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MEASURING THE EFFICIENCY OF HEALTH SYSTEM IN SUDAN USING DATA ENVELPMENT ANALYSIS (DEA)

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Abstract *One of the central engrossment of health sector is Efficiency. Objectives of the study to measure the efficiency of the health system in Sudan and to apply Data Envelopment Analysis (DEA) in studying the efficiency of the health system in Sudan. Two outputs and two inputs are the variables of this study; Outputs include life expectancy at birth, infant mortality rate. Inputs of this study include current health expenditure (% of GDP) and hospital beds. The most important result that health expenditure, (% of GDP), impact significantly the efficiency of the Sudan health system. The overall efficiency of the health system in Sudan is inefficient, with only3 years (2001, 2002, and2010) as efficient over the 19 years, with an efficiency average of 0.954. The study presents some recommendations such as direct to conduct a study on measuring Sudan's health system performance using more indicators.*

Key Words: *Data Envelopment Analysis, health system, health expenditure, Efficiency, Sudan.*

1. Introduction

In health systems, measuring efficiency is sometimes the primary step in auditing the individual performance of production units. property development goals, developed by the world organization General Assembly, includes health as a serious part to confirm healthy lives and promote well-being for all ages by 2030(Asandului, &Fatulescu, 2014). Many factors will affect the health standing and a country's ability to deliver quality health services. Consistent with the World Health Organization (WHO), the key determinants of health development measure concerning the social and economic context, physical standing, and also the person's characteristics and behaviors (Belkić et al., 2000).

In general, the economic language "efficiency" means the absence of waste or employing the resource as effectively as attainable to satisfy an individual's desires and wishes. The conception of efficiency encompasses a minimum of two parts, particularly a participant role efficiency and technical efficiency, locative (or Pareto) efficiency is that the profit because of the reorganization of the inputs (Lena Bedawi & Osman Elnoor, 2019). Efficiency scores are derived employing data on inputs and outputs utilized in the health system.

Charnes was the primary one UN agency introduced Data Envelopment Analysis, (DEA) could be a non-parametric applied mathematics approach (linear programming), Cooper, and Rhodes in 1978 and more formalized (Banker, Charnes and Cooper, 1984). The technique was

initial applied to study hospital production in(1986, Banker, Joseph Conrad, and Strauss) followed by (Grosskopf and Valdmanis , 1987).

LITERATURE REVIEW

Below are samples of those including total factor productivity, locative efficiency, and technical efficiency. (Lena Bedawi Elfadli Elmonshied and A.Osman Elnoor Mosa Fadlalla, 2019)Their study objective to examined from an empirical point of view, the efficiency of public hospitals in Sudan- Gezira state using the foremost recent advances within the empirical literature on the measurement of efficiency. during this study applied DEA-type Malmquist efficiency used for estimating public hospital's efficiency and identified the foremost important sources of productivity gains or losses For the DEA technique. the foremost important results concerning economic (cost) efficiency are summarized as follows the overall cost efficiency is estimated at 24 percent, implying a median cost inefficiency of 76 percent, results on productivity growth are public hospitals haven't been able to achieve productivity improvement for becoming more technologically advanced (average tech is -17 percent., the results concerning scale economy, supported the parametric method of the DEA, suggest that the foremost public hospitals in Sudan- Gezira state (60 percent) are in conditions of constant returns to scale thus, have the required optimal size. Furthermore, 40 percent of public hospitals within the sample are having size problems.

This study aimed to estimate the technical efficiency of the DHs in Bangladesh. A Book Tobit regression model was applied for assessing the association of institutional and environmental characteristics with the technical potency scores. Since the common technical efficiency of the DHs was seventy-nine, there's little scope for overall improvements in these facilities by adjusting inputs. Therefore, they recommend investing further within the DHs for the improvement of services (Sayed Ahmed, Md. Zahid Hasan, Samia Laokri, Zerin Jannat, Mohammad Wahid Ahmed, Farzana Dorin, Veronica Vargas, and Jahangir A. M. Khan, 2019).

(Mustapha D. Ibrahim and Sahand Daneshvar, 2018) the aim of the study, they evaluate the efficiency of the healthcare system in Lebanon from 2000 through 2015 by applying a modified data envelopment analysis (DEA) model. It additionally shows that reduction in health expenditure doesn't essentially reduce efficiency if the operational and technical side of the healthcare system is improved. The study infers that the healthcare system in Lebanon is capable of withstanding the rise in health demand provided any resources unit of measurement created accessibly and also the prevailing technical and operational improvement are maintained.

(GibrIlJarjue, Norashidah Mohamed Nor, Judhianaabdul Ghani, and SuhaIlaHj. Abd Jalil, 2015) during this study to measure the technical and scale efficiency of the health centers within The Gambia and to estimate the increase in output and/or a decrease in input that make inefficient health centers more efficient are specific objectives to this study. The study uses an output-oriented variable that comes to scale Data Envelopment Analysis (DEA) method. The widespread inefficiency across the complete secondary healthcare service delivery system within the African nation is horrifying and also the results recommend that health centers are using resources over they need.

(Martha Ramírez-Valdivia, Sergio Maturana, Jennifer Mendoza-Alonzo and Jaime Bustos, 2015)they're using different approaches for investigating and estimating the technical efficiency of a PHC. The information that was utilized during this study came from 259 Chilean municipalities. The study enclosed 2 outputs - medical and check-up visits - and three inputs - employees, general service, and medical expenses. For the DEA, The study utilized a variable return to scale output-oriented model. Additionally to process a frontier of "best practice", this study merged the PCA with the SFA to make an innovative approach to combining outputs.

(Mohamed Said Abou El-Seoud, 2013) aims at investigating and evaluating the efficiency of a sample of public hospitals in KSA, it adopted Data Envelopment Analysis (DEA). It is organized into five sections. The study results of measuring the efficiency of a sample of hospitals that 60% of them have low efficiency because of different reasons. The study suggests to lift the quantity of efficiency either increasing output or reducing inputs.

(Almoghirah Alamin Gadasseed Abdellah, 2012) The study disclosed that the common 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 additionally showed that 44.6% of direct and 43.7% of indirect health centers were run inefficiently. The study found that the type of the health facility, the size, and thus the location-size were found to be significant and negatively affecting the technical inefficiency of the hospice. Furthermore, the study suggested corrective actions for policymakers to bolster the performance of primary health centers.

(Ismail.M.A, 2010) aims at estimating and evaluating the relative technical efficiency of health institutions at the state level in Sudan and to draw policy implications for the health industry. Thereafter, the associate output-orientated Data Envelopment Analysis (DEA) model was accustomed to estimate the technical efficiency of states' health establishments in Sudan for the year of 2007. The results also show that 6 states were scale inefficient of which three states were operating under decreasing returns to scale (DRS) and also the remaining three were operating under increasing returns to scale (IRS). The study recommends that to redistribute health institutions within each inefficient state.

(Antonio C GonçalvesI; Cláudio P NoronhaI; Marcos PE LinsII, Renan MVR Almeida, 2007) the target of the study to use the Data Envelopment Analysis methodology for evaluating the performance of public hospitals, in terms of clinical medical admissions. The end up in the hospitals studied, circulatory diseases were the foremost prevalent (23.6% of admissions), and also the speed was 10.3% of admissions. Among the state, four reached 100% efficiency, seven were between eighty-five and 100%, 10 were between seventy and eighty-five percent and 10 had an efficiency of but 70%.

SUDAN ECONOMY AND HEALTH SECTOR

Briefly outlines of Sudan Economy

Sudan, once the most important country in Africa and therefore the Arab world until 2011, split into Sudan and South Sudan. Sudan is now the third-largest country in Africa and the Arab countries also. Half of the population over 15 years in northern states is literate, (49.2% of females and 50.6% of males) (Abubakr Abdelraouf et al,2016). According to the UNDP-HDI classification, Sudan is assessed amongst the lower-medium-income economies and low human

development group. Human Development Index for the country (0.505) was very low in 2004, accordingly, the country ranked 139 out of 177 countries that the index was calculated (World Development Indicator Database, 2005). Sudan's economy is largely agricultural, with inadequate infrastructure, and was skipped over different stages of evolution. Through these stages, different economic policies have been applied, which have had a transparent impact on the features formulation of this economy. According to the globe Bank, the most barriers preventing Sudan from achieving its economic goals are conflicts; reliance on oil; neglect of agriculture and livestock and energy sources; unfair distribution of economic resources and access to natural resources; government failure; the low credibility of public policy; and insufficient incentives for personal sector investors (Frank newsletter, 2016). Sudan's GDP growth was an estimated 4.1% in 2018, up slightly from 3.3% in 2017. On the demand side, private consumption was the most contributor to growth, while the present account deficit, an estimated 2.4% of GDP in 2018, detracted from growth. On the provision side, mining growth of However; this growth has not been translated into improved living standards for the bulk of the Sudanese people. Sudan is in debt distress, with external debt an estimated 62% of GDP in 2018(AFD, Sudan Economic Outlook, 2019). Sudan, once the biggest country in Africa and also the Arab world until 2011, split into Sudan and South Sudan. Sudan is now the third-largest country in Africa and therefore the Arab countries also. Since 1997, the annual growth of the economy has been around 5-6% and the rate of inflation has come right down to one digit. In 2011, under the terms of the good Peace Agreement, the Republic of South Sudan formed in formerly stated as southern Sudan states. After the separation, Sudan lost 75% of the oil resources and almost half the country's revenue. Although unemployment rose to 18% as a result of the rapid rate of exchange depreciation and protracted inflation, poverty and inequality declined between 2010 and 2015 (UNDP,2014).

Outlines the Health System in Sudan

The history of comprehensive and arranged medical services in Sudan dates back to 1899 with the inauguration of the Anglo Egyptian condominium rule, which showed some concern for the health of the indigenous population. In 1905 the Central Sanitary Board was established to safeguard the final public and curative health affairs. In 1924, health services followed, within the main, an officiated pattern with a mix of governmental control and governmental provision. The Ministry of Health (MOH) was established in 1949, representing a big development in the history of health administration in Sudan. In 1954 Sudan was admitted as an associate member of the planet Health Organization (WHO). This marked the start of WHO-assisted projects to assist the country face its major public health problems (Lena Bedawi et al, 2019). an oversized percentage of the population is young; the high ratio of adolescents and ladies implies a high rate of dependency and thus an overburdened work sector.

Health; Policies and Plans in Sudan

The most important of which are those regarding maternal health and birth prevention, Child care and immunization, and control programs of communicable diseases including Malaria, Schistosomiasis, Tuberculosis, HIV/AIDS, Leishmaniosis, and non-communicable disease

control programs. The available information showed that the final government health expenditure is extremely low and so the health sector is under-funded. The govt. was faced with several political and economic constraints that resulted during a decrease in the proportion of GDP allocated for health from 1.5% in 1982 to 0.07% in 1990. The average expectancy at birth was estimated at around 63.8 years for both sexes in 2014. Sudan continues to be at risk of epidemics including measles, meningitis, and acute watery diarrhea. The number, ratio, and kind of doctors differ from state to a distinct. The proportion of medical doctors, nurses, and midwives is 1.23 per 1000 population the country continues to be within the critical shortage zone in step with the WHO criteria of two.28 health care professionals per 1000 population and currently, Sudan has one physician for each 3,333 population in line with IBRD report (IBRD report, 2014). Within this broad vision, the health goals should ideally be supported the health challenges facing the country and thus due to efficiently and equitably address these challenges. Investing in future health policymakers and changers are the key to a much better health system and a healthier nation. The strength of the health system is that they need several long-term and short-term policies and techniques but because it was seen that it had been insufficient because there's no sustainability and no continuous updating of the implemented plans (Ibrahim M et al2017).

Health System Organization

Sudan's health system is complex with countless underdeveloped areas. Health services are provided by both the overall public and private sectors. the general public Health System was historically the only real provider of health services(Suzanne Sharief, 2014). Health services are provided through different partners including in addition to Federal and State Ministries of Health, soldiers, Police, universities, the private sector (both for-profit and philanthropic), and also civil society. the govt. the health system may be a three-tiered network. in theory, PHC units are staffed by community doctors (CHWs), dressing stations are staffed by a nurse, and dispensaries are headed by a health care provider. The medical institution is the referral point for the lower-level facilities. it's headed by a physician (medical officer). Health centers are managed by the localities. the agricultural hospitals, on the common, have bed capacities of 40 to 100 and managed by SMOHs. the most provider director and agency answerable for health services is that the Federal Ministry of Health besides the military and therefore the police hospitals and therefore the increasing number of personal hospitals and clinics(M. A. Ibrahim et al, 2017).

Health System in Sudan; Public Sector

The government of Sudan has succeeded in providing free health services since the colonial period, through independence and up until the start of the 1990s (Suzanne Sharief, 2014). The Federal Ministry of Health (FMOH), State Ministries of Health (SMOH), and the native Health System are the three-layered health system structure. The FMOH with its 10 general directorates became the most layer for Policymaking, strategic planning, coordination, regulation, diplomacy, and central source of technical support and guidance for the states. These roles are reflected within the organizational structure for the FMOH. The FMOH is linked to 18 State Ministries of

Health. Within each State, there is a form of localities (134 in total) managed through a district health system. The 2nd layer, composed of 18 State Ministries of Health, that shares the responsibility of coming up with, legislation and financing with the Federal MOH. However, it takes direct responsibility for the organization of health within the state and support of the local health system. Nevertheless, due to their weak capacities, there are notable gaps. The third layer within the federal setup is that the locality level. The local health system relies on the district health system approach. It emphasizes the principles of primary health care represented in decentralization, community participation, inter-sectoral coordination, and integration of services. The district health system has been established to strengthen the health management capacity within the executive boundaries of the localities. The implementation of the district health system faced plenty of constraints. the most constraints included instability of medical doctors, continuous amendments in government act, lack of state ministry of health support, lack of resources, and absence of community involvement in health affairs (Health system profile, Sudan, 2006).

Health System in Sudan; Private Sector

Until 1990 there are only 5 private hospitals, but the private sector in health care has expanded considerably during the 90s. Development of the for-profit private sector in recent years, encouraged by the govt., both provided a marketplace for and is maybe increasingly being driven by the large production of doctors. Private health services, are concentrated mainly in urban and better-off rural areas and are looked as if it would be of upper quality than government services and mainly accessed by the better-off. Public practitioners are allowed to practice within the private sector additionally to their public facilities. The private sector of health care also provides a wide selection of health services and is principally profitable. Larger public hospitals including teaching hospitals and specialized centers accept patients without being referred from the lower facilities indicating a poor referral system. within the last decade, the quantity of personal hospitals has been an increasing trend and it continues to be. On the opposite hand, non-profit organizations caring for several different programs are widely spreading in Sudan and are functioning in coordination with the federal ministry of health. for example, Medicines Sans Frontiers (MSF) ran a variety of hospitals in a few States particularly those undergoing armed conflicts and operated some health clinics. These hospitals provided secondary care, consultations, and hospitalization when needed, while health clinics provided reproductive health, antenatal care, on top of other basic medical care services. Furthermore, along with the FMOH, MSF conducted vaccination campaigns and operated some newly introduced mobile clinics concerned with education, vaccination, and child and ladies care (Health system profile, Sudan, 2006).

Health System in Sudan; obstacles & Challenges

The health system had two main obstacles: a scarcity of medical personnel, and a scarcity of health facilities. This disruption of the health system is within the kind of health infrastructure destruction or the requirement for maintenance and repair. the most problem in Sudan is the migration of trained professionals like most African countries, additionally to the poor

management and rationale distribution of the present physicians and paramedics. Furthermore, in the relevancy of the services provided at the general public health, these services don't seem to be achieving optimum utilization rates. as an example, only 81.6% of public health units provide vaccination for kids and 67.3% provide contraception services(Ibrahim M. A. Ibrahim et al, 2017). Health services suffer from a variety of challenges: weak health system with a very strong vertical programming approach, with a little window for effective integration that might result in huge opportunities to succeed in the 'most in need'. Deficiencies are noted within the services delivery modes also because the referrals system, insufficient financial resources and lack of a sustainable health financing strategy, poor distribution and retention of a certified health workforce, lack of implementation of standards of care, weak infrastructure and distribution, few health facilities constructed to code, and quality and unaffordability of tertiary services resulting in patients seeking treatment abroad. Endemic to health services in Sudan is additionally poor integration between curative and preventive services, and customarily limited vision, planning, and implementation.

2. Research Methodology

Nowadays, the organization of health services remains a key issue of concern. Progressing health goals is changing into more and more vital at the domestic, national, and international levels. In many countries, various studies were executed in evaluating the efficiency of health facilities by employing Data Envelopment Analysis (DEA). For the aim of this study, the Data Envelopment Analysis (DEA) methodology was used to see the technical efficiency of the public health system in Sudan.

Problem of the Study

The Data Envelopment Analysis (DEA) has become one of the constructive programs that employed as a measurement of the performance efficiency among health organizations. The infrastructure of the health system in Sudan is commonly weak with restricted access for rural and underprivileged population, shortage of essential equipment& medications and limited budget affected the health system, also the weaknesses within the efficiency of employing available resources. Therefore, the study plan to quantify (measure) the efficiency of the health system of Sudan.

Objectives of the Study

The overall objective of this study is to assess the efficiency and productivity of the health system in Sudan. The particular objectives are:
To measure (quantify) the efficiency of the health system in Sudan;
To stratify DEA in studying the efficiency of the health system in Sudan;
To appraise the efficiency and present efficiency of the health system within the context of finance, infrastructure, and medical indicators.

Importance of the Study

Sudan is split into 26 states, then it became 18 states, every state encompasses a ministry for health. The health sector in Sudan was (and is still) facing challenges, the assessment of the

health system and measuring of its efficiency became a necessity for guaranteeing the development of the standard and optimum utilization of resources. It's important for the health system in Sudan to measure the efficiency of rising the operations of the present health system that may impact the health system offered to the citizens.

Data Envelopment Analysis (DEA)

This study uses the information envelopment analysis(DEA) method developed by (Charnes et al. 1978) to judge the efficiency of the health system in Sudan. This method has made it possible to increase the analysis of technical efficiency to multi-product situations. Data Envelopment Analysis (DEA) could be a non-parametric mathematical programming approach to a frontier estimation that uses applied math to sketch a boundary function (efficient frontier) to observed data for relatively homogenous firms.

The formulation of the DEA method

To measure the efficiency of a unit: (Charmes, et al 1978), proposed the model (M1): to calculate efficiency for every unit of production (Charnes Cooper and Rodhes 1978 and Cooper et al. 2006 and Cooper et al. 2011) suggested the subsequent fractional model (CCR):

$$\text{Max } h_0 = \frac{\sum_{r=1}^{t} U_r \, Y_{rj0}}{\sum_{i=1}^{m} Vi \, Xij_o} \textbf{ (M1)}$$

Under constraint

$$\frac{\sum_{r=1}^{t} U_r \, Y_{rj0}}{\sum_{i=1}^{m} Vi \, Xij_o} \leq 1 \quad ; j = 1 \ldots j_0 \ldots n$$

$U_r, V_i \geq \varepsilon \;\; ; \forall r, i$

Y_{rj}: observed quantity of output r produced by unit j.

X_{ij}: the observed quantity of input i used by unit j.

U_r: the weight of the output r.

V_i: the weight of the input i.

N: the number of units.

ε: very small positive quantity.

M2

Since the BCC model is an extension of the CCR model, its formula is similar, and the difference between them is the inclusion of additional restrictions on the status of the BCC model. This restriction is known as the restriction of limits (Banker et al. 1984) and (Cooper et al. 2011). So the BCC model was hypothesized with the VRS hypothesis as:

The first step

$$\text{Max } h_0 = \sum_{r=1}^{t} U_r \, Y_{rj0} \qquad \textbf{(M2)}$$

Under constraint: $-Vi \leq -\varepsilon$

$$\sum_{r=1}^{t} Ur \, Y_{rj} - \sum_{i=1}^{m} Vi \, Xij \leq 0$$

Yrj: observed quantity of output r produced by unit j.
Xij: the observed quantity of input i used by unit j.
Ur: the weight of the output r.
Vi: the weight of the input i.
N: the number of units.
e: very small positive quantity.

Dual Step

This model can solve the dual of (M2) as the primal, if we have in the primal t + m variables then the dual has t + m constraint and if we have i+ j constraint in the primal then we have i+ j variable in the dual.

$$\text{Min } Z_0 - \varepsilon \sum_{r=1}^{t} s_r^+ - \varepsilon \sum_{i=1}^{m} S_i^- \qquad \textbf{(M3)}$$

$$X_{ij0} - S_i^- - \sum_{j=1}^{n} Xij \, \lambda_j = 0 \qquad ; i=1.....m$$

$$-S_r^+ + \sum_{r=1}^{t} Yrj\lambda \, j = Yrj_0 \qquad ;r=1.....t$$

$$\lambda_j, S_i^-, s_r^+ \geq 0 \, ; \forall \, j,r \text{ et } i$$

$$\lambda_j, S_r^+, S_i^- \text{ et } Z_0$$

Dual variables.

Yrj: observed quantity of output r produced by unit j.
Xij: the observed quantity of input i used by unit j.
N: the number of units.
e: very small positive quantity.
Is the optimal value of Z0 in (M3).
The unit j0 would be efficient in the Pareto sense if = 1 and are zero whatever i and r. The weights Vi and Ur defined in the model M1 considered as dual variables associated respectively with the inputs or outputs.

- **M4:**(Baker et al 1984) modified the model (M1), taking into account the non-constancy of scale returns. The model (M4) reports a measure of the efficiency "Pure technical" (input) of the unit j0.

$$\text{Minh} - \varepsilon\left[\sum_{i=1}^{m} S_i^- + \sum_{r=1}^{t} S_r^+\right]$$

Under constraint:

$$h\, X_{ij_0} - \sum_{j=1}^{n} X_{ij_0}\lambda j - s_i^- = 0 \quad ; \; i = 1.....m \quad \textbf{(M4)}$$

$$\sum_{j=1}^{n} Y_{rj}\lambda_j - S_r^+ = Y_{rj_0} \qquad ; r = 1.....t$$

$$\sum_{j=1}^{n} \lambda_j = 1, \; \lambda j \; , \quad S_i^- \; , \; S_r^+ \geq 0, \quad \lambda j \; , \; S_i^- , \; S_r^+$$

And
h are dual variables.
Yrj: observed quantity of output r produced by unit j.
Xij: the observed quantity of input i used by unit j.
N: the number of units.
e: Very small positive quantity.
The convexity constraint allows us to confirm that (M4) gives a measure of the "purely technical" efficiency of the unit j0. that the convexity constraint will make sure that a unit is composed of the identical scale size because of the target unit j0. The efficiency "Scale efficiency" given by the model (M3) is less than that given by the model (M4), due to the constraint of convexity added to(M4). The measurements "Scale efficiency" given by(M3) and (M4) are going to be equal if and on condition that, there exists an optimal solution of (M3) specified.

Efficiency Analysis of the Health System in Sudan

In this study, to judge the relative efficiency of the health system in Sudan over 19 years (2000–2018). This study utilized an input orientation model. The input-orientation model is appropriate in this context because the inputs are assumed to be at the discretion of the health sector and should be properly utilized to realize the simplest possible outcome. This analysis provides policymakers and the general public with useful information regarding the state of the health system and provides improvement focused on health outcomes for the proper utilization of resources. In this study for the efficiency, we decide lifespan at birth, morbidity rate(per 1,000 live births) as outputs. Current health expenditure (% of GDP) and hospital beds (per 1,000 people) as inputs. Expectancy at birth (years) could be a robust health system outcome used widely in the literature. The effect of an increase in health expenditure that has on lifetime was accentuated by. it's considered to be one of the first indicators of the health system efficiency of a country. The choice of inputs and outputs is illustrated within the context of the health system in Sudan for the amount of cover 2000-2018.

Table 1: Inputs and outputs selected

Inputs	Outputs
X1: Current health expenditure , (% of GDP)	Y1: healthy life expectancy at birth (years)
X2: Hospital bids (per 1000 people)	Y2: infant mortality rate(per 1,000 live births)

(Source: Ministry of Health of Sudan and World Bank Data)

Table 2: Variable used in the Study DEA Model

Variable	Role	Definition
Current Health Expenditure (% of GDP)	Input (x1)	The sum of public and private health expenditure whichcovershealthserviceprovision(preventive and curative).
Hospital beds (per 1,000 people)	Input (x2)	Hospital beds include inpatient beds available in public,private,general,andspecializedhospitals.
Life expectancy at birth, total(years)	Output (y1)	Lifeexpectancyatbirthindicatesthenumberofyears a newborn infant would live if prevailing patterns of mortalityatthetimeofitsbirthweretostaythesame throughout its life.
Mortality rate, infant (per 1,000 live births)	Output (y2)	Infant mortality rate is the number of infants dying before reaching one year of age.

This study uses the DEA model for variable returns to scale to measure the efficiency of the health system in Sudan for the period cover 2000 to 2018, this data are from the World Bank database. The results obtained by the DEAP2.1 software are shown in the following table:

Table 3: Score Efficiency between 2000 and 2018

Year	Score efficiency
2000	0.960
2001	1.000
2002	1.000
2003	0.997
2004	0.996
2005	0.996
2006	0.996
2007	0.996
2008	0.997
2009	0.999
2010	1.000
2011	0.882

2012	0.897
2013	0.890
2014	0.900
2015	0.898
2016	0.904
2017	0.905
2018	0.908

The efficiency scores for every year from 2000 to 2018; 1.000 significies the year as efficient and anything less as inefficient. The results of the DEA model reveals that the general efficiency of the health system in Sudan is inefficient, with only3 years (2001, 2002, and 2010) as efficient over the 19 years, with an efficiency average of 0.954, there's a pointy decrease in efficiency from 2011 to 2013.

3. Results & Discussion

3.1 Results

The efficiency improved constantly from 2000 to 2010, therefore the improvements in efficiency are often attributed to the improved health sector, additionally to strengthening other aspects of the administrative and technical nature of the health sector. the info within the study shows a decrease in health expenditure, total (% of GDP), from 2003 to 2009; however, the efficiency continues to signify steady improvement. The results contradict the hypothesis of which states that a rise publically health expenditure would automatically cause an improvement in self-estimated health status. The study analysis shows that improvement within the health system in Sudan has more to undertake health policy and proper implementation than increasing health expenditure. the burden distribution of the variables utilized in the efficiency evaluation shows that (x2) hospital beds (per 1,000 people) and (y1) lifetime at birth total (years) contribute the foremost to efficiency. Therefore, improving the utilization of the number of beds and increasing the anticipation at birth will affect efficiency significantly. Health expenditure, (x1) (% of GDP), impact significantly the efficiency of the Sudan health system.

Table 4: Levels of improvement required

Year		Original value	Projected value	The improvement required	Improvement rate
2000	health life expectancy at birth	58.472	60.579	2.107	----------
	Mortality rate, infant	66.900	66.900	----------	----------
	Hospital bids	0.800	0.720	0.080	----------
	Current health expenditure (%GDP)	3.607	3.463	0.144	----------
	health life expectancy at	58,859	58.859	----------	----------

	birth				
2001	Mortality rate, infant	65.000	65,000	----------	----------
	Hospital bids	0.700	0.700	----------	----------
	Current health expenditure (%GDP)	3.365	3.365	----------	----------
2002	health life expectancy at birth	59.258	59.258	----------	----------
	Mortality rate, infant	63.100	63.100	----------	----------
	Hospital bids	0.700	0.700	----------	----------
	Current health expenditure (%GDP)	3.300	3.300	----------	----------
2003	health life expectancy at birth	59.670	59.670	----------	----------
	Mortality rate, infant	61.200	61.200	----------	----------
	Hospital bids	0.700	0.698	0.002	----------
	Current health expenditure (%GDP)	3.892	3.780	0.022	----------
2004	health life expectancy at birth	60.092	60.092	----------	----------
	Mortality rate, infant	59.500	59.500	----------	----------
	Hospital bids	0.700	0.697	0.003	----------
	Current health expenditure (%GDP)	4.156	3.974	0.182	----------
2005	health life expectancy at birth	60.525	60.525	----------	----------
	Mortality rate, infant	57.800	57.800	----------	----------
	Hospital bids	0.700	0.697	0.003	----------
	Current health expenditure (%GDP)	4.094	4.079	0.015	
2006	health life expectancy at birth	60.969	60.969	----------	----------
	Mortality rate, infant	56.200	56200	----------	----------
	Hospital bids	0.700	0.697	0.003	----------
	Current health expenditure (%GDP)	4.885	4.358	0.527	----------

2007	health life expectancy at birth	61.422	60.422	----------	----------
	Mortality rate, infant	54.700	54.700	----------	----------
	Hospital bids	0.700	0.697	0.003	----------
	Current health expenditure (%GDP)	5.663	4.541	1.122	----------
2008	health life expectancy at birth	61.879	61.879	----------	----------
	Mortality rate, infant	53.400	53.400	----------	----------
	Hospital bids	0.700	0.698	0.002	----------
	Current health expenditure (%GDP)	5.423	4.709	0.715	----------
2009	health life expectancy at birth	62.330	62.330	----------	----------
	Mortality rate, infant	52.100	52.100	----------	----------
	Hospital bids	0.700	0.699	0.001	----------
	Current health expenditure (%GDP)	6.232	4.876	1.356	----------
2010	health life expectancy at birth	62.764	62.764	----------	----------
	Mortality rate, infant	50.900	50.900	----------	----------
	Hospital bids	0.700	0.700	----------	----------
	Current health expenditure (%GDP)	5.032	5.032	----------	----------

For the amount between 2000 and 2010, we notice a drop efficiency of the health system but it remains the performance turn and that we can consider it efficient. This success is thanks to the great economic performance of Sudan during the 2005-2010 periods which enabled the country to experience greater prosperity. In 2010, Sudan was considered because of the 17th fastest growing economy within the world given the rapid development of the country(Development Economics in Sudan). Five years of the unprecedented economic process. Sudan's production peaked at a median of virtually 500,000 barrels per day in 2007, before falling back somewhat in 2008-2009(Frank newsletter, 2016). The original value and also the projected value for the input & output indicators are equal within the years 2001, 2002, and 2010 meaning an efficient health system in Sudan were the efficiency score equal to 1.000.

Table 5: Levels of improvement required

Year		Original value	Projected value	The improvement required	Improvement rate
	health life expectancy at	63.171	63.171	----------	----------

	birth				-
2011	Mortality rate, infant	49.700	51.735	2.035	----------
	Hospital bids	0.800	0.706	0.094	----------
	Current health expenditure (%GDP)	5.685	5.016	0.669	----------
2012	health life expectancy at birth	63.542	63.542	----------	----------
	Mortality rate, infant	48.600	54.966	6.366	----------
	Hospital bids	0.800	0.718	0,082	----------
	Current health expenditure (%GDP)	5.310	4.763	0.547	_____
2013	health life expectancy at birth	63.875	63.875	----------	----------
	Mortality rate, infant	47.600	51.801	4.201	----------
	Hospital bids	0.800	0.712	0.088	----------
	Current health expenditure (%GDP)	6.501	5.121	1.380	----------
2014	health life expectancy at birth	64.169	64.169	----------	----------
	Mortality rate, infant	46.500	53.782	7.282	----------
	Hospital bids	0.800	0.720	0.080	----------
	Current health expenditure (%GDP)	5.528	4.977	0.551	----------
2015	health life expectancy at birth	64.429	64.429	----------	----------
	Mortality rate, infant	45.400	52.250	6.850	----------
	Hospital bids	0.800	0.719	0.081	----------
	Current health expenditure (%GDP)	6.805	5.165	1.640	----------
2016	health life expectancy at birth	64.663	64.663	----------	----------
	Mortality rate, infant	44.400	53.114	8.714	----------

	Hospital bids	0.800	0.723	0.077	----------
	Current health expenditure (%GDP)	5.665	5.119	0.546	----------
2017	health life expectancy at birth	64.881	64.881	----------	----------
	Mortality rate, infant	43.300	52.617	9.317	----------
	Hospital bids	0.800	0.724	0.076	----------
	Current health expenditure (%GDP)	6.136	5.202	0.934	----------
2018	health life expectancy at birth	65.099	65.099	----------	----------
	Mortality rate, infant	42.100	52.794	10.694	----------
	Hospital bids	0.800	0.726	0.074	----------
	Current health expenditure (%GDP)	6.205	5.219	0.986	----------

The indicator health lifetime at birth had a stable increase from 2005 till 2018 thanks to the rise in hospital beds. The low economic indicators and therefore the general decline in strength resulting from the economic difficulties in 2011 after the deterioration of the most economic aggregates and South Sudan separated as an independent country. After oil exportation started, Sudan's GDP witnessed continuous growth from 2000 until 2010. In 2012 after the secession of South Sudan and thereby remove roughly 75% of production, the speed declined to just one.4% (AEO, 2019).

3.2 Discussion

Poor distribution of health expenditure and corruption, regardless of the external threats such as brain drain, prolonged economic sanction, institutional and human capacity weaknesses, high youth unemployment, a high external debt burden, and climate change and separation from South Sudan also the with 13.9% only for education and public health that brought down the economic support to achieve the goals, the weaknesses within the health system in Sudan. After the year 2011, all these weak indicators led to the deterioration of the health system in Sudan.

4. Conclusion

In this study, we use the data envelopment analysis (DEA) model for assessing the efficiency of the health system in Sudan and to infer if the health system is capable of handling the increase in demand of health services due to the growing number of migration from rural areas to urban centers.

However, the study presents an overview of Sudan's health system performance based on the selected and available indicators. The study analysis was based on a time series data over 19 years and hence does not pretend to provide a definite conclusion regarding the overall health efficiency level of Sudan.

The main results of this study suggest that the health system in Sudan is improving its efficiency and continuous to do so, the competency of the health system to improve services if more resources are made available for the health system. In terms of funding and the ability of the Sudanese health system to withstand the increase in demand for services, further investment in the health system would yield a positive outcome, as the analysis has shown that the health system continues to improve even with the decrease in health expenditure.

Based on the results, the study presents some recommendations such as direct to conduct a study on measuring Sudan's health system performance using more indicators, encourage the studies for the determination of the causes for the weaknesses within the health system in Sudan.

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