# Examining the state level heterogeneity of public health expenditure in India: an empirical evidence from panel data

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**Abstract:** This study explores the relationship over an extended period of time between an increase in per capita public health expenditure and per capita state's domestic product (per capita income) of 16 states of India from 1980 to 2014. We consider eight panels of states based on geographical region and levels of economic development for examining the level of heterogeneity in the share of public health expenditure with respect to states' domestic product by using panel unit root, panel co-integration and panel Granger causality techniques. The empirical result shows that public health expenditure and states' domestic product are co-integrated in the long-run. The result also shows a positive and significant effect of per capita income in the growth of public health expenditure in the long-run. It finds that there is a bi-directional Granger causality between per capita income and public health expenditure in the short-run while the causality is unidirectional in the long-run. The overall result implies the existence of inequalities in the share of government health expenditure with respect to state's level of economic development in India. This study would offer effective fiscal policy instruments to minimising geographical inequity of health finance for achieving universal health coverage of Indian states.

**Keywords:** public health expenditure; PHE; Indian states; heterogeneity; panel data; universal health coverage; UHC Westerlund co-integration; VECM Granger causality.

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## 1 Introduction

'Health' is a state subject in India. Both the state government and the central government have an important role in financing public healthcare. The healthcare financing is a key building block of the health system[1] and plays an influential role in the attainment of universal health coverage goals (UHC)[2] (Kutzin, 2013). Mathauer and Guy (2011) explain that government expenditure is one of the important sources of finance for healthcare in low-income and low-middle income countries. They argue that the level of government health expenditure depends on the country's income level and the financial affordability of the government. The challenge for many low-income and middle-income countries is to increase government/public health expenditure (PHE) in order to achieve UHC because these countries rely heavily on out-of-pocket healthcare expenditure (Reeves et al., 2015).

India is not an exception in financial challenges of the health system and also undergoes a huge shortage of finance in public healthcare. As a consequence of this, the public healthcare delivery system suffers from inadequate healthcare services, severe staff shortage, lower quality of infrastructure and catastrophic out-of-pocket expenditure (Kurian, 2015). Choudhury (2014) says that the level of government health expenditure as a percentage of gross domestic product (GDP) is around 1% in most of the poor performing states in India due to low fiscal space (total government expenditure as a ratio of GDP). Duran et al. (2014) explain that fiscal space for health (government health expenditure as a ratio of total government expenditure) increased by only 0.2% from 4.6% to 4.8% in spite of a strong economic growth during the 2007–2008 to 2012–2013. Behera and Dash (2017b) suggests that India requires a systematic health financing framework for achieving UHC by improving the fiscal space position of Indian states through sustained economic growth. From the above conceptual framework, we try to examine the long-run impact of gross state domestic product (GSDP) (per capita income) on the level of PHE of Indian states. Further, it examines whether the government's response towards health expenditure is affected by the geographical location and the level of economic development over the period 1980–2014. The results of this study would help to identify the level of heterogeneity among states in the level of PHE associated with economic growth and thereby serve to develop effective fiscal policy instruments in minimising geographical inequity in financing healthcare.

The contribution of this paper may be described as follows: First, the paper aims to answer the question, whether there is a positive correlation between an increase in public healthcare expenditure and income in the states irrespective of the level of economic development which remained unexplored in the earlier studies. Thus, the paper aims to explore the level of heterogeneity of states by dividing the Indian states into various panels based on the geographical location of the states and the level of economic development. The motivation to identify the state level heterogeneity is derived from Narayan et al. (2012) and Apergis and Puja (2013) wherein sub-national level heterogeneity are studied in terms of the level of income and public expenditure in the context of India. Second, the empirical methodology used in this paper is more efficient than the methods used in previous studies such as Bhat and Nishant (2006), Rahman (2008) and Hooda (2015). The methodology used in these studies involves short-run estimator of OHE by applying panel random effect model, which provides the elasticity of public health expenditure with respect to income in the short-run. Other studies such as Behera and Dash (2016, 2017a) and Pradhan and Tapan (2012) used the long-run estimator of PHE by applying first generation panel unit root test as in Im et al. (2003) and the first generation panel cointegration test as in Pedroni (2004) and Kao (1999). The first generation methods implemented in these studies do not capture the cross-section dependency in the data. Therefore, we apply the second generation panel unit root test and panel co-integration as proposed in Pesaran (2007) and Westerlund (2007) respectively after verifying the existence of cross-section dependence in the data series as implemented in Pesaran (2004). Third, we examine the long-run effects of per capita GSDP on per capita PHE using long-run estimation techniques such as dynamic ordinary least square (DOLS) proposed by Kao and Chiang (2000). Fourth, we examine the causal relationships between per capita PHE and per capita GSDP using panel vector error correction model (VECM) that combines short-run and long-run dynamics. The VECM approach examines the direction and impact of heath-led growth/growth-led health hypothesis among the panel of states.

### *1.1 Previous literature*

There is a growing literature on the relationship between public/government health expenditure and income/GDP, which can be broadly grouped into three different lines of inquiry. The first strand of literature examines the elasticity of PHE with respect to income in the short-run as well as in the long-run. The literature deals with short-run estimator of PHE studies such as Sen (2005), Wang (2009), Baltagi and Francesco (2010), Cantarero and Lago Penas (2010), Farag et al. (2012), Magazzino and Mele (2012), Fan and William (2014) and the literature deals with the long-run estimators of PHE such as Narayan et al. (2010), Wang (2011), Tamakoshi and Shigeyuki (2014) and Khan et al. (2015). These studies find per capita income to be the most important determinant of per capita PHE. The economic interpretation of these findings is that the elasticity of PHE with respect to income is equal to or greater than one, leading to the conclusion that healthcare is a luxury rather than a necessity. When elasticity is less than unity, healthcare is closer to being a necessity than a luxury. Whether healthcare is a luxury or a necessity, it has an implication for the link between health expenditure and economic well-being. The second strand of literature (Hansen and Alan, 1996; McCoskey and Thomas, 1998; Gerdtham and Mickael, 2000; Herwartz and Bernd, 2003; Dreger and Hans, 2005; Wang, 2011; Tamakoshi and Shigeyuki, 2015) deals with investigating evidence for a long-run (co-integrating) relationship between PHE and income. The third strand of literature (Devlin and Paul, 2001; Erdil and Yetkiner, 2009; Hartwig, 2010; Wang, 2011; Magazzino and Mele, 2012; Amiri and Bruno, 2012) examines the causality between PHE and income in the short-run and as well as in the long-run. There are two possibilities in the direction of causality between health expenditure and income; it could be either unidirectional (that is, health expenditure as a function of income or income as a function of health expenditure) or bi-directional (that is, both health expenditure and income causing each other). The direction of causality is important, as the health policy implications are vastly different for each possible direction. Unidirectional causality from health expenditure to income (reverse causality) implies that the PHE has both direct and indirect effect on income growth (Hartwig, 2010). The theoretical argument says that health expenditure can be regarded as an investment in human (health) capital. Given that human capital is an input to economic production, an increase in health expenditure could be hypothesised to cause an increase in GDP (Devlin and Paul, 2001). The unidirectional causality from income growth to health expenditure growth is common among all countries. The significance of increasing PHE is that it not only reflects the intention of economic development but also demonstrates the greater value of upgrading the quality of life of people (Wang, 2011). The presence of bidirectional causality between health expenditure and income implies that PHE and GDP growth are jointly affected by shocks and any conservative health policies may have an adverse effect on income and vice-a-versa (Amiri and Burno, 2012; Wang, 2011). The argument of bi-directional causal relationship would be that PHE growth can stimulate income and vice-a-versa. Also, increased PHE is both a cause and consequence of increased income and lack of PHE may pose a restraint on the economic growth in the long-run. Further, bi-directional causality shows the confirmation of both growth-led health and health-led growth hypothesis.

Among studies in India, work on the relationship between PHE and income is rather limited. They can be broadly grouped into two different lines of inquiry. The first strand of literature examines the elasticity of per capita PHE with respect to the per capita GSDP using short-run model. The literature deals with short-run estimator of PHE studies such as Bhat and Nishant (2006), Rahman (2008) and Hooda (2015). The aim of these studies was to analyse the determinants of regional PHE in India. The empirical result shows that regional income (per capita GSDP) is the statistically significant determinant in the explanation of the volume of regional PHE. These studies use random effect regression model to estimate the short-run impact of income on the growth of PHE. The result shows that the value of income elasticity of PHE varies between 0.47–0.68, which implies that healthcare is not a luxury good among the Indian states. These studies have overlooked the long-run impact of regional income growth on the regional healthcare expenditure among the states of India. The second strand of literature deals with the long-run relationship between per capita PHE and per capita GSDP using a long-run econometric model such as Behera and Dash (2016, 2017a) and Pradhan and Tapan (2012). These studies examine the short-run as well as the long-run causal relationship between per capita PHE and per capita income of major Indian states. Pradhan and Tapan (2012) find bi-directional causality between PHE and income both in the short-run and in the long-run. While, Behera and Dash (2016, 2017a) find only unidirectional causality running from per capita income to per capita PHE in the long-run.

Based on the background information mentioned above, this paper examines the long-run relationship between per capita PHE and per capita GSDP using panel unit root, panel co-integration, panel long-run estimator and panel Granger causality test for 16 major states of India over the period 1980–2014.

The remainder of this paper is organised as follows. Section 2 presents a brief overview of PHE of the states of India. Section 3 describes the data and methodology. Section 4 presents the results from empirical analysis and Section 5 is the conclusion.

## 2 A brief overview of PHE trends of Indian states

The objective of this section is to provide a snapshot of the trend and variation of PHE as a percentage of GSDP of 16 Indian states[3]. Here, we have divided the states into four geographic regions: the western region that includes states such as Gujarat, Maharashtra and Madhya Pradesh; the northern region that includes states such as Haryana, Rajasthan, Punjab, Uttar Pradesh and Himachal Pradesh; the southern region that includes states such as Andhra Pradesh, Tamil Nadu, Karnataka, Kerala; and the eastern region with states such as West Bengal, Odisha, Assam and Bihar. On the basis of economic development, states are classified into high, middle and low-income states. Punjab, Haryana, Maharashtra and Gujarat are classified as high-income level states. Assam, Rajasthan, Madhya Pradesh, Odisha, Uttar Pradesh and Bihar are classified as low-income level states. Andhra Pradesh, Tamil Nadu, Karnataka, Kerala, West Bengal and Himachal Pradesh are classified as middle-income level states. Narayan et al. (2012) provide a description of the need for classifying the Indian states on the basis of the level of income and geographical location. First, India is a culturally diverse country associated with different languages and lifestyle habits as well as institutional differences across states. The cultural and institutional differences across states make the states heterogeneous in terms of the level of economic activity and spending priority towards the health sector. Second, Apergis and Puja (2013) argue that over the period 1981–2005, increases in PHE have been below the growth rate of real GDP for the majority of the Indian states. Only in four states, i.e., Andhra Pradesh, Karnataka, Punjab and West Bengal did the expenses grow at an annual rate of 7%, while in three states the decline was significant, i.e., Assam, Madhya Pradesh and Uttar Pradesh. The overall poor picture of public health spending could be a crucial factor for the slow improvement in a range of basic health indicators, such as life expectancy at birth, infant mortality and maternal mortality. It is finally worth pointing out that even states with high per capita real GSDP have poor per capita PHE, i.e., the western states and high-income states (Figures 1 and 2), while others, with low per capita real GSDP, indicate high per capita PHE on health, i.e., the eastern states and middle-income states (Figures 1 and 2). A clear analysis of the structure of PHE with respect to state's GDP across the Indian states over the period 1980-2014 can be seen in Table 1.

We begin with Table 1, where we report the trends of PHE as a percentage of GSDP. We present ten-years' averages for the period 1980–2009 and five-years' average for the period 2010–2014 for each of the 16 states. Two messages are worth noting here. First, for India as a whole, the PHE as a percentage of GSDP reduced from 1.30% over the period 1980–1989 to 0.70% of GSDP in the period 2000–2009. The second message is that, for the majority of the states, PHE as a percentage of GSDP has decreased during the period 2000–2009 compared to the 1980–1989 period.

From a simple trend analysis of the data, it is clear that states are heterogeneous in terms of average PHE. To measure the degree of heterogeneity further, Figure 1 plots PHE as a percent of GSDP by a regional panel of states. It shows that PHE as a percent of

GSDP has been the highest for the northern states. The largest decline has been in the panel of western states followed by eastern states. Figure 2 presents the trend in PHE as a percent of GSDP by income categories. It shows that the share of PHE to GSDP is much higher for the middle-income panel of states followed by a low-income panel of states. The PHE relative to GSDP of the middle and low-income panel of states has been above the all India average, while the PHE relative to GSDP of a high-income panel of states is below the national average. It shows that most of the high-income states such as Gujarat, Maharashtra and Punjab have been reducing the PHE as a percent of GSDP but on the contrary, the low-income states such as Odisha, Assam and Bihar etc. spend a larger share of GSDP on health. Here, we find that there is enough inequality in PHE growth among the states in different time periods irrespective of income level as well as geographic region.

**Figure 1** Region-wise growth trend of PHE as a percent of GSDP (in %) (see online version for colours)

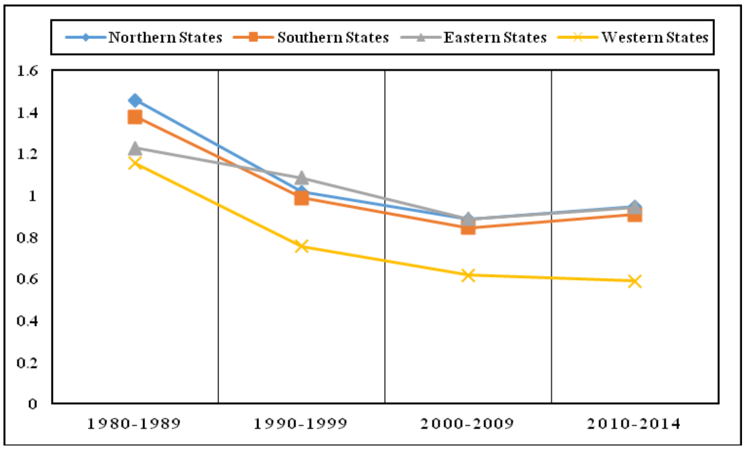


**Figure 2** Income-wise growth trend of PHE as a percent of GSDP (in %) (see online version for colours)

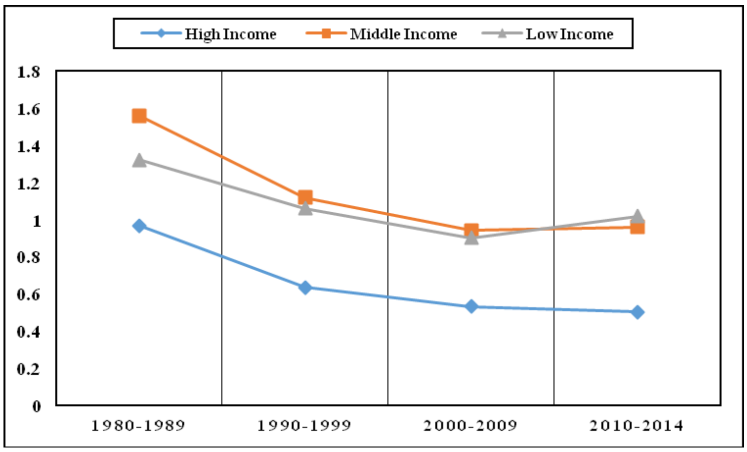

**Table 1** State-wise average trend of PHE as a percent of GSDP (in %)

| *Major Indian states* | *1980–1989* | *1990–1999* | *2000–2009* | *2010–2014* |
|---|---|---|---|---|
| Andhra Pradesh | 1.94 | 1.34 | 1.22 | 1.26 |
| Assam | 1.16 | 0.94 | 0.92 | 1.27 |
| Bihar | 1.52 | 1.60 | 1.12 | 0.95 |
| Gujarat | 0.94 | 0.69 | 0.57 | 0.32 |
| Haryana | 0.96 | 0.55 | 0.44 | 0.50 |
| Himachal Pradesh | 2.77 | 1.86 | 1.51 | 1.39 |
| Karnataka | 1.03 | 0.84 | 0.71 | 0.76 |
| Kerala | 1.32 | 0.92 | 0.79 | 0.91 |
| Madhya Pradesh | 1.47 | 1.01 | 0.79 | 0.94 |
| Maharashtra | 1.05 | 0.57 | 0.49 | 0.50 |
| Odisha | 1.15 | 0.90 | 0.74 | 0.80 |
| Punjab | 0.93 | 0.74 | 0.64 | 0.69 |
| Rajasthan | 1.54 | 1.00 | 0.88 | 0.99 |
| Tamil Nadu | 1.21 | 0.85 | 0.66 | 0.71 |
| Uttar Pradesh | 1.09 | 0.93 | 0.95 | 1.16 |
| West Bengal | 1.09 | 0.90 | 0.76 | 0.74 |
| All India | 1.11 | 0.80 | 0.72 | 0.81 |

*Source:* Computed from State Finance Budget Report (2015), Reserve Bank of India (RBI)

## 3 Data and methodology

### *3.1 Data description*

The selection of the period from 1980–1981 to 2014–2015 is based on the availability of the required data on PHE and relevance of the time period. This period is of great significance as it captures the period of two and a half decades of economic reform/liberalisation and also includes the impact of two national health policies such as National Health Policy, 1983 and 2002. It allows us to study the changing pattern and trend of PHE in various states of India. We have considered for our analysis, the 16 major states, covering 93% of the population and accounting for 95% of the total income of the country. The expenditure and population data are drawn from the State Finance Budget Report (2015) and Handbook of Statistics on the Indian Economy (2015) published by the Reserve Bank of India. The study considered real per capita GSDP as an independent variable and real per capita PHE[4] as the dependent variable. State-wise nominal government expenditure of health was deflated by the respective GSDP deflator to arrive at real government expenditure on health. We use constant (2004–2005 = 100) prices to convert the nominal values into real (constant) values. Finally, we convert the variables used in the empirical model into natural logarithmic form.

**Table 2** Result of descriptive statistics, cross-sectional dependency and unit root test of the data series by panel

| *Variables* | | *Full Sample* | *By Income* | | | *By Region* | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | *High* | *Middle* | *Low* | *North* | *South* | *West* | *East* |
| *Per capita public health expenditure (PCPHE)* | | | | | | | | | |
| Mean | | 229.07 | 220.37 | 302.71 | 161.24 | 273.93 | 267.05 | 198.86 | 158.09 |
| Standard deviation | | 141.81 | 89.86 | 183.23 | 68.74 | 190.46 | 124.32 | 90.13 | 64.30 |
| Pesaran (2004) CD test | | 51.73* | 12.42* | 20.85* | 16.97* | 14.93* | 13.38* | 8.62* | 9.86* |
| | | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000 | (0.000) | (0.000) |
| Im et al. (2003) unit root test | Level | 4.270 | 2.539 | 1.507 | 3.412 | 1.919 | 1.758 | 3.770 | 1.403 |
| | | (1.000) | (0.994) | (0.934) | (0.999) | (0.972) | (0.960) | (0.999) | (0.919) |
| | 1st difference | 18.092* | 7.997* | 11.207* | 11.828* | 9.079* | 7.539* | 7.518* | 11.962* |
| | | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Pesaran (2007) unit root test | Level | –2.481 | –2.516 | –2.188 | –2.604 | –1.956 | –2.268 | –2.425 | –1.947 |
| | | (0.260) | (0.344) | (0.144) | (0.231) | (0.338) | (0.150) | (0.433) | (0.361) |
| | 1st difference | –3.695* | –3.763* | –2.628* | –3.616* | –2.567* | –3.526* | –3.763* | –3.749* |
| | | (0.000) | (0.001) | (0.014) | (0.000) | (0.031) | (0.000) | (0.003) | (0.000) |

Note: All the variables are in real term of constant (2004–2005) prices, India Rupees. Probability values are given in parenthesis. *Statistical significant at 1% level.

**Table 2** Result of descriptive statistics, cross-sectional dependency and unit root test of the data series by panel (continued)

| *Variables* | | *Full Sample* | *By Income* | | | *By Region* | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | *High* | *Middle* | *Low* | *North* | *South* | *West* | *East* |
| *Per capita gross state domestic product (PCGSDP)* | | | | | | | | | |
| Mean | | 25,172.32 | 35,256.99 | 27,869.74 | 15,751.79 | 27,508.36 | 28,215.70 | 28,892.14 | 16,494.48 |
| Standard deviation | | 15,685.35 | 17,437.61 | 15,680.37 | 6,732.986 | 1,6143.13 | 15,573.05 | 18,406.29 | 7,939.790 |
| Pesaran (2004) CD test | | 63.41* | 14.37* | 22.80* | 22.08* | 18.53* | 14.43* | 10.14* | 13.72* |
| | | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Im et al. (2003) unit root test | Level | 4.163 | 2.126 | 2.245 | 5.279 | 3.140 | 0.565 | 2.040 | 3.573 |
| | | (1.000) | (0.983) | (0.402) | (1.000) | (0.999) | (0.285) | (0.979) | (0.999) |
| | 1st difference | 23.250* | 11.719* | 9.263* | 19.436* | 14.651* | 8.952* | 11.958* | 10.807* |
| | | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Pesaran (2007) unit root test | Level | –2.017 | –1.758 | –2.039 | –1.487 | –2.003 | –2.021 | –0.893 | –0.595 |
| | | (0.929) | (0.519) | (0.250) | (0.991) | (0.298) | (0.304) | (0.949) | (0.994) |
| | 1st difference | –3.162* | –2.774* | –2.499* | –3.125* | –2.918* | –2.761* | –2.854* | –3.045* |
| | | (0.000) | (0.017) | (0.030) | (0.014) | (0.003) | (0.018) | (0.024) | (0.004) |
| *Number of observations* | 560 | 140 | 210 | 210 | | 175 | 140 | 105 | 139 |

Note: All the variables are in real term of constant (2004–2005) prices, India Rupees. Probability values are given in parenthesis. *Statistical significant at 1% level.

Table 2 presents three important preliminary results of our study such as the descriptive statistics result of the data, cross-section dependency result among the data and panel unit root result of variables. The result has been discussed income-wise and region-wise separately. The descriptive statistics (mean and stand deviation) result shows that there is a high degree of variation in per capita PHE across Indian states. Also, it shows that all the variables per capita public health expenditure (PCPHE) and PCGSDP reveal a considerable degree of standard deviation in the full panel of states as well as by regional panel and income panels. Pesaran (2004) cross-section dependence test result shows that a cross-correlation exists among the data series and we reject the null hypothesis of no cross-section dependence at the one% (1%) level of significance in full panel as well as sub-panels. After getting the existence of cross-section dependence among the data, we applied Im et al. (2003) and Pesaran (2007) panel unit root test and found that variables such as PCPHE and PCGSDP are first difference stationary.

### *3.2 Empirical methods*

The empirical analysis of panel data in this study consists of the following five steps. First, we applied Pesaran's (2004) cross-section dependence test for the existence of common shocks among sample states. Second, after the existence of cross-correlation among the sample states, we applied the second generation of panel unit root rest such as cross-section augmented Im-Pesaran-Shin (CIPS) test proposed by Pesaran (2007). Third, after having established the order of integration in the series, we used the tests of Pedroni (2004), Kao (1999) and Westerlund (2007) to examine the long-run relationships between the variables in question. Fourth, after confirming the long-run co-integration among the variables, we applied the panel DOLS technique to estimate the long-run coefficients. Finally, we applied panel VECM Granger causality test to determine the direction of causality between PHE and income in both short-run as well as long-run dynamics.

### *3.3 Panel unit root test*

In this section, the goal is to ascertain the panel stationarity properties of the data series. The dataset includes two variables namely, real per capita GSDP and real per capita PHE. We applied Pesaran's (2007) second generation panel unit root test to determine the order of integration of these variables for eight panels of states including the full panel of 16 states, the four regional panels and the three income panels. Since we use a balanced panel data, Pesaran's (2007) test is more suitable in dealing with heterogeneity across cross-sectional units. The earlier tests such as Levin et al. (2002), Breitung (2001) and Im et al. (2003) are not applicable if cross-sectional correlation is present among the variables and assumes the residuals are cross-section dependent. In the presence of such cross-section dependency, Pesaran (2007) proposed the cross-sectionally augmented regression for the individual series for models without residual serial correlations.

### *3.4 Panel co-integration test*

If the variables contain a panel unit root, then the next issue is: are the variables panel co-integrated in the long-run? To answer this question, panel co-integration test proposed by Pedroni (2004) is used which allows for a heterogeneous panel with multiple regressors as well as asymptotic and finite sample properties of panel data. It provides as many as seven test statistics to examine the null of no co-integration in heterogeneous panels. These multiple test statistics ensure robust evidence on panel co-integration. Essentially, the tests can be categorised into two groups. One group of tests is termed 'within dimension' (panel tests) and the other group of the test is termed 'between dimension' (group tests). The 'within dimension' tests take into account common time factors and allow for heterogeneity across states. The 'between dimensions' tests are 'group mean co-integration tests' and allow for heterogeneity of parameters across states. The seven Pedroni (2004) panel co-integration test statistics that we use are panel v-statistics, panel and group Phillip Perron type rho-statistics, panel and group Phillip Perron type t-statistics, panel and group ADF type t-statistics. If the test statistic exceeds the critical values in Pedroni (2004), the null hypothesis of no co-integration is rejected, resulting in a long-run relationship between PHE and income. Pedroni's (2004) seven test statistics are based on the following panel co-integration regression:

$$y_{i,t} = \alpha_i + \delta_i t + \beta_{1i} x_{1i,t} + \ldots + B_{Ni} x_{Mi,t} + e_{i,t} \tag{1}$$

Here $t = 1 \ldots T$; $i = 1 \ldots N$; $m = 1 \ldots M$, where $T$ refers to the number of observations over time, $N$ refers to the number of individual states in the panel and $M$ refers to the number of regression variables. The variables $y_{it}$ and $x_{it}$ are assumed to be integrated of order one, denoted $I(1)$ for each member state $i$ of the panel and under the null hypothesis of no co-integration. The parameters $\alpha_i$ and $\delta_i$ allow individual specific effects and deterministic trends respectively. Also the slope coefficient $\beta_i$ varies across individual states. So, the co-integrating vectors should be heterogeneous across member states of the panel.

### *3.5 The error correction-based panel cointegration test*

Westerlund (2007) uses four-panel cointegration tests namely Pt, Pa and Gt, Ga to test the null hypothesis of no cointegration. The first pair of the statistics Pt and Pa referred as panel statistics are based on pooling the information regarding the error correction along the cross-sectional dimension of the panel. The second pair Gt and Ga refers to a group mean statistics. The first two tests are meant to test the alternative hypothesis that the panel is cointegrated as a whole, while the other two test the alternative that at least one unit is cointegrated. The advantages of these tests are that they are normally distributed and also accommodate unit-specific short-run dynamics, unit-specific trend and slope parameters and cross-sectional dependence. Also the bootstrapped version of this test provides a robust result which is very effective in eliminating the effects of the cross-sectional dependence without sacrificing power. But before applying Westerlund error correction-based cointegration test, first we need to test the unit root of order one, $I(1)$ and then whether the variables or residuals are serial correlated or not through the cross-sectional dependency tests.

### *3.6 Panel long-run estimators*

If one finds a long-run relationship between the variables, the next step is to estimate the long-run effects of per capita GSDP on per capita PHE. To estimate the long-run effects, we use the panel DOLS estimator proposed by Kao and Chiang (2000). Kao and Chiang (2000) examined the finite sample properties of ordinary least squares (OLS), fully-modified OLS (FMOLS) and DOLS. They found that, because OLS and FMOLS exhibit substantial bias in panels up to N = 60, T = 60, DOLS is superior to OLS and FMOLS in all cases. Pedroni (2001) employed DOLS techniques in the study on purchasing power parity test. We employed the same model specification for the estimation of real per capita PHE and real per capita GSDP. The simple panel regression equation becomes:

$$Y_{it} = \alpha_i + \beta_i X_{it} + \mu_{it} \tag{2}$$

In equation (1), $Y_{it}$ and $X_{it}$ are co-integrated with slopes $\beta_i$ which may or may not be homogeneous across $i$. In this case, the null hypothesis is $H_0$: $\beta_i = 1$ for all $i$. Let $\varepsilon it == (\hat{\mu}_{it}, \Delta X_{it})'$ be a stationary vector consisting of the estimated residuals from the co-integrating regression and difference in $X_{it}$. Let $\Omega_i \equiv \lim_{T\to\infty} E\left[T^{-1}\left(\sum_{t=1}^{T}\varepsilon_{it}\right)\left(\sum_{t=1}^{T}\varepsilon'_{it}\right)\right]$ be the long-run covariance matrix and it can be decomposed as $\Omega i = \Omega_i^0 + \Gamma_i + \Gamma'_i$ where $\Omega_i^0$ is the contemporaneous covariance and $\Gamma_i$ is a weighted sum of auto-covariances.

In a similar fashion, the panel DOLS regression equation becomes:

$$Y_{it} = \alpha_{it} + \beta_i X_{it} + \sum_{k=-K_i}^{K_i} \gamma_{ik} \Delta X_{it-k} + \mu_{it} \tag{3}$$

From equation (2), we construct the panel DOLS estimator, mentioned as follows:

$$\hat{\beta}_{GD} = \left[N^{-1}\sum_{i=1}^{N}\left(\sum_{t=1}^{T} z_{it} z'_{it}\right)^{-1}\left(\sum_{t=1}^{T} z_{it}\tilde{Y}_{it}\right)\right] \tag{4}$$

where $\hat{\beta}_{GD}$ is group mean distributor of panel dynamic OLS, $Z_{it} = (X_{it} - \overline{X}_i, \Delta X_{it-K}, \ldots, \Delta X_{it+K}),\ \tilde{Y}_{it} = Y_{it} - \overline{Y}_i$ and $Z_{it}$ is the $2(K + 1)*1$ vector of regressors.

### 3.7 VECM panel Granger causality test

Engle and Granger (1987) propose the cointegration and error correction model (ECM) for the long-run causation between the variables. The error correction mechanism says that a proportion of the disequilibrium from one period is corrected in the next period. In the two variables case, the change in one variable in one period may depend upon the past equilibrium error, as well as to past changes in both the variables. If $X$ and $Y$ are 1(I) and co-integrated, then the causality is tested by using ECM.

Model 1

$$\begin{aligned} \Delta \ln PCPHE_{it} &= \beta_{1g} + \sum_p \beta_{11ip}\Delta PCPHE_{it-p} + \sum_p \beta_{12ip}\Delta \ln PCGSDP_{it-p} + \psi_{1i} ECT_{t-1} \\ \Delta \ln PCGSDP_{it} &= \beta_{2g} + \sum_p \beta_{21ip}\Delta PCGSDP_{it-p} + \sum_p \beta_{22ip}\Delta \ln PCPHE_{it-p} + \psi_{2i} ECT_{t-1} \end{aligned} \tag{5}$$

Here all the variables are previously defined in the descriptive statistics. Δ-denotes the first difference of the variables, *p* denotes the lag length and *ECT* is white noise error term. The long-run causality can also be obtained in the VECM model by looking at the significance of the estimated coefficient on lagged error correction term. The joint $\chi^2$ (chi-square) statistics for the first-differenced lagged independent variables are used to investigate the direction of short-run causality between the variables. For example, $B_{12,ip} \neq 0 \; \forall_i$ shows that economic growth causes health expenditure for health and vice-versa if $B_{12,ip} \neq 0 \; \forall_i$.

## 4 Empirical results and discussion

### *4.1 Results of cross-section dependency and panel unit root test*

Table 2 presents the estimated results obtained from Pesaran's (2004) cross-sectional dependency test. The test statistics indicate that the null hypothesis of no cross-sectional dependency can be rejected for all variables at one% (1%) level of significance. Therefore, it implies the existence of some serial correlations among the states of India. This type of correlation arises from macroeconomic shocks with heterogeneous impact across states of India. Therefore, the residuals from the standard panel regression would be contemporaneously correlated and this should be addressed by employing CIPS, the second generation panel unit root test which accounts for cross-section dependence.

Results from the CIPS panel unit root test are reported in Table 2 for per capita GSDP and per capita PHE with individual intercept and time trend. We conducted this exercise for the full panel of 16 states plus four regional panels and three income panels as well. The result implies that per capita GSDP and per capita PHE is panel unit root at level. After converting to first difference, the variables are integrated of order one. Further, we applied Im et al. (2003) the first generation panel unit root test and found that variable, i.e., PCGSDP and PCPHE are stationary in first difference.

### *4.2 Long-run relationship between PHE and GSDP*

After verifying unit root tests of order one I(1), we proceed to test for co-integration in order to determine the long-run relationship between PCPHE and PCGSDP. Therefore, we have applied three types of co-integration tests: Pedroni (2004), Kao (1999) and Westerlund (2007) error correction-based panel co-integration tests and the results are reported in Table 3 for each of the regional and income panels of states. The results from Pedroni panel cointegration test explain that real per capita PHE is a function of real per capita GSDP. The result also shows that the null of no panel cointegration is rejected in all the seven test statistics in case of a full panel of 16 states, for the different income categories except high-income panels. Almost three test statistics of Westerlund (2007) error correction panel cointegration test have also been found to be significant. The result reveals that there is a long-run association between per capita PHE and per capita GSDP in case of a full panel of 16 states, for the different income categories except for high-income panels and for the different level of development except for the western region of panels.

**Table 3** Co-integration test (PCPHE and PCGSDP)

| | *Full sample* | *By income* | | | *By region* | | | |
|---|---|---|---|---|---|---|---|---|
| | | *High* | *Middle* | *Low* | *North* | *South* | *West* | *East* |
| *Pedroni (2004)* | | | | | | | | |
| Panel v | 2.346* | 0.826 | 0.714 | 0.844* | 1.658** | 0.966 | 1.342*** | 0.767 |
| | (0.009) | (0.204) | (0.237) | (0.002) | (0.048) | (0.166) | (0.089) | (0.221) |
| Panel rho | –5.003* | –0.618 | –3.493* | –4.517* | –1.912** | –2.518* | –1.641*** | –3.700* |
| | (0.000) | (0.268) | (0.000) | (0.000) | (0.027) | (0.005) | (0.050) | (0.000) |
| Panel PP | –5.068* | –0.293 | –3.473* | –4.845* | –1.905** | –2.338* | –1.556*** | –4.016* |
| | (0.000) | (0.384) | (0.000) | (0.000) | (0.028) | (0.009) | (0.059) | (0.000) |
| Panel ADF | –4.829* | –0.511 | –3.228* | –4.845* | –2.476* | –1.999** | 0.046 | –4.107* |
| | (0.000) | (0.304) | (0.000) | (0.000) | (0.006) | (0.022) | (0.518) | (0.000) |
| Group rho | –2.854* | 0.267 | –1.887** | –4.250* | –0.792 | –1.270 | –1.377*** | –2.321** |
| | (0.002) | (0.605) | (0.029) | (0.000) | (0.214) | (0.101) | (0.084) | (0.010) |
| Group PP | –4.357* | 0.278 | –2.782* | –2.991* | –1.426*** | –1.747** | –1.879** | –3.710* |
| | (0.000) | (0.609) | (0.002) | (0.001) | (0.076) | (0.040) | (0.030) | (0.000) |
| Group ADF | –3.618* | –0.116 | –2.414* | –4.560* | –2.070** | –1.363*** | 0.232 | –3.725* |
| | (0.000) | (0.453) | (0.007) | (0.000) | (0.019) | (0.086) | (0.592) | (0.000) |
| Kao test (1999) | –3.661* | –1.395*** | –3.072* | –3.399* | –1.239 | –2.027** | –1.246 | –2.390* |
| | (0.000) | (0.081) | (0.001) | (0.000) | (0.107) | (0.021) | (0.106) | (0.008) |
| *Westerlund (2007) ECM panel cointegration test, $H_0$: no cointegration* | | | | | | | | |
| Gt | –3.455* | –2.682 | –4.055* | –3.370* | –3.155** | –4.139* | –2.981*** | –3.500* |
| | (0.000) | (0.208) | (0.000) | (0.001) | (0.013) | (0.000) | (0.089) | (0.002) |
| Ga | –10.389 | –9.055 | –6.397 | –15.271 | –10.932 | –5.346 | –10.183 | –14.908 |
| | (0.818) | (0.804) | (0.979) | (0.107) | (0.627) | (0.976) | (0.672) | (0.183) |
| Pt | –12.550* | –4.615 | –8.686* | –7.911* | –8.194* | –6.803* | –3.499 | –6.810* |
| | (0.000) | (0.325) | (0.000) | (0.001) | (0.000) | (0.001) | (0.574) | (0.001) |
| Pa | –16.778* | –8.363 | –18.081* | –19.667* | –20.692* | –16.283* | –9.436 | –20.130* |
| | (0.000) | (0.578) | (0.000) | (0.000) | (0.000) | (0.007) | (0.444) | (0.000) |

Notes: Probability values are given in parenthesis. * Statistical significant at 1 percent level. ** Statistical significant at 5 percent level. *** Statistical significant at 10 percent level.

This implies that there exists a long-run relationship between real per capita PHE and real per capita GSDP in India at the aggregate level (national) as well as for the four geographic regions namely North, South, West and East. Amongst income categories, the low-income and middle-income states show strong evidence in the growth of per capita PHE with respect to per capita GSDP (income), than high-income states. It also reflects that the rising share of PHE in terms of GSDP in the poor income states like Bihar, Odisha, Uttar Pradesh and Madhya Pradesh has been increasing consistently in the post-2000 years as compared to the 1990s. Similarly, amongst all the regions, the western region does not support the long-run relationships between PHE and income, primarily because of the declining share of total PHE in state income in industrial states like Maharashtra and Gujarat, particularly during the period 1991–1992 to 2000–2001. Particularly in the eastern region of India, the low-income category states have a strong long-run relationship between PHE and per capita income. There are at least two reasons that may help support the strong association. First, the share of PHE as a percentage of income has increased since 2000 and second the growth of per capita PHE has increased dramatically. So, it is evident that real per capita PHE and real per capita GSDP of states move together in the long-run.

## *4.3 Long-run estimator of PHE and GSDP*

Based on the evidence of co-integration, we estimate the long-run elasticity of PHE with respect to per capita GSDP (income) by using the panel DOLS estimators. The results for the estimated models of eight panels of states (listed column-wise) are reported in Table 4. We find that in all the eight panels, real per capita GSDP has a statistically significant and positive effect on real per capita PHE. In the case of a full panel of states, a one% (1%) increase in real per capita GSDP leads to a 0.53% increase in the real per capita PHE. The estimated coefficient from the estimators of real GSDP per capita is smaller than unity and positively significant in full panel, regional panel and income panel as well. The middle-income and southern region states show high elasticities compared to the full panel. A one% (1%) increase in real per capita GSDP increases the real per capita PHE by 0.55% in middle-income states and by 0.54% in the southern region of states. So, it implies that health care is not a luxury good. The findings are similar to those of Behera and Dash (2016, 2017a), Khan et al. (2015) and Wang (2011), which shows that per capita income is the main determinant of the growth of per capita PHE in long-run and regression coefficient is around 0.53–0.79% (less than unity), recognised that health is not treated as luxury, but rather a necessity in an emerging country like India.

**Table 4** DOLS test for long-run estimator (PCPHE and PCGSDP)

| *Statistics* | *Full sample* | *By income* | | | *By region* | | | |
|---|---|---|---|---|---|---|---|---|
| | | *High* | *Middle* | *Low* | *North* | *South* | *West* | *East* |
| Coefficient | 0.532* | 0.524* | 0.555* | 0.516* | 0.538* | 0.549* | 0.523* | 0.515* |
| Std. error | 0.002 | 0.006 | 0.004 | 0.003 | 0.004 | 0.005 | 0.006 | 0.004 |
| Prob. | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Note: *indicate statistical significance at the 1% level.

### 4.4 Granger causality between PHE and GSDP

After confirmation of the long-run relationship between per capita PHE and per capita GSDP, Table 5 shows the panel Granger causality test results. The results for short-run Granger causality come from the first difference of the variables while the evidence for long-run Granger causality is obtained from one period lagged error correction term. The relevance of ECM test shows the direction of causality and also enables to distinguish between short-run and long-run Granger causality.

First, there is evidence of bi-directional Granger causality between Δln (PCPHE) and Δln (PCGSDP) in the short-run and, unidirectional Granger causality from Δln (PCGSDP) to Δln (PCPHE) in the long-run in full sample panels. The long-run causality indicates the negative and significant t-statistics from the ECM (ECMit-1), while short-run causality shows through the chi-square statistics from the Wald test. Second, in terms of evidence from income panel of states, we notice that for the middle-income panel of states both Δln (PCPHE) and Δln (PCGSDP) Granger cause each other in the short-run and unidirectional Granger causality running from Δln (PCGSDP) to Δln (PCPHE) in the long-run. Third, when we consider all income panel of states, we find that there is evidence of unidirectional Granger causality found from Δln (PCGSDP) to Δln (PCPHE) in the long-run while, we do not find any long-run Granger causality from Δln (PCPHE) to Δln (PCGSDP) across income panels. Fourth, we find that Δln (PCGSDP) does not cause Δln (PCPHE) in the short-run while it causes in long-run in both high-income and low-income panel of states. Fifth, we find that Δln (PCPHE) is causing Δln (PCGSDP) in the short-run while does not cause in the long-run in both high-income and low-income panel of states. Sixth, in terms of the regional panel of states, we find that there is evidence of unidirectional Granger causality running from Δln (PCGSDP) to Δln (PCPHE) in the long-run, except in the north region panel. Further, we do not find any long-run Granger causality from per capita PHE to per capita GSDP across all regional panel of states. Seventh, there is evidence of bi-directional Granger causality between Δln (PCGSDP) and Δln (PCPHE) in the short-run in all the regional panels except in the Western and Eastern region panels.

Overall VECM Granger causality result shows that per capita GSDP (income) causes per capita PHE (health expenditure) in the long-run in case of the full sample, income panels (high, middle and low) and regional panels (south, west and east). Our findings are in line with the earlier studies namely Pradhan and Bagchi (2012), Behera and Dash (2016, 2017a), Wang (2011) and Khan et al. (2015) that found a long-run causality from per capita income to per capita PHE. Further, there is the existence of bi-directional Granger causality between per capita GSDP (income) and per capita PHE (health expenditure) in the short-run in case of the full sample, middle-income panel and regional panels (north and south). Our findings are thus in line with that of Pradhan and Bagchi (2012), Behera and Dash (2016, 2017a), Wang (2011), Khan et al. (2015) and Erdil and Yetkiner (2009) which had reported short-run bi-directional causality between increase in health expenditure and increase in per capita income.

**Table 5** Results of VECM Granger causality test

| *Equation* | *Dependent Variable* | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | *Full Sample* | | *By Income* | | | | | |
| | | | *High* | | *Middle* | | *Low* | |
| | *Δln(PCPHE)* | *Δln(PCGSDP)* | *Δln(PCPHE)* | *Δln(PCGSDP)* | *Δln(PCPHE)* | *Δln(PCGSDP)* | *Δln(PCPHE)* | *Δln(PCGSDP)* |
| Δln(PCGSDP) | 1.168[a]* | | 0.240 | | 1.018*** | | −0.128 | |
| | [17.213][b] | | [3.206] | | [9.299] | | [4.334] | |
| | (0.004)[c] | | (0.523) | | (0.097) | | (0.114) | |
| Δln(PCPHE) | | −0.154* | | −0.175* | | −0.184* | | 0.109** |
| | | [50.404] | | [30.585] | | [36.168] | | [7.534] |
| | | (0.000) | | (0.000) | | (0.000) | | (0.023) |
| ECMit-1 | −0.001** | 0.0262* | −0.132* | 0.045** | −0.027* | 0.053* | −0.236* | 0.040** |
| | [−2.449] | [4.894] | [−5.717] | [2.613] | [−3.105] | [5.553] | [−5.359] | [2.524] |
| | (0.014) | (0.000) | (0.000) | (0.010) | (0.002) | (0.000) | (0.000) | (0.012) |
| *Equation* | *By Region* | | | | | | | |
| | *North* | | *South* | | *West* | | *East* | |
| | *Δln(PCPHE)* | *Δln(PCGSDP)* | *Δln(PCPHE)* | *Δln(PCGSDP)* | *Δln(PCPHE)* | *Δln(PCGSDP)* | *Δln(PCPHE)* | *Δln(PCGSDP)* |
| Δln(PCGSDP) | 2.493* | | 0.934*** | | −0.013 | | −0.586 | |
| | [15.190] | | [9.420] | | [0.659] | | [4.503] | |
| | (0.004) | | (0.093) | | (0.718) | | (0.105) | |
| Δln(PCPHE) | | −0.097* | | −0.223* | | 0.056 | | 0.097** |
| | | [35.849] | | [31.366] | | [0.979] | | [6.192] |
| | | (0.000) | | (0.000) | | (0.612) | | (0.045) |
| ECMit-1 | −0.028 | −0.0003* | −0.030* | 0.050* | −0.155* | 0.061* | −0.286* | 0.043** |
| | [−1.136] | [−3.118] | [−2.802] | [4.312] | [−3.296] | [3.325] | [−4.193] | [2.264] |
| | (0.257) | (0.002) | (0.006) | (0.000) | (0.001) | (0.001) | (0.000) | (0.025) |

Notes: [a], [b] and [c] denote the sum of coefficients, statistics value, and p-value, respectively. Chi-square statistics from Wald test shows the short-run causality between health expenditure and economic growth, and t-statistics testing for long-run causality through the error-correction adjustment coefficient. Probability values are given in parenthesis. *Statistical significant at 1% level. **Statistical significant at 5% level.

## 5 Conclusions

This paper examines the long-run relationship between per capita PHE and per capita GSDP using panel unit root, panel co-integration, panel long-run estimator and panel Granger causality test for 16 major states of India over the period of 1980–2014. The study is motivated towards finding out a positive correlation between the increase in PHE and per capita income in the states with low and high incomes and examines whether the different levels of per capita income growth (or increase in PHE) will change the level of PHE (or level of per capita income growth). Therefore, we divide the Indian states into eight panels based on the geographical location and level of economic development for examining the level of heterogeneity in the share of PHE with respect to states' domestic product.

The results reveal that generally for all panels, there is evidence of panel unit root and panel co-integration. This allows us to estimate the long-run income elasticities of PHE. We find that all the panels of states – full sample, regional panels and different income panels of states, real per capita GSDP (PCGSDP) depict a statistically significant and positive effect on real PCPHE. Overall VECM Granger causality result shows that per capita GSDP (income) causes per capita PHE (health expenditure) in the long-run in the case of the full sample, income panels (high, middle and low) and regional panels (south, west and east). Further, there is the existence of bi-directional Granger causality between per capita GSDP (income) and per capita PHE (health expenditure) in the short-run in case of the full sample, middle-income panel and regional panels (north and south). In conclusion, health is not a luxury good in the states of India because the elasticity of health expenditure with respect to state's income is less than one in the long-run regression estimation. There is a long-run relationship between health expenditure and income. Both income and healthcare expenditure affect each other in the short-run. However, in the long-run, income growth leads to the increase in PHE and PHE does not cause income growth. Therefore, it confirms that economic growth leads to better health outcome, in turn, leads to health expenditure in the short-run. Interestingly, we find that for high-income states and the states of the western region, there is a rise in income which shows less increment in government health expenditure, whereas the low-income states, as well as the states of the southern region, show high increment in government health expenditure with moderate income growth.

Overall the result implies that there is state-level heterogeneity in the share of PHE with respect to state's economic growth. The policy implication would be that growth is certainly important for spending on healthcare, but it requires enough revenue for transforming growth to health and vice-versa. The health sector has a huge requirement for financial resources to mitigate health-related infrastructure. The fiscal space of the state government may not be sufficient to fill the gap between supply and demand of health sector. Here, it can be inferred that there is a necessity of an alternative source of funding for strengthening the fiscal space for health. So, there is a need for central allocation not only in the health sector but also in other social sectors because states cannot maintain all health sector demands with their own revenue resources. The state government should increase fiscal space for the health sector in order to mobilise resources for health system financing and eventually will reduce the out-of-pocket health expenses. This study would serve as effective fiscal policy instrument to minimising geographical inequity of health finance for achieving UHC of Indian states.

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## Notes

1 Health system includes all the activities whose primary purpose is to promote, restore or maintain health. Health systems are not just concerned with improving people's health but with protecting them against the financial costs of illness. The challenge facing governments in low-income countries is to reduce the regressive burden of OOP payment for health by expanding prepayment schemes, which spread financial risk and reduce the spectra of catastrophic health care expenditures (World Health Organization, 2000).

2 UHC provides assurance of health services to all needy people under three objectives such as equity in access, quality of health services and ensuring financial risk protection (Duran et al., 2014).

3 India is subdivided into 29 states and seven union territories. All states are represented by the state government and the head of state government (Chief Minister) is chosen by the legislators elected by the people, of the concerned states. The study has taken 16 major states because of the data availability over the entire study period.

4 The provision of healthcare is mainly the responsibility of the state government, in which the share of medical and public health around 90% of the total state's expenditure. The central grants to state's medical and public health budget are mainly allocated to the certain centrally sponsored disease control programme and the centre provides almost all funds for family planning programmes of the states (Tulsidhar, 1993). So, we have focused only on the state's budgetary expenditure on public health and medical and family welfare expenditure.