Published by

British Journal of Contemporary Research

BEXFORD PUBLISHING

Evaluating the Efficiency of Malaria Treatment in Primary Healthcare Facilities in Gombe State Using Data Envelopment Analysis

Original Research Article | Volume 1 | Issue 2 | 2026 | Article Number: 047

Accepted: 23 June 2026 | Published: 10 July 2026 | ISSN: 2979-8582 (Online)

Abubakar Sadeeq Adamu[1], Dr. A M Yami[1], A S Aliyu[1], E O Harrison[1], M I Muhammad[1]

[1]Department of Operations Research, Faculty of Computing Modibbo Adama University (MAU) Yola, Nigeria

AAS 0009-0003-5702-1240

Correspondence: Abubakar Sadeeq Adamu, abubakarsadeeq966@gmail.com

Abstract

Malaria remains a major public health challenge in northern Nigeria, with primary healthcare facilities (PHCs) serving as the first point of diagnosis and treatment for most patients. Despite continued investments in healthcare personnel, infrastructure, and diagnostic resources, evidence on how efficiently these inputs are converted into positive malaria treatment outcomes is limited. This study evaluates the relative efficiency of 7 PHCs across the 11 local government areas of Gombe State using data envelopment analysis (DEA). An output-oriented Variable Return to Scale (VRS) model employed to assess the ability of facilities to maximize malaria recovery outcomes given existing resource levels. Eight (8) input variables: Number of Doctors, Number of Nurses, Number of Laboratory Technicians, Personnel Salaries, Number of Beds, and Number of Patients with Fever Tested using RDT/Widal, Number of Confirmed Uncomplicated MalariaCases and Number of RDT Test Kits Used were evaluated against a single output: The Number of Patients Recovered from Malaria. DEA results revealed significant variations in efficiency across facilities. Of the 78 facilities analyzed, 28 PHCs achieved an efficiency score of 1, representing approximately 35.9% of the sample, demonstrating optimal alignment between resource utilization and recovery outcomes. However, 50 (64.1%) facilities showed varying degrees of inefficiency characterized by underutilized staff, low diagnostic productivity, and mismatches between patient load and available beds or test kits. Maikaho Primary Healthcare Centre (DMU68) was the top performer, appearing in 50 reference sets and ranking first in efficiency. Efficient PHCs provided replicable best-practice models for improving resource deployment and treatment effectiveness across the state. The study offers actionable insights for policymakers, health managers, and the Gombe State Primary Healthcare Development Agency, particularly in strengthening diagnostic accuracy, optimizing workforce deployment, and improving malaria case management. Overall, these findings contribute to building a more effective PHC system and advancing public health outcomes in resource-limited settings.

Keywords: Data Envelopment Analysis, Primary Healthcare, Malaria Treatment, Technical Efficiency

Background to the Study

Malaria fever is among the most widespread diseases in the universe. The disease has been linked to poverty and underdevelopment, resulting in severe morbidity and mortality. Malaria is a fever infection and one of the deadliest diseases in the world, caused by one or more species of Plasmodium. These include Plasmodium falciparum, Plasmodium vivax, Plasmodium ovale, Plasmodium malariae, and Plasmodium knowlesi. Malaria affects around half of the global population. Fatumo (2013) opined that malaria causes considerable morbidity and mortality worldwide. Nigeria bears a significant share of the global malaria burden, with the diseases placing substantial pressure on primary healthcare systems, especially in rural and peri-urban communities.

Primary Healthcare Facilities (PHCs) constitute the foundation of Nigeria's healthcare delivery system and are responsible for the diagnosis, treatment, and referral of uncomplicated malaria cases. In Gombe State, PHCs play a critical role in malaria control through case detection, rapid diagnostic testing, and prompt treatment using artemisinin-based combination therapies. However, differences in staffing levels, infrastructure, and diagnostic capacity raise concerns about whether available resources are being utilized efficiently to achieve optimal malaria treatment outcomes.

Problem Statement

Lack of comprehensive analysis on the operational efficiency of these healthcare facilities results in a gap in understanding the variations in treatment outcomes and resource utilization. This study aims to address this gap by evaluating the efficiency of malaria fever treatment in primary healthcare facilities in Gombe State using Data Envelopment Analysis (DEA). DEA is a robust analytical tool that assesses the relative efficiency of decision-making units (in this case, primary healthcare facilities) by comparing the inputs used and outputs produced. By applying DEA, this study will identify best practices, uncover inefficiencies, and provide actionable insights to enhance the performance of primary healthcare facilities in the state.

Aim and Objectives

The aim of this study is to evaluate the efficiency of malaria treatment in primary healthcare facilities in Gombe State using Data Envelopment Analysis (DEA) to identify best practices, uncover inefficiencies, and provide actionable insights for improving healthcare delivery and resource utilization.

The objectives are to:

i. Determine efficient primary healthcare facilities among the primary healthcare in Gombe State.
ii. Evaluate the treatment outcomes for malaria and in terms of recovery rates.
iii. Identify an underutilized resources in the Primary Healthcare Facilities in Gombe State (e.g., excess staff or unused beds)

Review of Related Literature

Malaria Diseases

Malaria is caused by obligate intracellular parasites that live inside host erythrocytes and remodel these cells to best suit their own needs. It is a major public health problem in tropical areas and is estimated to cause 1 to 3 million deaths and 300 to 500 million infections annually (Prasanna 2011, p. 1–5). Uneke (2008) also noted that malaria remains the most complex and overwhelming health problem facing humanity in the vast majority of tropical and subtropical regions of the world, with 300 to 500 million cases and 2 to 3 million deaths per year. Approximately 90% of all malaria deaths in the world today occur in sub-Saharan Africa, where the majority of infections are caused by Plasmodium falciparum, the most dangerous of the four human malaria parasites, accounting for an estimated 1.4 to 2.6 million deaths per year in this region. In addition, the most effective malaria vector, Anopheles gambiae, is the most widespread in the region and the most difficult to control. In areas where malaria is highly endemic, protective semi-immunity to P. falciparum is acquired during the first 10-15 years of life, and the majority of malaria-related morbidity and mortality occurs in young children. Malaria is an infectious disease caused by the parasite Plasmodium species, of which Plasmodium falciparum is the most common among the other species (vivax, malariae, ovale, and knowlesi), particularly in Nigeria and other sub-Saharan African countries where infection is endemic. It is the most virulent, dominant, and widespread strain of malaria. Malaria is transmitted from person to person through the bite of an infected female Anopheles mosquito.

According to the World Health Organization (WHO) malaria terminology (2021 update, pp. 16–17), in malaria control settings, a "case" is the presence of a documented malaria infection, with or without symptoms. In settings where malaria is being or has been actively eliminated, a "case" is defined as any documented malaria infection, with or without symptoms. Occurrence of malaria infection in a person in whom the presence of malaria parasites in the blood has been confirmed by a diagnostic test, a suspected case of malaria cannot be considered a case of malaria until parasitological confirmation has been obtained. A malaria case may be classified as confirmed, fever, index, locally acquired, presumed, imported, indigenous, induced, introduced, relapsing or recrudescent, management, notification (depending on the source of infection), and symptomatic or asymptomatic.

The clinical diagnosis of malaria is usually based on the patient's symptoms, which include fever, chills, sweats, headaches, muscle pains, nausea, and vomiting, which are also associated with other diseases. This makes early diagnosis difficult, leading to delays in the commencement of treatment. Van Eijk et al., (2020) cited that many symptoms were more common, including headaches, chills, body aches, vomiting, disorientation, fever, or a combination of these. Younger age groups were more likely to report coughing and vomiting, as well as recorded fever, than older adults (15+ years), although there were no differences based on gender or season. Bria et al. (2021) contended that some symptoms may appear in the early stages of malaria; the combination of shivering, fever, and sweating is often employed as the three major symptoms, with other related symptoms considered supportive. This notion is shown by the three stages of shivering (cold stage), fever (hot stage), and sweating (sweating stage) in tertian malaria caused by P. vivax and Plasmodium ovale.

Medical diagnosis is a categorization task that allows physicians to make predictions about clinical situations and determine the appropriate course of action (Oguntimilehin & Adetunmbi, 2015); if the final diagnosis agrees with a disease that afflicts patients, the diagnostic process is correct; otherwise, a misdiagnosis occurs. Prompt and accurate diagnosis of malaria is required to institute timely therapy, thus reducing morbidity and mortality especially in young children and prevent unnecessary use of antimalarials, thus reducing emerging resistance. Diagnosis of malaria involves identification of malaria parasite or its antigens/products in the blood of the patients. The most commonly used diagnostic test for malaria is microscopy to detect parasites in stained blood films. Thick blood films are used in routine diagnosis and as few as one parasite per 200 µl blood can be detected. The method can be used to differentiate between different parasite species and stages of the life cycle.

Parasitological or confirmatory diagnosis can be done by the following:

Light Microscopy: Smears can be made from blood, bone marrow or skin scrapings. Peripheral blood smear examination is the "gold standard" for diagnosis of malaria. Blood should be collected before administration of antimalarial and smears should be prepared soon after to prevent distortion of parasite morphology. Thick and thin blood smears are stained with Giemsa. At least 100 fields are examined at 100X oil immersion before labeling a slide negative. Single negative peripheral smear examination does not rule out malaria.

Immunochromatographic Rapid Diagnostic Tests (RDTs) these detect antigens or enzymes specific to the genus or species of plasmodium.

a. pfHRP2: Specific for P. falciparum
b. pLDH: Two forms are available, species specific LDH (P. falciparum and P. vivax) and a pan malarial LDH.
c. pAldolase: It is panning malarial antigen and thus can detect malaria but not the species.

RDTs are easy to use, give rapid results, are able to detect sequestered parasites in cases of P. falciparum infection, and have high sensitivity especially at high parasite densities. The overall sensitivity of RDTs to detect any plasmodium species is 82% and for P. falciparum is 95%. The pfHRP2 based RDTs have >95% sensitivity and specificity to detect P. falciparum. However, RDT kits need stringent temperature (2–30 °C) and humidity control. The pfHRP2 stays positive for 28 days after infection. Aldolase and LDH based RDTs become rapidly negative after treatment, however can be positive due to presence of gametocytes. Thus, RDTS cannot be used for monitoring response to the therapy.

Treatment

The World Health Organization (WHO) recommends that malaria treatment be based on a laboratory-confirmed diagnosis, with the exception of children under the age of five in high transmission areas, who may be treated based on a clinical diagnosis (Onanuga et al., 2015). However, the high prevalence of silent diseases, combined with a lack of resources such as microscopes and skilled microscopists in highly endemic areas, has led peripheral health facilities to adopt "presumptive treatment". Children with fever without a clear cause are presumed to have malaria and treated accordingly. According to Ananda et al. (2024, pp. 5-6). The World Health Organization (WHO) now recommends six alternative artemisinin-based combination therapies (ACTs) for malaria treatment worldwide. The known antimalarial drug combinations are listed below:

a. The combination of artesunate and amodiaquine,
b. Artemether paired with lumefantrine,
c. Artesunate combined with sulfadoxine pyrimethamine,
d. Artesunate in conjunction with mefloquine,
e. Artesunate together with pyronaridine, and
f. Dihydroartemisinic jointly administered with piperaquine.

The utilization of multiple artemisinin-based combination therapies (ACTs) is a fundamental aspect of the therapeutic approaches implemented by different nations facing the challenge of malaria prevalence together. Artemisinin-based Combination Therapy (ACT) is widely employed as the primary and secondary treatment strategy for malaria in numerous regions affected by the dis- ease. The ACT regimen is composed of a synergistic blend of artemisinin or its derivatives, along with other pharmacological agents known as partner medicines, the standard first-line treatment for malaria, known as ACT (Artemisinin-based Combination Therapy), combines a powerful artemisinin derivative with a companion medicine that has a longer duration of action. Prominent instances encompass artemether–lumefantrine (CoArtem) and amodiaquine–artesunate (Coarsucam).

Primary Healthcare

Primary healthcare Centre (PHC) has received increased attention and dedication worldwide in the wake of the 2018 Astana Declaration. The World Health Assembly of 2019 subsequently approved a resolution recognizing PHC's role in providing the whole range of healthcare services—including palliative care, treatment, prevention, and rehabilitation—that are necessary for individuals to require throughout their lives. It was agreed that in order to accomplish the health-related Sustainable Development Goals (SDGs), such as universal health coverage (UHC), better PHC would be required (Akwaowo et al., 2020). Reviving primary healthcare is identified as essential to Nigeria's achievement of universal health coverage in the National Strategic Health Development Plan. In 1978, the Nigerian Health System adopted Primary Healthcare Centre (PHC), the lowest set of healthcare services that every person and community should get. The general health of the nation was greatly enhanced by this, especially in terms of making healthcare more accessible to those who lived in rural areas. Oluwasogo and Ibrahim (2020) assert that the PHC bears the responsibility of guaranteeing that the health status of the communities is enhanced, as demonstrated by a reduction in mortality and morbidity along with a rise in survival rates.

Patients frequently miss their appointments with doctors, and some find it difficult to express their health concerns. Consequently, physicians face time constraints that hinder them from posing all the pertinent queries (Fatumo, 2013). Despite claims that PHC is the cornerstone of the country's healthcare system, little use of its services is made of them. The inadequate infrastructure and staffing levels in these facilities are a primary cause of the low utilization rates. The majority of PHC facilities nationwide lack the necessary minimum staffing complement as well as the resources and health technologies needed to provide basic, high-quality healthcare. Research reveals that just 25% of healthcare facilities had more than 25% of the required equipment package, while 40% of PHCs have less than 40% of the equipment. In a different poll, 46% of PHC facilities had fewer than half of the needed pharmaceuticals on hand, and less than half of the facilities possessed a list of essential drugs. The death of PHC in Nigeria has been linked to a shortage of healthcare personnel, both in terms of quantity and quality, which is required to staff the facilities. It has long been recognized that PHC is not being carried out well, and several attempts have been undertaken to improve and revitalize PHC.

It is recommended that forty percent of the Basic Health Provision Fund be allocated towards the purchase of essential drugs, immunizations, and supplies from the Revenue Fund. Furthermore, the monies are to be used for emergency medical care (10%), human resource development (20%), laboratory, equipment, and transportation (30%), as well as building provision and upkeep. PHC's aforementioned sectors are vital components, and supporting them will aid in the organization's expansion. In addition, the Act aims to outlaw quacks from practicing medicine and offer universal health coverage. The Act also required disadvantaged and impoverished groups to get free services and health insurance. For example, the nation's hospitals would ensure that their children receive regular pediatric treatment, and more pregnant moms would benefit from free birth services (Oluwasogo & Ibrahim, 2020). The National Council on Health in 2011 saw the implementation of Nigeria's "Bringing PHC under one roof (PHCUOR)" national strategy, which aimed to eradicate fragmentation in the health sector and unify PHC management. The model for the strategy was the Gunduma system, a Jigawa State pilot project that merged the assets and duties of 27 local government boards into a single Gunduma Health System Board. As a result, the health system reform known as "Bringing PHCUOR" was adopted. This program was a component of a fresh governance overhaul meant to enhance PHC execution. Therefore, PHCUOR is a policy that integrates all PHC services under a single authority in order to eliminate fragmentation in the delivery of PHC services, with the Local Government Health Authority (LGHA) supervising PHC delivery at healthcare facilities and in communities and reporting to the State Primary Healthcare Development Agency/Board (SPHCDA/B), this policy consolidated PHC under its purview (3). The Minimum Service Package (MSP) was also implemented by the PHCUOR policy. Citizens are entitled to a minimal degree of healthcare services at PHC institutions, such as health posts, primary health clinics, and primary healthcare centers. This fundamental service package is adaptable enough to meet the requirements of individual states (Akwaowo et al., 2020).

Data Envelopment Analysis (DEA)

DEA is a mathematical technique used to evaluate the relative efficiency of decision-making units (DMUs) based on their input-output relationships. DEA is a non-statistical and non-parametric approach which makes no assumptions regarding the distribution of inefficiencies or the functional form of the production function (although it does impose some technical restrictions such as monotonicity and convexity (David, 2015). DEA is a nonparametric linear programming method for assessing the efficiency and productivity of DMUs (Ji & Lee, 2010). Data envelopment analysis (DEA) is a mathematical programming-based approach for measuring relative efficiency of decision-making units (DMUs) that have multiple inputs and outputs (Cook et al., 2014). DEA is a technique of mathematical programming that enables the determination of a unit's efficiency based on its inputs and outputs, and compares it to other units involved in the analysis (Martić et al., 2009). DEA is a method for evaluating performance of peer decision making units (DMUs) with multiple performance measures that are termed as inputs and outputs (Zhou et al., 2018).

The purpose of DEA was to create a framework that would enable decision-making units (DMUs) with comparable characteristics to be grouped together, and to identify as an effective frontier those DMUs that exhibited best practices. Furthermore, the methodology enables the assessment of non-frontier units' efficacy and the identification of benchmarks for the evaluation of these ineffective units (Cook & Seiford, 2009). DEA is a DMU efficiency assessment method that uses linear programming techniques to as closely as possible encapsulate observable input-output vectors (Ji & Lee, 2010). There are several chances to utilize the DEA to evaluate the efficacy of different organizations, including social services, farms, hospitals, schools, banks, and entire regions or economic systems (Martić et al., 2009). DEA compares each DMU to a "best practice" frontier, illustrating the optimal combination of inputs to provide a given number of outputs. DMUs on the frontier are considered fully efficient, whereas those below the frontier are considered inefficient. In cases where there are differences in efficiency between certain subgroups of the entire sample (public versus private institutions in the USA, for example), it is better to apply DEA separately to each subgroup in order to identify appropriate peer groups for the inefficient DMUs.

Research Gap

Despite extensive studies on malaria and its epidemiology, a critical gap exists in understanding the efficiency of healthcare facilities in managing malaria and using data-driven methods. While existing literature discusses malaria and prevalence, causes, and classifications, limited research applies **Data Envelopment Analysis (DEA)** to evaluate the efficiency of **Primary Healthcare (PHC) facilities** in diagnosing and treating malaria and . Furthermore, little attention has been given to the comparative effectiveness of treatment strategies within resource-constrained settings. Addressing this gap will provide empirical insights into optimizing healthcare resource allocation and improving disease management efficiency.

Methodology

Study Area and Data Source

The study was conducted in Gombe State, Nigeria, covering seventy-Eight (78) Primary Healthcare Facilities across the eleven (11) local government area of Gombe state. Data on in/out patients of Malaria/ treatment and recovery was collected from Gombe State Primary Healthcare Development Agency (GSPHCDA) for a six month period (July – December 2024).

Study Design and Variables

An efficiency evaluation framework was adopted using DEA. Eight input variables were considered: Number of doctors, nurses, laboratory technicians, personnel salaries, number of beds, number of fever cases tested using Widal or RDT, number of patients with confirmed uncomplicated malaria, and number of RDT test kits used. The output variable was the number of patients who recovered from malaria fever.

Analytical Technique

An output-oriented Variable Return to Scale (VRS) DEA model was employed to measure technical efficiency. This orientation was selected to reflect the objective of maximizing treatment outcomes given existing resource levels. DEA efficiency scores were computed using excel-based DEA add-in. Facilities with an efficiency score of one were classified as efficient, while those with score above one were considered inefficient. Reference set and slack analyses were conducted to identify benchmarks and quantity resource adjustment required for inefficient facilities to achieve efficiency. The BCC Output — oriented (Variable Returns to Scale) Envelopment model is presented as:

$$Max\,\phi - \varepsilon\left(\sum_{i=1}^{m} S_i^- + \sum_{r=1}^{S} S_r^+\right) \quad (1)$$

Subject to

$$\sum_{j=1}^{n} X_{ij}\lambda_j + S_i^- = X_{io} \quad (2)$$

$$\sum_{j=1}^{n} Y_{rj}\lambda_j - S_r^+ = \phi Y_{ro} \quad (3)$$

$$\sum_{j=1}^{n} \lambda_j = 1 \quad (4)$$

i = 1, 2…, 10 **(5)**

r = 1, 2 **(6)**

j = 1, 2…, 78 **(7)**

Where;

X_{io} = Amount of input i into unit o

Y_{ro} = Amount of output r from unit o

X_{ij} = Amount of input i into unit j

Y_{rj} = Amount of output r from unit j

λ_j = Variable representing Weights

ε = Positive non-Archimedean infinitesimal

S^- = Input slack

S^+ = Output slack

ϕ = Efficiency score

n = Total Number of DMUs

Results

Relative performance within a specific sample is indicated by the Relative Technical Efficiency ratings. Primary healthcare facilities are classified as being on the efficient frontier if their efficiency score is 1, and as being inefficient compared to those on the efficient frontier if it is greater than 1. In addition to identifying a reference set (benchmark/peer) for every inefficient healthcare facility, a collection of efficient Primary healthcare facilities was also determined. If those inefficient units are to become efficient, they must imitate their counterparts. Appendix II contains the data that were used for the study, and Appendix V displays the correlation between the variables. The results of the Data Envelopment Analysis (DEA) Excel Solver are shown in Appendix I.

Table 1 Efficient Primary Healthcare Facilities

Name of Primary Healthcare Facilities	Efficiency Score
1. Akko Primary Healthcare Centre	1
2. Kumo Primary Healthcare Centre	1
3. Tukulma Primary Healthcare Centre	1
4. Putoki Primary Health Centre	1
5. Talasse Primary Health Centre	1
6. Bambam Primary Health Centre	1
7. Tudu Primary Healthcare Centre	1
8. Ketengereng Primary Healthcare Center	1
9. Kekkel Primary Healthcare Centre	1
10. Todi Primary Healthcare Centre	1
11. Hashidu Primary Healthcare Centre	1
12. Bajoga Primary Health Centre	1
13. Ribadu Primary Health Centre	1
14. Jalingo Primary Health Centre	1
15. Tudun-Wada Primary Health Centre	1
16. Pantami Primary Healthcare Centre	1
17. Jekadafari Primary Healthcare Centre	1
18. Kaltin Primary Health Centre	1
19. Nafada Primary Health Centre	1
20. Burak Primary Health Centre	1
21. Lapan Primary Health Centre	1
22. Maikaho Primary Health Centre	1
23. Nono S/Kudu Primary Health Centre	1

24. Shinga Primary Health Centre	1
25. Kurjale Primary Health Centre	1
26. Hina Primary Health Clinic	1
27. Zambuk Primary Health Centre	1
28. Kagarawal Primary Health Clinic	1

Table 2 Efficient Primary Healthcare Facilities and their Reference Sets Counts

Name of Primary Healthcare Facilities	Reference Sets Counts
1. Akko Primary Healthcare Centre	0
2. Kumo Primary Healthcare Centre	1
3. Tukulma Primary Healthcare Centre	0
4. Putoki Primary Health Centre	5
5. Talasse Primary Health Centre	11
6. Bambam Primary Health Centre	18
7. Tudu Primary Healthcare Centre	5
8. Ketengereng Primary Healthcare Center	0
9. Kekkel Primary Healthcare Centre	27
10. Todi Primary Healthcare Centre	6
11. Hashidu Primary Healthcare Centre	7
12. Bajoga Primary Health Centre	0
13. Ribadu Primary Health Centre	0
14. Jalingo Primary Health Centre	0
15. Tudun-Wada Primary Health Centre	12
16. Pantami Primary Healthcare Centre	7
17. Jekadafari Primary Healthcare Centre	0
18. Kaltin Primary Health Centre	0
19. Nafada Primary Health Centre	10
20. Burak Primary Health Centre	29
21. Lapan Primary Health Centre	2
22. Maikaho Primary Health Centre	50
23. Nono S/Kudu Primary Health Centre	5
24. Shinga Primary Health Centre	0
25. Kurjale Primary Health Centre	0
26. Hina Primary Health Clinic	5
27. Zambuk Primary Health Centre	2
28. Kagarawal Primary Health Clinic	0

Table 3 Efficient Primary Healthcare Facilities, Reference Sets Counts and Rank

Name of Primary Healthcare Facilities	Reference Sets Counts	Rank

1.	Akko Primary Healthcare Centre	0	23
2.	Kumo Primary Healthcare Centre	1	17
3.	Tukulma Primary Healthcare Centre	0	23
4.	Putoki Primary Health Centre	5	12.5
5.	Talasse Primary Health Centre	11	6
6.	Bambam Primary Health Centre	18	4
7.	Tudu Primary Healthcare Centre	5	12.5
8.	Ketengereng Primary Healthcare Center	0	23
9.	Kekkel Primary Healthcare Centre	27	3
10.	Todi Primary Healthcare Centre	6	10
11.	Hashidu Primary Healthcare Centre	7	8.5
12.	Bajoga Primary Health Centre	0	23
13.	Ribadu Primary Health Centre	0	23
14.	Jalingo Primary Health Centre	0	23
15.	Tudun-Wada Primary Health Centre	12	5
16.	Pantami Primary Healthcare Centre	7	8.5
17.	Jekadafari Primary Healthcare Centre	0	23
18.	Kaltin Primary Health Centre	0	23
19.	Nafada Primary Health Centre	10	7
20.	Burak Primary Health Centre	29	2
21.	Lapan Primary Health Centre	2	15.5
22.	Maikaho Primary Health Centre	50	1
23.	Nono S/Kudu Primary Health Centre	5	12.5
24.	Shinga Primary Health Centre	0	23
25.	Kurjale Primary Health Centre	0	23
26.	Hina Primary Health Clinic	5	12.5
27.	Zambuk Primary Health Centre	2	15.5
28.	Kagarawal Primary Health Clinic	0	23
29.	Kagarawal Primary Health Clinic	0	1 8

Results Discussion

According to Table 1, 28 out of 78 analyzed PHCs (approximately 35.9%) achieved an efficiency score of 1, indicating optimal resource utilization and placement on the efficient frontier. These facilities effectively maximized outputs relative to inputs, serving as benchmarks for best practices. The remaining 50 facilities (64.1%) exhibited inefficiencies, with efficiency scores above 1, indicating potential for improvement through better resource allocation.

The reference set frequency analysis, detailed in Table 2 and visualized in Appendix VI identified Maikaho Primary Health Centre (DMU68) as the top-performing facility, appearing in 50 reference sets. This high frequency underscores DMU68's role as a benchmark for efficiency, consistently optimizing its inputs to achieve superior outputs. Table 3 further confirmed DMU68's dominance, ranking it number 1 among all facilities. The prominence of DMU68 suggests it employs exemplary operational strategies, such as efficient staffing, cost management, or diagnostic protocols, which warrant further investigation for replication across other facilities. The reference set frequency analysis, with peers listed in Appendix I, provides a clear framework for inefficient facilities to emulate top performers, fostering system-wide improvements.

The primary healthcare center facilities located in Akko (DMU1), Tukulma (DMU9), Ketengereng (DMU18), Bajoga (DMU30), Ribadu (DMU33), Jalingo (DMU38), Jekadafari (DMU47), Kaltin (DMU48), Shinga (DMU70), Kurjale (DMU71), and Kagarawal (DMU77) were ranked lowest among the efficient healthcare center facilities because they were not included as reference sets and could not provide examples of best practices for inefficient healthcare center facilities to follow.

Analysis of inefficient facilities, such as Pindiga, Barambu, Bangu, Dukku, and Tongo PHCs (Tables 4–8), revealed common excess inputs, including doctors, nurses, laboratory technicians, personnel salaries, beds, fever-tested patients, confirmed cases, and diagnostic test kits (RDT and Widal). For instance, Tongo PHC reported excesses of 3 doctors, 7 nurses, and ₦347,178.83 in salaries, while Pindiga had 2 doctors, 3 nurses, and ₦192,703.05 in excess salaries. These excesses indicate overstaffing, underutilized infrastructure, and inefficiencies in diagnostic and inventory management. Conversely, no excesses were consistently reported for patients with confirmed uncomplicated malaria, suggesting efficient management of malaria-related services.

The Hypothetical composite unit (HCU) analysis (Appendix III) quantified input adjustments needed for inefficient facilities to reach the efficient frontier, emphasizing tailored strategies like workforce reallocation, infrastructure optimization, refined diagnostic protocols, and improved inventory management. These findings highlight the need for targeted interventions to reduce excess inputs, lower costs, and enhance patient outcomes. By emulating efficient peers like DMU68, inefficient PHCs can improve technical efficiency, contributing to a more effective primary healthcare system in Gombe State. Future research should incorporate longer timeframes, additional outputs, and contextual factors to provide a holistic understanding of efficiency drivers.

These findings consistently identified overstaffing, excessive salary expenditures, underutilized beds, and overuse of diagnostic resources as key drivers of inefficiency. However, the appropriate utilization of inputs like laboratory technicians (in some facilities) and malaria case management suggests that these facilities have the potential to achieve efficiency by addressing excess inputs.

Conclusion

The technical efficiency analysis of 78 primary healthcare facilities in Gombe State, based on data from January to June 2024, reveals that 28 facilities (35.9%) operate at peak efficiency, with Maikaho Primary Health Centre (DMU68) emerging as the top performer due to its frequent appearance in reference sets and optimal input utilization. The remaining 50 facilities (64.1%) exhibit inefficiencies, characterized by excess inputs, including doctors, nurses, laboratory technicians, salaries, beds, fever-tested patients, cases, and diagnostic test kits.

Facilities like Pindiga, Barambu, Bangu, Dukku, and Tongo demonstrate significant overstaffing, underutilized infrastructure, and inefficient diagnostic and inventory management, which inflate costs and hinder performance. By reducing these excesses through workforce optimization, infrastructure reallocation, refined diagnostic protocols, improved inventory management, and emulation of best practices from efficient peers like DMU68, inefficient facilities can enhance resource utilization and patient outcomes. The study provides a robust framework for improving primary healthcare efficiency in Gombe State, with potential scalability to other regions. However, limitations in qualitative insights and contextual factors highlight the need for further research integrating staff expertise, patient's demographics, and longitudinal data to sustain and refine these improvements

Recommendations

The study's findings highlight significant inefficiencies in primary healthcare facilities in Gombe State, Nigeria, in managing fever and malaria. To address these challenges and improve treatment outcomes, we recommend the following:

1. **Optimize Workforce Allocation**: Inefficient facilities, such as Tongo (3 excess doctors, 7 nurses) and Pindiga (2 excess doctors, 3 nurses), should reallocate surplus staff to high-demand facilities or adjust shift schedules to align with patient volumes. The Gombe State Primary Healthcare Development Agency (GSPHCDA) should conduct a workforce assessment to ensure staffing levels match operational needs, reducing excessive salary expenditures (e.g., ₦347,178.83 at Tongo, ₦192,703.05 at Pindiga).
2. **Enhance Infrastructure Utilization**: Facilities like Barambu (3 excess beds), Dukku (1 excess bed), and Tongo (1 excess bed) should repurpose underutilized beds for other services, such as maternal or chronic disease care, or transfer them to facilities with higher patients loads. A system-wide audit of bed utilization can optimize infrastructure efficiency across the 78 PHCs.
3. **Refine Diagnostic Protocols**: Excesses in fever-tested patients (e.g., 77 at Dukku, 70 at Tongo) and confirmed cases (e.g., 14 at Tongo, 11 at Bangu) suggest inefficiencies in diagnostic processes. Facilities should standardize protocols to reduce unnecessary RDT/Widal testing and invest in community health education to prevent , lowering diagnostic and treatment burdens.
4. **Improve Inventory Management**: The overuse of diagnostic resources, such as 87 RDT test kits at Dukku and 70 at Tongo, indicates inventory inefficiencies. Implementing just-in-time procurement and demand forecasting can minimize waste, ensuring optimal use of RDT and Widal test kits across all facilities.
5. **Emulate Best Practices from Top Performers**: Inefficient facilities should adopt operational strategies from Maikaho Primary Health Centre (DMU68), which appeared in 50 reference sets and ranked first inefficiency. The GSPHCDA should facilitate knowledge-sharing workshops to disseminate DMU68's practices, such as efficient staffing, cost management, and diagnostic protocols, to improve system-wide performance.

This study demonstrates the usefulness of DEA in evaluating the efficiency of malaria fever treatment at the PHCs level. The findings highlight substantial inefficiencies across many facilities and provide actionable insight for improving resource utilization and healthcare performance in Gombe State and similar settings.

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APPENDICES

Appendix I: DATA ENVELOPMENT ANALYSIS EXCEL SOLVER RESULTS

S/N	Organization Unit Name	Efficiency Scores	Reference Sets
1	Akko Primary Healthcare Centre	1	
2	Bogo Model Primary Health Center	1.004330502	DMU39(0.08), DMU41(0.42), DMU62(0.01), DMU68(0.49)
3	Kumo Primary Healthcare Centre	1	
4	Tumu Primary Healthcare Centre	1.000223848	DMU28(0.32), DMU58(0.19), DMU62(0.13), DMU68(0.00), DMU69(0.36)
5	Pindiga Primary Healthcare Centre	1.041334622	DMU21(0.61), DMU39(0.02), DMU68(0.38)
6	Barambu Primary Healthcare Centre	1.063042986	DMU15(0.39), DMU62(0.17), DMU68(0.44)
7	Kalshingi Primary Healthcare Centre	1.027147557	DMU17(0.19), DMU21(0.14), DMU41(0.08), DMU68(0.59)
8	Gadawo Primary Healthcare Centre	1.042636237	DMU14(0.06), DMU15(0.14), DMU62(0.32), DMU68(0.48)
9	Tukulma Primary Healthcare Centre	1	
10	Kashere Primary Healthcare Centre	1.038562606	DMU15(0.20), DMU39(0.01), DMU62(0.07), DMU68(0.71)
11	Bangu Primary Health Centre	1.044654276	DMU14(0.12), DMU21(0.46), DMU68(0.42)
12	Putoki Primary Health Centre	1	
13	Nyuwar Primary Health Centre	1.01588141	DMU21(0.12), DMU23(0.03), DMU58(0.12), DMU62(0.58), DMU68(0.15)
14	Talasse Primary Health Centre	1	
15	Bambam Primary Health Centre	1	
16	Cham Primary Health Centre	1.074340799	DMU15(0.01), DMU39(0.00), DMU62(0.17), DMU68(0.82)
17	Tudu Primary Healthcare Centre	1	

18	Ketengereng Primary Healthcare Center	1	
19	Sansani Primary Healthcare Centre	1.094328346	DMU14(0.01), DMU15(0.34), DMU21(0.03), DMU62(0.12), DMU68(0.50)
20	Banganje Primary Healthcare Center	1.084725955	DMU62(0.48), DMU68(0.16), DMU72(0.36)
21	Kekkel Primary Healthcare Centre	1	
22	Ayaba Primary Healthcare Centre	1.041911781	DMU62(0.01), DMU68(0.45), DMU72(0.54)
23	Todi Primary Healthcare Centre	1	
24	Dukku Primary Healthcare Centre	1.045771933	DMU14(0.42), DMU21(0.20), DMU68(0.38)
25	Gombe Abba Primary Healthcare Centre	1.088002836	DMU15(0.30), DMU62(0.30), DMU68(0.40)
26	Zange Primary Healthcare Centre	1.036296138	DMU12(0.61), DMU14(0.07), DMU21(0.12), DMU68(0.20)
27	Malala Primary Healthcare Centre	1.039743108	DMU15(0.33), DMU68(0.67)
28	Hashidu Primary Healthcare Centre	1	
29	Sangaru Primary Health Centre	1.022559944	DMU14(0.15), DMU15(0.27), DMU21(0.22), DMU62(0.12), DMU68(0.24)
30	Bajoga Primary Health Centre	1	
31	Bage Primary Health Centre	1.044648433	DMU15(0.21), DMU62(0.42), DMU68(0.37)
32	Tongo Primary Health Centre	1.004423839	DMU21(0.40), DMU39(0.32), DMU68(0.28)
33	Ribadu Primary Health Centre	1	
34	Jillahi Primary Health Centre	1.030924765	DMU15(0.04), DMU21(0.59), DMU23(0.18), DMU68(0.19)
35	Kupto Primary Health Centre	1.055081964	DMU12(0.01), DMU21(0.03), DMU28(0.20), DMU62(0.63), DMU68(0.03), DMU69(0.10)
36	Tilde Primary Health Center	1.030723799	DMU12(0.11), DMU14(0.44), DMU15(0.03), DMU21(0.07), DMU62(0.17), DMU68(0.19)

37	Wakaltu Primary Healthcare Centre	1.049985033	DMU21(0.03), DMU28(0.03), DMU58(0.02), DMU62(0.69), DMU68(0.23)
38	Jalingo Primary Health Centre	1	
39	Tudun-Wada Primary Health Centre	1	
40	Town Primary Healthcare Centre	1.020333433	DMU21(0.48), DMU39(0.06), DMU68(0.46)
41	Pantami Primary Healthcare Centre	1	
42	Nassarawo Primary Healthcare Centre	1.045145566	DMU21(0.31), DMU39(0.04), DMU68(0.65)
43	Herwagana Primary Healthcare Centre	1.059690527	DMU15(0.28), DMU62(0.23), DMU68(0.49)
44	Bolari Primary Healthcare Centre	1.038607818	DMU3(0.12), DMU17(0.16), DMU21(0.08), DMU41(0.05), DMU68(0.59)
45	Kumbia Kumbia Primary Health Centre	1.033570887	DMU39(0.14), DMU41(0.02), DMU68(0.84)
46	Madaki Primary Healthcare Centre	1.018232301	DMU39(0.27), DMU41(0.02), DMU68(0.71)
47	Jekadafari Primary Healthcare Centre	1	
48	Kaltin Primary Health Centre	1	
49	Gujuba Primary Health Centre	1.022972708	DMU15(0.26), DMU23(0.02), DMU62(0.52), DMU68(0.20)
50	Abuja Primary Health Centre	1.018626227	DMU21(0.59), DMU39(0.04), DMU68(0.37)
51	Mallam Sidi Primary Health Centre	1.047774005	DMU62(0.14), DMU68(0.63), DMU72(0.23)
52	Malleri Primary Health Centre	1.057667295	DMU12(0.57), DMU14(0.01), DMU21(0.18), DMU62(0.09), DMU68(0.15)
53	Jurara Primary Healthcare Centre	1.029483956	DMU12(0.24), DMU21(0.04), DMU28(0.11), DMU62(0.57), DMU68(0.04)
54	Gadam Primary Health Centre	1.039964923	DMU58(0.17), DMU68(0.58), DMU72(0.25)
55	Kwami Model Primary Health Centre	1.182503771	DMU17(0.44), DMU68(0.56)

56	Daban Fulani Primary Health Centre	1.035737206	DMU21(0.11), DMU39(0.04), DMU41(0.06), DMU58(0.01), DMU68(0.78)
57	Dukkul Primary Health Centre	1.014723789	DMU17(0.24), DMU21(0.20), DMU41(0.06), DMU58(0.08), DMU68(0.42)
58	Nafada Primary Health Centre	1	
59	Mada Primary Health Centre	1.063013455	DMU15(0.01), DMU23(0.30), DMU62(0.18), DMU68(0.51)
60	Barwo Nasarawo Primary Health Centre	1.060557064	DMU15(0.10), DMU62(0.25), DMU68(0.65)
61	Barwo Winde Primary Health Centre	1.062966143	DMU21(0.01), DMU28(0.01), DMU62(0.77), DMU68(0.21)
62	Burak Primary Health Centre	1	
63	Kulishin Primary Health Centre	1.038227107	DMU28(0.23), DMU62(0.57), DMU68(0.10), DMU75(0.10)
64	Gundale Primary Health Centre	1.052193112	DMU21(0.05), DMU23(0.22), DMU58(0.20), DMU62(0.49), DMU68(0.04)
65	Lapan Primary Health Centre	1	
66	Deba Primary Healthcare Centre	1.018754753	DMU28(0.09), DMU58(0.05), DMU62(0.24), DMU68(0.30), DMU72(0.15), DMU75(0.16)
67	Lano Primary Health Centre	1.017968747	DMU14(0.02), DMU15(0.01), DMU21(0.58), DMU68(0.26), DMU69(0.13)
68	Maikaho Primary Health Centre	1	
69	Nono S/Kudu Primary Health Centre	1	
70	Shinga Primary Health Centre	1	
71	Kurjale Primary Health Centre	1	
72	Hina Primary Health Clinic	1	
73	Dangar Primary Health Centre	1.031077377	DMU21(0.17), DMU39(0.04), DMU58(0.52), DMU68(0.25), DMU69(0.02)

74	Liji Primary Health Clinic	1.001680213	DMU17(0.08), DMU21(0.05), DMU23(0.31), DMU58(0.41), DMU68(0.15)
75	Zambuk Primary Health Centre	1	
76	Lubo Primary Health Centre	1.039142315	DMU14(0.01), DMU15(0.00), DMU62(0.25), DMU65(0.04), DMU68(0.67), DMU69(0.03)
77	Kagarawal Primary Health Clinic	1	
78	London Maidorowa Health Clinic	1.029832435	DMU14(0.05), DMU15(0.02), DMU21(0.12), DMU62(0.06), DMU65(0.32), DMU68(0.43)

Appendix II: SUMMARY OF DATA COLLECTED FROM GOMBE STATE PRIMARY HEALTHCARE DEVELOPMENT AGENCY (GSPHCDA) FOR THE PERIOD OF JANUARY - JUNE (2024)

S/N	Organization Unit Name	Number of Doctors(X1)	Number of Nurses(X2)	Number of lab. Technicians(X3)	Personnel Salaries (X4)	Number of Beds (X5)	Patients with Fever and Tested with RDT or Widal Test (X6)	Patients with Confirmed Uncomplicated Malaria (X7)	RDT Test Kits Used (X8)	Patients Recovered from Malaria (Y1)	Recurrence Cases (Y2)	Treatment Failure (Y3)
1	Akko Primary Healthcare Centre	7	16	3	814679.56	12	842	255	660	237	15	15
2	Bogo Model Primary Health Center	14	34	8	1754694.43	26	5543	4548	5234	4328	109	98
3	Kumo Primary Healthcare Centre	12	30	7	1535357.63	18	2050	1382	1843	1309	34	14

4	Tumu Primary Healthcare Centre	6	15	3	752011.9	11	846	462	727	441	16	15
5	Pindiga Primary Healthcare Centre	13	31	8	1629359.12	19	2145	897	1758	845	36	24
6	Barambu Primary Healthcare Centre	8	20	5	1034016.36	14	1008	654	898	614	24	22
7	Kalshingi Primary Healthcare Centre	13	34	9	1754694.43	19	2257	1603	2054	1515	42	22
8	Gadawo Primary Healthcare Centre	8	21	6	1096684.02	15	1034	697	928	667	17	16
9	Tukulma Primary Healthcare Centre	10	27	7	1378688.48	18	1776	300	1318	265	35	19
10	Kashere Primary Healthcare Centre	10	23	6	1222019.34	13	1286	963	1186	924	22	20
11	Bangu Primary Health Centre	12	28	7	1472689.97	18	1884	825	1555	779	32	29
12	Putoki Primary Health Centre	6	15	4	783345.73	11	800	242	627	235	7	9
13	Nyuwar Primary Health Centre	7	17	4	877347.22	12	988	515	841	479	18	16

14	Talasse Primary Health Centre	11	29	7	1472689.97	16	1411	292	1064	287	9	9
15	Bambam Primary Health Centre	7	16	5	877347.22	10	858	229	669	227	5	4
16	Cham Primary Health Centre	9	23	6	1190685.51	13	1244	1028	1177	956	36	35
17	Tudu Primary Healthcare Centre	10	26	6	1316020.83	18	1796	707	1511	658	23	21
18	Ketengereng Primary Healthcare Center	9	22	6	1159351.68	13	803	259	634	236	13	15
19	Sansani Primary Healthcare Centre	11	25	6	1316020.83	14	1099	723	982	659	32	30
20	Banganje Primary Healthcare Center	7	17	4	908681.05	11	777	491	716	446	23	29
21	Kekkel Primary Healthcare Centre	13	32	8	1660692.95	21	2418	641	1822	618	17	16
22	Ayaba Primary Healthcare Centre	9	20	5	1065350.19	12	1084	811	1042	770	20	20
23	Todi Primary Healthcare Centre	7	17	4	908681.05	10	710	234	562	222	6	7
24	Dukku Primary	12	28	7	1472689.97	17	1646	699	1369	662	24	20

	Healthcare Centre											
25	Gombe Abba Primary Healthcare Centre	9	22	6	1159351.68	15	1086	626	991	574	27	28
26	Zange Primary Healthcare Centre	10	23	6	1222019.34	16	1151	480	943	456	16	17
27	Malala Primary Healthcare Centre	10	25	6	1284687	15	1166	873	1075	839	19	19
28	Hashidu Primary Healthcare Centre	6	13	3	689344.24	7	608	436	533	404	18	15
29	Sangaru Primary Health Centre	11	26	7	1378688.48	16	1385	566	1131	547	13	12
30	Bajoga Primary Health Centre	11	26	7	1378688.48	15	1370	301	1038	265	23	21
31	Bage Primary Health Centre	10	23	6	1222019.34	12	919	594	818	567	16	19
32	Tongo Primary Health Centre	16	38	9	1974031.24	23	3783	1773	3159	1694	52	42
33	Ribadu Primary Health Centre	9	20	5	1065350.19	12	882	243	684	233	8	7
34	Jillahi Primary Health Centre	12	29	7	1504023.8	19	1896	653	1510	618	22	22
35	Kupto Primary Health Centre	6	14	3	720678.07	10	733	352	615	324	19	18

36	Tilde Primary Health Center	10	23	6	1190685.51	14	1243	474	1004	455	14	13
37	Wakaltu Primary Healthcare Centre	6	15	4	783345.73	11	831	496	727	461	18	17
38	Jalingo Primary Health Centre	7	17	4	908681.05	14	1122	284	862	272	11	11
39	Tudun-Wada Primary Health Centre	17	41	10	2130700.38	31	7456	3708	6293	3513	109	112
40	Town Primary Healthcare Centre	13	31	8	1598025.29	20	2294	1080	1917	1036	29	28
41	Pantami Primary Healthcare Centre	18	43	11	2256035.7	39	10037	8577	9584	8143	206	153
42	Nassarawo Primary Healthcare Centre	11	26	7	1378688.48	18	1939	1114	1683	1052	32	40
43	Herwagana Primary Healthcare Centre	9	22	5	1128017.85	13	1025	707	926	666	21	21
44	Bolari Primary Healthcare Centre	12	29	7	1535357.63	19	2017	1472	1848	1378	45	44
45	Kumbia Kumbia Primary Health Centre	13	31	8	1629359.12	21	2385	1692	2170	1602	47	45
46	Madaki Primary	16	38	10	2005365.07	28	3194	2022	2830	1925	51	32

	Healthcare Centre											
47	Jekadafari Primary Healthcare Centre	7	16	4	814679.56	12	823	768	806	719	23	22
48	Kaltin Primary Health Centre	5	13	3	658010.41	9	782	189	598	161	15	14
49	Gujuba Primary Health Centre	9	20	5	1065350.19	12	813	433	695	421	8	7
50	Abuja Primary Health Centre	13	31	8	1598025.29	22	2305	970	1891	931	24	23
51	Mallam Sidi Primary Health Centre	10	23	6	1222019.34	14	1075	900	1024	855	22	21
52	Malleri Primary Health Centre	11	25	6	1316020.83	13	1152	459	937	426	22	20
53	Jurara Primary Healthcare Centre	8	19	5	971348.7	10	747	326	616	309	11	10
54	Gadam Primary Health Centre	9	20	5	1065350.19	13	1072	937	1030	892	22	21
55	Kwami Model Primary Health Centre	10	23	6	1190685.51	18	1584	1142	1450	118	19	18
56	Daban Fulani Primary Health Centre	10	23	6	1190685.51	21	2275	1701	2097	1605	46	46
57	Dukkul Primary Health Centre	10	24	6	1253353.17	22	2130	1369	1894	1305	32	32

58	Nafada Primary Health Centre	4	9	2	470007.44	10	798	717	773	685	15	14
59	Mada Primary Health Centre	9	22	5	1128017.85	13	1012	726	923	679	23	22
60	Barwo Nasarawo Primary Health Centre	10	23	6	1222019.34	13	1098	860	1024	810	25	30
61	Barwo Winde Primary Health Centre	7	16	4	846013.39	10	777	462	679	432	17	16
62	Burak Primary Health Centre	6	13	3	689344.24	8	606	257	498	254	3	2
63	Kulishin Primary Health Centre	7	17	4	908681.05	11	714	450	632	417	17	15
64	Gundale Primary Health Centre	6	14	4	752011.9	12	869	402	755	371	16	20
65	Lapan Primary Health Centre	6	14	3	720678.07	13	1187	434	953	422	10	12
66	Deba Primary Healthcare Centre	6	15	4	783345.73	11	904	715	845	689	13	12
67	Lano Primary Health Centre	11	26	6	1347354.65	24	2012	745	1619	717	23	23
68	Maikaho Primary Health Centre	8	19	5	1002682.53	14	1297	1187	1239	1187	34	14
69	Nono S/Kudu Primary Health Centre	5	12	3	626676.58	13	1130	425	911	413	13	15

70	Shinga Primary Health Centre	6	14	3	720678.07	9	776	634	732	612	12	11
71	Kurjale Primary Health Centre	11	26	6	1347354.65	20	1946	1895	1930	1843	24	12
72	Hina Primary Health Clinic	6	13	3	689344.24	9	614	505	579	489	9	12
73	Dangar Primary Health Centre	7	17	4	877347.22	18	1507	940	1331	883	29	28
74	Liji Primary Health Clinic	7	16	4	814679.56	12	1020	637	901	605	15	15
75	Zambuk Primary Health Centre	6	14	3	720678.07	10	859	802	842	767	17	16
76	Lubo Primary Health Centre	7	17	4	908681.05	14	1155	888	1072	853	17	16
77	Kagarawal Primary Health Clinic	6	14	4	752011.9	8	776	411	663	370	21	16
78	London Maidorowa Health Clinic	8	19	5	1002682.53	16	1390	761	1195	732	17	20

Appendix III: INPUTS USED BY COMPOSITE UNIT (CU) AND INEFFICIENT DMUS

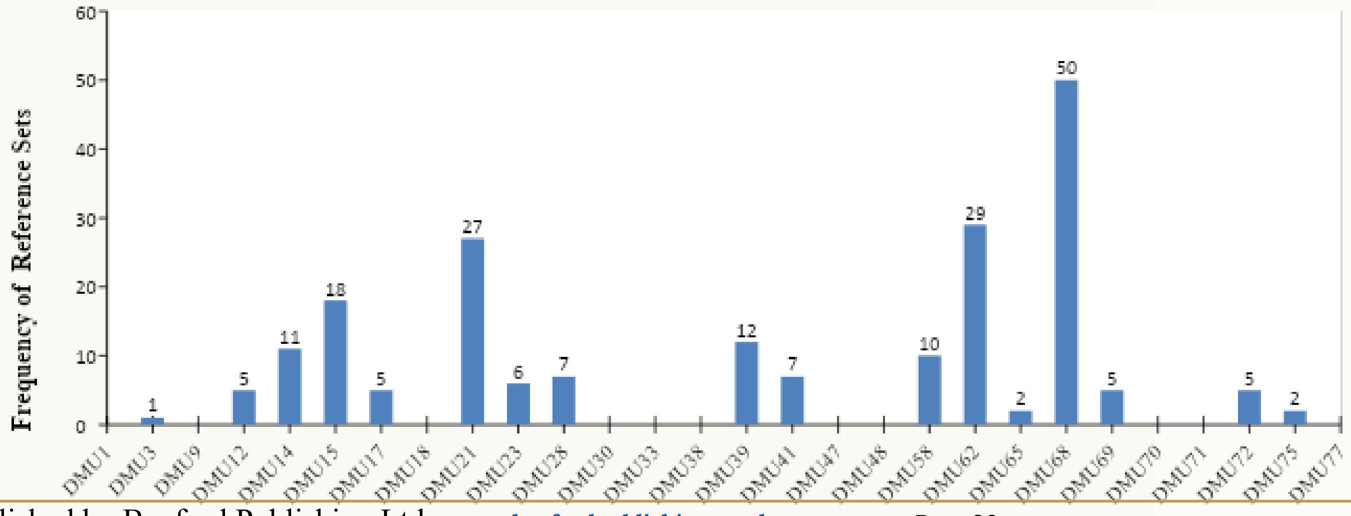
Inputs	Reference sets					HCU	Inefficient DMUs	Excess Inputs
	Kekkel Primary Healthcare Centre		Tudun-Wada Primary Health Centre		Maikaho Primary Health Centre		Pindiga Primary Healthcare Centre	
Number of Doctors	0.61 * 13	+	0.02 * 17	+	0.38 * 8	11.31	13	1.69
Number of Nurses	0.61 * 32	+	0.02 * 41	+	0.38 * 19	27.56	31	3.44
Number of laboratory Technicians	0.61 * 8	+	0.02 * 10	+	0.38 * 5	6.98	8	1.02
Personnel Salaries	0.61 * 1660692.95	+	0.02 * 2130700.38	+	0.38 * 1002682.53	143866 56.07	1629359.12	192703.05
Number of Beds	0.61 * 21	+	0.02 * 31	+	0.38 * 14	18.75	19	0.25
Patients with Fever and Tested with RDT/Widal test	0.61 * 2418	+	0.02 * 7456	+	0.38 * 1297	2116.96	2145	28.04
Patients with Confirmed Uncomplicated Malaria	0.61 * 641	+	0.02 * 3708	+	0.38 * 1187	897	897	0
Patients with Confirmed Uncomplicated	0.61 * 188	+	0.02 * 385	+	0.38 * 17	128.84	139	10.16
RDT Test Kits Used	0.61 * 1822	+	0.02 * 6293	+	0.38 * 1239	17081	1758	49.9
Widal test Kits Used	0.61 * 18	+	0.02 * 63	+	0.38 * 12	16.8	18	1.2
	Bambam Primary Health Centre		Burak Primary Health Centre		Maikaho Primary Health Centre		Barambu Primary Healthcare Centre	
Number of Doctors	0.39 * 7	+	0.17 * 5	+	0.44 * 8	7.1	8	0.9
Number of Nurses	0.39 * 16	+	0.17 * 13	+	0.44 * 19	16.81	20	3.19

Number of laboratory Technicians	0.39 * 5 +	0.17 * 3 +	0.44 * 5	4.66	5	0.34
Personnel Salaries	0.39 * 877347.22 +	0.17 * 689344.24 +	0.44 * 1002682.53	900534.25	1034016.36	133482.11
Number of Beds	0.39 * 10 +	0.17 * 8 +	0.44 * 14	11.42	14	2.58
Patients with Fever and Tested with RDT/Widal test	0.39 * 858 +	0.17 * 606 +	0.44 * 1297	1008	1008	0
Patients with Confirmed Uncomplicated Malaria	0.39 * 229 +	0.17 * 257 +	0.44 * 1187	654	654	0
Patients with Confirmed Uncomplicated	0.39 * 63 +	0.17 * 35 +	0.44 * 17	38	46	8
RDT Test Kits Used	0.39 * 669 +	0.17 * 498 +	0.44 * 1239	890.73	898	7.27
Widal test Kits Used	0.39 * 7 +	0.17 * 5 +	0.44 * 12	8.86	9	0.14
	Talasse Primary Health Centre	Kekkel Primary Healthcare Centre	Maikaho Primary Health Centre		Bangu Primary Health Centre	
Number of Doctors	0.12 * 11 +	0.46 * 13 +	0.42 * 8	10.66	12	1.34
Number of Nurses	0.12 * 29 +	0.46 * 32 +	0.42 * 19	26.18	28	1.82
Number of laboratory Technicians	0.12 * 7 +	0.46 * 8 +	0.42 * 5	6.62	7	0.38
Personnel Salaries	0.12 * 1472689.97 +	0.46 * 1660692.95 +	0.42 * 1002682.53	1361768.22	1472689.97	110921.75
Number of Beds	0.12 * 16 +	0.46 * 21 +	0.42 * 14	17.46	18	0.54
Patients with Fever and Tested with RDT/Widal test	0.12 * 1411 +	0.46 * 2418 +	0.42 * 1297	1826.34	1884	57.66
Patients with Confirmed Uncomplicated Malaria	0.12 * 292 +	0.46 * 641 +	0.42 * 1187	825	825	0

Patients with Confirmed Uncomplicated	0.12 * 117 +	0.46 * 188 +	0.42 * 17	107.66	119	11.34
RDT Test Kits Used	0.12 * 1064 +	0.46 * 1822 +	0.42 * 1239	1486.18	1555	68.82
Widal test Kits Used	0.12 * 11 +	0.46 * 18 +	0.42 * 12	14.64	16	1.36
	Talasse Primary Health Centre	Kekkel Primary Healthcare Centre	Maikaho Primary Health Centre		Dukku Primary Healthcare Centre	
Number of Doctors	0.42 * 11 +	0.20 * 13 +	0.38 * 8	10.26	12	1.74
Number of Nurses	0.42 * 29 +	0.20 * 32 +	0.38 * 19	25.8	28	2.2
Number of laboratory Technicians	0.42 * 7 +	0.20 * 8 +	0.38 * 5	6.44	7	0.56
Personnel Salaries	0.42 * 1472689.97 +	0.20 * 1660692.95 +	0.38 * 1002682.53	1331687.74	1472689.97	141002.23
Number of Beds	0.42 * 16 +	0.20 * 21 +	0.38 * 14	16.24	17	0.76
Patients with Fever and Tested with RDT/Widal test	0.42 * 1411 +	0.20 * 2418 +	0.38 * 1297	1569.08	1646	76.92
Patients with Confirmed Uncomplicated Malaria	0.42 * 292 +	0.20 * 641 +	0.38 * 1187	699	699	0
Patients with Confirmed Uncomplicated	0.42 * 117 +	0.20 * 188 +	0.38 * 17	93.2	97	3.8
RDT Test Kits Used	0.42 * 1064 +	0.20 * 1822 +	0.38 * 1239	1282.1	1369	86.9
Widal test Kits Used	0.42 * 11 +	0.20 * 18 +	0.38 * 12	12.78	14	1.22
	Kekkel Primary Healthcare Centre	Tudun-Wada Primary Health Centre	Maikaho Primary Health Centre		Tongo Primary Health Centre	
Number of Doctors	0.40 * 13 +	0.32 * 17 +	0.28 * 8	12.88	16	3.12
Number of Nurses	0.40 * 32 +	0.32 * 41 +	0.28 * 19	31.24	38	6.76

Number of laboratory Technicians	0.40 * 8	+	0.32 * 10	+	0.28 * 5	7.8	9	1.2
Personnel Salaries	0.40 * 1660692.95	+	0.32 * 2130700.38	+	0.28 * 1002682.53	162685 2.41	1974031.24	347178.83
Number of Beds	0.40 * 21	+	0.32 * 31	+	0.28 * 14	22.24	23	0.76
Patients with Fever and Tested with RDT/Widal test	0.40 * 2418	+	0.32 * 7456	+	0.28 * 1297	3713.48	3783	69.52
Patients with Confirmed Uncomplicated Malaria	0.40 * 641	+	0.32 * 3708	+	0.28 * 1187	1773	1773	0
Patients with Confirmed Uncomplicated	0.40 * 188	+	0.32 * 385	+	0.28 * 17	203.16	217	13.84
RDT Test Kits Used	0.40 * 1822	+	0.32 * 6293	+	0.28 * 1239	3089.48	3159	69.52
Widal test Kits Used	0.40 * 18	+	0.32 * 63	+	0.28 * 12	30.72	32	1.28

Appendix IV: Reference Sets Counts Chart



Appendix V: CORRELATION ANALYSIS

Correlations

		X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	Y1	Y2	Y3	Y4
X1	Pearson Correlation	1													
	Sig. (2-tailed)														
	N	78													
X2	Pearson Correlation	.991**	1												
	Sig. (2-tailed)	.000													
	N	78	78												
X3	Pearson Correlation	.972**	.981**	1											
	Sig. (2-tailed)	.000	.000												
	N	78	78	78											
X4	Pearson Correlation	.993**	.999**	.984**	1										
	Sig. (2-tailed)	.000	.000	.000											
	N	78	78	78	78										
X5	Pearson Correlation	.871**	.878**	.852**	.875**	1									
	Sig. (2-tailed)	.000	.000	.000	.000										
	N	78	78	78	78	78									

X6	Pearson Correlation	.762**	.761**	.728**	.760**	.889**	1						
	Sig. (2-tailed)	.000	.000	.000	.000	.000							
	N	78	78	78	78	78	78						
X7	Pearson Correlation	.633**	.625**	.598**	.626**	.787**	.935**	1					
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000						
	N	78	78	78	78	78	78	78					
X8	Pearson Correlation	.689**	.704**	.670**	.697**	.704**	.695**	.398**	1				
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000					
	N	78	78	78	78	78	78	78	78				
X9	Pearson Correlation	.737**	.735**	.703**	.734**	.874**	.996**	.964**	.624**	1			
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000	.000				
	N	78	78	78	78	78	78	78	78	78			
X10	Pearson Correlation	.737**	.735**	.703**	.734**	.874**	.996**	.963**	.627**	1.000**	1		
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000	.000	.000			
	N	78	78	78	78	78	78	78	78	78	78		
Y1	Pearson Correlation	.628**	.621**	.592**	.622**	.779**	.932**	.995**	.400**	.960**	.958**	1	
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000		
	N	78	78	78	78	78	78	78	78	78	78	78	
Y2	Pearson Correlation	.701**	.714**	.683**	.709**	.715**	.696**	.400**	.992**	.626**	.628**	.402**	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	

	N	78	78	78	78	78	78	78	78	78	78	78	78		
Y3	Pearson Correlation	.665**	.664**	.638**	.665**	.796**	.949**	.970**	.500**	.967**	.966**	.968**	.491**	1	
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000		
	N	78	78	78	78	78	78	78	78	78	78	78	78	78	
Y4	Pearson Correlation	.638**	.631**	.602**	.633**	.773**	.930**	.927**	.533**	.942**	.941**	.924**	.527**	.967**	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.00	.000	
	N	78	78	78	78	78	78	78	78	78	78	78	78	78	78

**. Correlation is significant at the 0.01 level (2-tailed).