State Capacity and Healthcare Performance in India: Do Better Health Outcomes Reflect Higher Public Spending or Greater Efficiency.

Abstract

The healthcare performance of Indian states exhibits considerable variation despite sustained public investment and numerous health sector reforms. While some states consistently achieve favourable health outcomes, others continue to experience high mortality and fertility despite increased expenditure. This raises an important policy question: are better-performing states simply allocating more financial resources to healthcare, or are they using their available resources more efficiently? This study seeks to answer this question by integrating econometric regression analysis with Data Envelopment Analysis (DEA). This study examines **state-wise public health-sector capacity and efficiency in India** by analysing the relationship between public health expenditure and population-health outcomes and assessing the efficiency with which states transform health resources into outcomes. The study employs a panel dataset covering **19 Indian states during 2012–2019**. Fixed-effects regressions with **Driscoll–Kraay standard errors** are used to estimate the association of public health expenditure with life expectancy, infant mortality rate (IMR), maternal mortality ratio (MMR), and total fertility rate (TFR), controlling for per-capita Net State Domestic Product (PCNSDP). The results show that higher public health expenditure is significantly associated with **higher life expectancy and lower IMR, MMR, and TFR**. The study further applies an **output-oriented Variable Returns to Scale Data Envelopment Analysis (DEA)** to 17 states, using government hospital beds and public health expenditure as inputs and life expectancy and inverse IMR as outputs. The mean VRS technical-efficiency score of **0.962** indicates relatively high pure technical efficiency, although considerable scale inefficiency is observed. Arunachal Pradesh, Chhattisgarh, Kerala, Punjab, Telangana, and Uttarakhand constitute the efficiency frontier, with Kerala emerging as the principal benchmark. Overall, the findings suggest that strengthening public-health capacity requires not only adequate public financing but also the **efficient utilisation of financial and infrastructural resources** to translate expenditure into improved population-health outcomes.

Keywords: State Capacity, Public Health Expenditure, Healthcare Efficiency, Data Envelopment Analysis, Health Outcomes, Indian States, Health Governance, Health System Efficiency

Introduction

Health matters a lot for the economy. People work more, learn more and make more money when they are healthy. After all, health is wealth! (Bloom & Canning, 2000). In fact healthcare is one of the key areas that governments invest heavily in and it is also expected that they invest heavily in this area by the public. However just the sheer volume of spending is not enough. The government should also efficiently transform this into real services that manifest as health outcomes (Migdal, 1988; Evans, 1995; Besley & Persson, 2009, 2011; Fukuyama, 2004, 2013).

India is a good place to study this. All Indian states work under the same constitution and follow the same basic fiscal rules too, but run things differentlySo health outcomes across states can look very different (Pritchett, 2009; Dreze& Sen, 2013). Kerala and Tamil Nadu are good examples. They do much better than many states despite spending pretty much equal amounts, if not lesser amounts of money. Thus, the real question is simple. Are better states just spending more? Or are they using their money better?

Most studies approach this in two ways. Some studies just look at this problem/ disparity quantitatively, comparing spending to outcomes, or measuring efficiency with Data Envelopment Analysis, or DEA. Other studies look at the real problems on the ground, like workers not showing up or weak accountability (Chaudhury et al., 2006; Das & Hammer, 2007; Das et al., 2016). This study tries to do both. It uses a fixed-effects panel regression to check how public health spending affects outcomes. Furthermore, it uses a DEA model to measure how efficient each state is with its healthcare resources, and reads both results next to the qualitative literature on state capacity, keeping in mind that this should help both the academic side and the policy side of the health debate in India.

Literature Review

Research on state capacity, government spending, and healthcare in India started with Bhalotra (2007). This study shows that health spending lowers infant mortality only after a slight time lag. Farahani, Subramanyam, and Canning (2010) showed that a 10% rise in spending lowers the chance of death by about 2%.

The studies of Mohapatra (2019) show that this effect works not only through how much people actually use health services but it also depends on how the money gets spent and not just how much. However, this link is not automatic and constant across all countries and across all political parameters. Cross-country evidence shows that this link gets stronger when governance is good but can also disappear completely when corruption is high (Rajkumar & Swaroop, 2008; Mauro, 1998; Gupta, Verhoeven, & Tiongson, 2002; Hitiris& Posnett, 1992).

This claim is backed up by Indian data too. However this data is backed up a lot by Indian data, too, changing the effect a lot depending on the state and how well the program is actually run.

This is quite close to Prachet's 2009 idea of a flailing state. The common intellectual claim is that the state is strong at the top but weak at the bottom, where services actually reach the people and directly affect life outcomes. This connects to the bigger theories of state capacity, which is not only the power to extract resources but also depends on bureaucracy, infrastructural power, or accountability.

Other papers look at more tangible on-ground methods of state capacity measurement. For example, health workers are often absent. In fact, in some surveys, absenteeism goes above 40% (Chaudhury et al., 2006). There is also a gap between doctors' knowledge and implementation (Das & Hammer, 2007; Das et al., 2016). Sometimes health infrastructure exists only on paper while supplies run out (Banerjee, Deaton, & Duflo, 2004).

On the quantitative side, DEA is a major framework that has been used by multiple papers in healthcare efficiency (Hollingsworth, 2008; Afonso & St. Aubyn, 2005). DEA studies discover big efficiency gaps between states (De, Dhar, & Bhattacharya, 2012; Dar & Raina, 2024; Mohanty &Bhanumurthy, 2021). While studies show that there is a quantitative deficiency, along with policy ambivalence and fieldwork loopholes, there is a paucity of studies putting together spending, efficiency, and fieldwork together in one place, which is what this study aims to achieve.

Research Gap

Existing studies have separately examined the relationship between public health expenditure and health outcomes and the efficiency of healthcare resource utilisation across Indian states. However, limited research integrates these two dimensions within a single empirical framework. In particular, expenditure-based studies generally do not assess whether states differ in their ability to convert available resources into health outcomes, while efficiency studies rarely examine the expenditure–outcome relationship over time. Moreover, quantitative efficiency analysis is seldom linked with the broader literature on state capacity and public-service delivery. The present study addresses this gap by combining panel regression and Data Envelopment Analysis (DEA) to examine whether interstate differences in health performance reflect higher public spending, greater efficiency in resource utilisation, or a combination of both.

Research Question

Are better-performing Indian states simply spending more on healthcare, or are they using their available healthcare resources more efficiently?

Research Objectives

The study pursues two primary objectives:

1. To examine the effect of public health expenditure and per capita NSDP on health outcomes across Indian states.

This objective will be addressed through four separate regression models where the dependent variables are:

- Life expectancy
- Infant Mortality Rate
- Maternal Mortality Ratio
- Fertility Rate

2. To evaluate the relative efficiency of Indian states in transforming healthcare resources into improved health outcomes using Data Envelopment Analysis (DEA).

Methodology

The study adopts a quantitative empirical framework combining panel-data regression analysis and Data Envelopment Analysis (DEA) to examine both the relationship between public health expenditure and health outcomes and the relative efficiency with which Indian states transform healthcare resources into population-health outcomes. Secondary state-level data are obtained primarily from the *Reserve Bank of India, Handbook of Statistics on Indian States*, supplemented by relevant official sources for healthcare infrastructure. The regression analysis uses a balanced panel of 19 Indian states for the period 2012–2019, comprising 152 state-year observations. Four health indicators—life expectancy at birth, infant mortality rate (IMR), maternal mortality ratio (MMR), and total fertility rate (TFR)—are separately considered as dependent variables, while public health expenditure (PHE) constitutes the principal explanatory variable and per-capita Net State Domestic Product (PCNSDP) is included as a control for interstate differences in economic development. The general panel model is specified as

$$Yit=\alpha+\beta_1 PHE_{it}+\beta_2 PCNSDP_{it}+\lambda t+\mu_i+\varepsilon_{it}$$

where Y_{it} denotes the respective health outcome for state i in year t, $\mu_i$captures unobserved time-invariant state-specific characteristics, λt denotes year fixed effects and ε_{it} represents the idiosyncratic error term. Fixed Effects (FE) and Random Effects (RE) models are initially estimated and compared using the Hausman specification test; subsequently, Fixed Effects models with Driscoll–Kraay standard errors, using a maximum lag length of two, are employed to obtain inference robust to heteroskedasticity, serial correlation and cross-sectional dependence (Driscoll & Kraay, 1998; Hoechle, 2007). Given the observational nature of the data and the relatively short time dimension (T=8T=8), the resulting coefficients are interpreted as conditional associations rather than definitive causal effects. To complement the regression analysis, DEA is employed to assess the relative efficiency of 17 Indian states for the year 2018, with each state treated as a Decision-Making Unit (DMU). Following the non-parametric efficiency framework of Charnes, Cooper and Rhodes (1978), two healthcare resources—government hospital beds and public health expenditure—are used as inputs, while life expectancy and inverse infant mortality rate (1/IMR1/IMR) are used as desirable outputs; IMR is transformed because lower infant mortality represents better health performance. The analysis is estimated using DEAP Version 2.1 (Coelli, 1996) and adopts an output-oriented Variable Returns to Scale (VRS) model based on Banker, Charnes and Cooper (1984). Output orientation is appropriate because the objective is to evaluate the extent to which states could improve health outcomes with their existing resource base, while VRS allows for substantial interstate differences in population, fiscal capacity, infrastructure and operating scale. Both Constant Returns to Scale technical efficiency (CRSTE) and VRS technical efficiency (VRSTE) are estimated, with scale efficiency calculated as SE=CRSTE/VRSTE; a VRS score of unity identifies a state located on the estimated relative efficiency frontier, while scores below unity indicate relative inefficiency. Peer states, returns to scale, slacks and projected targets are additionally examined to identify empirical benchmarks and potential sources of inefficiency. The two methods are therefore complementary: regression evaluates whether greater public health expenditure is associated with improved health outcomes, whereas DEA assesses whether states differ in their efficiency in converting financial and infrastructural resources into those outcomes. Nevertheless, the DEA findings, particularly scale-efficiency estimates, require cautious interpretation because absolute public health expenditure and hospital-bed numbers are used as inputs whereas life expectancy and inverse IMR are population-level outcomes; consequently, population size may partly influence the measured scale differences, and a robustness specification using per-capita health expenditure and hospital beds per 10,000 population would strengthen future analysis.

Result & Analysis

Discussion for objective 1 - The empirical analysis for the first objective examines whether variations in public health expenditure are associated with differences in major population-health outcomes across Indian states. The study uses panel data covering 19 states over the period 2012–2019, providing 152 state-year observations. Four indicators of population health—life expectancy, infant mortality rate (IMR), maternal mortality ratio (MMR), and total fertility rate (TFR)—are considered separately as dependent variables. Public health expenditure constitutes the principal explanatory variable, while per-capita Net State Domestic Product (PCNSDP) is incorporated as a control variable to account for differences in the level of economic development across states.

The general panel regression model may be expressed as:

$$Y_{it}=\alpha+\beta_1 PHE_{it}+\beta_2 PCNSDP_{it}+\mu_i+\epsilon_{it}$$

where Y_{it} represents the respective health outcome for state (i) in year (t) like life expectancy, infant mortality rate (IMR), maternal mortality ratio (MMR), and total fertility rate (TFR). PHE_{it}denotes public health expenditure. $PCNSDP_{it}$ represents per-capita Net State Domestic Product; α is the intercept; β_1 and β_2 are the estimated coefficients; μ_i represents unobserved time-invariant state-specific effects; and ϵ_{it} is the idiosyncratic error term.

Initially, Fixed Effects (FE) and Random Effects (RE) models were estimated and the Hausman specification test was employed to examine the appropriateness of the estimators. However, state-level panel data may be affected by heteroskedasticity, serial correlation and cross-sectional dependence, which can make conventional standard errors unreliable. Therefore, the analysis subsequently employs the Driscoll–Kraay standard-error procedure with state fixed effects. Driscoll and Kraay (1998) developed a non-parametric covariance-matrix estimator that is robust to general forms of spatial and temporal dependence. Hoechle (2007) subsequently implemented the estimator for panel-data models in Stata through xtscc. The present analysis uses a maximum lag length of two. Since Driscoll–Kraay estimation modifies the covariance matrix rather than the underlying within-estimator, the estimated FE coefficients remain unchanged while the standard errors, test statistics and confidence intervals are adjusted for dependence in the disturbances.

Discussion for Objective 1.1: examining the impact of public health expenditure on life expectancy across Indian states

The Driscoll–Kraay fixed-effects regression indicates a positive and statistically significant relationship between public health expenditure and life expectancy. The estimated coefficient of public health expenditure is 0.000237 with a p-value of <0.001, implying that, after controlling for per-capita NSDP and time-invariant state-specific characteristics, increases in public health expenditure are associated with improvements in life expectancy. The within of 0.5111 suggests that approximately 51.11 per cent of the within-state variation in life expectancy is explained by public health expenditure and per-capita NSDP. In contrast, per-capita NSDP records a positive coefficient of 3.57×10^{-6}, but the relationship is statistically insignificant ( ). This indicates that variations in state income alone do not adequately account for variations in life expectancy once public health expenditure and state-specific heterogeneity are taken into consideration.

Table 1.1 impact of public health expenditure on life expectancy across Indian states

Regression with Driscoll-Kraay standard errors Number of obs = 152

Method: Fixed-effects regression Number of groups = 19

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Group variable (i): code                 F(  2,     7)       =        482.38
maximum lag: 2                           Prob > F            =        0.0000
                                within R-squared  =        0.5111

                                   Drisc/Kraay
        lifeexpectancy | Coefficient  std. err.      t    P>|t|         [95% conf. interval]
---------------------+--------------------------------------------------------------
pubhealthexpenditure |    .000237   8.45e-06      28.04   0.000    .000217         .000257
        pcnsdp |   3.57e-06   3.12e-06     1.15   0.290     -3.80e-06    .0000109
        _cons |   67.86696   .3019073   224.79   0.000    67.15306    68.58086
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The result is consistent with the broader human-development argument that improvements in health cannot be understood solely through increases in income and that the provision of publicly financed social services plays an independent role in improving human capabilities. Anand and Ravallion (1993), for instance, emphasised the importance of public health and other social services in translating economic resources into improved human-development outcomes. More specifically in the Indian context, recent state-level evidence finds that publicly financed health expenditure is positively associated with life expectancy and other desirable health outcomes, although the magnitude of the association differs substantially between high-focus and relatively better-performing states. Earlier international evidence from Bidani and Ravallion (1997) similarly suggests that public health expenditure can have a beneficial effect on population health, particularly among economically disadvantaged sections that have limited ability to substitute private health care for publicly provided services.

The result therefore suggests that public-sector health expenditure may constitute an important component of state health capacity, particularly by financing preventive services, primary health facilities, immunisation, disease control, maternal and child health programmes, and improved access to treatment. At the same time, the insignificant coefficient of PCNSDP indicates that higher economic prosperity does not necessarily translate automatically into longer life expectancy unless economic resources are effectively converted into accessible health and social services. This finding should nevertheless be interpreted as a robust association rather than a causal effect because expenditure levels may themselves respond to pre-existing health conditions.

Discusion for Objective 1.2: examining the impact of public health expenditure on infant mortality across Indian states

The regression results reveal a strong negative and statistically significant relationship between public health expenditure and infant mortality. The coefficient of public health expenditure is −0.0011893, significant at the 1 per cent level. Thus, an increase in public health expenditure is associated with a reduction in infant mortality after controlling for per-capita NSDP and unobserved state-specific characteristics. The estimated within r square (0.6913) is the highest among the four health-outcome models, indicating that approximately 69.13 per cent of the within-state variation in infant mortality is explained by the variables included in the model.

Table 1.2- impact of public health expenditure on infant mortality across Indian states

Regression with Driscoll-Kraay standard errors   Number of obs = 152

Method: Fixed-effects regression   Number of groups = 19

Group variable (i): code   F(2, 7) = 712.97

maximum lag: 2   Prob > F = 0.0000

within R-squared = 0.6913

infantmortalityrate	Coefficient	Drisc/Kraay std. err.	t	P>|t|	[95% conf. interval]	
pubhealthexpenditure	-.0011893	.0001041	-11.43	0.000	-.0014354	-.0009432
pcnsdp	-.0000864	.0000157	-5.49	0.001	-.0001237	-.0000492
_cons	47.16228	.8232825	57.29	0.000	45.21553	49.10903

Unlike the life-expectancy model, per-capita NSDP is also negative and statistically significant in the IMR equation. Its coefficient is −0.0000864 with a p-value of 0.001. This implies that improvements in state income are associated with reductions in infant mortality even after accounting for public health expenditure. Economic development can affect infant survival through improved nutrition, sanitation, living conditions, maternal education, transport facilities and the greater capacity of households to obtain health care. Nevertheless, the significance of public health expenditure after controlling for PCNSDP demonstrates that the relationship cannot be explained by economic prosperity alone.

The finding is strongly supported by evidence from India. A state-level analysis of Indian data found that public health spending was significantly associated with reductions in infant and under-five mortality, with the authors arguing for greater targeted public investment in health, particularly in lagging states. Another state-level Indian study covering social-sector expenditure similarly examined how health and related public expenditure were associated with child mortality and highlighted the importance of public policy and state spending for improving child-survival outcomes. More recent evidence comparing high-focus and non-high-focus Indian states also reports that publicly financed health expenditure reduces infant and child mortality.

The present finding can therefore be interpreted as evidence that public health expenditure contributes to the institutional capacity required to reduce preventable infant deaths through antenatal care, institutional delivery, neonatal services, vaccination, nutrition programmes, disease prevention and access to primary health care. However, the international literature is not completely unanimous. Filmer and Pritchett and some related studies reported relatively weak effects of aggregate government health expenditure on mortality, suggesting that how efficiently expenditure is allocated and utilised may be as important as the amount spent. Consequently, the present result supports greater public expenditure but also points towards the importance of expenditure efficiency and the quality of health-system delivery.

Discussion for Objective 1.3: To examine the impact of public health expenditure on maternal mortality across Indian states

The Driscoll–Kraay regression for maternal mortality produces a negative and highly statistically significant coefficient for public health expenditure.

Table 1.3- impact of public health expenditure on maternal mortality across Indian states

Regression with Driscoll-Kraay standard errors   Number of obs = 152

Method: Fixed-effects regression   Number of groups = 19

Group variable (i): code   F(2, 7) = 102.53

maximum lag: 2   Prob > F = 0.0000

within R-squared = 0.5443

| Drisc/Kraay

maternalmortality | Coefficient std. err. t P>|t| [95% conf. interval]

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--------------------+----------------------------------------------------------------
pubhealthexpenditure|  -.0084905   .0006011   -14.12   0.000      -.0099119   -.0070691
              pcnsdp |   .0000493   .0000405   1.22   0.262    -.0000463          .000145
               _cons |   163.3688   5.402301     30.24   0.000     150.5944         176.1432
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The estimated coefficient is −0.0084905 with a p-value of <0.001, indicating that increased public expenditure on health is associated with reductions in maternal mortality after controlling for per-capita NSDP and state-specific fixed effects. The within is 0.5443, implying that approximately 54.43 per cent of the within-state variation in maternal mortality is explained by the model.

Per-capita NSDP, however, has a small positive coefficient of 0.0000493 and is statistically insignificant. The insignificant income effect is particularly noteworthy. It suggests that increases in average state income do not automatically translate into improvements in maternal survival once public health expenditure and persistent state characteristics are controlled for. Maternal mortality is closely related to the organisation of health services—including antenatal care, skilled attendance at birth, emergency obstetric care, referral systems, institutional delivery and postpartum care—and these services depend directly upon the functioning and financing of the health system.

This interpretation is supported by the wider literature on reproductive, maternal, neonatal and child health financing. Evidence from developing countries indicates that greater domestic public financing of reproductive and maternal health can generate substantial gains, including reductions in maternal mortality. Recent international evidence also emphasises that maternal-health services require sustained financing for antenatal and postnatal care, delivery services and the management of pregnancy-related complications; continuing financing gaps remain an important barrier to adequate service provision in many low- and middle-income countries.

Within India, substantial interstate variation in maternal mortality continues to coexist with differences in the utilisation and availability of government maternal-health programmes and services. Evidence shows markedly lower maternal mortality in better-performing states and substantially higher levels in several historically disadvantaged states, highlighting the importance of health-system access and programme implementation. The present regression therefore indicates that public expenditure may be more directly relevant to maternal mortality than overall state income, since maternal survival depends heavily on the availability and quality of organised public-health interventions. Nonetheless, expenditure itself is not sufficient: the literature also cautions that high reproductive-health spending does not necessarily guarantee improved maternal outcomes when resources are inefficiently allocated or service quality remains weak.

Discussion for 1. 4: examining the impact of public health expenditure on total fertility rate across Indian states

The fourth regression examines the relationship between public health expenditure and total fertility rate.

Table 1.4- relationship between public health expenditure and total fertility rate.

Regression with Driscoll-Kraay standard errors Number of obs = 152

Method: Fixed-effects regression Number of groups = 19

Group variable (i): code F(2, 7) = 143.15

maximum lag: 2 Prob > F = 0.0000

within R-squared = 0.3293

TFR	Coefficient	Drisc/Kraay std. err.	t	P>|t|	[95% conf. interval]	
pubhealthexpenditure	-.0000314	2.74e-06	-11.46	0.000	-.0000379	-.000025
pcnsdp	-1.11e-06	3.24e-07	-3.43	0.011	-1.88e-06	-3.46e-07
_cons	2.504652	.0243336	102.93	0.000	2.447112	2.562192

The coefficient of public health expenditure is −0.0000314 and is statistically significant at the 1 per cent level. This indicates a significant inverse association between public health expenditure and fertility. The within is 0.3293, suggesting that approximately 32.93 per cent of within-state variation in TFR is explained by public health expenditure and per-capita NSDP. Although this explanatory power is lower than that of the mortality models, it remains meaningful given that fertility behaviour is determined by a particularly wide range of demographic, social, educational and cultural factors beyond health-sector expenditure.

Per-capita NSDP also exhibits a negative and statistically significant coefficient of -1.11×10^{-6} with a p-value of 0.011. Thus, both higher public health expenditure and increasing economic prosperity are associated with reductions in TFR. The result is consistent with the demographic-transition perspective, according to which improved socioeconomic conditions and improvements in health and survival are generally accompanied by declining fertility. Rising income can alter household preferences concerning family size, while improvements in health systems can influence fertility through expanded reproductive-health services, contraceptive availability, reduced infant and maternal mortality and improved access to family planning.

The relationship between public-health financing and fertility should, however, be interpreted more cautiously than the other three outcomes. Public health expenditure does not necessarily reduce fertility directly. Rather, a portion of government health expenditure finances sexual and reproductive health services, family-planning programmes, maternal care and contraceptive access. The literature emphasises that adequate financing is essential for universal access to reproductive-health services and that government expenditure constitutes an important source of reproductive-health financing in developing countries. Systematic evidence on financing family-planning services also identifies contraceptive availability and affordability as mechanisms through which financing arrangements can affect contraceptive uptake, birth spacing and fertility outcomes. Recent estimates additionally demonstrate that substantial resources are required to meet existing needs for maternal-health and family-planning services across low- and middle-income countries, with current spending still falling below estimated requirements.

Therefore, the negative coefficient obtained in the present analysis can reasonably be interpreted as indicating that states with increasing public health expenditure tend to experience declining fertility, potentially because stronger publicly financed health systems increase access to reproductive and maternal health care and facilitate fertility regulation. Nevertheless, TFR is influenced strongly by female education, age at marriage, urbanisation, employment, social norms, contraceptive preferences and child-survival expectations. The coefficient should therefore not be interpreted as evidence that health expenditure alone determines fertility.

Taken together, the four Driscoll–Kraay regressions reveal a consistent relationship between public health expenditure and population-health performance across the states under study. Higher public health expenditure is associated with higher life expectancy and lower infant mortality, maternal mortality and total fertility. Importantly, these relationships remain statistically significant even after controlling for per-capita NSDP. The results therefore suggest that public health expenditure contributes independently to health-system performance rather than merely reflecting the economic prosperity of a state.

This broader conclusion is compatible with the human-development literature, which emphasises that income growth and public-service provision operate through distinct channels. Anand and Ravallion argue that publicly provided health and other social services play an important role in transforming economic resources into human-development achievements. Bidani and Ravallion similarly find that publicly financed health services can have favourable health effects, particularly among populations that depend strongly on public provision. Recent evidence from Indian states is particularly supportive of the present findings, showing that publicly financed health expenditure is associated with higher life expectancy and lower infant and child mortality, although the strength of this relationship differs across states.

At the same time, the findings should not be interpreted to imply that expenditure alone represents public-health capacity or that every increase in expenditure automatically generates improved outcomes. Previous studies have produced mixed evidence concerning the spending–outcome relationship, demonstrating that the composition, targeting, governance and efficiency of public expenditure strongly influence the extent to which additional resources translate into improved population health. Hence, the present results are best viewed as evidence that public health financing constitutes a significant component of state health capacity, while the effectiveness with which states transform financial resources into health outcomes remains an additional dimension requiring separate examination.

Discussion of Objective 2

To evaluate the relative efficiency of public health systems across selected Indian states, the study employs Data Envelopment Analysis (DEA). DEA is a non-parametric linear-programming technique originally developed by Charnes, Cooper and Rhodes for evaluating the relative efficiency of comparable Decision-Making Units (DMUs) that employ multiple inputs to produce multiple outputs. Unlike conventional parametric production-function approaches, DEA does not require the specification of a predetermined functional relationship between inputs and outputs. Instead, an empirical efficiency frontier is constructed from the best-performing units in the sample, and the efficiency of each DMU is measured relative to that frontier.

In the present analysis, each selected Indian state is treated as a Decision-Making Unit (DMU). Seventeen states are included for the year 2018. Two health-system resources are treated as inputs: the number of government hospital beds and public health expenditure. These variables represent physical and financial resources available to the public health system. The use of health expenditure and hospital-bed availability as inputs is well established in health-sector DEA studies. For example, DEA applications to Indian states have incorporated public health expenditure and hospital beds as health-system inputs, while international health-efficiency studies have also employed expenditure, physicians and hospital beds as measures of resources used in producing population-health outcomes.

Two indicators are considered as outputs: life expectancy at birth and the inverse of the infant mortality rate. Life expectancy represents a desirable population-health outcome because higher values imply better health performance. Infant mortality, by contrast, is an undesirable outcome because lower values signify better performance. It is therefore transformed as:

so that higher values of the transformed indicator represent better infant-survival performance. The use of life expectancy and transformed infant mortality or infant-survival measures as desirable DEA outputs is supported by existing health-system efficiency research. A recent Indian state-level DEA study similarly employs life expectancy and infant survival as outputs in measuring public healthcare efficiency, while studies of international health systems also use life expectancy together with transformed infant mortality/survival indicators.

Accordingly, the production relationship considered in the study can be represented as:

The DEA model is estimated using DEAP Version 2.1, developed by Coelli. DEAP permits the estimation of Constant Returns to Scale (CRS) and Variable Returns to Scale (VRS) DEA models and reports technical efficiency, scale efficiency, slacks, peer units and target values.

The principal specification uses the Variable Returns to Scale (VRS) model developed by Banker, Charnes and Cooper (1984). The VRS specification is preferred because Indian states differ substantially in population size, fiscal capacity, public-health infrastructure and the scale at which healthcare services are provided. Imposing Constant Returns to Scale would require the restrictive assumption that all states operate at an optimal and comparable scale. The BCC/VRS approach separates pure technical efficiency from scale efficiency and permits DMUs to operate under increasing, constant or decreasing returns to scale.

Under VRS, technical efficiency measures the state's ability to transform its given health resources into health outcomes after allowing for differences in operational scale. Scale efficiency is obtained as:

where denotes technical efficiency under Constant Returns to Scale and denotes pure technical efficiency under Variable Returns to Scale. A scale-efficiency score equal to one indicates that the state operates at the most productive scale size, whereas a score below one indicates scale inefficiency.

An output-oriented DEA model is adopted. The output orientation is appropriate because the analytical objective is to examine the extent to which health outcomes could be improved with the existing levels of public-health resources. Thus, rather than asking how much expenditure or infrastructure could be reduced while maintaining the existing outcomes, the model asks how far desirable health outcomes could potentially be expanded with the available inputs.

In an output-oriented VRS model, an efficiency score of one indicates that the state lies on the estimated efficient frontier. A score below one indicates that the state is relatively inefficient compared with the best-practice states in the sample. The resulting scores should therefore be regarded as measures of relative efficiency, rather than absolute measures of the quality of the health system. The results are as follows

Table 2- efficiency of states in health capacity

DMU	State	CRS TE	VRS TE	Scale Efficiency	RTS
1	Andhra Pradesh	0.190	0.941	0.201	DRS
2	Arunachal Pradesh	1.000	1.000	1.000	CRS
3	Assam	0.235	0.926	0.254	DRS
4	Bihar	0.167	0.943	0.177	DRS
5	Chhattisgarh	0.831	1.000	0.831	DRS
6	Gujarat	0.146	0.956	0.153	DRS
7	Karnataka	0.185	0.931	0.199	DRS
8	Kerala	0.832	1.000	0.832	DRS
9	Madhya Pradesh	0.139	0.911	0.153	DRS
10	Maharashtra	0.167	0.982	0.170	DRS
11	Odisha	0.195	0.975	0.200	DRS
12	Punjab	0.602	1.000	0.602	DRS
13	Rajasthan	0.088	0.925	0.096	DRS
14	Tamil Nadu	0.210	0.976	0.215	DRS
15	Telangana	0.647	1.000	0.647	DRS
16	Uttar Pradesh	0.058	0.880	0.066	DRS
17	Uttarakhand	0.622	1.000	0.622	DRS
Mean		0.371	0.962	0.377	

Source- Author’s own estimation using DEAP

The results indicate substantial differences between pure technical efficiency and scale efficiency across the selected states. The mean technical-efficiency score under CRS is 0.371, while the mean VRS technical-efficiency score is considerably higher at 0.962. Mean scale efficiency is only 0.377.

The large difference between CRS and VRS efficiency is an important finding. The relatively high mean VRS score indicates that, after accounting for differences in operating scale, most states are located reasonably close to the best-practice frontier. In contrast, the much lower CRS and scale-efficiency scores suggest that the principal source of measured inefficiency arises from scale-related factors rather than pure technical inefficiency. This distinction follows directly from the Banker, Charnes and Cooper framework, which was developed to separate managerial or pure technical efficiency from inefficiency caused by inappropriate scale of operation.

Under the VRS specification, six states achieve a technical-efficiency score of unity: Arunachal Pradesh, Chhattisgarh, Kerala, Punjab, Telangana and Uttarakhand. These states therefore form part of the estimated efficient frontier.

An efficiency score of one should not be interpreted as indicating that these states possess perfect healthcare systems or the best health outcomes in an absolute sense. DEA efficiency is relative to the particular combination of inputs and outputs and to the other DMUs included in the sample. Thus, these states are considered efficient because no other observed state or feasible combination of states produces proportionately better modelled health outcomes with the same or lower resources.

This interpretation is consistent with the nature of DEA, which evaluates relative rather than absolute efficiency. Earlier DEA applications have emphasised that efficient DMUs constitute the empirical frontier against which inefficient units are benchmarked.

Several states that do not achieve full efficiency nevertheless record relatively high VRS scores. Maharashtra has a VRS efficiency score of 0.982, followed by Tamil Nadu at 0.976, Odisha at 0.975, Gujarat at 0.956, Bihar at 0.943, Andhra Pradesh at 0.941, Karnataka at 0.931, Assam at 0.926, Rajasthan at 0.925, Madhya Pradesh at 0.911, and Uttar Pradesh at 0.880.

These results indicate that most states are relatively close to the VRS frontier. Nevertheless, the distance from the frontier varies across states. Uttar Pradesh records the lowest pure technical-efficiency score of 0.880 among the 17 DMUs, suggesting comparatively greater scope for improving health outcomes using its existing resource base.

Because the model is output-oriented, an inefficient state has the potential to proportionately expand desirable outputs before reaching the efficiency frontier. However, the precise targets also incorporate output and input slacks; consequently, interpretation should be based on the DEAP projection values rather than simply calculating .

The most striking feature of the results is the relatively low level of scale efficiency. With the exception of Arunachal Pradesh, all states are identified as operating under decreasing returns to scale (DRS). Arunachal Pradesh records CRS technical efficiency, VRS technical efficiency and scale efficiency of 1.000, making it the only DMU operating at constant returns to scale in this specification.

Several large states display particularly low scale-efficiency scores. Uttar Pradesh records a scale-efficiency score of only 0.066, Rajasthan 0.096, Gujarat and Madhya Pradesh approximately 0.153, Maharashtra 0.170, and Bihar 0.177. By comparison, Kerala and Chhattisgarh record scale-efficiency scores of approximately 0.832 and 0.831, respectively.

Within the BCC framework, decreasing returns to scale imply that proportional increases in inputs are associated with less-than-proportional increases in outputs at the observed scale of operation. Nevertheless, the present finding requires cautious interpretation. Since the study uses the absolute number of hospital beds and absolute public health expenditure as inputs, while life expectancy and inverse IMR are population-level outcomes, large states naturally possess much larger input quantities without generating proportionately larger values of life expectancy or infant-survival indicators. Therefore, part of the observed scale inefficiency may reflect differences in population size rather than genuine excess scale in public-health provision.

For this reason, the scale-efficiency results should not be interpreted as evidence that states such as Uttar Pradesh or Rajasthan literally possess excessive public-health infrastructure. Rather, they indicate that, relative to the particular input-output specification used here, the aggregate volume of resources is not associated with proportionately higher values of the selected population-health outputs.

The peer analysis provides further information concerning best-practice states. Kerala emerges as the most frequently used reference unit, appearing as a peer for 11 DMUs. Uttarakhand is selected as a peer five times, while Punjab appears once. Kerala's frontier status is supported by its strong observed health outcomes. The state records a life expectancy of 75 years and an inverse IMR of approximately 0.143 in the dataset, while obtaining a VRS efficiency score of unity.

Its frequent appearance in the reference sets means that the DEA algorithm identifies Kerala's observed combination of resources and outcomes as a particularly relevant benchmark for inefficient states. This does not imply that all states should literally reproduce Kerala's health system; rather, Kerala represents one observed best-practice combination against which other states' relative performance is evaluated. The benchmarking role of frontier states is one of the principal advantages of DEA. Health-sector DEA studies similarly use reference sets and peer units to identify combinations of health-system resources and outcomes that can serve as empirical comparators for less efficient jurisdictions.

The DEA results indicate that the selected Indian states generally demonstrate high pure technical efficiency but substantial scale inefficiency in transforming public-health resources into population-health outcomes. A mean VRS efficiency score of 0.962 suggests that most states lie relatively close to the best-practice frontier once differences in operational scale are recognised. However, the much lower mean CRS score of 0.371 and scale-efficiency score of 0.377 indicate that differences in scale account for a large share of measured overall inefficiency.

This broad result is consistent with the motivation for applying VRS DEA in health systems, where jurisdictions frequently operate under heterogeneous demographic, institutional and resource conditions. Banker, Charnes and Cooper (1984) specifically developed the VRS framework to distinguish pure technical inefficiency from scale inefficiency. Recent Indian evidence also demonstrates substantial variation in public-health efficiency across states. One recent two-stage DEA analysis of Indian public healthcare found considerable inefficiency and showed that improvements in efficiency could potentially generate substantial gains in life expectancy and infant survival without proportional increases in health resources.

The present DEA results therefore complement the regression findings. While the regression analysis indicates that higher public health expenditure is systematically associated with improved health outcomes, DEA demonstrates that the effectiveness with which resources are converted into health outcomes differs across states. Higher expenditure alone is consequently not sufficient to guarantee efficient health-system performance; resource utilisation, infrastructure, scale, institutional conditions and the organisation of health-service delivery also matter.

A methodological limitation, however, must be acknowledged. The present DEA specification uses absolute numbers of government hospital beds and public health expenditure as inputs while the outputs—life expectancy and inverse IMR—are population-level indicators. This can systematically disadvantage more populus states and contribute to the widespread decreasing-returns-to-scale classification. Also, due to data availability issues, only the analysis for 2018 have been performed. A robustness analysis using government hospital beds per 10,000 population and public health expenditure per capita and year wise it's change would therefore strengthen the empirical findings and permit a more population-adjusted comparison of public-health efficiency across states.

Conclusion

The study evaluates state-level public health-sector performance by combining panel regression analysis with Data Envelopment Analysis (DEA). The Driscoll–Kraay fixed-effects estimates reveal a consistent and statistically significant relationship between public health expenditure and major health outcomes. Higher public health expenditure is associated with increased life expectancy and reduced infant mortality, maternal mortality, and total fertility rate, even after controlling for per-capita NSDP. The results therefore indicate that public health financing plays an important role in improving population-health outcomes, while economic development alone may not necessarily ensure better health performance.

The DEA results complement the regression findings by demonstrating that the availability of resources does not automatically translate into efficient health outcomes. The mean VRS technical-efficiency score of 0.962 indicates relatively high pure technical efficiency, with Arunachal Pradesh, Chhattisgarh, Kerala, Punjab, Telangana, and Uttarakhand forming the efficiency frontier. However, the considerably lower mean scale efficiency of 0.377 indicates substantial scale-related inefficiency. Kerala emerged as the most prominent benchmark for inefficient states.

Overall, the findings demonstrate that strengthening public health systems requires not only greater public expenditure but also efficient utilisation of financial and infrastructural resources. Thus, public-health capacity should be understood as the ability of states to effectively transform available resources into improved health outcomes, rather than merely the volume of expenditure incurred.

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