The Efficiency of Anganwadi Centers Located in Rural Field Practice Area of a Medical College in North India: Data Envelopment Analysis

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Abstract

Background: The Integrated Child Development Services (ICDS) scheme was launched in 1975 for the improvement in maternal and child health and nutrition. The services under ICDS are implemented through Anganwadi centers (AWCs) and are delivered by Anganwadi workers (AWWs) at grassroots level. To evaluate the efficiency of all AWCs located in the field practice area of the medical college in North India, using data envelopment analysis (DEA) technique. **Materials and Methods:** A cross-sectional study was conducted in the catchment area of rural health training center. Each of the 15 AWCs was considered a decision-making unit (DMU), and physical structure and logistics were included as input variables; and percentage of beneficiaries receiving supplementary nutrition and health checkups were included as output variables. DEA technique was used to calculate the efficiency score for each DMU with the help of DEAOS free online software. **Results:** DMU 14th was found to be most efficient (100%) and DMU second was the least efficient (45%). DMU 13 and 14 demonstrated a level of performance that is superior to all other DMUs. DMU 13th and 14th were, therefore, considered 100% efficient. DEA analysis showed that total output increases and/or input reductions were required for making the inefficient DMUs efficient. **Conclusion:** Most of the AWCs were inefficient and an improvement in the infrastructure and logistics is likely to improve the efficiency of AWCs.

Keywords: DEA, DMU, efficient, envelopment frontier

Introduction

The Integrated Child Development Services (ICDS) scheme is the largest program for promotion of maternal and child health (MCH) and nutrition in India. The scheme was launched in 1975 in pursuance of the National Policy for Children. The beneficiaries are children less than 6 years, adolescent girls, pregnant and lactating women, and women in the age group of 15–44 years.[1] The package of six services under the scheme includes supplementary nutrition, pre-school non-formal education, immunization, nutrition and health education, health checkup, and referral services. These services are made available at Anganwadi centers (AWC) and are delivered by Anganwadi workers (AWWs) at grassroots level.[2]

Currently, 35.5% of India's children aged less than 5 years are stunted and 32.1% are underweight.[3] A WHO and UNICEF review in 2018 suggested that the aspiration of Sustainable Development Goals (SDG) goal of eliminating all forms of malnutrition by 2030 was not achievable on the basis of trends.[4] Government of India's Prime Minister's Overarching Scheme for Holistic Nutrition (POSHAN) Abhiyaan or the National Nutrition Mission, launched in early 2018, has taken important steps towards building capacities of AWWs. It places greater emphasis on the delivery of nutrition services during the first 1,000 days of a child's life. The period, from conception until 2 years of age, is critical for a child to grow, learn, and thrive but has been largely ignored earlier when the focus was placed on the 3–6-year-olds. Attention is also given on children

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in the age group of 3–6 years for their overall development through the platform of the AWCs.[5] The program's scale is huge – it covers every village in the country's 36 states and union territories.[6]

As Prime Minister stated "*SabkaSaath, SabkaVikas, SabkaVishwas and SabkaPrayas*" (everyone's support, everyone's development, everyone's trust, and everyone's efforts), we need to focus more at the grassroots level for the achievement of our goals.[7] A multi-dimensional problem such as under nutrition requires multi-sectoral intervention, hence, the centrality of convergence as the key strategy.[8]

Success of any program largely depends on proper planning and its effective implementation. ICDS program though well conceptualized definitely has some issues in implementation. Most of these revolve around the AWW and the AWC, a factor that assumes a pivotal place in the scheme of things because of its close and continuous proximity to the beneficiaries.[9] Thus, periodic assessments of services delivered will help in improving their performance and achieve the program objectives.

Of late, data envelopment analysis (DEA) has emerged as a powerful tool for evaluating the efficiency of decision-making units (DMU) in health sectors. From the point of view of assessing the efficiency of health care units, DMUs can represent different levels of health care, including a complete health care system in the country, districts, hospitals, specific service providers, departments, or individual physicians.[10] DEA, a benchmarking technique based on linear programming, converts multiple input and output measures into a single comprehensive measure of performance (an "efficiency score") for each of a group of DMUs.[11] Each input and output variable can be measured independently in any useful unit, without being transformed into a single metric.[12] With DEA, each DMU is evaluated by comparing its performance with that of other DMUs. A DMU is considered to be "inefficient" when another DMU, or composite of two or more of them, can produce more outputs with the same inputs (the "output-oriented" model).[13]

In view of the above, this study was undertaken to evaluate the efficiency of all AWCs located in the field practice area of the medical college in North India, using DEA technique.

MATERIALS AND METHODS

This cross-sectional study was conducted in the catchment area of rural health training center (RHTC) of department of community medicine of a medical college in Lucknow District of Uttar Pradesh. The study was conducted during the month of December 2020–February 2021.

All the 15 AWC located in the catchment area were included in the study. The investigators visited the centers and interacted with the AWWs. Physical structure and logistics were included as input variables, and percentage of beneficiaries receiving supplementary nutrition and health checkups were included as output variables. Details are as under:

Input variables

(a) Physical structure – presence of pucca building, toilet facility, electricity, fan, piped/hand pump as source of water, covered storage of drinking water, proper storage of supplementary nutrition, and absence of rodents/cockroaches.

(b) Logistics – regular supply of supplementary nutrition, adequate supply of supplementary nutrition, properly maintained registers for record keeping, weighing scale in working condition, stadiometer, growth monitoring of registered child, preschool education material, supply of adequate medicines, iron and folic acid tablets, and vitamin A syrup.

Each variable was given a score of 10 (ten) if present and 0 (zero) if absent. Thus, the maximum score was 180 and minimum score 0.

Output variables

(a) Output 1: Percentage of beneficiaries receiving supplementary nutrition (number of beneficiaries receiving supplementary nutrition/total number of beneficiaries enrolled). The beneficiaries included – children 6 months–6 years and pregnant and nursing mothers.

(b) Output 2: Percentage of beneficiaries receiving health checkup (number of beneficiaries receiving health checkup/total number of beneficiaries enrolled). The beneficiaries include – children 0–6 years, pregnant and nursing mothers, and adolescent girls.

For quality assurance, the information provided by the AWW was cross checked with the records available at AWC and by interaction with the parents of the children present at the AWC.

For the purpose of study, each AWC was considered as a DMU. A separate linear programming formulation (basic radial model-envelopment forms) was used to calculate the efficiency score for each DMU with the help of DEAOS (DEA Online Software). Relative efficiency scores were calculated for the DMUs on selected input variables to get the results for output variables and, thus, the difference in efficiencies between the most efficient and lesser efficient DMUs.

Ethical clearance from Institutional Human Ethical Committee of T S Misra Medical College and Hospital, Lucknow (Ref. No. TSMMCH&H/ADMIN/11/2019/MEU) was obtained before starting the study.

RESULTS

The 15 DMUs included in this cross-sectional study have a total of 2,066 beneficiaries enrolled with a minimum of 91 beneficiaries in DMU 1 and 4 and a maximum of 185 beneficiaries in DMU 7. The beneficiaries included 476 children, 180 pregnant mothers, 173 lactating mothers, 390 adolescent girls, and 847 women of 15–44 years age group. Twenty-five beneficiaries' data were incomplete; hence, a total of 2,041 beneficiaries were a part of the study. Details of the services provided to beneficiaries (the output) and the points

scored by DMUs towards the availability of physical structure and logistics (the input) are given in Table 1.

The overall efficiency scores of each DMU were calculated using DEAOS online software and depicted in Figure 1. The performance ratio of "output per input" also known as relative efficiency/efficiency score suggests that DMU 14 (100%) is the most efficient DMU. The efficiency scores of all DMUs are relative to DMU 14. DMU 2 is the least efficient (45%).

The positions on the graph [Figure 2] represented by DMU 13 and 14 demonstrate a level of performance that is superior to all other DMUs. DMU 13 and 14 are, therefore, considered 100% efficient: DMU 14 on *y* axis (ratio of output2/input equal to 100) because it is the most efficient at output2 (health checkup) and DMU 13 on *x* axis (ratio of output1/input equal to 86.8) because it is the most efficient at output1 (nutrition). A horizontal line can be drawn from the *y*-axis to DMU 14, from DMU 14 to DMU 13, and a vertical line from 13 to the *x*-axis. This line is called the efficient frontier (sometimes also referred to as the efficiency frontier). Mathematically, the efficient frontier is the convex hull of the data. The efficiency frontier, derived from the most efficient branches in the dataset, represents a standard of best-achieved performance. As a result, it can be used as a threshold against which to measure the performance of all the other DMUs. The efficient frontier represents a standard of performance that other DMU not on the efficient frontier could try to achieve. The efficient frontier envelopes (encloses) all the data, thus, the term DEA arises.

The efficiency frontier "envelops" the inefficient units within it and clearly shows the relative efficiency of each DMU. DMUs that are located on the frontier, i.e., DMU 13 and 14 are

performing better than any DMUs below the frontier. The other DMUs are not 100% efficient as they are not on the frontier.

DMU 15, for example, could become efficient if it increased its outputs, in the same proportions, while keeping its input the same. If it did this, it would eventually reach the efficiency frontier at the point marked ("intersection"). Its actual efficiency is calculated simply by the ratio of its distance from the origin over the distance from the origin to the point marked. This gives DMU 15 an efficiency of 73% and DMU 10 efficiency of 56%.

Table 2 presents the total output increases and/or input reductions required for making the inefficient DMUs efficient. The results show that, to become efficient, the inefficient DMUs would need to decrease inputs by respective percents shown in Table 2, keeping the current output levels constant. Alternatively, the inefficient DMUs could become efficient by increasing output1 (supplementary nutrition) by the percentages given in Table 2 with the current inputs. According
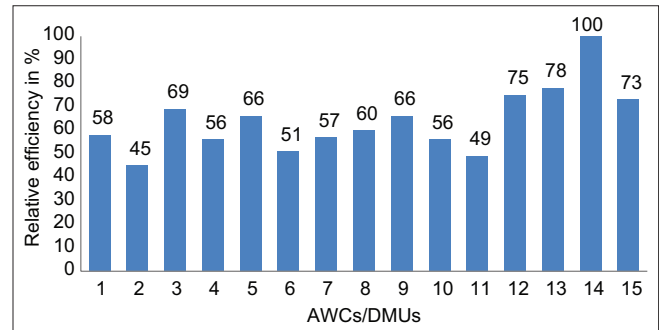

Figure 1: Relative efficiency score of each Anganwadi center

Table 1: Distribution of enrolled beneficiaries, input, and output variables according to DMUs

AWC/ DMUs	Total No. of beneficiaries enrolled *n*=2041	Population *n*=15618	Input variable			Output variable	
			Physical structure score (Max 80)	Logistics score (Ma×100)	Total score (Ma×180)	Beneficiaries receiving supplementary nutrition (%)	Beneficiaries receiving health checkup (%)
DMU1	91	769	70	70	140	78.69	71.43
DMU2	158	1288	80	100	180	81.03	69.06
DMU3	102	852	60	80	140	81.82	97.8
DMU4	91	801	70	90	160	69.79	96
DMU5	139	1069	70	70	140	92.11	77.7
DMU6	127	1073	70	100	170	73.94	85.23
DMU7	185	1206	70	90	160	76.29	91.35
DMU8	136	1049	70	90	160	95.37	80.77
DMU9	164	1186	70	80	150	94.85	88.03
DMU10	100	845	70	90	160	85.85	80.95
DMU11	162	1269	70	70	140	69.61	58.13
DMU12	179	1100	30	100	130	83.46	97.01
DMU13	141	1092	30	80	110	95.51	63.12
DMU14	142	1074	40	60	100	85	100
DMU15	124	945	40	80	120	63.72	97.87
Mean	136.1	1041.2	66.7	83.3	144	81.8	83.6
SD	29.4	160.3	16.1	11.9	21.5	9.7	13.1

AWCs=Anganwadi centers, DMU=decision-making unit

| Table 2: Total output/input increase/decrease needed to make inefficient AWCs efficient					
AWC	Input (Physical structure and logistics %)		Output1 (Beneficiaries receiving supplementary nutrition %)		Output2 (Beneficiaries receiving health checkup %)	
	Projected	Decrease/Increase %	Projected	Increase %	Projected	Increase/decrease %
1	91.6	−35	78.7	0	71.4	0
2	94.1	−48	81.0	0	69.1	0
3	97.8	−30	83.1	1.3	97.8	0
4	96	−40	81.6	11.8	96	0
5	106.9	−24	92.1	0	77.7	0
6	86.9	−49	73.9	0	85.2	0
7	91.4	−43	77.6	1.4	91.4	0
8	110.7	−31	95.4	0	80.8	0
9	110.5	−26	94.9	0	88.0	0
10	100.0	−37	85.9	0	81	0
11	80.8	−42	69.6	0	58.1	0
12	98.1	−25	83.5	0	97.0	0
13	110	0	95.5	0	63.1	0
14	100	0	85.0	0	100	0
15	97.9	−18	83.2	19.5	97.9	0

AWCs=Anganwadi centers

to DEAOS online software, output2 (health checkup) does not need to be increased or decreased shown by slack (additional improvement: increase in outputs and/or decrease in inputs, needed for a unit to become efficient) to be zero.

DISCUSSION

This DEA model on AWC in the catchment area of RHTC of a medical College in Lucknow generates a scalar efficiency ratio and identifies a group of comparative DMUs for input and output variables. Those DMUs with a relative efficiency ratio of less than 100 are considered "inefficient" compared to DMUs with an efficiency ratio of 100. In this study, the AWC with an efficiency ratio of 100, does not necessarily mean to be 100% efficient in the absolute sense, but it represents the "best-practice" DMU compared with others in the group. The efficiency of the DMU represents its distance from the efficiency frontier.

A study conducted for evaluation of AWC performance under ICDS program in Gujarat[14] showed that the performance of AWCs and MCH services delivered by AWCs still needs improvement, and coordinated steps catering to different services provided at the centers are needed to optimize the functioning of the ICDS scheme. Similar results were found in another study conducted in South India[15] in which various facility and service-related constraints were found in MCH services in AWCs.

All the DMUs except DMU 13 and 14 are inefficient because the relative weights or importance of the input (physical infrastructure and logistics) and output measures (nutrition and health checkup) are not equal. Similar findings were shown by Aparna John *et al.*[16] in a study in Bihar that showed that the main constraints in performance of AWC were limitations in resources and logistics. Kumar *et al.*[17] in their study showed
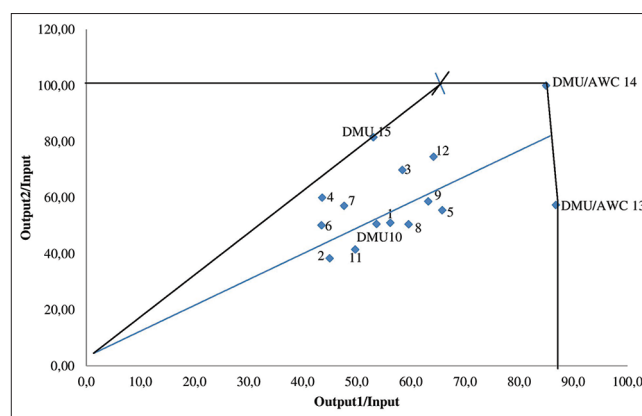
Figure 2: Graphical Analysis of DEA

that basic amenities (physical structure and resources) in AWC, health services, and checkups were not up to the mark. Siddalingappa *et al.*[18] showed that most of the Anganwadis were given the basic facilities and functioning optimally but still there were some shortcomings in infrastructure and physical growth of the children. Another study conducted by Panda[19] in 19 states/union territories (510 AWCs) showed deficiencies in infrastructure and logistics.

Sabat *et al.*[20] in a study conducted in Chatrapur block between 2016 and 2018 showed adequate lighting and piped water supply was present in 75%, pucca building in 95.8%, toilet facility in 91.7%, and electricity supply was seen in all AWCs (100%). Preschool education material, growth charts, medicine kit, and utensils were available in all the AWCs (100%). Salter weighing machine and adult weighing machine in working condition were present in 95.8% and 83.3% AWCs, respectively. A gross deficit in services provided by the AWC under ICDS scheme was found by Sharma *et al.*[21] in Raipur District.

The studies conducted so far assessed the performance of AWC on certain parameters. The present study used a composite indicator (efficiency scores) using DEA model to assess the AWCs by relative comparison among them. It shows how much relative decrease in input variables and increase in output variables can lead to betterment in efficiency of the AWC as shown in a study conducted in Aurangabad District[22] and rural Wardha[23] that showed that there exists excessive workload on AWWs; hence, a decrease in excessive maintenance of records (input in present study) would be useful.

Ministry of Women and Child Development in their Annual Report of 2020–21 has also acknowledged the need of improvement in the infrastructure at AWCs. Revised guidelines have been issued for construction of four lakh AWC buildings across the country.[24] Findings of this study provides significant inputs to the decision makers and administrators for reviewing and responding appropriately to improve the performance of AWCs.

The limitation of the study is that during the study period, there was social disruption because of Covid-19 pandemic. This could have caused fewer beneficiaries to avail services. However, the study was conducted in rural areas where most of the services were being implemented and were not affected considerably by the pandemic.

CONCLUSION

This study has significant policy implications for strengthening the health care delivery system. The findings of the study showed that an improvement in the infrastructure and logistics are likely to improve the performance of AWCs as well as health-related output. However, there appears to be a need for applying DEA model on larger scale to identify the inefficient DMUs as well as the extent of inefficiency that could be overcome by altering the input. More studies need to be conducted in this area to generalize the findings in context of India.

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Conflicts of interest
There are no conflicts of interest.

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