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EFFICIENCY IN HEALTH CARE DELIVERY: A DEA ANALYSIS OF HOSPITALS AT THE SECONDARY HEALTH CARE LEVEL IN PLATEAU STATE, NIGERIA

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ABSTRACT

Data Envelopment Analysis (DEA) has evolved into one of the most efficient tools for analysis of resource utilization in most systems. The operations of hospitals at the secondary health care level was analysed using DEA. Data on hospital operations were collected and analyzed using DEA EXCEL Solver add-in Zhu (2003). Benchmark and target analyses were also carried out. The results show a generally poor performance for the hospitals at this level. The target analyses show that most hospitals would have done better without a Medical Doctor. The study therefore recommends among others, a DEA analysis involving value judgment for this and similar cases.

Key words*:* Envelopment, Benchmark, Efficiency, Performance

INTRODUCTION

Background of Health Care Services in Plateau State

Plateau State is located in North Central region of Nigeria. It has a population of about 2.8million, about 49.9% of which are males while 50.1% are females. The state is reasonably covered with health facilities as a result of the active participation of government, individuals and voluntary agencies in the health sector. In all, the Plateau State Government has fifteen Hospitals, forty-eight Maternal and Child Welfare Clinics, fifty-nine General Clinics and 285 Dispensaries. Individuals have forty-seven Hospitals, six Maternal Clinics, sixty-two Child Welfare Clinics, 310 General Clinics and 119 Dispensaries. Voluntary agencies own and operate five Hospitals, three Maternal Clinics, sixty-two General Clinics and forty-five Dispensaries (PLSG, 2004).

Although the number and variety of health facilities in Plateau State are impressive, it appears that there is still a need for improvement in health care delivery as can be seen from the UNFPA report below:

The maternal mortality ratio in the state is estimated at 1000 deaths per 100,000 live births which is above the national average of 704 deaths per 100,000 live births, while infant mortality rate is 85 deaths per 1000 live births as against the national average of 75 deaths per 1000 live births. The area has a contraceptive prevalence rate of 1.2% which is below the national rate of 9%; this partly explains the high HIV prevalence rate of 8.5% as against national average of 5.4% (UNFPA, 2005)

STATEMENT OF THE PROBLEM

From the background above, it can be seen that effective health care delivery in the state is still far from reality, despite the available facilities provided by the various stakeholders.

Since substantial amounts of resources have been committed into Health care provision (as evidenced by the number of Institutions / facilities listed above), it is obviously a serious matter of concern that this does not seem to achieve the goals for which they were intended. The question of efficiency rightly comes to mind here.
Determining whether these facilities are efficient or not would have been quite easy, except that the output of services as provided by the health systems are not quantifiable in units consistent with the units of the resources committed into the process. This compounds the problem of determining these efficiencies. This study therefore determines whether or not these hospitals are efficient in the conversion of the resources invested in them.

OBJECTIVES OF THE STUDY

This study therefore determines:

1. DEA Efficiency scores for all the eighteen (18) Hospitals operating at the Secondary level of Health Care in the state.
2. Determine Benchmarks for any Inefficient Hospitals.
3. Determine the conditions necessary for any Inefficient hospital to become Efficient.

Measuring Hospital Technical Efficiency with DEA

In DEA analyses, the units whose efficiency is being measured are referred to as Decision Making Units (DMUs). Suppose we have *J* homogeneous hospitals *(j =* 1,…, J) to be evaluated, each utilizing varying quantities, x_{ij}, of *I* different inputs *(i = 1, …,*I) to produce varying quantities, y_{kj}, of *K* different outputs *(k = 1, … ,K*). Defining u_{kj} and v_{ij} as the weights attached to the k^{th} output and to the i^{th} input respectively, the Technical Efficiency e_j of hospital *j* can be written as:

$$e_j\left(y_j, x_j, u_j, v_j\right) = \frac{u_{1j}y_{1j} + u_{2j}y_{2j} + \ldots + u_{kj}y_{kj} + \ldots + u_{Kj}y_{Kj}}{v_{1j}x_{1j} + v_{2j}x_{2j} + \ldots + v_{ij}y_{ij} + \ldots + v_{Ij}x_{Ij}} = \frac{\sum_{k=1}^{K} u_{kj}y_{kj}}{\sum_{i=1}^{I} v_{ij}x_{ij}} \quad \ldots\ldots(1)$$

Since the model can provide only relative efficiency scores, the hospital *j's* efficiency ratio e_j is defined as a percentage of the highest level of absolute technical efficiency attainable, where all the hospitals are assigned the weights chosen by hospital *j* in order to maximize its absolute efficiency. This is equivalent to attaching to outputs and inputs of hospital *j* those weights that cast its activity in the best light.

The relative efficiency of hospital *j* is calculated by solving the following mathematical linear programming problem:

$$\underset{u_j, v_j}{Max}\; e_j\left(y_j, x_j, u_j, v_j\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$Subject\ to: \frac{\sum_{k=1}^{K} u_{kj}y_{kl}}{\sum_{i=1}^{I} v_{ij}x_{il}} \le 1, \quad i = 1, \ldots, J \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

$$u_{kj}, v_{ij} \ge 0, \quad k = 1, \ldots, K; i = 1, \ldots, I \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Equation (3) sets an upper limit equal to 1 for the efficiency indicators of all the hospitals calculated with the weights of hospital *j.* Equation (4) imposes the non-negativity of weights. Problem (2) can be solved in either of two ways: by minimizing the quantities of inputs to obtain preset output levels *(input-oriented model*), or by maximizing the quantities of outputs produced by given levels of inputs *(output-oriented model*).
The maximization problem for hospital j is solved by finding the vectors of weights u_j and v_j that maximizes the efficiency score e_j. These are the best possible weights for the hospital as any other weight vector would lead to a lower efficiency indicator. If a combination of weights for which $e_j = 1$ can be found, then hospital j is efficient. On the other hand, if a value of $e_j < 1$ were found, then hospital j is inefficient. In the latter case, we can say that there are no weights u_j and v_j that could put hospital j at the top of the efficiency league of the hospitals examined.

This process is repeated to obtain the level of relative technical efficiency (efficiency score) and the "optimal" weights required to attain that level for each of the J hospitals. The optimal weights obviously differ from hospital to hospital. The DEA weights provide particularly important information about the implicit choices made by each hospital in order to appear as efficient as possible in relation to the others. Making the weight attachment process endogenous can thus lead to different input and output weights depending on which hospital is considered. This is one of the strengths of DEA but, at the same time, it is also one of its weaknesses. It is a strength because if a given hospital is found to be inefficient even when the most favourable weights are applied for measuring its efficiency, then there are reasonable grounds to classify it as inefficient. In fact, despite the best weights being selected to maximize its efficiency, a score $e_j < 1$ indicates that a more efficient linear combination of other hospitals exists. It is a weakness because each hospital can obtain a high level of efficiency by choosing the most suitable weights. Hence the efficiency scores calculated for the various DMUs are not properly comparable as they derive from different weighting processes. In this way, however, outliers that focus on just one output (input) while neglecting the rest may appear to be fully efficient (O'Neill, 1998) that is, the *Maverick* DMU.

METHODOLOGY

Type and Source of Data

The data used for this study were secondary data. These are records of transactions of the various hospitals covered by this study. These include:

- Total number of admissions in each hospital in the year.
- Total number of discharges in each hospital in the year.
- Average number of Physicians in each hospital in the year.
- Average number of Nurses and Midwives in each hospital in the year.
- Annual Budgetary Allocation to each hospital in the year.
- Number of beds in each hospital.
- Number of emergency / casualty cases handled by each hospital in the year.

These data were collected from the records of each of the fourteen hospitals operating under the HMB and the four voluntary agency owned hospitals. See Appendix I

Method of Data Analysis

The Microsoft EXCEL add-in developed by Joe Zhu (2003) was used to analyse the data. The results obtained are as follows:

Table 1. **Input Oriented CRS DEA analysis result**

Input-Oriented CRS			**Sum of lambdas**	**RTS**	**Benchmarks**	
DMU No.						
1	DMU O1	1.00000	1.000	Constant	DMU 01	
2	DMU 02	0.59832	0.546	Increasing	DMU 01	DMU 04
3	DMU 03	0.95440	0.589	Increasing	DMU 01	DMU 04
4	DMU 04	1.00000	1.000	Constant	DMU 04	
5	DMU 05	0.83489	0.612	Increasing	DMU 01	DMU 11
6	DMU 06	0.25701	0.092	Increasing	DMU 01	DMU 04
7	DMU 07	0.74122	0.252	Increasing	DMU 04	DMU 11
8	DMU 08	0.29311	0.099	Increasing	DMU 01	DMU 04
9	DMU 09	0.61872	0.531	Increasing	DMU 01	DMU 11
10	DMU 10	1.00000	1.000	Constant	DMU 10	
11	DMU 11	1.00000	1.000	Constant	DMU 11	
12	DMU 12	0.54990	0.158	Increasing	DMU 04	DMU 11
13	DMU 13	0.50662	0.223	Increasing	DMU 01	DMU 11
14	DMU 14	0.53839	0.190	Increasing	DMU 01	DMU 04
15	DMU 15	1.00000	1.000	Constant	DMU 15	
16	DMU 16	1.00000	1.000	Constant	DMU 16	
17	DMU 17	0.46504	0.520	Increasing	DMU 01	DMU 11
18	DMU 18	0.34456	0.481	Increasing	DMU 01	DMU 11

From the result above six (6) DMUs (Hospitals) are DEA efficient, while the remaining twelve (12) DMUs are inefficient. For each of the inefficient DMU, a benchmark DMU is found for it as can be observed from columns 7 and 8. For the efficient DMUs, they are the benchmark DMU for themselves.

Another very important result obtained from this analysis is contained on the table below. The target for each inefficient DMU is indicated. i.e. the amount of improvement necessary for any such DMU to achieve efficiency.

Table 2. Input Oriented CRS Model Target

DMU No.	DMU Name	Efficient Input Target Doctors	Nurses	Beds
1	DMU O1	2.00000	27.00000	91.00000
2	DMU 02	1.79495	14.95789	64.61806
3	DMU 03	1.90880	16.22481	62.03604
4	DMU 04	3.00000	20.00000	121.00000
5	DMU 05	1.66978	20.70680	54.26789
6	DMU 06	0.25701	2.57012	10.27018
7	DMU 07	0.79414	5.92979	25.20161
8	DMU 08	0.29311	2.93108	11.39402
9	DMU 09	1.23744	12.08814	18.56157
10	DMU 10	3.00000	16.00000	26.00000
11	DMU 11	2.00000	17.00000	16.00000
12	DMU 12	0.56058	4.39924	16.49713
13	DMU 13	0.50662	6.00185	15.70527
14	DMU 14	0.53839	5.92228	16.15168
15	DMU 15	6.00000	55.00000	125.00000
16	DMU 16	8.00000	102.00000	212.00000
17	DMU 17	1.39512	18.47921	54.48685
18	DMU 18	1.03367	12.90725	37.90138

From the above table, it can be seen that six DMUs (6, 7, 8, 12, 13, 14) could have achieved efficiency with less than one Medical Doctor. i.e. the target number of Doctors for such DMUs is less than one, implying that they could achieve efficiency without a Medical Doctor. This however is not achievable if these DMUs must remain at the Secondary level of Health care as having a Medical Doctor is a necessary condition for any Hospital operating at that level of Health Care delivery.

CONCLUSION

From the results of the analysis shown on Table 1 above, most of the Hospitals are inefficient. Implying that the Health Care machinery at this level is generally below expectation. This appears to agree with the situation in the state as conveyed in UNFPA (2005) above. However, looking at Table 2, One can see that part of the cause of this inefficiency (particularly in the six Hospitals identified) is as a result of having one or more Medical Doctors and not as a result of any failures in those hospitals. The hospitals would have been efficient if they had operated without a Medical Doctor. But a medical Doctor is a necessary condition for them to operate at this level of health care. Therefore most of these hospitals are inefficient, not because they are not doing well enough but simply because they have to operate at the secondary level of health care delivery. Therefore the reason for the poor Health in the state report above is not attributable to this level of health care.

RECOMMENDATION

Following the findings of this study, and the subsequent conclusion, this study believes that the following measures would enhance Health Services delivery in Plateau State.

1. Carry out a DEA analysis (taking into account, management preferences regarding what constitutes best practice) of the hospitals operating at the secondary level of health care to confirm the fact that the health care machinery at this level is not generally inefficient.
2. Evaluate other levels of health care delivery to ascertain their level of efficiency in the health care delivery process.
3. To monitor the operation of individuals and small groups in the delivery of health care in the state.
4. A DEA Windows Analysis should be carried out to establish the consistency of the results.

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APPENDIX I SHOWING THE RAW DATA COLLECTED

Hospitals*		**Discharges**	**Admission**	**Casualty**	**Doctors**	**Nurses**	**Beds**
1	DMU01	2567	3202	18115	2.00	27.00	91.00
2	DMU02	1859	2380	9577	3.00	25.00	108.00
3	DMU03	2004	2519	9915	2.00	17.00	65.00
4	DMU04	2531	3203	18588	3.00	20.00	121.00
5	DMU05	2281	2827	10012	2.00	28.00	65.00
6	DMU06	298	342	1654	1.00	10.00	42.00
7	DMU07	72	947	3920	2.00	8.00	34.00
8	DMU08	351	365	1759	1.00	10.00	44.00
9	DMU09	1146	1233	7659	2.00	30.00	30.00
10	DMU10	538	641	14149	3.00	16.00	26.00
11	DMU11	1259	1532	14149	2.00	17.00	16.00
12	DMU12	629	640	2133	2.00	8.00	30.00
13	DMU13	596	683	3669	1.00	24.00	31.00
14	DMU14	675	752	3054	1.00	11.00	30.00
15	DMU15	9500	10800	400	6.00	55.00	125.00
16	DMU16	15042	18005	11020	8.00	102.00	212.00
17	DMU17	2031	2541	9002	3.00	42.00	132.00
18	DMU18	1256	1342	8243	3.00	51.00	110.00

Source: Survey, 2008.

APPENDIX II (Confidential)
KEY TO THE DMUs

S/N	DMU	HOSPITAL
01	DMU01	General Hospital B/Ladi
02	DMU02	General Hospital Pankshin
03	DMU03	General Hospital Langtang
04	DMU04	General Hospital Shendam
05	DMU05	General Hospital Mangu
06	DMU06	General Hospital Angware
07	DMU07	Cottage Hospital Dengi
08	DMU08	Cottage Hospital Tunkus
09	DMU09	Cottage Hospital Bassa
10	DMU10	Cottage Hospital D_Kowa
11	DMU11	Cottage Hospital Bokkos
12	DMU12	Cottage Hospital Wase
13	DMU13	Cottage Hospital Kwala
14	DMU14	Cottage Hospital Dyerok
15	DMU15	OLA Hospital
16	DMU16	ECWA Evangel Hospital
17	DMU17	Vom Christian Hospital
18	DMU18	Mangu Hospital & Rehabilitation Centre