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Measuring the Efficiency of Tertiary Care Hospitals and Medical Colleges in Punjab, an Application of Non- Parametric Approach DEA

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Abstract

Efficient utilization of resources required that the healthcare units should operate at their full capacity and increase their efficiency to yields best quality healthcare services and more savings. To measure the capacity utilization of medical collages/attached teaching hospitals in Punjab, the study incorporated the Data Envelopment Analysis (DEA). This is a cross sectional study for the academic year 2015, by using the primary data collected by "Punjab Economic Research Institute (PERI)". The main objective to address the efficiency issue in this study is to provide empirical evidence for public policy to provide for tertiary health care facilities. The results showed that 78% medical colleges in a sample data are unity, indicating that they are perfectly utilizing their resources while the remaining 22% have more close to unity, showing that they have only small capacity to increase their output within available resources. In case of teaching hospitals, there are 56% hospitals in Punjab, which are not operating at their maximum level of output indicating that they have the capacity to provide more services. While 44% are using their resources efficiently. The higher efficiency score of medical colleges/teaching hospital in provincial capital reflected the fact that Decision Making Units (DMUs) in Lahore are relatively more efficient in the management of resources. In the second stage, by using a Tobit regression, the inefficacies are regressed against various indicators of inputs and outputs. Finally, the finding of this study suggests some policy recommendation to make the medical colleges/teaching hospitals more resource effective in order to accelerate the highest efficiency scores.

Keywords: Data development analysis, Medical colleges efficiency, Hospitals efficiency, Tobit regression.

Contents

1. Introduction **15**
2. Public Health Sector in Punjab **15**
3. Private and Public-Sector Tertiary Care Hospitals in Punjab **17**
4. Objective of the Study **17**
5. Significance of the Study **17**
6. Organization of the Study **18**
7. Theoretical Framework of DEA **18**
8. Mathematical Frame Work of DEA **18**
9. Constant Return to Scale and Variable Return to Scale **19**
10. Data and Variable Selection **19**
11. Variable and Its Description **19**
12. Descriptive Analysis of Inputs and Output Variables of Medical Colleges/Universities **20**
13. The Efficiency and Productivity Estimates of Medical Colleges **20**
14. Pearson Correlation of Inputs Indicators and Efficiency Scores **22**
15. Econometric Analysis of the Efficiency Scores and Its Determinants **22**
16. Results of Tobit Regression **22**
17. Data and Variable Selection for Teaching Hospitals in Punjab **23**
18. Descriptive Analysis of Inputs and Output Variables of Attached Teaching Hospitals **23**
19. The Efficiency and Productivity Estimates of Teaching Hospitals by Using Output Oriented DEA **24**
20. Policy Recommendation **24**
References **24**

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1. Introduction

Service-oriented commercial world is getting growing apprehension in all over the world. Consequently, the researchers are now more interested to incorporate the efficiency analysis in service sector than to industrial and production sector e.g. the healthcare and education institution. Health sector has been emerged as a fastest growing sector in the global world during last few decades. The health care providing system involves high costs, especially in the developing areas like Punjab because the health service facilities in Punjab are very much resource intensive. So, the efficient utilization of resources required that the healthcare units operates at their full capacity and increase their efficiency to yields best quality healthcare services and more savings. However, unlike other types of service organizations, the management of health sector in Punjab focus more on the supply side of clinical, and non-clinical healthcare physical infrastructure such as to upgrade the infrastructure, building up new primary, secondary and tertiary heath units but the quality issues get less consideration by them. Unfortunately, these clinical and non-clinical considerations are often found to be simple medical error when appraisal of the decisions making is taken. The basic reason is that the policy makers often do not come up with lessons and insights on how to deal with the basic requirement through knowledge based real and applied studies and practices, which is more relevant, useful and sensitive to indigenous people. These inaccuracies in healthcare facilities can be magnificently resolved if hospital management is aware of global better practices. These types of inefficiencies by the management generates the requirement for endorsing access to high-quality healthcare services that is efficient, effective, and equitable the demand for operational research in the health is needs of time and is rising very fast since last few decades. It is for this reason the hospitals and medical colleges efficiencies are regularly evaluated in many developed and developing countries in order to streamline the health activities and to increase control over quantity, quality and efficiency of resources. Many studies have been conducted in this perspective but most of the researchers consider only operational attributes; there are only few studies in literature which have also considered the qualitative indicator such as patient satisfaction level from health service, the data on such indicator is obtained via patient satisfaction surveys quality in healthcare services but however, it is a difficult perspective and not easy job to quantify it.

The global demand for operational research in health care services and succeeding action produced many studies over the years around the world, resulting in extensive literature on healthcare services efficiency measurement. Some of the researchers measure quality and performance of the hospitals which incorporate quality of health care service and efficiency of the practice. Some techniques used by researchers' measures a mixture of quality & quantity attributes and operational efficiency or they checked the productivity of governmental reforms in healthcare. Thus, the hospitals' efficiency and productivity can be measured by using specific indicators so that the promoted efficiency in health system can be realized, by analyzing and planning for a better efficiency index.

This study intends to make use of non-parametric technique, collectively known as Data Envelopment Analysis (DEA) that is intensively used in measuring the hospital efficiency. The methodological framework of DEA enables the researchers to evaluate the efficiency of those particular organizations which possess multiple homogenous inputs and outputs, and where data about prices is missing. Thus, the technique is well fitted for calculation of hospital efficiency. In reality, multiple inputs/outputs are commonly recurring rationalization for using DEA-type approaches. Furthermore, the decision makers can also use DEA as analytical tool for monitoring purposes such as to point out hospitals with deviating performance structures. Such monitoring may help the management to identify the gaps and increase the efficiency of the hospital. It offers an idealized benchmark to evaluate economic performance of healthcare service. Secondly; the efficiency scores can also be helpful as contextual information in the distribution of resources to different hospitals. This is particularly relevant not only for the regulated tertiary care hospital sectors of Punjab but also for all other health care units in Punjab health system. So, this study incorporates the efficiency measurement of tertiary care hospitals and medical colleges in Punjab.

2. Public Health Sector in Punjab

The population of Punjab is more than ten million, which is about 56 percent of the total population of Pakistan. In spite of the fact that the province has an extensive network of primary, secondary and tertiary health care infrastructure, health indicators have not reached the desired level. I77/1000 live births infant mortality ratio, 112/1000 live births Under 5 mortality rate. 300/100,000 live births Maternal mortality ratio (Information & Communication Cell, 2016) is recorded in year 2015, Total fertility rate has been reached to 4.7, the malnourished children in Province are about four million, and about a third of all pregnant women are estimated to have iron deficiency anemia. Stunting and wasting is estimated to be 34 percent and 10 percent respectively. Undernourishment is found to be a major contributor to maternal and infant deaths. With these highest mortality ratios, Pakistan slipped from 147th to 149th position in global ranking (Ikram, 2015). Table 1 provides broad indicators of health infrastructure in the state.

Table-1. Number of Functional and Reporting Health Facilities in Punjab 2015

Health Facility	DHOS	THQ	DHQ	RHC	BHU	MCH	DISP	SHC	TBC
Total	33	109	27	302	2483	224	319	26	14
Per 100,000 population	0.032	0.106	0.026	0.296	2.43	0.219	0.312	0.254	0.013

Source: District Health Information Report (DHIS) 2015

Besides the above-mentioned health care infrastructure, there is also network of health services that has been specifically designed for implementing various national health programmes. In terms of availability of workforces in health sector, The Punjab has 74500 registered doctors (PM and DC, n.d) of which about 1/7th are working in public health units. Besides doctors, there is qualified manpower such as nurses, technicians, LHVs, LHWs, dispensers, vaccinators, midwives etc., in health sector as well. The total allocated beds allocated to all public health units are 37,272; hospital beds work out to be 37 beds per lakh of population or one bed for 2736 persons.

Health department of Punjab provides preventive, curative and promotive types of care, Preventive health facilities aim to prevent diseases through different interventions, Curative services aims to cure diseases once they befell and Health promotive services are associated to health education. To deliver these services, health units in Punjab are divided into three categories. First, Primary health care contains Rural Health Centers (RHCs), Basic Health Units (BHUs), Dispensaries and Maternal and Child Health Centers (MCHCs). Secondly,

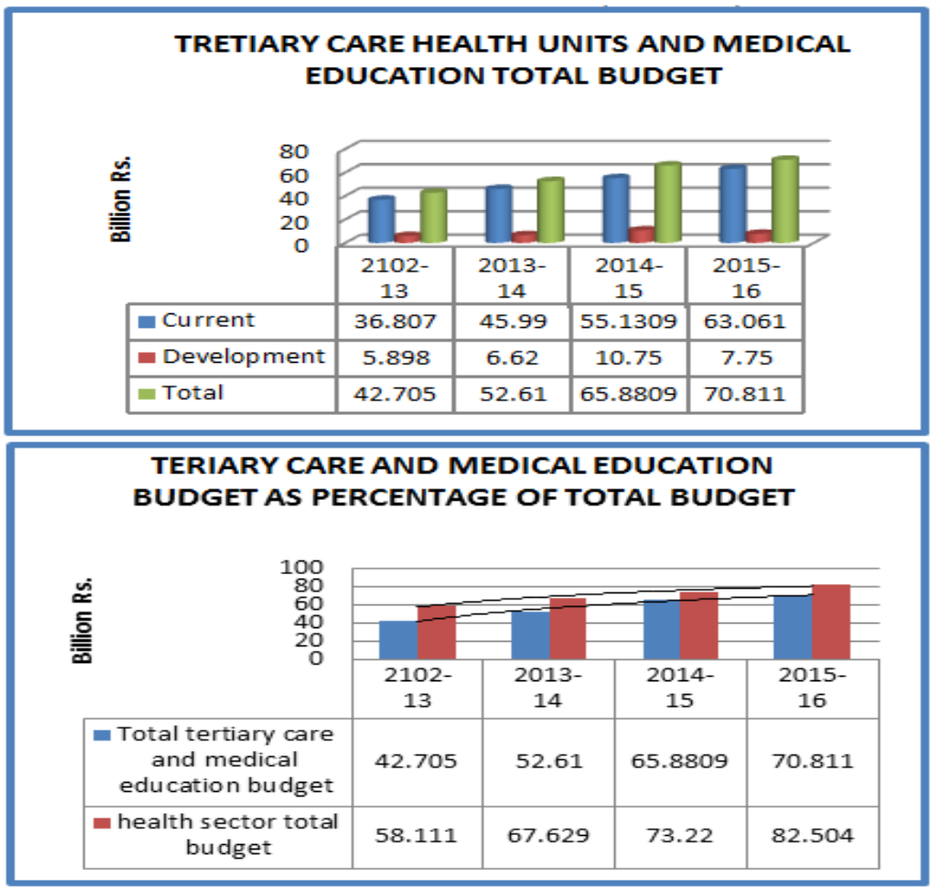

Figure-1. Tertiary Care Hospitals and Medical Education Nominal Budgeting Structure
Source: Annual Development Programme (ADP) & Current Budget statements, Punjab

Secondary health services comprises of Tehsil Headquarter Hospitals (THQs), and District Headquarter Hospitals (DHQs) which are first and second level referral facilities to provide critical, ambulatory and inpatient health care. The third category includes the teaching hospital or Tertiary Care Hospital (TCH) which are the main health units with specialized facilities under the administrative authority of province.

This study made use of tertiary care hospitals and medical colleges' data in private and public sector to measure the capacity utilization of resources of the units fall in third category. Given the declining development budget allocations to the tertiary health sector and generous more focus on preventive health in Punjab has made it critical and very significant the efficient use of existing resources.

Tertiary care health service is the expensive and advance level of health care compared to primary and secondary health care. Curative tertiary care health is the necessity and fundamental right for individuals at micro level, and a crucial requirement for human capital growth and development in a country at the macro level. The total public sector budgetary expenditure on health sector shows positive but not promising figures in last 4 years, however, the share of development spending on tertiary health facilities is still very low (see Figure 1). The total public sector expenditure on health has increased from Rs 58.11billion in 2012-13 to Rs 82.504 billion in 2015-16 but the development budget presents worst picture in year 2015-16 as the share has been reduced to 34% which was 43% in 2014-15.

In case of infrastructure provision, availability of inpatients beds varies across private and public sector, from one bed per 4730 inhabitants in public sector to 9716 in private sector. Both, the number of beds per head of population and the occupancy rate are comparatively high. Admission rates and turnover rates have also been relatively high in provincial tertiary care hospitals.

Table-2. Population to Bed Ratio in Private and Public Sector Tertiary Care Medical Facilities

	Public Sector		**Private Sector**	
	Beds	**Population to Bed**	**Beds**	**Population to Bed Ratio**
Essential Specialties	25356	8984	7248	13990
Allied Specialties	10147	9993	3188	31806
Total	21434	4730	10436	9716
Overall Public and Private Sectors Population to Bed Ratio				
	Beds			Population to Bed Ratio
Essential Specialties	18535			5470
Allied Specialties	13335			7604
Total	31870			3181

Source: author's calculation by using available data of tertiary heath sector Punjab

3. Private and Public-Sector Tertiary Care Hospitals in Punjab

Besides public health and medical institutions, Punjab has a significant existence of private medical colleges and affiliated teaching hospitals. The influence of many of these health units in serving the inhabitants and addressing their health needs is quite impressive. These private sector health and medical institutions have also the managerial capacity to generate their own resources through user fees and donations. The government of Punjab has set some guidelines for these private sector institutions to run which implies that these institutions do not have complete autonomy in their decision making such as in admissions of medical students, recruitment, procurement of supplies and capital investment etc. Most of the decisions are held under the rules of Pakistan Medical and Dental Council (PM&DC). The improvement in of quality services, efficiency and performance must be the key indicators in these decisions. They generate most of their revenue by the user fees. Another source of revenue can be to raise funds through donations and grants from community and trusts including private sector and industry. This gives them much better financial flexibility. The public sector medical institutions and health units are mostly funded by the public sources. The distribution of medical colleges/attached teaching hospitals in Punjab is given in Table 3.

In Punjab, there are 19 medical colleges and 28 affiliated teaching hospitals in public sector out of which, 6 medical colleges and 8 affiliated hospitals are in Lahore. In private sector, there are 35 medical colleges and 56 attached teaching hospitals. The tertiary care health sector in Punjab is facing breaks and diversion in the accessibility of funds due to more concentration and allocations on the procurement of preventive health care facilities in previous some years as has been shown in Figure 1 that the development budget spent on tertiary care facilities has been decreased by 43 percent to 34 percent in 2015-16. The primary objective to measure efficiency in health sector is to improve the productivity of existed resources of health care (Romley, 2009).

Table-3. Private and Public Medical Colleges and teaching hospitals in Different Districts

District with Medical Colleges/Teaching Hospitals	**Public Medical Institutions**	**Attached Tertiary Care Hospital**	**private Medical Institutions**	**Attached Tertiary Care Hospital**
Lahore	06	08	14	22
Faisalabad	01	02	03	04
Sialkot	01	02	02	05
Multan	01	01	03	03
Gujarat	01	01	01	03
Rawalpindi/Islamabad	03	07	09	14
Sargodha	01	01	01	02
Sheikhupura	00	00	01	02
Wah Cantt	00	00	01	01
Sahiwal, Gujranwala, Bahawalpur, Rahim Yar Khan, Dg Khan	05 (01 each)	06	0	0
Total	19	28	35	56

Source: Pakistan Medical & Dental Council(PM&DC)

4. Objective of the Study

- The primary objective of this study is to evaluate the relative efficiency of public and private tertiary care hospitals and medical colleges of Punjab by using non- parametric approach.
- The second objective is to compare the aggregate efficiency of private sector tertiary health care units to public units.
- To provides suggestion for two sets of institutions on the basis of empirical findings by using data set in specific time period.

5. Significance of the Study

Several attempts by various researchers have been made to evaluate the efficiency of public and private sector's hospitals in different countries of the world by using different parametric and non-parametric methods particularly in developing economies like china (Sun, 2016) Saudi Arabia (Al-Shayea, 2011) India (Mogha, 2012) etc., but only few studies have been found in Punjab especial in the area of measuring the efficiency of medical colleges/universities, so this study is an attempt to fill this gap. This study would also provide guidance to the management of each DMU in the institution to make improvement in the use of resources and providing services. This study would highlight the weak aspects of the management of institutions through comparative inputs/outputs analysis and provide proposition to make changes in quantity and quality of inputs and outputs variables in order to achieve high rank of efficiency.

6. Organization of the Study

The rest of the study is ordered as the next part gives a brief view of Data Envelopment Analysis literature and mathematical framework. Part 7-11 discusses the theoretical and mathematical framework of methodology, selected variables and its description, data compilation etc. Part 12-19 talked about the results derived from empirical data. The conclusion with the final comments and future extension has been given in last part.

7. Theoretical Framework of DEA

The concepts of efficiency used in this study means the technical efficiency. A Decision-Making Unit (DMU) is considered technically efficient if it is an efficient producer of the product or service relative to others. The classical linear programming provides rationale for Data Envelopment Analysis (DEA) technique. DEA sometimes known as frontier analysis is non-parametric mathematical procedure used to calculate the relative efficiency and productivity of managerial decision making units which possess several inputs and outputs. The DEA has been pioneered by Charnes *et al.* (1978). The DEA model given by Charnes was known as CCR model. The CCR model was initially applied only on those technologies distinguished by constant return to scale. Some extensions were made in CCR model by Banker *et al.* (1984) to address the technologies categorized by variable return to scale. Until now, the significant developments in DEA were acknowledged by. At the present time, the usage of DEA methodology to compute the relative efficiency of homogenous decision making units of profit and non-profit organization, for example universities, schools, police stations, public and private libraries, agricultural farms, hospitals, insurance companies, commercial banks, national parks have become very common. The following table gives us information about record of the references published on the use of DEA methodology from 1978 through 2016. This information table supported the growth of DEA as an acknowledged effective tool in a various set of fields.

Table-4. List of the most popular keywords by number or Publication

Keywords	Number of Publications	Keywords	Number of Publication
Bank or Banking	4730	Non-Parametric	3540
DEA Or Data Envelopment Analysis	17600	Mathematical Programming	13200
Decision Making Units	29600	Health Care or Hospital	69
Decision Theory	36800	Non-Parametric Statistics	2620
Economics of DEA	16300	Education	9520
Efficiency	651000	Optimization	4700
Linear Programming	17900	Multivariate Analysis	1680
Management	16,100	Regression Analysis	5530
Mathematical Models	19100	Production	753
Operational Research	18900	Benchmarking	1960
Performance (Management or Evaluation)	9090	Resource Utilization	2700
Productivity	48200	Parametric	80
Technical Efficiency	22,000	Statistical Analysis	58

Source: authors search by using google scholar search engine

8. Mathematical Frame Work of DEA

DEA model in mathematical form can be written as following:

If all decision-making units are expressed by N, every DMU has m inputs and n outputs. The technical efficiency score of every DMU can be measured by solving the following model proposed by Charnes *et al.* (1978)

$$\text{for each } DMU_P \qquad P = 1,2,3.....$$

$$\text{maximize} \qquad E_P = \frac{\sum_{j=i}^{n} u_j y_{jp}}{\sum_{k=1}^{m} v_k x_{kp}}$$

$$\text{subject to} \qquad \frac{\sum_{j=1}^{n} u_j y_{j_i}}{\sum_{k=1}^{m} v_k x_{k_i}} \pounds 1 \qquad " \ i$$

$$u_j, v_k \ ^3 0 \qquad " \ k, j \qquad (1)$$

Where

K = 1, 2, 3……. *n*

J = 1, 2, 3……...*m*

I = I, 2, 3……...*N*

y_{ji} = the amount of output j produced by *i*th unit,

x_{ki} = the amount of inputs k utilized by *i*th unit,

u_j = weights given to output *j*

v_k = weights given to inputs

The problem set shown in can be transformed into linear programming as following;
Decision variables

u_j *weight of output j* (*unitless*)

v_k *weight of inputs k* (*unitless*)

The weights are unidentified as priory. The unknown weights of outputs u_j and weights of inputs v_k are calculated via DEA software, by using the data set of variables, as a method of measuring the relative efficiency of each DMU. These unknown weights are estimated individually for each unit of organization so that the level of highest efficiency score can be attained. Furthermore, these inputs and outputs weights should be categorically positive so that the chance that some inputs or outputs might be omitted in the process of measuring the efficiency of each DMU can be avoided.

$$\begin{aligned} \max \quad & \sum_{j=1}^{n} u_j y_{jp} \\ s.t \quad & \sum_{k=1}^{m} v_k x_{kp} = 1 \\ & \sum_{j=1}^{n} u_j y_{ji} - \sum_{k=1}^{m} v_k x_{ki} \le 1 \qquad \forall i \\ & u_i, v_k \ge 0 \quad \forall \quad k, j. \end{aligned} \tag{2}$$

9. Constant Return to Scale and Variable Return to Scale

The productivity change can be measured under constant return to scale and variable return to scale. The constant return to scale approach was pioneered by Charnes *et al.* (1978). While the variable returns to scale approach was introduced by Banker *et al.* (1984). By constant return to scale it means that one unit change in inputs will cause one unit change in output produced while variable return to scale means that each additional unit of input will increase the output more than one unit.

To measure the relative efficiency of wildlife and public and private tertiary care hospitals and medical colleges, DEA has been used in this study. The tertiary care hospitals in urban areas and wildlife parks are considered one of the very important tool of curative health and to generate economic gains for many people around the area of hospital by producing so many activities. Consequently, a competent, adequate, well organized and efficient hospital allows metropolitans to offer healthy human capital and also grows as catalysts for economic, social and ecological development.

10. Data and Variable Selection

No computerized and centralized data of medical colleges was available publicly. The data of 35 medical colleges and 54 attached teaching hospitals in both public and private sector for the year 2015 has been collected through survey by the Punjab Economic Research Institute (PERI) team. The variables selected are different from other health sector DMUs (hospitals, BHUs, RHCs) due to change in responsibilities of each. Only those inputs and outputs variable are selected for analysis, which reflect the informative, comprehensive and general results.

For medical colleges, we have considered three outputs such as Total Revenue from student fee, Total Number of Enrolled Undergraduates Student (Salleh *et al.*, 2016) in each medical colleges of Punjab, Total Number of Enrolment of Postgraduate Trainees (Ruggiero, 2016) Quantity Of Undergraduate Degrees [1] (Johns, 2006). Total number of Medical Teaching Staff (Deng, 2016) is incorporated here as an input variable. Furthermore, medical/lab equipment, fine buildings and essential utilities are all fundamental elements of medical colleges/universities infrastructure that support students, trainees and teaching faculty to perform their work efficiently, accordingly, Total Number Building Infrastructure Facilities [2] is also included as an indicator of input, Total available Training Beds, Total Employment Related Expenses are also indicators of inputs.

11. Variable and Its Description

In medical teaching institutes, many inputs have been used by the management to yield a particular health care outputs through a production process. The eventual goal/output of establishing medical institute in a society is to produce competent professionals in healthcare system to bring the quality change in health status but this indicator is intangible and very hard to measure. Consequently, some intermediary outputs as given in Table 5 customarily become the primary indicators to measure the output. This production process does not occur in a vacuum; besides many internal factors, it is also being influenced by a number of economic, political, social and environmental factors. Both factors are important and equally influence the efficiency of production units. Due to data constraints on external variables, only those indicators are selected for analysis which is considered to be well-regulated by the hospital managers.

The figure illustrates the connection between medical college system inputs, the production process, and the outputs.

[1] All the students cleared the degree exam are considered eligible for MBBS degree Only undergraduate's degrees are included for analysis because in many private sector colleges, there is no facility of post-graduation

[2] building infrastructure includes all basic and essential clinical departments, faculty area, tutorial rooms and labs or museum as per PMDC approved criteria. The facilities are counted in numbers only.

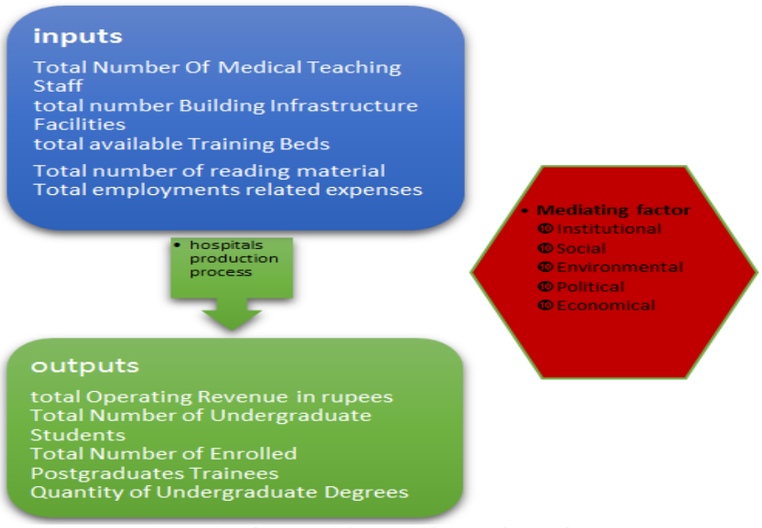

Figure-2. internal and external factors influence the production process
Source: Author's selection by using available literature

12. Descriptive Analysis of Inputs and Output Variables of Medical Colleges/Universities

The wide variation can be observed across medical colleges in private and public sector.by means of the descriptive statistics (mean, slandered deviation, minimum and maximum) (Table 6). The total number of undergraduate students vary between 46 to 1713. The annual fees from undergraduate students are the major source of revenue in medical colleges which vary from Rs. 1.6 billion to 5.17 billion/year. Similarly, the employment related expenses vary from minimum 2.711 billion to maximum 11.2 billion/year

Table-6. Descriptive Statistics of the Inputs and Outputs of Medical Colleges in Punjab (N = 35)

Variables	N	Mean	Std. Dev.	Min	Max
Total operational revenue	35	197709778.9	176420781.9	16608390	517484000
Total numbers of undergraduate student	35	726.6857	503.1613	46	1713
Total number of enrolled PG trainees	35	104.257	139.0360	0	447
Quantity of undergraduate degrees awarded	35	125.800	123.6275	0	463
Total number of medical teaching staff	35	206.114	126.0672	38	653
Total number of building infrastructural facilities	35	5.314	1.58618	5	6
Total number of training beds	35	752.886	675.9040	25	3216
Total number reading material in libraries	35	22334.257	26014.7935	1780	94936
Total employment related expenses	35	271182058	112411691.2	123200100	698873640

Source: author's calculation

The output oriented DEA technique has helped us to measure the relative efficiency of 35 private and public sector medical colleges. For given a fixed quantity of inputs, when Decision Making Units (DMUs) are expected to produce output as much as possible, the output oriented model in suitable to apply. The results have been obtained by using DEAP 2.1 software.

13. The Efficiency and Productivity Estimates of Medical Colleges

Both the VRS (Variable Return to Scale) and CRS (Constant Return to Scale) has been executed for calculation, because practically, all Decision-Making Units DMus) are not functioning at an optimal scale**.** Figure 4 provides the relative efficiency estimates 35 public and private medical colleges in Punjab. DEA results have been divided into 3 categories to show the efficiency of medical colleges. these categories are CRS, VRS and Scale Efficiency (SE). The efficiency aggregates in Table 6 shows that 71% hospitals are technically efficient under CRS and 82% under VRS. The average VRS efficiency score illustrating that inefficient medical colleges are 10% less utilized their current resources. The average scale efficiency is 96% indicating that the existing medical colleges have the capacity of only 4% to alternate their scale without interrupting their output level. The maximum efficiency score is 100 or 1 whereas, the minimum efficiency score is 0.305. Seven (20%) medical colleges are functioning under DRS indicating that their medical education and relating health care services outputs is expected to increase by a lower proportion for any increase in inputs. These medical units are not required to increase their size to achieve optimal level of output or at CRS level. Four DMUs are functioning under IRS and 17 are operating under constant return to scale implying that these DMUs are operation at their optimal level and that increase in inputs will give an equal proportion of output**.**

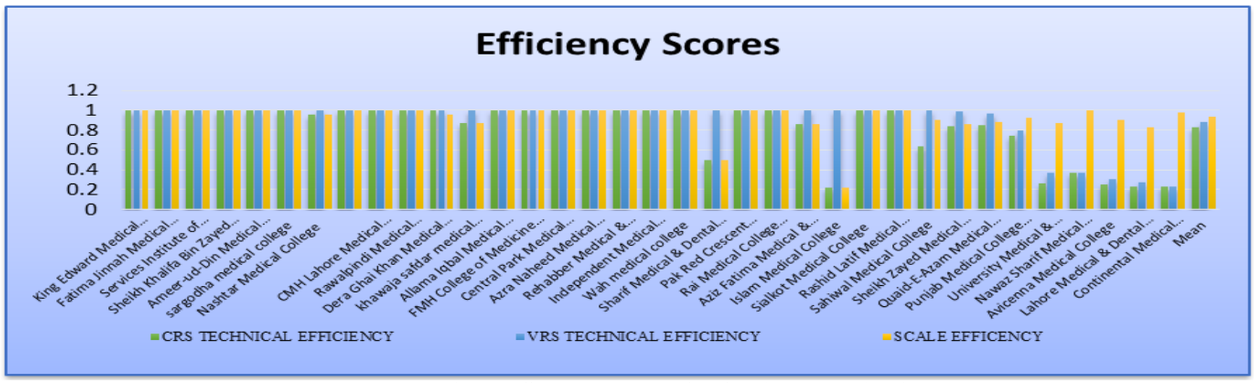

Figure-3. Technical Efficiency Estimates of Medical Colleges in Punjab

Source: Authors estimations by using DEAP software

Scale inefficiency does not appear to be a common problem in medical colleges of Punjab, 71% medical colleges are found technically scale efficient. The mean of e scale efficiency score is 93% which illustrates that on average, the scale inefficient medical colleges can supposedly shrink or increase their size by 7% without upsetting their current productivity level.

Table-7. Ranking of Medical Colleges on the Base of VRS Technical Efficiency Scores

Medical college name	RANKING	RETURN TO SCALE	Medical college name	RANKING	RETURN TO SCALE
King Edward Medical University Lahore	1	CRS	Wah medical college	1	CRS
Fatima Jinnah Medical University Lahore	1	CRS	Sharif Medical & Dental College, Lahore.	1	IRS
Services Institute of Medical Sciences	1	CRS	Pak Red Crescent Medical and Dental College	1	CRS
Sheikh Khalifa Bin Zayed Al-Nahyan Medical and Dental College , Lahore	1	CRS	Rai Medical College Sargodha	1	CRS
Ameer-ud-Din Medical College	1	CRS	Aziz Fatima Medical & dental College Fsd	1	IRS
sargodha medical college	1	CRS	Islam Medical College	1	DRS
Nashtar Medical College	1	DRS	Sialkot Medical College	1	CRS
Gujranwala Medical College	1	-	Rashid Latif Medical College	1	CRS
CMH Lahore Medical College and Institute of Dentistry	1	-	Sahiwal Medical College	1	DRS
Rawalpindi Medical College	1	DRS	Sheikh Zayed Medical College R.Y.k	2	DRS
Dera Ghai Khan Medical College	1	IRS	Quaid-E-Azam Medical College	3	DRS
khawaja safdar medical college, sialkot	1	DRS	Punjab Medical College Faisalabad(Allied)	4	-
Allama Iqbal Medical College.	1	CRS	University Medical & Dental College Faisalabad	5	DRS
FMH College of Medicine & Dentistry	1	CRS	Nawaz Sharif Medical College University Of Gujrat	6	DRS
Central Park Medical College	1	CRS	Avicenna Medical College	7	DRS
Azra Naheed Medical College	1	CRS	Lahore Medical & Dental College	8	DRS
Rehabber Medical & Dental College, Lahore	1	CRS	Continental Medical College Lahore	9	IRS
Independent Medical College Faisalabad	1	CRS			

Source: Author's calculations

The total number of efficient medical colleges in Punjab are 20 under CRS and 26 under VRS. The 20 colleges are found scale efficient. The maximum efficiency score is 100% while the minimum efficiency score under CRS is 0.232 obtained by the continental medical college in private sector.

Table-8. Summary of Efficiency Aggregates

EFFICIENCY AGGREGATES	UNDER CRS	UNDER VRS	SCALE EFFICIENCY
Number of efficient medical colleges	20	27	20
Number of inefficient medical colleges	15	8	15
Maximum efficiency (percentage)	1.00	1.00	1.00
Minimum efficiency(percentage)	0.227	0.232	0.233

Source: author's calculations

14. Pearson Correlation of Inputs Indicators and Efficiency Scores

The Pearson Correlation has been computed between input indicators mentioned in Table 4 and VRS efficiency scores. These indicators are not expected to be the defining factors of efficiency scores. These indicators must not be highly correlated to the efficiency scores, because they only partially measure the relation between some inputs and outputs. All the indicators are found insignificantly correlated to efficiency scores (Table 7) except employment related expenses. The employment related expenses however are negatively and significantly correlated with the VRS efficiency scores. The higher the employment related expenses of DMU would resulting a lower efficiency score.

15. Econometric Analysis of the Efficiency Scores and Its Determinants

The relative efficiency scores of medical colleges calculated in the previous section was regressed by using Tobit Regression in this section against both discretionary and non- discretionary factors indicated in Figure 2. There are number of regression techniques which can be usefully applied at this second stage to identify the most influencing factors of inefficiency such as the maximum likelihood (ML) based Probit, Logit, the Ordinary Least Square Method(OLS) and Censored & Truncated Regression (Tobit). In this analysis, we employ the Tobit model or censored normal regression model because of the condition that all values of DEA efficiency scores are clustered around 0 to 1. For computational convenience, the Tobit model is assumed to be left censored to zero. For Tobit regression analysis, the first step is to transform the VRS DEA efficiency scores into inefficiency scores. For transformation, the formula given below is used. (See equation 1)

$$\text{Inefficiency score} = \frac{1}{VRSefficiencyscore} - 1 \quad \ldots\ldots\ldots\ldots (1)$$

To investigate the relationship between inefficiency of medical colleges and its determining factors, the standard Tobit model can be defined as follows:

$$\begin{aligned} y^* &= \beta x_i + \varepsilon_i \\ y_i &= y_i^* \text{ if } y^* > 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2) \\ y_i &= 0 otherwise \end{aligned}$$

where $\varepsilon_i \sim N(0, \sigma^2)$, β represent the coefficient parameter for all explanatory variable X*i*. After the transformation of DEA scores, the coefficient of the Tobit model can be interpreted as if it is a coefficient of an ordinary least squares regression that represent the proportionate change
in response variable, due to a one unit change in explanatory variable while keeping constant.
To significantly explain the determinants of inefficiencies, we have selected some potential variables. By using an iterative process, the models consist of several endogenous and exogenous variables have been run but the finally selected model to explain the empirical results is based on chi square and is given below:

$$Ineffmc = \alpha + \beta_1 Tenrolled + \beta_2 UG\deg + \beta_3 TR + \beta_4 \exp + \beta_5 Tstaff + \beta_6 own$$

Total undergraduate enrolled students in the institution and undergraduate degrees issued by the institution are the important output of any medical institution. Accordingly, both variables are incorporated here. Student's fees are the major operating revenue of medical college/university. The indicators of total expenditures in term of teaching staff salaries and total number of staff is also incorporated in model. The dummy variable of medical college/university ownership status has also been included in the model to reflect the effect on the inefficiencies

16. Results of Tobit Regression

It is observed that the coefficients of all variables are not jointly equal to zero(prob>chi2), so we are in the position to reject the null hypothesis that the regression coefficients of all independent variables are jointly equal to zero, consequently the model as a whole is fit significantly. The coefficient of total number of enrolled undergraduate students reflect negative sign but the coefficient is statistically insignificant at the selected level. Total number of UG enrolled students in the institution are negatively linked to the inefficiencies and is statistically significant to determine the inefficiency. One unit increase in number of UG students is likely to decrease the inefficiency score by .00205%. Total revenue from student fee(TR) is also found statistically significant which means that this indicator has negatively influencing feature on the inefficiency of medical colleges during the period of analysis. Employment related expenses variable is also found statistically significant and is positively linked to determine the inefficiency of unit. Total teaching staff, available training beds and ownership status are not significant indicators to explain the inefficiency of medical colleges. We can conclude that the management and ownership of medical colleges are likely to be more efficient if focus on the significant indicators influencing the inefficiency of medical colleges.

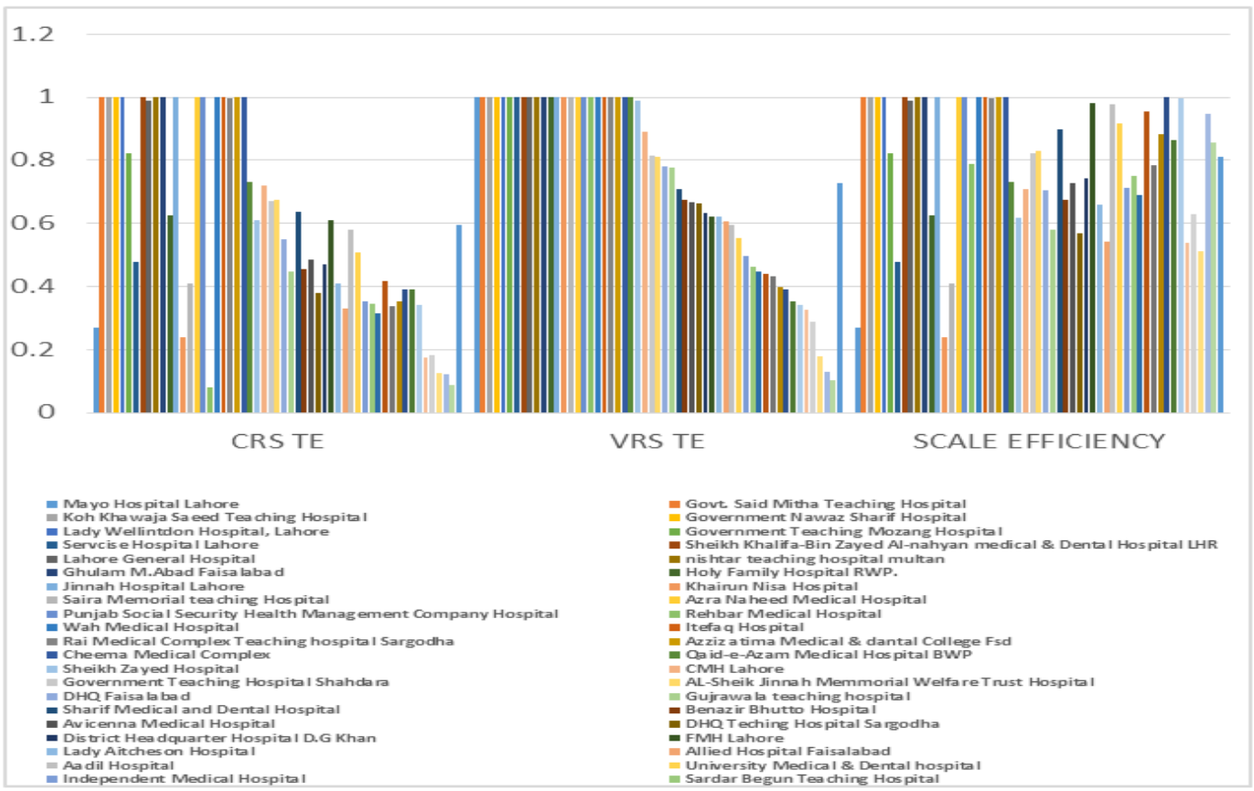

Figure-4. Efficiency Scores of Teaching Hospitals

Source: Author's calculations

Table-10. Results of Tobit model

Variables	coefficient	t	*P>|t|*
Total Number of Undergraduate enrolled (T enrolled)	-.002327	-1.43	0.164
Quantity of Undergraduate Degrees (UG deg)	-.002055	3.75	0.001
Total Revenue from students' fee(TR)	-.0000075	-2.62	0.014
Total teaching staff (T staff)	.0016315	0.47	0.645
total available Training Beds (TB)	-.0001604	0.17	0.863
Total employments related expenses	.000000586	1.90	0.069
Ownership	1.5591	-0.47	0.644

Source: author's calculations
Number of observations = 35 LR chi2(7) = 20.66 Prob > chi2 = 0.0043
Log likelihood =214383 Pseudo R2 = 0.3252

17. Data and Variable Selection for Teaching Hospitals in Punjab

The most important output of any hospital is the number of inpatient and outpatient (Mogha, 2012) so both variables are incorporated here for analysis as outputs. Different types of diagnostic test are one of the important source of revenue of teaching hospitals whether they are operated in public or private sector, so used in this study as outputs but are segregated as low, medium and high, on the base of cost per test. Total number of serving staff (Mujasi, 2016) and total beds allocated (Mujasi, 2016) in each hospital are used as inputs

18. Descriptive Analysis of Inputs and Output Variables of Attached Teaching Hospitals

Descriptive statistics showed a wide variation across teaching hospitals. The total inpatients vary between 408 to 7080000. The diagnostic laboratory tests are the major source of revenue in teaching hospitals. Revenue from low cost diagnostic test vary from 40210 to 70200000. In some teaching hospital, there is no facility of medium and high cost diagnostic test, so minimum values are zero. Similarly, the total allocated beds vary from minimum 25 to maximum 2330.

Table-12. Descriptive Statistics of The Inputs and Outputs of Teaching Hospitals (N = 54)

Variables	N	Mean	Std. Dev.	Min	Max
Total inpatients revenue	54	106701	171446.1	408	7080000
Total outpatients'	54	217088.03	176323.5	3510	734483
Total low diagnostic test	54	15700000	.000952	40210	70200000
Total Medium diagnostic test	54	3630000	.000676	0	31400000
Total high diagnostic test	54	2320000	.000425	0	20400000
Total serving staff	54	433.8333	576.5917	28	3759
Total allocated beds	54	518.5741	475.3034	25	2330

Source: Author's calculations by using STATA 13.0

19. The Efficiency and Productivity Estimates of Teaching Hospitals by Using Output Oriented DEA

The relative efficiency estimates of 54 public and private teaching hospitals in Punjab under CRS, VRS and Scale Efficiency (SE) are showed in figure 9. The average efficiency under CRS is about 60% which indicates that inefficient teaching hospitals are 40% less utilizing their resources than the optimal level. The resource utilization of teaching hospitals under VRS assumption is 73% indicating that the inefficient teaching hospitals have 27% more capacity to better make better utilization of their resources.

20. Policy Recommendation

- To make the analysis more definitive, the qualitative and quantitative data on all relevant inputs and output of all private and public sector medical colleges/ teaching hospitals should be frequently composed. Health sector, PM&DC and UHS can initiate if the data of all type of indicators of medical education/hospitals is available then it can be organized as a part data-collection platforms such as district health information reports and demographic health surveys etc. Furthermore, in order to attract the donor agencies such as the USAID, World Bank, UNICEF for strong funds/aids flowing into the health sector, all types of management weaknesses and resources waste is necessary to be eliminated or significantly reduced. Technical inefficiency is an example of such weaknesses.
- For efficient utilization of resources, the system performance assessment should be a priority area of policy makers.
- For efficient service delivery of medical education and tertiary health care, basic missing staff vacancies must be fulfilled. Staff training to improve the quality of service is also necessary. The government can take initiative to establish a training institute for medical teaching doctors/service providers for capacity building in both private and public sector and to meet the international standers.
- Total number of students enrolled every year and undergraduate degrees issued by the institution are needed to be revised. The inefficiency of medical institutions is likely to be improved by increasing the number of seats.
- majority of the medical teaching institutes/ teaching hospital in both private and public sector are located in Lahore and these are operating at their full capacity level. The government should take initiatives to establish the new tertiary health care institution in other cities also.
- Continuous monitoring and evaluation of the institutions are necessary as in most of the institutions, the serving staff does not meet the PM&DC criteria. The check list of PM&DC is also needed to revised according to efficiency estimates.
- Missing specialties in inefficient teaching hospitals are needed to be established to facilitate the inpatients and outpatients.
- There is a great burden of inpatients and outpatients in teaching hospitals at Lahore. The current data shows that the patients are treated beyond the capacity of the Hospitals and Doctors. Government is required to make policies to establish similar facilities in teaching hospitals of other districts as well so as to lower the burden and to provide access to speedy health facilities. The private teaching hospitals may have encouraged in this perspective by enhancing their facilities and infrastructure. The government can provide subsidies to private sector hospitals to improve their services and to provide services at minimum cost.

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