Efficiency and Performance of sub-centres on selected Maternal and Child Healthcare services: A Case Study of Hailakandi District in Assam

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Abstract - The status of Maternal and child Healthcare (MCH) services under primary healthcare in Assam is very poor than national average. Being a first peripheral contact between beneficiary and public health system, sub-centre performs an important role to strengthen MCH service Assam. In this conjuncture, it is equally important to know whether our sub-centres are performing efficiently or not. To get an answer these, using Health Management and Information System (HMIS) data 2017-18 we are trying to measure the performance and efficiency of sub-centre in Hailakandi district of Assam using data envelopment analysis technique. The study reveals that total sub-centres included in the study, 31 (51%) were technically efficient constituting the 'best practice frontier'. The other 49 percent were technically inefficient with an average TE score 0.70. It is also found that all four inputs considered in the study were operated below optimum efficiency level and there is a further scope for improvement. However in output side sub-centres could become efficient by increasing the number of cases of PNC as top by 224.63 percent, and then followed by BCG by 74.08 percent, ANC by 49.38 percent, number of cases of FSA by 49.26 percent with existing level of inputs.

Keywords: Assam, Benchmarking, Efficiency, Hailakandi, Primary healthcare, Sub-centre

I. INTRODUCTION

Despite India's fastest economic growth, maternal and child healthcare especially in rural areas still remain a policy concern. It was in the year 1946 under Sir Joseph Bhore, the county's first basic foundation on primary healthcare laid on. Later Minimum Needs Program (MNP) was introduced in the country in the first year of the Fifth Five Year Plan (1974–78) with the objective to provide certain basic minimum needs and thereby improve the living standards of the people. In the field of rural healthcare, the objective was to establish: one Sub-centre for a population 5000 people in the plains and for 3000 in tribal and hilly areas [1], when sub-centre (SC) –the first peripheral contact between health beneficiary and health administration was established. The programme got momentum again after launching of National Rural health Mission (NRHM) in the year 2005 where basic mother and child healthcare reaffirm in a new energy. But believe it, still we the north-eastern states are lacking far than national average such as infant mortality, maternal mortality, life expectancy, total fertility where the state Assam is ranked top in many parameters. Based on joint study of ICMR death due to communicable, maternal, neonatal and nutritional diseases was 32.1 percent in north-eastern states compared to national average 27.5 percent. However 83 percent of the deaths were under the age group of 0-14 years [2].

Now the problem in the primary healthcare (public) in India as well as its states is dual; firstly constraints of financing the vast population and secondly acute shortage of health professionals. In this background, efficient utilisation of existing financial and human resources becomes very significant to augment the healthcare service in the country. The assessment of existing health facilities can show a path to the policy decision makers in ensuring the optimum utilisation of available resources.

Rationale of the Study

With the government sparing just 1.3 per cent of the GDP for public healthcare, way less than the global average of 6 per cent, there remains a severe scarcity of doctors in the country and people continue to incur heavy medical expenditure across rural and urban hospitals. Efficient

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utilisation of healthcare services gives an impetus to address the problem of serious financial shortage in general and human resource crisis in particular in the sector. Optimum utilisation demand and supply of health sector can lead a remarkable change in many ways. In a classic example, Sri Lanka, the near eradication of malaria during 1947-77 is estimated to have raised national income by 9 percent in 1977 [3]. Over the period of three decades, the cumulative cost of such an initiative was $52 million as compared to the cumulative gain in national income of $7.6 million, implying a remarkable cost-benefit ratio. Again the successful eradication of Polio disease from Indian land provides an age in resource conservation, which could easily be allocated where the need arises [3].

Justification of Selection of Hailakandi district

Geographically, this state Assam is the second largest (2.39 percent of the country's total area) in the North-east Indian region and consists of 2.58 percent of Indian population [4]. Comparing to state Hailakandi district is the 3rd smallest district with 2.11 percent total population and density of 497 per square kilometres as per 2011 census. Assam suffers 390 maternal deaths for every 100,000 live births and is among the states with highest Maternal Mortality Ratio (MMR) in the Northeast India and far beyond national average MMR 212 [5]. The state aimed at achieving an ambitious target of reducing MMR to less than 100 per 100,000 live births by the year 2010 which have not been realised till 2015, after five years the goal were set. Now the state has introduced new population policy in the year 2017 and setup a target to achieve this by the year 2030 [6]. To achieve this, the state government is making strenuous efforts to increase the availability and the use of maternal healthcare services including institutional deliveries and emergency obstetric care services. As part of these efforts, district hospitals and basic primary health service centres (sub-centres) are being strengthened as comprehensive service and emergency obstetric care centres. Sub-centres are the prime resource units in the district hospitals primary healthcare system of the state and consume a minimum share of resources for healthcare. Efficient sub-centre can contribute considerably toward achieving the reduction in MMR and infant mortality rate (IMR). Therefore capturing and monitoring their inefficiencies has become significant.

Table 1: Basic Primary healthcare indicator of Hailakandi, Assam and India

Sl No	*Particulars*	*Hailakandi*	*Assam*	*India*
1	Maternal mortality ratio (MMR Bulletin 2011-13)	NA	300*	167
2	Infant mortality rate (NFHS IV)	52**	48	37
3	Under five mortality rate (NFHS IV)	NA	56	50
4	Full Vaccination Coverage (NFHS IV)	39.2 percent	47 percent	62 percent
5	Children's Nutritional status (children age below 5 years who are underweight) (NFHS IV)	32.5 percent	29.8 percent	35.7 percent
6	Anemia among children (children age 6-59 months who are anemia) (NFHS IV)	29 percent	35.7 percent	58.5 percent
7	Underweight women with BMI below normal (NFHS IV)	33.2 percent	25.7 percent	22.9 percent
8	Life expectancy at birth Male (NFHS IV)	43.82#	63.6	67.3
9	Life expectancy at birth Male (NFHS IV)		64.8	69.6

Source: Compiled from various Government survey and reports.

*Highest among all states, NFHS IV: National Family Health Survey-4, 2015-16.

**Annual Health Survey 2012-13, NA: Not available, # Based on HDR Survey 2013.

In this backdrop, it is assumed that the evaluation of efficiency in the functioning of sub-centres of Hailakandi district of Assam with special reference to the maternal healthcare services deserves special attention. The results of the study expected to be useful for improving the performance of sub-centres.

Objectives of the Study

On the light of the above discussion the present study revolves around the following objectives

- To examine the efficiency of sub-centres in the Hailakandi district.[measured in terms of technical efficiency]
- To find the ways for making inefficient sub-centres efficient in the district in terms of total output increases else input reductions required as revealed by technical efficiency analysis.
- To bench-mark or to find out the 'best performing' sub-centre in the district.

Organisation of the paper

The paper is organized as follows: Section 2 literature review of the primary healthcare followed primary healthcare infrastructure literature and Efficacy of DEA methodology ; Section 3 makes a brief description of DEA conceptual framework, justification of model considered, study variables, samples selection and data collection and Section 4 presents Analysis and interpretation followed by suggestion for improvement, scope of future research; and in Section 5, followed by conclusions of the study.

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II. REVIEW OF LITERATURE

a] Major studies relating to primary healthcare infrastructure in Indian context

A study report on Healthcare system in Madhya Pradesh 2016, [7] founded by research division, NITI Aayog, Government of India, has claimed that in Sub Centre Levels, there should be two ANMs: one to be stationed at the head quarters of SC all the time and other to be mobile for supervising the activities of ASHA and Anganwadi Workers (AWWs) at the villages under the SC. The SC building will also be the nodal centre for all villagers for dispensing outpatient (OP) services by visiting allopathic/AYUSH doctors at least thrice a week.

Garg Suneela et al., 2012, [8] suggest that there is an urgent need to develop the healthcare infrastructure and health workforce. According to them, at the PHC/CHC level, there is a 23% shortfall of nurse midwives or staff nurses. The corresponding figures for pharmacists are 22.5%, laboratory technicians 47.4% and radiographers 53.9%. There is a 37.8% shortfall in the number of health assistants (female) at PHCs, while the number of health assistants (male) is less by 41.6%. There is a 1.9% deficit in the number of health workers (female) at the sub-centre and PHC. The number of health workers (male) is short by 64.6% at the sub-centre level.

Another reports aiming to improve the healthcare scenario in Assam, the state team of the National Rural Health Mission (NRHM) three important initiatives in 2010 [9] ; i) Nutrition Counselling-cum-Management Centres (NCMC) ii) Mamata and iii) Morom. These three programmes were launched initially in four districts (Dibrugarh, Nagaon, Darrang and Morigaon) and later extended to the remaining 23 districts with different objectives. Firstly NCMCs, extensions of Nutritional Rehabilitation Centres (NRCs), have been set up with the objective of expanding reach in peripheral areas to identify and provide medical care to children with severe acute malnourishment (SAM) under the age of five years and educate mothers on appropriate nutritional practices. Mamata, on the other hand, aims to incentivise mothers for seeking postpartum care by providing them baby kits. The objective of Morom is to provide monetary incentives to in-patients at public health facilities so as to motivate them to access healthcare.

The key challenges of the programmes were on the one hand Counsellors are found to be over burdened as they are responsible for providing a vast range of services and deal with increasing footfalls at the NCMCs. In the other hand Mobilisation of mothers and children remains a big challenge. Doctors are not adequately sensitised to the role performed by counsellors, and there is low appreciation of counsellors among other medical personnel. Lastly concluded that strategy of using incentives was successful to address access constraints and to motivate beneficiaries to adopt health seeking behaviour seems to offer a workable solution for improving rural healthcare.

The report of augmenting sub-centre service delivery of Assam by National Health Mission (NHM), Assam in collaboration with technical support institute National Health System Resource System (NHSRS), 2014 [10] suggests the number of issues such as; upgradation of diploma into bachelor degree with the extension of six months to one year, a regular cadres of Rural Health Practioners (RHPs) renamed as Community Health Officer (CHO) and retaining them in the health system for improved health status of SCs, creation of enabling environment RHPs-provision of residential quarters or rental arrangements, so that RHPs stay close to their work place, trained the RHPs to address health service delivery gap.

b] Efficacy of DEA methodology to study the considered problem as revealed by past studies

Deidda M et al., 2014, [11] Using a new database about primary care centres (PCC) in the Basque Country in Spain, they have performed an efficiency analysis using a four-stage DEA methodology. In particular, they have introduced two innovative elements with respect to previous literature. Firstly, they have contributed to the recent debate regarding the extent to which health information technology should lead to more efficient and higher-quality care by explicitly introducing technology in the production function. Given that ICT usage has been increasing exponentially in the last years, they consider its role when measuring the performance of PCCs. In this regard, the Basque constitutes an interesting case study for their purpose, given that developments in terms of ICTs in the health sector have been evolving. Secondly, the role of non-discretionary variables (i.e. those variables which represent the main characteristics of the population using the services provided by the PCCs) is taken into account by using an extension of the Data Envelopment Analysis.

They also suggested that it is not just investment, but use, what influences the efficiency of PCCs. Even though all general practitioners in the Basque Country have access to the Electronic Health Record (EHR) system, there are differences regarding how often they use this system in their medical practice. These differences affect the efficiency of the PCCs, when controlling for the contextual indicators of the population covered by each centre.

Tej Ram Jat and Miguel San Sebastian, 2013, [12] this study was to evaluate the technical efficiency (TE) of the public district hospitals in Madhya Pradesh, India, with special emphasis on maternal healthcare services, using data envelopment analysis (DEA). Data from 40 district hospitals from January to December 2010 were collected from the health management information system and other records of the department of health and family welfare of

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the state. DEA was performed with input orientation and variable returns to scale assumption. TE and scale efficiency scores of the district hospitals were 0.90 (SD=0.14) and 0.88 (SD=0.15), respectively. Of the total district hospitals in the study, 20 (50%) were technically efficient constituting the 'best practice frontier'. The other half were technically inefficient, with an average TE score of 0.79 (SD=0.12) meaning that these hospitals could produce the same outputs by using 21% less inputs from current input levels. Twenty-six (65%) district hospitals were found to be scale inefficient, manifesting a mean score of 0.81 (SD=0.16). Half of the district hospitals in the study were operating inefficiently. Decision makers and administrators in the state should identify the causes of the observed inefficiencies and take appropriate measures to increase efficiency of these hospitals.

Brijesh C. Purohit, 2010, [13] has make an attempt to extend health system efficiency analysis to focus on healthcare system at the sub-state level (i e, the district level) in India using Karnataka state and district-level panel data. In a multi-stage model in the first stage of estimation used life expectancy (lexp) as the dependent variable, since it is widely accepted as a variable to represent health system outcomes for a particular geographic region. The explanatory variables comprised variables representing health sector inputs including infrastructure, manpower and material inputs. Among these were included infrastructure variables such as availability of hospitals, hospital beds, PHCs and sub-centres (SCs). Manpower variables used in our specification included availability of doctors, nurses, auxiliary nurses male (ANMs), as well as untrained and trained birth attendants. The material inputs included availability of medicines and drugs at heath facilities and immunisation coverage.

Gattoufi et al., 2004, [14] have claimed that in total 67% of the DEA articles presented a real world application and following banking, education (including higher education) healthcare and hospital efficiency were found to be the third most popular application areas.

From the above it can discern primary healthcare infrastructure deserves attention and DEA based conceptual framework vis-à-vis models can not only suitably applied but also has sufficient scope to fulfil the objective of the present study to fill up the research gaps in the domain of primary healthcare infrastructure in relation to Hailakandi district of Assam.

III. METHODOLOGY

DEA model

Data envelopment analysis (DEA) technique combing with linear programming has widely recognised by researcher in late seventies. It has come up one of the most widely acceptable non-parametric techniques after the classical work by Charnes et. al,1978 [15]. It determines an empirical frontier of production possibilities based on the most efficient input–output combinations. It can be of two types. ***Input-oriented technical efficiency* measure** deals with the maximum amount of input quantities, which can be proportionately reduced without changing quantities produced as output. ***Output-oriented technical efficiency*** deals with the maximum output quantities that can be proportionately increased without altering input quantities. Comparing traditional efficiency measurement (how the activities transform input into output) it allows determining how well resources are used to produce the desired outputs. The unit involved in the analysis of input and output is known as decision making unit (DMU).

It has certain advantages over parametric technique; can handle multiple input and output, doesn't required specific functional form, can handle small sample size, better discrimination but highly sensitive [16].

Justification of considered model

There are two major components in overall efficiency measurement of any decision making units (DMU) that is technical and allocative efficiency. A DMU is considered to be technically efficient if it is able to produce maximum output from a given set of inputs and a DMU is allocatively efficient, if it is able to use the inputs in optimum proportions, given their respective costs. Now, as in our study the data on cost of inputs were not available, so the allocative efficiency measures were not employed. We performed DEA with 'output orientation' considering the limited control of district hospitals over their outputs. Our study focuses the question: *by how much output quantities that can be proportionately increased without altering input quantities?*

The technical efficiency comprises of pure technical and scale efficiency (SE) components. The SE has a direct impact on the overall efficiency of the DMU. The increased scale of operations of DMU results in economies and diseconomies of scale. In this context, the choice of assumption of variable returns to scale (VRS) or constant returns to scale (CRS) in estimating a DEA model becomes of critical importance. The CRS assumption focuses productivity without altering the scale of operations. Whereas in the VRS assumption, interest is on the extent to which the scale of operation affects productivity. Another reason, for preferring VRS assumption, in our study is that, all DMUs under analysis are not operating at an optimum scale. So we carried out analysis with the VRS assumption.

However, being an extreme point measure, the technique has certain disadvantages, that is, sensibility to outliers, errors measurements and random influences on the data. Internal generation of weight is another disadvantage of DEA. Apart from all these disadvantages, DEA is probably because of its large comparative advantages, the most appropriate technique presently available to the relative

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efficiency in health services efficiency measurement literature [17].

According to DEA the efficiency of a multiple-output, multiple-input DMU K, where K varies from 1,2,3…...n, can be presented [17] as follows:-

$$\frac{\sum_j \upsilon j y j k}{\sum_i v i \chi i k} = \theta_\kappa \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots (i)$$

Whereas, u measures the weight of each output yj (j=1,2,……,s),

v indicates the weight of each input xi (i=1,2,………,m).

The efficient frontier of the group (ratio of output by input, θ = 1) is represented by the most efficient DMUs to which the efficiencies of the remaining DMUs are related. The 'best performer' or 'benchmarker' DMUs is those who do not waste any input and therefore is regarded as 'peers' for entities with a weak evaluation and less efficiency. That means the efficiency scores θ falls in ranges between 0 and 1.

To estimate efficiency frontier in the present study the managers must set certain direction, (input or output orientation), which helps his/her to specify the kinds of quantities to have under control. In our study the output orientation approach considered to be appropriate as because we have limited control over output of healthcare services in our case. On the other hand the input-oriented approach should be in the case if a fixed level of output has to be achieved by minimum quantity of inputs. However the DMUs might be different, according to their size and quantity of inputs used and outputs produced accordingly, the assumptions concerning the returns to scale have to be formulated. The Charnes, Cooper, Rhodes (CCR) model incorporates constant returns to scale in production. To obtain a linear programming problem the Charnes Cooper transformation [18] was considered for formulation of the problem. The output oriented linear programming envelopment for DMUs under evaluation k can be represented as;

$$\max_{\eta\,\phi} \quad \eta,$$

$$\text{Subject to,} \quad xik \geq \sum_j \phi j \cdot xij$$

$$\eta \cdot yjk \leq \sum_j \phi \cdot yij$$

$$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (ii)$$

$$\phi j \geq 0,$$

Whereas η is defined based on the efficiency scores of DMUs k;

$$\eta k = \frac{1}{\phi_k} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (iii)$$

Whereas the vector ϕ represents intensity variables which represents the necessary combinations of efficient entities (reference or peers) for every inefficient DMUs in order to form a 'benchmark' on the frontier. The concept returns to scale tells us how output respond in the long run to changes in the scale/size (inputs) of the hospital. The in appropriate size of DMU might result in scale inefficiency, which can be further divided into two forms: increasing returns to scale (IRS) and decreasing returns to scale (DRS). The IRS denotes that the size of DMU is very small for the volume of its operations (output may increase by a larger proportions than each of the inputs). However a DMU exhibiting DRS is very large for its volume activity and operations (output increases by smaller proportion than each of the inputs). A scale efficient DMU operates under constant returns to scale (CRS) [19, 20].

Variables considered under the present study

Selection of input and output variables is very important in the studies applying DEA. In healthcare, hospital turns input into output (health services) in the production process. The inputs are divided into three broad categories: labour (human resources), material (drugs), and capital (building and equipment). It is widely accepted in healthcare literature [19] that the ultimate output in the production process of health facilities is reflected in the improvement in health population. However due to measurement complexities and non availability of data for this type of analysis, it becomes difficult to assess the improvements in population health is a great challenge to healthcare. Therefore intermediate outputs are generally used as a preferred choice [20, 11, 13].

For modelling the health service production, keeping an eye on the similar past studies we have used four input and four output variables in our study.

Input Variables	Output Variables
1. STAFF (sub-centre staff including Community Health Officer (CHO), Auxiliary Nurse Midwife (ANM) & Male Health Worker (MPW)) 2. ASHA -Accredited Social Health Activist (considered separate as they are not fully regular employees of Govt) 3. MTGS (No of	1. ANC (Full ante-natal care visits) 2. PNC (post-natal care within 24 hrs under HBNC-Home base new born care) 3. BCG (No bacillus Calmette-Guérin Vaccine immunisation given to New born immediately after birth) 4. FSA (No of newborn given full schedule

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village health sanitation and nutrition committee (VHSNC) meeting during the month) 4. S&M (No of Supervision and Monitoring Visits by Supervisor/Monitor)	visits by Accredited Social Health Activist)

To select these variables for the study was guided by the literature review [21] on hospital efficiency assessment using DEA technique, the availability of data and, our interest in maternal healthcare services. Due to data limitations, we had restricted our analysis to the above mentioned input and output variables and had a balanced DEA model.

Table 2: Population and Sample

District	Health Block	Population of Sub-centres	Sample Sub-centres
Hailakandi	Lala	47	24
	Algapur	30	15
	Kalinagar	7	4
	Katlicherra	35	18
Total		119	61

Source: Rural Health Statistics, 2016, Govt. of India

From the above explanatory table it is discernible that for the present study 50% percent of the population was covered under the study. The selection of sample is based on the K M model of sample selection.

Data Collection

We collected the data from the HMIS and others records of the Department of health and family welfare, Government of Assam as well as India. Half of all sub-centres (61 out of total 119 sub-centres operational as above mentioned table) from four rural blocks of Hailakandi district were included in the study. Data from 61 sub-centres for the period 2016-17 and reported as on July 2017 were used.

IV. ANALYSIS AND INTERPRETATION

Firstly, descriptive statistics of all inputs and outputs variables were calculated by using Stata 12.0 special edition software (developed by Stata Corp. Inc., TX, USA). The mean, standard deviation (SD), minimum and maximum values of all input and output variables are presented. Subsequently, technical efficiency (TE) scores were computed using the DEA programme version 2.1 (DEAP: 2.1), developed by Tim Coelli.

Table: 3 Descriptive statistics of input and output variables, sub-centres of Hailakandi district, Assam

Variable	Definition	Mean	Standard Definition	Minimum Value	Maximum Value
(1)	(2)	(3)	(4)	(5)	(6)
	Input				
STAFF	Sub-centre staff including Community Health Officer (CHO), Auxiliary Nurse Midwife (ANM) & Male Helath Worker (MPW)	2.10	0.79	1	4
ASHA	Considered separate as they are not fully regular employees of Govt.	5.75	2.40	2	13
MTGS	No of village health sanitation and nutrition committee (VHSNC) meeting during the month	16.19	9.31	4	48
S&M	No of Supervision and Monitoring Visits by Supervisor/Monitor	3.55	1.90	1	9
	Output				
ANC	Full Ante-natal care visits	22.31	12.31	2	52
PNC	Post-natal care (PNC) within 24 hrs under Home base new born care (HBNC)	10.88	13.72	1	68
BCG	No of bacillus Calmette-Guérin Vaccine (BCG) immunisation given to New born immediately after birth	25.55	13.77	3	60
FSA	No of newborn given full schedule visits by Accredited Social Health Activist	30.67	16.64	3	74

Source: Calculated by authors

This study used DEA technique to assess the TE of 61sampled sub-centres of Hailakandi district of Assam. In the Table: 3 present the descriptive statistics of the variables of interest [column-2].

The VRS model of TE and SE scores and returns to scale related characteristics for the individual sub-centres are given in Table: 4.

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Table: 4 Technical efficiency (TE), scale efficiency (SE) scores and returns to scale characteristics of each sub-centres of Hailakandi district, Assam

Sub-centre Name	TE score	SE score	Type of SE
Mahammedepur SC	1	0.989	*IRS*
Krisnapur SC	1	0.837	*IRS*
Joykishnapur SC	0.603	0.99	*DRS*
Vichingcha SC	0.953	0.901	*DRS*
Nischintapur SC	0.895	0.992	*IRS*
Baliura SC	1	0.749	*IRS*
Monacherra SC	1	0.932	*DRS*
Ainakhal SC	0.568	1	-
ShingalaSC	1	0.617	*IRS*
Chandrapur SC	0.935	0.816	*DRS*
Ismailtilla SC	0.566	0.985	*IRS*
Lalamukh SC	0.888	1	-
Sontilla SC	0.47	1	-
Lalacherra SC	1	1	-
Madaripar SC	0.479	0.963	*IRS*
Nityanandapur NSC	0.581	1	-
Nimaichanpur SC	0.876	0.835	*IRS*
Kuchila SC	1	1	-
Rajyeswarpur SC	1	0.48	*IRS*
Borbond SC	0.54	1	-
Katagaon SC	0.392	0.932	*IRS*
Bilaipur SC	0.755	0.99	*IRS*
Balicherra SC	1	1	-
Kacharitol NSC	1	1	-
Vojantipur SC	0.929	0.765	*DRS*
Barhailakandi SC	1	1	-
Dakshin Sunapur SC	1	0.408	*IRS*
Purbagool SC	1	0.789	*DRS*
Rongpur SC	1	0.868	*IRS*
Lakshirbond SC	0.944	0.804	*DRS*
Nitinagar SC	0.708	0.706	*DRS*
Sib Uttar SC	0.825	0.915	*DRS*
Tupkhana SC	1	1	-
Uzankupa SC	1	1	-
Bowarthal SC	0.707	0.907	*DRS*
Chandipur-IV SC	1	0.894	*DRS*
Bhatirkupa SC	0.704	0.99	*DRS*
Kanchanpur SC	1	1	-
Mohanpur Grant SC	1	0.989	*DRS*
Panchgram SC	0.845	0.657	*DRS*
Polarpar SC	0.7	0.878	*DRS*
kalinagar VSC	0.566	0.985	*IRS*
kalinagar VIIISC	0.5	1	-
Jhalnacherra SC	1	1	-
Ramnathpur SC	1	1	-
Gharmura SC	0.727	0.991	*IRS*
Jecobpur SC	0.662	0.987	*DRS*
Killarbak SC	1	1	-
Bagcherra SC	1	0.714	*IRS*
Dumcherra SC	1	1	-
Raifelmara SC	1	0.685	*IRS*
Gutguti SC	1	1	-
Sultani SC	1	0.83	*DRS*
Niskar SC	0.573	0.997	*DRS*
Lalpani SC	1	0.409	*IRS*
Harishnagar I SC	0.443	0.857	*DRS*
Harishnagar III SC	0.614	0.963	*DRS*
Boruncherra SC	1	1	-
Dariarghat SC	1	0.95	*IRS*
Appin SC	1	0.94	*DRS*
Rongpur MSC	0.947	0.845	*DRS*

Source: Calculated by authors

The interpretation of the Table-4 reveals that the mean scores of pure TE and SE sub-centres were 0.85 and 0.90 respectively. Of the total sub-centres included in the study, 31 (51%) were technically efficient constituting the 'best practice frontier'. The other 49 percent were technically inefficient with an average TE score 0.70. This implies that these thirty inefficient sub-centres could potentially reduce their current input endowment by 51 percent while leaving their output unchanged. In other words these thirty technically inefficient sub-centres could, on an average, produce 51 percent more output by utilising the existing levels of input.

Twenty (33%) sub-centres had SE of 100% implying thereby that they had the most productive scale size (MPSS) for that input –output mix. The remaining 41 (67%) sub-centres were found to be scale inefficient, showing a mean of SE score 0.90. This indicates that, on average the scale-inefficient sub-centres could reduce their input size by 10 percent without affecting their current output levels.

Out of 41 scale-inefficient sub-centres, 19 (46.3%) showing increasing returns to scale (IRS) and remaining 22 (53.6%) revealed decreasing returns to scale (DRS). These findings reveal the fact that 46.3% scale–inefficient sub-centres in Hailakandi are too small for their operations and to operate at their Most Productive Scale Size (MPSS), they need to expand their scale of operations. However 53.6% scale –inefficient sub-centres in the district need to scale down their operations to achieve constant returns to scale (CRS).

Table: 5 Total output (input) increases (reductions) needed to make inefficient sub-centres efficient.

Variables	Original Value	Projection	Difference (%)
(1)	(2)	(3)	(4)
Output			
Full Ante-natal care visits	667	996.36	49.38

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(ANC)			
Post-natal care within 24 hrs under Home Base New Born Care (PNC)	184	597.32	224.63
No bacillus Calmette-Guérin Vaccine immunisation given to New born immediately after birth (BCG)	659	1147.19	74.08
No of newborn given full visits by Accredited Social Health Activist (FSA)	880	1313.46	49.26
Input			
Sub-centre staff including CHO, ANM & MPW (STAFF)	61	39.18	-35.77
Accredited Social Health Activist are considered separate as they are not fully regular employees of Govt. (ASHA)	27	16.44	-39.11
No of VHSNC meeting during the month (MTGS)	426	303.53	-28.75
No of Supervision and Monitoring Visits by Supervisor/Monitor (S&M)	88	49.81	-43.40

Source: calculated by authors

The above Table: 5 represents the total output increases and/or input reductions required for making the inefficient sub-centres efficient. The interpretation of the table -5 reveals that to become efficient, the inefficient sub-centres combined would need to reduce the number of STAFF by 35.77 percent , number of ASHA by 39.11 percent, number of MTGS by 28.75 percent and No of S&M by 43.40 percent keeping the current level of output unchanged. On the other hand, the inefficient sub-centres could become efficient by increasing the number of cases of ANC by 49.38 percent, PNC by 224.63 percent, BCG by 74.08 percent, number of cases of FSA by 49.26 percent with existing level of inputs.

Now in order to **benchmarking** or find out, 'best performing' sub-centre among different inefficient sub-centres, peers are set a potential role models, in identifying the most efficient one. It is assumed that, on a frontier, each sub-centre tries to move either horizontally or vertically, that is either to increase its outputs or reducing its inputs by following the closest sub-centre to become efficient. For each set of inefficient sub-centre, a single or set of inefficient sub-centres acts as a peers, which the inefficient sub-centre needs to follow to become efficient.

Table: 6 Peers of Inefficient sub-centres of Hailakandi District, Assam

Sl No	Sub-Centres	Peers
1	Mahammedepur SC	Mahammedepur SC
2	Krisnapur SC	Krisnapur SC
3	Joykishnapur SC	Kuchila SC, Gutguti SC, Ramnathpur SC, Jhalnacherra SC, Boruncherra SC
4	Vichingcha SC	Kuchila SC, Jhalnacherra SC, Kacharitol NSC, Ramnathpur SC
5	Nischintapur SC	ShingalaSC, Jhalnacherra SC, Kuchila SC, Balicherra SC, Dumcherra SC
6	Baliura SC	Baliura SC
7	Monacherra SC	Monacherra SC
8	Ainakhal SC	Kuchila SC
9	ShingalaSC	ShingalaSC
10	Chandrapur SC	Kuchila SC, Appin SC, Bowarthal SC
11	Ismailtilla SC	Kuchila SC, ShingalaSC, Balicherra SC, Jhalnacherra SC
12	Lalamukh SC	Gutguti SC, Kuchila SC, Ramnathpur SC
13	Sontilla SC	Gutguti SC, Kuchila SC, Ramnathpur SC
14	Lalacherra SC	Lalacherra SC
15	Madaripar SC	Jhalnacherra SC, Kuchila SC, ShingalaSC, Balicherra SC
16	Nityanandapur NSC	Ramnathpur SC
17	Nimaichanpur SC	Gutguti SC, ShingalaSC, Kuchila SC, Balicherra SC
18	Kuchila SC	Kuchila SC
19	Rajyeswarpur SC	Rajyeswarpur SC
20	Borbond SC	Kuchila SC, Ramnathpur SC, Gutguti SC
21	Katagaon SC	Kuchila SC, Barhailakandi SC, Gutguti SC, Jhalnacherra SC
22	Bilaipur SC	Killarbak SC, Ramnathpur SC
23	Balicherra SC	Balicherra SC
24	Kacharitol NSC	Kacharitol NSC
25	Vojantipur SC	Kuchila SC, Chandipur-IV SC, Jhalnacherra SC
26	Barhailakandi SC	Barhailakandi SC
27	Dakshin Sunapur SC	Dakshin Sunapur SC
28	Purbagool SC	Purbagool SC
29	Rongpur SC	Rongpur SC
30	Lakshirbond SC	Appin SC, Tupkhana SC, Kuchila SC, Chandipur-IV SC, Kacharitol NSC
31	Nitinagar SC	Jhalnacherra SC, Kacharitol NSC, Chandipur-IV SC, Mohanpur Grant SC
32	Sib Uttar SC	Kuchila SC, Jhalnacherra SC, Monacherra SC, Tupkhana SC, Kacharitol NSC
33	Tupkhana SC	Tupkhana SC
34	Uzankupa SC	Uzankupa SC
35	Bowarthal SC	Jhalnacherra SC, Kuchila SC, Kacharitol NSC, Ramnathpur SC
36	Chandipur-IV SC	Chandipur-IV SC
37	Bhatirkupa SC	Kuchila SC, Jhalnacherra SC
38	Kanchanpur SC	Kanchanpur SC
39	Mohanpur Grant SC	Mohanpur Grant SC
40	Panchgram SC	Chandipur-IV SC, Kacharitol NSC, Mohanpur Grant SC

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41	Polarpar SC	Kuchila SC, Chandipur-IV SC, Jhalnacherra SC
42	kalinagar VSC	Kuchila SC, ShingalaSC, Balicherra SC, Jhalnacherra SC
43	kalinagar VIIISC	Kuchila SC, Jhalnacherra SC
44	Jhalnacherra SC	Jhalnacherra SC
45	Ramnathpur SC	Ramnathpur SC
46	Gharmura SC	Jhalnacherra SC, Tupkhana SC, Balicherra SC, Ramnathpur SC, Boruncherra SC, Gutguti SC
47	Jecobpur SC	Jhalnacherra SC, Ramnathpur SC, Balicherra SC, Tupkhana SC, Boruncherra SC
48	Killarbak SC	Killarbak SC
49	Bagcherra SC	Bagcherra SC
50	Dumcherra SC	Dumcherra SC
51	Raifelmara SC	Raifelmara SC
52	Gutguti SC	Gutguti SC
53	Sultani SC	Sultani SC
54	Niskar SC	Gutguti SC, Jhalnacherra SC, Tupkhana SC, Kacharitol NSC, Boruncherra SC, Kuchila SC
55	Lalpani SC	Lalpani SC
56	Harishnagar I SC	Ramnathpur SC, Kacharitol NSC, Jhalnacherra SC, Purbagool SC
57	Harishnagar III SC	Boruncherra SC, Gutguti SC, Kacharitol NSC, Kuchila SC, Ramnathpur SC
58	Boruncherra SC	Boruncherra SC
59	Dariarghat SC	Dariarghat SC
60	Appin SC	Appin SC
61	Rongpur MSC	Appin SC, Kuchila SC, Chandipur-IV SC

Source: calculated by authors

From the above Table no.6 it may be interpreted that the peers for all the sub-centres, where Kuchila SC (under Lala health block) came up to be the best efficient sub-centre (23 times referred as peers), and then Jalnacherra SC as second (under kalticherra health block was referred by 18 times as peers) to be followed by all the inefficient sub-centres. Kuchila SC has optimal levels of inputs combination to achieve the most efficient output.

It is also to be noticed that all sub-centres are not inefficient; that is revealed by the fact that out of four district health blocks as Lala, Algapur, kalinagar and katlicherra, two of them namely Katlicherra (6 sub-centre) and Algapur (4 sub-centre) were achieved 'best practice frontier' as well as operate at their Most productive Scale Size (MPSS). And the other two namely Kalinagar (0 out of 0 sub-centre) and Lala (4 out of 9 sub-centre) were achieved the same.

V. SUGGESTIONS FOR IMPROVEMENT

Although the aim of the study was not only to establish a relationship between sub-centre efficiency and improved maternal health and obstetric outcome, one would expect that the increasing technical efficiency (better use of existing resource management) would lead to an increase in health service coverage improving ultimately health outcome.

The average pure TE score of 0.85 shows that sub-centres included in the study can produce the same amount of output by saving 25 percent inputs. This implies that the input saving could be utilised to provide healthcare services to more poor and below poverty line through these sub-centres where these services required. These could significantly contribute towards ensuring equitable availability of maternal healthcare services in the district. The results of this study showed that 49 percent (thirty) of sub-centres are operating at less than optimum level and 11 of them obtained efficiency score below 0.60. This result manifests that the inefficient sub-centres could significantly improve their efficiency through better resource management with existing system.

However, katlicherra and Algapur health block are fall in the most advanced city of district as reported no of govt reports in considering various socio-economic parameters as roads, electricity, communication and other public utilities. The 'best practice frontier' as well 'Most productive Scale Size (MPSS)' in the district efficiency achievement the role of other environmental factors might have influence in those sub-centres. Hence efforts to be made to augment road, electricity, communication and other public utilities in respect of inefficient sub-centres too.

VI. SCOPE OF FUTURE RESEARCH

The factors influencing efficiency of these sub-centres (as mentioned block wise) should be identified and appropriately addressed. This may be achieved by second stage DEA (which is beyond our study coverage) i.e; conducting regression analysis of the environmental factors associated with these sub-centres using a Tobit Analysis [22] or by exploring these factors through qualitative research.

VII. CONCLUSION

The study is the first attempt at evaluating the technical efficiencies of district level sub-centres in north-eastern state Assam by using DEA methodology with best of our knowledge. Though the Department of Public Health and Family Welfare of the state collaborating with National Mission Health has significantly improved in recent years, the study showed a remarkable scope for further improvement in the primary healthcare in the sub-centre level. The findings of our study have very significant policy implications for strengthening healthcare service delivery in the district. Considering the poor health indicators of the state and scarcity of resources in the district, ensuring

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efficient functioning of these sub-centres will be of immense health importance. The findings of the study are based on specific input-output mix; No consideration of factors causes this efficiency/inefficiency is the big limitation; the policy implications related to these findings also considered within that perspective only.

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