and major surgery

47.85% from 2001 to 2004. Yet in 2004, these inefficient hospitals can become as efficient as the hospitals in their reference set, if they could expand their outputs. In 2004, an average hospital may be able to reduce its bed size by 0.5%, doctors by 9.91%, PMS by 22.91% and to expand outpatients by 46.58%, indoor patients by 62%, minor surgery by 168.8% and major surgery by 94.77% relative to the best practice hospital.

Table 4
Target Values of Input and Output Variables under CCR output Model (2001-2004)

Years	*Target Values of Input Variables*			*Target Value of output variables*			
	Beds (No.)	*Doctors (No.)*	*PMS (No.)*	*Out Patients (No.)*	*Indoor Patients (No.)*	*Minor Surgery (No.)*	*Major Surgery (No.)*
2001	75.16	11.38	34.49	99252.98	6439.96	1327.54	784.88
	(4.21)	(21.09)	(10.41)	(87.82)	(89.17)	(272.25)	(142.62)
2002	71.10	14.21	30.82	83510.28	5463.62	930.32	531.25
	(4.59)	(1.81)	(20.30)	(65.85)	(67.14)	(187.81)	(107.37)
2003	73.38	14.95	32.29	78940.84	6118.75	1057.05	535.92
	(0.44)	(12.30)	(13.89)	(57.39)	(80.46)	(195.68)	(74.48)
2004	78.95	17.16	32.38	99422.26	6828.24	1269.29	691.16
	(0.50)	(9.91)	(22.91)	(46.58)	(62)	(168.80)	(94.77)
2001-2004	(3.7)	(11.18)	(-12.5)	(41.24)	(27.18)	(103.45)	(47.85)

Figures in bracket are the per centage reductions in the corresponding inputs and per centage additions in corresponding outputs to make the hospital efficient.

Region-wise Comparison of Performance of Hospitals

The next stage in the analysis is to explore the source of each efficiency measure for each of the year across regions. Table 5 presents the descriptive statistics of the comparative performance of hospitals across regions. The average efficiency scores (OTE and SE) across regions are shown in Figure 3.

It is apparent from the information given in Table 5 that hospitals of Kumaon Region (KR) have a lower level of average efficiency scores and a higher variation in the efficiency measures as compared to the hospitals of Garhwal Region (GR). However, hospitals of both the regions have experienced improvement in each of the efficiency measures. Average OTE of hospitals of GR has increased from 0.687 in 2001 to 0.787 in 2004, while in KR; it has increased from 0.620 to 0.731 during the same period. It is clear from Figure 3 that hospitals of GR has higher average efficiency scores (OTE and SE) as compared to their counterparts in KR in the whole study period. The average OTE of GR has shown a steady rise over the years, whereas average OTE of KR has increased between 2001 and 2003 but decelerated in 2004. The average SE of GR shows the improvement between 2001 and 2003 but it slightly decline in year 2004. Contrary to this, the average SE of KR region shows gradual improvement in the whole study period. So it implies that the decline in OTE from the year 2003 to 2004 of the entire sample hospitals is due to decline in OTE of the hospitals of KR whereas decline in SE is due to the decline in SE of GR.

Figure 3: Region-wise Comparison of OTE and SE (2001-2004)

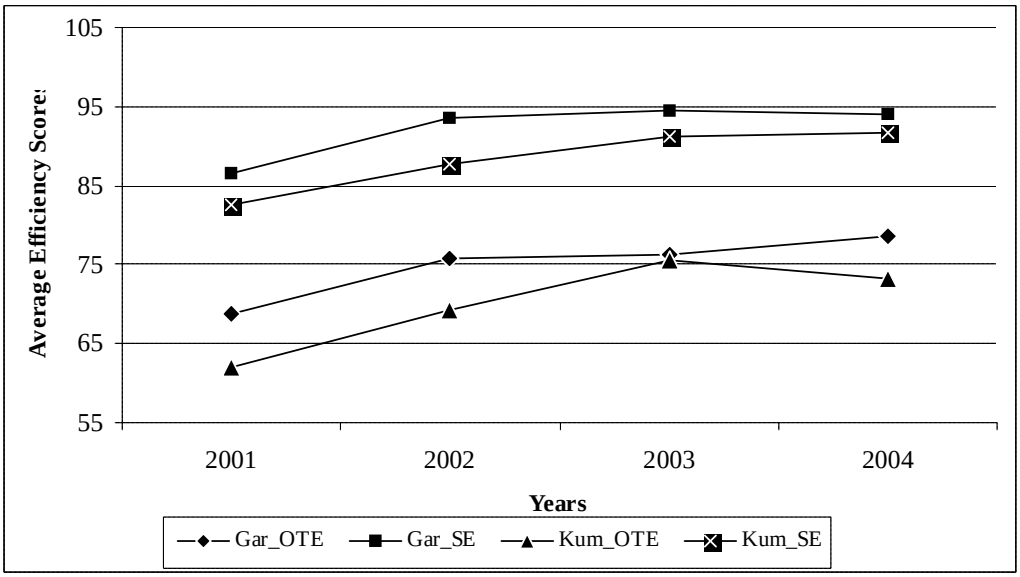


Table 5
Region-wise Descriptive Statistics of OTE and SE (2001-2004)

	Garhwal Region							
	Overall Technical Efficiency				*Scale Efficiency*			
Years	*2001*	*2002*	*2003*	*2004*	*2001*	*2002*	*2003*	*2004*
Min	0.366	0.434	0.484	0.518	0.639	0.677	0.729	0.736
Max	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Mean	0.687	0.759	0.763	0.787	0.866	0.935	0.944	0.939
S.D.	0.210	0.203	0.199	0.173	0.137	0.102	0.077	0.081
No. of efficient	3	4	4	4	3	4	4	4
hospitals (%)	(21.43%)	(28.57%)	(28.57%)	(28.57%)	(21.43%)	(28.57%)	(28.57%)	(28.57%)
No. of hospitals	14	14	14	14	14	14	14	14
	Kumaon Region							
Min	0.211	0.232	0.259	0.307	0.223	0.232	0.328	0.385
Max	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Mean	0.620	0.692	0.755	0.731	0.825	0.878	0.912	0.916
S.D.	0.266	0.282	0.265	0.275	0.197	0.200	0.176	0.160
No. of efficient	2	4	5	5	2	4	5	5
hospitals (%)	(13.33%)	(26.67%)	(33.33%)	(33.33%)	(13.33%)	(26.67%)	(33.33%)	(33.33%)
No. of hospitals	15	15	15	15	15	15	15	15

It is also observed from Table 5 that the hospitals of KR has the lower level of the minimum value of each of the efficiency scores relative to their counterparts of GR which implies that the worst performer hospitals belong to the set of hospitals of KR. These results divulge that most of the variation in the efficiency measures of the public

hospitals in Uttaranchal is due to the higher variation in the efficiency measures of the hospitals of KR.

Category-wise Comparison of Performance of Hospitals

To explore the source of inefficiency of hospitals, category-wise study of the performance of the hospitals is also done. The results are shown in Table 6 and Figure 4.

Table 6
Category-wise Descriptive Statistics of OTE and SE (2001-2004)

	Combined and Base Hospitals							
	Overall Technical Efficiency				*Scale Efficiency*			
2001	*2002*	*2003*	*2004*	*2001*	*2002*	*2003*	*2004*	
Min	0.211	0.232	0.259	0.334	0.223	0.232	0.328	0.385
Max	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Mean	0.614	0.681	0.701	0.733	0.837	0.878	0.906	0.929
S.D.	0.249	0.246	0.268	0.257	0.202	0.198	0.170	0.158
No. of efficient hospitals (%)	2 (12.5%)	3 (18.75%)	5 (31.25%)	6 (37.5%)	2 (12.5%)	3 (18.75%)	5 (31.25%)	6 (37.5%)
No. of hospitals	16	16	16	16	16	16	16	16
	District Male Hospitals							
Min	0.405	0.502	0.697	0.607	0.639	0.989	0.936	0.858
Max	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Mean	0.629	0.772	0.871	0.822	0.823	0.996	0.981	0.925
S.D.	0.203	0.223	0.134	0.145	0.150	0.004	0.026	0.057
No. of efficient hospitals (%)	1 (16.67%)	2 (33.33%)	2 (33.33%)	1 (16.67%)	1 (16.67%)	2 (33.33%)	2 (33.33%)	1 (16.67%)
No. of hospitals	6	6	6	6	6	6	6	6
	Female Hospitals							
Min	0.333	0.255	0.549	0.307	0.749	0.756	0.729	0.736
Max	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Mean	0.760	0.784	0.796	0.762	0.881	0.890	0.932	0.926
S.D.	0.241	0.276	0.178	0.239	0.098	0.108	0.096	0.100
No. of efficient hospitals (%)	2 (28.57%)	3 (42.86%)	2 (28.57%)	2 (28.57%)	2 (28.57%)	3 (42.86%)	2 (28.57%)	2 (28.57%)
No. of hospitals	7	7	7	7	7	7	7	7

Table 6 shows that there is no systematic pattern of OTE and SE along category. Variations in each of the efficiency measures are quite similar in Combined/base and Female hospitals but slightly lower in District male hospitals. This indicates that high variations in the entire sample are mainly due to the higher variation in former category but later one also plays an important role. Combined/base hospitals and District male hospitals show significant improvement (11.9 % and 19.3 %, respectively) in OTE in the year 2004 relative to 2001 whereas female hospitals show only 0.2% improvement in 2004 as compared to 2001.

Figure 4: Category-wise Comparison of OTE and SE (2001-2004)

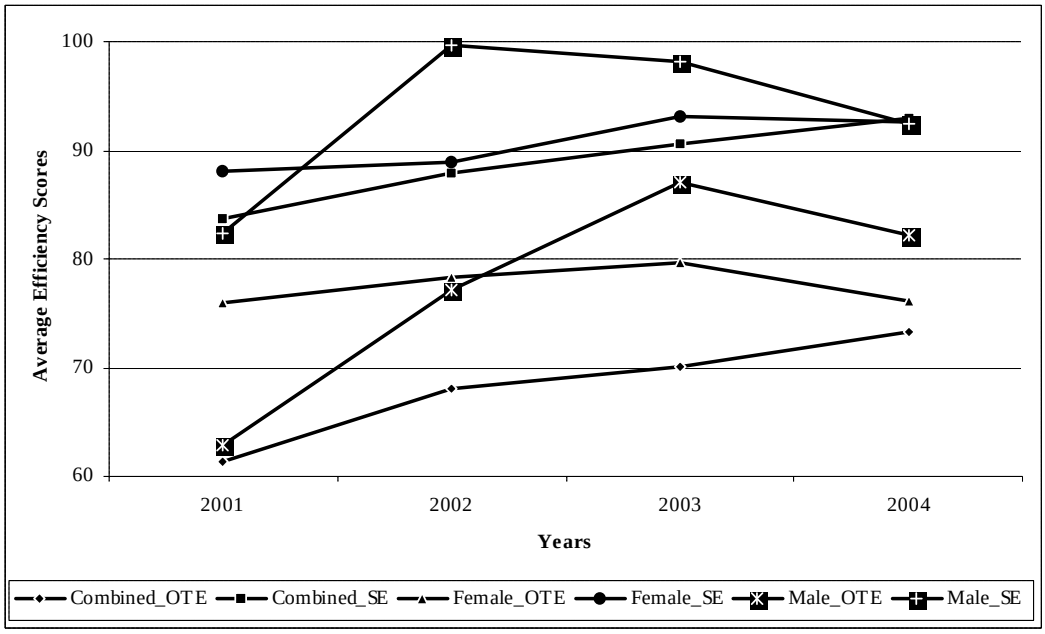


Figure 4 demonstrates that OTE of Combined/base hospitals is at lower level in comparison of their counterparts but it gradually increased between 2001 and 2004 whereas OTE of District male hospitals and female hospitals improved from 2001 to 2003 and then decelerated in 2004. District male hospitals show 24.2 % increment in their OTE in 2003 over 2001.

Similarly, average SE of Combined/base hospitals is relatively at low level but steadily increased over the years. The SE scores of District male hospitals and female hospitals have increased in 2003 over 2001 and then decreased in 2004. Further, District male hospitals demonstrate high variation in SE across years. These observations imply that the high variation in OTE and SE across the years is due to the high variation in OTE and SE of District male hospitals. OTE and SE of Combined/ base hospitals have gradually increased over the years but they are still far from efficient level.

CONCLUSIONS AND POLICY IMPLEMENTATIONS

This paper measures technical and scale efficiencies (OTE and SE) of 29 government hospitals of Uttaranchal State in India through DEA methodology. The detailed information on input and output data reveals that there exist disparities in the distribution of healthcare facilities between hospitals of hill and plain regions and also between hospitals of Garhwal and Kumaon regions. As doctors, nurses and other

paramedical personnel are transferable from one hospital to another, they generally prefer to be transferred to the better-located hospitals. This creates imbalances in the distribution of these resources across hospitals and thus affects the efficiency of individual hospitals. As the government owns these resources, they may be appropriately reallocated through transfer so as to improve the efficiency of relatively inefficient hospitals.

The results of DEA models confirm that performance of the hospitals has improved in 2004 over 2001. Average OTE and SE scores have gradually increased over the period. Moreover, number of hospitals at MPSS has increased from 5 in 2001 to 9 in 2004. Thus, hospitals are found moving towards the optimal scale size but still they are far from the optimal scale size. The study finds that only 14% hospitals have remained overall technical and scale efficient for the entire period. These hospitals can be considered as best-practice hospitals to be followed by the inefficient hospitals to improve their efficiency scores.

Region-wise comparison of the efficiency scores reveals that hospitals in GR has achieved higher average efficiency scores (OTE and SE) as compared to the hospitals of KR. Further, the analysis shows that there is no systematic pattern of OTE and SE along category. Combined/base hospitals and District male hospitals demonstrate major improvement in OTE (11.9 % and 19.3 %, respectively) whereas female hospitals show only 0.2 % improvements in OTE in 2004 over 2001. The high variation in efficiency scores of the entire sample across years is largely due to the variation in efficiency scores of District male hospitals.

Targets set for relatively inefficient hospitals confirm that performance of the hospitals has improved during the period under study but still they have greater scope for further improvement. Their performance can be improved by recruiting motivated and trained health workers and capacity building of the existing staff through training and orientation programmes. In addition, to improve the productivity and commitment level and work environment of health personnel, some motivational policies such as promotions and performance based reward systems should be introduced.

Another point requiring attention is the quality of the outputs because facilities apparently efficient are not necessarily producing high quality outputs, and this could render them ultimately inefficient. Our sample is relatively small so we adopted simplistic production model which does not include the quality variable. This perhaps has resulted in missing some cause of quality inefficiency. These inefficiencies may be occurred due to some issues such as the lack of awareness of available facilities and services offered in public hospitals, the large proportion of vacant healthcare positions, lack of consumer awareness, the absence of advocacy groups, lack of adequate equipment, the lack of training institutes and poor transport facilities.

The targets setting results show that both minor and major surgeries have the significant scope to expand. These can be expand by using the proper referral system

for the secondary and tertiary hospitals so that these hospitals may not have to spend time and resources on providing primary healthcare or treating minor ailments.

APENDIX 1
List of Sample Hospitals

Sr. No.	*Hospital Code*	*Hospital Name*
1.	H1	Combined Hospital Kotdwar
2.	H2	HNB Base Hospital Srinagar
3.	H3	Combined Hospital Srinagar
4.	H4	District Hospital Uttarkashi
5.	H5	District Suman Hospital Narendra Nagar
6.	H6	Combined Hospital Roorkee
7.	H7	SPS Hospital Rishikesh
8.	H8	BDP District Female Hospital Nainital
9.	H9	BDP District Male Hospital Nainital
10	H10	GSM Civil Hospital Ranikhet
11	H11	LDB Hospital Kashipur
12	H12	Combined Hospital Ramnagar
13	H13	JLN District Hospital Rudrapur
14	H14	Base Hospital Almora
15	H15	GBP Hospital Nainital
16	H16	District Male Hospital Dehradun
17	H17	District Female Hospital Dehradun
18	H18	District Male Hospital Pauri
19	H19	District Female Hospital Pauri
20	H20	District Hospital Gopeswar
21	H21	HMG District Male Hospital Hardwar
22	H22	CRW District Hospital Hardwar
23	H23	District Male Hospital Almora
24	H24	District Female Hospital Almora
25	H25	District Male Hospital Pithoragarh
26	H26	District Female Hospital Pithoragarh
27	H27	Base Hospital Haldwani
28	H28	Female Hospital Haldwani
29	H29	CHC Bageshwar

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