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Scaling up Maternal and Child Healthcare Delivery among Mission Hospitals in Southeast Nigeria: An Empirical Application of Data Envelopment Analysis for Setting Benchmarks and Targets

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Henry E. Aloh[1, 2], Obinna E. Onwujekwe[2], Hyacinth E. Ichoku[3] and Augustine C. Osigwe[4]*

Health Economics and Policy Research Unit, Department of Health Services, Alex Ekwueme Federal University Ndufu-Alike Ikwo, Ebonyi State, Nigeria[1]; Department of Health Administration & Management, Faculty of Health Sciences, College of Medicine, University of Nigeria, Enugu Campus, Nigeria[2]; Department of Economics, University of Nigeria, Nsukka, Nigeria[3]**;** Department of Economics and Development Studies, Alex Ekwueme Federal University, Ndufu-Alike, Ikwo, Nigeria[4]

***For Correspondence:** Email: *henryealoh@gmail.com*; Phone: +234 803 309 7760

Abstract

The health system in many parts of Nigeria has been dysfunctional in several domains including financing, human resources, infrastructure, health management information system and hospital services. In an attempt to scale up Maternal and Child Health (MCH) services and ensure efficiency, Ebonyi State Government in Southeast Nigeria provided funding to mission hospitals across the State as a grant. This study used nonparametric method to assess the effect of this public financing on the efficiency of the mission hospitals. Operational cost and number of hospital beds were used as the input variables, while antenatal registrations, number of immunization doses and hospital deliveries were the output variables. The hospitals were disaggregated into 15 hospital-years. The mean overall technical efficiency of the mission hospitals was 84.05±22.45%. The mean pure technical efficiency was 95.56±6.9% and the scale efficiency was 88.05±22.20%. About 46.67% of all the hospital-years were technically and scale efficient. Although, 55.33% were generally inefficient, only 33.33% of hospital-years exhibited pure technical inefficiency. Low immunization coverage was the major cause of inefficiency. Th**e** study showed increased maternal health service output as result of public funding or intervention; however, the mission hospitals could have saved 16% of input resources if they had performed efficiently. It also shows that data envelopment analysis can be used in setting targets/benchmarks for relatively inefficient health facilities, and in monitoring impact of interventions on efficiency of hospitals over-time. *(Afr J Reprod Health 2019; 23[3]: 57-67).*

Keywords: Mission hospitals, Data envelopment analysis, Efficiency, Setting targets, Southeast Nigeria

Résumé

Dans de nombreuses régions du Nigéria, le système de santé est dysfonctionnel dans plusieurs domaines, notamment le financement, les ressources humaines, les infrastructures, le système d'information sur la gestion de la santé et les services hospitaliers. Dans le but de renforcer les services de santé maternelle et infantile et d'assurer l'efficacité, le gouvernement de l'État d'Ebonyi, dans le sud-est du Nigéria, a octroyé une subvention aux hôpitaux des missions de l'État. Cette étude a utilisé une méthode non paramétrique pour évaluer l'effet de ce financement public sur l'efficacité des hôpitaux de mission. Le coût opérationnel et le nombre de lits d'hôpitaux ont été utilisés comme variables d'entrée, tandis que les variables de sortie étaient les enregistrements prénatals, le nombre de doses d'immunisation et les accouchements à l'hôpital. Les hôpitaux ont été ventilés en 15 années d'hospitalisation. L'efficacité technique moyenne globale des hôpitaux de mission était de 84,05 ± 22,45%. Le rendement technique pur moyen était de 95,56 ± 6,9% et le rendement d'échelle de 88,05 ± 22,20%. Environ 46,67% de toutes les années d'hospitalisation ont été efficients sur le plan technique et sur l'échelle. Bien que 55,33% aient été généralement inefficaces, seulement 33,33% des années d'hospitalisation ont montré une inefficacité technique pure. La faible couverture vaccinale était la principale cause d'inefficacité. L'étude a révélé une augmentation de la production de services de santé maternelle résultant d'un financement ou d'une intervention publique; toutefois, les hôpitaux de mission auraient pu économiser 16% des ressources en intrants s'ils avaient fonctionné efficacement. Il montre également que l'analyse de l'enveloppement des données peut être utilisée pour fixer des objectifs/critères pour des établissements de santé relativement inefficaces et pour surveiller l'impact des interventions sur l'efficacité des hôpitaux à terme. *(Afr J Reprod Health 2019; 23[3]: 57-67).*

Mots-clés: Hôpitaux de mission, analyse d'enveloppement des données, efficacité, définition des objectifs, sud-est du Nigeria

Introduction

The health system in many parts of Nigeria is generally inefficient, inequitable and weak. These problems are clearly manifested in the poor health indices in the country[1]. A major factor that contributes to the weak Nigeria health system is the inefficiency of public health facilities, especially the public hospitals. This has led to the growth of formal and informal public health facilities, including hospitals, in order to fill the gap left by inefficient public hospitals. The inefficiency of public hospitals in southeast Nigeria is a huge contributory factor to the ineffectiveness of Nigeria health systems and exposes the constraints in the use of available scarce general tax revenue to deliver quality services[2]. It has been found that public hospitals, especially those located in rural areas are worse-off, as they operate under very poor conditions ranging from poor infrastructure, inadequate equipment, and lack of medical supplies to inadequate human resources for health[3]. Private hospitals, especially the mission hospitals, in southeast Nigeria tend to be more efficient than public hospitals[4]. Mission hospitals, which are a part of the private sector, play an important role[5] in ensuring the healthcare of the people. Large proportions of health care delivery in the Southeast Nigeria are provided by these private-not-for-profit mission hospitals, mainly because of the poor state of public health facilities[6].

The efficiency of the health system could be improved by using public-private partnership (PPP) models to fill in the gap created by low performing public health facilities[7-8]. This could be achieved if private care providers such as mission hospitals adopt open system business model in managing their facilities, just as having appropriate equipment, good supplies of drugs and competent staff in a correct mix is also contingent to achieving efficiency[9]. Thus, in line with the PPP approach, Ebonyi State in Southeast Nigeria used periodic releases of funds to strengthen maternal and child healthcare services in six selected rural mission hospitals, between 2008 and 2014. The program was designated as Rural Health Program (RHP). This study investigated how efficient (technically and scale wise) these mission hospitals were in providing maternal and child healthcare services both before and during the period of intervention. Technical efficiency has more to do with managerial challenges, where more service outputs are required from a given level of resources[10]. Technical inefficiency signals failure to produce an expected output with minimal input[11]. It is therefore appropriate to evaluate how this intention of the government translated into increased service output or efficiency. Whether the improved funding of the mission hospitals was associated with enhanced efficiency [12]. The study is motivated by several considerations; prominent among these is the substantial proportion of the State Ministry of Health (MOH) budget that was being spent on the Rural Health Program. The lack of baseline study on technical efficiency of individual health facilities prior to the introduction of the program is also an information gap that should be filled for an objective evaluation of the intervention. This paper adds to the literature on the efficiency of hospitals, as well as provides information on efficiency before and after an intervention that was meant to boost the service delivery of mission hospitals. The information generated by this study could constitute a basis for hospital reforms in the public sector, especially in similar setting.

Methods

Study area

Ebonyi State is located between longitude 7° 30’ and 8°30’ E, and Latitude 5° 40’ and 6° 45’ N in the south eastern part of Nigeria and had a population of about 2.67million people in 2006. The southeast zone of Nigeria comprises five (5) states, with a total population of about 30 million people[6].

Description of the public private partnership (PPP) in the study

The PPP as operated in Ebonyi State; Southeast Nigeria involved disbursement of financial grants to six private-not-for-profit (PNFP) mission hospitals so as to increase provision health care services to rural communities. The grants were allocated in the following manner: 50% for free

maternal health services, 4% for promotion of child health such as strengthening routine immunization and other disease control, 28% for health human resource support (staff salaries) and 18% for rehabilitation/construction and procurement of equipment[6,13-14]. Thus, the program was meant to implement selected user fees removal for maternal and child healthcare services in the mission hospitals[15-17]. A total of about 1.3 Billion Naira (an equivalent of 8.125 Million USD at a prevailing exchange rate of 160NGN per 1$) was disbursed for this purpose to the 6 mission hospitals in a periodic but irregular manner[6,13-14].

Study design

This study is a descriptive cross-sectional and retrospective type, covering the period from January 2007 to January 2012. Secondary data from the State Ministry of health and respective mission hospitals were used. Only input and output variables that were common or available for all the 15 hospital-years were qualified for inclusion in the analysis.

Sampling technique

The period, 2007 to 2011, was selected using quota and purposive sampling method and mission hospitals were disaggregated into 15 hospital-years, otherwise called decision making units (DMUs).

Source of data

Hospital financial records, equipment/supply inventory, personnel record/information and healthcare delivery records on immunization, maternity deliveries, outpatients and inpatients were collected. The data were categorized into two sets of variables: inputs and outputs. The inputs are resources needed by the health facilities for production or provision of health services and include human resources such as clinical Staff and Non-clinical Staff, but here represented by their wages as part of operational cost. Also included as part of the operational cost are the amounts used for procurement of consumables such as drugs, laboratory reagents and sundry expenses for daily running of the hospital. The capital inputs include the number of buildings and equipment, which were represented by the number of hospital beds and baby cots. The outputs reflect the type of health services delivered by the mission hospitals, and these were easily measured as number of outpatients, number of Antenatal Clinic (ANC) registrations, the number of immunization doses or percentage of coverage and the number of patient admissions or/and the number of deliveries for each hospital-year. The choice of the above variables was guided by two factors, namely similar past studies in Africa[18] and the availability of data in the mission hospitals.

Theoretical framework of the data analysis

Data Envelopment Analysis (DEA) was used in estimating the level of technical and scale efficiencies of the DMUs, both under constant return to scale (CRS) and variable return to scale (VRS)[17,18]. DEA is a non-parametric programming technique that defines efficiency as the ratio of the weighted sum of outputs of DMUs such as health facilities to its weighted sum of inputs[19].

$$\text{Efficiency (E)} = \frac{\text{Weighted sum of outputs}}{\text{Weighted sum of inputs}}$$

DEA is based on relative efficiency concept proposed by Farrell (1957) following an earlier work done by Dantzig (1951). This was later developed by Charnes, Cooper and Rhodes (1978) who extended and developed Farrell's approach, to assume constant return to scale (CRS)[20]. A second DEA model which assumes a variable return to scale (VRS) was later developed and this separates pure technical efficiency from scale efficiency[21-22]. DEA measures the efficiency of a hospital relative to the efficiency of its peer group, with a notional ''production frontier'' representing optimal efficiency[23]. Thus, a hospital is said to be efficient if it operates on this production frontier, and inefficient if it operates below it.

Mathematically, with DEA, the efficiency of 'k' number of hospitals or hospital-years using a multiple input to produce a multiple outputs or services can be presented as follows:

$TE_k(\theta_k) = \frac{\sum_{j=1}^{s} UjY_{jk}}{\sum_{i=1}^{m} ViX_{ik}}$; Where $_k$= number of DMUs or hospital-years, i.e. k =1,2,…, n; While, θ_k = Efficiency Score which ranges from 0-1 (0-100%); Y = output; U = weights of output; $_j$ = number of outputs, example $_{j = 3}$
and X = input; V = weights of input; $_i$ = number of inputs, example $_{i = 2.}$
Literally, the efficiency score (θ_k) for a group of peer DMUs (k = 1,… n) is computed from the selected outputs (Y_{jk}, r = 1, …, s) and inputs (X_{ik} , i = 1, …, m), using U_j as weights of outputs and V_i as weights of inputs for focal DMU, k[24-25]. In this study the total number of DMUs, using hospital – year is k = 15; outputs, j is 3 and number of inputs, i is 2.

DEA models

This is either an input-orientation or an output-orientation[26]. With input-orientated model, the focus is to alter the technical efficiency by reducing the number or/and quantity of input used. While with the output-oriented model, the focus is on expanding or adjusting the output quantity so as to increase efficiency[27]. This present study assumes an *input orientation*. Thus, technical efficiency of each hospital-year is taken to be the ability of the hospital management to properly harness sufficient resource to maximize their service output[28-30]. This is more suitable because the management of the three hospitals under study have sufficient control and are at liberty to source for additional funding from the church or their proprietor(s).

Estimation technique

The inputs and outputs data were entered into DEA Frontier solver which is an Excel add-on software developed by Joe Zhu, version 2.1[31]. This was downloaded into a computer from www.deafrontier.net/order/index. The first column of this excel sheet is recognized as the hospital-year (DMU) identifier. This is followed by two columns for input(s), and next is a blank column and then three columns for the outputs. The DEA Frontier is then activated, appropriate Envelopment Model options (e.g. CRS) were chosen followed by the choice of model orientation, in this case an input orientation. From Stata11 software (STATA Corp. Inc. TX, USA), the mean, Standard Deviation (SD), minimum and maximum values of all input and output variables were calculated. Subsequently, the technical efficiency (TE) and scale efficiency (SE) scores were computed for the hospital-years. The software minimizes the possibility of a mis-presentation of DEA models during coding[31].The DEA-Frontier works under Excel XP-2013 and Windows XP-Windows 8. Under Excel 2007 and earlier versions, the Excel Solver parameters dialog box has to be displayed once before the DEA-Frontier software is loaded. To test the robustness of DEA results regarding outlier of the mission hospitals two options were used: Jack-knifing analysis which was carried out by removing the most efficient hospital-year and then recalculating the efficiency scores again[21]. By removing one at a time, efficient hospital-year and recalculating the efficiency score, several new models were obtained and the efficiency ranking compared. The second method used for testing robustness in this study was the use of a different health service model or DEA specifications for obtaining and ranking the efficiencies of the various hospital-year units (DMUs).

Results

Descriptive statistics

The descriptive statistics of the sample as shown in Table 1 clearly enumerate the mean bed-space as 136±122.4 beds, and a mean operational cost of NGN69,195,827.33 (US$432,473.92). All the mission hospitals show gradual increase in service outputs over the years, from 2007 to 2011. There is also marked variation in the level of outputs from the mission hospitals, in spite of the fact that they received near equal amount of grant from the government. For instance, the mean antenatal clinic (ANC) registration for the sample is 5973±3987.69, while the mean number of deliveries during the 5years under study is 940±907.84.

Table1: Descriptive Statistics of Input and Output Variables of 3 Mission Hospitals in Southeast Nigeria over 5-year Period

		INPUTS		OUTPUTS			
S/NO.	Hospital -Years (DMUs)	No. of Beds	Operational Cost (mNGN) per year	Grant from EBSG in Million NGN	No. of Ante-natal Registration	No. of Normal Delivery	No. of Immunization Doses	No. of Paediatric Admission
1	MFH-07	86	104.2	0	5761	1173	15493	1107
2	MFH-08	86	113.2	35.2	6739	1883	14535	1029
3	MFH-09	86	128.8	64.6	6878	2021	29246	1120
4	MFH-10	86	143.9	22.2	7613	2484	16997	1103
5	MFH-11	86	157.7	27.4	16638	2651	25883	1408
	Sub-sum		***647.8(62.4%)***	***149.3(30.4%)***	***43629(48.7%)***	***10212(72.4%)***	***102154(65.7%)***	***5767(64.8%)***
6	RIM-07	20	21.5	0	3407	30	614	67
7	RIM-08	20	25.8	40.1	438	20	1104	97
8	RIM-09	20	33.7	50.0	1450	109	1402	100
9	RIM-10	30	33.1	33.1	3243	243	1753	130
10	RIM-11	25	37.0	33.0	2702	206	1300	179
	Sub-sum		***151.2(14.6%)***	***156.2(31.8%***	***11240(12.5%)***	***608(4.3%)***	***6173(3.9%)***	***573(6.4%)***
11	MHA-07	300	31.7	0	4277	407	8004	459
12	MHA-08	300	38.0	60.7	4634	351	10242	417
13	MHA-09	300	51.3	54.0	9748	1049	12383	541
14	MHA-10	300	53.7	35.3	7176	710	7902	634
15	MHA-11	300	64.2	35.6	8896	768	8694	511
Sub-sum			***239.0(23%)***	***185.6(37%)***	***34731(38.9%)***	***3285(23.3%)***	***47225(30.4%)***	***2562(28.8%)***
Sum		**---**	**1037.9**	**490.1**	**89600**	**14105**	**155552**	**8902**
Mean		**136.33**	**69.2**	**27.0**	**5973.3**	**940.3**	**10370.1**	**593.47**
Median		**86**	**51.3**	**35.5**	**5761**	**710**	**8694**	**511**
Std dev.		**122.74**	**46.9**	**13.3**	**3987.7**	**907.8**	**8948.3**	**452.6**
Minimum		**20**	**21.5**	**22.2**	**438**	**20**	**614**	**67**
Maximum		**300**	**157.7**	**64.5**	**16638**	**2651**	**29246**	**1408**

(MFH = Mile Four Hospital; RIM = Reform Improvement Mission, and MHA = Misericordiae Hospital Afikpo; EBSG= Ebonyi State Government; mNGN = Million Nigeria Naira; DMUs = Decision making units).

State Government financed 47.31% of the total operational cost for the mission hospitals over the 5 years. Mile-Four hospital (MFH) alone spent 62.41% of the overall operational cost and provided about 62.89% of the health care services; Mater Misericordiae used 23.03% of the operational cost but provided 29.35% of the services, and Rural Improvement Mission (RIM) hospital, Ikwo spent as much as 14.56% of the total operational cost, but provided the least proportionate quantum of health care services of only 6.85%. The operational costs of two of the hospitals (RIM and MHA) were largely the grants from State Government which shared equally among the hospitals. A total of 89,600 antenatal registrations with 14,105 normal deliveries (that is 15.74% of antenatal clinic attendance) were recorded during the five years. During the same period a total of 155,552 immunization doses were achieved and 8,902 pediatric admissions were made by the mission hospitals. Mile – Four hospitals provided more than half of all the health services rendered, except for ANC.

Technical and scale efficiency

Table 2 shows the efficiency analysis of the mission hospitals on maternal and child healthcare services during the period under study. Seven hospital-years exhibited constant return to scale and were technically efficient (100%), while eight units that were inefficient has a mean technical efficiency of 70.09%. Two of the mission hospitals had aggregated technical and scale efficiencies that were as high as: TEcrs = 92.95%, SE = 99.04% for Mile-four hospital, and TEcrs = 95.97%, SE = 99.79% for Mater Misericordiae hospital. This affirms that Misericordiae hospital Afikpo is the most efficient, technically and scale wise. All the hospital-years of RIM were inefficient from 2008 to 2012; with an average technical efficiency of only 52.28% during this period. From 2008 all the four units of RIM exhibited increasing return to

Table 2: Data envelopment analysis on maternal & child healthcare services as provided by 3 mission hospitals, Southeast Nigeria over a 5-year period

DMUs	No. of beds	Op. Cost (mNGN)	No. of ANC	Imm. Dose	No. of Paed. Admission	TEcrs	TEvrs	SE	RTS
MFH-07	86	104.2	5761	15493	1107	1.000	1.000	1.000	Constant
MFH-08	86	113.2	6739	14535	1029	0.889	0.907	0.980	Increasing
MFH-09	86	128.8	6878	29246	1120	1.000	1.000	1.000	Constant
MFH-10	86	143.9	7613	16997	1103	0.829	0.853	0.972	Increasing
MFH-11	86	157.7	16638	25883	1408	1.000	1.000	1.000	Constant
MFH Mean						**0.929**	**0.952**	**0.990**	
RIM-07	20	21.5	3407	614	67	1.000	1.000	1.000	Constant
RIM-08	20	25.8	438	1104	97	0.364	1.000	0.364	Increasing
RIM-09	20	33.7	1450	1402	100	0.384	1.000	0.384	Increasing
RIM-10	25	33.1	3243	1753	130	0.729	0.904	0.806	Increasing
RIM-11	30	37.0	2702	1300	179	0.615	0.862	0.713	Increasing
RIM Mean						**0.618**	**0.953**	**0.653**	
MHA-07	300	31.7	4277	8004	459	1.000	1.000	1.000	Constant
MHA-08	300	38.1	4634	10242	417	1.000	1.000	1.000	Constant
MHA-09	300	51.3	9748	12383	541	1.000	1.000	1.000	Constant
MHA-10	300	53.7	7176	7902	634	0.997	1.000	0.997	Decreasing
MHA-11	300	64.2	8896	8694	511	0.801	0.807	0.992	Increasing
MHA Mean						**0.959**	**0.961**	**0.998**	
Mean	**136.3**	**69.2**	**5973.3**	**10370.1**	**593.5**	**0.841**	**0.956**	**0.881**	
Median	**86.0**	**51.3**	**5761**	**8694**	**511**	**0.997**	**1.000**	**0.997**	
Std (SD)	**122.7**	**46.9**	**3987.7**	**8948.3**	**452.6**	**0.225**	**0.069**	**0.222**	
Min. Eff.						**0.364**	**0.807**	**0.364**	
Max. Eff.						**1.000**	**1.000**	**1.000**	

MFH is Mile Four Hospital; RIM is Reform Improvement Mission, and MHA is Misericordiae Hospital Afikpo; mNGN is Million Nigeria Naira.

Table 3: Summery of Inefficient DMUs and their mean Efficiencies for Maternal & Child Health care

Model Specification	Overall (TEcrs)	Technical Efficiency		Pure Technical Efficiency (TEvrs)			Scale Efficiency (SE)			Returning to Scale (RTS)
	Eff. DMUs	Ineff. DMUs	Mean Eff.	Eff. DMUs	Ineff. DMUs	Mean Eff.	Eff. DMUs	Ineff. DMUs	Mean SE	
Maternal & Child health Services (MCH)	**7(46.6%)**	**8(53.3%)**	**0.701**	**10(66.7%)**	**5(33.3%)**	**0.867**	**7(46.67%)**	**8(53.3%)**	**(0.744) 0.776**	**CRS: 7 (46.7%); IRS: 7 (46.7%); DRS: 1 (6.7%)**

(Number and percentage in bracket (%); CRS is constant return to scale; IRS is increase return to scale; DRS is decrease return to scale)

scale (IRS). With scale efficiency (SE) of only 65.33%, Rural Improvement Mission (RIM) hospital needed to increase its size by as much as 34.67%. The findings show that all the hospital was technically and scale efficient in 2007 (TEcrs = 1 and SE = 1) preceding the intervention by the State Government, thus justifying the assumption by the government that the three mission hospitals were doing well and needed to be encouraged. On the whole the mean technical efficiency of the hospitals was 84.05±22.45%.

On the other hand, the mean scale efficiency for the DMUs was 88.05%. A little less than half of the units were 100% scale efficient, manifesting Constant Return to Scale (CRS). These units operated at their most productive scale sizes (MPSS). For such units increment in their inputs would yield the same proportional increase of service outputs, because their average and marginal productivity remains constant. Another seven hospital-years exhibited increasing return to scale and had mean scale efficiency (SE) of 74.4%. See Table 3.

Thus, for these units to become scale efficient or operate at most productive scale size (MPSS) they need to expand their operation by

Table 4: Potential Output Improvement for each of the Inefficient Hospital-year for Maternal and Child Healthcare Services

DMUs	SE	RTS	Actual Outputs			Output Slack (%)			Outputs Targets if Inefficient DMUs are to be made Efficient		
			No. of ANC Registration	No. of Immun. Doses	No. of Paed. Admission	No. of ANC Registration	No. of Immuniz Dose	No. of Paed. Admission	No. of ANC Registration	No. of Immuniz Doses	No. of Paed. Admission
MFH07	1	Constant	5761	15493	1107	NIL	NIL	NIL	5761	15493	1107
MFH08	0.98	Increasing	6739	14535	1029	**5**	**788**	NIL	***6744***	***15323***	1029
MFH09	1	Constant	6878	29246	1120	NIL	NIL	NIL	6878	29246	1120
MFH10	0.97	Increasing	7613	16997	1103	**3859**	**2243**	NIL	***11472***	***19240***	1103
MFH11	1	Constant	16638	25883	1408	NIL	NIL	NIL	16638	25883	1408
RIM07	1	Constant	3407	614	67	NIL	NIL	NIL	3407	614	67
RIM08	0.36	Increasing	438	1104	97	**167**	**320**	NIL	***605***	***1424***	97
RIM09	0.38	Increasing	1450	1402	100	NIL	***508***	***6***	1450	***1910***	***106***
RIM10	0.81	Increasing	3243	1753	130	NIL	***433***	***9***	3243	***2186***	***139***
RIM11	0.71	Increasing	2702	1300	179	NIL	***1904***	NIL	2702	***3204***	179
MH07	1	Constant	4277	8004	459	NIL	NIL	NIL	4277	8004	459
MH08	1	Constant	4634	10242	417	NIL	NIL	NIL	4634	10242	417
MH09	1	Constant	9748	12383	541	NIL	NIL	NIL	9748	12383	541
MH10	0.997	Decreasing	7176	7902	634	NIL	**3808**	NIL	7176	***11710***	634
MH11	0.992	Increasing	8896	8694	511	NIL	**2536**	NIL	8896	***11230***	511

(MFH is Mile Four Hospital; RIM is Reform Improvement Mission, and MH is Misericordiae Hospital Afikpo; ANC is antenatal clinic)

25.6%; and because they exhibited increasing return to scale (IRS) any increase in their input will lead to their output increasing by greater proportion. Only one mission hospital exhibited decreasing return to scale (DRS) in 2010 with scale efficiency of 99.75%.

Potential maternity and child healthcare (MCH) services output improvement and implication for policy

The output increases that would have made each individual inefficient hospital-year efficient for the given period are shown in Table 4. The table presents the total output slack and target obtained from input orientation CRS model of DEA. The addition of slack to the actual output gives expected or target output. Inefficient DMUs that exhibited increasing return to scale will need to increase its output by the value obtained as output slack in order to become efficient. For instance, Mile Four Hospital in 2008 needed additional 5 ANC registrations and 788 number of immunization doses to be technically efficient and in 2010 it needed as much as 3,859 ANC registrations and 2,243 immunization doses to meet efficiency target. RIM hospital exhibited slacks in service outputs from year 2008 to 2011, especially as regards immunization coverage. Two of the hospitals exhibited output slack for ANC registration and immunization coverage in 2008 and 2010, and one of the hospitals for only Immunization from year 2008 to 2011.

Discussion

This study has measured both technical and scale efficiencies of PNFP mission hospitals over a period of 5 years (2007-2011) and identified the percentage of input reductions and/or output increases needed to make inefficient units or facilities efficient. It compared how different units or mission hospitals fared in the provision of various maternal and child healthcare services over period, a time during which the PNFP mission hospitals were benefited from State Government funding that were made available as grants. The study indicated that between 2007 and 2011 46.7% of the mission hospitals were technically and scale efficient with the overall mean technical efficiency of 84.05% for the hospitals. Thus, if the mission hospitals had been 100% efficient, they could have produced the same level of maternal and child healthcare services by saving 15.95% of the inputs cost or resources used during the 5years. Such savings could be utilized to provide healthcare services to greater population or could significantly be used to ensure equitable

availability of maternal and child healthcare services in the state. The mean technical efficiency for the inefficient hospital-years was 70.1%, implying that they needed to increase their output by about 29.9% to become efficient. On the other hand, they could have saved 29.9% of the inputs or hospitals into pure technical efficiency and scale efficiency.

And this shows that the number of hospital-years that exhibited pure technical efficiency of 1 (100%) increased to 66.7%. Thus, the size or scale of operation of the units was a major cause of the observed inefficiencies. Only 46.7% of the DMUs operated at their most productive scale size (MPSS) for the set of input-output mix used in this study. Another 46.7% of the DMUs exhibited increasing return to scale (IRS), implying that they would need to increase their scale of operation in order to improve their efficiency. Only Mile-Four Hospital in 2010 exhibited decreasing return to scale (DRS), meaning that it needs to reduce its scale of operation by as little as 0.25% to become efficient. One third of the hospital-years, mainly from Mile-Four and Reform Improvement mission hospitals, that exhibited pure technical inefficiency also had managerial factor(s) as part of the causes of their inefficiency.

Prior to the intervention the mission hospitals were technically and scale efficient as shown by efficiencies of the mission hospitals in 2007. The release of additional fund by the State Government to the PNFP mission hospitals did not maintain the 100% level of efficiency, though there were increased healthcare service outputs. Efficiency scores in this study provide insight into the level of mismanagement of the increased resources by the mission hospitals. An obvious example is that of Rural Improvement Mission (RIM) hospital, Ikwo that utilized 14.56% of the total input resources provided only 6.85% of the total outputs in the form of healthcare services. The technical efficiency (TEcrs) of RIM was only 61.83% and this seems to buttress the above findings. All the hospital-years of RIM were inefficient from 2008 to 2012. The most efficient mission hospital among them is Misericordiae hospital Afikpo, with an average overall technical efficiency of 95.96%, pure technical efficiency of 96.14% and scale efficiency of 99.79%.; as against resources while providing the same level of healthcare services, if they had performed efficiently. The application of DEA under variable return to scale decomposed the overall technical efficiency of the

the general average efficiency of 84.05% (TEvrs), 95.56% (TEcrs) and 88.05% (SE) respectively. Efficiency studies in other African countries, though on public hospitals, show that the mean efficiency scores in this study are fair scores. The technical efficiency recorded in Botswana stood at 74.2% and 76.8%[24], Angola 65.8%-67.5%[18]; Ghana-61%[32]; Benin-63.30% to 85.8%[33]; Kenya-84%[34]; Namibia-62.7 to 74.3%[35] and Uganda-90.2% to 97.30%[36]. The scale efficiency obtained here could be compared to results obtained from Namibia (80.7%-87.3%) by Mbeeli[35], Ghana (89.1%) by Osei[32]; and Kenya (96.8%) by Kirigia[34].

The study shows that all the mission hospitals, especially Rural Improvement Mission Ikwo, manifested significant gaps in their immunization coverage. Mile Four hospital needed to provide as much as 3864 ANC registration and immunization coverage of 3031 doses to meet its efficiency target during the 5 years under study. On the other hand, Rural Improvement Mission Ikwo needed as much as 167 ANC registrations, 3165 immunization doses and 15 paediatric admissions to meet efficiency frontier. Mater hospital, though the most efficient, need as much as 6344 immunization doses to be 100% efficient through the 5 years. Thus, this study was able to show that the healthcare output that exhibited significant slack or gaps were immunization and Antenatal Clinic (ANC) registration. Poor immunization coverage was a major source of inefficiency, especially for Rural Improvement Mission hospital. Thus, most of the inefficient hospital-years could have increased their efficiency by improving their immunization coverage. This observation is of policy implication for the State Ministry of Health, whose responsibility is to implement and monitor the State Rural Health Program, under which the Government awarded grants to these mission

hospitals. One good way to improve the efficiency is through hospital health services' demand creation, for example the use of health promotion strategies and techniques such as advocacy, social mobilization, social marketing; intensive use of information, education and communication (ICT) on routine immunization[37].

Limitations

The study has some limitations upon which future studies should improve upon. One of such limitations is the small sample size which limits the generalization of the study findings. DEA result can be sensitive to sample size. The second limitation is the poor quality of healthcare record or data keeping in developing countries like Nigeria. Of the six, the three other PNFP mission hospitals were left out because of incomplete data. Since DEA is non-stochastic, it does not capture random noise or man-made mistakes in computation of the variables. It attributes any deficiency from the frontier to inefficiency and it is not possible to undertake a statistical test of hypothesis regarding the inefficiency and the structure of the production unit.

Recommendations

The study has proved that Data Envelopment Analysis (DEA) can be used in identifying efficient operating practices and efficient strategies, setting targets/benchmark for relatively inefficient health facilities, and monitoring the effects of health sector reforms on efficiency over-time[23]. In line with the "Health financing: A strategy for the African Region''[37], which was adopted by the 56th WHO Regional Committee for Africa, there is need for various governments to make efficiency a policy objective and institutionalize efficiency monitoring as a tool within the health management information system (HMIS) of various Ministries of Health[38,39].

Conclusion

The study has demonstrated that DEA as a nonparametric method is a useful and indeed an essential tool for identifying the most and least efficient health facilities, and strategies for saving resources or inputs and/or for increasing services outputs. In spite of the grants from the State government for the purpose of providing maternal and child healthcare services through public – private – partnerships, some degree of inefficiency among the benefiting mission hospitals was noticeable over the years. The performance of these mission hospitals in the provision of immunization and antenatal services accounted for most of the inefficiency observed. Thus, there is need for improvement in these areas through increased funding and via effective and efficient resource use[40]. A more intensive health social marketing and advocacy may also reduce the observed inefficiency.

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Competing Interests

The authors have no competing interests.

Author Contributions

HA conceived the study and collected the data. He also wrote the first draft of the manuscript. OO and HI contributed to the design of the study and reviewed of the manuscript. AO analyzed the data. All the authors approved the manuscript.

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