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Full Length Research Paper

Technical Efficiency of Primary Health Care Facilities in Addis Ababa: Data Envelopment Analysis

Serkalem Girma Moges[1]*, Lebitsi Maud Modiba[2]

[1]University of South Africa, Ethiopia Country Office, Addis Ababa, Ethiopia.
[2]University of South Africa, Department of Health Studies, Pretoria, South Africa.

Abstract

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Background: This study assessed the technical efficiency of 94 health centers in Addis Ababa, Ethiopia. It aimed to identify inefficiency sources and estimate potential cost savings. **Methods:** A quantitative, input-oriented, variable returns to scale Data Envelopment Analysis (DEA) model was applied, using secondary data on health service inputs and outputs from July 2017 to June 2018. Five input and four output variables were combined into a composite output index. **Results:** Of the 91 health centers included in the analysis, only 4 (4%) were technically efficient. Efficiency scores ranged from 11.8% to 100%, with an average of 69%, indicating wide variation in performance. The main inefficiency source was scale inefficiency, reflecting suboptimal operating size, followed by pure technical inefficiency. If all health centers operated at the efficiency level of the best performers, approximately 15% of the healthcare budget, about 147 million ETB, could be saved. **Conclusions:** By leveraging routine data systems, the study offers a robust framework for ongoing efficiency assessment and benchmarking. For Ethiopian policymakers and health managers, the findings underscore that improving efficiency is not only a technical requirement but a strategic lever. Saved resources could be immediately redirected to expand access, enhance service quality, and improve frontline workforce advancing equitable and sustainable healthcare delivery.

Keywords: Technical Efficiency, Data Envelopment Analysis (DEA), Health Service Delivery, Scale Inefficiency, Cost savings, Healthcare Budget Optimization, Ethiopian Health System.

BACKGROUND

Globally, an estimated 20% to 40% of all health spending is wasted, including funds that could otherwise increase access to care or save lives (Jordi et al., 2020). Africa's health systems suffer from significant inefficiencies, fueled by a high burden of disease and limited financial resources, which together intensify the pressure on already fragile healthcare infrastructures (Kirigia and Barry, 2008; McIntyre and Meheus, 2012). While there is abroad agreement on the benefits of reducing resource waste and promoting efficiency in the health sector, practical challenges in conceptualization, measurement, and improvement of efficiency, particularly for resource-limited countries.

At a health center serving one of Addis Ababa's largest neighborhoods, dozens of patients arrive early each morning only to wait for hours. "We have trained staff ready to help, but we simply don't have the supplies to do our jobs." This lived experience of systemic inefficiency is reflected in operational shortcomings, that are rarely documented in routine reports. These are not isolated incidents but daily compounding problems that affect not only the application of policies but also the standard, promptness, and fairness of patient care.

Improving the performance and efficiency of health systems has become a central focus for policymakers in Ethiopia in the recent years (Ministry of Health, 2010). Recent health reform efforts, such as hospital reforms and health center reforms guidelines, intend to transform how health care systems deliver care to achieve high performance (Manyazewal and Matlakala, 2018).

*Correspondence: serkalemgirma88@gmail.com

Although attempts to measure the impact of health sector reforms and to monitor health sector performance over time have been made for the last few decades, the concept of efficiency as a measure of health system performance gained a substantial grip on the first Health Sector Transformation Plan (Ministry of Health, 2015).

The health centers in Ethiopia are resources intensive, accounting for a significant share of capital and recurrent health sector expenditures (Ministry of Health, 2017). According to the seventh national health account report, 41% of the total health expenditure is allocated to primary health care units, including health centers, and health posts, compared to 29.4% for hospitals (Ministry of Health, 2019). In addition, the ongoing health sector transformation Programme in Ethiopia places considerable interest and focus on primary health care units, as they are the principal point of patient contact with formal health care systems. In urban settings, health centers are essentially designed to meet 80% or more of the population's health needs (Ministry of Health, 2019).

Efficiency defined as the optimal use of inputs to achieve desired health outcomes and measures the extent to which health system inputs in the form of expenditure are used to create valued- based care (Carrin and Evans, 2010; Revangard et al., 2014). It is also a key indicator of progress toward universal health coverage (UHC) (Jordi et al., 2020). Furthermore, the significance of performance management and efficiency in accelerating health outcomes in the context of insufficient health resources and slow economic growth is well documented (Cantor and Poh, 2018).

Building on the evidence presented above, the inefficient use of health care resources is a critical concern that affects both individual health outcomes and the overall well-being of society. In settings with limited budgets and high demand for services, inefficiency translates into missed opportunities for prevention, treatment, and improved quality of care.

Despite the significance of this issue, there remains limited empirical evidence on the extent and underlying causes of inefficiency in Ethiopia's healthcare system. For instance, a study on the efficiency of Ethiopian health centers found that only 35% of 40 sampled facilities were efficient (Mann et al., 2018). Similarly, an assessment of 16 public health centers in Jimma reported that only half (8) were technically efficient (Firew et al., 2015).

This study addresses key gaps in the measurement and improvement of health system efficiency and performance in Ethiopia. Specifically, it aims to assess the technical efficiency of health centers in Addis Ababa, identify the main sources of inefficiency, and estimate potential cost savings. In doing so, it contributes to the evidence base needed to support more efficient resource allocation and to strengthen the resilience of Ethiopia's health system.

METHODS

Study design

This study employed quantitative research design, utilizing an institutional survey that included all health centers in Addis Ababa. The total number of health centers during the study period (July 2017 to 30 June 2018) was ninety-four (94).

Choice of inputs and outputs variables

The selection of variables for this study was primarily guided by existing literature and data availability. Input variables were chosen based on prior empirical evidence from healthcare efficiency studies. For example, Chirikos and Sear (2013) employed capital costs and fixed assets to represent non-labor inputs in hospital production functions highlighting their significance in resource efficiency assessment. Moreover, their systematic review stressed that clinical staff such as physicians and nurses play a crucial role in healthcare efficiency.

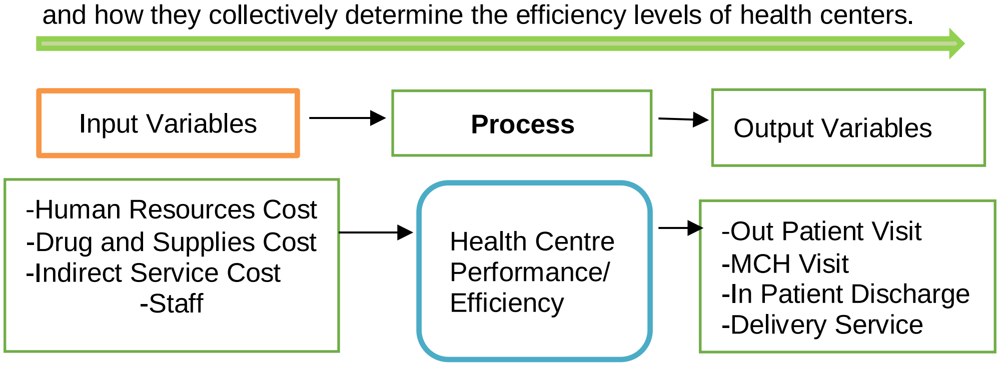
Output variables were similarly grounded in prior research from diverse contexts. In Eritrea, Kirigia and Asbu (2013) conducted a Data Envelopment Analysis of 19 public community hospitals, using outpatient department visits and hospital discharges as output measures. In Turkey, Sahin and Narci (2017) examined the technical efficiency of maternal and child health (MCH) hospitals using DEA, focusing on variables such as outpatient visits and inpatient discharges to underscore the role of MCH services. Similarly, Wang et al. (2016) assessed MCH hospitals in Guangxi, China, incorporating inpatient discharges as key output indicators in their efficiency model. In Ethiopia, Firew, Elias, and Tsega (2015) conducted a two-stage Data Envelopment Analysis of public health centers in three Woredas of Jimma Zone, incorporating delivery services as key output variables. Their study demonstrated that including maternal health services such as deliveries was essential for assessing the technical efficiency of health centers supporting the rationale for the variable selection in this study.

Building on this foundation, the current study employed four input and four output variables to measure the efficiency levels of health centers. The independent (input) variables included human resource costs, indirect health service costs (such as electricity, water, and maintenance), drug and medical supply costs, and staff numbers. Correspondingly, the dependent (output) variables were captured through an array of intermediate health services, including the total number of outpatients, inpatients, maternal, neonatal and child health (MNCH) visits, as well as the total number of delivery services conducted during the study period.

Source of data

The data used in this research came from secondary sources using data extraction tools. The data collection tool was prepared and pretested to collect three sets of data for one fiscal year from 1 July 2017 to 30 June 2018. The first section of the tool was designed to capture the budget and expenditure status of health centers. The second section intended to capture the human resource

Figure 1. illustrates the relationship between these input and output variables and how they collectively determine the efficiency levels of health centers.



data, including the number and qualifications of staff working in the health centers. The last section of the data collection tool captured comprehensive health service delivery statics of the health centers. The data for the input variables were extracted from two sources. These are the Addis Ababa Bureau of Finance and economic development database and the Addis Ababa city administration health bureau human resources information database. The data for output variables were extracted from the health center health management information system database (HMIS). Tool was pre-tested on a small sample of health facility reports to assess completeness, clarity, and consistency with routine health information system indicators. Revisions were made based on feedback from this pre-test to ensure reliability and usability of the tool during full-scale data extraction.

Data Organization

Three input variables were measured using a single unit measurement in terms of financial value in Ethiopian Birr (ETB). For this study, computing input variables are straightforward. However, for output variables composite service indicator was created by aggregating different categories of health services, such as inpatient, outpatient, MNCH, and delivery services. The key step in aggregation is the selection of weights to be allocated to each service output category. Based on literature reviews, the researcher selected as a benchmark a recent primary health care facility cost study (Firew et al., 2015). According to this study, the relative resource intensity of health services was used to assign a weight for each service output. For example, inpatient visits on average require more staff time, and medical supplies. All the service output data of 91 health centers were organized and converted into one composite service index called outpatient equivalent visit.

Data analysis

Descriptive statistics, including mean, standard deviation (SD), minimum, and maximum values for all input and output variables, were computed using Stata 13. After excluding three health centers due to grossly incomplete data, 91 health centers were included in the Data Envelopment Analysis (DEA). DEA is a non-parametric linear programming technique that establishes an efficient frontier based on the performance of the most efficient unit in the group (Jordi et al., 2020).

This study utilized an input-oriented, variable returns to scale DEA model. A health center that achieves the maximum possible output with a given level of input is considered 100% technically efficient, representing the best performing unit. Consequently, the technical efficiency of other health facilities is expressed as a percentage relative to this best performer.

RESULTS

Characteristics of study health centers

Table 1: highlights the wide variability in resources use and service provision among health centers, underscoring the diverse operating conditions across facilities. Human resources costs among the sampled health centers ranged substantially, from as low as 1.5 million ETB to a peak of nearly 15 million ETB, with an average of 7.5 million ETB. This reflects not only the scale of operations but potentially differing levels of staff composition and workload. Similarly, expenditures on drugs and medical supplies varied sharply. The maximum amount of money utilized for drug and medical supplies was 3.9 million ETB, the minimum being around 300,000 ETB. On average the sampled health centers utilized 1.8 million ETB for indirect health service costs. In terms of staffing, health center had, on average,77 medical staff and 63 support staff. Health centers' health service outputs also differed markedly. The maximum number of patients visiting the health center outpatient department during the study year was 50,596, the average being 45,078. In contrast, the inpatient services were limited in several facilities; some recorded zero discharges, while the most efficient health center discharged 311 inpatients during the study period. All

Table 1. Summary statistics of inputs used, and outputs produced (n=91).

Variables	**Statistics**			
Inputs (ETB/Number)	**Mean**	**Min**	**Max**	**SD**
Human resource cost (ETB)	7,464,986	1,516,334	15,150,363	1,716,641.13
Drug Costs (ETB)	1,480,679	308,961	3,972,653	639,793.88
Indirect service Cost (ETB)	1,817,177	622,190	3,609,838	166,180,604
Medical Staff (number)	77	54	115	12
Non-Medical Staff (number)	63	24	107	13
Outputs (Numbers)				
Outpatient Visits	45,078	3,499	50,596	9957
Inpatient Discharges	26	0	311	38
MCH Visits	2,293	299	9,864	1880
Deliveries	458	46	2,169	433
Notes: ETB (Ethiopian Birr)				

health centers provided delivery services, but again, the variation was striking from as few as 46 deliveries to a high of 2,169 (with SD=433).

Overall relative technical efficiency of health centers

Table 2 presented the Input-oriented technical efficiency scores for all 91 health centers included in the study. These scores, generated through Data Envelopment Analysis (DEA), offer insight into the relative efficiency of each facility in converting inputs into health service outputs. Amongst the 91 health centers assessed, only four 4 (4%), specifically HC7, HC54, HC80, and HC91 were identified as technically efficient with an overall technical efficiency (OTE) score of 1. These facilities serve as benchmarks within the sample, indicating that they operated with optimal input utilization during the study period. In other words, they achieved their output levels without any measurable input waste. The remaining 87 health centers (96%) with OTE scores less than 1 were found to be technically inefficient. This suggests that the vast majority of centers had room to improve efficiency by reducing input use while maintaining the same level of output.

Interestingly, the distribution of the efficiency scores revealed substantial variation. For instance, among Addis Ababa health centers, efficiency scores ranged from 11.8% (HC 17) to 100% (HC7, HC54, HC80, and HC91). This wide disparity suggests uneven resource utilization patterns across facilities, even in relatively similar urban settings. To illustrate consider HC17: with an efficiency score of 0.118, this facility would theoretically need 11.8% of the inputs to produce the same output, indicating significant inefficiency and potential overuse of resources. On the opposite end of the spectrum, HC60, one of the better-performing inefficient centers, had an OTE score of 0.974, meaning it could reduce input use by just 2.6% to operate efficiently.

These findings are further reflected in the overall technical inefficiency (OTIE) scores. Efficient centers (OTE = 1) scored zero for OTIE, implying virtually no input waste. Meanwhile, inefficient centers showed a wide range of OTIE values, from 2.6% in HC60 to as high as 88.2% in HC17. This suggests varying levels of inefficiency across the network, with some facilities close to the efficient frontier and others substantially distant from it.

Comparison of overall technical efficiency between efficient and inefficient health centers

Table 3 compares how inputs were allocated between inefficient (n=87) and efficient (n=4) health centers. In both groups, human resources accounted for the largest share of the total input cost: 69% in inefficient health centers and 67% in efficient ones followed by drug and medical supply at 17% and 18% respectively.

A comparable share of input is observed between efficient and inefficient health centers; human resources expenditures take close to two thirds of the total expenditure of the health facilities, followed by drug and medical supplies, with the least share going toward indirect service delivery.

Figure 2 below illustrates a clear difference in productivity between efficient (4) and inefficient (87) health centers in relation to the input used in terms of human resources and the output they produced (outpatient equivalent visits). On average medical staff in the efficient health centers provided 611 outpatient equivalent visits per year compared to 336 in the inefficient health centers. On-medical staff showed a similar

Table 2. Ranking of health centers in terms of their overall technical efficiency (OTE) scores in Addis Ababa (n=91).

Code	OTE Score	OTIE (%)	Rank	Code	OTE Score	OTIE (%)	Rank	Code	OTE Score	OTIE (%)	Rank
Dmu7	1	0	1	Dmu52	0.703	0.297	32	Dmu83	0.505	0.495	63
Dmu54	1	0	2	Dmu36	0.694	0.306	33	Dmu75	0.497	0.503	64
Dmu80	1	0	3	Dmu70	0.691	0.309	34	Dmu38	0.49	0.51	65
Dmu91	1	0	4	Dmu78	0.669	0.331	35	Dmu15	0.483	0.517	66
Dmu60	0.974	0.026	5	Dmu82	0.661	0.339	36	Dmu5	0.481	0.519	67
Dmu33	0.963	0.037	6	Dmu89	0.661	0.339	37	Dmu39	0.481	0.519	68
Dmu2	0.961	0.039	7	Dmu45	0.652	0.348	38	Dmu3	0.454	0.546	69
Dmu88	0.95	0.05	8	Dmu72	0.648	0.352	39	Dmu40	0.451	0.549	70
Dmu35	0.937	0.063	9	Dmu51	0.644	0.356	40	Dmu43	0.427	0.573	71
Dmu79	0.933	0.067	10	Dmu24	0.643	0.357	41	Dmu81	0.422	0.578	72
Dmu1	0.866	0.134	11	Dmu47	0.643	0.357	42	Dmu85	0.405	0.595	73
Dmu53	0.859	0.141	12	Dmu57	0.642	0.358	43	Dmu9	0.4	0.6	74
Dmu29	0.838	0.162	13	Dmu34	0.637	0.363	44	Dmu86	0.393	0.607	75
Dmu64	0.834	0.166	14	Dmu69	0.635	0.365	45	Dmu6	0.387	0.613	76
Dmu71	0.814	0.186	15	Dmu25	0.634	0.366	46	Dmu18	0.366	0.634	77
Dmu22	0.813	0.187	16	Dmu62	0.632	0.368	47	Dmu49	0.361	0.639	78
Dmu41	0.795	0.205	17	Dmu68	0.614	0.386	48	Dmu23	0.357	0.643	79
Dmu28	0.779	0.221	18	Dmu46	0.611	0.389	49	Dmu87	0.33	0.67	80
Dmu77	0.777	0.223	19	Dmu31	0.606	0.394	50	Dmu42	0.319	0.681	81
Dmu13	0.776	0.224	20	Dmu37	0.606	0.394	51	Dmu4	0.317	0.683	82
Dmu63	0.772	0.228	21	Dmu74	0.603	0.397	52	Dmu76	0.312	0.688	83
Dmu21	0.768	0.232	22	Dmu55	0.601	0.399	53	Dmu10	0.283	0.717	84
Dmu56	0.766	0.234	23	Dmu50	0.578	0.422	54	Dmu44	0.277	0.723	85
Dmu12	0.753	0.247	24	Dmu14	0.574	0.426	55	Dmu65	0.272	0.728	86
Dmu67	0.739	0.261	25	Dmu16	0.569	0.431	56	Dmu8	0.262	0.738	87
Dmu20	0.736	0.264	26	Dmu84	0.554	0.446	57	Dmu27	0.239	0.761	88
Dmu58	0.736	0.264	27	Dmu66	0.552	0.448	58	Dmu59	0.152	0.848	89
Dmu73	0.729	0.271	28	Dmu19	0.534	0.466	59	Dmu90	0.132	0.868	90
Dmu30	0.71	0.29	29	Dmu11	0.533	0.467	60	Dmu17	0.118	0.882	91
Dmu32	0.705	0.295	30	Dmu26	0.524	0.476	61				
Dmu48	0.704	0.296	31	Dmu61	0.515	0.485	62				

Notes: OTE= Overall technical efficiency, OTIE%= overall technical inefficiency in percentage
TIE%=Overall technical inefficiency=(1-OTE) ×100

trend, with 688 outpatient visits in efficient health centers versus 409 in inefficient once. This result indicates effective staff utilization in efficient facilities, highlighting human resource management as a key driver of efficiency.

Sources of inefficiency

To explore the underlying drivers of inefficiency among the health centers, overall technical efficiency (OTE) was decomposed into pure technical efficiency (PTE) and scale efficiency (SE). This decomposition was conducted using Data Envelopment Analysis (DEA) under both variable returns to scale (VRS) and constant returns to the scale (CRS) assumptions. The results are presented in Figure 3 which displays OTE PTE and SE scores for each of the 91 health centers.

The analysis under the VRS model revealed that 24% of the health centers(n=22) achieved a PTE score of 100%. These health centers reflected managerial efficiency or good performance in organizing inputs to provide maximum possible outputs. Conversely, the remaining 76% (n=69) demonstrated varying degrees of managerial inefficiencies or managerial underperformance in organizing inputs to produce maximum outputs as reflected by the PTE scores of less than 100%.

Comparison of OTE scores and PTE scores, as indicated in figure 3, further differentiates the sources of inefficiency. While 22 HCs (24%) were found to be technically efficient under PTE measurement; however, under OTE measurement only 4 (4%) were found to be efficient. This discrepancy indicates that the remaining 18, (20%) of the health centers managerially efficient,

Table 3. Comparison of input cost used among efficient (n=4) and inefficient (n=87) health centers in Addis Ababa

Statistics	**HR Cost (ETB)**	**Indirect Cost (ETB)**	**Drug Cost (ETB)**
Inefficient Health centers (n=87)			
Min	1,779,084	308,961	622,190
Max	15,150,363	3,972,653	3,609,838
Average	7,464,986	1,480,679	1,817,177
Total	649,453,815	128,819,050	158,094,394
Percentage	69%	14%	17%
Efficient Health centers (n=4)			
Min	1,516,334	1,214,149	1,625,127
Max	10,736,392	2,421,887	2,546,013
Average	7,348,923	1,634,689	2,021,552
Total	2,9395,692	6,538,754	8,086,210
Percentage	67%	15%	18%
Note: Percentage Cost for Non efficient HCs (HR/Indirect/ drug) = (Total cost HR/Indirect/ drug) ÷Total Number of non-efficient health centers) x100 Percentage cost for non-efficient HCs (HR/Indirect/ drug) = (Total cost HR/Indirect/ drug) ÷Total Number of non-efficient health centers) x100 Percentage of medical staff= (medical staff÷ total staff) x100 Percentage of non-medical staff= (non-medical staff÷ total staff) x100			

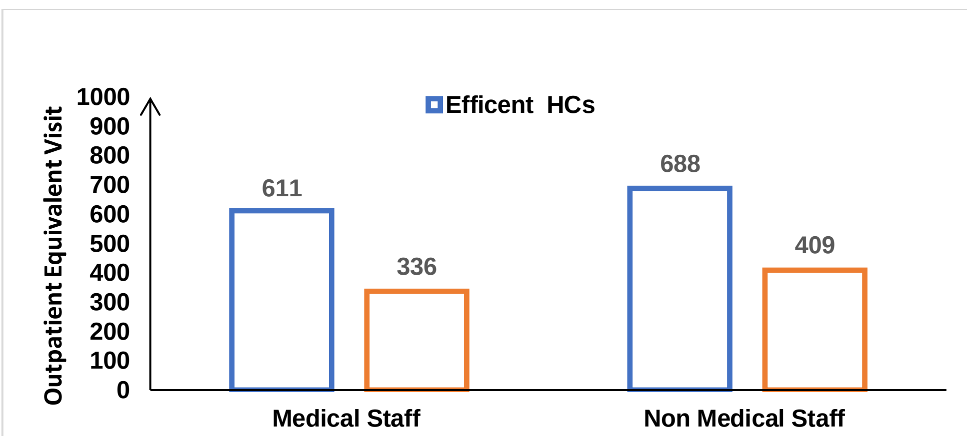


Figure 2. Outpatient equivalent visits per medical and non-medical staff among non-efficient (n=87) and efficient (n=4) health centers per year.

were scale inefficient, suggesting that they were not operating at an optimal production scale. These findings imply that the inefficiency observed in the health centers was attributable to suboptimal scale size rather than managerial inefficiencies.

Further analysis of SE showed that only 4 HCs (4%) were operating at the most productive scale size (SE=1) while the remaining 87HCs (96%) had SE scores less than 100% indicating scale inefficiency. This suggests that a significant proportion of the health centers were either too big or too small relative to their service demands, thereby failing to capitalize on economics of scale. In

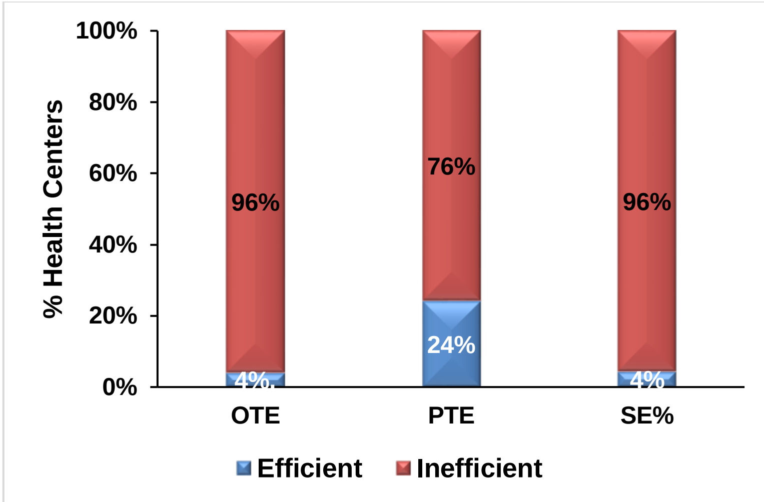


Figure 3. Percentage of efficient and inefficient health centers under OTE, PTE, and SE measurement.

summary, the findings indicate that the sources of overall technical inefficiency were both poor utilization of inputs (managerial inefficiency) and failure to operate at the most productive scale size (scale inefficiency).

Scale efficiency and the nature of returns to the scale

As depicted in figure 4 scale efficiency (SE) scores across the 91 health centers varied considerably. The maximum scale efficiency score is 1, a score achieved by 4 health centers (data labels filled in red), implying these facilities were operating at an optimal scale. These health centers serve as benchmarks, demonstrating the capacity to maximize output with their current input and size. In contrast, the lowest SE score was 0.135 (13.5%), indicating that the corresponding health center was 0.865(1-0.135) scale inefficient. This finding implies that the health center had the potential to increase output by 86.5% without requiring additional input by operating at a more appropriate scale. Overall, the substantial variation in scale efficiency highlights that a significant proportion of health centers are operating either above or below their most productive scale size.

Scale efficiency in DEA takes three forms: Constant returns to the scale (CRS), decreasing returns-to scale (DRS), and increasing returns-to-scale (IRS). As presented in table 4 only four health centers (4%) were operating under CRS, indicating that they were functioning at the most productive scale size. These facilities are considered both technical and scale efficient. In contrast, all inefficient health centers 87 (96%) are experiencing increasing returns to scale (IRS). This implies that all the inefficient HCs were operating at a suboptimal scale and have the potential to improve efficiency by expanding their output levels without proportionally increasing input use. Notably, no health centers in the sample that fall in the decreasing returns to the scale (DRS) category. This indicates that none of the health centers were oversized or suffering from diseconomies of scale during the study period. These results highlight the predominant challenge of suboptimal scale among inefficient health centers, reinforcing the need for strategies that promote scaling up service delivery to achieve better efficiency outcomes.

Areas for efficiency improvement

To identify key areas of efficiency improvement, further analysis was conducted to estimate the input reductions required for inefficient health centers to operate efficiently. Table 5 presents the target input values and associated potential cost savings for the 87 health centers identified as inefficient. All inefficient health centers (87) used a total input cost close to 1 billion ETB and employed 12,832 staff to provide service to 2,477,530 patients. Based on the DEA analysis results the same output could have been achieved with 833 million ETB and 11,185 staff, indicating a substantial opportunity to improve resource utilization. This implies a potential cost saving of 147 million ETB, equivalent to 15% of the total annual expenditure among inefficient health centers, without compromising service volume. Human resources account for the largest portion of this cost-saving: a reduction of 896 medical staff and 750 non-medical staff, equivalent to 91 million ETB. Further savings include34 million ETB in drugs and supplies and 22 million ETB in indirect service costs.

These results indicate considerable inefficiencies in current input use. Improving technical efficiency across these facilities could yield significant cost savings and strengthen the sustainability of health service delivery without affecting access to health services.

Areas for efficiency improvement: slacks

Slacks provide key information regarding the areas of

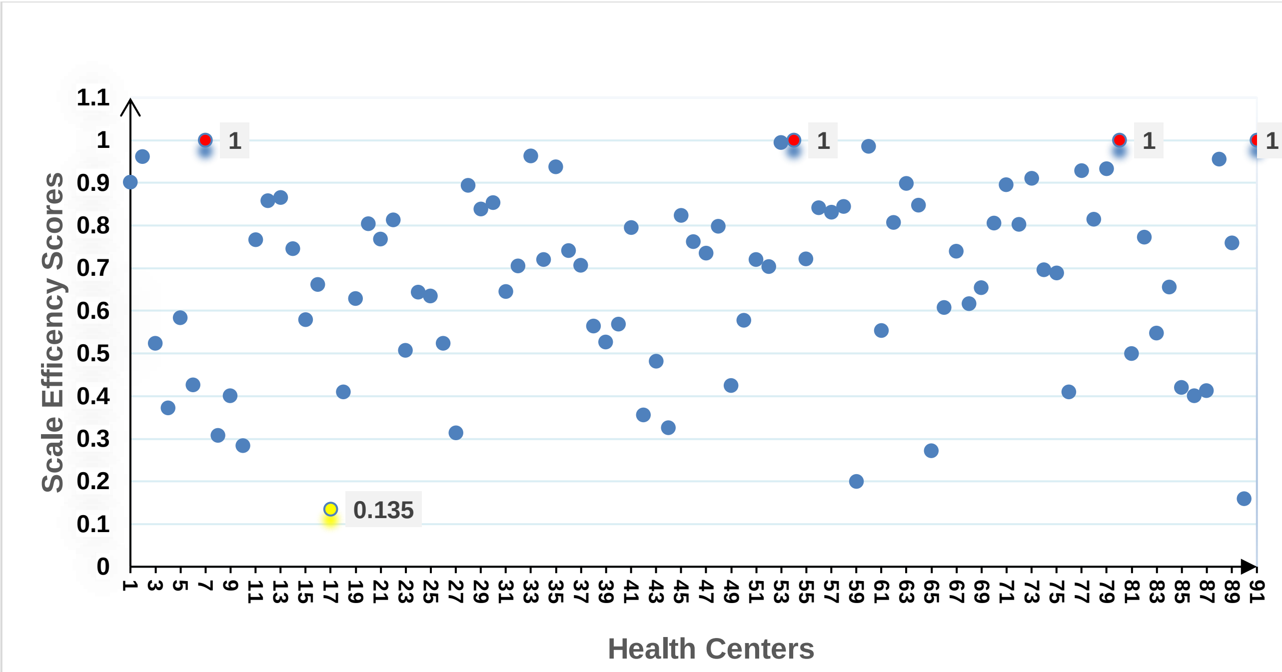


Figure 4. Scale efficiency score distribution of 91 health centers.

Table 4. Nature of returns to the scale (n=91).

Nature of Returns to the Scale	Frequency	Percent
Number	91	100
CRS	4	4%
IRS	87	96%
DRS	0	0
Note: CRS (constant returns scale), IRS (Increasing returns to scale) DRS (Decrease returns to scale		

excess input use that contributes to inefficiency in health centers. In this study 87 health centers were identified as inefficient, and the presence of slacks offers valuable insights into specific inputs that require optimization for these centers to reach an efficient performance level. Table 6 displayed the summary of input slacks derived from DEA analysis. The analysis reveals that among the input variables, 20 (23%) of the health centers have non-zero slacks in human resources costs, indicating potential overuse in this category. Additionally, 38 (44%) of the HCs have non-zero slacks for drug and supply costs, suggesting substantial room for cost reduction in this area. Furthermore, 9 (10%) HCs non-zero slack has been observed for indirect service costs.

In terms of staffing, 12 health centers (14%) and 20 health centers (23%) non-zero slacks were observed for medical and non-medical staff, respectively. These findings highlight critical areas where resource reallocation or process optimization could enhance overall efficiency. Overall, the slack analysis not only quantifies inefficiencies but also provides actionable insights for health center administrators and policymakers. By focusing on the specific input areas where excess use occurs, targeted interventions can be designed to support underperforming centers in their transition toward efficient and sustainable operation.

DISCUSSION

This study found that a striking 95% of the health centers were technically inefficient. Although technical inefficiency is widely prevalent according to studies conducted in African countries, the finding of the current study is notably higher than what has been reported elsewhere. For example, Bobo et al. (2018) reported that 50% of public health centers in Ethiopia were technically

Table 5, Targets and input (cost) reduction for inefficient health centers (n=91)

Input Variables	Input Used	Input Targets	Input Reduction	Percent Input (Cost) Reduction
HR Cost (ETB)	678,849,506	588,681,139	90,168,367	13%
Drug Cost (ETB)	135,357,804	101,004,621	**34,353,183**	25%
Indirect Cost (ETB)	166,180,604	143,449,320	22,731,284	14%
Total Input Cost	980,387,916	833,135,080	147,252,836	15%
Medical staff(n)	7033	6136	896	13%
Non-Medical Staff(n)	5799	5048	750	13%
Total Staff	12,832	11,185	1647	13%
Note: Input (Cost) Saving = Input Used – Input targets Percent input(cost) reduction = (Input Used – Input targets) x 100				

Table 6. Summary descriptive statistics input and output slack for inefficient health centers (n=87).

Input Variables	**Number of Health Centers**	**Frequency of Slacks**	**Percent Frequency of Slacks**
Human resources Cost	87		
Non-zero (Yes)		20	23%
Zero (No)		67	77%
Drug and supplies cost	87		
Non-zero (Yes)		38	44%
Zero (No)		49	56%
Indirect service cost	87		
Non-zero (Yes)		9	10%
Zero (No)		78	90%
Medical staff	87		
Non-zero (Yes)		12	14%
Zero (No)		75	86%
Non-Medical Staff	87		
Non-zero (Yes)		20	23%
Zero (No)		67	77%

inefficient. Similarly, Marschall and Flessa (2011) found that 66% of primary care facilities in rural Burkina Faso were inefficient, while Moran and Jacobs (2013) reported a 56% inefficiency rate in inpatient mental healthcare systems. In Ghana, Novignon and Lawanson (2014) observed that 78% of public health centers were inefficient. Other comparative studies also highlight widespread inefficiencies across African health systems (Kirigia, 2015; Färe et al., 2017).

Understanding the extent and nature of this inefficiency is essential, especially when looking at how much room there is for improvement. The average OTIE is set at 39% with an SD of 22%. In practical terms, this means that the health centers could reduce their input by nearly 40% without reducing output, if they adopted more efficient practices. The marginally inefficient health center in the sample needs to reduce 2.6% of inputs, while the most inefficient health center in the sample should reduce 88.2% of inputs, to move to the efficient frontier. These findings are consistent with what has been found in previous studies conducted in Ethiopia. Mann et al. (2018) found an average technical efficiency score of 79%, implying 21% of input wastage among the sampled health centers. A similar pattern was observed in the study by Bobo et al. (2018), conducted in three districts of Ethiopia, which found an overall average technical efficiency score of 77%.

The key findings that emerge from the present study suggest that the management teams of the inefficient health centers could and can do a lot more to make better use of resources allotted to their centers. In particular, the overall technical efficiency and inefficiency scores are indicative of the level of improvement expected from each health center in Addis Ababa. One of the most interesting findings is that there was no significant difference between efficient and inefficient health centers in terms of the average input cost utilization for human resources, drug and medical supplies, or indirect health services. This is mostly the reflection of the government's budgetary allocations to the health facilities. According to the health center data collected on sources of finance, almost all health centers received a significant portion of their annual budget from the government treasury. This suggests that it's not necessarily about how much money is being allocated, but rather how those resources are being used. In many ways, this brings the focus squarely onto the role of health center management. Managers may have limited influence over how much budget is allocated, but they do play a key role in how efficiently services are delivered and how well that budget is translated into health services.

Human resources used close to two thirds of the total annual health centers' spending, this was followed by drug and medical supplies, with indirect service delivery accounting for the smallest portion. Yet even with this consistent pattern, many health centers showed inefficiencies in how they used their staff and supplies. Several facilities had non-zero slack values, particularly in the use of both medical and non-medical staff, as well as in drug and supply costs. This suggests that there is significant scope for better planning, task allocation, and procurement practices. These are areas where targeted interventions could make a real difference.

Another important takeaway is the finding that most health centers were operating under increasing returns to scale (IRTS). This indicates that these health centers are too small to be efficient and could benefit from scaling up their operation. This has implications for planning and resource distribution. Expanding services such as outpatient, inpatient, MCH, and delivery services could help centers move closer to the efficient frontier. Policymakers might consider ways to strengthen demand for services or even rethink how catchment areas are defined to ensure optimal health facility use. At the same time, we recognize there are limits to what facility managers can do on their own. Broader system level support, including better training, clearer performance expectations, and stronger governance structures, would be essential for any meaningful change. Without these supports, the risk is that inefficiencies persist, not because of a lack of will, but because of structural and policy constraints.

There are, of course, several limitations to this study. The analysis relied on routine data, which can vary in accuracy. We also focused solely on health centers in an urban setting, meaning the findings may not be directly applicable to rural or private facilities. Moreover, DEA measures efficiency relative to peers but doesn't account for quality of care, something we believe future studies should integrate, especially when considering the impact of efficiency on patient outcomes.

Finally, while our findings point to areas for improvement, implementing change is rarely straightforward. Managers often face competing demands, limited autonomy, and constrained resources. Still, regular efficiency assessments and modest reforms at the facility level, such as improving how services are scheduled or aligning staffing more closely with demand can add up to meaningful improvements. Over time, such changes could help ensure that health centers not only operate more efficiently but also serve their communities more effectively.

CONCLUSION

This study highlights how data envelopment analysis can be used to uncover meaningful inefficiencies in the operation of health centers in Addis Ababa. The huge variation in efficiency scores underscores the untapped potential for better utilization of existing resources to improve service delivery. Most importantly, the findings reveal that scale inefficiency reflecting suboptimal size along with managerial inefficiency are key drivers of underperformance. If all health centers in Addis Ababa were operated at the best-practice performance efficiency level as defined by the DEA model, approximately 15% of the health care budget could be saved. These savings could be redirected toward other priority health sector needs, such as improving service quality or expanding access to care.

However, efficiency scores alone are not a solution. For facility managers, the path forward must include identifying the root causes of inefficiency and developing targeted strategies to address them. This calls for improved managerial capacity, informed decision-making, and system level support. Health authorities and policymakers should prioritize the integration of routine efficiency assessments into health system planning and provide technical support to underperforming health centers.

Looking ahead, future research should explore efficiency trends over time through longitudinal studies and consider complementary methods that account for allocative efficiency and external factors affecting performance. Such work could provide a more holistic picture of health system productivity. The time to act is now. In a resource-constrained environment like Ethiopia's, improving efficiency is not a technical luxury, it is a moral imperative. What would our health system look like if every birr spent truly delivered its full value?

List of abbreviations

DEA, Data envelopment analysis; HC, Health centre; OTE, Overall technical efficiency; PTE, Pure technical efficiency; SE, Scale Efficiency; TE, Technical efficiency.

Operational Definition of terms

Health System Efficiency: For this study, the notion of cost efficiency is used as a definition of efficiency. Cost efficiency measures the extent to which inputs in the form of expenditure and other resources are used in the best possible way to ensure the maximum level of health system outputs (Chisholm & Evans 2010:3). In this study, health system efficiency refers to the extent to which health center inputs, in the form of expenditure and human resources, are used to produce health service outputs, measured in the form of outpatient equivalent visits.

Technical efficiency: measures the conversion of inputs (annual spending on health staff and health facilities) into outputs in terms of health services, such as outpatient services and inpatient discharges.

DECLARATIONS

Ethics approval and consent to participate

Ababa City Administration Health Bureau Public Health Research and Emergency Management Core Process. Participants' informed consent was obtained.

Authors' contributions

Both authors contributed equally.

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Competing interests

The authors declare that they have no competing interests.

Author details

1 Department of Health Studies, University of South Africa, P/O.BOX 12640, Addis Ababa Ethiopia.
2 Department of Health Studies, University of South Africa, South Africa, Pretoria

Consent for publication

Not applicable.

Availability of data and materials

Data sets used in this study can be abstracted from the Health Sector information system database FY 2017/2018. Human Resource Information Systems data base at Addis Ababa city administration health bureau. Contact Serkalem Girma Moges at serkalemgirma88@gmail.com for the data.

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