# Efficiency Assessment of Maternal health services in the Aspirational Districts of EAG states in India:

# A Data Envelopment Analysis Approach

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# Efficiency Assessment of Maternal health services in the Aspirational Districts of EAG states in India: A Data Envelopment Analysis Approach

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**Abstract**: India has achieved a momentous leap in economic growth in last few decades despite that it exhibits two disparate spectrums. At one spectrum, there are rapidly urbanizing mega-cities and wealth expansion of prosperous communities, while on the other hand a large number of people are lacking essential healthcare accessibility, social services and securities. Even in the healthcare system this gap is prominent and is expanding due to virtual alienation of the lagging masses by the health system essentially dominated by the private sector. At this juncture the role of the Government in enabling a sustainable health infrastructure with suitable manpower becomes very critical for the lagging units.

The study keeps this as a primary backdrop to throw light onto the performance of the aspirational districts in the Empowered Action Groups (EAG) states of the country. The study sought to assess the performance of these districts by drawing to sum up the efficiency of health outcomes across a range of input-output spectrum specifically targeted to maternal health. Strengthening maternal health services in aspirational districts has been a key concern for policymakers across India and the present study will establish the input lacunae hindering the achievement of the desired outputs.

Data Envelopment Analysis (DEA) was used to analyze the efficiencies in terms of maternal health care for the aspirational districts. For the application of the said method, Institutional Deliveries (ID) was chosen as the output variable. Perusal of the DEA results reveal startling lags in terms of efficiencies observed in each of these districts with regards to maternal health.

The results of this study showed that 84 percent of the aspirational districts in the EAG states are operating at less than optimal level and 42 of these obtained efficiency scores below 80 percent. This finding implies that the inefficient districts could significantly improve their efficiency by better resource management and allocation. The results suggested that the district of Gaya has the maximum scope to increase the output (Institutional Deliveries) from its current levels. The study has also quantified the peers for inefficient aspirational districts. Sirohi and Bokaro being the most cited peers certainly have put forth key takeaways in terms of strengthening maternal healthcare models for other aspirational districts.

***Keywords:*** *Aspirational Districts, EAG states, Maternal Healthcare systems, Technical Efficiency, Data Envelopment Analysis*

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## 1. Introduction

India has achieved a momentous leap in economic growth in last few decades despite that it exhibits two disparate spectrums. At one spectrum, there are rapidly urbanizing mega-cities and wealth expansion of prosperous communities, while on the other hand a large number of people are lacking essential healthcare accessibility, social services and securities. Even in the healthcare system this gap is prominent and is expanding due to virtual alienation of the lagging masses by the health system essentially dominated by the private sector. The burden of health expenditure thus falls largely on the lagging masses given the very low levels of public spending on health which, have progressively declined over the years. At this juncture the role of the Government in enabling a sustainable health infrastructure with suitable manpower becomes very critical for the lagging units

The study keeps this as a primary backdrop to throw light onto the performance of the aspirational districts in the Empowered Action Groups (EAG) states of the country. Under the stewardship of NITI Ayog, The 'Transformation of Aspirational Districts' program aims to effectively transform districts under the three core principles of convergence, collaboration and competition. The study seeks to assess the performance of these districts by drawing to sum up the efficiency of health outcomes across a range of input-output spectrum specifically targeted to maternal health. Strengthening maternal health services in aspirational districts has been a key concern for policymakers across India and the present study will establish the input lacunae hindering the achievement of the desired outputs.

Maternal health is an important component in the ongoing debate regarding reproductive and sexual health. In its bid to provide equitable access to maternal and reproductive health care in India, the Government of India has launched numerous ambitious flagship projects. However, the programs remain insufficient to cater to the targeted vows and there remains a huge regional disparity in stated outcomes. The vulnerabilities are exacerbated in regions already affected by the already existing lags in overall socio-economic profile.

The present research places its focus in terms of study area on the aspirational districts of the EAG states in India. The combined healthcare vulnerabilities of aspirational districts as well the as the EAG states in the country advocate a strong cause to understand the status of maternal health in these regions and improve upon the gaps identified. The inter-state and inter-district variations drive the performance of key parameters of maternal health at a national level, and poor national outcomes specific to the said domain projects the country's inefficiencies at a global level.

Inclusion of various maternal health indicators in global and national policies and goals calls for identification of the right set of interventions tailored to target the key factors responsible for inefficient outcomes. Maternal health programmes under National Health Mission are an aggregation of solutions to foster the desired growth envisioned for India.

### 1.1. An overview of trends in Maternal Mortality Ratio of Aspirational Districts in the EAG states of India

**Figure 1** reveals the trends in Maternal Mortality Ratio (MMR) as observed in the EAG states of India. Maternal Mortality Ratio is defined as Maternal Deaths per 1 lakh live births. A temporal comparison for over four years depicts that all EAG states have shown certain improvement with respect to MMR as is apparent in the absolute as well as percentage decline. Chhattisgarh and Uttarakhand emerge as the only two states among the EAG group to have recorded an overall increase in MMR over 2015-17 to 2016-18. Uttar Pradesh records the highest MMR among the EAG states of India, at 197 maternal deaths per 1 lakh live births. However, the state did record a percentage change of negative nine percentage points over the said years. Chhattisgarh recorded the highest percentage increase in the MMR, recording an overall increase of 13 percent from the years 2015-17 to 2016-18. Rajasthan recorded the lowest MMR at 71 in the year 2016-18 while the state of Rajasthan showed maximum improvement in terms of percentage change recording an overall decline of 12 (negative) percentage points over 2015-17 to 2016-18.

**Figure 1: Percentage and Absolute change in Maternal Mortality Ratio in the EAG States of India, SRS Publications, 2015-17 & 2016-18**

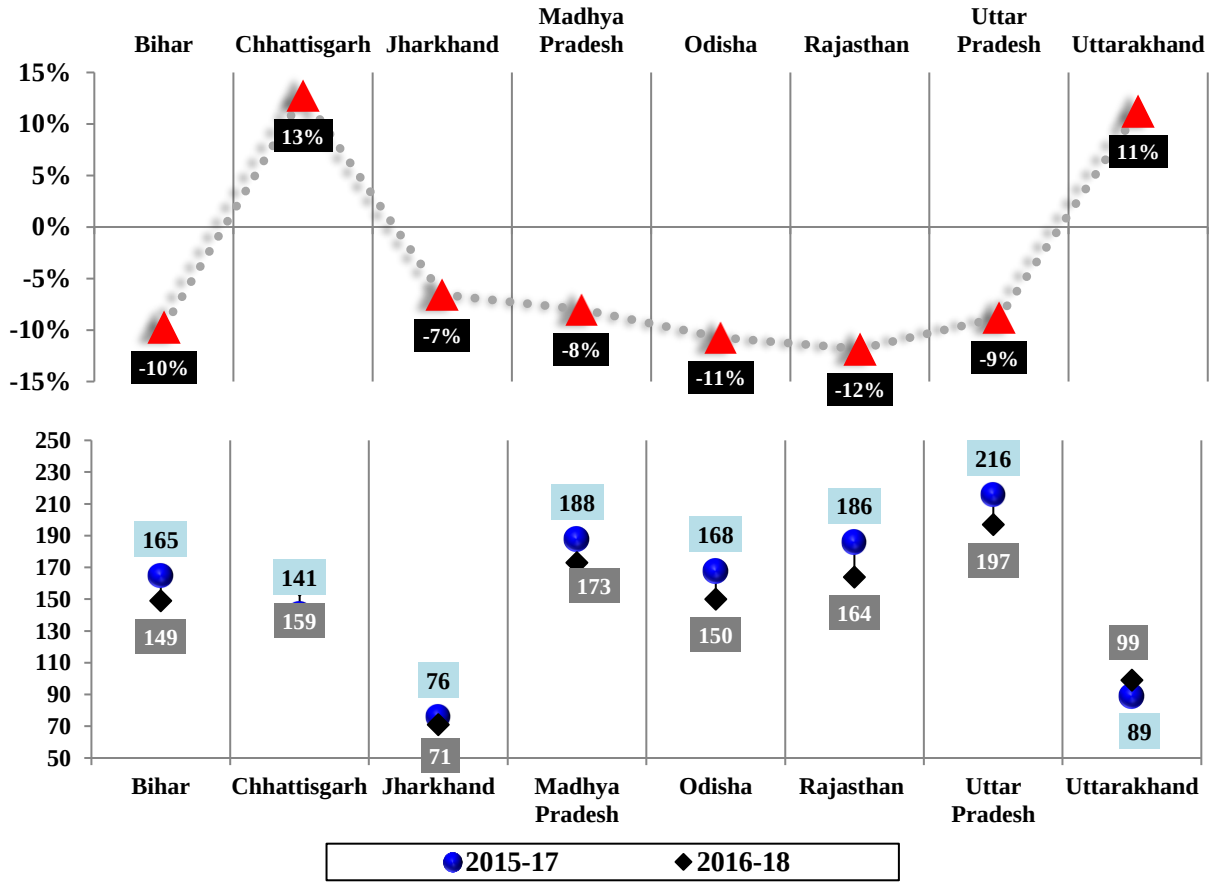


**Figure 2: Maternal Mortality Ratio of Aspirational Districts in the EAG States of India, HMIS, 2018-19**

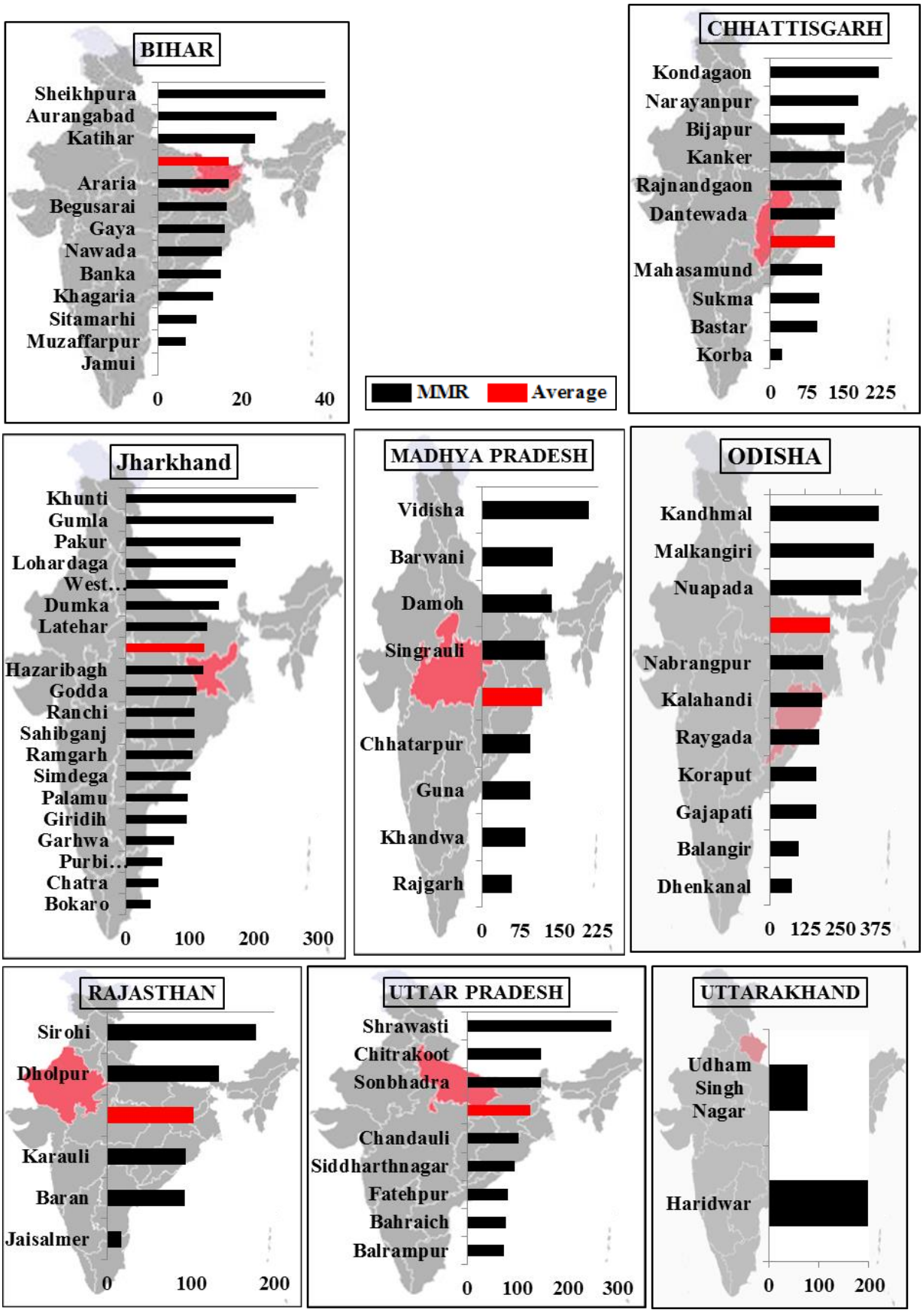


**Figure 2** presents the level of Maternal Mortality Ratio for the aspirational districts across the EAG states of India for the year 2018-19.

**Bihar**: The MMR ranged from 0 (Jamui) to 40 (Sheikhpura). The average MMR for the aspirational districts of Bihar was calculated at 17 maternal deaths per one lakh live births. Among the thirteen aspirational districts of Bihar, three districts – Katihar, Aurangabad and Sheikhpura – recorded MMR at higher than the average value.

**Chhattisgarh**: The MMR ranged from 26 (Korba) to 223 (Kondagaon). The average MMR for the aspirational districts of Chhattisgarh was calculated at 132 maternal deaths per one lakh live births. Among the ten aspirational districts of Chhattisgarh, six districts – Kondagaon, Narayanpur, Bijapur, Kanker, and Rajnandgaon – recorded MMR at higher than the average value.

**Jharkhand**: The MMR ranged from 40 (Bokaro) to 266 (Khunti). The average MMR for the aspirational districts of Jharkhand was calculated at 123 maternal deaths per one lakh live births. Among the nineteen aspirational districts of Jharkhand, seven districts – Khunti, Gumla, Pakur, Lohardaga, West Singhbhum, Dumka, and Latehar – recorded MMR at higher than the average value.

**Madhya Pradesh**: The MMR ranged from 57 (Rajgarh) to 207 (Vidisha). The average MMR for the aspirational districts of Madhya Pradesh was calculated at 117 maternal deaths per one lakh live births. Among the eight aspirational districts of Madhya Pradesh, four districts – Vidisha, Barwani, Damoh, and Singrauli – recorded MMR at higher than the average value.

**Odisha**: The MMR ranged from 79 (Dhenkanal) to 385 (Kandhmal). The average MMR for the aspirational districts of Odisha was calculated at 214 maternal deaths per one lakh live births. Among the ten aspirational districts of Odisha, three districts – Kandhmal, Malkangiri and Nuapada – recorded MMR higher than the average value of the aspirational districts combined.

**Rajasthan**: The MMR ranged from 17 (Jaisalmer) to 178 (Sirohi). The average MMR for the aspirational districts of Rajasthan was calculated at 103 maternal deaths per one lakh live births. Among the five aspirational districts of Rajasthan, two districts – Dholpur and Sirohi – recorded MMR at higher than the average value.

**Uttar Pradesh**: The MMR ranged from 76 (Balrampur) to 283 (Shrawasti). The average MMR for the aspirational districts of Uttar Pradesh was calculated at 126 maternal deaths per one lakh live births. Among the eight aspirational districts of Uttar Pradesh, three districts – Sonbhadra, Chitrakoot and Shrawasti – recorded MMR at higher than the average value.

**Uttarakhand**: The MMR ranged from 199 (Hardwar) to 77 (Udham Singh Nagar). The average MMR for the aspirational districts of Uttarakhand was calculated at 138 maternal deaths per one lakh live births.

**Table 1** clearly illustrates huge inter-state as well as intra-state variations with respect to MMR prevail for the EAG states in India. Curbing maternal mortality is regarded as a key goal for various programmes globally as well as nationally. Improvement in maternal healthcare provisions with respect to ideal availability of manpower and infrastructure as

per Indian Public Health Standards (IPHS) must necessarily be considered so as to eliminate the prevailing accessibility barriers.

**Table 1: Maternal Mortality Ratio of Aspirational Districts in the EAG States of India, HMIS, 2018-19**

| States | Aspirational Districts | MMR | States | Aspirational District | MMR |
|---|---|---|---|---|---|
| Bihar | Jamui | 82 | Madhya Pradesh | Vidisha | 207 |
| | Purnia | 62 | | Barwani | 137 |
| | Sheikhpura | 40 | | Damoh | 136 |
| | Aurangabad | 28 | | Singrauli | 123 |
| | Katihar | 23 | | Chhatarpur | 94 |
| | Araria | 17 | | Guna | 93 |
| | Begusarai | 16 | | Khandwa | 85 |
| | Gaya | 16 | | Rajgarh | 57 |
| | Nawada | 15 | Orissa | Kandhmal | 385 |
| | Banka | 15 | | Malkangiri | 371 |
| | Khagaria | 13 | | Nuapada | 325 |
| | Sitamarhi | 9 | | Nabrangpur | 189 |
| | Muzaffarpur | 7 | | Kalahandi | 186 |
| Chhattisgarh | Kondagaon | 223 | | Raygada | 176 |
| | Narayanpur | 180 | | Koraput | 164 |
| | Bijapur | 153 | | Gajapati | 164 |
| | Kanker | 152 | | Balangir | 101 |
| | Rajnandgaon | 146 | | Dhenkanal | 79 |
| | Dantewada | 132 | Rajasthan | Sirohi | 178 |
| | Mahasamund | 106 | | Dholpur | 133 |
| | Sukma | 101 | | Karauli | 94 |
| | Bastar | 97 | | Baran | 93 |
| | Korba | 26 | | Jaisalmer | 17 |
| Jharkhand | Khunti | 266 | Uttar Pradesh | Shrawasti | 286 |
| | Gumla | 231 | | Chitrakoot | 148 |
| | Pakur | 179 | | Sonbhadra | 146 |
| | Lohardaga | 171 | | Chandauli | 103 |
| | West Singhbhum | 159 | | Siddharthnagar | 94 |
| | Dumka | 146 | | Fatehpur | 80 |
| | Latehar | 127 | | Bahraich | 77 |
| | Hazaribagh | 121 | | Balrampur | 73 |
| | Godda | 110 | Uttarakhand | Haridwar | 199 |
| | Ranchi | 107 | | UdhamSinghNagar | 77 |
| | Sahibganj | 107 | | | |
| | Ramgarh | 105 | | | |
| | Simdega | 101 | | | |
| | Palamu | 97 | | | |
| | Giridih | 95 | | | |
| | Garhwa | 76 | | | |
| | Purbi Singhbhum | 57 | | | |
| | Chatra | 52 | | | |
| | Bokaro | 40 | | | |

## 2. Review of Literature

Vora etal (2009) points out to the chronic level of underfunding of the health ministry since the last 4 decades. The Govt spending on health is one of the lowest in the world, amounting to less than 1% on total health services by both the Central and State Governments spending. The country cannot strive to improve its health system only based on donor's support. "Compounding this low level of funding, the financial systems of the Indian Government are highly bureaucratic, slow, and procedure-oriented, resulting in non-availability of funds at peripheral locations where needed even when money is centrally available, remaining unused funds, and hence funds are lapsed after the financial year is over". With the launch of NHM, the Government has been trying to streamline the funding process. Most of the Indian states bear testimony of severe shortage of funds because of reluctance of collecting taxes and unplanned expenditure of the Government which have hugely affected maternal health.

Despite numerous multi-pronged central and state policies formulated, Deka (2014) points out that maternal health scenario still remains to be threatened with high rates of maternal mortality and lack of efficient nutrition provision to pregnant women in Odisha. Promoting institutional deliveries remains the cause of concern as the high rates of maternal deaths are attributed to paucity of trained and skilled birth attendants which leads to low institutional delivery rates. Major part of the debate on women's reproductive health care needs has from its earliest time emphasized the role of maternal health underpinning to population control policies and the family planning targets achievement. What it currently attributes to as a potential paradigm shift from family planning stated targets to use of modern terminology like "Expected Level of Achievement" (ELA), is nothing but mimicking the older family planning monitoring targets revolving around unmet demand and contraceptive usage. The Trained Birth Assistants further work under the camouflage of meeting reproductive needs by encouraging family planning among the couples. Lastly, there exists a substantial lack of understanding of knowledge of health services among the people partly due to lack of trained health personnel. (Hathi & Srivastava, 2020).

Sinha (2015) points out that the increment in the extent of antenatal care (ANC) services did not match the same coverage as that of delivery services. The percentage of women making ANC visits three or more times (as recommended) has gone up from 52% to only 63% and a similar percentage of women has reported having an ANC in the first trimester. Therefore, a third of pregnant women in the country are still not even getting the basic recommended ANC". Pointing to the lack of one-sided focus towards promoting institutional deliveries, required interventions for other aspects such as ANC services were lacking. In case of postnatal care (PNC) even less than half of the women were getting the needed services within 48 hours after delivery which constitutes a critical period to avert maternal mortality.

Concerns have been raised relating to healthcare quality in the health facilities and degree of affordability of services in all health care facilities. Studies have pointed out that although ANC and institutional delivery has increased manifold in public facilities after the launch of Janani Suraksha Yojana (JSY) in Bihar, utilization of complete maternal services have not

risen at the same pace in both public and private health care facilities. The lack of complete maternal care has risen questions about the care continuum of maternal healthcare services. It leaves to underscore the concerted need for recognition of JSY in the future. Specifically, the programme priority under the JSY should with regards to increasing institutional delivery in public facilities, must be strengthened further along with ensuring continuity of care.

Measuring efficiency in utilization of resources in the health sector has been globally recognized. A WHO framework for health system performance (Christopher & Julio, 1999) has been extensively used to unravel the nature of accountability for health systems. By the level of assessment of health-system goals achievement, countries or regions are brought to highlight how much each have progressed in improving health, and in reduction of health inequalities, through developing a responsible framework and ensuring accountability of financing. Secondly, on a relative standpoint it seeks to assess how well a country has been able to progress after controlling for the non-health system factors and whether efficiency of a good health care system can have a positive influence over other factors through inter-sectoral interventions.

In health sector, efficiency is to ensure available resources are utilized in a way to warrant population is as healthy as possible. The process of attainment value for money or acting with minimum expense, waste or effort is understood as efficiency. In production function process, firstly transforming input into output; secondly, costs of resources used are taken into consideration; and thirdly, those are compared with the value of output produced (Mills & Gilson, 1988).
Efficiency as a concept defines a process of allocating resources or inputs to yield the maximum possible output or about performing operations in optimal way (Martinez-Giralt, 2010). It is the ratio of total output to input. There are two major types of efficiency, namely: allocative efficiency and technical efficiency. Allocative efficiency refers to allocations of resources yielding the maximum possible output. Allocative efficiency occurs when goods and services are distributed according to consumer preferences. An economy could be productively efficient but produce goods people don't need; which would be allocative inefficient.

Technical efficiency is the effectiveness with which a given set of inputs is used to produce an output. Technical efficiency means the ability of a production unit or decision making unit (DMU) to achieve maximum output with the given level of input or minimum amount of resources used with the given level of output (Akazili et al., 2008a; Obure et al., 2016). An organization is technically efficient if it is producing the maximum output from the minimum quantity of inputs, such as labor, capital and technology. The technical efficiency scores can be decomposed into pure technical efficiency and scale efficiency to determine the main source of the technical efficiency (Abel, S & Bara, A. 2017). Pure technical efficiency refers to producing a maximum amount of output from a given amount of input or alternatively, producing a given output with minimum input quality (Farrell, 1957); and on the other hand scale efficiency refers to the relationship between the level of output and the average cost hence it relates to the size of operation in the organization. (Achoki et al., 2017).

Hollingsworth & Wildman (2003) had re-estimated the WHO panel data to examine the performance of health systems across the world. They urge to broaden the techniques of efficiency assessment as the contextual factors may get hidden in order to create a league table of good and bad performers.

Evans et al. (2001) note that efficiency is closely related to per capita health expenditure as it was indeed quite difficult for countries to be tagged as good performers if they had per capita expenditure beyond a certain level which implies for an optimum bare minimum health expenditure levels below which the health system gets jeopardized into host of institutional problems. Given the fact that there is substantial variation in efficiency at different health expenditure levels, there could be two critical pathways to improve health system efficiency, one direction would be to move towards the frontier and the second is to follow the expansion path as suggested in the World Health Report by increasing health expenditures.

Using Data Envelopment Analysis Approach, De. et al (2012) points to manpower and health infrastructure inadequacy in the EAG states like Bihar, Uttar Pradesh, Madhya Pradesh, Orissa, Odisha and Rajasthan. On the other hand, health outcomes stand at much better position for the southern states: Kerala, Tamil Nadu, Karnataka and Andhra Pradesh as well as for Punjab, Maharashtra and West Bengal. Some of the health outcomes such as female life expectancy and child survival rate have been reportedly functioning poorly in these states. Primarily these states also fit into the poor resource regions essentially housing the largest number of poor. Therefore, they point out that the health policy system should be synergistic to maximize resource utilization and divert resources and spending on the states where the health outcomes are poor by providing more infrastructure and establishing manpower.

Using Data Envelopment Analysis at sub-state level of Bihar, Purohit (2017) finds that there exists inefficient utilization of various health inputs despite substantial funds flowing from the NHM to tackle optimum utilization of the poor performing districts. On average, some of the districts have reported poor efficiency in the utilization of inputs such as beds, doctors, and workload for each facility. Whereas some districts are still lagging behind in terms of certain inputs; by addressing these inadequacies, the non-efficient input system can be strengthened to enhance overall efficiency and outputs.

Health systems in developing countries are faced with critical resource constraints in pursuing the goal of improving the health status of the population (Akazili et al., 2008). The efficient utilization of existing financial, infrastructural and human resources becomes crucial for strengthening the healthcare delivery in the country. The assessment of efficiency of health facilities can thus guide decision makers in ensuring the optimum utilization of the available resources. (Akazili et al., 2008)

## 3. Rationale for the study

Scarcity of resources for healthcare is a well acknowledged problem. There are large inter-district variations in India due to which it is essential to have decentralized district-based health planning. The health inadequacies observed in the aspirational districts of India has garnered serious policy interventions over the last few years. There have been increased efforts to upscale the overall health outputs in these districts. However, a change of narrative from unavailability and inaccessibility of healthcare services in these districts to equitable access and availability will require significantly greater efforts. EAG states in India have been recognized to be laden with relatively poorer health scenarios. Aspirational Districts within the EAG states, in a way, present a dual vulnerability and hence twice as big a reason to intervene and address the inefficiencies at hand.

The present study aims to highlight the crucial factors of Maternal Health Care in the aspirational districts of the EAG states in India. Measuring the efficacy of services at the district level with regards to the interplay of various input variables, we will try to ascertain an efficiency score specific to Maternal Health Care Provision in these districts. The study is crucial to understanding the relationship between the health utilizations (such as personnel, capital and equipment) and the health outcomes in the studies aspirational districts.

The present study also finds its relevance in light of how important can understanding of efficiency serve in low resource settings. The EAG states have been socio-economically backward and the further deprivations of the aspirational districts, only mount up the pre-existing vulnerabilities. Given that accelerating the development of Maternal Health Care is crucial to the development of health, economic as well as social status of any state or district or community in general, the present study explores the health inefficiencies specific to Maternal Health in the study area. The study aims to provide strategies which are more attuned to the specific needs of Maternal Health Care in the aspirational districts of the EAG states in India.

The choice of Institutional Delivery as the output variable to be studied emerges from the fact that institutional delivery enables of the holistic care with respect to maternal health and further facilitates low mortality and morbidity scenarios, for both, the mother and the child. The first input, that is, the number of women who availed full ANC Check-up, or, the number of women who availed at least 4 ANC visits during her pregnancy, is crucial to understanding the service efficiency aspect of the output to be studied. Pattern of Full ANC Check-up majorly explains the variations in the pattern of Institutional deliveries given that the former is a key enabler for ensuring the latter. The second and third inputs, that is, the number of ASHAs and ANMs positioned and the total number of health facilities, account for two of the most crucial inputs while studying any health care system – Manpower and Infrastructure. The ideal availability of both is crucial to strengthening the overall health outputs in any setting. It is key to reflect on the component of efficiency to strengthen the advocacy of maternal health care refinement in the aspirational districts of the EAG states in India.

## 4. Data and Methodology

The present research aims to measure the technical efficiency with regards to 'Institutional Deliveries'- a crucial factor significantly representative of maternal health status – in the aspirational districts of the EAG states in India. The study uses a set of input and output variables to measure the said efficiency of maternal health status in these regions. These are summarized in the table below:

| | | |
|---|---|---|
| **Output Variable** | **Institutional Delivery** *(desirable output)* | Number of deliveries conducted in a health facility. |
| **Input Variables** | **Full ANC Check-ups** *(service indicator)* | Number of women who received 4 or more ANC checkups during pregnancy. |
| | **Total no. of ASHAs and ANMs** *(manpower indicator)* | Total number of ASHAs and ANMs positioned in the district. |
| | **Total Health Facilities** *(infrastructure indicator)* | Number of DHs, SDHs, CHCs, PHCs and SCs in the district. |

### 4.1. Data Source

Data for the present study has been sourced from Health Management Information System (HMIS) for the year 2018-19. Of the total 117 Aspirational Districts in India identified by the NITI Aayog, Seventy-five (64%) of these Aspirational Districts belong to the EAG states of India. The aspirational districts from the EAG states included in the present study are tabulated as below:

**Table 2: List of Aspirational Districts, EAG States, included in the Study**

| EAG States | | Aspirational Districts |
|---|---|---|
| **Bihar** | **13** | Araria, Aurangabad, Banka, Begusarai, Gaya, Jamui, Katihar, Khagaria, Muzaffarpur, Nawada, Purnia, Sheikhpura, Sitamarhi |
| **Chhattisgarh** | **10** | Bastar, Bijapur, Dantewada, Kanker, Kondagaon, Korba, Mahasamund, Narayanpur, Rajnandgaon, Sukma |
| **Jharkhand** | **19** | Bokaro, Chatra, Dumka, Garhwa, Giridih, Godda, Gumla, Hazaribagh, Khunti, Latehar, Lohardaga, Pakur, Palamu, Purbi Singhbhum, Ramgarh, Ranchi, Sahibganj, Simdega, West Singhbhum |
| **Madhya Pradesh** | **8** | Barwani, Chhatarpur, Damoh, Guna, Khandwa, Rajgarh, Singrauli, Vidisha |
| **Odisha** | **10** | Balangir, Dhenkanal, Gajapati, Kalahandi, Kandhmal, Koraput, Malkangiri, Nabrangpur, Nuapada, Raygada |
| **Rajasthan** | **5** | Baran, Dholpur, Jaisalmer, Karauli, Sirohi |
| **Uttar Pradesh** | **8** | Bahraich, Balrampur, Chandauli, Chitrakoot, Fatehpur, Shrawasti, Siddharth Nagar, Sonbhadra |
| **Uttarakhand** | **2** | Hardwar, Udham Singh Nagar |

### 4.2. Data analysis

This study employed an output-oriented Data Envelopment Approach (DEA) method. Much like the stochastic production frontiers, DEA estimates the maximum potential output for a given set of inputs, and has extensively been used in the estimation of efficiency towards many studies in the domain of public health. The technique has been rigorously applied by key stakeholders in healthcare to ascertain efficient input-output matrices. It gives a finer and more detailed overview when compared to a simplistic rank analysis.

In the present study, the DEA method included 1 output variable and 3 input variables for 45 Decision Making Units (DMUs), which in the scope of our study, are the Aspirational Districts of the EAG States in India. Using output-orientation and VRS approach, the DEA model was run to compute the Overall Technical Efficiency (OTE), Pure Technical Efficiency (PTE) and Scale Efficiency (SE). The results were obtained using R programming Language Version 4.0.2.

A number of DEA models have been designed that measure the efficiency in varying manners. However, these can be largely categorized into either input-oriented or output-oriented models. The input-oriented DEA, is a linear programming model configured in a manner to determine the level of input that can be reduced by the DMUs so as to still achieve the same output levels. In public health studies, unless the scope of the study is to reduce costs or reduce the level of some undesirable output say Infant Mortality Rate, etc,, the input-oriented DEA approach is seldom used. In contrast, the output-oriented DEA, is a linear programme configuration, which measures that if a DMU were to operate efficiently, i.e.,

similar to the DMUs on the efficiency frontier, what can be its potential output levels given the level of inputs.

For the present study, the output-orientation approach was thus preferred as the study aims to ascertain the how the output – Institutional Deliveries- can be maximized or made efficient in light of the given levels of input variables – Full ANC check-ups, HR, and Health Infrastructure – suggesting nay reduction in which, would not be ideal.

Another important variation in the application of DEA model comes with respect to scale assumptions. DEA method generally employs two scale assumptions, i.e., Constant Returns to Scale (CRS) and Variable Returns to Scale (VRS). While CRS assumes that the proportion of change in both, inputs and outputs would be the same, VRS reflects that the DMUs may exhibit constant, increasing or decreasing returns to scale. For the present study, the assumption of CRS would have been definitely wrongful and there are a priori reasons to assume that health systems across various districts would not each exhibit constant returns to scale. Therefore, the assumption of VRS is retained for the present study.

Once the input and output variables for all DMUs are specified, DEA method calculates efficiencies which can be defined as a weighted sum of total outputs divided by a weighted sum of total inputs. It must be noted here that DEA only measures relative efficiencies, i.e., efficiencies relative to the data considered. These efficiencies are restricted to lie between 0 and 1, wherein, an efficiency score of 1.00 or 100.00% will indicate that the DMUs are efficient and an efficiency score of less than 1.00 or 100.00% shall indicate that the DMUs are inefficient. The method also describes pathways for the inefficient DMUs to achieve the efficient frontier by either reducing their inputs whilst keeping their output constant; or increasing their outputs whilst keeping their inputs constant; or apply some combination of both.

DMUs lying on the efficient frontier, i.e. those with the efficiency score of 1 do not simply imply that their performance cannot be improved upon any further. While it may or may not be possible to do that, an efficiency score of 1 speaks strictly in terms of data available only. Further, for the inefficient DMUs, the efficiencies are usually taken as indicative of the fact that other efficient DMUs are adopting practices and procedures which, if inefficient DMUs were to adopt, it would enable them to improve their performance.

The concept of peer groups or reference set also emerges in the application of DEA method. The reference set or peers for any DMU with less than 100% efficiency consists of those DMUs with 100% efficiency to which it is most directly comparable. Broadly put, this implies that the DMUs in the reference set/peer groups have a close to "similar" mix of inputs and output. Thus, DEA species a point on the efficient frontier for each inefficient DMU such that, were these DMUs to exist at that point on the frontier, they would have the same input-output mix as their specified efficient DMU peer and would have an efficiency of 100%.

The Linear Programming of output orientation is given below:

The objective of the output-oriented model is maximizing output at the same level of inputs. Let $\Upsilon_j$ = $(y_{1j} \dots \dots y_{rj}) \geq 0$ and $\chi_j$ = $(x_{1j} \dots \dots x_{ij})$ = (x1j…..xij) ≥ 0, j = 1, 2, …,75. The efficiency score for the aspirational district $j_o$ , which is the reciprocal of the inefficiency, θ is obtained by solving the following linear programming.

***Maximize θ***

Subject to:

$$\sum_{j=1}^{75} \partial_j x_{ij} \leq x_{ijo} \, \forall_i = 1,2$$

$$\sum_{j=1}^{75} \partial_j y_{rj} \leq \theta y_{rjo} \, \forall_r = 1,2$$

$$\sum \partial_j = 1$$

where, $\partial_j \geq 0, j = 1, 2,3 \dots \dots . j_o..75$

## 5. Data and Methodology

**Table 3** presents the details of the inputs and output variables included in the study. Huge variations can be observed with regards to each study variable. The table can be pursued by understanding the relationship between two important variables; i) institutional deliveries, and ii) total full ANC check-ups. The average percentage of institutional deliveries to total ANC checkups in Bihar, Chhattisgarh, Jharkhand, Madhya Pradesh, Odisha, Rajasthan, Uttar Pradesh and Uttarakhand for the year 2018-19 was 74, 88, 94, 88, 101, 156, 75 and 111 percent, respectively. Clearly, the aspirational districts of Rajasthan perform significantly better in terms of Institutional deliveries and ANC routine than the aspirational districts of other EAG states. The lowest performing states in this regard were Bihar, Chhattisgarh, and Madhya Pradesh, where, the average percentage of institutional deliveries to total ANC checkups in the aspirational districts of these states was recorded at below 90 percent. The districts of Aurangabad (57%) and Sonbhadara (58%) recorded the lowest percentage of institutional deliveries to total ANC checkups during the study period. Overall, a review of the aspirational districts reveals that 22 districts recorded percentage of institutional deliveries to total ANC checkups at 100 or more percentage; 31 districts recorded the said percentage in the range of 80 – 99 percent. For 20 the percentage of institutional deliveries to total ANC checkups was recorded between 60 – 80 percent and for 2 districts, namely Aurangabad (Bihar) and Sonbhadra (Uttar Pradesh), the said percentage stood at 57 percent. The bottom 5 performing districts in this regard include 2 districts from Uttar Pradesh, 2 districts from Bihar and 1 district from Chhattisgarh. In this respect, among the best performing set of the top 5 aspirational districts, four out of these five districts belong to the state of Rajasthan.

**Table 4** summarizes the descriptive statistics for the input and output variables included in the study. The number of Institutional Deliveries (IDs) in the aspirational districts range from 2428 IDs in Narayanpur, Chhattisgarh to 78790 IDs in Purnia, Bihar. On an average, the aspirational districts included in the study sample recorded 28,909 (SD: 16304) Institutional Deliveries in the year 2018-19. The number of pregnant women who received full Antenatal Care ranges from 2433 women in Narayanpur, Chhattisgarh to 99164 women in Muzzafarpur, Bihar, during the said year. The number of ASHAs and ANMs positioned in the aspirational districts is lowest (33) for the district of Muzzafarpur, Bihar and highest (696) for Gaya, Bihar. With respect to the Total Number of Health Facilities, the district of Ramgarh, Jharkhand reported the minimum number of health facilities at 63 and Muzzafarpur, Bihar had the health infrastructure of 605 health facilities as per the data reported on the HMIS portal. The total number of health facilities in the district include a sum total of District Hospitals (DHs), Community Health Centres (CHCs), Primary Care Centers (PHCs), and Sub-Health Centers(SCs).

**Table 3: Details of Inputs and Output Variables of Maternal Health for the Aspirational Districts of the EAG states in India, 2018-19**

| State | Aspirational Districts | Institutional Deliveries | Full ANC Check-ups | Health Workers (ANMs & ASHAs) | Health Facilities |
|---|---|---|---|---|---|
| **Bihar** | **Araria** | 55188 | 68635 | 289 | 270 |
| | **Aurangabad** | 32666 | 57082 | 275 | 324 |
| | **Banka** | 35935 | 43671 | 361 | 297 |
| | **Begusarai** | 51816 | 85900 | 397 | 340 |
| | **Gaya** | 51775 | 80662 | 696 | 567 |
| | **Jamui** | 33312 | 33137 | 309 | 277 |
| | **Katihar** | 65012 | 80065 | 369 | 407 |
| | **Khagaria** | 37790 | 47756 | 228 | 222 |
| | **Muzaffarpur** | 70357 | 99164 | 33 | 605 |
| | **Nawada** | 32055 | 40241 | 187 | 227 |
| | **Purnia** | 78790 | 82649 | 361 | 533 |
| | **Sheikhpura** | 14105 | 21971 | 166 | 131 |
| | **Sitamarhi** | 51476 | 78880 | 174 | 267 |
| **Chhattisgarh** | **Bastar** | 18508 | 18731 | 357 | 292 |
| | **Bijapur** | 4692 | 6656 | 118 | 91 |
| | **Dantewada** | 5755 | 8097 | 103 | 94 |
| | **Kondagaon** | 10488 | 11093 | 189 | 202 |
| | **Korba** | 22981 | 31114 | 227 | 331 |
| | **Mahasamund** | 17913 | 19927 | 261 | 265 |
| | **Narayanpur** | 2428 | 2433 | 70 | 73 |
| | **Rajnandgaon** | 33629 | 31617 | 378 | 394 |
| | **Sukma** | 4000 | 6479 | 88 | 107 |
| | **Kanker** | 10675 | 13146 | 331 | 292 |
| **Jharkhand** | **Bokaro** | 46114 | 44859 | 159 | 144 |
| | **Chatra** | 22042 | 27048 | 116 | 107 |
| | **Dumka** | 27499 | 34107 | 501 | 263 |
| | **Garhwa** | 31069 | 30754 | 135 | 131 |
| | **Giridh** | 42409 | 45234 | 185 | 211 |
| | **Godda** | 31837 | 34182 | 282 | 202 |

| | | | | | |
|---|---|---|---|---|---|
| | **Gumla** | 17355 | 15873 | 349 | 254 |
| | **Hazaribagh** | 35417 | 33933 | 261 | 169 |
| | **Khunti** | 9970 | 10974 | 205 | 123 |
| | **Latehar** | 16500 | 16928 | 172 | 112 |
| | **Lohardaga** | 11070 | 15579 | 138 | 88 |
| | **Pakur** | 19187 | 28632 | 74 | 135 |
| | **Palamu** | 46028 | 47938 | 235 | 202 |
| | **Purbi Singhbhum** | 38605 | 51310 | 369 | 269 |
| | **Ramgarh** | 15732 | 18898 | 88 | 63 |
| | **Ranchi** | 66340 | 62563 | 536 | 342 |
| | **Sahebganj** | 30396 | 24508 | 196 | 158 |
| | **Simdega** | 11478 | 12842 | 202 | 172 |
| | **West Singhbhum** | 33239 | 34515 | 436 | 374 |
| **Madhya Pradesh** | **Barwani** | 29873 | 37783 | 413 | 401 |
| | **Chhatarpur** | 38740 | 40531 | 248 | 304 |
| | **Damoh** | 24331 | 25717 | 255 | 217 |
| | **Guna** | 26612 | 28055 | 196 | 206 |
| | **Khandwa** | 24790 | 28003 | 238 | 245 |
| | **Rajgarh** | 24068 | 32027 | 193 | 274 |
| | **Singrauli** | 27512 | 26918 | 211 | 250 |
| | **Vidisha** | 24002 | 30849 | 216 | 245 |
| **Odisha** | **Balangir** | 30008 | 22116 | 297 | 292 |
| | **Dhenkanal** | 13827 | 15276 | 219 | 218 |
| | **Gajapati** | 7786 | 7787 | 185 | 167 |
| | **Kalahandi** | 20073 | 22641 | 406 | 307 |
| | **Kandhmal** | 12445 | 11675 | 233 | 228 |
| | **Koraput** | 24596 | 26807 | 379 | 377 |
| | **Malkangiri** | 11747 | 11904 | 189 | 194 |
| | **Nabrangpur** | 24140 | 25643 | 400 | 342 |
| | **Nuapada** | 12669 | 11093 | 141 | 119 |
| | **Raygada** | 18550 | 19023 | 294 | 288 |
| **Rajasthan** | **Baran** | 22655 | 17500 | 278 | 328 |
| | **Dholpur** | 29219 | 19028 | 292 | 267 |
| | **Jaisalmer** | 16665 | 8918 | 165 | 191 |
| | **Karauli** | 29505 | 19860 | 366 | 325 |
| | **Sirohi** | 26137 | 14209 | 250 | 262 |
| **Uttar Pradesh** | **Bahraich** | 67694 | 87533 | 317 | 375 |
| | **Balrampur** | 35509 | 58052 | 237 | 254 |
| | **Chandauli** | 33585 | 49116 | 295 | 344 |
| | **Chitrakoot** | 19277 | 19333 | 133 | 168 |
| | **Fatehpur** | 42161 | 54092 | 387 | 390 |
| | **Shrawasti** | 28109 | 32991 | 156 | 144 |
| | **Siddharth Nagar** | 43941 | 50633 | 356 | 400 |
| | **Sonbhadra** | 28910 | 49613 | 220 | 240 |
| **Uttarakhand** | **Haridwar** | 29450 | 27282 | 182 | 205 |
| | **Udham Singh Nagar** | 25986 | 22569 | 116 | 195 |

**Table 4: Descriptive statistics for input and output variables included in the study**

| Indicators | Mean | SD | Min | Max |
|---|---|---|---|---|
| **Institutional Delivery** | 28909 | 16304 | 2428 | 78790 |
| **Full ANC** | 33525 | 22182 | 2433 | 99164 |
| **Total Number of ASHAs and ANMs** | 254 | 118 | 33 | 696 |
| **Total number of Public Health Facilities** | 252 | 110 | 63 | 605 |

**Figure 3** presents the correlation between the input and output variables. The application of the DEA model necessitates that while a certain level of a relationship between the input and output variables indicates suitability; there must not exist a very high correlation between the input variables employed in the analysis. The correlation between 4 ANC checkups (Input 1) with Total number of ASHAs and ANMs (Input 2) is 0.37 and Total number of Public Health Facilities (Input 3) is 0.66. The correlation for Input 2 and Input 3 is measured at 0.68. Thus, a very strong correlation between the input variables does not exist thereby ascertaining the suitability of the choice of input variables.

**Table 5** summarizes the TE scores for the 75 aspirational district included in the study. A score of 1.0 is considered to be efficient, thus implying that the district lies on the efficiency frontier, while any scores below 1.0 indicate inefficiency which implies that the respective districts are operating below the efficient frontier. 12 (16%) of the 75 aspirational districts in the EAG states on the country had efficient maternal healthcare systems, ascertained by the fact that the efficiency score obtained by these districts was 1. Overall, among the 8 EAG states, Bihar, Chhattisgarh, Jharkhand, Rajasthan, Uttar Pradesh, and Uttarakhand recorded 2, 1, 5, 2, 1, and 1 efficient aspirational districts respectively, with regards to maternal healthcare system within the given input-output matrix. The mean scores of pure Technical Efficiency and Scale Efficiency for the aspirational districts were 0.77 (SD: 0.15) and 0.91 (SD: 0.08), respectively.

The **technically inefficient aspirational districts** recorded an average TE score of 0.72 (SD: 0.13). This finding implies that these 63 **inefficient aspirational districts** could potentially reduce their current input levels by 28% while leaving their output levels unchanged. In other words, these 63 technically inefficient aspirational districts could, on an average, produce 28% more outputs by utilizing the current levels of inputs. Further, eight (12%) aspirational districts (Muzzafarpur, Bokaro, Sahebganj, Guna, Kandhmal, Jaisalmer, Sirohi, Udham Singh Nagar) recorded a **Scale Efficiency** of 1, implying thereby that they were operating on the most productive scale for the given levels of input and outputs. The remaining 68 aspirational districts (90%) were found to be scale inefficient, administering an average scale efficiency of 0.91 (SD 0.08). This implies that, on an average, the scale-inefficient aspirational districts could reduce their overall input size by 9% without affecting their current output levels, i.e., Institutional deliveries. Out of the 68 scale-inefficient aspirational districts, 20 districts (29%) manifested increasing returns to scale (IRS) and 39 (57%) revealed decreasing returns to scale (DRS). These findings reveal that 29% of scale-inefficient aspirational districts in the EAG states of India are too small for their operations, i.e., they require more input in terms of full ANC checkups, frontline workers and health infrastructure; and to operate at their optimal scale, these districts need to expand their scale of operations with regards to the institutional deliveries conducted.

**Figure 3: Correlations between study variables**

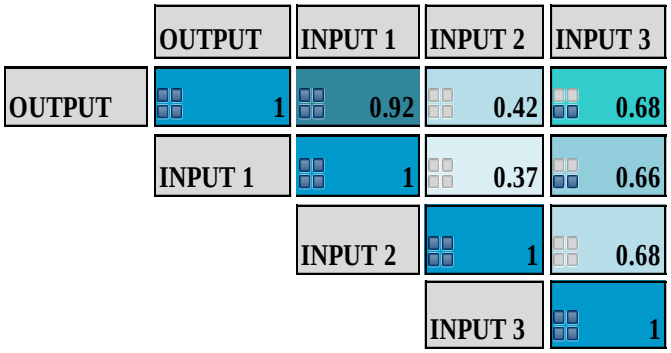


**Table 5: Output Oriented Efficiency Scores of VRS Approach**

| State | DMUs (Aspirational Districts) | Efficiency Scores | | | Returns to Scale |
|---|---|---|---|---|---|
| | | OTE | PTE | SE | |
| **Bihar** | **Muzaffarpur** | **1** | **1** | **1** | **-** |
| **Bihar** | **Purnia** | 0.873 | **1** | 0.873 | DRS |
| **Bihar** | **Araria** | 0.754 | 0.948 | 0.795 | DRS |
| **Bihar** | **Sitamarhi** | 0.83 | 0.942 | 0.881 | DRS |
| **Bihar** | **Katihar** | 0.741 | 0.929 | 0.798 | DRS |
| **Bihar** | **Jamui** | 0.756 | 0.815 | 0.927 | DRS |
| **Bihar** | **Begusarai** | 0.56 | 0.795 | 0.704 | DRS |
| **Bihar** | **Khagaria** | 0.719 | 0.759 | 0.948 | DRS |
| **Bihar** | **Nawada** | 0.723 | 0.737 | 0.98 | DRS |
| **Bihar** | **Banka** | 0.654 | 0.726 | 0.901 | DRS |
| **Bihar** | **Gaya** | 0.506 | 0.668 | 0.757 | DRS |
| **Bihar** | **Aurangabad** | 0.515 | 0.565 | 0.912 | DRS |
| **Bihar** | **Sheikhpura** | 0.531 | 0.555 | 0.957 | IRS |
| **Chhattisgarh** | **Narayanpur** | 0.534 | **1** | 0.534 | IRS |
| **Chhattisgarh** | **Sukma** | 0.702 | 0.828 | 0.848 | DRS |
| **Chhattisgarh** | **Bastar** | 0.582 | 0.619 | 0.941 | DRS |
| **Chhattisgarh** | **Mahasamund** | 0.581 | 0.607 | 0.958 | DRS |
| **Chhattisgarh** | **Dantewada** | 0.474 | 0.604 | 0.785 | IRS |
| **Chhattisgarh** | **Bijapur** | 0.44 | 0.595 | 0.74 | IRS |
| **Chhattisgarh** | **Rajnandgaon** | 0.572 | 0.588 | 0.972 | DRS |
| **Chhattisgarh** | **Korba** | 0.523 | 0.538 | 0.972 | IRS |
| **Chhattisgarh** | **Uttar Bastar Kanker** | 0.382 | 0.507 | 0.753 | IRS |
| **Chhattisgarh** | **Kondagaon** | 0.435 | 0.44 | 0.986 | DRS |
| **Jharkhand** | **Bokaro** | **1** | **1** | **1** | **-** |
| **Jharkhand** | **Pakur** | 0.718 | **1** | 0.718 | IRS |
| **Jharkhand** | **Ramgarh** | 0.803 | **1** | 0.803 | IRS |
| **Jharkhand** | **Ranchi** | 0.902 | **1** | 0.902 | DRS |
| **Jharkhand** | **Sahebganj** | **1** | **1** | **1** | **-** |
| **Jharkhand** | **Garhwa** | 0.937 | 0.965 | 0.971 | IRS |
| **Jharkhand** | **Hazaribagh** | 0.912 | 0.924 | 0.988 | DRS |
| **Jharkhand** | **Palamu** | 0.878 | 0.922 | 0.953 | DRS |
| **Jharkhand** | **Giridh** | 0.879 | 0.901 | 0.975 | DRS |
| **Jharkhand** | **Latehar** | 0.781 | 0.866 | 0.902 | IRS |
| **Jharkhand** | **Chatra** | 0.762 | 0.826 | 0.922 | IRS |
| **Jharkhand** | **Godda** | 0.773 | 0.802 | 0.964 | DRS |
| **Jharkhand** | **West Singhbhum** | 0.66 | 0.773 | 0.854 | DRS |
| **Jharkhand** | **Lohardaga** | 0.598 | 0.718 | 0.833 | IRS |
| **Jharkhand** | **Purbi Singhbhum** | 0.648 | 0.702 | 0.923 | DRS |
| **Jharkhand** | **Khunti** | 0.615 | 0.694 | 0.885 | IRS |
| **Jharkhand** | **Dumka** | 0.619 | 0.66 | 0.937 | DRS |
| **Jharkhand** | **Gumla** | 0.637 | 0.639 | 0.996 | DRS |
| **Jharkhand** | **Simdega** | 0.563 | 0.591 | 0.953 | IRS |
| **Madhya Pradesh** | **Chhatarpur** | 0.804 | 0.856 | 0.939 | DRS |
| **Madhya Pradesh** | **Singrauli** | 0.794 | 0.801 | 0.991 | DRS |
| **Madhya Pradesh** | **Guna** | 0.771 | 0.771 | **1** | - |
| **Madhya Pradesh** | **Damoh** | 0.706 | 0.724 | 0.976 | DRS |
| **Madhya Pradesh** | **Khandwa** | 0.673 | 0.692 | 0.972 | DRS |
| **Madhya Pradesh** | **Barwani** | 0.55 | 0.653 | 0.842 | DRS |
| **Madhya Pradesh** | **Vidisha** | 0.629 | 0.642 | 0.98 | DRS |

| | | | | | |
|---|---|---|---|---|---|
| **Madhya Pradesh** | **Rajgarh** | 0.63 | 0.641 | 0.982 | DRS |
| **Orissa** | **Balangir** | 0.86 | 0.917 | 0.937 | DRS |
| **Orissa** | **Nuapada** | 0.785 | 0.891 | 0.881 | IRS |
| **Orissa** | **Nabrangpur** | 0.594 | 0.677 | 0.877 | DRS |
| **Orissa** | **Koraput** | 0.566 | 0.672 | 0.843 | DRS |
| **Orissa** | **Raygada** | 0.582 | 0.615 | 0.946 | DRS |
| **Orissa** | **Kalahandi** | 0.556 | 0.606 | 0.918 | DRS |
| **Orissa** | **Malkangiri** | 0.57 | 0.592 | 0.962 | IRS |
| **Orissa** | **Kandhmal** | 0.576 | 0.576 | **1** | - |
| **Orissa** | **Dhenkanal** | 0.555 | 0.561 | 0.989 | IRS |
| **Orissa** | **Gajapati** | 0.535 | 0.558 | 0.959 | IRS |
| **Rajasthan** | **Jaisalmer** | **1** | **1** | **1** | **-** |
| **Rajasthan** | **Sirohi** | **1** | **1** | **1** | **-** |
| **Rajasthan** | **Dholpur** | 0.948 | 0.972 | 0.975 | DRS |
| **Rajasthan** | **Karauli** | 0.856 | 0.957 | 0.894 | DRS |
| **Rajasthan** | **Baran** | 0.742 | 0.785 | 0.945 | DRS |
| **Uttar Pradesh** | **Bahraich** | 0.748 | **1** | 0.748 | DRS |
| **Uttar Pradesh** | **Chitrakoot** | 0.806 | 0.828 | 0.974 | IRS |
| **Uttar Pradesh** | **Siddharth Nagar** | 0.702 | 0.801 | 0.876 | DRS |
| **Uttar Pradesh** | **Shrawasti** | 0.78 | 0.79 | 0.987 | IRS |
| **Uttar Pradesh** | **Fatehpur** | 0.63 | 0.729 | 0.865 | DRS |
| **Uttar Pradesh** | **Chandauli** | 0.58 | 0.64 | 0.906 | DRS |
| **Uttar Pradesh** | **Balrampur** | 0.575 | 0.636 | 0.904 | DRS |
| **Uttar Pradesh** | **Sonbhadra** | 0.537 | 0.566 | 0.949 | DRS |
| **Uttarakhand** | **Udham Singh Nagar** | **1** | **1** | **1** | **-** |
| **Uttarakhand** | **Haridwar** | 0.888 | 0.888 | 0.999 | DRS |

*OTE: Overall Technical Efficiency as from CRS DEA;*
*PTE: Pure Technical Efficiency from VRS DEA;*
*SE=scale efficiency;*
*IRS=increasing returns to scale; DRS=decreasing returns to scale*

- **BIHAR:** Bihar recorded an average technical efficiency of 0.81 (SD: 0.15) and an average scale efficiency of 0.88 (SD: 0.09). This implies that, among the 11 technically inefficient aspirational districts in Bihar, on an average, 12% more output could be produced by utilizing the current levels of inputs. Two aspirational districts from Bihar (Muzzafarpur and Purnia), were found to be technically efficient. Muzzafarpur being technically efficient is more so for the fact that it recorded among the lowest number of one of the health inputs – number of ASHAs and ANMs. Otherwise, the performance of Muzzafarpur with regards to Institutional delivery has major scope of improvement.

- **CHHATTISGARH:** Chhattisgarh recorded an average technical efficiency of 0.63 (SD: 0.16) and an average scale efficiency of 0.84 (SD: 0.14). This implies that, among the 9 technically inefficient aspirational districts in Chhattisgarh, on an average, 16% more output could be produced by utilizing the current levels of inputs. The district of Narayanpur was found to be technically efficient in the analysis. The technical efficiency of Narayanpur here is again backed by the fact that is accords for among the lowest health inputs both in terms of both, Health Infrastructure (Input3) and Human Resource (Input2). Fact remains that the district ranks second when we compare maternal mortality ratio of

the aspirational districts of Chhattisgarh. As we will see in the further analysis, Narayanpur district will rarely be grouped as a peer for the other set of districts.

- **JHARKHAND:** Jharkhand recorded an average technical efficiency of 0.84 (SD: 0.14) and an average scale efficiency of 0.91 (SD: 0.07). This implies that the 10 technically inefficient aspirational districts in Jharkhand could, on an average, produce 16% more output by utilizing the current levels of inputs. Five Aspirational districts from Jharkhand (Bokaro, Pakur, Sahebganj, Ramgargh and Ranchi) were found to be technically efficient with Bokaro and Sahebganj recording pure technically efficiency of 1 from both the CRS as well as the VRS approach. Even the scale efficiency for Bokaro was at the optimum.

- **MADHYA PRADESH:** Madhya Pradesh recorded an average technical efficiency of 0.73 (SD: 0.08) and an average scale efficiency of 0.96 (SD: 0.05). This implies that the technically inefficient aspirational districts in Madhya Pradesh could, on an average, produce 27% more outputs by utilizing the current levels of inputs. The district of Guna was found to be scale efficient in the analysis. All the aspirational districts in Madhya Pradesh recorded Decreasing Returns of Scale.

- **ODISHA:** Odisha recorded an average technical efficiency of 0.66 (SD: 0.13) and an average scale efficiency of 0.93 (SD: 0.05). This implies that, the 6 technically inefficient aspirational districts of Odisha could, on an average, could produce 7% more outputs by utilizing the current levels of inputs. No aspirational district from Odisha, that was included in this study, was found to be technically efficient. The highest technical efficiency in the state was accorded to Balangir district. District Kandhmal recorded pure scale efficiency.

- **RAJASTHAN:** Rajasthan recorded an average technical efficiency of 0.94 (SD: 0.09) and an average scale efficiency of 0.96 (SD: 0.04). Among the five aspirational districts of Rajasthan, two aspirational districts (Jaisalmer and Sirohi) were found to be technically efficient with regards to overall and pure technical efficiency as well as scale efficiency. Overall, the technical efficiency of maternal health services in Rajasthan was found to be far superior to the other EAG states as well as other aspirational districts. Rajasthan has indeed seen considerable improvements in its health structure and many health outputs in the past and the current analysis speaks for its achievements. The percentage of overall institutional deliveries with respect to total ANC registration in the aspirational districts of Rajasthan was above 100 percent for all the aspirational districts of the state. It is ascertained that Rajasthan can increase the level of output by 6 percent while utilizing the current level of outputs.

- **UTTAR PRADESH:** Uttar Pradesh recorded an average technical efficiency of 0.74 (SD: 0.13) and an average scale efficiency of 0.90 (SD: 0.07). This implies that, these 7 technically inefficient aspirational districts in Uttar Pradesh could, on an average, produce 26% more outputs by utilizing the current levels of inputs. Bahraich was found to be

technically efficient recording a scale efficiency of 0.74. The highest technical efficiency in the state among the inefficient aspirational districts was accorded to Chitrakoot district.

- **UTTARAKHAND:** A total of two aspirational districts have been identified in Uttarakhand – Haridwar and Udham Singh Nagar. The present analysis reveals that the district of Udham Singh Nagar recorded pure technical and scale efficiency. Udham Singh Nagar being scale efficient implies that it was operating on the most productive scale for the given input output mix. Haridwar also recorded the technical efficiency at 0.88 implying that the district could increase its output by approximately 12 percent with the same level of input and output.

The above analysis, presents a striking picture of the maternal health system efficiency observed in the aspirational districts of the EAG states in India. While some districts depict fairly well with respect to the overall technical efficiency, certain districts still present with a huge scope of further improvement.

**Figure 4: Difference in efficiency scores of non-efficient DMUs with respect to maximum efficiency score**

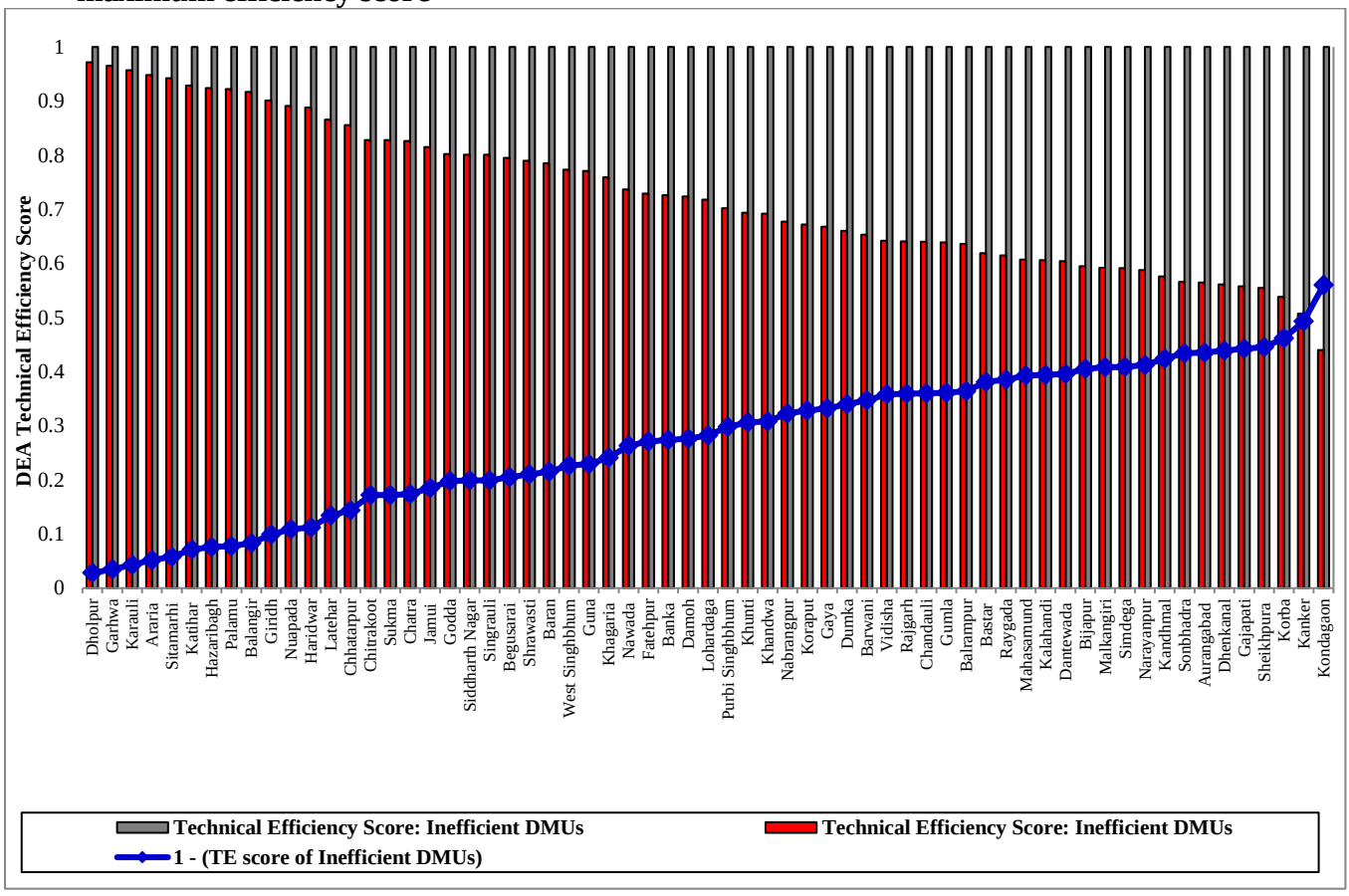


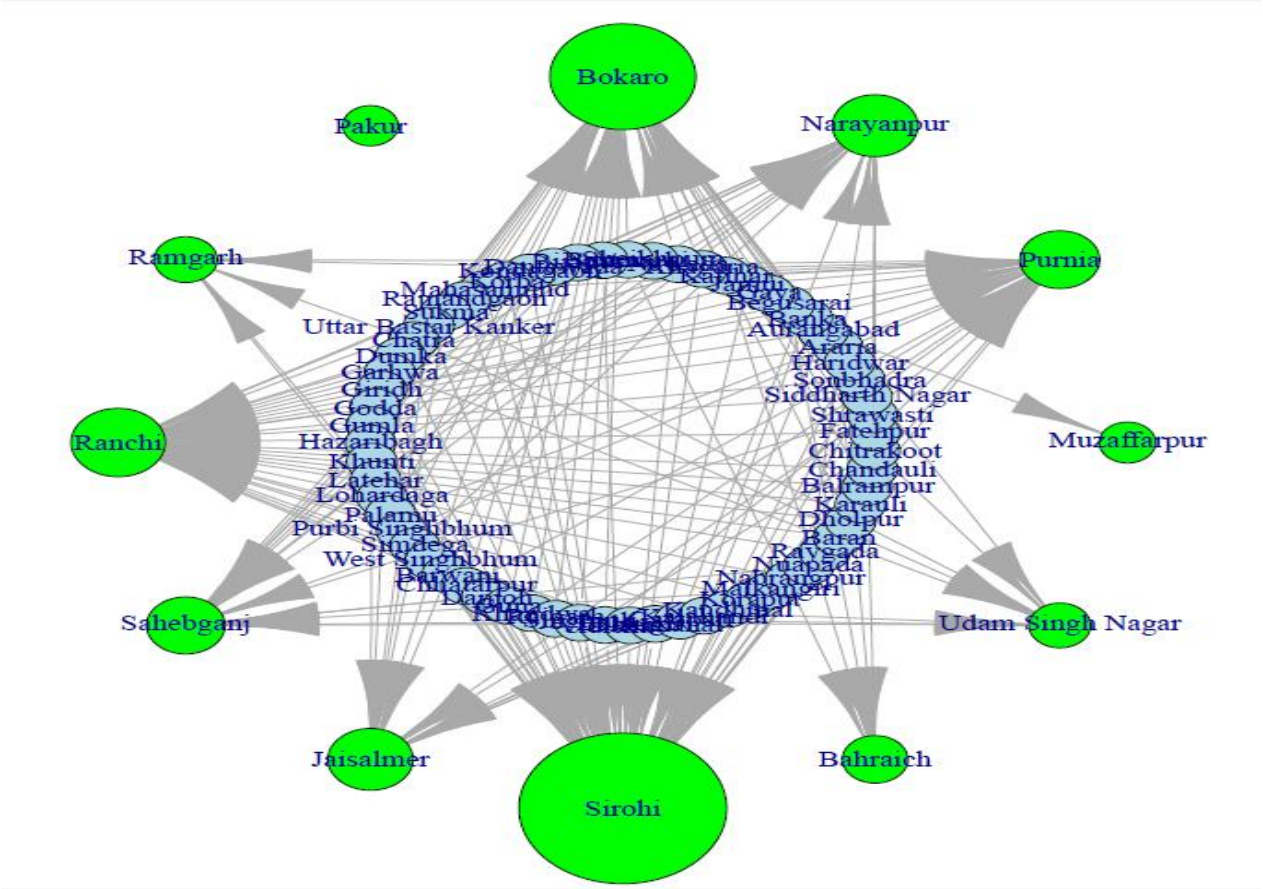

**Figure 4** presents the difference in efficiency scores of non-efficient DMUs with respect to maximum efficiency score, i.e. 1. The difference between the DEA scores of aspirational districts found to be efficient and those found to be inefficient varied between 0.02 to 0.56. This showed that the examined aspirational districts across EAG states did not have relatively similar outputs. Although, within states, these differences varied minimally implying that the

output was more similar in the intra-state comparison. The blue line in the graph above represents the difference between the efficient score of 1 and the technical efficiency of inefficient aspirational districts, as computed. This difference was observed to be the lowest for the districts Dholpur, Rajasthan (0.028), and the said difference was noted to be the maximum for the district Kondagaon, Chhattisgarh (0.56).

**Figure 5** illustrates the peers for all the inefficient aspirational districts. The next step in the analysis is benchmarking process or identifying 'peer' groups of the different inefficient units. Peers or reference sets are a set of potentially efficient DMUs who an inefficient DMU can emulate to become efficient or arrive at the efficient frontier. On a frontier, each DMU tries to move either horizontally or vertically, that is, increasing its outputs or reducing its inputs by following the closest DMU to reach the efficient frontier.

Bokaro, Sirohi, and Ranchi have emerged to be the best efficient aspirational districts to be emulated by a set of the inefficient DMUs. These districts have the optimal levels of inputs to achieve the output. The said districts were considered as peers for 43, 34, and 31 inefficient aspirational districts, respectively.

**Figure 5: Peers of inefficient aspirational districts**




| | | |
|---|---|---|
| **Sirohi** | **43** | Baran, Gumla, Bastar, Raygada, Dholpur, Karauli, Mahasamund, Balangir, Kalahandi, Kanker, Nabrangpur, Koraput, Rajnandgaon, Khandwa, Damoh, West Singhbhum, Singrauli, Jamui, Korba, Kandhmal, Dumka, Vidisha, Barwani, Dhenkanal, Guna, |

| | | |
|---|---|---|
| | | Chhatarpur, Siddharth Nagar, Rajgarh, Godda, Haridwar, Banka, Chandauli, Fatehpur, Nawada, Kondagaon, Hazaribagh, Aurangabad, Purbi Singhbhum, Malkangiri, Khagaria, Sonbhadra, Giridh, Palamu |
| **Bokaro** | **34** | Giridh, Nawada, Palamu, Khagaria, Sonbhadra, Garhwa, Balrampur, Sitamarhi, Shrawasti, Rajgarh, Hazaribagh, Godda,Vidisha, Araria, Guna, Aurangabad, Singrauli, Chatra, Damoh, Korba, Haridwar, Purbi Singhbhum, Chhatarpur, Khandwa, Chandauli, Dumka, Chitrakoot, Banka, Jamui, Begusarai, Mahasamund, Gumla, Katihar, Dholpur |
| **Ranchi** | **31** | Nuapada, Barwani, Gumla, West Singhbhum, Purbi Singhbhum, Pakur, Korba, Begusarai, Koraput, Nabrangpur, Dantewada, Balrampur, Giridh, Guna, Kalahandi, Balangir, Narayanpur, Karauli, Raygada, Chhatarpur, Rajnandgaon, Vidisha, Bahraich, Khagaria, Sonbhadra, Baran, Araria, Palamu, Khunti, Khandwa, Mahasamund |
| **Purnia** | **20** | Gaya, Aurangabad, Siddharth Nagar, Chandauli, Fatehpur, Katihar, Chhatarpur, Sonbhadra, Balrampur, Khagaria, Korba, Giridh, Banka, Khandwa, Palamu, Vidisha, Jamui, Nawada, Purbi Singhbhum, Mahasamund |
| **Sahebganj** | **16** | Sheikhpura, Latehar, Nuapada, Khunti, Simdega, Hazaribagh, Dantewada, Dhenkanal, Lohardaga, Bijapur, Shrawasti, Malkangiri, Kondagaon, Gumla, Gajapati, Damoh |
| **Narayanpur** | **14** | Bijapur, Dantewada, Sukma, Nuapada, Khunti, Latehar, Lohardaga, Garhwa, Gajapati, Chatra, Chitrakoot, Shrawasti, Simdega, Sheikhpura |
| **Jaisalmer** | **14** | Gajapati, Kondagaon, Malkangiri, Simdega, Kandhmal, Chitrakoot, Dhenkanal, Kanker, Khunti, Nuapada, Shrawasti, Sukma, Garhwa, Bijapur |
| **Udham Singh Nagar** | **8** | Chitrakoot, Haridwar, Sukma, Guna, Chatra, Garhwa, Rajgarh, Singrauli |
| **Ramgarh** | **5** | Gaya, Aurangabad, Siddharth Nagar, Chandauli, Fatehpur |
| **Bahraich** | **5** | Katihar, Begusarai, Araria, Sitamarhi, Balrampur |
| **Muzaffarpur** | **1** | Sitamarhi |
| **Pakur** | **0** | |

**Figure 6** illustrates the summary of output targets presented in the structure of original versus target values. In this context, the target values depict the increase in the number of Institutional deliveries that the aspirational districts can achieve given the same level of inputs and in some cases, by even reducing some input or inputs in combination.

Since, our model is output oriented and we aim to maximize our 'Institutional deliveries', any reduction in input variables thus suggested can be safely kept out of consideration since in the study of healthcare system efficiency, it becomes rather a question of ethics to recommend any reduction in key inputs like Health Infrastructure and Human Resources.

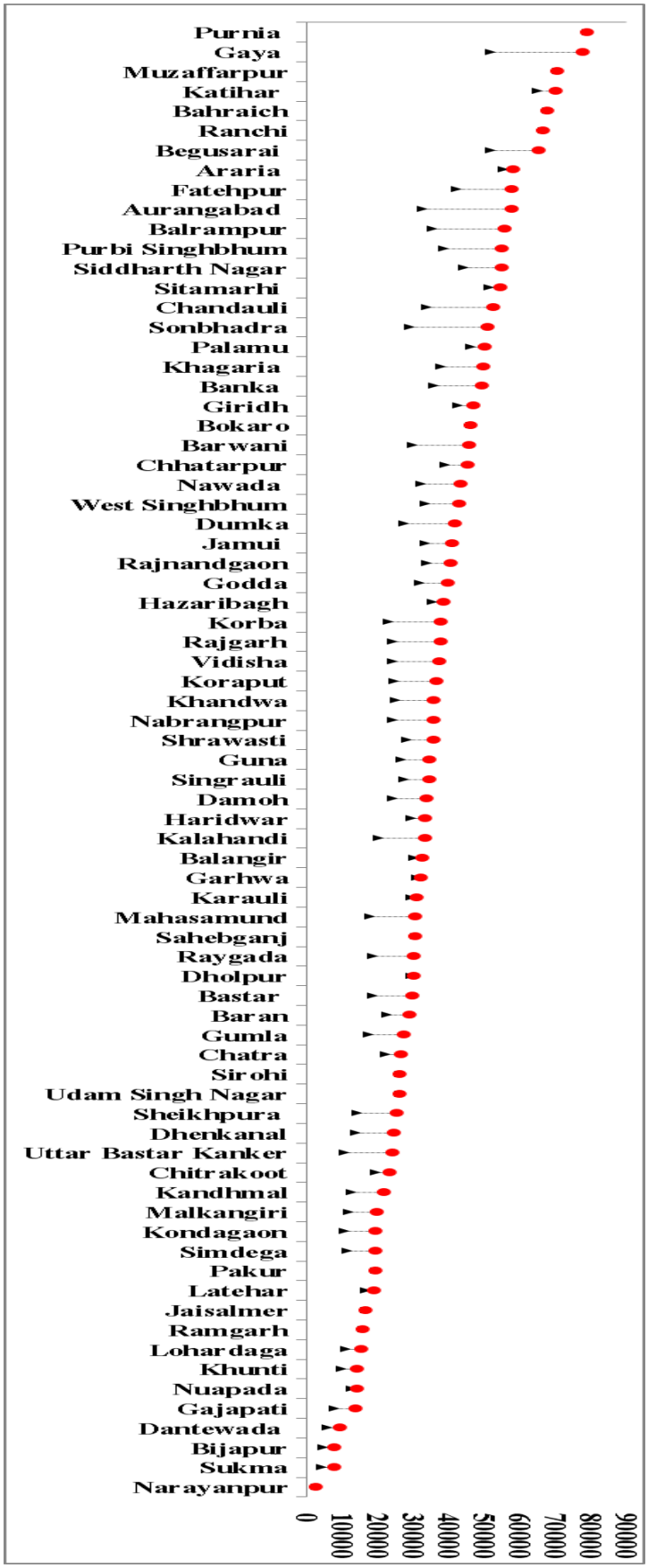
A projected increase of more than 20,000 annual Institutional deliveries was noted for the districts Korba, Khandwa, Chhatarpur and Hazaribagh. The lowest projected increment was modeled for the districts Balangir, Sonbhadra, Khagaria, Haridwar and Aurangabad, each recording a projected increase in Institutional deliveries upto 2500 only.

In terms of percentage increment, the highest projected increase in the institutional deliveries has been recorded for the district Kanker (127%) followed by district Sukma (97%). Eight districts - Chhatarpur, Hazaribagh, Purbi Singhbhum, Koraput, Bastar, Damoh, Latehar, and Banka - recorded an percent5age increemnet at the given level of outpurts in the range of 70-85 percent. A review of projected output reveals some startling operative inefficiencies for certain aspirational districts. The aspirational districts of Jharkhand, Madhya Pradesh, Chhattisgarh and Bihar have recorded a relatively higher scope to increase the levels of Institutional Deliveries in their aspirational districts. This also goes to signify, that at the present level, these districts are definitely operating at less than their capacity and with about no change in the level of inputs – Full ANC checkups, Health Infrastructure and Health Human Resource – the output, which is, Institutional Deliveries, can be increased to the specified extent.

## 6. Conclusion

The study attempts to evaluate the technical efficiencies of the aspirational districts in the EAG states of India with regards to Maternal Health Services. The transformation of the aspirational districts of India is aimed to be achieved by the year 2022. In the composite ranking of these districts, the component of 'Health and Nutrition' remains a major

**Figure 6: Original vs. Projected Output values**



component for consideration. While strategic interventions towards ensuring Universal Health Coverage has resulted in significant improvements in the maternal health status of the country, the progress has not been uniform given significant inter-state and intra-state variations. A number of districts exhibit significant lags in terms of maternal healthcare and healthcare in general. The Government of India has thus recognized an urgent need to transform the healthcare narratives of the laggard districts so that an inclusive growth can be reflected for the country as a whole.

The present study first explored the trends in Maternal Mortality Ratio as recorded for the aspirational district of the EAG states in India. A state-level analysis reveals that Chhattisgarh and Uttarakhand are the only two states among the EAG group to have recorded an overall increase in MMR over 2015-17 to 2016-18. Uttar Pradesh records the highest MMR among the EAG states of India, at 216 maternal deaths per 1 lakh live births. However, the state did record a percentage change of negative nine percentage points over the said years. Chhattisgarh recorded the highest percentage increase in the MMR, recording an overall increase of 13 percent from the years 2015-17 to 2016-18. Jharkhand recorded the lowest MMR at 71 in the year 2016-18 while the state of Rajasthan showed maximum improvement in terms of percentage change recording an overall decline of 12 (negative) percentage points over 2015-17 to 2016-18. (Figure 1)

A district level analysis reveals that MMR ranged from 0 to 385 in Odisha with Kandhmal district reporting the highest MMR in the year 2018-19. Bihar, Chhattisgarh, Jharkhand, Madhya Pradesh, Odisha, Rajsthan, and Uttar Pradesh recorded MMR in the range of 7 to 82, 26 to 223, 40 to 266, 57 to 207, 79 to 385, 17 to 178, and 73 to 286 respectively. The following set of aspirational districts - Jamui, Bihar (82), Kondagaon, Chhattisgarh (223), Khunti, Jharkhand (266), Vidisha, Madhya Pradesh (207), Kandhmal, Orissa (385), Sirohi, Rajasthan (178), Shrawasti, Uttar Pradesh (286) and Hardwar, Uttarakhand (199) - constitute of the worst performing aspirational districts in terms of MMR for each the listed EAG states. (Table 1)

Data Envelopment Analysis (DEA) was used to analyze the efficiencies in terms of maternal health care for the 75 aspirational districts. For the application of the said method, Institutional Deliveries (ID) was chosen as the output variable and ‘4 or more ANC checkups’, ‘Total Number of ASHAs and ANMs’ and ‘Total number of Health Facilities’ were chosen as Input variables. The perusal of the DEA results reveal startling lags in terms of efficiencies observed in each of these districts with regards to maternal health.

The number of Institutional Deliveries (IDs) in the aspirational districts range from 2428 IDs in Narayanpur, Chhattisgarh to 78790 IDs in Purnia, Bihar. On an average, the aspirational districts included in the study sample recorded 28,909 (SD: 16304) Institutional Deliveries in the year 2018-19. The number of pregnant women who received full Antenatal Care ranges from 2433 women in Narayanpur, Chhattisgarh to 99164 women in Muzzafarpur, Bihar, during the said year. The number of ASHAs and ANMs positioned in the aspirational districts is lowest (33) for the district of Muzzafarpur, Bihar and highest (696) for Gaya,

Bihar. With respect to the Total Number of Health Facilities, the district of Ramgarh, Jharkhand reported the minimum number of health facilities at 63 and Muzzafarpur, Bihar had the health infrastructure of 605 health facilities as per the data reported on the HMIS portal. The total number of health facilities in the district include a sum total of District Hospitals (DHs), Community Health Centres (CHCs), Primary Care Centers (PHCs), and Sub-Health Centres(SCs) (Table 4).

The analysis of efficiency scores after applying the DEA model reveals that out of the 45 aspirational districts included in the study only 12 were found to be efficient with respect to maternal health care, that is, they have the right mix of inputs to achieve the existing output levels seen in output approach. These districts are **Sirohi, Bokaro, Ranchi, Purnia, Sahebganj, Narayanpur, Jaisalmer, Udham Singh Nagar, Ramgarh, Bahraich, Muzaffarpur, and Pakur** as against the other 63 aspirational districts positioned farther away from the frontier. The average pure technical efficiency (PTE) score of 0.79 shows that the aspirational districts included in the study can produce the same amount of outputs by saving 21% inputs. This could significantly contribute towards ensuring equitable availability of maternal healthcare services in these states. The results of this study showed that 75% of aspirational districts in the EAG states are operating at less than optimal level and 20 of these obtained efficiency scores below 80 percent. This finding implies that the inefficient districts could significantly improve their efficiency by better resource management and allocation. The factors influencing efficiency of these districts should be identified and appropriately addressed. The study has also quantified the peers for inefficient aspirational districts. Sirohi and Bokaro being the most cited peers certainly have put forth key takeaways in terms of maternal healthcare models for other aspirational districts. (Table 5)

It must be noted that the DEA analysis provides relative efficiencies. Thus, the best performing districts or district with PTE score of 1 or 100% do not imply that they cannot be improved any further. While more improvements even in the districts regarded as perfect in the analysis may or may not be possible, the data at hand cannot provide that information. Among the 12 aspirational districts which gained 100 percent efficiency score in the present analysis, some points must be noted with specific to the districts Muzzafarpur and Narayanpur. Muzzafarpur being technically efficient is more so for the fact that it record among the lowest number of one of the health inputs – number of ASHAs and ANMs. Otherwise, the performance of Begusarai with regards to Institutional delivery has major scope of improvement. The technical efficiency of Narayanpur here is again backed by the fact that is accords for among the lowest health inputs both in terms of Infrastructure (Input3) and Human Resource (Input2). Fact remains that in the year 2018-19, of the total ANC registrations, Narayanpur accounted for only 63 percent of institutional deliveries and also ranks second when we compare maternal mortality ratio of the aspirational districts of Chhattisgarh. It was seen, that these two districts were referenced as peers for only a handful of other districts.

There thus exists a strong need to study comprehensive efficiencies than just pursuing ranks based on certain indicators. Healthcare outputs are affected by a number of factors and

consequently, can be improved by an integrated and inclusive mix of approaches. To study maternal health in terms of just 'Institutional delivery percentages' can at best provide us with a preliminary outlook into a much deeper domain. An in-depth analysis into the problem will require simultaneous study of the factors which affect our study variable. Thus DEA method was chosen for the present study to understand the interplay of input-output variables to determine the efficiency of operations with respect to maternal health in each of the aspirational districts.

In conclusion, 'Institutional deliveries' is a significant representative of the efficacies/inefficacies for the overall status of maternal health in any region. Strengthening the institutional deliveries open gateways of improvements for many allied indicators of maternal healthcare. The results from the present study can be used towards identifying the most laggard districts in terms of overall efficiency. Interventions must be considered with respect to improving health infrastructure by increasing the number of delivery points, and filling up all vacant positions of ASHAs and ANMs given that they are the catalyst for bringing the desired change in the maternal healthcare system. Service delivery must be strengthened in terms of 1st trimester registration and 4 or more ANC check-ups for improving the number of Institutional deliveries.

An American-Austrian educator, consultant and author - Peter Drucker – remarked that "Efficiency is doing things right; effectiveness is doing the right things". The study of operational efficiency for the study districts essentially summarizes the gaps in 'doing things right'. Once the efficiency in terms of health outputs is actualized in these districts, the shared mission of NHM and NITI Aayog's Programme for Transformation of Aspirational Districts will definitely be met and a path from efficiency to effectiveness will be relatively easier to unlock.

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