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Technical efficiency of public hospitals in east Africa: a systematic review and meta-analysis

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Abstract

Background Hospitals usually encounter human, capital, and financial resource constraints which alerts the efficient use of allocated resources more than ever. Health system managers are required to identify inefficient hospitals and the drivers of the inefficiencies. Although there are multiple studies examining the efficiency of public hospitals in East Africa, their findings are often variable and inconsistent. Therefore, this study aimed to review published articles on technical efficiency of public hospitals in East African countries.

Methods A systematic search of published articles on the technical efficiency of public hospitals was employed using Pubmed, Cochrane library, and google scholar and thirteen studies were included to this review. The studies were described in terms of their publication year, sample size, inputs and outputs used in the efficiency analysis, and the technical efficiency levels. Finally, we assessed their quality and estimate the mean technical efficiency using meta-analysis.

Results The technical efficiency score of public hospitals varied across countries in east Africa which ranged from 0.64 ± 0.34 in Tanzania to 0.99 ± 0.03 in Ethiopia. The mean technical efficiency was 0.82 (95% CI = 0.56, 1.07) for primary hospitals and 0.88 (95% CI = 0.82, 0.95) for secondary level hospitals. Technical efficiency of public hospitals was negatively correlated with the number of hospitals (the sample size) and positively correlated with the number of inputs and outputs included in the efficiency analysis.

Conclusions This review revealed that the technical efficiency of public hospitals in east Africa requires an improvement. To enable effective and efficient hospital management and improvement in hospital efficiency, health managers and policymakers must identify the drivers of hospital inefficiency. Systematic reviews on public hospital efficiency, which are currently rare in Africa, should be conducted on a much larger scale in order to create more, and validated information for use in policy-making.

Trial registration This review protocol was registered and approved by the international prospective register of systematic reviews with a Protocol ID: CRD42023444729.

Keywords Technical efficiency, Hospitals, Data envelopment analysis, East Africa, Systematic review

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Introduction

The African continent has a population representing 14.4% of the world's people, but it accounts for only 1% of the total global health spending. The continent spent only 5.3% of its GDP on health in 2019 which is lower as compared to Americas (7.2%) and Europe (7.6%) [1]. Health facilities are known to consume the highest proportion of total health expenditure in most African countries [2]. As health facilities are increasingly consuming more in health-care budget, there is a need to determine whether the limited resources allocated to these parts of the health system are used efficiently.

Hospitals have an undeniable role in the provision healthcare services to society but their increasing cost has become an important challenge for many countries in Africa. This is due to the utilization of technologies, new methods of diagnosis and treatments, increasing chronic diseases, and increasing demands for healthcare services. Subsequently, hospitals always encounter human, capital, and financial resource constraints which alerts the efficient use of allocated resources more than ever [3]. Since the efficiency of hospitals can be increased not only by adding the factors of production but also by doing interventions on the factors which involved for the inefficient performances, health system managers are required to identify inefficient hospitals and identify the drivers inefficiencies [4].

Efficiency of hospitals has been assessed by using different methods across the world [5]. The parametric (econometric) and non-parametric (deterministic frontier approach) techniques are the two common methods which are applied by many researchers. The econometric approach specifies a production function and normally recognizes that deviation away from the given technology (as measured by the error term) is composed of two parts, one representing randomness (or statistical noise) and the other inefficiency. The usual assumption with the two-component error structure is that the inefficiencies follow an asymmetric half-normal distribution and the random errors are normally distributed. The random error term is generally thought to encompass all events outside the control of the organisation, including both uncontrollable factors directly concerned with the 'actual' production function (such as differences in operating environments) and econometric errors (such as misspecification of the production function and measurement error). This type of reasoning has primarily led to the development of the 'stochastic frontier approach' (SFA) which seeks to take these external factors into account when estimating the efficiency of real-world organisations. The deterministic frontier approach (DFA) which assumes that all deviations from the estimated frontier represent inefficiency. In contrast to the econometric approaches which attempt to determine the absolute economic efficiency of organisations against some imposed benchmark, the non-parametric approach seeks to evaluate the efficiency of an organisation relative to other organisations in the same industry. The most commonly employed version of this approach is a linear programming tool referred to as 'data envelopment analysis' (DEA). DEA essentially calculates the economic efficiency of a given organisation relative to the performance of other organisations producing the same good or service, rather than against an idealised standard of performance [5, 6].

Studies have been conducted on assessment of hospital efficiency globally using both the parametric and non-parametric approaches [4, 7–9]. In Africa, recent studies observed the technical efficiency of hospitals based on the data envelopment analysis technique [10–16]. However, most of these studies were primary studies which took inadequate sample sizes and limited for the generalizability of the finding to other settings. Only two systematic reviews were conducted on assessing efficiency of health facilities in Africa as far as our extensive searches were concerned [2, 17]. The former was the study by Juliet Nabyonga-Orem et al. which assessed the efficiency of health systems from 39 eligible studies in Africa. The second review was based on 40 studies of sub-Saharan Africa and reported the efficiency levels and drivers of inefficiency after systematically reviewed the included studies [17]. This study will systematically review published articles on technical efficiency of public hospitals in East African countries and estimate the mean technical efficiency using meta-analysis.

Methods

Inclusion criteria

In this review, we included studies if they were conducted from 2013 to 2023, used public hospitals as a unit of analysis, performed in East Africa, were written in English, assessed technical efficiency, and reported the mean and standard deviation of the technical efficiency scores, and we excluded studies if they assessed only cost or allocative efficiency, evaluated the private hospitals or clinics without considering public hospitals, and were thesis and/or reports.

Search strategies

We used PubMed, Cochrane Library, and google scholar to search studies by restricting the search date from 2013 to 2023 and studies with only English language publications. To ensure a broad range of relevant studies, we used an appropriate combination of medical subject heading (MeSH) terms and text word. The search terms used in all the search databases and the combinations of

those terms used in Pubmed advanced search are found in additional file 1. The electronic search was complemented by hand-searching of the related articles as well as the reference lists of the final studies.

Study selection process

After the search results were imported to EndNote X9 reference manager, duplicates were first removed electronically and then manually. The title and abstract of the studies were independently screened by all authors, and irrelevant studies were removed. Subsequently, the full text of the studies was retrieved and reviewed by Lamesgen, A., Endalew, B., Mengie, M.G., Simegn, M.B., Tilahun, W.M, and Birhanu, M.Y against the inclusion criteria for further screening. Disagreement on whether to include articles if they fulfil some inclusion criteria but not the whole was resolved by the involvement of the other authors. Finally, articles that fulfil all the inclusion criteria were included to the review.

Data abstraction and study quality assessment

Lamesgen, A., Endalew, B., Mengie, M.G. performed the data extraction independently. Data extracted for each study comprised: study authors, year of publication, number of hospitals included in the study, the country where the study was conducted, level of hospitals (primary, general and/or tertiary), input and output variables, techniques of efficiency analysis, and estimated efficiency scores with their standard deviations. To assess the quality of the studies, we used the the Joanna Briggs Institute critical appraisal tools which is a checklist composed from nine items. Criteria for assessment of study quality mainly include population and sampling; data collection process and instruments to measure the variables; and statical analysis and reporting of results. The assessment was conducted by Lamesgen, A., Endalew, B., Mengie, M.G. and discrepancies were then resolved either by discussion and/or by the other authors.

Data synthesis

We have described the included studies by their publication year, level of hospitals considered within each study, number of inputs and outputs used, and the technical efficiency scores. We also assessed the quality of the studies and present their score in percent. Before we conducted the meta-analysis, statistical heterogeneity among the studies was assessed by Cochran's Q statistic, I^2 index, and using the forest plot. As the analytical result revealed a high heterogeneity, the sub group analysis was conducted to see the sources of heterogeneity among the studies. Finally, the association between the technical efficiency of hospitals and different characteristics of the studies was observed after we had estimated the spearman's rank correlation coefficient. All these statistical analyses were conducted using the Stata version 17 statistical software.

Results

A total of 103 records were retrieved from PubMed, Cochrane library, and google scholar. After excluding duplicates, 95 records were selected for screening and 72 records were removed after reviewing their title and abstracts. Subsequently, we reviewed 23 full-text articles for eligibility and excluded 10 articles because they did not fulfil our inclusion criteria. Finally, 13 articles were found eligible. The reference lists of these 13 articles were manually searched, but no additional studies were found (Fig. 1). We used The PRISMA flow diagram [18] for screening and selecting studies.

Majority of the studies were published after 2015 with only one study [19] in 2013 and nearly half of the studies were conducted in Ethiopia and Kenya ($N=6$). Most of the studies assessed the efficiency of hospitals with different levels including primary, secondary, and tertiary hospitals. Two studies [20, 21] assessed only primary hospitals. The sample size ranges from five in Mauritius [22] to forty in Uganda [23]. Technical efficiency was estimated by using inputs used and outputs of health services from different levels of hospitals in each of the reviewed studies. The predominant inputs used in the analysis were labour (number of clinical staffs and number of administrative staffs), capital (number of beds, number of rooms), and expenses for non-salary costs including expenses for drugs and medical supply. Number of outpatient visits, number inpatient visits, total operations, and deliveries were the common outputs used. Two studies [16, 24] used number of ANC visits, PNC visits, and family planning services in the hospitals as output variables (Table 1).

All of the studies scored more than 75% of the Joanna Briggs Institute checklist for study quality assessment and none of them were excluded from the analysis. The quality assessment score of the studies was oscillated between 77.7% and 88.9% which is described in the last column of Table 1. Almost in all of the studies, the study setting and the study participants were well described including the sampling frame though in 55.6% of the studies the sampling procedure was unclear. The appropriate statistical analysis used was described and the measurement of the condition (i.e. technical efficiency) was standard and consistent for all participants in each of the included studies.

The technical efficiency score of hospitals was ranged from 0.64 ± 0.34 in Tanzania [25] to 0.99 ± 0.03 in Ethiopia [16] (Table 1). The results from forest plot indicated a high level of heterogeneity between the studies (Cochran's Q statistic with $p=0.00$ and $I^2=76.26\%$)

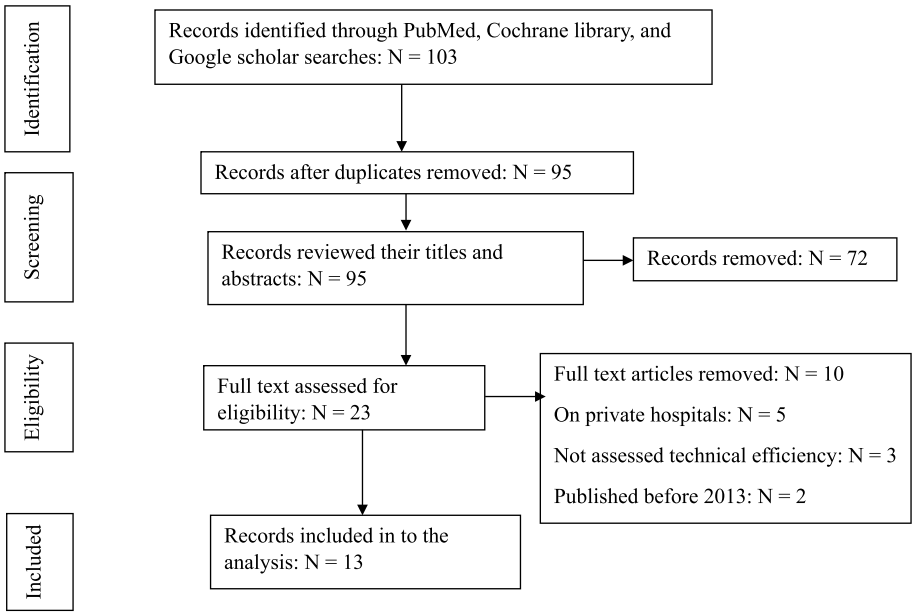

Fig. 1 Flow chart for the systematic search and study selection proccess

(Fig. 2). Subsequently, the potential source of heterogeneity was examined by conducting the sub group analysis with the level of hospitals, sample size, and quality score of the studies.

Sub-group analysis based on the level of hospitals indicated that the mean technical efficiency of public hospitals in east Africa was 0.82 (95% CI: 0.56, 1.07), 0.88 (95% CI: 0.82, 0.95), 0.93 (95% CI: 0.87, 1.00) for the primary hospitals, secondary hospitals, and tertiary hospitals, respectively. The analysis also revealed that the mean technical efficiency was 0.82 (95% CI: 0.72, 0.92), and 0.91 (95% CI: 0.86, 0.97) for the studies with the study quality assessment score of 77.8%, and 88.9%, respectively (Table 2).

The association between the technical efficiency of hospitals and different characteristics of the studies which include the sample size, publication year, number of inputs, and number of outputs used in the analysis was observed after we had estimated the spearman's rank correlation coefficient. Accordingly, the technical efficiency had a negative relationship with the sample size for the studies and a positive relationship with the number of inputs and outputs used in the analysis (Table 3).

Discussion

Efficiency analysis of health service providers is used to provide an evidence-based information which is applied to put informed decisions by policy makers within most country's health systems in the world [26].

Efficiency of hospitals has been assessed in primary studies [13, 27–30] as well as with systematic reviews [3, 4, 31–33] across different areas of the world. In this study, we reviewed 13 studies which measured the technical efficiency of public hospitals in East Africa. We also estimated the mean technical efficiency of public hospitals in east Africa using meta-analysis.

The majority of the studies were conducted in Ethiopia and Kenya. This may be due to the fact that the health ministries in these countries have recognized the efficiency of health system as the key prioritized strategy to deliver quality health services given that the funds from the government to the health sector is notably inadequate. Almost all studies except the study in Mauritius [22] used the DEA method to assess the technical efficiency of public hospitals. The use of DEA is well justified by its capability to handle multiple inputs and outputs in different units, and also its functional flexibility in practical application [20, 24].

In this review, the mean technical efficiency of public hospitals varied across countries. It was lower in Tanzania and Zimbabwe but higher in Ethiopia and Eritrea. This may be due to the difference in health systems across areas. Besides this, studies conducted in Tanzania and Zimbabwe used higher number of DMUs as compared to other studies which can resulted in lower efficiency scores [34]. Effective health care financing reforms [25], timely training of staffs and qualifying health manpower [23, 35], internal and external supervisions [36], and allocating more resources to older

Table 1 Characteristics of the included studies on the technical efficiency of public hospitals in east Africa ($N=13$)

Authors	Publication year	Country	Level of hospitals	Sample size	Inputs	Outputs	TE score		Quality assessment score (%)
							Mean	SD	
Ali, Murad et al	2017	Ethiopia	primary, secondary and tertiary	12	Total health staffs, cost for drug supply, number of beds	Outpatient department visits, inpatient days, number of surgeries	0.89	0.18	88.9%
Amare, Tsegaw et al	2020	Ethiopia	primary, secondary and tertiary	12	Salary expense, non- salary expense, number of beds	ANC visits, skilled deliveries, post nata deliveries	0.92	0.14	88.9%
Ayiko, Rogers et al	2020	Uganda	secondary	40	Hospital beds, medical personal	OPD visits, medical admissions, deliveries	0.82	0.05	88.9%
Binyaruka, Peter et al	2020	Tanzania	primary, secondary and tertiary	24	Clinical staffs, beds, medical commodities	Outpatient visits and deliveries	0.64	0.34	77.8%
Guillon, Marlène et al	2020	Zimbabwe	primary	31	Nurses, Docters, and beds	Inpatient, outpatient, and operations	0.69	0.11	77.8%
Kirigia, Joses M et al	2013	Eritrea	secondary	19	Number of Docters, number of nurses, midwifes, number of lab technicians, number of beds	Number outpatient visits, and number of discharges	0.97	0.06	88.9%
Lamesgen, Anteneh et al	2022	Ethiopia	primary	15	Non salary costs, salary costs, and number of beds	Number of admissions, Outpatient visits, and number referrals	0.95	0.11	88.9%
Mujasi, PN et al	2016	Uganda	Secondary	13	Number of staff, number of beds	Number of outpatient visits, deliveries, inpatient days	0.92	0.15	77.8%
Mwihia, Francis Kimani et al	2018	Kenya	Secondary	25	number of beds, doctors, and nurses	total outpatient visits and total admissions	0.84	0.14	77.8%
Nundoochan, Ajoy et al	2020	Mauritius	Secondary	5	Number of nurses, doctors, beds, non-clinical staffs	Number of outpatients, inpatients, hospital days, average length of stay, bed occupancy rate	0.83	0.13	88.9%
Rithaa, Gilbert et al	2019	Kenya	Secondary	34	Beds and cots, medical consultants, General medical officers, Clinical officers, Nurses, Therapy specialists, Laboratory Technologist	Outpatient visits, discharges, total operations	0.94	0.11	88.9%
Yitbarek, Kiddus et al	2019	Ethiopia	primary and secondary	14	Expense for non-salary costs, expense for salary for both administrative and clinical staffs, beds, rooms	numbers of Antenatal care (ANC) visits, delivery, Postnatal care (PNC), Family Planning (FP), abortion and post abortion services delivered in the hospitals	0.99	0.03	88.9%
Elmonished, Lena et al	2019	Sudan	primary, secondary and tertiary	10	Number of doctors, number of nurses, number of administrative staffs, number of assistant medical staffs, number of beds	Outpatient department visits and inpatient days	0.91	0.08	77.8%

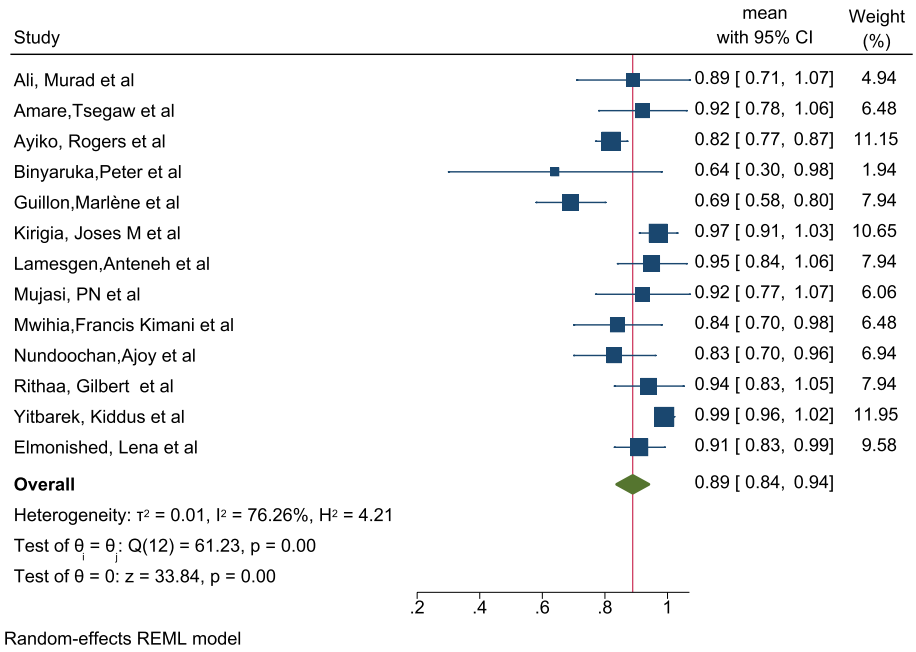

Fig. 2 Forest plot and technical efficiency estimates of public hospitals in east Africa

Table 2 Subgroup analysis of the technical efficiency scores by the level of hospitals, sample size, and quality score of the included studies on the technical efficiency of public hospitals in east Africa (*N* = 13)

Variable	Group	Number of studies	Mean TE	95% CI	I^2
Level of hospital	Primary	2	0.820	(0.565, 1.075)	90.65
	Secondary	6	0.888	(0.826, 0.951)	62.54
	Primary, secondary, and tertiary	5	0.936	(0.872, 1.000)	47.50
Sample size	≥ 15	7	0.860	(0.775, 0.944)	80.85
	< 15	6	0.929	(0.872, 0.985)	48.95
Quality score in percent	77.8%	5	0.824	(0.720, 0.928)	65.88
	88.9%	8	0.919	(0.865, 0.973)	73.61

Table 3 Spearman's rank correlation between the technical efficiency scores and different characteristics of the included studies (*N* = 13)

	Technical efficiency	Sample size	Publication year	Number of inputs	Number of outputs
Technical efficiency					
Spearman's rho correlation coefficient	1.00	−0.19	−0.35	0.29	0.21

hospitals with large catchment population coverage [16] had significant impacts on the technical efficiency of hospitals.

In this study, the meta-analysis result based on subgroup with level of public hospitals revealed that the mean technical efficiency of primary hospitals was about 0.82 which is lower as compared to secondary level hospitals with the mean technical efficiency of 0.88. This finding is consistent with the study conducted in Turkey [37] which showed that the efficiency scores of training and research hospitals were higher than the general and branch hospitals. This might be

due to the high rate of input and the referral point for all higher-level hospitals which can result is higher number of inpatient and outpatient visits.

This review showed that the technical efficiency of public hospitals has a negative relationship with the number of hospitals (the sample size). Similar findings have been reported in previous reviews, which argued that higher efficiency scores may occur with small sample size. This might be due to the fact that a hospital can be considered efficient when there is smaller comparator within the sample [2, 31, 38].

This review has limitations though it shows the general picture on the technical efficiency of public hospitals in east Africa. Firstly, this review investigates the technical efficiency of public hospitals without considering private health institutions and even lower health facilities like health centers. Secondly, the review focuses on east African health system only. These could limit the generalizability to the whole health system of Africa at large which cover wide range of health institutions at different levels.

Conclusion

The results from this systematic review showed that the technical efficiency of public hospital in Eastern African countries requires an improvement. This can be achieved through either increasing the service outputs of the public hospitals such as number of outpatient visits, number inpatient visits, total operations, and deliveries or minimizing the use of inputs (transferring the under used inputs to other public hospitals) of the public hospitals such as labour (number of clinical staffs and number of administrative staffs), capital (number of beds, number of rooms), and expenses for non-salary costs including expenses for drugs and medical supply.

The effective means of improving performances of health institutions is exercising the use evidence-based decisions. To this end, health system leaders in east African countries need to recognize the root causes of hospital (in)efficiency and take essential interventions to facilitate the best way of using limited health service resources. To create an evidence-based scientific information for decision making, studies on public hospital efficiency should be conducted to develop high-quality data: this have to be by considering all health care activities and services, their health outcomes, and covering a wide range of health system areas. Systematic reviews on public hospital efficiency, which are currently rare in the east Africa, need to be conducted on a much larger scale in order to create more, and validated information for use in policy-making.

Abbreviations

ANC	Anti Natal Care
DEA	Data Envelopment Analysis
DMUs	Decision Making Units
GDP	Growth Domestic Product
MeSH	Medical Subject Heading
PNC	Post Nata Care
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
SFA	Stochastic Frontier Analysis

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12913-024-12166-7.

Supplementary Material 1.

Supplementary Material 2.

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Authors' contributions

A.L and B.E: initiated and designed the study; A.L, B.E, and MG.M: analyzed the data and write the manuscript; all authors reviewed, read and approved the manuscript.

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Data availability

All the data analysed during this study are included in the additional file (Additional file 2).

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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