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**Research Paper**

# Evaluating the Efficiency of Public Healthcare Facilities in Nagaland, India

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***Abstract:*** *This paper evaluates the efficiency of public healthcare facilities in Nagaland, India.*
*The study used Input-Oriented Data Envelopment Analysis. The variables were inputs such as beds, doctors, nurses, pharmacists, and lab technicians and the outputs were IPD and OPD for all 11 districts of public healthcare facilities (2020-21).*
*Findings reveal that districts like Kohima, Mokokchung, Phek, Mon operates under Decreasing Returns to Scale (DRS) i.e. they are too large in operation. Therefore, they could reduce scale by downsizing to improve efficiency. Longleng district has Increasing Returns to Scale i.e. too small in operation. It shows technically efficient under VRS but has IRS, which suggest that it could benefit from increasing scale or could grow to achieve optimal efficiency.*
*Districts like Dimapur, Tuensang, Zunheboto, Wokha, Peren, Kiphire have Constant Returns to Scale i.e. they are operating at an optimal scale. Zunheboto operates under CRS, however, it has VRS TE, and has input slacks, therefore, it should reduce inputs to reach at an optimum efficiency.*
*It is to be noted that the scope of the study is limited by the number of input and output variables considered and therefore the technical and scale efficiencies obtained in this study are limited and could be further improved by including additional variables.*

***Keywords:*** *Public healthcare efficiency; Data Envelopment Analysis; Nagaland; India*
**JEL code: I10, I11, I18**

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## I. Introduction:

UN Sustainable Development Goal no. 3 calls for "Good Health and Well-Being for all at all stages". Nagaland State Human Development Report (SDHR) 2016 has indicated that the availability of timely healthcare services is likely to remain a challenge in the foreseeable future. Additionally, Covid -19 pandemic has awakened the state about the healthcare system's resilience and weakness. A healthcare system is the organization of people, institutions and resources that delivers healthcare to meet the needs of the people (World Health Organisation, n.d.). Thus, efficient utilization of resources is crucial to strengthen the healthcare system and ensure the optimum utilization of the available resources.

Public healthcare facilities like hospitals, Community and Primary Healthcare Centres (CHC's & PHC's), State Health Centre's (SHC's), Dispensaries, Mental & TB Hospital play an important role in delivering tertiary health care services towards achieving good health. Healthcare resources are constrained with limited resources or very low health expenditure allocation in the country. Therefore, it is important to use public health resources wisely to an optimum level.

This paper evaluates the efficiency of public healthcare facilities in the state. Public healthcare facilities efficiency refers to the physical relation between resource inputs (capital and labour) and outputs. It indicates how far the system is from minimizing the use of inputs in achieving the outputs.

The evaluation uses Data Envelopment Analysis (DEA), which is a useful method in the study of the efficiency of Decision-Making Units (DMUs) and is also a very popular model to study hospitals or healthcare institutions. Based on the DEA model, many studies have been conducted on the hospital's efficiency outside India but very few studies in India.

Therefore, an attempt has been made to study the efficiency of the public healthcare facilities of Nagaland, India.

## II. Literatures:

(Osei et al., 2005) estimates the relative technical efficiency (TE) and Scale efficiency (SE) and demonstrates policy implications for health sector policymakers of Ghana. The study adopted Input oriented DEA for hospital study and Output oriented DEA model for health centre analysis. The data were collected from 21(17) public hospitals and 21 public health care centres for the year 2000 using the WHO African Regional Efficiency questionnaire. The inputs used were medical officers, technical officers like nurses, paramedical staff, medical assistants, Support/ subordinate staff like cleaners, drivers, watchmen etc., and beds. Outputs were MCH visits (antenatal care, postnatal care, family planning, immunization), child deliveries, and patients discharged excluding deaths.

The study revealed that 47% of the Decision-Making Units (DMUs) were technically inefficient, while 59% experienced inefficiencies related to scale. It indicated that these underperforming hospitals could improve technical efficiency by increasing their outputs—specifically, by providing 25% more maternal and child health (MCH) visits, 12% more deliveries, and 1% more patient discharges. Alternatively, efficiency could be achieved by reducing input levels, including a 44% decrease in medical officers, a 22% reduction in technical staff, 28% fewer sub-staff, and a 29% reduction in beds, without changing output levels. For future studies, the authors recommended examining allocative efficiency and conducting an analysis using the Marginal Productivity Index.

The paper used mostly the outputs related to mother and child health. However, my study includes the use of IPD and OPD visits which is essential for comprehensive efficiency study.

Kounetas, K., Papathanassopoulos, F., (2013) measured Greek hospital performance using different input-output combinations and identified the factor that influences their efficiency. The study adopted Input oriented DEA and conducted the DEA Bootstrapping. The estimated technical and scale efficiency which were regressed against geographical factors such as population density and population change; however, it did not improve the econometric performance of the model. Mann Whitney test was used to test the efficiency between different models. The study covered 114 hospitals for the year 2008 using the Ministry of Health and social solidarity welfare, as well as face-to-face interviews with hospital and regional health managers. The Inputs variables such as fixed capital like beds, and human capital like doctors, and nurses were used and the Output variables were IPD, OPD, surgeries and total medical examinations performed at each hospital.

The study found that the TE score appeared to be low, while different input-output combinations did not alter the scores; the use of medical examinations decreased the productive size inefficiency. Bed occupancy ratio was inversely related to technical and scale inefficiency, organizational transition of medical technology impacted the hospital market since it reduced the scale inefficiency. The study pointed out some limitations to be included for future research such as the use of cost data, time, and effort for readmissions as a proxy of hospital quality, waiting time as a performance indicator or operational staff expense.

The study by Kounetas used face to face interview. However, due to time constraint and other constraints, no such methods were used in my present paper.

O'Donnell, C, J., Nguyen, K. (2013) studied how data on output and input quantities alone can be used to estimate the productive performance of hospitals and shows how using both the amount of output and the total cost can help figure out the highest efficient price for what's being produced. The authors studied 116 public hospitals in Queensland by taking the data from 1996 to 2004. The variables taken were inputs such as beds, medical officers, and nurses, while the outputs were OPD visits, medical care or IPD and surgical care visits.

The study concluded that the hypotheses of technical inefficiency and Constant Returns to Scale were both rejected with 99% confidence i.e. 1% level. Thus, for good evidence-based hospital policy making the prerequisite is improving the quality of hospital data.

The paper studied Productive performance of hospitals over the years, and the CRS were rejected. However, my present paper tried to evaluate the technical efficiency of public district hospitals.

(Tigga & Mishra, 2015) studied the efficiency of the health system in India, using DEA based output-oriented model with Variable Returns to Scale assumption. It included 27 states' data for the year 2012, taking inputs such as health workers per 1000 population (doctors, nurses, and paramedical staff), health centres per 1000 pop (PHCs, CHCs, SCs); while the outputs were Infant Survival rate (instead of IMR) and Percentage of institutional deliveries.

The authors found that only six states' health system was efficient. The less efficient units used more than the required inputs (health workers and health centres); thus, the excess inputs could be redeployed to the regions having low health workers in the health centres. The study identified Kerala as the most efficient state compared to others, establishing it as a benchmark for the rest. However, one limitation was the inclusion of too many inputs and outputs in a relatively small sample, which resulted in a large number of states appearing on the efficiency frontier and being classified as efficient.

The paper used too many inputs and outputs for a small sample size, using Output-Oriented DEA model. However, my present paper tried to evaluate Input-Oriented DEA model as the paper tried to find out the efficiency of inputs and how to effectively utilise inputs, if found inefficient. Also, the variables I have considered for the study and the sample size is good enough for the analysis.

Bhat, R., Verma, B, B., Reuben. (2001) studied the general status of the healthcare services provided by 41 hospitals (20 districts and 21 grant-in-aid hospitals) in terms of technical and allocative efficiency in the state of Gujarat. The authors used a detailed questionnaire method with stepwise regression to identify the relation between the input variables. A sensitivity analysis was also performed to check how variables influenced resource use. The inputs were Capital such as physical infrastructure, expenditure on drugs, equipment index, no. of beds, maintenance expenditure, and technology such as specialized infrastructure, specialized equipment, the staff-related input variables included outpatient department (OPD) hours per week, laboratory hours per week, doctors, nursing staff, paramedical staff, administrative personnel, and non-technical staff. The output variables consisted of medico-legal cases, laboratory cases, inpatients, OPD visits, and maternal and child health cases. Additionally, explanatory variables covered areas such as preventive healthcare, maternal and child health services, communicable disease management, and non-communicable disease services, Curative medical service, high tech equipment per 100 beds, staff per 100 beds.

The study found greater differences in efficiency among District Hospitals compared to Grant-in-aid hospitals. Additionally, Grant-in-aid hospitals demonstrated higher overall efficiency than district hospitals. The determination of location in the efficiency levels of hospitals found that less efficient hospital was not located in one specific area.

This paper compared both district hospitals and grand-in-aid hospitals. However, my paper has analysed only public district hospitals of the state. Also, the paper used many variables losing focus on a particular area. However, my paper focused on few variables with enough sample size, for some in-depth analysis.

Surat,S., Dalbir, S., Kamlesh,S. (2017) conducted an analysis of allocative efficiency and total factor productivity growth within public hospitals in Haryana. To evaluate hospital performance, they focused on measuring both technical and scale efficiency using Data Envelopment Analysis (DEA). Specifically, the researchers applied an input-oriented DEA model, which concentrates on minimizing inputs while maintaining output levels. To gain a deeper understanding of inefficiencies, they incorporated slack variable analysis, which helps identify excess inputs or shortfalls in outputs beyond the primary efficiency scores.

Furthermore, the study employed the dual input-oriented CCR (Charnes, Cooper, and Rhodes) model and the BCC (Banker, Charnes, and Cooper) model that assumes Variable Returns to Scale (VRS). This approach enabled the decomposition of overall efficiency into two distinct components: scale efficiency, which measures the ability of hospitals to operate at an optimal size, and pure technical efficiency, which reflects the effectiveness of management in utilizing resources. By combining these models, the study provided a comprehensive assessment of the hospitals' operational performance, highlighting areas for improvement in resource allocation and productivity.

Allocative efficiency is measured by using the multi-output and multi-input- CRS input-oriented DEA model. Total Factor Productivity Growth is measured by using multi-input and multi-output CRS input-oriented DDEA-based MPI. Output elasticities were also calculated to assess how changes in input levels affect output, using the Cobb-Douglas production function expressed in a log-linear form. The study utilized data from the years 2013 to 2015, incorporating inputs such as the number of doctors and support staff—including nurses, lab technicians, pharmacists, and others. The outputs considered were outpatient visits and inpatient services, measured by the average number of beds multiplied by 365 days.

The study showed that 90% of hospitals were technically inefficient. While 90% were scaled inefficient, 60% of hospitals make efficient use of doctors and 35% efficient in support staff., 60% were efficient in inpatients, and 85% in outpatients. About 55% were found efficient in allocating their resources. It was found that the major contribution of TFP is technical change than efficiency change, and inefficiency has been due to IRS. The estimate of total elasticity suggested IRS in public hospitals in the state.

The study used Total Factor Productivity over the years. However, my present paper focused on one year and not the productivity over the years and tried to study the efficiency with the real-world situations, like Covid-19 Mortality.

## III. Objectives:

- To study the Technical Efficiency of public healthcare facilities in Nagaland.
- To study the Scale Efficiency of public healthcare facilities in Nagaland.

## IV. Demographic Features of the state:

Nagaland is one of the North-eastern states in India. It has a population of 19 lakhs in an area of 16579 sq. km with 119 per sq. km of density. The state has a literacy rate of 79.23 % with a female sex ratio of 931 per 1000 male.

**Table 1**: Key Demographic and Socio-economic indicators of the districts in Nagaland

| Districts | Area in sq km | Population | Sex Ratio (Females per 1000 males) | Literacy Rate (%) | Density/ sq. km | % share to the total geographical area (%) |
|---|---|---|---|---|---|---|
| Nagaland | 16579 | 1978502 | 931 | 79.23 | 119 | 100 |
| Kohima | 1463 | 267988 | 928 | 85.23 | 183 | 8.82 |
| Dimapur | 927 | 378811 | 919 | 84.79 | 409 | 5.59 |
| Phek | 2026 | 163418 | 951 | 78.05 | 81 | 12.22 |
| Mokokchung | 1615 | 194622 | 925 | 91.62 | 121 | 9.74 |
| Wokha | 1628 | 166343 | 968 | 87.69 | 102 | 9.81 |
| Zunheboto | 1255 | 140757 | 976 | 85.26 | 112 | 7.56 |
| Tuensang | 2536 | 196596 | 929 | 73.08 | 78 | 15.29 |
| Mon | 1786 | 250260 | 899 | 56.99 | 140 | 10.77 |
| Peren | 1651 | 95219 | 915 | 77.95 | 58 | 9.95 |
| Kiphire | 1130 | 75004 | 956 | 69.54 | 65 | 6.81 |
| Longleng | 562 | 50484 | 905 | 72.17 | 90 | 3.35 |

Source: Census 2011[1]

Table 1 presents comparative data on different demographic and socio-economic indicators of 11 districts in the state. The table shows that Dimapur district has the highest population with 37 lakhs population in a 927 sq. km area with a population density of 409 per sq. km, the most densely populated district in the state. The least populated district is Longleng with a 50,484 population, and its density is 90 per sq. km Kiphire with a 7,05,004 population is the least densely populated district with 65 per sq. km.

In Nagaland, health is managed by the Directorate of Health and Family Welfare, Nagaland. The department's administration is led by a cabinet minister and a Principal Secretary at the state level, supported by one Principal Director and two Directors at the Directorate level, along with various subordinate officers and staff.

At the time of statehood in 1963, the department of Health and Family Welfare inherited a rudimentary infrastructure with 27 hospitals and 33 Primary Health Centres with a 689 hospital beds including a handful of doctors and nurses. (*Department of Health & Family Welfare, Nagaland*, n.d.)

**Table 2**: No of Hospitals/ CHC's/PHC's/Dispensaries in Nagaland during the year 2020-21

| | KOHIMA | DIMAPUR | MOKOKCHUNG | TUENSANG | ZUNHEBOTO | WOKHA | PHEK | MON | PEREN | KIPHIRE | LONGLENG | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| District Hospital | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 11 |
| CHC | 4 | 3 | 4 | 3 | 4 | 2 | 4 | 3 | 2 | 2 | 2 | 33 |
| PHC | 17 | 10 | 18 | 17 | 13 | 14 | 22 | 15 | 8 | 4 | 5 | 143 |
| SHC | | | | 1 | | | | | | | | 1 |
| Dispensaries | | | 2 | | | | | | | | | 2 |
| TB Hospitals | 1 | | 1 | | | | | | | | | 2 |
| Mental Hospital | 1 | | | | | | | | | | | 1 |
| Sub-Centre | 45 | 90 | 61 | 69 | 65 | 45 | 51 | 75 | 30 | 31 | 17 | 583 |
| DTC | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 11 |
| Post-Mortum Centre | 1 | | 1 | 1 | | | | | | | | 3 |

[1] Note: At present, there are 16 districts in Nagaland which was bifurcated from old districts. However, 11 districts are selected for the study since there are only 11 district public hospitals.

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Para- Medical Training Centre | 1 | | | | | | | | | | | 1 |
| School of Nursing (GNM) | 1 | 1 | 1 | | | | | | | | | 3 |
| School of Nursing (ANM) | | | | 1 | | | | | | | | 1 |
| State Health Food Lab | 1 | | | | | | | | | | | 1 |
| Urban PHC | 2 | 2 | 1 | 1 | | | | | | | | 6 |
| Health and Wellness Centre | 22 | 23 | 19 | 25 | 14 | 16 | 25 | 19 | 13 | 17 | 9 | 202 |
| Ayush Hospital | 2 | 2 | 2 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 8 |
| Total | 100 | 133 | 112 | 121 | 98 | 80 | 104 | 114 | 55 | 56 | 35 | 1012 |

Source: Data obtained from the *Statistical Handbook of Nagaland 2020-21*, published by the Department of Economics and Statistics, Government of Nagaland.

Currently, the state has 11 district hospitals, one State Mental Health Institute, two TB and Chest Disease Hospitals, 33 community health centers, several sub-centers, two large dispensaries, and one subsidiary health center.It has a few private hospitals mostly located in urban cities such as Dimapur and Kohima. The state has 202 Health and Wellness Centres and 8 Ayush hospitals. The state also has huge private hospitals and pharmacies, especially around Dimapur and Kohima. (*Statistical Handbook Nagaland 2021*, n.d.)

## V. Methodology:

### 5.1. Data Envelopment Analysis (DEA):

DEA uses linear programming techniques to create a non-parametric, piecewise frontier based on data, which is then used to estimate the relative efficiencies of decision-making units (DMUs) against this frontier.

Charnes, Cooper, and Rhodes (1978) introduced the input-oriented DEA model under the assumption of Constant Returns to Scale (CRS). CRS implies that any proportional change in inputs results in a proportional change in outputs. Later, Banker, Charnes, and Cooper (1984) developed the Variable Returns to Scale (VRS) DEA model. Unlike CRS, VRS allows for situations where increases or decreases in inputs or outputs do not lead to proportional changes, thereby accommodating Increasing Returns to Scale (IRS), Decreasing Returns to Scale (DRS), or CRS.

CRS is appropriate when all DMUs operate at an optimal scale. However, factors like imperfect competition or financial constraints may prevent some DMUs from operating efficiently at this scale. To address such cases, Banker, Charnes, and Cooper extended the CRS DEA model to incorporate VRS, which enables the measurement of Technical Efficiency while accounting for scale effects.

Scale efficiency can be determined by comparing technical efficiency scores obtained under CRS and VRS assumptions for the same data set. The difference between these two scores for a given DMU reflects scale inefficiency.

Many studies prefer input-oriented DEA models because inputs are often the primary variables under management control. Although input- and output-oriented models establish the same efficiency frontier and identify the same efficient DMUs, the efficiency scores for less efficient units may differ between these orientations.

### 5.2. DEA Model:

This study employs an Input-Oriented Technical Efficiency approach, which focuses on reducing or optimizing inputs without altering output levels. Technical Efficiency is composed of Scale Efficiency and Pure Technical Efficiency. We applied the Variable Returns to Scale (VRS) model because hospital input-output relationships are generally linear.

Returns to Scale describe how output changes in response to variations in the size or scale of hospital inputs over the long term. Healthcare facilities that are scale inefficient exhibit either Increasing Returns to Scale (IRS) or Decreasing Returns to Scale (DRS). DRS indicates that the facility is too large relative to its operations, meaning output increases at a lower rate than inputs. Conversely, IRS implies that the facility is too small for its level of activity, with output growing faster than inputs. A healthcare facility is considered scale efficient when it operates under Constant Returns to Scale (CRS), where output changes proportionally with inputs.

### 5.3 Study Variables:

Normally, for a non-parametric study using DEA, a hospital is considered a DMU for comparisons. Therefore, in our study, we have considered a DMU as each 11 public district healthcare facilities in Nagaland for the year 2020-21.

Hospitals/ DMU's turn inputs into outputs in its production process. Generally, in hospitals, output should be the outcome or improvement in the health of society. However, due to complexities and the non-availability of secondary data on the health outcome of the people, we have used outputs.
Here, we have considered 5 inputs and 2 outputs. The input for capital is no. of beds, while for the case of human resources the inputs are doctors, nurses, pharmacists, and lab technicians. On the other hand, outputs are taken as no of Outpatient (OPD) visits and Inpatient (IPD) admissions.

**5.4. Study Area:**
Public healthcare facilities includes district hospitals, Community Health Centres (CHC's), Primary Healthcare Centres (CHC's), State Health Centre's (SHC's), Dispensaries, Mental & TB Hospital. The study is done for the year 2020-21 in the 11 districts of Nagaland.
**5.5. Sources:**
The study's data variables were sourced from the Department of Economics and Statistics, Government of Nagaland. Various other government publications, journals, articles etc is also taken from the secondary source.
**5.6. Scope:**
The findings of the study will help us to find out which district healthcare facilities are more efficient in terms of resources used. This will also help us to use the healthcare resources efficiently and to use the right use of inputs the produce the best of outputs. These results will guide policymakers in strengthening health system performance and optimizing public healthcare delivery in the state.

**5.7. Research Gap:**
The state of Nagaland has been chosen for the study because though the state performs well in some health indicators like IMR, however, in terms of Maternal mortality it is the worst in the country. The state also has been receiving a lot of funds from the World Bank to improve the health care system of the state. Therefore, in this regard also the paper choses the State of Nagaland for the study.

The paper studied only the public healthcare facilities in the state and does not cover the private hospitals, nursing homes and other private clinic because of many constraints. Also, because most private players were either not willing to share their data nor do they have data, as they do not maintain a proper healthcare management system, unlike the advance states. Therefore, with the available data only the public district healthcare facilities were studied.

**Table No.3:** Inputs and Outputs

| Sl. No | Inputs | Outputs |
|---|---|---|
| 1 | Beds | OPD days |
| 2 | No. of doctors | IPD days |
| 3 | No. of nurses | |
| 4 | No. of Pharmacists | |
| 5 | No. Lab Technician | |

The study variables were taken from the Statistical Handbook of Nagaland 2020-21 published by the Department of Economics and Statistics, Government of Nagaland.

## VI. Analysis:

Technical efficiency scores were computed using DEAP 2.1, a DEA software program developed by Tim Coelli.The correlation of two outputs was conducted to find the correlation between the two output variables and it found that the outputs had a high correlation of 83%.

**Table 4**: Inputs and outputs of all 11 public healthcare facilities for the year 2020-21 in Nagaland

| Particulars | Doctors | Pharmacists | Lab Technician | Nurses | Total Beds | IPD | OPD |
|---|---|---|---|---|---|---|---|
| Kohima | 110 | 72 | 21 | 287 | 556 | 23138 | 53302 |
| Dimapur | 65 | 54 | 11 | 190 | 255 | 1720 | 9549 |
| Mokokchung | 72 | 61 | 19 | 234 | 364 | 6479 | 33833 |
| Tuensang | 52 | 27 | 14 | 176 | 293 | 1952 | 2442 |
| Zunheboto | 42 | 27 | 10 | 120 | 215 | 2437 | 7150 |
| Wokha | 44 | 47 | 5 | 120 | 152 | 4266 | 9003 |
| Phek | 63 | 34 | 7 | 145 | 279 | 3140 | 20099 |
| Mon | 53 | 23 | 9 | 125 | 190 | 16659 | 19844 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Peren | 36 | 16 | 3 | 69 | 124 | 1317 | 5764 |
| Kiphire | 26 | 14 | 2 | 56 | 92 | 2677 | 9748 |
| Longleng | 23 | 9 | 5 | 46 | 80 | 2534 | 11464 |

Source: Author's computed result.

## VII. Results:

The study employed Data Envelopment Analysis (DEA) to evaluate technical efficiency and Scale efficiency of 11 district public healthcare facilities in the state of Nagaland. Table 4 presents inputs and outputs of all Public healthcare facilities in Nagaland.

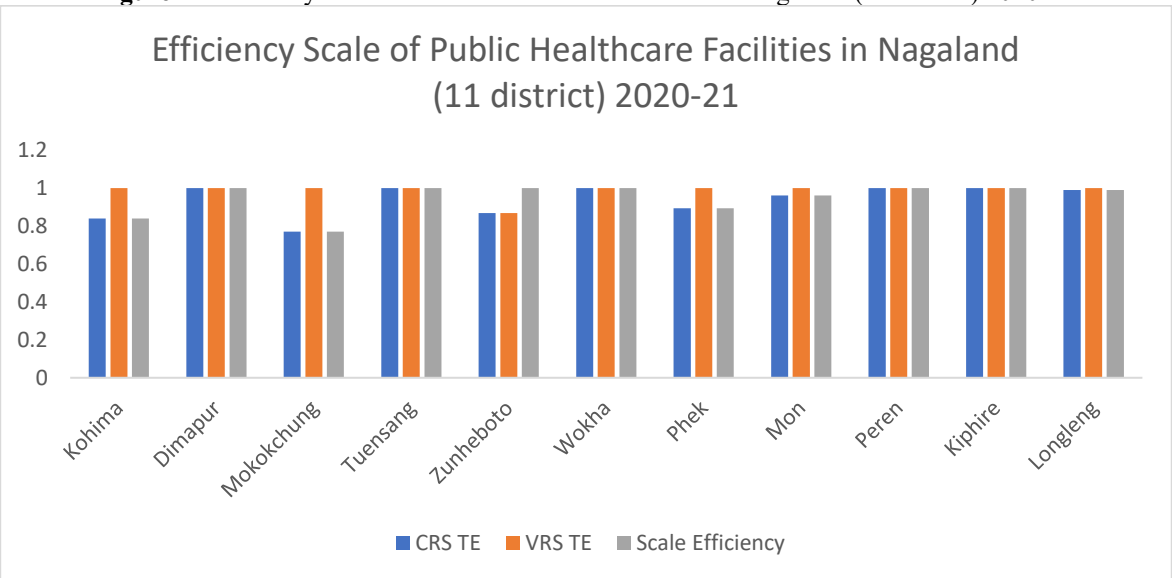
Table 5 presents Input-Oriented Technical Efficiency and Scale efficiency scores for all 11 district public healthcare facilities in Nagaland. The mean of Pure Technical Efficiency (VRS TE) and Scale Efficiency was 98% (Standard Deviation = 0.039) and 95% (Standard Deviation = 0.080) respectively.

**Table 5:** Efficiency Scale of Public Healthcare Facilities in Nagaland (11 district) 2020-21

| Districts | Constant Returns to Scale Technical Efficiency | Variable Returns to Scale Technical Efficiency | Scale Efficiency | Returns to Scale |
|---|---|---|---|---|
| Kohima | 0.839 | 1 | 0.839 | DRS |
| Dimapur | 1 | 1 | 1 | CRS |
| Mokokchung | 0.771 | 1 | 0.771 | DRS |
| Tuensang | 1 | 1 | 1 | CRS |
| Zunheboto | 0.869 | 0.869 | 1 | CRS |
| Wokha | 1 | 1 | 1 | CRS |
| Phek | 0.893 | 1 | 0.893 | DRS |
| Mon | 0.961 | 1 | 0.961 | DRS |
| Peren | 1 | 1 | 1 | CRS |
| Kiphire | 1 | 1 | 1 | CRS |
| Longleng | .99 | 1 | 0.99 | IRS |
| Mean/ Average | .938 | 0.988 | 0.950 | |
| Standard Deviation | .082 | .039 | 0.080 | |

Source: Author's computed result from DEAP 2.1 software

**Figure 1**: Efficiency Scale of Public Healthcare Facilities in Nagaland (11 district) 2020-21




The Mean shows the average efficiency scores of 11 district healthcare facilities. The Standard Deviation (SD) shows the variability or spread of efficiency scores across all districts.

The Mean of CRS TE shows that on an average, under the CRS, districts are operating at 93.8% efficiency. The CRS TE shows that districts like Dimapur, Tuensang, Wokha, Peren, Kiphire lie on the efficient frontier of 1, and all other districts are inefficient. In other words, under CRS, districts like Kohima, Mokokchung, Zunheboto, Mon, Longleng could reduce inputs by 6.2% while still producing the same output. The SD of CRS TE (0.082) shows that there is moderate variation in overall efficiency across districts. This reveals that some districts are less efficient than others which is due to differences in both technical and scale efficiency.

The Mean of VRS TE shows that an average efficiency is 98.8%. This value suggest that most districts are technically efficient in managing their resources. The VRS TE shows that all other districts are technically efficient i.e. they lie on the efficient frontier of 1, except for Zunheboto which should reduce the inputs.

The result of the DEA analysis shows that Zunheboto district has non-zero input slacks, which indicates excess use of doctors (3.064 units), Lab Technicians (22.624 units) and beds (6.536 units). All other districts have zero input/output slacks, meaning their inefficiencies (if any arises) are due to proportional scaling and not excess use. Therefore, Zunheboto should reduce inputs to reach their optimal scale efficiency.

The Peer Analysis of the DEA result also shows that Zunheboto depends on Dimapur, Tuensang, Wokha, Peren as benchmarks.

The SD of VRS TE (0.039) shows low variability i.e. most districts are close to 100% technically efficient and that the differences in CRS scores are mostly due to scale inefficiencies, and not due to poor resource use.

The Mean of Scale efficiency is 95%, which implies that some efficiency is lost due to districts not operating at an optimal scale. This means that on an average the scale less efficient districts can reduce their current level of inputs size by 95% keeping the current output unchanged. Or, in other words, they could increase their output size by 95% using their current inputs. The SD of Scale efficiency (0.080) shows moderate variability i.e. some districts are scale inefficient those with IRS or DRS, which is seen from the table that only six districts i.e. Dimapur, Tuensang, Zunheboto, Wokha, Peren, Kiphire are 100% scale effiicient while Kohima, Mokokchung, Phek , Mon, Longleng are scale inefficient. Those districts with 100% scale efficiency shows that they have the most productive scale size of inputs and outputs.

The Efficiency Distribution shows that most inefficiencies are due to scale inefficiency and not due to technical efficiency i.e. firms are not operating at an optimal scale. Most of the district healthcare facilities exhibit Decreasing Returns to Scale (DRS), indicating that their operations are oversized and that efficiency could be enhanced by reducing their scale.

Districts like Kohima, Mokokchung, Phek, Mon operates under Decreasing Returns to Scale (DRS) i.e. they are too large in operation. Therefore, they could reduce scale by downsizing to improve efficiency.

Longleng district has Increasing Returns to Scale i.e. too small in operation. It shows technically efficient under VRS but has IRS, which suggest that it could benefit from increasing scale or could grow to achieve optimal efficiency.

Districts like Dimapur, Tuensang, Zunheboto, Wokha, Peren, Kiphire have Constant Returns to Scale i.e. they are operating at an optimal scale. Zunheboto operates under CRS, however, it has VRS TE, and has input slacks, therefore, it should reduce inputs to reach at an optimum efficiency.

## VIII. Conclusion:

This paper examines the strength of Nagaland's healthcare system by applying Data Envelopment Analysis (DEA) to evaluate the technical and scale efficiency of 11 public district healthcare facilities in the state.

Districts like Kohima, Mokokchung, Phek, Mon operates under Decreasing Returns to Scale (DRS) i.e. they are too large in operation. Therefore, they could reduce scale by downsizing to improve efficiency.

Longleng district has Increasing Returns to Scale i.e. too small in operation. It shows technically efficient under VRS but has IRS, which suggest that it could benefit from increasing scale or could grow to achieve optimal efficiency.

Districts like Dimapur, Tuensang, Zunheboto, Wokha, Peren, Kiphire have Constant Returns to Scale i.e. they are operating at an optimal scale. Zunheboto operates under CRS, however, it has VRS TE, and has input slacks, therefore, it should reduce inputs to reach at an optimum efficiency.

Therefore, the policymakers can make policies as to which district needs to improve efficiency. The policymakers can also improve the technical efficiency to improve the overall healthcare system in the state.

The SD of Scale efficiency (0.080) shows moderate variability i.e. some districts are scale inefficient those with IRS or DRS, which is seen from the table that only six districts i.e. Dimapur, Tuensang, Zunheboto, Wokha, Peren, Kiphire are 100% scale effiicient while Kohima, Mokokchung, Phek , Mon, Longleng are scale inefficient. Those districts with 100% scale efficiency shows that they have the most productive scale size of inputs and outputs.

It is to be noted that the scope of the study is limited by the number of input and output variables considered and therefore the technical and scale efficiencies obtained in this study are limited and could be further improved by including additional variables. Also, the study is limited only to public healthcare system and did

not consider the study of private hospitals, due to many constraints. Therefore, the future researchers could take up these issues as well for the future study.

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