Technical Efficiency of Public Insurance Health Centers in Gezira State of Sudan

Almoghirah Alamin Gadasseed Abdellah*

Abstract

This is the first study that addresses the technical efficiency in primary health care level in Sudan according to the available information. The study aimed to measure the technical efficiency of 31 direct and 57 indirect insurance public primary health centers in Gezira State in Sudan and to identify the possible factors affecting the technical inefficiency of both. In the first stage, an input orientated data envelopment analysis (DEA) was done to compute the technical efficiency scores for both types of health centers. In the second stage regression analysis was done using Tobit model to determine the effect of certain factors in terms of magnitude and direction on technical inefficiency of the health centers.

The study revealed that the average technical efficiency score of direct and indirect health centers was 32% for constant returns to scale and 77% for variable returns to scale. The results also showed that 44.6% of direct and 43.7% of indirect health centers were run inefficiently. From the results of the regression analysis, the type of the health center, the size and the location-size were found to be significant and negatively affecting the technical inefficiency of the health center. The location, the ratio of medical to non-medical staff, the size in form of square and the time dummy variable for year 2012 were significantly affecting the technical inefficiency but in the positive direction. Other factors found to have insignificant effects including the time dummies for years 2010 and year2011. Furthermore the

* Master's student, Master of Science in Health Economics and Health Care Management Program, Chulalongkorn University; Email: moghira_alamin@yahoo.com

study recommended corrective actions for policy makers to improve the performance of primary health centers.

Key Word: Data Envelopment Analysis, Indirect Primary Health Centers Constant, Technical Efficiency, Variable Return to Scale

Introduction

Efficiency in health sector

Policy makers now have become more concerning on efficient ways to deliver health services .Efficiency improvements in the health sector, even in small amounts, can produce considerable savings of resources or expansion of services for the community.(Peacock, Chan, Mangolini, & Johansen, 2001)

Overview of health system in Sudan

Health services are provided through different partners including in addition to Federal and State Ministries of Health, national health insurance, armed Forces, police, universities, private sector (both for profit and philanthropic). However, before the establishment of the Health Coordination Council at the federal level, those partners used to perform in insolation due to ill-defined managerial systems for coordination and guidance (Regional Health System Observatory, World Health Organization, 2004).

Direct Provision of Health services by NHIF

Since 2002 the National Health Insurance Fund (NHIF) in Sudan has been affiliated to the Ministry of Welfare and Social Security after being under direct supervision of Ministry of health (MOH) for 7 years. Thence it has started to provide health services by direct provision method beside the indirect one. So there are two types of health centers through which NHIF avails medical services to its clients:

Direct health centers: These are the centers that owned and/or directly administered by NHIF. The total number of direct health centers is 294 in 2010. (NHIF, 2010)

Indirect health centers: These are the health centers that NHIF purchases medical services from, and that is on contract basis. The total number of indirect health centers is 289 in 2010.(NHIF, 2010)

Health Insurance in Gezira State

The institutes that provide medical health services to NHIF clients amount to 190, in the 1st quarter 2011, including 64 teaching general and special hospitals as well as a rural under direct administration of SMOH and other providers, 126 primary health centres of which 31 are under direct NHIF administration (direct centers), as well as 95 indirect health centres of which 68 are under localities (SMOH).(Directorate, 2011)

Objectives and Scope

Objectives

General Objective: To assess the technical efficiency of direct and indirect primary health centers that provide medical insurance services to NHIF's clients at Gezira State and to determine the factors that affect their efficiencies.

Specific Objectives: 1) To calculate the technical efficiency scores of direct and indirect primary health centers of NHIF at Gezira State during the period 2009 to2012. 2) To identify the factors affecting technical inefficiency of direct and indirect health centers.

Scope of Study

This study was confined to public health centers that provide medical services to NIHIF's clients in primary health care level in Gezira State. So, it included all the 31 direct health insurance centers and 57 indirect public health centers. The secondary data required

were collected in the period from 2009 to 2012 for the direct centers, and for the indirect public health centers for the year 2012.

Literature Review

Definition of Efficiency

It is defined as production of maximum quantity of output for a given value of a set of inputs or the production of a given quantity of output produced with the least cost set of inputs. Sometimes called cost efficiency or operational efficiency. A decision making unit (DMU) is to be rated as fully (100%) efficient on the basis of available evidence if and only if the performances of other DMUs does not show that some of its inputs or outputs can be improved without worsening some of its other inputs or outputs.(Cooper, Seiford, & Zhu, 2011)

Measurement of efficiency begins with Farrell (1957) who drew upon the work of Debren (1951) and Koopmans (1951) to define a simple measure of firm efficiency which could account for multiple inputs. He proposed that the efficiency , which reflects the ability of a firm to obtain maximal output from a given set of inputs, and allocative efficiency which reflects the ability of a firm to use the inputs in optimal proportions, given their respective prices. These two measures are then combined to provide measure of total economic efficiency. (Coelli, 1996)

Some previous studies on efficiency of different levels of health care

Kirigia et al (2001) measured the technical efficiency of public health centers in Kenya using the DEA approach. The study was carried out in a selection of 32 public health centers out of a total number of 350. The study used 10 intermediate ouputs including different common diseases' visits as well as antenatal care, immunization and family planning visits. The study found that 44% of

the health centers in Kenyan sample were technically inefficient. (Joses, Ali, Luis, Nzoya, & Wilson, 2004)

Kirigia et al (2001) conducted a study aiming at investigating the technical efficiency of public clinics in Kwazulu- Natal province in South Africa and to draw policy implications. That cross-sectional study was based on 155 public clinics and used DEA as a method to measure the technical efficiency. The main outcome measures were technical and scale efficiency scores. The results obtained by the study revealed that 30% of public clinics were found to be technically efficient. (Joses, Luis, & H., 2001)

Osei et al (2005) conducted a pilot study on technical efficiency of public district hospitals and health centers in Ghana 2005. The objectives were to estimate the relative technical efficiency and scale efficiency of a sample of public district hospitals and health centers in Ghana and to demonstrate policy implications for health sector policy-makers. The method used by the study was the DEA approach to estimate the efficiency of 17 district hospitals and 17 health centers. The study revealed that 47% of hospitals were technically inefficient with an average T.E score of 61%.(Osei et al., 2005)

Research Method

Study design, population and sample

This is an analytical study using mathematical and econometric techniques. The study population included public primary health care centers in Gezira State that provided health care services to NHIF clients. All direct health centers in Gezira State, which were 31 in number and, 57 indirect public centers, constituted the study sample.

Data collection

Secondary data for specific inputs and outputs of the health centers were collected retrospectively. Form the period 2009 to 2012 (4 years) for the direct centers and for the year 2012 for indirect ones. So the total was 176 observations.

The specific inputs and outputs variables that contributed to the production function of these centers were defined as follows:

1) Inputs variables;

Number of physicians: including general and specialists physicians and medical assistants.

Number of laboratory technicians: including all technical personnel working in the laboratory department such as laboratory technicians, laboratory assistants, malaria technicians and laboratory attendants.

Operational expenditure: These include all non-wage recurrent expenses such as, water, electricity and telephone bills, maintenances for buildings and equipment and stationaries.

2) Output variables;

Number of outpatient visits: The main output of these primary centers is the total number of outpatient visits per year. These include mainly the common acute diseases visits, chronic diseases follow up visits, minor surgical procedures like cut wound repairs, dressing and drainage of small abscesses.

Number of children vaccinated: As an essential part of the primary package of health services the total number per year of children vaccinated against vaccine- preventable diseases according to Expanding Program of Immunization (EPI) in Gezira State was considered as an output.

Data analysis

Two techniques were used as analytical tools into two stages. In the1st stage, Data Envelopment Analysis (DEA) was used to calculate the technical efficiency scores of the chosen health centers. Data were analyzed using DEA computer program (DEAP version 2.1). Input-orientated DEA model was used in this study with two assumptions constant return to scale (CRS) and variable return to scale (VRS).

In the 2nd stage, regression was done using Tobit analysis to identify the factors that affect technical inefficiency of primary centers.

The regression model: The regression model was formulated as follows:

$$T.I_i = \beta_0 + \beta_1 TYPE_i + \beta_2 LOC_i + \beta_3 SIZE_i + \beta_4 RMD_i + B_5 SIZE_i^2 + \beta_6 TYPE*YR10_i + \beta_7 TYPE*YR11_i + \beta_8 TYPE*YR12_i + B_9 LOC_i*SIZE_i + \varepsilon_i$$

Where:

$T.I_i$: is the technical inefficiency score (VRS) for the ith health center, generated from the obtained technical efficiency (T.E) score of the ith center (VRS) as follows: $T.I_i = 1 - T.E_i$

β_0: is the constant term.

$\beta_1 - \beta_9$ are the coefficients of the explanatory variables.

$TYPE_i$: is dummy variable =1 if direct center, = 0 if indirect center

LOC_i: is a dummy variable = 1 if the center is located in an urban area and = 0 if in a rural area.

RMD_i: is the ratio of number of medical staff/number of non-medical staff.

$SIZE_i$: is number of departments or divisions of the health center.

$SIZE_i^2$: is the square of number of departments or divisions of the health center.

$LOCi*SIZE_i$: is a cross term between the size and the location of the center used here because the relationship between the size of the center and technical inefficiency was expected to vary with location

$TYPE*YR10_i$: is a time dummy for efficiency scores in the year 2010 for direct centers.

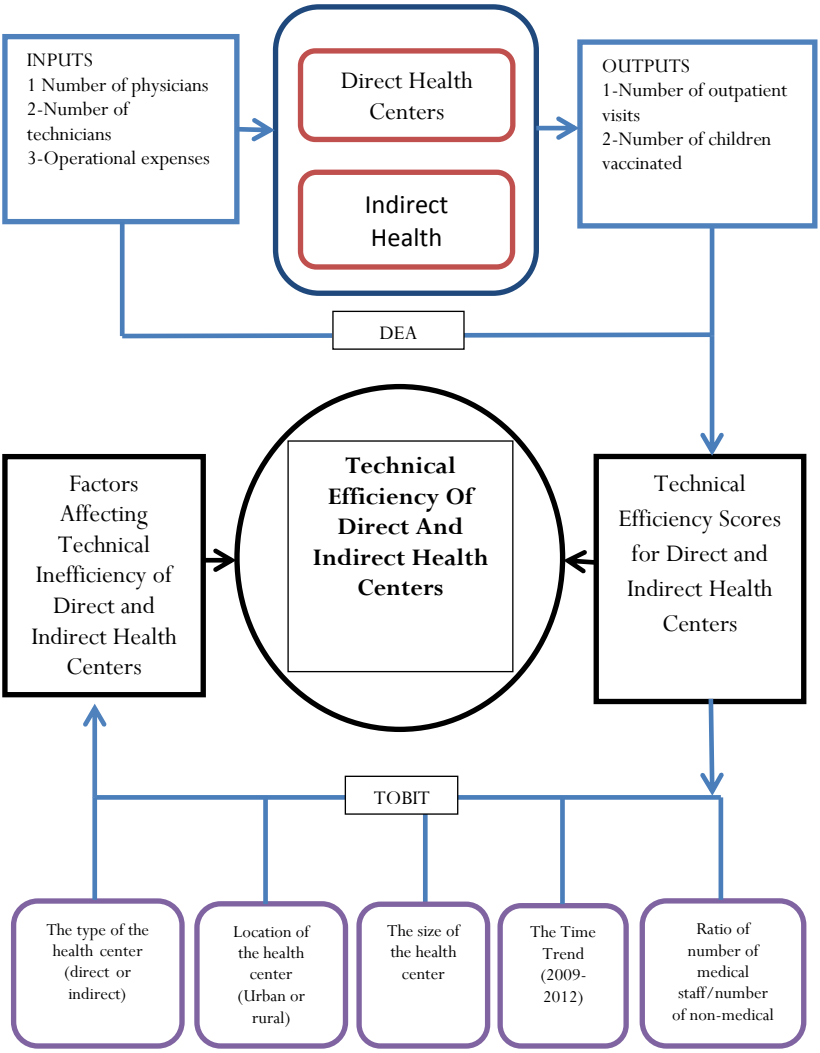
$TYPE*YR11_i$: is a time dummy for efficiency scores in the year 2011 for direct centers.

$TYPE*YR12_i$: is a time dummy for efficiency scores in the year 2012 for direct centers.

ε_i: is the error term.

Conceptual Framework

The conceptual framework of this study is illustrated in Figure 1.



Research Result

Results of input-orientated DEA

The study revealed that the means for technical efficiency scores of all centers were found to be 0.32 under CRS assumption and 0.774 under VRS. Table 1

Table 1 Summary statistics for TECRS and TEVRS scores for all center

	CRSTE	VRSTE
Mean	0.32	0.77
Maximum	1	1
Minimum	0.046	0.184
Std. Dev.	0.227	0.264

It was revealed that 45% of the centers were technically inefficient, 31.8% of these had technical efficiency scores ranging between 50 and 74.9% and 12% of them having scores below 50% (Table 1).

Table 2 Ranking of technical efficiency scores (TEVRS) for direct and indirect health centers

TEVRS	Direct Centers	%	Indirect Centers	%	All Centers	%
100%	65	54.6	32	56.1	97	55.1
75-99.9%	2	1.7	0	0	2	1.1
50-74.9%	38	31.9	18	31.6	58	31.9
<50%	14	11.8	7	12.3	21	11.9
	119		57		176	

The time trend for technical efficiency (VRS) of the direct centers over the period between the year 2009 and 2012 showed a declining pattern. The mean technical efficiency score was 0.86 in 2009, 0.80 in 2010, 0.77 in2011 and reached 0.69 in 2012 (Figure 1).

Input savings

One of the valuable advantages of DEA is the measurements of the levels of inputs and outputs that are needed for an inefficient DMU in order to be efficient. Including in the result of DEA are the calculated input slacks for each individual health center in this study. Table (3) shows the summary of the amounts needed from each input for both direct and indirect health centers to reach the level of 100% technical efficiency under variable return to scale assumption.

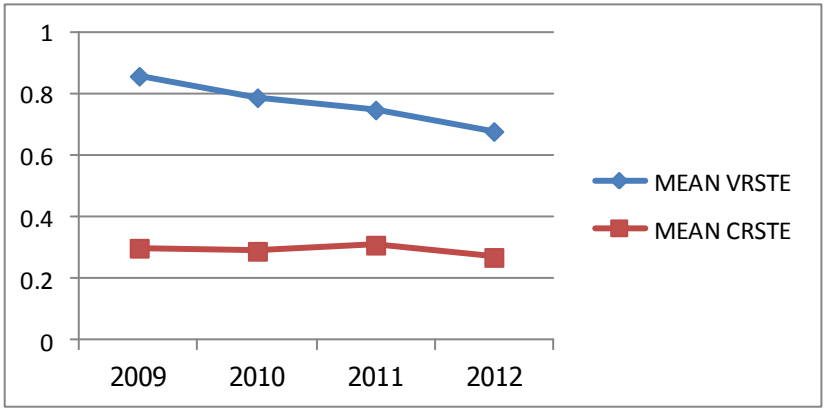


Figure 1 Time trend over the period (2009-2012) for technical efficiency (CRS) and (VRS) for direct centers

Table 3 Summary of input savings for direct and indirect health centers

Variables	Direct		Indirect	
	Actual	Excess	Actual	Excess
Physicians	80	3	109	5
Lab Technicians	113	20	134	31
Operational Expenses	446506	103796	343579	137822

Results of regression analysis

The result of regression analysis confirmed that the type of the health center whether direct or indirect was significantly affecting the technical inefficiency of the center. The negative sign of the coefficient indicates that if the center is direct; administered by NHIF the technical inefficiency will be lower by 0.44 times compare with indirect center, holding other variables constant (Table 4).

The location of the health center is proved by the result of the regression analysis in this study to have a significant effect on the technical inefficiency. The positive sign indicates that being in an urban area the health center will have increased technical inefficiency score by a magnitude of 1.7 when compared to rural health centers holding other variables constant (Table 4) and considering this as a base line effect (without the interaction effect of size discussed below). This could be explained by that the urban health centers use more inputs in order to keep an accepted level of quality as well as the uses of sophisticated equipment which consume more expenses and use more personnel. The mean for operational expenses per year was found to be 22303 SDG for urban centers compared with 6954 SDG for rural centers. Another explanation is that in the rural centers usually there were fewer labors, due to the less preference of medical personnel to work in rural areas. The mean for labor in urban centers was found to be 19 compared with 13 for rural centers.

The size of the health center (SIZE) was found to have a significant effect on its technical inefficiency score at 90% confidence interval in this study. Bigger health centers were 0.2 times less technically inefficient than smaller ones holding other variables

constant and considering this as a base line effect (without the effect of location in the interaction term discussed below). The sign of the coefficient was shown to be negative and this was expected since the bigger the health center (having more departments) the more attractive it would be for clients and consequently more output it produced, hence less technically inefficient.

The size square ($SIZE^2$) was also significantly influencing the technical inefficiency of the center. The positive sign of its coefficient meant that as the squared size of the center increased by one unit its technical inefficiency increased by 0.03 holding other variables constant. The study used this variable because the technical inefficiency is bound while the size is not. It was found that as the size increased the technical inefficiency decreased up to a certain level after which the technical inefficiency increased with increasing size.

Table 4 Result of Tobit regression

Tobit regression				Number of obs	=	176
				LR chi2(9)	=	59.79
				Prob > chi2	=	0
Log likelihood =	-97.4611			Pseudo R2	=	0.2347
TI	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
TYPE	-0.43588	0.133568	-3.26	0.001	-0.69958	-0.17218
LOC	1.706059	0.385478	4.43	0	0.945022	2.467096
SIZE	-0.20942	0.125528	-1.67	0.097*	-0.45725	0.038406
RMD	0.081998	0.037303	2.2	0.029	0.008351	0.155644
$SIZE^2$	0.026036	0.009008	2.89	0.004	0.008251	0.043821
TYPE* YR10	0.138572	0.138907	1	0.32	-0.13567	0.412811
TYPE* YR 11	0.167488	0.140785	1.19	0.236	-0.11046	0.445436
TYPE* YR 12	0.34764	0.134733	2.58	0.011	0.08164	0.61364

Table 4 (Continue)

LOC*SIZE	-0.19436	0.049737	-3.91	0	-0.29256	-0.09617
_cons	-0.01434	0.450519	-0.03	0.975	-0.90379	0.875103
/sigma	0.419076	0.038176			0.343707	0.494445
Obs. summary:						
		97 left-censored observations at ti<=0				
		79 uncensored observations				
		0 right-censored observations				

The ratio of medical staff to non-medical staff (RMD) was used in this study as a proxy for the redundancy in employment. It was confirmed by the result of the regression analysis that the effect of (RMD) on technical inefficiency was significant, and it contributed positively to it. This implied that as the (RMD) increased the technical inefficiency of the center increased by 0.08. This was true since the mean of (RMD) in this study was greater than one (>1) as shown by descriptive analysis having a figure of 1.9.

Three time dummy variables were used by this study to assess the time trend of technical inefficiency over the period from 2009 to 2012 and that was confined to the direct centers only due to availability of data over the above mentioned period of time. To obtain this the time dummies were multiplied by (TYPE). The result of regression revealed that the technical inefficiency of the direct centers was increasing over the period from 2009 to 2012 indicated by the positive signs of all time dummy variables meaning that the technical inefficiency scores of the centers in year 2010 and the year 2011 increased with reference to year 2009 but this increasing in technical inefficiency was insignificant statistically as shown by p values of 0.32 and 0.236 respectively (Table 4). The same as with the year 2012 the technical inefficiency scores increased by 0.35 with reference to year 2009 and that was statistically significant ($p<0.05$). This can be explained by the increase in inputs of the direct centers over these years. By comparing the means of each input and output between the

year 2009 and year 2012 it is found that the number of physicians increased by 60% and the number of laboratory technicians increased by 23% while the operational expenses decreased only by 10%. On the side of outputs there was 9% increase in the number of outpatient visits on average while the number of vaccinated children increased by 21%.

The variable LOC-SIZE was used in this study as an interaction term to assess the relationship between this complex and the technical inefficiency testing the hypothesis that the effect of the size of the health center varied with location. The result showed that the effect of size on technical inefficiency significantly varied with location as denoted by $p<0.05$ (Table 4). The negative sign of the coefficient indicated that the slope (that reflected the relationship between the size and technical inefficiency of the health center) was lower for urban center compared with rural one. The magnitude of the coefficient (0.19) indicated the difference between the effect of urban and rural location on the technical inefficiency of the health center. From the descriptive statistics it was found that the mean of the center size was 8.2 for urban centers compared with 7.2 for the rural.

Conclusion and recommendation

The results of this study are not far from what was obtained by previous studies in the region, Kirigia et al (2001) and Osei et al (2005).

This study shows that there were 45% of primary public health centers in Gezira State which run inefficiently. The direct, the rural, the large sized centers (to a certain limit) and centers with low medical staff to non-medical staff are more technically efficient than their counterparts.

Policy implications

Direct provision of services by NHIF would be confined only for efficient or potentially efficient health centers for better usage of resources.

The size of the health center should be adjusted to the optimum level that positioned the center in technically efficient status. Furthermore any plan of expansion of a health center or any department should be based on efficiency improving background.

Recommendations

Excess physicians or laboratory technicians as well as monetary resources can be reallocated to the most needed facilities.

It is important for the NHIF to consider the comprehensive package of primary health care with special attention to the vaccination of children in its all health centers for further improvement of their performance.

It is essential to exert more efforts for monitoring the trend of technical efficiency of primary health centers over time continuously through meticulous reporting of special targeted information in order to take appropriate protective and corrective actions as early as possible.

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