Examination On Level Of Scale Efficiency In Public Hospitals In Tanzania

Fatuma Fumbwe
Mzumbe University
Robert Lihawa
Mzumbe University
Felician Andrew
Mzumbe University
George Kinyanjui
University of Capetown
Eliaza Mkuna (eliazamkuna@hotmail.com)
Mzumbe University https://orcid.org/0000-0001-7682-0740

Research

Keywords: Scale efficiency, Public hospitals, Data Envelopment Analysis

Posted Date: January 4th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-42431/v2

Version of Record: A version of this preprint was published at Cost Effectiveness and Resource Allocation on August 11th, 2021. See the published version at https://doi.org/10.1186/s12962-021-00305-4.

Examination On Level Of Scale Efficiency In Public Hospitals In Tanzania

FatumaFumbwe[1]., Robert Lihawa[1*]., Felician Andrew[1]., George Kinyanjui[2]., Eliaza Mkuna[1]
[1]Mzumbe University, Faculty of Social Sciences, Department of Economics, P. O Box 5, Morogoro Tanzania
[2] Senior Researcher, University of Cape Town, South Africa
*Corresponding author: ejmkuna@mzumbe.ac.tz or eliazamkuna@hotmail.com

Abstract

Purpose: Tanzania has implemented policies that aim at improvinghealth sector performance as well as the general health status of citizens. Establishment of community insurance fund, increase government budget allocation in health sector, establishment of institutions for critical and special diseases like Tanzania Ocean road cancer institute, Muhimbili Orthopaedic Institute and many other that aim at improving sector efficiency. These efforts and policies had a direct impact on improving the health sector and achieving Sustainable Development Goals (SDGs). Despite these improvement efforts, the health sector continues to face enormous challenges. Among the major challenges identified is the level of inefficiencies in healthcare delivery. It is for this reason; this paper examines the scale efficiency level in Tanzania's public hospitals.

Methods: Using data from the Ministry of Health, this paper employs the Data Envelopment Analysis (DEA) to examine Tanzania's public hospital efficiency levels.

Results: Findings showed that the average scale efficiency was 78.6%.and 72.9%for regional and district hospitals respectively. Additionally, 43.8% of the regional referral hospitals attained the most productive scale size compared to 21.05% in district hospitals.

Conclusion: The study concludes that there is dire need for the ministry of health to consider resource reallocation across public hospitals. Periodic re-estimation of efficiency levels coupled with increased health care input injection is of urgent need.

Keywords: Scale efficiency, Public hospitals, Data Envelopment Analysis,

1.0 Background

The estimation of efficiency in Tanzania's public hospitals is crucial in evaluating health policy initiatives and making comparative health analyses(Biorn, 2003). Improvement in the efficiency of hospitals can lead to a decrease in the government spending on healthcare services. Moreover, the saved funds can be reallocated in the expansion of other healthcare programs like rehabilitation, cure and increase engagement in diseases' preventive programs. In the end this will have great impacts in the development of the quality of the provided health services in a country (WHO, 2019).

In improving the efficiency in the health sector, the Government of Tanzania has increased efforts to address health sector challenges. Among others, the efforts include construction of health facilities throughout the country, training health experts, increasing the budget for medication, implementation of various Health Sector Strategic Plans (HSSP I, II, III and the current HSSP IV of 2015 to 2020) and enhance country medical store department (MSD).In spite of the efforts, it has been observed that efficiency in the health sector has continued to be a significant problem. A case in point, in 2018, there were 350 health centers and 1,000 dispensaries countrywide, whereby one medical doctor was attending approximately 26,000 to 30,000 patients per year (WHO, 2019). This ratio is higher than the requirements of the international standards based on the WHO recommendation for developing countries, which advised that one medical doctor should attend a maximum number of 10,000 patients per year. On the other hand, the WHO (2016) reported that, Tanzania has 0.39 nurses and 0.26-0.30 clinical staff (medical doctors, assistant medical officers and clinical officers) per 1000 population. This indicates that, on average, there is one prescriber (generally mid-level providers trained in-country, rather than medical doctors) in each primary facility with the workload averaging 29 outpatients per clinician per day in health centers and 20 in dispensaries. Regarding hospital facilities, the World Bank (2018), reported that hospital beds for the Tanzania were 0.7 units per thousand people in 2010 which is 50% short from 1976 ratio of 1.4 units per thousand people. It is for this reason, the WHO had recently ranked Tanzania healthcare system at 156 out of 191 countries with the overall efficiency index of 0.422(WHO, 2019).

Inefficiency in the public health sector has further being caused by inadequate government budget allocation. For instance, between the years 2002 and 2013, in real terms, the government of

Tanzania's health expenditure as a percentage of total health expenditure decreased from 45% to 36%. High proportions of Tanzania's total health expenditure are financed by foreign donors that reached to 48% in fiscal year 2011/12with the household/out-of-pocket spending of 33% in 2011/12 rather than from sustainable or prepaid sources such as general government revenue or health insurance (Tanzania Health Financing Profile, 2016). In addition, Tanzania's current Health Sector Strategic Plan IV that has reached the midterm of its implementation, realized government revenue to fund the plan, and other social-sector objectives did not meet initial projections. Substantial resource gaps remain to finance the full implementation of the plan, estimated at 21,945 billion Tanzanian shillings (TZS) for the period of 2015–2020 (MoH, 2015). While mobilizing and pooling other sources of funds for the health sector remains difficult, fear remains that it might result into continuous delays in translating the country's National Health Financing Strategy into policy.

Despite the fact that the WHO (2019) has shown there is a problem of efficiency in the Tanzania's health sector, it is still unclear about the precise level of efficiency (both technical and scale in public hospitals) in the country. Thus, this paper examines the scale efficiency level in Tanzania's public hospitals using Data Envelopment Analysis, for 2016 secondary data from public hospitals in Tanzania. This paper will contribute to giving information on improving Tanzania public hospitals' efficiency. Also, it adds valuable information of the efficiency in public hospitals that will be used by all important and interested stakeholders who will help in public hospitals' management auditing and other necessary procedures for the development of the health sectors in a country.

2.0 Theoretical Perspective of Data Envelopment Analysis (DEA)

The term efficiency explains thedegree of performances which portrays the lowest amount of inputs used in the creation of the highest amount of outputs.Therefore,it is quantifiable, measurable and analyzed by the use of ratios of output to the available total input.

$$Efficiency = outputs/inputs$$

A number of techniques can be used to estimate efficiency. The study has applied DEA which explains managerial capability to choose the optimum size of the hospital, as hospital size may result into having efficiency or inefficiency.

DEA is a non-parametric technique of estimating efficiency by using linear programming method. It does not need an explicit functional form and can construct the frontier from the observed inputs and outputs ratios. Charness*et al.*, (1978) formulated a DEA model which is mathematically expressed as:

$$Max_{\theta, \lambda}\ \theta$$

Subject to

$$X\lambda \leq x_0$$

$$\theta y \leq Y\lambda$$

$$\lambda \geq 0$$

Whereas X is the output of$i$ input of a matrixthat has x_i number of columns, another output Y from the matrix of y_i number of columns withλ being an input of vector $i\ X\ 1$. By the use of DEA, producers' performance problems are determined through their abilities in expanding the output vector subjected to their constraints that have been imposed with the available practices that yield optimal outputs. If producers' radial growthis possible,then the optimal θ will be greater than one and equal to one when growth is not going to be reached at all.

DEA as a non-parametric approach has various benefits which help in making it becoming more influential and better in terms of theoretical perspective (Korir, 2010).DEA can be categorized intoconstant return to scale and variable return to scale and it can fall under two models or approaches of input and output models. The input model represents the inefficient unit, which is made to be efficient byproportionate reduction on the input, whilethe proportion of the outputis held constant. The output is expandingin the output modelbytaking input into control (Marti *et al.*, 2009). Moreover, DEA has been an appropriate measure for the estimation of efficiency in hospitals, since the price data is hard to obtain and the multi-output productionsare relevant.

2.1 Empirical Literature Review

Number of literatures has applied DEA in examining the efficiency of various private and public institutions. Most if these literatures have chosen DEA based on the linear programming ability of the DEA in producing feasible choices.

Dong and Li (2015) examinedefficiency in the Chinese public hospitals in 2012. They usedBootstrap DEA methodsin analyzing technical efficiency. To avoid double-counting problems

or to mix allocative and technical efficiency in the selection of output/input indicators, the study used quantity of available beds andhospital staffasinput indicatorswhilenumbers of diagnosed patients and discharged inpatients were regarded as output indicators. The study revealed that there were 8 hospitals with an efficiency score of 1 using the traditional BCC model. The new score of the efficiency revealed that 5 hospitals had excellent performance, 1 hospital had an average performance, and 5 hospitals had an average performance with ample scope for improvement. Furthermore, 2 hospitals needed to improve performance and 1 hospital needed urgent improvement. Despite the strength of Bootstrap DEA used, the study had some failures as all environmental factors were considered as a random factor in the estimation of efficiency score. Moreover, the study could estimate efficiency by DEA's and SFA during first and second stage respectively and traditional BCC-DEA model in the third stage to re-estimate efficiency (Dong and Li, 2015).

Hamidi (2016) measured the efficiency of government hospitals in Palestine using stochastic frontier approach(SFA). The study's objectives were to estimate the technical efficiency and measures the effects of numbers of bed and health sector technical and non-technical human resources. The study collected data from the ministry of health, for the period of 6 years from 2006 to 2012 for 132 observations. The author used numbers of doctors, nurses, beds as well as nonmedical staff as inputs.Nevertheless, the number of admitted patients, the average length of stay, number of days being hospitalized, operations cases as well as the number of outpatients visited the hospital wereregarded as outputs variable. Furthermore, the study explored thatthe mean technical efficiency reached 55%, and medical doctors and nurses are important factors in the hospital production.

Flokou*et al*., (2017) applied DEAin measuringthe efficiency of a public hospital in Greece from2009 to 2013 following the financial crisis of 2007-2008. Specifically, their study intended examining the efficiency of government-owned health facilities from 107 Greek hospitals. The study used inputs such as the number of beds in a hospital, medical professionals, while the in-patients,and outpatients, were used as output variables.The study used twoyears DEA in assessingthe scale and technical efficiency. Moreover, the studyanalyzed the basis of production changes between two consecutive years by using the Malmquist productivity index. The study found some improvement in the scale and technical efficiencies at the end of fiveyear of the

financial crisis period. However, the study did not use a parametric approach in the estimation of efficiency which is more effective in measuring productive efficiency of decision-making units. This study addressed this gap through the use of DEA to the estimation of efficiency in Tanzania

3.0 Methodology

DEA can handle the efficiency estimates of multiple inputs and outputs without any judgement of relative importance of the difference inputs or outputs; this study adopted input-model asthe public hospital have control over the inputs used in the production process than the output obtained. Moreover,the inputs orientation score signifies the maximum allowed extensive reduction of input capable forgeneratingthe same level of outputs. The study also adopted assumptions of return to scale under the input orientation since variables returns to scale is regarded as suitable in measuring hospital efficiency since public hospitals differ by size, different factor inputs likenumber of bedsetc. Therefore, from the variables' return to scale, the problem of linear programming is explained by:

Minimize θ

Subject to

$$-y_{jm} + \sum_{j=1}^{M} y_{jm} \lambda_j \geq 0, m = 1,2.$$

$$\theta x_{jk} - \sum_{j=1}^{m} x_{jk} \lambda_j \geq 0, k = 1.$$

$$\sum_{j=1}^{M} y_j = 1$$

$\lambda_j > 0$, j = 1, 2.....m

Definition and Measurement of Variables

The study obtained secondary data from19 regional referral hospitals and 119 districts hospitals collected in 2016. Choice of these hospitals is because they provide service to a great number of populations, and they are the biggest consumer of health sector resources. Furthermore, considering inputs and outputs that were selected for the study, these hospitals were appropriate. From the empirical review it is evidenced that most study have been using variables that are consistence with economic and production theory (Mujasi *et al.,* 2016; Makheti, 2017; Bwana, 2018; Top *et al.,* 2020). On the other hand as limitation with data availability especially for the

selected year of analysis, some key variables to measure efficiency such as length of stay, number of surgeries, drugs and lab test could not be used in this study. However Korir (2010) used occupancy rate and length of stay as output to determine scale efficiency for selected public, district and provincial hospital in Kenya. Nevertheless Osie *et al.* (2005) used maternal and child healthcare visits and inpatient discharges as output while inputs used doctors, dentist, subordinate and beds as inputs. Therefore, estimation of efficiency for these hospitals can be generalized for all public hospitals in Tanzania mainland as well.

Table 3.1: Variables of the study

	Variables	Description
Input	Beds	Includes number of beds available in each health facility
	Medical staff	Includes number of medical doctors, nurses, clinical officers, and medical attendant
Output	Inpatients	Includesnumber of inpatients or admission recorded by the facility in 2016
	Outpatients	Includes total number of outpatients visited the facility in 2016

Source:Own calculation, 2018

4.0 Results of the Study

Scale Efficiency of District Hospitals

24 out of 114 district hospitals which is equivalent to21.05% had efficiency score of 1, which show scale efficiency of 100%. The remained 90 district hospitals 78.95% of the total district hospitals were scaled inefficiently.25 hospitals out of 90 inefficient district hospitalshad a scaling efficiency of less than 0.5. 24 hospitals had a scaling efficiency of between 0.51 – 0.70 and the remained 41 hospitals had an efficiency score of between 0.71-0.99. Within 90 inefficient district hospitals, 87.8% of hospitals discovered (79 hospitals) to have increasing return to scale (IRS), and 12.2% of hospitals (11hospitals)had decreasing return to scale (DRS). This finding shows that 87.8% of the inefficient district hospitals in Tanzania for the year 2016 were too small for their operation, and were needed to expand their scale of operation while the 12.2% of the inefficient district hospitals were needed to scale down their operation in order to attain constant return to scale (CRS).

Table 4.1: Summary of Scale Efficiency for District Hospitals

Scale efficiency score	Frequency	Percent	Cumulative percentage
0.0-0.50	25	21.93	21.93
0.51-0.70	24	21.05	42.98
0.71-0.99	41	35.96	78.95
1	24	21.05	100
Total	114	100	

Source:Researcher's Own calculation, 2018

Scale Efficiency of Regional Referral Hospitals

As shown in Table 4.2, out of 16 studied regional referral hospitals the average scale efficiency was 0.786. In addition to that 7out of 16 regional hospitals equivalent to 43.75% attained 100% efficiency as they had ascale efficiency score of 1 and deemed as scale efficient regional referral hospitals for the year 2016. These 7 regional referral hospitals attained the most productive scale size (MPSS), and hence they obtained constant return to scale (CRS). The remaining 9 hospitals equivalent to 56.25% were termed as scale inefficient regional referral hospitals as they obtained efficiency score of less than 1.Moreover, 2out of these 16 regional hospitals equivalent to 22.2% of all regional hospitals had efficiency score of less than 0.50, 3 hospitals equivalent to 33.3% of the hospitals had efficiency score of between 0.51-0.70 and 4 (44.4%) hospitals obtained efficiency score of between 0.71 – 0.99. However, all 9 scale inefficient regional referral hospitals had an increasing return to scale (IRS) meaning that the inefficient hospitals are too small for their operation to operate at their MPSS thus they need to expand their scale of operation so as for them to attain the CRS.

Table 4.2: Results from DEAP Efficiency Summary

Hospitals ID	Scale Efficiency	Return to scale type
1	1	CRS
2	0.781	IRS
3	1	CRS
4	0.774	IRS
5	0.633	IRS
6	0.267	IRS
7	1	CRS
8	0.858	IRS
9	0.28	IRS
10	0.882	IRS

11	1	CRS
12	1	CRS
13	1	CRS
14	0.576	IRS
15	1	CRS
16	0.527	IRS
Mean	0.786	

Source: Researcher's own calculation, 2018

Amount of Inputs Available for Reallocation and Output Increase Potentials in District Hospitals

Slacks show resources underuse or overuse at the hospital, and hence enables suggestion on whether there should be an adjustment on inputs used to attain efficiency. Since in the analysis of study input orientation was assumed, increase or decrease of inputs has to be done to achieve hospital efficiency. For the district hospitals,39.5% of hospitals do not require inputs reallocation and the remained 60.5% hospitals can reallocate its inputs to achieve efficiency. District hospitals could reallocate its inputs by transferring from efficient hospitals to inefficient ones.

Slacks in the outputs shows that inputs are underutilized, thus reallocation of the inputs might achieve efficiency. Moreover for hospitalswith outputs slacks and no inputs slacks, measures such as more knowledge on the importance of using hospitals. Since some Tanzanian still prefer use of traditional treatment and others than going to hospital, these measure can increase the inpatient and outpatients of hospitals and thus attain efficiency.If district hospitals were working as a group were required on average to increase inpatients by 736 and outpatients by 15517without changing the quantity of inputs. Also they were required to decrease inputs such as beds by 2, medical doctor by 3, Nurse by 5, clinical officer by 1 and medical attendant by 11 to attain efficiency.

Amount of Inputs Available for Reallocation and Output Increase Potential in Regional Referral Hospitals

With the presented slacksshowed in Table 4.3, 62.5% (10) regional referral hospitals do not require any adjustment and remained 37.5% need reallocation to achieve efficiency. To achieve efficiency, regional referral hospitals as a group could on averagely increase output by 1131 in inpatients and 5160 in outpatients without changing inputs mix. As well as averagely decrease its' inputs by 3 in medical doctors, 7nurses, 1clinical officer, and 5 medical attendants.

Table 4.3: Summary of Input and Output Slacks for Regional Referral Hospital

Hospitals	Beds	Medical doctors	Nurse	Clinical officer	Medical attend	Inpatient	Outpatient
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	34.711	2.545	22.969	0.000	16779.768
3	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	6.793	24.643	0.121	31.551	0.000	23087.879
5	0.000	6.793	24.643	0.121	0.000	5482.162	0.000
6	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8	0.000	30.977	10.553	7.497	30.132	2622.338	0.000
9	0.000	8.078	15.252	0.000	0.000	7716.948	36736.866
10	0.000	0.000	0.000	0.000	0.000	0.000	0.000
11	0.000	0.000	0.000	0.000	0.000	0.000	0.000
12	0.000	0.000	0.000	0.000	0.000	0.000	0.000
13	0.000	0.000	0.000	0.000	0.000	0.000	0.000
14	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15	0.000	0.000	0.000	0.000	0.000	0.000	0.000
16	0.000	0.192	4.236	0.000	0.000	2277.168	5947.797
Average	0.000	3.302	7.127	0.643	5.291	1131.164	5159.519

Source: Researcher’s own calculation, (2018)

5.0 Discussion of Findings on Scale Efficiency in Public Hospitals

The average scale efficiency for regional hospitals was 78.6%, and 43.8% of the regional referral hospitals attained the most productive scale size, and 56.25% were scale inefficient withincreasing return to scale.Increase return to scale means enjoying economies of scale thus increase in one input use results to more increase in output. This implies that the inefficient hospitals are too small for their operation to operate at their MPSS thus they need to expand their scale of operation so as for them to attain the CRS. The findings are similar to study of Kirigia and Asbu (2013) in Eritrea; Kinyanjui *et al.,* (2015) in Kenya; Achoki *et al.,* (2017) in Zambia; Aloh et *al.,* (2020) in South East Nigeria; Babalola and Moodley (2020) in overall Sub-saharan African countries. All these findings found that on average the scale efficiency in regional hospital ranges between 40 to 80% in both regional hospital and regional referral hospitals.

The average scale efficiency was 72.9% for district hospitals. 21.05% of the district hospitals attained the most productive scale size, termed as scale efficient hospital and the remained 78.95% did not attain MPSS and termed as scale inefficient district hospitals.For scale inefficient hospitals, 87.8%had increasing return to scale and the remaining 12.25% had decreasing return to scale. Hospitals with IRS are too small for their operation and are needed to expand scale of operation, while those with DRS are needed to scale down their operation

6.0 Conclusions

The overall findings revealed that for the year 2016, 56.25% and 78.95% of regional referral and district hospital respectively were scaled inefficient. The Tanzania Ministry of Health, Ministry of Finance and Planning and other concerned ministries need to increase efforts on reducing inefficiency in public hospitals. Based on the findings that there is a high level of inefficiency in district hospitals and some regional referral hospitals were inefficient in 2016. Regular estimation of efficiency both technical and scale efficiency in public hospitals must be done in order to ease decision making processes and improving health sector resource allocation.

Furthermore, Ministry of Health, Community Development, Gender, Elderly and Children (MoHCDGEC), President's Office Regional Administration and Local Government (PORALG) can reallocate the inputs resources such as medical doctor, nurses, medical attendant, clinical officers and beds to enable public hospitals attain efficiency. Since study revealed that some hospitals have serious under utilization problems as there are excess inputs which is not equivalent to the output produced which create inefficiency and therefore reallocation is prerequisite and unavoidable.Moreover, hospitals with shortage resources need to be provided with sufficient resources to attain efficiency, and hospitals with excess needs to be considered in reallocation of the inputs.

Also other stakeholders and government can provide education on importance of getting medical help from hospitals curative, treatment and preventive assistance.Increase of this knowledge can increase the need for hospitals service and thus utilize the resources allocated to the hospitals, hence increase efficiency. Moreover,increasing level of efficiency in public hospitals depict improvement in the provision of health service and availability of better health services, thus attaining Tanzania vision of 2025 and Sustainable Development goals 2030.

Declarations

Ethics approval and consent to participate

The study obtained consent from the Ministry of Health, Community Development, Gender, Elderly and Children (MoHCDGEC), under the Policy and Planning Department, and Health Management Information System to use data from the District health Information system (DHIS2) which provided information on various services offered by each hospital available in each district, and the reports on public health facilities

Consent for publication: All authors agreed to allow publication of this manuscript once is accepted for publication

Availability of data and materials: Data will be available upon request

Competing interests: The authors declare that they have no conflict of interest.

Funding: No funding that was provided for this study by any institution

Authors' contributions: FatumaFumbwe prepared the initial draft of manuscript, Robert Lihawa., Felician Andrew., George Kinyanjui and EliazaMkuna provided comments, improvement and critical discussion on the results and discussion

Acknowledgements: N/A

REFERENCE

Achoki, T., Hovels, A., Masiye, F., Lesego, A., Leufkens, H., & Kinfu, Y. (2017). Technical and scale efficiency in the delivery of child health services in Zambia: results from data envelopment analysis. BMJ open, 7(1).

Appiah, J. C., Sekidde, S., Adjuik, M., Akazil, J., Almeida, D. S., Nyonator, F., Kirigia, M, J. (2015). Ownership and technical efficiency of hospitals: evidence from Ghana using data envelopment analysis. Cost effectiveness and resources allocation

Babalola, T. K., & Moodley, I. (2020). Assessing the Efficiency of Health-care Facilities in Sub-Saharan Africa: A Systematic Review. *Health Services Research and Managerial Epidemiology*, *7*, 2333392820919604.

Biorn, E., Hagen, T.P., Lversen, T., & Magnussen, J. (2003). The effect of Activities based financing of hospital efficiency: A Panel Data analysis of DEA efficiency scores1999-2000. Health management science, 6, 271-83.

Bwana, K. M. (2018). Investigating Efficiency Based On the Hospitals Size: An Application of a Non-Parametric Approach to the Private Hospitals in Tanzania. *African Journal of Applied Research*. 4(1): 106-119

Bwana, K., & Raphael, G. (2015). Technical Efficiency of Tanzania Teaching Hospitals: The Case of Private not for profit Hospitals. Business Management and Strateg y, 6. doi:10.5296/bms.v6i1.7575

Charnes, A., Cooper W. & Rhodes E. (1978). Measuring the Efficiency of Decision Making Units. *European Journal of Operational Research*, 2, 429-444.

Fatuma Manzi, Joanna Armstrong Schellenberg, Guy Hutton, Kaspar Wyss, Conrad Mbuya , Kizito Shirima, Hassan Mshinda, Marcel Tanner, and David Schellenberg .(2012). Human resources for health care delivery in Tanzania: a multifaceted problem. MedPub. 10.1186/1478-4491-10-3

Ferrier, G. D. & Lovell, C. A. K. (1990). Measuring Cost Efficiency in Banking: Econometric and Linear Programming Evidence. *Journal of Econometrics*, 46, 229-245.

Flokou, A., Aletras, V, &Niakas, D. (2017). A window-DEA based efficiency evaluation of the public hospital sector in Greece during the 5 -year economic crisis. Plos one journals, 12(5). doi: 10.1371/journal.pone.0177946

Government of United Republic of Tanzania (2015).Health Sector Strategic Plan (HSSP). Ministry of Health, Community Development, Gender, Elderly and Children.

Hamidi, S. (2016). Measuring efficiency of governmental hospitals in Palestine using Stochastic Frontier Analysis. *Cost Effective Resource Allocation* 14 (3). DOI 10.1186/s12962-016-0052-5

Health Sector Strategic Plan IV (2015). Ministry of Health, Community Development, Gender, Elderly and Children

Irungu, N. K. (2012). Analysis of efficiency of public hospitals in KENYA: 2008-2011(Master's thesis, arts in economics). University of Nairobi

Jat, R. T., & Sebastian, S, M. (2013). Technical efficiency of public district hospitals in Madhya Pradesh, India: a data envelopment analysis, *Global Health Action*, 6:1, 21742, DOI: 10.3402/gha.v6i0.21742

Kinyanjui, G.K., Gachanja, P.M., Muchai, J.M (2015). Technical Efficiency of Hospitals Owned by Faith Based Organisations in Kenya. *The Journal of Pan African Studies* .8(6): 45-65

Kirigia, J. M., & Asbu, E. Z. (2013). Technical and scale efficiency of public community hospitals in Eritrea: an exploratory study. *Health economics review*, *3*(1), 1-16.

Kirigia, M. J. &Asbu, Z. E. (2013). Technical and scale efficiency of public community hospitals in Eritrea: an exploratory study. A springer open jornal, 3:6.

Korir, J. K. (2010). The data envelopment analysis and stochastic frontier approaches to the measurement of hospital efficiency in Kenya. Nairobi: Kenyatta University Institutional Repository.

Li, H., & Dong, S. (2015). Measuring and Benchmarking Technical efficiency of public hospital in Tianjin, China: A Bootstrap–Data Envelopment Analysis Approach. *The Journal of Health Organisation, Provision, and Financing*, 1–5. doi: 10.1177/0046958015605487.

Maddala, G. S., & Ellen, M., 1989. Microeconomics: Theory and Applications. McGraw-Hill, Newyork.

Makheti, A. J. (2017). Technical Efficiency in Public Health Facilities in Meru County: Dea Analysis. *Health Economics & Outcome Research: Open Access*, *3*(4), 1-6.

Matric, M. M., Novakovic, S. M. &Baggia, A. (2009). Data Envelopment Analysis - Basic Models and theirUtilisation, Organisacija journals, 42 (2). doi: 10.2478/v10051-009-0001-6

Mujasi, P. N., Asbu, E. Z., & Puig-Junoy, J. (2016). How efficient are referral hospitals in Uganda? A data envelopment analysis and tobit regression approach. *BMC health services research*, *16*(1), 230.

Nunamaker, T. (1985). Using data envelopment analysis to measure to measure the efficiency of non-profit Organisations: A critical evaluation. Journal of managerial and Decision Economics, 50-58.

Osei, D., d'Almeida, S., George, M. O., Kirigia, J. M., Mensah, A. O., & Kainyu, L. H. (2005). Technical efficiency of public district hospitals and health centres in Ghana: a pilot study. *Cost Effectiveness and Resource Allocation*, *3*(1), 9.

Rezaei, S., Zandian, H., Baniasadi, A.,Moghadam, Z, T., Delavari, S, and Delavari, S. (2016). Measuring the Efficiency of a Hospital based on the Econometric Stochastic Frontier Analysis (SFA) Method. Plos one journals,doi: 10.19082/2025

Samsudini, S., Jaafar, S. A., Applanaidu, D, S., Ali, J. & Majid, R. (2016). Are Public Hospitals in Malaysia Efficient?An Application of DEA and Tobit Analysis. Southeast Asian Journal of Economics 4(2),1-20

Simon, M. (2015). Resource allocation for health in Tanzania. 415: 659- 689

Top, M., Konca, M., & Sapaz, B. (2020). Technical efficiency of healthcare systems in African countries: an application based on data envelopment analysis. *Health Policy and Technology*, *9*(1), 62-68.

World Health Organisation (2016). Global Health Observation

World Health Organisation (2019). Global Health Observation

Zere, E. (2000). "Hospital Efficiency in Sub Saharan Africa: Evidence from South Africa". United Nations University/WIDER working paper No.187.

APPENDIX 1

Summarization of Inputs and Outputs – District Hospitals

Hospital	BED	MD DCT	NURSE	CLNOFF	MEDATT	IPD	OPD
1	0.0	8.6	6.8	0.0	0.0	400.4	14993.5
2	0.0	3.4	0.0	0.0	13.2	0.0	0.0
3	0.0	0.7	0.0	0.0	8.2	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	32.2	0.0	8.7	0.0	32.8	1542.4	1284.7
6	0.0	4.7	0.0	0.0	30.2	2397.8	26120.5
7	0.0	1.2	0.0	0.0	0.0	2680.2	35235.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	11.7	0.0	54.2	1797.2	31523.4
10	0.0	0.4	0.0	0.0	2.8	0.0	24021.2
11	0.0	2.6	4.7	0.0	0.0	0.0	12808.6
12	0.0	4.9	0.0	0.0	0.0	916.4	1253.8
13	0.0	0.0	37.4	0.0	3.2	0.0	25964.2
14	0.0	8.8	0.0	0.0	6.4	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	0.0	3.4	0.0	0.0	1.0	3670.8	0.0
17	0.0	3.1	6.0	0.0	0.0	0.0	28028.5
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	0.0	1.5	0.8	0.0	0.0	3171.7	33365.2
20	0.0	10.4	8.5	0.0	0.0	3052.0	0.0
21	0.0	1.3	1.5	0.0	0.0	0.0	24975.5
22	0.0	1.2	0.0	0.0	0.0	0.0	28043.5
23	0.0	2.0	0.0	0.0	22.2	0.0	11764.3
24	0.0	2.0	2.1	0.0	0.0	3714.5	44287.1
25	0.0	4.7	0.0	0.0	2.1	0.0	6388.3
26	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	18.8	0.0	21.8	0.0	61.8	3404.1	555.0
28	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31	0.0	2.4	0.0	19.5	20.7	0.0	0.0
32	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33	0.0	1.6	4.7	0.0	0.0	3300.3	33215.5
34	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36	0.0	1.2	0.0	0.0	6.6	0.0	0.0

37	0.0	6.0	0.0	0.0	0.0	1192.0	19369.1
38	0.0	0.7	0.0	0.0	0.0	1634.7	27596.0
39	0.0	9.1	18.1	0.0	64.5	0.0	25339.3
40	0.0	0.0	0.0	0.0	1.0	296.5	18432.8
41	0.0	10.0	4.7	0.0	0.0	3540.9	11170.1
42	0.0	4.7	2.6	0.0	0.0	1062.7	23170.0
43	0.0	0.0	0.0	0.0	0.0	0.0	0.0
44	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45	0.0	0.0	0.0	0.0	17.0	0.0	2413.0
46	0.0	4.7	0.0	0.0	0.0	0.0	20250.7
47	0.0	2.5	5.6	0.0	0.0	0.0	25699.2
48	0.0	0.0	0.0	0.0	0.0	0.0	0.0
49	0.0	4.7	3.0	0.0	0.0	3317.0	40554.3
50	0.0	0.0	13.3	0.0	80.7	3930.7	15076.5
51	0.0	0.0	13.3	0.0	70.8	2897.5	17289.1
52	0.0	7.4	3.2	0.0	0.0	601.3	22519.0
53	0.0	0.0	0.0	0.0	0.0	0.0	0.0
54	0.0	0.4	0.0	0.0	0.0	1929.8	5092.3
55	0.0	0.3	10.8	0.0	0.0	1228.4	17347.3
56	0.0	0.0	0.0	0.7	47.3	0.0	63639.8
57	0.0	0.0	0.0	0.0	7.4	0.0	28492.0
58	0.0	4.5	0.6	0.0	0.0	982.8	18372.9
59	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60	0.0	0.7	0.0	0.0	0.0	0.0	0.0
61	0.0	0.0	0.0	0.0	0.0	0.0	0.0
62	0.0	0.0	28.8	0.0	0.0	0.0	67901.3
63	0.0	55.0	265.1	0.0	335.0	0.0	2929.4
64	0.0	10.4	0.0	0.0	21.6	5262.0	18372.7
65	0.0	0.0	0.0	1.6	0.0	0.0	29637.8
66	70.0	2.0	0.0	0.0	0.0	2689.0	15660.0
67	0.0	2.9	0.0	0.0	0.0	3987.7	32358.7
68	0.0	3.5	4.6	0.0	0.0	0.0	44565.3
69	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70	0.0	0.0	0.0	0.0	0.0	0.0	0.0
71	0.0	7.6	0.0	0.0	17.5	0.0	1211.2
72	0.0	0.0	0.0	18.2	1.0	0.0	63179.1
73	0.0	0.0	0.0	0.0	0.0	0.0	0.0
74	0.0	0.0	0.0	1.7	38.1	0.0	33050.5
75	0.0	0.0	0.0	1.0	75.0	0.0	10014.5
76	0.0	0.0	0.0	0.0	0.0	0.0	0.0
77	0.0	0.0	56.2	0.0	0.0	45.1	33904.7

78	0.0	0.0	0.0	0.0	0.0	0.0	0.0
79	0.0	3.1	0.0	0.0	3.1	3708.9	31659.1
80	0.0	2.6	0.0	0.0	0.0	0.0	21754.5
81	0.0	2.8	0.0	0.0	4.8	170.1	58.5
82	0.0	0.0	0.0	0.0	0.0	0.0	0.0
83	0.0	0.0	0.0	0.0	9.1	0.0	0.0
84	0.0	0.0	0.0	0.0	3.4	0.0	0.0
85	0.0	0.0	3.0	0.0	0.0	2157.1	36718.5
86	0.0	2.0	2.3	0.0	0.0	0.0	21941.0
87	0.0	9.3	0.0	6.0	0.0	2845.7	22188.5
88	0.0	0.0	0.0	0.0	0.0	0.0	0.0
89	62.5	0.8	18.5	0.0	0.0	0.0	211455.6
90	0.0	3.5	0.0	0.0	1.1	0.0	85894.8
91	0.0	0.0	0.0	0.0	0.0	0.0	0.0
92	0.0	2.8	3.3	0.0	0.0	4105.3	42023.3
93	0.0	1.1	0.0	0.0	0.0	19.7	15614.9
94	0.0	9.6	0.0	0.0	61.8	0.0	0.0
95	0.0	5.1	0.0	0.0	4.6	0.0	0.0
96	0.0	0.0	0.0	0.0	0.0	0.0	0.0
97	0.0	0.0	0.0	0.0	0.0	0.0	0.0
98	0.0	1.0	0.0	0.0	0.0	80.8	7054.7
99	0.0	2.4	0.0	0.0	0.0	318.6	15534.4
100	0.0	5.1	0.0	0.0	11.1	1293.5	18692.0
101	0.0	0.0	0.0	0.0	0.0	0.0	0.0
102	0.0	3.6	0.0	0.0	2.2	585.7	31753.6
103	0.0	0.0	0.0	0.0	0.0	0.0	0.0
104	0.0	0.6	0.0	0.0	0.0	0.0	84.4
105	0.0	0.0	0.0	0.0	0.0	0.0	0.0
106	0.0	0.0	0.0	0.0	0.0	0.0	0.0
107	0.0	0.0	0.0	0.0	0.0	0.0	0.0
108	0.0	0.0	0.0	0.0	0.0	0.0	0.0
109	0.0	11.5	0.0	0.0	46.0	0.0	0.0
110	0.0	0.0	6.9	0.0	32.1	1041.6	26476.5
111	0.0	3.6	0.0	0.0	23.4	1778.5	0.0
112	0.0	10.0	0.0	0.0	22.4	878.6	16983.2
113	0.0	0.0	0.0	0.0	0.0	0.0	0.0
114	0.0	0.0	0.0	9.9	0.0	245.4	24626.4
Average	1.610	2.526	5.075	0.514	11.118	735.750	15517.108