India's Public Healthcare System in Different Dimensions: An Econometric Review across Major Indian States from 1981-2015

Sovik Mukherjee
Assistant Professor, Department of Economics, Faculty of Commerce & Management Studies, St. Xavier's University, Kolkata
Soumak Basumallik
Ph.D. Scholar and Graduate Assistant**,** University of Colorado Denver, Denver, USA

Abstract
The objective of this paper is to take a closer look at the liaison between the two focus variables viz. growth and public healthcare expenditure, and the associated implications for public health infrastructure development and related health inequality. We make use of panel cointegration and causality in a Vector Error Correction Mechanism (VECM) framework using panel data from 1981-2015. Though reducing health inequalities is an important policy agenda, till now research on health inequality has been mostly concentrating on the developed countries and there is a very scant literature in the Indian context and herein lies our contribution to the existing literature. India, being a developing country, now has comprehensive datasets for some socio-economic health indicators like, — Life Expectancy Rates, Infant Mortality Rates, Total Fertility Rates, etc. and their related disparities. Hence, research on health inequalities could be instrumental in drawing attention to the health of socio-economically vulnerable groups. In this endeavour, we have tried to examine the inequality in two crucial health related variables, 'life expectancy at birth' and 'infant mortality rates' for 23 major states in India. To do this, we have used the tool of the Concentration Index (CI), a frequently used indicator of the socio-economic inequality of health. To give more tangible policy directions on the position of public healthcare infrastructure vis-à-vis health inequalities, we have used Euclidean distance function approach to construct a public health infrastructure index (PHII) across 23 major states in India for two terminal time points i.e. 2005-06 and 2014-15. This index will be serving as a measure for evaluating the variations in the inter-state performance in public healthcare infrastructure and related implications thereof.
Key Words: *Cointegration, Concentration Index, Difference Equations, Euclidean Distance, Economic Growth, Granger Causality, Public Health Infrastructure.*

1. Introduction

Health is like the money we never have a true idea of its value until we lose it.

— Josh Billings

In the modern world characterized by the rapid change of globalization, one of the alarming concerns that we face today is of the economic and social inequalities faced by its inhabitants. These social and economic inequalities translate into nutritional and health inequalities. It is true that, with advancements in technology, there has been a massive progress in healthcare industries over the last two decades, India being no exception. However, the overall picture of health in the world is still somewhat ambiguous wherein the massive inequality in health among the people of different countries is definitely very unsettling. Access to preventive and protective healthcare enhances the entitlements of the poor by enabling steady employment generation and improved productivity. Hence, health-status among the inhabitants of a society can be considered as most crucial to economic development as higher inequality in health among the poor is detrimental to the overall development of the society. In pursuit of moving up the hierarchy of economic development, development of infrastructure in terms of both quantity and quality is a must. It is suggested that infrastructure supports the processes of growth on which depends much of the poverty/inequality reduction. For a systematic understanding of the healthcare policy and the associated welfare mechanisms, it becomes crucial to study the health infrastructure conditions of an economy (Novick & Mays, 2005). In India, the healthcare services are alienated into State List and Concurrent List. Some items like public hospitals come under the jurisdiction of the State List, while population control and family welfare, medical education, and quality control of drugs are included in the Concurrent List. The Union Ministry of Health and Family Welfare (UMHFW) functions as the pivotal force for the implementation of various schemes in the field of family welfare, curative prevention, and control of major diseases.

Healthcare in India has been developed as a three-tier structure. The Sub-Centres form the lower tier of the structure followed by Primary Health Centres and Community Health Centres forming the middlemost and uppermost tiers respectively. Talking about the recent health infrastructure position in India, there exist 1 Sub-Centre per 5,000 populations in the general areas and 1 Sub- Centre per 3,000 populations in the tribal and hilly areas. For Primary Health Centres, the figure stands at 1 per 30,000 of populations and 1 per 20,000 of populations in general and tribal areas respectively. Coming to the overall position in India, there are around 1,53,655 Sub-Centres (SCs), 25,308 Primary Health Centres (PHCs), 5,396 Community Health Centres (CHCs), 1022 Sub-divisional Hospitals (SDHs) and 763 District Hospitals (DH) in the country. There is an acute shortfall of 33145 SCs (20 per cent), 6556 PHCs (22 per cent) and 2316 CHCs (32 per cent) across the country according to the Rural Health Statistics of 2015. There needs to be a lot of improvement in this arena given the fact that India's total health expenditure is 4 per cent of GDP whereas public health expenditure stands at an all time low of 1 per cent of GDP.

In this backdrop, this paper explores the impact of health expenditure on growth and also the position of the states with regards to the health infrastructure situation. Although, studies about the interaction between health and per-capita economic growth have been flourishing but panel data studies for any of the developing countries is a rare phenomenon. So, a modest attempt has been made in this regard.

Moving into the domain of health inequality given the existing public healthcare infrastructure, India now has ample data sets for analyzing some socio-economic health indicators like, Life Expectancy Rates, Infant Mortality Rates, Total Fertility Rates, etc. and their related disparities. As a result, research on health inequalities is taking center stage and has been drawing attention to the health of socio-economically disadvantaged groups in India. Studies on health inequalities in India have shaped the dialogue for public health action, emphasized the need for greater and targeted investments in health, and can be an important indicator for the effectiveness of public healthcare services (Kumar & Acanfora, 2001; Balarajan et al., 2011). However, though reducing health inequalities is an important policy agenda, till now research on health inequality has been mostly concentrated on developed countries and there is a scant literature on this in the Indian context. Herein, we have attempted to fill in the gap.

The rest of the paper has been organized as follows. To start with, a brief evaluation of the select literature has been carried out in Section 3 preceded by the objectives in Section 2. Section 4 illustrates the econometric methodology employed and hence puts forward the empirical results and discussions thereof pertaining to growth and public healthcare expenditure; health inequality and public health infrastructure. The paper ends with a conclusion.

2. Objectives of the Study

The objective of this paper is to take a closer look at the liaison between the two focus variables *viz.* growth and public healthcare expenditure, and the associated implications for public health infrastructure development and health inequality in a framework using panel data from 1981-2015. Though reducing health inequalities is an important policy agenda, till now research on health inequality has been mostly concentrating on the developed countries and there is a very scant literature in the Indian context and herein lies our contribution to the existing literature. In this endeavour, we have tried to examine the inequality in two crucial health related variables, 'life expectancy at birth' and 'infant mortality rates' for 23 major states in India. In the light of health inequality and public healthcare expenditure, we construct a public health infrastructure index (PHII) across 23 major states in India for two terminal time points i.e. 2005-06 and 2014-15 as a measure for evaluating the variations in the inter-state performance in public healthcare infrastructure and related implications thereof.

3. Review of Select Literature

One of the essential issues in healthcare systems across the world is that what factors control the resources a country allocates to medical care. The share of health expenditures of GDP in the developing countries is often less as compared to the developed countries. The role of health care spending on stimulating economic growth was first suggested by Mushkin (1962). This is known as the "health-led growth hypothesis". According to Mushkin's hypothesis, "health is a capital, thus investment on health can increase income, hence lead to overall economic growth." In fact, health affects the growth prospects of a nation through its impact on human and physical capital accumulation. Since healthier people are much more productive, they have a strong incentive to develop their knowledge and skills because they want to savour the benefit over a longer period of time (Bloom & Canning, 2000). In contrast, poor health status has an unfavourable impact on productivity, thus it transpires to be a significant factor in explaining the under-development in many regions throughout the world.

On the other hand, economic growth can also liven up the health status of the population in two aspects :– Firstly, economic growth implies rising per-capita income and a part of this increased income goes into the consumption of a higher quantity of nourishing food. As a result, health improves. Secondly, economic growth is fuelled by the technological health care expenditure and part of this progress is reflected in improvements in medical science. From the microeconomic perspective, when individual's income is low, demand for medical care also tends to be low. As a result, the marginal rate of return to invest in health through medical care investment is very high. Hence, a small percentage increase of income will strongly improve the health state. When an individual attains a very healthy condition, an additional income will not make this individual healthier, but stagnant. As a result, the effect of economic growth on the health status of a nation is concave and depends on the level of development (Preston, 1975).

Shifting the focus, a variety of empirical studies, based on time-series or cross-country data, have estimated the extent of the contribution of public expenditures to economic growth. Some studies try to associate levels of public expenditures to growth while others focus have focused on the relationship between certain expenditure components, such as public investment which includes education or health expenditures. Some studies (Devarajan, Swaroop & Zou 1996; De & Endow, 2008) have predicted a positive unidirectional relation between the focus variables while others (Baltagi & Moscone, 2010; Erdil & Yetkiner, 2009) have hit upon a positive bidirectional impact between health expenditure and income. The authors of Baltagi and Moscone (2010) examined the long run relationship between health expenditure and income growth in 20 OECD countries during 1971-2004. The study by Erdil and Yetkiner (2009) shows that the bidirectional causality between health expenditure and GDP growth depends on the type of countries *viz.* high, low and middle income countries. Their analysis brings to light that one-way causality runs from GDP to healthcare expenditure in the low and the middle income countries, whereas the reverse holds for high income countries. Initially, health expenditure acts as an investment in human capital, and given that human capital accumulation is an elemental source of economic growth, an increase in healthcare expenditure in due course leads to a higher level of GDP. Additionally, an increase in the healthcare expenditures associated with effective health intervention increases labour supply and productivity. This in turn increases the earnings of an individual which ultimately leads to a rise in GDP. Thus, all kinds of expenditure on health make a positive contribution to economic growth by developing the quality of human capital. Taking a walk down memory lane, the study by Sorkin (1978) can be regarded as one of the earliest studies of its kind to examine the impact of health on economic growth. Sorkin (1978) argues that a decline in the birth rate positively affects economic growth. Similar research papers such as Arora (2001) scrutinized the effect of health on economic growth for 10 industrialized countries. With a rise in the growth rate, health parameters have significantly improved. Bhargava et al. (2001) have studied the impact of health indicators for the period 1965-90 for developed and developing countries. The extent of increase in economic growth performance with the improvement in public health in developing countries is much more as compared to the developed countries. Going by Bloom et al. (2001), an annual improvement of 1 year in the life expectancy component increases growth to the tune of 4 per cent. Howitt (2005) highlighted the channels that influence the health of the country in the light of Schumpeterian growth theory. Some time series studies like Halder (2008), McCoskey and Selden (1998) have tried to focus on the direction of causality and issue of cointegration between health expenditure and growth. The empirical literature however brings in controversial results as research papers have come up with bidirectional, unidirectional or no causality results (Devlin & Hansen, 2001). Heading for a different issue, Aghion et al. (2011) portrays the relationship between health and growth in the light of modern endogenous growth theory and observed that in those OECD countries where mortality rates are less than 40 years have experienced increase in growth. In India, studies with regard to the trivariate analysis of growth, health infrastructure and health expenditure are very few. Ghei et al. (2010) found positive association between child immunization and availability of adequate healthcare infrastructure whereas Datar, Mukherji and Sood (2007) showed that the availability of healthcare infrastructure had only a modest effect on immunization coverage.

Furthermore, very few studies have focused on assessing health inequalities in India. Till date, the Indian policy sphere is devoid of discussion on health inequalities. In time, it was with a series of global and national events that brought health inequalities on the policy radar in India. The spotlight of India’s health research during the eighties was on family planning, reproductive health and child survival (Das Gupta, 1990). Also, due to world-wide policy emphasis on the role of women in reducing health disparities in reproductive and child health led to mainstreaming of gender in research (Catino, 1999), the issue of health inequality in gender came to the forefront. As a result, gender and poverty were considered the structural determinants of health inequalities in maternal and child health. It is important to know how inequalities in health vary with the level of development of states, especially in the context of previous studies that have shown that improvement in level of development is accompanied by rising health inequalities (e.g. Wagstaff, 2000, 2002; Naschold, 2002; Victoria et al., 2003 and Graham & Kelly, 2004). Sadly, studies assessing the health inequalities across states in India are very few. Moreover, the notable socio-economic and demographic disparities across the major states of India provide an ideal setting for assessing health inequalities. That is to say, we need to quantify the inequalities in public healthcare since reducing health inequalities is an important part of the agenda of health policymakers globally. Therefore, steps should be taken to document the basic levels of health inequality across individuals, over time periods, across countries and regions or states or any other cluster because public health policy needs to be targeted at reducing such inequalities, in addition to reducing disparities in average health status across groups in society.

4. The Empirical Framework

4.1 Data Description

This paper evaluated the causality and long-run relationship existence between economic growth (using Gross State Domestic Product, GSDP) and public healthcare expenditure (PHE) across 23 major states in India from 1981-2015 using Panel Cointegration method. The 23 major states on which this analysis has been carried out includes — Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Goa, Gujarat, Haryana, Himachal Pradesh, Jammu and Kashmir, Karnataka, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Nagaland, Orissa, Punjab, Rajasthan, Sikkim, Tamil Nadu, Tripura, Uttar Pradesh and West Bengal. Uttarakhand was created out of Uttar Pradesh in 2000, so the data for Uttar Pradesh post 2000 includes the data of Uttar Pradesh plus Uttarakhand to maintain uniformity. Same is the case for Bihar and Madhya Pradesh which includes the data for Jharkhand and Chattisgarh post 2000. In the backward areas, private healthcare institutions are limited and to get an appropriate idea of the extent of public healthcare intervention, the spotlight has been only on public healthcare expenditure. Also, since the objective of this paper is to throw light on the public health infrastructural issues, private healthcare expenditure has not been taken into account. Annual data on the necessary components have been extracted from the Sample Registration System-Registrar General, Budget minutiae of the State Governments, the Reserve Bank of India Bulletin (several issues), Central Statistical Organization and the Ministry of Statistics and Programme Implementation (MOSPI), Government of India, New Delhi. Also, for extracting data on the per-capita state GDP at market prices, the website *www.indiastat.com* was visited. In order to avoid the scale effect, the authors have considered state public healthcare expenditure as a percentage of the GSDP (both in real per-capita terms) coupled with real per-capita GSDP growth rate. It needs to be noted that the expenditure on health does not include fund allocation for water supply and sanitation.

4.2 Econometric Methodology

Before starting off with the panel unit root tests, the heteroskedasticity needs to be looked at. The Chi-Square value of 18.22 in Table 1 is low and lies within the confidence limits and the results undeniably confirm the absence of heteroskedasticity as the null hypothesis of "constant variance in the model" gets accepted. The foremost difference lies in the fact that in case of a panel data study, it is required to take into account the asymptotic behaviour of the time-series dimension *T* and cross-sectional dimension *N*.

Table 1. Heteroskedasticity Results

	Likelihood-ratio test LR Chi-Square value (χ^2)	Probability > Chi-Square (χ^2)
H_0 : Constant variance	18.22	0.98*

Notes: * denotes significance at 95 per cent level and calculation has been done by the authors in Stata 12

Levin, Lin and Chu (LLC) unit root tests have been used in this study. The test is based on their model given below :

$$\Delta y_{it} = \alpha_i y_{it-1} + \sum_{j=1}^{p_j} \beta_{ij} \Delta y_{it-j} + x_{it}{}'\delta + \varepsilon_{it}$$

Here, α_i is the error correction term and consequently, the null hypothesis of non-stationarity is as follows :

Tests hypotheses :

H_0 : $\alpha_i = 0$ for all the cross section units, so the series is non-stationary and has a unit root.

H_1 : $\alpha_i < 0$ for at least one cross section unit, so the series is trend stationary.

When the probability value obtained from the test results is smaller than 0.05, H_0 is rejected and the stationarity of the series gets determined. LLC panel unit root test results that we have got are reported in Table 2. As Levin, Lin and Chu (2002) have pointed out; this test-statistic performs well when N lies between 10 and 250 and when T lies between 5 and 250. To determine whether a cointegrating relationship exists or not, the methodology proposed by Pedroni (1999) has been employed. Fundamentally, it employs four panel statistics and three group panel statistics to test the null hypothesis of no cointegration against the alternative hypothesis of cointegration. The first set is the within-dimension approach comprising of four statistics that are - panel v-statistic, panel ρ-statistic, panel PP-statistic and the panel ADF-statistic (Pedroni, 1999). This set pools the autoregressive coefficients across various members for the unit root tests to be carried out on the estimated residuals. The second set of statistics, centered on the between-dimensional approach, includes three statistics that are respectively the group ρ-statistic, group PP-statistic and group ADF-statistic. If the variables are not cointegrated it implies that the residuals are not I(0). These estimators are based on Monte Carlo simulations and the details for these calculations are given in the original paper (Refer to Pedroni, 1999). If the null hypothesis is rejected in the panel case, then the variables in question are cointegrated for all the 23 states considered. On the other hand, if the null is rejected in the group panel case, then cointegration among the relevant variables exists for at least one of the states. The VECM framework used has been given below.

$$\Delta GDP_{i,t} = \alpha_{1,i} + \varphi_{1,i} ECT_{i,t} + \sum_{j=1}^{k} \beta_{1,j,i} \Delta HE_{i,t-j} + \sum_{j=1}^{k} v_{1,j,i} \Delta GDP_{i,t-j} + \varepsilon_{1,i,t}$$

$$\Delta HE_{i,t} = \alpha_{2,i} + \varphi_{2,i} ECT_{i,t} + \sum_{j=1}^{k} \beta_{2,j,i} \Delta HE_{i,t-j} + \sum_{j=1}^{k} v_{2,j,i} \Delta GDP_{i,t-j} + \varepsilon_{2,i,t}$$

Where i (i = 1,…N) denotes the state, t (t = 1,...T) the period, j is the optimum lag considering the Akaike Information Criteria (AIC). ECT is the lagged error correction term derived from the long-run co-integrating relationship; the φ_1 and φ_2 are the adjustment coefficients and $\varepsilon_{1,i,t}$ and $\varepsilon_{2,i,t}$ are disturbance terms assumed to be white-noises and uncorrelated. The coefficients on the ECTs represent how fast the deviations from the long-run equilibrium are eliminated following a change in each of the variables. If the ECTs coefficients are zero ($\varphi_{1,i} = 0$, or $\varphi_{2,i} = 0$) for all i, then there is no error correction and thus there exists no cointegration. But if ($\varphi_{1,i} < 0$, or $\varphi_{2,i} < 0$) then there exists error correction and consequently, we have cointegration. This paper examines the health expenditure and per-capita GDP growth rate relationship by taking advantage of the heterogeneous panel cointegration framework developed by Pedroni (1999) across the 23 major states in India. It should be noted that the first four statistics comply with the 'within-dimension' based terminology of panel data and the rest are 'between-dimension' based statistics. Now, we move on to the causality issue in case of panel data. Given that, this analysis is being carried out across the 23 major states in India, the assumption that coefficients are different across cross-sections follows from Dumitrescu and Hurlin (2012), i.e.

$\alpha_{0,i} \neq \alpha_{0,j}, \alpha_{1,i} \neq \alpha_{1,j}, \ldots \alpha_{p,i} \neq \alpha_{p,j}$,

$\mu_{0,i} \neq \mu_{0,j}, \mu_{1,i} \neq \mu_{1,j}, \ldots \mu_{p,i} \neq \mu_{p,j}$ and

$\beta_{1,i} \neq \beta_{1,j}, \ldots \beta_{p,i} \neq \beta_{p,j}$ &

$\eta_{1,i} \neq \eta_{1,j}, \ldots \eta_{p,i} \neq \eta_{p,j}$ for all i and j.

Bivariate regressions in Dumitrescu and Hurlin (2012) take the form,

$$y_{i,t} = \alpha_{0,i} + \sum_{p=1}^{k} \alpha_{p,i} y_{i,t-p} + \sum_{p=1}^{k} \beta_{p,i} x_{i,t-p} + \varepsilon_{i,t}$$

$$x_{i,t} = \mu_{0,i} + \sum_{p=1}^{k} \mu_{p,i} x_{i,t-p} + \sum_{p=1}^{k} \eta_{p,i} y_{i,t-p} + e_{i,t} \text{ where,}$$

t denotes the time period dimension of the panel, and i denotes the cross-sectional dimension and k is the number of lags. This assumption is applicable for India contrary to the assumption where the panel is treated as one large stacked data set. The intention is to perform Granger causality regressions for each and every individual cross-sectional unit. Subsequently, take the average of the Wald statistics derived from each cross section to get the W-bar statistic.

4.3 Results and Discussion

Table 2 presents the results of the Levin, Lin, Chu (LLC) unit root tests. The results indicate that both variables are stationary after first differencing. In other word, both variables are integrated of order (1). Hence, we can apply the procedure of Pedroni (1999) to look into the cointegration possibility between the focus variables. In this study, given the AIC criteria, an optimum lag of 2 has been considered. The results in Table 3 designate the existence of a cointegrated relationship between health spending and per-capita economic growth in the long run. Under the alternative hypothesis, the panel-v statistic diverges to positive infinity (∞^{+}), and the right-hand tail of the standard normal distribution has been used to reject the null hypothesis. However, all the other panel cointegration test statistics diverge to negative infinity (∞^{-}). Therefore, the left-hand tail of the standard normal distribution is used to reject the null hypothesis. There is a strong evidence of panel cointegration as the test statistic values lie in the critical region (be it right-hand tail or left-hand tail) and the null hypothesis of 'no cointegration' gets resoundingly rejected.

Table 2. LLC Unit Root Test Results

Variables	**Level**	**Probability**	**1st Difference**	**Probability**	**Result**
GSDP	0.37	0.61	-3.40	0.00*	I(1)
PHE	-0.63	0.27	-4.62	0.00*	I(1)

Notes : * denotes significance at 95 per cent level and calculation has been done by the authors in Eviews-7

This tests that whether GSDP and PHE follows a unit root process or not. At the level value, the approximate p-value for GSDP and PHE is 0.61 and 0.27 respectively. So, the null hypothesis of existence of unit root cannot be rejected. The next step is to carry out the first order differencing of the data and the results suggest that the both the GSDP and PHE series become stationary at the first order. The p-value of 0.00 implies that the null hypothesis of presence of unit root gets rejected. This helps in building up a model based on first order stationary data set. However, the presence of a cointegrating liaison does not give any clear idea regarding the causality between the concerned variables in this section. The results of the test for causality are reported in Table 4 below.

Table 3. Panel Cointegration Test

Test procedure	**Test statistic**	**Probability value**	**Result**
Panel v-statistic	3.19	0.00*	Cointegration
Panel rho-statistic	-2.35	0.00*	Cointegration
Panel PP-statistic	-3.08	0.00*	Cointegration
Panel ADF-statistic	-2.90	0.00*	Cointegration
Group rho-statistic	-4.72	0.00*	Cointegration
Group PP-statistic	-2.77	0.00*	Cointegration
Group ADF-statistic	-8.11	0.00*	Cointegration

Notes : * denotes significance at 95 per cent level and calculation has been done by the authors in Eviews-7

Table 4. Results of Panel Causality Test

Null Hypothesis	**W-bar statistic**	**Probability**
PHE does not Granger Cause GSDP	3.23	0.00*
GSDP does not Granger Cause PHE	4.59	0.00*

Notes : * denotes significance at 95 per cent level and calculation has been done by the authors in Eviews-7

The authors have found only one cointegrating vector. This is justified because if investment on public health rises, it is bound to create a repercussion effect on income growth in the long run. Consequently, the policy formulations at the federal level should take into account this liaison but what happens to this relationship at the state level has been left for further research and is worth exploring. The Wbar statistic for both cases lies in the critical borough as suggested by the p-value and the null hypothesis of 'PHE does not Granger Cause GSDP' and 'GSDP does not Granger Cause PHE' gets rejected. Therefore, there exists a bilateral causality running between GSDP and PHE which is in harmony with the results obtained in Hurd and Kapteyn (2003). The higher is the healthcare expenditure, better are the infrastructural facilities and as people are able to avail these facilities, the burden of disease falls. Thus, labourers become more productive and are capable enough to bring in more income. A rise in income in the subsequent periods leads to growth. In contrast, if economic growth rises it means that citizens are better off. This in turn means that the citizens will be capable enough to demand high quality health infrastructure which in turn will put pressure on the Government to increase healthcare expenditure. These arguments can be seen in light of a negative perspective also. If healthcare expenditure is at its minimal level, quality of health infrastructure will be poor and labour productivity will fall. The quality of the healthcare infrastructure is actually poor for many states across India (Refer to Table 7). Consequently, economic growth peters out. When economic growth is low, this means that people are not proficient enough to earn more, so demand for quality healthcare services will be less. This justifies the fact that healthcare expenditure will also be less. As a result, the bidirectional causal relation is justified in the Indian context.

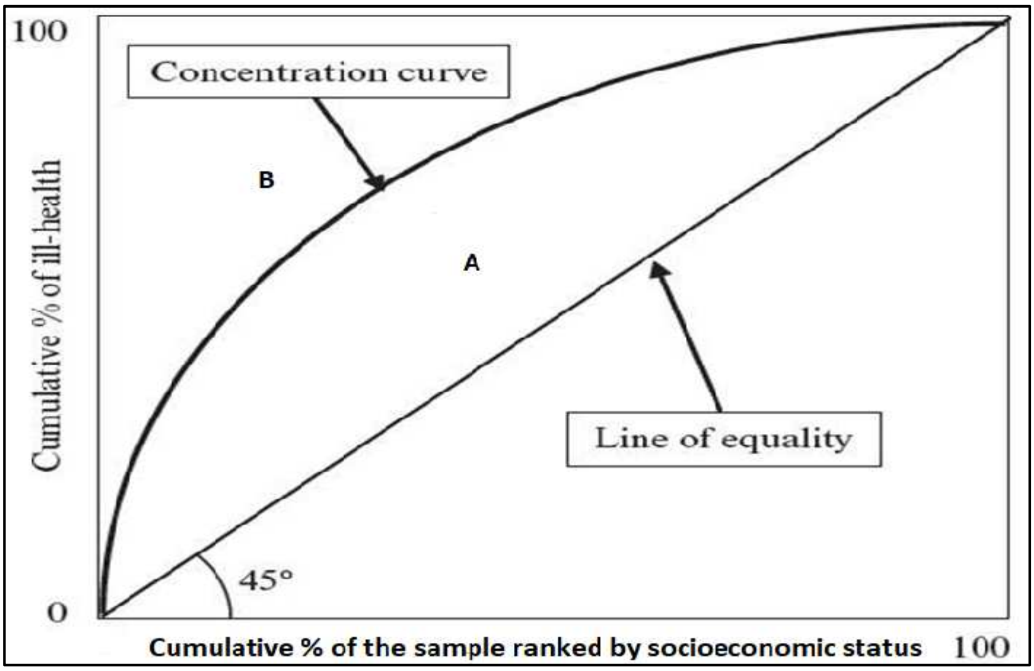
4.4 Income related Inequalities in Health

Given the results in Section 4.3, now, its time to assess the inequality in the level of health status across the major states in India over the time period concerned and then move on to the granular assessment of the formulation of the health infrastructure index to validate these results. To begin with, our basic objective, in this section, is to explore the inequality associated with per capita health expenditure and health (health being captured by Infant Mortality Rate (IMR) and Life Expectancy at Birth (LEB)) across 23 major states in India (ranked with respect to state-wise per capita health expenditure) over the range of the years. It needs to be noted that IMR is an indicator of 'ill-health' status while LEB is an indicator of 'good-health' status.

Computational Methodology of Health Inequality – Use of Concentration Index

A Concentration Curve displays the share of health accounted for by cumulative proportions of individuals in the population ranked from poorest to the richest (Kakwani, et al. 1997; Wagstaff, et al. 1991). It can be used to examine inequality not just in health outcomes but in any health sector variable of interest over time and across countries. The two key variables underlying the Concentration Curve are, the health variable; the distribution of which is the subject of interest and a socio-economic variable capturing living standards, against which the distribution of the sample is to be assessed. The health variable must be measured in units that can be aggregated across individuals or quantiles or groups. However, this is not necessary for the socio-economic variables, which is used only to rank individuals from richest to poorest (or lowest to highest). So, for example, the curve might show the cumulative percentage of health subsidies accruing to the poorest *p* % of the population. If everyone, irrespective of his or her living standards, has exactly the same value of the health variable, the concentration curve will be a 45-degree line, running from the bottom left-hand corner to the top right-hand corner. This is known as the **line of equality** (as shown in Figure 1). If, by contrast, the health sector variable takes higher values among poorer people, the CC will lie above the line of equality. The further the curve is above the line of equality, the more concentrated the health variable is among the poor. In other words, it means that the health variable is disproportionately concentrated on the poor. Alternatively, if the health variable takes on smaller values amongst the poor, the CC will lie below the line of equality, and the further below the line of equality the CC lies, the more concentrated the health variable will be among the better off section of the population. In this case, it means that the health variable is disproportionately concentrated on the rich.

Figure 1. Ill-Health Concentration Curve



Source: Obtained by the authors

Now, from Figure 1, technically we can define the Concentration Index (*CI*) as *twice the area between the Concentration Curve (CC) and the line of equality (the diagonal of CC)*. Based on Figure 1, the CI can be defined as $\mathrm{C} = \frac{\mathrm{A}}{\mathrm{A+B}}$; C being the CI. By putting B = 0.5 – A in $\mathrm{C} = \frac{\mathrm{A}}{\mathrm{A+B}}$ we have, $\frac{\mathrm{A}}{\mathrm{A+B}} = \frac{\mathrm{A}}{\mathrm{A+0.5-A}} = \frac{\mathrm{A}}{0.5}$ = 2A. Therefore, C = 2A, which translates into twice the area between the CC and the line of equality.

Now, since the CI is bounded between -1 and $+1$ we can say that, $-1 \leq \mathrm{C} \leq 1$. Based on that some *characteristics of the CI* are as follows :

- $C > 0 \Rightarrow$ Health Variable is disproportionately concentrated on the richer sections of the population.
- $C = 0 \Rightarrow$ Health Variable is proportionately distributed between the richer and poorer sections of the population.

- $C < 0 \Rightarrow$ Health Variable is disproportionately concentrated on the poorer sections of the population.
- $C = -1 \Rightarrow$ The poorer sections of the population absorb all the health variable.
- $C = 1 \Rightarrow$ The richer sections of the population absorb the entire health variable.

Formally, the Concentration Index (CI) can be computed in many numbers of ways. The different formulae for the computation of the CI are given below,

Firstly, when the health variable in question is continuous, the CI can be expressed as follows,

$$C = 1 - 2\int_0^1 L_h(p)dp \qquad \ldots\ldots\ldots\ldots (1)$$

where, C is the CI and $L_h(p)$ is the area above the CC. This formula defines the CI as 1 minus twice the area above the CC. Therefore, based on this formula in relation to Fig. 1, the CI can be defined as C = 1 – 2B, where C is the CI. But since B = 0.5 – A, by putting B in C = 1 – 2B, we have C = 2A, which basically again translates into twice the area under the CC and the line of equality.

Secondly, when the living standards variable is discrete, the CI can be expressed as follows,

$$C = \frac{2}{n\mu}\sum_{i=1}^{n} h_i r_i - 1 - \frac{1}{n} \qquad \ldots\ldots\ldots\ldots (2)$$

where h_i is the health sector variable, μ is its mean, and $r_i = i/n$ is the fractional rank of individual i in the living standards distribution, with $i = 1$ for the poorest and $i = n$ for the richest. This formula makes it clearer that the CI reflects the relationship between the health variable and rank in the income distribution. Here for large n, the final term approaches zero and is often omitted.

Thirdly, for computational purpose, a more convenient formula for the CI expresses it in terms of the covariance between the health variable and the fractional rank in the living standards distribution (Kakwani, 1980) and can be expressed as follows,

$$C = \frac{2}{\mu} cov(h, r) \qquad \ldots\ldots\ldots\ldots (3)$$

This formula for computation of the CI is called the '**Convenient Covariance Formula**' where h is the health sector variable, μ is its mean, and r is the fractional rank of the individual in the living standards distribution. This formula makes it even more explicit, how the CI is related to the correlation between the health variable and rank in the income (living standards) distribution. In fact, it is the covariance between these two variables scaled by 2 divided by the mean of the health variable.

In relation to these formulae for computation of the CI, one needs to keep in mind that the CI depends only on the relationship between the health variable and the rank of the living standards variable and not on the variation in the living standards variable itself. Therefore, a change in the degree of income inequality need not affect the CI measure of income-related health inequality.

The Concentration Index (CI) can be computed easily from micro data by using the "Convenient Covariance Formula" (Equation 3). If the sample is not self-weighted, weights are needed to be applied in computation of the covariance, the mean of the health variable, and the fractional rank. Given the relation between Covariance and Ordinary Least Squares regression, an equivalent estimate of the CI can be obtained from a "Convenient Regression" of a transformation of the health variable of interest on the fractional rank in the living standards distribution (Kakwani et al., 1997). Therefore, to estimate the Concentration Index from micro data, one can equivalently use the '**Convenient Regression Formula**' which is given as follows,

$$2\sigma_r^2\left(\frac{h_i}{\mu}\right) = \alpha + \beta r_i + \epsilon_i \qquad \ldots\ldots\ldots (4)$$

where $\sigma_r^{\,2}$ is the variance of the fractional rank. Here, the *OLS estimate of β gives an estimate of the CI* equivalent to that obtained from Equation 4. The LHS variable in the **Convenient Regression Formula** is a transformation of the health variable of interest (h_i), i.e. it is multiplied by twice the variance of the income-rank (σ_r^2) and divided by its mean (μ). The only right-hand-side variable is the fractional income-rank (r_i). A constant (ϵ_i) is included.

This method gives rise to an alternative interpretation of the CI as the slope of a line passing through the heads of a parade of people, ranked by their living standards, with each individual's height being proportional to the value of his or her health variable, expressed as a fraction of the mean.

In the case that the data is weighted, computation of the fractional rank variable becomes slightly complicated. The fractional rank now, in this case, becomes the **Weighted Fractional Rank ($\mathbf{r_i}$)** and is calculated as follows if there are weights (w),

$$r_i = \sum_{j=0}^{i-1} w_j + \frac{w_i}{2} \qquad \ldots\ldots\ldots (5)$$

where w_i is the sample weight scaled to sum to 1, observations are sorting in ascending order of living standards, and $w_0 = 0$.

Because weights are applied, the generated variable rank is the weighted fractional rank. It is important to give weights to the observations of the living standards variable since if simple fractional rank is used (where $r_i = i/n$) then the weight of the first observation is *1/n*, the second is *2/n*, the third is *3/n* and so on. It effectively means that the difference in weights between any two consecutive observations is always *1/n* which is actually not the case. As a result, we need to use weighted fractional rank. Therefore, the weighted fractional rank is basically the cumulative sum of weights (scaled to sum to 1) to the preceding observation plus half the observations' own weight with observations ranked from poorest to richest by the living standards variable as given by Equation 5.

It is important to understand that regression is being used here only as a computation device and no model is being proposed. So, no assumptions about the distribution of the error term need hold for OLS to give the estimate of the Concentration Index.

In this paper, the formula in Equation 5 has been used for the computation of the Concentration Indices (CIs) to quantify the levels of health inequalities across the major states of India over time. Since the CI is directly related to the Concentration Curve, hence while calculating the relevant CIs, it can be said that (with respect to Figure 1), '**cumulative percentage of ill-health**' is being measured along the vertical (Y) axis and '**cumulative percentage of the selected states ranked by their socio-economic status**' is being measured along the horizontal (X) axis. Then the **Convenient Regression Formula** has been used to compute the relevant CIs for the selected states over time in order to depict the levels of health inequalities across these states.

Description of Variables

The reasons for choosing IMR as one of the health variables for this paper is that, not only is IMR a most important health variable relating to child health but also it was an indicator used to monitor progress towards the Fourth Goal (to reduce level of child mortality) of the Millennium Development Goals (MDG which ended in 2015) set by the United Nations (UN). IMR is now a target in the Sustainable Development Goals (SDG which replaced the MDG) set by the UN for Goal Number 3 (Ensure healthy lives and promote well-being for all at all ages) post 2015. The variable of IMR has been used as a proxy for child health. Also, the reasons for choosing LEB as one of the health variables lies in the importance of this indicator of expected life years as an important component of Human Development Index (HDI) but also increasing life expectancy is now a target in the Sustainable Development Goals (SDG) set by the UN for Goal Number 3 (Ensure healthy lives and promote well-being for all at all ages) post 2015.

Table 5. Definitions of Health and Socioeconomic Indicators Used

Health Indicators	
Infant Mortality Rate (IMR)	Infant mortality rate is defined as the number of infants dying before reaching one year of age, per 1,000 live births in a given year. Here, we have considered State Infant Mortality Rates. Figures are based on the 'number of deaths per one-thousand infants' of a state in a given year.
Life Expectancy at Birth (LEB)	Life expectancy at birth indicates the number of years a new-born infant would live if prevailing

	patterns of mortality at the time of his/her birth were to stay the same throughout his/her life. Here we have considered State-wise Life Expectancy Rates. Figures are in 'number of years'.
Socioeconomic Indicators	
Per Capita Health Expenditure (PCHE)	PCHE (state-wise) is the public health expenditure as a ratio of the total population of a state for a specified year. It covers the provision of health services (preventive and curative), family planning activities, nutrition activities, and emergency aid designated for health but does not include provision of water and sanitation. Figures are in 'rupees per person'.

Since the data on the Total Population (state-wise) is only available in a gap of 10 yearly period based on the census data, the data for the other years have been calculated with the help of appropriate 'Interpolation' and 'Extrapolation'. In case of the health variable of LEB (as in table 5), since state-wise data for life expectancy at birth is available in five-yearly format, so when calculating CIs based on LEB, we have converted all the values of the socioeconomic variable, i.e. PCHE in a five-yearly format by using a simple five-yearly moving average to make them compatible.

Estimation of Concentration Index and Discussions Thereof

At first, let us look into the health expenditure (PCHE) related inequalities in health, given by IMR across the selected 23 Indian states over time. This has been examined by calculating the relevant CIs for IMR based on PCHE from the years 1981 to 2015 (see Table 6). From Table 6, it can be seen that all the CI values for health expenditure – related inequalities in health (IMR) across the selected states over the range of 35 years (1981-2015) are found to be negative thereby confirming the prevalence of health (in terms of IMR) inequalities that manifest primarily among the states with low expenditure on health.

Table 6. CI for Health Expenditure - related Inequalities in Infant Mortality Rate

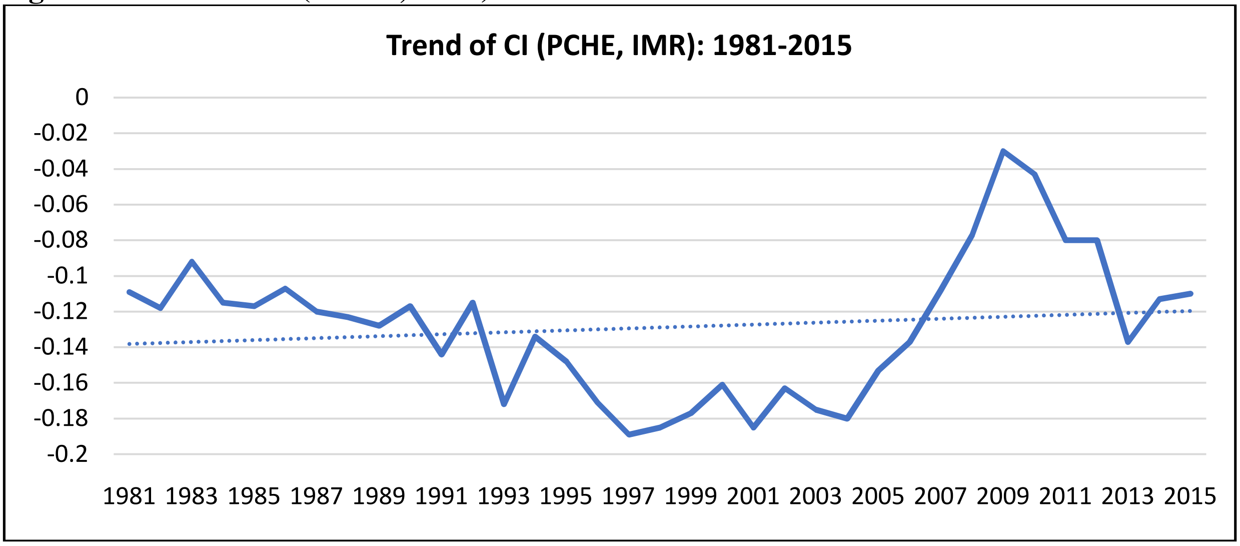
(Values in parentheses represents SE)			
, * Statistical Significance at 5% & 1% respectively			
Year	**CI (PCHE, IMR)**	**Year**	**CI (PCHE, IMR)**
1981	-0.109**(0.044)	1998	-0.185***(0.041)
1982	-0.118**(0.047)	1999	-0.177***(0.045)
1983	-0.092(0.048)	2000	-0.161***(0.036)

1984	-0.115**(0.049)	2001	-0.185***(0.045)
1985	-0.117**(0.046)	2002	-0.163***(0.045)
1986	-0.107**(0.051)	2003	-0.175***(0.045)
1987	-0.120**(0.047)	2004	-0.180***(0.045)
1988	-0.123**(0.046)	2005	-0.153***(0.047)
1989	-0.128**(0.053)	2006	-0.137***(0.046)
1990	-0.117(0.060)	2007	-0.108(0.057)
1991	-0.144**(0.054)	2008	-0.077(0.062)
1992	-0.115**(0.044)	2009	-0.030(0.056)
1993	-0.172***(0.056)	2010	-0.043(0.050)
1994	-0.134**(0.054)	2011	-0.080(0.041)
1995	-0.148**(0.051)	2012	-0.080(0.043)
1996	-0.171***(0.049)	2013	-0.137**(0.048)
1997	-0.189***(0.051)	2014	-0.113(0.058)
1998	-0.185***(0.041)	2015	-0.110(0.057)

Note: Results as obtained by the authors using Stata 12

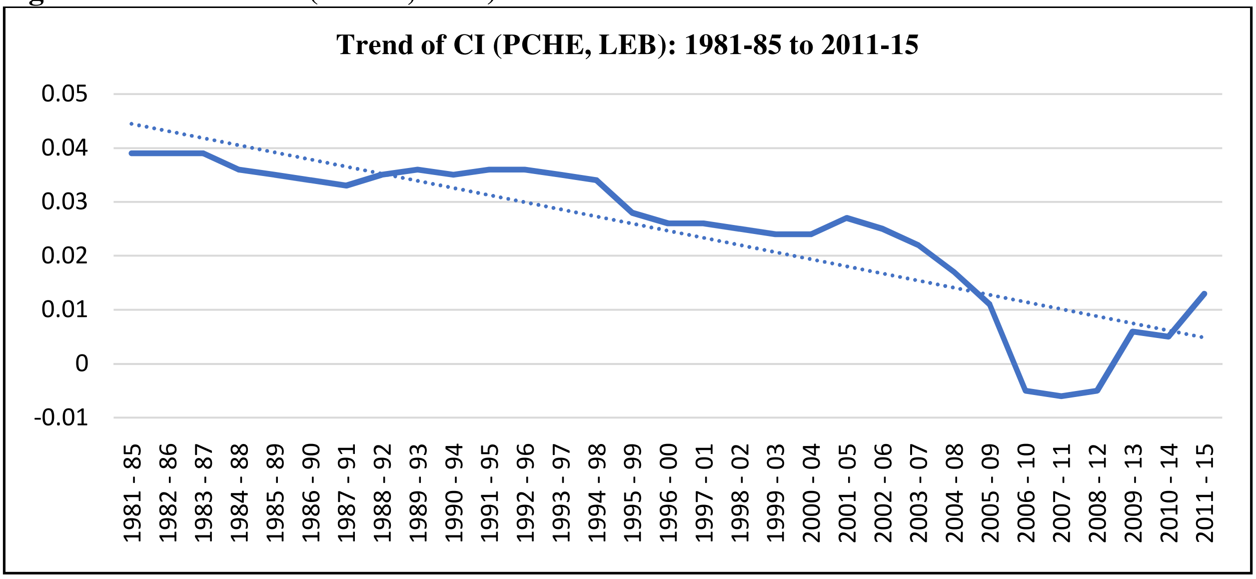
Examining Table 6, it can be seen that CIs from the years 1981-06 are all statistically significant barring only the years 1983 and 1990. Initially the magnitude of these CIs is also low and their magnitudes have increased over time (though the increase is not uniform). However, from the years 2007-15 all the CIs are insignificant (except for the year 2013) and there is a sharp decline in the magnitude of these CIs from the years 2007-12. Again, in the year 2013 the CI becomes significant accompanied by an increase in magnitude. But during the years 2014 and 2015 the CIs once again become insignificant and they have fallen in magnitude. To properly analyze the pattern of the computed CIs over time, the time trend of these CIs needs to be looked at (see Figure 2). Fitting a trend line to the time trends of these CIs it can clearly be seen that the CIs follow an increasing trend, that is to say the CIs tend to converge over time. IMR being an 'ill-health' variable, the CIs based on it following an increasing pattern means that, in India along with increase in spending on public health and healthcare of the states by both the central and state governments over the years, the health expenditure – related inequalities in health (IMR) tend to decrease. Therefore, it can be asserted that, over time the health variable of IMR have been slowly becoming less and less disproportionately concentrated on those states which have lower levels of per capita health expenditure (PCHE); thereby tending towards health equality.

Figure 2. Trend of CI (PCHE, IMR): 1981-2015



Source : Obtained by the authors

Figure 3. Trend of CI (PCHE, LEB) : 1981-2015



Source: Obtained by the authors

Coming to LEB, from Table 7, it can be seen that the CI values for health expenditure related inequalities in health (LEB) across the selected states over the specified range are found to be positive (except for the periods of 2006-10, 2007-11 and for 2008-12) implying that the health variable of increasing LEB is disproportionately concentrated on the states with high levels of health expenditure. Since LEB is a ‘good-health’ variable, this in turn confirms the prevalence of health (in terms of LEB) inequalities among the states with low expenditure on health.

Table7. CI for Health Expenditure - related Inequalities in Life Expectancy at Birth

(Values in parentheses represents SE)			
, * Statistical Significance at 5% & 1% respectively			
Year	**CI (PCHE, LEB)**	**Year**	**CI (PCHE, LEB)**
1981 - 85	0.039***(0.009)	1996 - 00	0.026***(0.007)
1982 - 86	0.039***(0.009)	1997 - 01	0.026***(0.026)
1983 - 87	0.039***(0 .009)	1998 - 02	0.025***(0.007)
1984 - 88	0.036***(0.009)	1999 - 03	0.024***(0.007)
1985 - 89	0.035***(0.009)	2000 - 04	0.024***(0.007)
1986 - 90	0.034***(0.009)	2001 - 05	0.027***(0.006)
1987 - 91	0.033***(0 .010)	2002 - 06	0.025***(0.007)
1988 - 92	0.035***(0.009)	2003 - 07	0.022***(0.007)
1989 - 93	0 .036***(0.009)	2004 - 08	0.017(0.010)
1990 - 94	0.035***(0 .009)	2005 - 09	0.011(0.013)
1991 - 95	0.036***(0.009)	2006 - 10	-0.005(0.009)
1992 - 96	0.036***(0.008)	2007 - 11	-0.006(0.009)
1993 - 97	0.035***(0.008)	2008 - 12	-0.005(0.008)
1994 - 98	0.034***(0.008)	2009 - 13	0.006(0.005)
1995 - 99	0.028***(0.007)	2010 - 14	0.005(0.005)
1996 - 00	0.026***(0.007)	2011 - 15	0.013(0.007)

Note: Results as obtained by the authors using Stata 12

Examining Table 7, it can be seen that initially the CIs from the periods of 1981-85 to 2003-07 are all statistically significant whereas later the CIs from the periods of 2004-08 to 2011-15 become insignificant. The significant CIs from 1981-85 to 2003-07 are also high in magnitude but the magnitude of these CIs tend to follow a decreasing trend along the years as shown in Figure 3. The magnitude of these CIs falls even further from the years 2004-08 to 2011-15 when they become insignificant. The CIs infact turn negative from 2006-10 to 2008-12. This basically means, during this period the health variable, i.e. increasing life expectancy is disproportionately concentrated on those states which spend less on health. However, since the CIs of these periods are statistically insignificant this possibility can thus be ignored. From the periods of 2009-13 to 2011-15 the magnitudes of the CIs again increase and become positive but still these CIs remain insignificant. Overall the CIs from 1981-85 to 2011-15 indicate a fall in health (LEB) when the states are ranked in terms of per capita health expenditure. This in turn indicates lower levels of health expenditure related inequalities in LEB over the years.

To properly analyze the pattern of the computed CIs over time, the time trend of these CIs (see Figure 3) needs to be looked at. Fitting a trend line to the time trends of these CIs, it can be seen that the CIs follow a decreasing trend, that is to say the CIs tend to converge over time. In fact, the CIs do converge around the periods of 2006-10 to 2008-12 and become negative. However, they again become positive from 2009-13. LEB being a 'good-health variable', the CIs based on it following a decreasing pattern means that, in India along with increase in spending on public health and healthcare of the states by both the central and state government over the years, the health expenditure related inequalities in health (LEB) tend to decrease. Hence, it can be asserted that, over time the health variable of LEB have been becoming less and less disproportionately concentrated on those states which have higher levels of per capita health expenditure (PCHE) and better position of public health infrastructure, thereby tending towards health equality.

4.5 Public Health Infrastructure and Health Expenditure in India

Although, we see that health inequalities in terms of both the health variables follow a declining trend, researchers should note that we are not claiming absence of inequality. In this regard, our objective is to see whether such health inequalities have anything to do with the level of public healthcare expenditure and levels of public health infrastructure thereof, across 23 major states in India.

This section primarily aims at constructing the health infrastructure index across 23 major states in India. As already mentioned, the idea is explore the link between public health infrastructure and health expenditure given the fact that public healthcare expenditure is cointegrated with per-capita growth rate of the states. To construct the index, two terminal points have been considered *viz.* 2005-06 and 2014-15. After the index construction, the position of the states with respect to this index will be discussed in the light of per-capita health expenditure of the concerned states. Before moving onto the index construction, the methodology needs to be discussed in detail.

The Key Dimensions

This paper considers five dimensions on the basis of which the index will be constructed. These include –

i) Number of Sub-Centres (SC)
ii) Number of Primary Health Centres (PHC)
iii) Number of Community Health Centres (CHC)
iv) Number of District Hospitals (DH)
v) Percentage of SCs, PHCs and CHCs adequately equipped with supply of drugs, attendants, nurses, etc (ADQ)

Coming to the problem of multicollinearity, the most widely-used marker for multicollinearity, is the variance inflation factor (VIF). It may be calculated for each predictor by performing a linear regression of that predictor on all the other predictors in the model (Table 8). VIF is defined as –

$$VIF = \frac{1}{1-R^2}$$

The rule of thumb is that VIFs over and above the value of 4 demand further investigation, while VIFs exceeding 10 gives an indication of severe multicollinearity and hence requires correction.

Table 8. Results of VIF Test

Variables	**VIF**
(SC)	3.82
(PHC)	2.67
(CHC)	3.41
(DH)	1.39
(ADQ)	1.20
Mean Score VIF	2.49

Notes : Computed by the authors in Stata 12

Each of the dimensions taken into account is assumed to be independent given that the value of VIF is below 4. One can include other indicators like number of beds, health assistants but these factors depend on the figures of SCs, PHCs, CHCs and the number of hospitals. Consequently, if these factors are included, the independence assumption will break down on account of very high correlation.

Methodology for Calculating the Index

The following steps are to be followed for calculating the index.

Step 1 : Normalizing the parameters

It is an aggregate index comprising of five parameters (already stated) so cannot be aggregated to derive the composite index as the parameters have different units of measurement.

As a result, each parameter is normalized by –

$$X_{iN} = \frac{(X_i - X_{\min})}{(X_{\max} - X_{\min})}$$ where,

X_{iN} is the normalized value, X_{min} is the minimum value observed across the 23 states considered for some parameter, X_{max} is the maximum value observed across the 23 states for a particular parameter and X_i is the value a particular parameter for state i.

Normalization yields a value for every parameter for every state which lies between 0 and 1. The value '0' depicts the worst case and '1' depicts the best case scenario.

Step 2 : Aggregation using the Weighted Euclidean Distance Method

Firstly, in this analysis the authors has given equal weights to all the parameters given the fact that all the parameters are of equal importance in judging the quality of healthcare infrastructure. The five dimension-indices may be represented in a five-dimensional space with the value '0' being the minimum value and '1' as the ideally required value.

The Public Health Infrastructure Index (PHI) uses inverse of the weighted Euclidean distance from the ideal point of (1,1,1,1,1). So the PHI calculation for state i is given by:

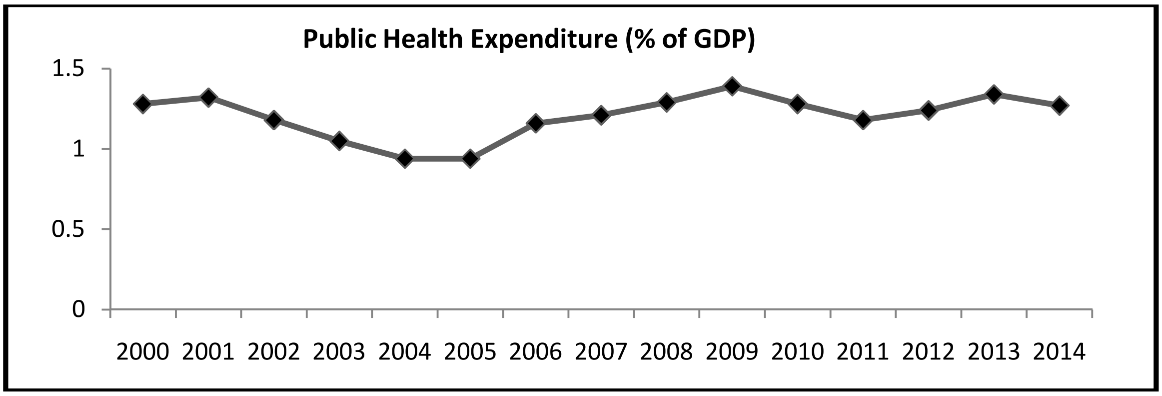
$$PHI_i = 1 - \sqrt{\frac{\left[[\left(1 - SC_i\right)^2 + \left(1 - PHC_i\right)^2 + \left(1 - CHC_i\right)^2 + \left(1 - DH_i\right)^2 + \left(1 - ADQ_i\right)^2\right]}{5}}$$

The numerator of the term within the square root gives the Euclidean distance of state i from the ideal point (1,1,1,1,1). The inverse distance has been calculated to show that higher is the value of PHI, better will be the public health infrastructure and higher will be the position of the state concerned among other states. As proposed by Nathan et al. (2008), this PHI index satisfies the properties of *NAMPUS* i.e. normalization, anonymity, monotonicity, proximity, uniformity and signaling. Moreover, this framework relaxes the assumption of a perfect substitutability among the five-dimension indices signifying that a decent performance taking into account one specific dimension does not make up for the bad performance with respect to another dimension.

The results reported in Table 10 provide us with the PHI scores (rounded up to 3 decimal places) and ranks for the 23 states. Though, data is available from 1981 onwards, for comparison of the current inter-state performance, time points 2005-06 and 2014-15 have been taken into account. The trends in public healthcare expenditure from 2001 onwards have been reported in Figure 4. Public healthcare expenditure has more or less hovered between 1.1 to 1.4 per cent of GDP in the Indian context.

Now, the question is to what extent this has impacted health infrastructure.

Figure 4. Trends in Central Public Health Expenditure (as a percentage of GDP) in India



Source: Obtained by the authors

Table 9. Pattern of Central Allocation (Total vs. Healthcare) (crore INR)

Plan period	**Total planned investment**	**Family welfare allocation**	**Total for health sector**
Eighth Plan (1992-97)	434100	6500 (**1.5%**)	14102.2 (**3.2%**)
Ninth Plan (1997-2002)	859200	15120.2 (**1.76%**)	35204.95 (**4.09%**)
Tenth Plan (2002-07)	1484131.3	27125 (**1.83%**)	58920.3 (**3.97%**)
Eleventh Plan (2007-12)	2156571	136147.0 (**6.31%**)	140135 (**6.49%**)

Source: Compiled from Planning Commission of India (2011)

Table 10. PHI Scores

State	**PHI Score (2014-15)**	**PHI Score (2005-06)**	**Rank (2014-15)**	**Rank (2005-06)**	**Real Per-capita PHE (2005-06)**	**Real Per-capita PHE (2014-15)**
Andhra Pradesh	0.351	0.332	9	9	0.41	0.34
Arunachal Pradesh	0.313	0.309	12	12	0.55	0.36
Assam	0.217	0.191	16	17	0.56	0.38
Bihar	0.151	0.148	20	21	0.43	0.00
Goa	0.534	0.487	2	4	0.47	0.42
Gujarat	0.328	0.311	11	11	0.59	0.69
Haryana	0.410	0.370	8	7	0.42	0.35

Himachal Pradesh	0.414	0.387	6	6	0.73	0.67
Karnataka	0.331	0.330	10	10	0.63	0.58
Kerala	0.561	0.509	1	2	0.79	0.67
Madhya Pradesh	0.274	0.254	14	14	0.44	0.51
Maharashtra	0.431	0.427	5	5	0.46	0.39
Manipur	0.157	0.151	19	20	0.28	0.27
Meghalaya	0.143	0.122	22	23	0.36	0.35
Nagaland	0.142	0.131	23	22	0.00	0.24
Orissa	0.234	0.196	15	16	0.50	0.37
Punjab	0.519	0.489	4	3	1.00	1.00
Rajasthan	0.196	0.215	17	15	0.51	0.37
Sikkim	0.149	0.156	21	19	0.42	0.31
Tamil Nadu	0.520	0.512	3	1	0.53	0.58
Tripura	0.176	0.174	18	18	0.39	0.24
Uttar Pradesh	0.304	0.296	13	13	0.34	0.44
West Bengal	0.411	0.365	7	8	0.36	0.29

Notes: Computed by the authors

The real per-capita public health expenditure data in Table 7 has also been normalized based on the normalization criteria (value lies between 0 (min) and 1 (max)) in the previous sub-section.

Table11. Summary Statistics of PHI Scores of 2014-15 and 2005-06 – A Comparison

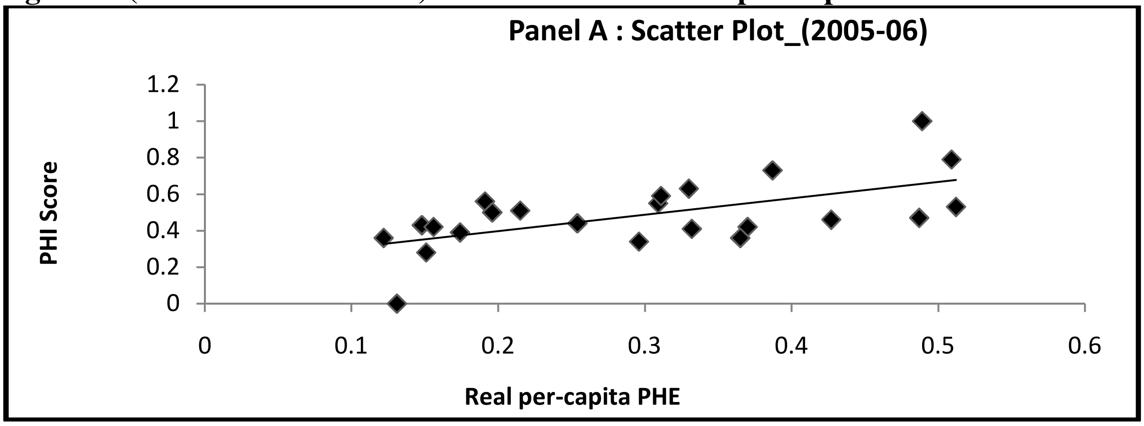
Observations	23	**PHI_Scr_14_15**	
	Percentiles		
1%	0.142	Mean	0.31591
25%	0.176	Standard Deviation	0.13910
50%	0.313	Variance	0.01935
75%	0.414	Skewness	0.28569
99%	0.561	Kurtosis	1.83167
		PHI_Scr_05_06	
	Percentiles		
1%	0.122	Mean	0.29835
25%	0.174	Standard Deviation	0.12940
50%	0.309	Variance	0.01675
75%	0.387	Skewness	0.25213
99%	0.512	Kurtosis	1.81361

Notes: Computed by the authors in Stata 12

He results in Table 10 help us to judge the position of the states with respect to public healthcare infrastructure in light of real per-capita GSDP. Table 11 is an extension of Table 10 in the sense that it gives us an idea about the average values of public healthcare infrastructure in the country, measures of dispersion and other distributional features of the health infrastructure. Before going on to the explanation of Table 10, a snapshot analysis of Table 11 demonstrates that the average value of the index hovers around 0.3 indicating that overall position in terms of public healthcare infrastructure is not quite up to the mark. Between 2005-06 and 2014-15, there has not been any significant improvement in the health infrastructure index. The median value (50^{th} percentile) has remained almost the same at 0.31. The value of kurtosis less than implies that the distribution of the PHI Scores has too thick tails and flat in the middle i.e. platykurtic in nature. The percentile values show the percentage of states having PHI Scores at or below the corresponding partition value. It is appalling to observe that 99 per cent of the values for PHI Scores lie below 0.56 in 2004-05. The figure has further deteriorated to 0.51 as the maximum value of the PHI Score has worsened. The value of variance in 2005-06 is 0.016 and in 2014-15 it has been 0.019. This gives an indication that the estimates have been highly consistent and that the predicted values are very close to the observed ones. This also validates the absence of heteroskedasticity in the analysis. Another motivating feature is the measure of the skewness (i.e. positively skewed) which reflects that a majority of the states have performed disappointingly with regards to the public health infrastructure index.

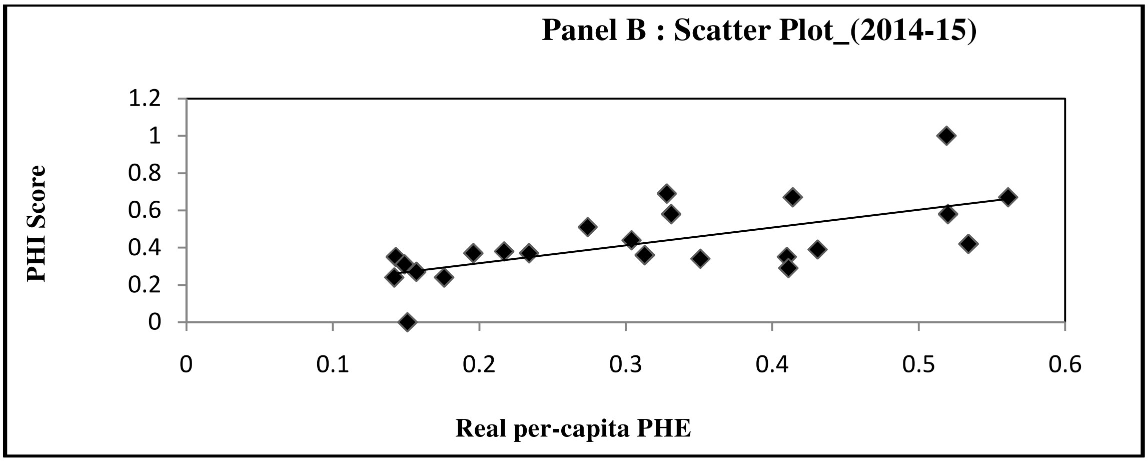
Looking at Table 10, the top 5 performing states are Kerala, Punjab, Tamil Nadu, Maharashtra and Goa. As before, the position of Maharashtra has remained the same but the position of the other top performing states have changed but they have remained within the top 5 bracket. The highest score is 0.56, attained by Kerala, signifying that even the top performing state needs to improve a lot in terms of public health infrastructure development. Interestingly, the scores obtained by all the states have improved between this time span except for Rajasthan and Sikkim. For states like Goa and Maharashtra, in spite of spending somewhat less on real per-capita health, its position on the health infrastructure index is at the top indicating that a majority of health expenditure has been incurred on development of health infrastructure. On the contrary, the position of states like Rajasthan, Karnataka and Arunachal Pradesh on the index is not consistent to per-capita health expenditure. This draws our attention to the fact that per-capita health expenditure has not been incurred on the development of public health infrastructure *per se*.

Figure 5. (Panel A and Panel B). PHI Scores and Real per-capita PHE Scatter Plots



Coming down to the final part of the analysis, the relation between the normalized value of real per-capita spending and health infrastructure index has been explored in Figure 5. Due to lack of data points (since I have considered health infrastructure at two points *viz.* 2005-06 and 2014-15), it was not possible to carry out a panel data analysis. As an alternative, a scatter plot analysis has been carried out (Refer to Panel A and Panel B in Figure 5).

There are exceptions where in spite of increase in healthcare spending, infrastructure position has deteriorated but in general the relation is clearly positive indicating that the increase in real per-capita health expenditure indeed influences the health infrastructure of the state concerned. The relationship has more or less remained the same between the time periods considered.



Source: Obtained by the authors

5. Overall Discussions: Summing Up

This issue of the triangular analysis of health expenditure, healthcare infrastructure and economic growth has cropped up on account of India's healthcare system primarily focusing on curative measures rather than preventive ones. Their focus has never been on health infrastructure *per se*. Therefore, both the central and the state governments have a critical role in the development of health infrastructure of the states concerned and the country in general. Figuring out the pattern of investments, sources of funding and proportion of allocation against the total allocation helps us to comprehend the health outcomes as regards to the healthcare expenditure. The data in Table 9 below table shows the percentage of allocation for the health sector alongside the total planned investment in the country by the centre. Figure 4 noticeably shows the decline in the total health sector allocation from 2001 onwards.

It increased to some extent in the 11th Plan when the National Rural Health Mission (NRHM) schemes were initiated. There are several schemes under the umbrella of NRHM, which includes Facility Based Newborn and Child Care (FBNC), Janani Shishu Suraksha Karyakram (JSSK), Facility Based Integrated Management of Neonatal and Childhood Illness (F-IMNCI), Navjat Shishu Suraksha Karyakram (NSSK), etc. but none of them are concerned with the development of healthcare infrastructure. Infrastructure development is a part of preventive measure which the Indian health sector has not yet been able to come to terms to. As per the Rural Health Statistics (RHS) reported on 31.3.2015, there is an acute shortfall of 33145 SCs (20%), 6556 PHCs (22%) and 2316 CHCs (32%) across the country.

Kerala's noticeable health indices are partially attributed to a health infrastructure developed by a government committed to healthcare. Even, that has started to collapse. This can be attributed to the poor condition of the public hospitals coupled with the private sector becoming the major source of curative healthcare in the rural and the urban areas. Precisely, in public hospitals, the administrators fight for funds and in this process many specialists switch to corporate hospitals where the incentives are much more.

This reduces public hospitals to sheer 'dumping grounds' for the unwanted cases. The question is that how can India maintain the growth given such a level of health infrastructure. Moreover, it is clear that with better health infrastructure, real per capita GDP growth goes up. This also gets established through the health related inequalities falling down over the years when states are ranked by PCHE to get the overall CI. Interestingly, an increase in real per-capita healthcare expenditure not only leads to a fall in health inequality but also leads to a rise in the value of the infrastructure index when one does the granular assessment of the states across India (see Figure 5, Panel A and B).

On the whole, India's public healthcare system is erratic, underfunded coupled with overcrowded hospitals and clinics, and lack of penetration in the rural areas. Cutting down on funding by the Government of India has been accredited for the celebrated failures on the part of the Ministry of Health and Family Welfare to use up its allocated budget wholly. Now, healthcare services are increasingly becoming unreachable because of the lack of government support and the growing penetration of private institutes in the medical sector. A question which warrants an immediate answer is concerned with the role of the current public healthcare system. Despite, the growth of public-private partnership (PPP) model, financial as well as logistical constraints still hinders the development of large scale undertakings under such a framework. The private sector is not only promising to be a major player in terms of service provision but is also trying to fill in the gaps left by the public sector. The speedy growth of the private health sector has resulted in a situation where these private players have become commercial units and the social-welfare goal has taken a backseat. This is of serious concern from the welfare perspective. Therefore, the twofold goals of both the centre and the state under such a situation should be to arrange for equitable access to healthcare services and preserving the standard of health infrastructure.

This paper shows that the North Eastern states are the worst performers in terms of development of public healthcare infrastructure. Not only there is an acute shortage of health centres but also trained personnel including doctors, nurses, mid-wives and other health workers. In line with the "Look East" policy of the Government of India, various private healthcare providers are either setting up their amenities or formulating plans for exploiting the potential in the North Eastern market. For example, only a few days back, Kolkata was the sole healthcare hub in Eastern India for catering to the requirements of the patients coming from all the North Eastern states, Bihar, Orissa as well as from Bangladesh and Nepal. To lessen the burden on Kolkata and also for the purpose of decentralization of the health sector, recently three cities (*viz.* Asansol and Siliguri in West Bengal and Bhubaneswar in Odisha) have emerged as future healthcare hubs in the Eastern part of India. Given their performance, do the North Eastern states have the potential to become the Mecca of healthcare on their own? It is our belief that the performance of the governments (at all levels) will go a long way in determining whether North East India gets to welcome the rising healthcare sun.

Summing up, it is clear that for a society's comprehensive development, not only do we require income equality but also health equality. In a developing country, like India, where the problems of poverty and income inequality are widespread, focus on health inequality has always been side-lined. Given this econometric analysis, one can see that health equality, public healthcare infrastructure and economic growth operate through a triangular nexus. An effect on one will generate some kind of feedback effects for the others and hence the justification for carrying out this analysis.

6. Concluding Remarks and Future Research Possibilities

India has grown steadily in the last decade excluding the period of the global financial crisis i.e. (between 2009 and 2013). In what we see, health expenditure will motivate the dual benefits of health progress in particular and economic growth in general. In terms of the public healthcare infrastructure, mostly, the north eastern states have performed poorly. Table 10 shows that the states spending comparatively more on healthcare have scored high on the infrastructure index, *vice versa*. But, the states that are positioned at the top have not spent that significant an amount so the question is that in spite of spending somewhat less how they have been able to maintain their position up on the growth trajectory. This is the puzzle the paper talks about. One has to appreciate the fact that the reduction in health inequalities (that we see through the calculation of the CI index) to a certain extent is influenced by the big players in the private healthcare sector like Narayana Hrudayalaya, Wockhardt, Fortis, MEDICA, Columbia Asia and others are making their presence increasingly felt across the states which in turn is pushing up the growth. Actually, the private health sector is the missing link in this analysis. Given the variability in the PHI index, the fallacy in the "one-size-fits-all" strategy which is followed for the allocation of funds across the states gets exposed. Here, the focus is primarily on the health variable so incorporating an additional variable like education expenditure as a percentage of GSDP would put in another dimension to the subject. Hence, the impact of healthcare spending on economic growth coupled with the implications for health inequality and thereby health infrastructure endorses the requirement for governments' intervention to develop a healthier and productive India.

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