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Public Health Expenditure and Health Outcomes in India: A Comparative Analysis Between Odisha and Bihar

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ABSTRACT

Health expenditures form an important tool for improving the health status of populations as well as reducing health disparities, especially in the case of underdeveloped economies. This research explores the dynamics between public health expenditures, economic growth and health outcomes, specifically in relation to the IMR in the states of Odisha and Bihar over the period of 1991-2023. For this purpose, the ARDL Bounds Testing technique is used to evaluate both short-term and long-term relationships among the selected variables. It was found that there exists a significant long-term cointegration relationship between public health expenditures and infant mortality. A comparison of findings implies that the state of Odisha has been successful in translating public health spending into improved health status. Specifically, the error correction coefficient for Odisha was approximately -0.08, which indicates that Odisha adjusts towards the long-term equilibrium state faster compared to Bihar, which has an error correction coefficient of -0.03. The robustness and validity of the estimation results are confirmed through the CUSUM and heteroscedasticity tests. The findings also show that although a rise in public health spending continues to be important for health improvement, more funding is not enough for Bihar. Better health outcomes require greater effectiveness in delivering health care services and ensuring that funds allocated are translated into results efficiently. Learning from the experiences of the state of Odisha, it can be recommended that Bihar focus on enhancing its healthcare systems by way of improved governance and execution ability rather than merely increasing its spending on healthcare.

Keywords: Health expenditure, Health outcomes, ARDL Bounds test, Odisha and Bihar

INTRODUCTION

Healthcare forms an integral part of human development, and hence, acts as a foundation for economic development and social welfare. In the case of developing nations such as India, betterment of health conditions among its citizens has been one of the main objectives for their governments. As per Sen (1999), proper development happens when humans are liberated from the clutches of poverty, starvation and undernourishment, and they can live

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healthier lives. Healthcare investments play an indispensable role in ensuring improved health and well-being (Grossman, 1972; Laporte, 2015). Affordability and accessibility are important aspects to ensure good health conditions and empowerment of individuals. Government intervention is necessary in the field of healthcare due to information asymmetry in the market. Investment in public health care is an effective tool for ensuring improved health conditions among the population and reducing health inequities and inequalities. Public health care spending is of immense importance in the case of developing nations such as India where there are vast differences in socioeconomic conditions and private healthcare service providers wield significant influence.In the federal administrative structure prevailing in India, it is the state government that shoulders the main burden of health. Thus, the states have a major influence on how health resources are spent, their efficiency, and amount allocated. In such an administratively decentralized health care setup, there exist large disparities among states regarding expenditures made for public health as well as health indicators. Hence, state-wise assessment is needed to evaluate the performance of the health sector (Rao & Choudhury, 2012).

The evidence from Indian states suggests that apart from the amount of healthcare expenditure, the distribution of expenditure has an important bearing on health outcomes as well. Rao et al. (2014) noted that health-related expenditure made on primary healthcare, maternal and child healthcare programs, and preventive health measures yield more positive results for health outcomes compared to health expenditure focused on tertiary level healthcare facilities. Even though there has been consistent growth in the economy of India, the proportion of health expenditure as a percentage of GDP has continued to be low during the last two decades. The lack of adequate public health expenditure has led to high out-of-pocket expenditure on healthcare by the individuals (Berman et al., 2010). Previous empirical literature shows that public health expenditure leads to better health outcomes and lower infant and maternal mortality rates provided that the health expenditure is optimally utilized (Gupta et al., 2010; Mohanty & Behera, 2020). As is well-known, after the economic liberalization policy was introduced by the Indian government in 1991, the country witnessed an improvement in public spending in the field of health. Nonetheless, it should be stated that this expenditure has produced very different results depending on the state concerned. Although several states managed to reduce infant mortality substantially owing to their efforts, others failed to reach their targets despite allocating more funds to this area.

The current paper aims at analyzing the performance of two adjacent states, namely Odisha and Bihar in eastern India. It is known for sure that, historically, Odisha and Bihar were characterized by the same development problems such as poverty and predominantly rural communities along with poor medical infrastructure. Yet, as time went by, there appeared to be a difference between their developmental achievements with respect to healthcare. In particular, Odisha made remarkable progress in improving its healthcare performance due to such policies as Biju Swasthya Kalyan Yojana. Fiscal management has been better in Odisha, along with an increased dedication towards social sector spending, compared to Bihar, where there have been difficulties due to insufficient funds as well as other issues related to governance that affected the quality of public services. The construction of health facilities and conducting disease control programs has helped Odisha improve its health status.

Consequently, infant and maternal mortality rates have gradually decreased over the years, although still being higher than the national average.

The problems of poor governance, poor infrastructure, and poor government funding of healthcare facilities have hindered the provision of effective health services in Bihar. The level of government funding of health facilities per capita is one of the lowest in India, although there has been an extensive reliance by individuals on out-of-pocket spending for health (Dash & Mohanty, 2019). As a result, Bihar has had a poor record of health, with high rates of infant mortality and maternal mortality as well as a low rate of institutional delivery. However, some recent studies indicate that specific programs initiated by central sponsorship of health programs have made considerable contributions towards improving health status.The theoretical base of the current study emanates from the concept of health production function, whereby health results from several economic and social determinants. According to this theory, public health expenditure has been cited as one of the determinants of better health statuses because of its ability to lower mortality rates and promote economic growth. There has been an abundant amount of literature focusing on the correlation between health expenditure and health status in India. However, majority of these studies have concentrated on trends at the national level and have not given much attention to the state-level institutions and policies. Comparisons between states like Odisha and Bihar using recent data have been quite scarce. Moreover, not many studies have analyzed the process through which states adapt themselves and attain equilibrium in health status after any economic shock. This study tries to fill the existing gap in literature by analyzing the long run and short run effects among public health expenditure, per capita net state domestic product, and infant mortality rate in the states of Odisha and Bihar. It also examines the process through which Odisha and Bihar achieve equilibrium after any economic shock.

REVIEW OF LITERATURE

The relationship between health spending, economic growth, and health outcomes has drawn much scholarly interest in the field of public and health economics. Traditional economists such asMusgrave (1959) posit that economic growth entails an increase in government expenditures in sectors of society including the provision of health services. Nonetheless, there have been inconsistent findings on the efficacy of such spending. Specifically, Filmer and Pritchett (1999), in a cross-national assessment, found that public health spending had little effect on infant mortality in relation to socio-economic variables like female literacy and per capita income levels. On the contrary, research by Anyanwu and Erhijakpor (2009) on developing nations indicated that increased investment in health would lead to significant declines in infant and under-five mortality if used effectively.Investments in healthcare made by governments have been considered an important tool that can help improve the health status of the population and human development. The theory of human capital created by Grossman in 1972 considers health care not only as a consumption commodity but also as an investment one since being healthy enables individuals to live longer, be more productive, and be happier. Public intervention in this sphere should be supported because the market is characterized by imperfections that can result in inequality in accessing medical services and low availability of preventive measures. This situation in developing countries is particularly

problematic since, due to private fragmentation and high payments out-of-pocket, investments of the government can help overcome these barriers (Gupta et al., 2003). Many studies both theoretical and empirical reveal that the relationship between expenditure on public health care and the health outcomes might not be strictly linear. The positive correlation between health expenditures and improvement in the health outcome indicators could be observed at low expenditure levels through mortality reductions and reduced prevalence rates; however, it would start weakening after reaching the critical coverage levels (Bokhari et al., 2007). It is important to note that the success of public expenditures also greatly depends on the effective use of those funds and institutional capacity. Thus, in areas lacking adequate capacities, the higher expenditures may not contribute much to achieving health improvement goals (Mohanty & Behera, 2023). In the same way, it should be highlighted that according to Hooda (2013), out-of-pocket payments for health services continue being high in India, proving the insufficiency of current public health care expenditure for offering financial protection to vulnerable social groups.

Several research papers have highlighted the inadequacy of rising spending in the area of public health towards ensuring positive health impacts unless there are proper governance and implementation mechanisms. Earlier research by Gupta and Mitra (2004) highlighted that factors such as higher per capita income, urbanization, IMR, adult literacy, improved access to safe drinking water and sanitationcontribute positively to better health outcomes. These findings are particularly relevant for states like Odisha and Bihar, where structural weaknesses in healthcare delivery continue to persist despite increased allocations under the National Health Mission. The literature further suggests that financial resources alone cannot guarantee improved health indicators. The availability of healthcare infrastructure, skilled manpower, effective governance, and efficient policy implementation are equally important determinants of success (Savedoff, 2011).

Demand-side approaches are also supported by international experience regarding their significance in improving the impact of government spending on the health sector. Research on conditional cash transfers in other nations suggests that demand-side measures that focus on increasing utilization of institutional health care, antenatal care, and child immunizations can significantly increase health benefits (Lagarde et al., 2007). This further implies that a combination of efforts from both sides is more likely to achieve better outcomes compared to the separate use of each strategy. The same logic lies behind similar Indian schemes such as Janani Suraksha Yojana.The Indian scenario brings in further complications as the provision of healthcare falls under the domain of the states within a federal structure. Public spending on health has been low throughout India, accounting for around 1.2–1.5 percent of GDP, and even out-of-pocket health expenditures have constituted a sizeable portion of health expenditure. Per capita public health spending shows significant variation between the states. Odisha has made steady progress towards better spending in terms of health with higher fiscal and institutional capacity for investing in the social sector(Kaur & Chakraborty, 2021). Besides, Das Gupta et al. (2010) pointed out that poor implementation of government health programs and lack of institutional support had resulted in poor access to quality health care in Bihar.Though there may be variations in the extent of the relationship, empirical research done using Indian states as case studies suggests that there is a positive relationship between

increased public spending on health and improved maternal and child health. In a panel regression analysis conducted by Babbar and Bhandari (2025), they investigate the effect of spending on health at the state level and its impact on infant and neonatal mortality rates in 16 states in India. From their results, it appears that for every 1 percent increase in spending on public health, there is about a 0.11 percent decline in infant mortality rate.

DATA AND METHODOLOGY

This section discusses the econometric model and the methodology adopted to estimate the relationship between Public Health Expenditure (PHE), Per Capita Net State Domestic Product (PCNSDP), and Infant Mortality Rate (IMR) in Odisha and Bihar. In order to conduct an analysis of the short-term and long-term interactions between these variables, an Autoregressive Distributed Lag (ARDL) Bounds Testing technique suggested by Pesaran et al. (2001) has been used in this study. There are two major reasons for choosing ARDL method. First, this technique allows using variables that are non-stationary of different orders as long as no one of the variables is stationary of the second order. Second, ARDL technique shows good performance under conditions of small sample size; therefore, it fits well with yearly time series data. The model applied is based on the health production function theory according to which the output in terms of health depends on economic and healthcare-related factors. In our case, the dependent variable is IMR, whereas PHE and PCNSDP are regarded as independent factors that determine IMR.

$$lnIMR_t = \beta_0 + \beta_1\, lnPHE_t + \beta_2\, lnPCNSDP_t + \varepsilon_t \quad \ldots\ldots \quad (1)$$

To evaluate the adjustment process and short-term shocks, we transform the above equation into the ARDL error correction framework:

$$\Delta lnIMR_t = \alpha_0 + \sum_{i=1}^{p} \gamma_i\, \Delta lnIMR_{t-i} + \sum_{j=0}^{q1} \delta_j\, \Delta lnPHE_{t-j} + \sum_{k=0}^{q2} \theta_k\, \Delta lnPCNSDP_{t-k} + \lambda_1\, lnIMR_{t-1} + \lambda_1\, lnIMR_{t-1} + \lambda_1\, lnIMR_{t-1} + \mu_t \quad \ldots.. \quad (2)$$

Where Δ denotes the first difference operator capturing immediate changes, p, q_1, q_2 are the optimal lags selected via the Akaike Information Criterion, the coefficients $\lambda_1, \lambda_2\, \lambda_3$ represents the long-run multipliers, which tell how health outcomes stabilise over decades. Lastly μ_t is the error term.

The research applies annual time series data from 1991 to 2023 for both Odisha and Bihar. The data were derived from the Reserve Bank of India and the Ministry of Statistics and Programme Implementation. Table 1 shows a summary of the variables and their sources:

Table 1. Summary of parameters and their sources

Variables	Description	Source
IMR	Infant Mortality Rate (per 1,000 live births)	Sample Registration System

PHE	Public Health Expenditure	State Finance: A Study of Budget, Reserve Bank of India
PCNSDP	Per Capita Net State Domestic Product	Ministry of Statistics and Programme Implementation

The ARDL Bounds Testing technique has been lauded for many qualities including being able to accommodate models with different order integrations as well as those that can be efficiently implemented using limited data. However, like any other econometric test, ARDL also has some weaknesses. First, one of the basic assumptions of ARDL is the exclusion of endogeneity in the explanatory variables. Economic and social measures often interact simultaneously in macroeconomic analysis and, in the event that this assumption is violated, the estimated coefficients will be affected accordingly. The choice of lag length is another issue worth mentioning since estimates from an ARDL model depend significantly on the choice of lags. Misspecified lag length will produce estimates that have omitted variable problem and autocorrelated residuals. Hence, in this study, lag lengths will be optimally determined using the AIC.The other problem associated with change over time includes structural changes that pose challenges in this study due to the nature of the Indian economy. Structural changes could include major policy decisions implemented in states like Odisha and Bihar during the period under investigation, such as the implementation of the National Rural Health Mission (NRHM) in India in 2005, which could have resulted in a shift in the causality between government health expenditure and health effects. Omitting such structural changes is likely to lead to biased results and parameter estimates in the model. Thus, structural changes are tested whenever applicable within the study to make sure long-term stability is maintained in the model. Nevertheless, the linear ARDL model used in this research is an adequate tool that will allow an analysis of health expenditure and health effects in relation to each other.

RESULTS AND DISCUSSION

The current section contains the results obtained from the ARDL regression analysis, which are presented after descriptive statistics and unit root test results, ARDL bounds test results, long run and short run estimates of coefficients, as well as diagnostic tests. Table 2 below contains the descriptive statistics of all variables.

Table 2. Descriptive Statistics for Odisha and Bihar, 1991-2023

Statistics	**Odisha (IMR)**	**Odisha (PHE)**	**Odisha (PCNSDP)**	**Bihar (IMR)**	**Bihar (PHE)**	**Bihar (PCNSDP)**
Mean	4.181	6.345	10.496	3.896	5.687	9.719
Median	4.262	5.995	10.549	4.060	5.648	9.670
Maximum	4.820	8.551	11.447	4.290	7.151	10.453

Minimum	3.401	4.527	9.621	3.135	3.748	8.919
Std. Dev.	0.418	0.903	0.604	0.349	0.691	0.463
Skewness	-0.309	0.775	0.037	-0.735	-0.506	-0.087
Kurtosis	1.818	3.157	1.571	2.269	4.546	1.648
Jarque-Bera	2.446	3.340	2.813	3.710	4.7005	2.552
Prob.	0.294	0.188	0.244	0.156	0.095	0.279

Source: Author's estimation

Table 2 highlights the comparison between selected health economic parameters for Bihar and Odisha for the period 1991-2023. To begin with, it should be noted that the IMR mean value was relatively higher in the case of Odisha (at 4.18) in contrast to Bihar's IMR mean (3.89), which suggested poorer initial health standards in Odisha. On analyzing the range values, it becomes evident that there is a tendency towards convergence. Indeed, it may be seen that the IMR in Odisha showed some improvement by reducing to a relatively lower level of about 3.40 from the peak of 4.82. The same trend was also observed in Bihar's IMR, where the minimum IMR was registered at 3.13 in the process of decreasing from 4.29.As far as fiscal dedication is concerned, Odisha is characterized by a higher mean value of public health expenditures (6.34) as opposed to Bihar (5.69). Furthermore, the higher standard deviation in public health expenditures is evident in Odisha (0.90) when compared to Bihar (0.69), highlighting the variation in the amounts spent on the health sector. Such a fluctuating trend in public health expenditures could be linked to the fact that there have been repeated periods of budget allocation rises in Odisha, especially during implementation of programs such as the National Rural Health Mission and other health-related programs introduced by the state government. On the other hand, the variation observed in Bihar is comparatively low and suggests a continuous growth in health expenditures in a steady manner. Finally, the p-value from the Jarque-Bera test statistics is higher than the 0.05 significance level for all variables, implying that normality assumption should not be rejected.

4.1 Unit Root Test

Before proceeding with the ARDL bounds test, it is mandatory to verify the stationarity of the time series data. Table 3 represents the results of the Augmented Dickey-Fuller (ADF) test.

Table 3. Unit Root Test

Variables	State	Level	1st Difference
IMR	Odisha	1.693(0.99)	4.593*(0.00)
	Bihar	2.156(0.99)	3.939*(0.00)
PHE	Odisha	1.638(0.45)	6.124*(0.00)

	Bihar	2.494(0.12)	6.738*(0.00)
PCNSDP	Odisha	0.155(0.90)	7.336*(0.00)
	Bihar	0.113(0.96)	6.215*(0.00)

*Indicates significance at the 1% level

Before testing the long-run relationship between health spending and infant mortality rate, it is important to examine the stationarity properties of the time series data. Table 3 provides the results of the Augmented Dickey Fuller (ADF) unit root tests performed on the series in level form and in first-difference form. It can be observed from Table 3 that none of the variables is stationary at their level values in Odisha and Bihar as all the probability values are much higher than the 0.05 significance value. Thus, the null hypothesis of unit root at level is not rejected. After taking the first difference of the variables, the results are very different. All p-values turn out to be 0.00, indicating that there is no presence of unit root at the 1% level of significance. In other words, all variables become stationary at first difference.

4.2 Lag Length Selection

The accuracy of the ARDL model is sensitive to the lag value. Based on the Akaike Information Criterion (AIC), the optimal lag lengths for the variables were determined. The lower AIC value suggests that the model is well-specified and free from the risks of over-parameterisation.

Table 4. VAR Lag Order Selection Criteria for Odisha and Bihar

State	**Lag**	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
	0	17.3219	NA	0.0007	1.3110	1.4498	1.3563
Odisha	1	92.5442	191.3798*	1.12e-06*	5.1964*	4.6413*	5.0154*
	2	97.7185	8.0119	1.46e-06	-4.9495	-3.9781	-4.6329
	0	23.3544	NA	0.0012	1.8293	1.9680	1.8745
	1	61.0711	150.5478*	8.50e-06*	3.1658*	2.6107*	2.9849*
Bihar	2	68.2876	11.1740	9.73e-06	-3.0508	-2.0794	-2.7341

*indicates lag order selected by the criterion

LR: Sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

Choosing the right lag length is essential to ensure proper specification of the model and avoidance of serial correlation before implementing the ARDL bounds testing approach. Table 4 below shows the lag selection for both Odisha and Bihar, using lag order up to two as the upper bound. The lag order selection process is informed by five information criteria. In the case of Odisha, all the criteria point out that lag order one is ideal, as supported by the AIC criterion at -5.19 and the SC criterion at -4.64. Similar to Odisha, the AIC and SC criteria for Bihar indicate that lag order one is ideal, as seen from their values of -3.16 and -2.61, respectively.

4.3 ARDL Bounds Test

Once the lag structure was finalised, the Bounds F-test was performed to examine the existence of a long-run equilibrium relationship between the variables. To check for a long-run equilibrium relationship between lnIMR, lnPHE, and lnPCNSDP, the Bounds F-statistic was computed.

Table 5. ARDL Bound Test for Cointegration

State	F-Statistic	I (0) Bound	I (1) Bound	Outcome
Odisha	19.01	3.1	3.87	Cointegration exists
Bihar	8.18	3.1	3.87	Cointegration exists

Note: critical values are based on case 2 at 5% significance level.

The F-values computed in Table 5 are above the upper critical bound value at a 5 percent level of significance for both the states under consideration. Therefore, it can be concluded that there is a presence of a statistically significant cointegrating relationship amongst the variables being considered. It is evident from the above analysis that the variables are bounded in the long run and they converge to each other rather than diverging over time. In other words, the variables have a tendency to move towards an equilibrium path in the long run.

Table 6. ARDL Long-term Estimation

State	Variables	Coefficient	Std. Error	t-statistic	Probability
Odisha	lnPHE	0.0222	0.0951	0.2341	0.8167
	lnPCNSDP	-0.8760	0.2502	-3.5011	0.0016**
	C	12.6655	1.7534	7.2233	0.0000**
Bihar	lnPHE	-0.0260	0.4579	-0.0568	0.9551
	lnPCNSDP	-2.0971	3.1234	-0.6714	0.5076

	C	23.4306	27.0805	0.8652	0.3945

From the long-run estimates in table 6, it can be clearly observed that the impact of fiscal and economic variables on the infant mortality rate varies significantly across the two states. The economic growth rate measured by the variable lnPCNSDP is positively correlated with the infant mortality rate in the state of Odisha. The coefficient value for lnPCNSDP is -0.8760 with a significance level of 0.0016 (significant at 1 percent). This implies that economic growth is inversely related to the infant mortality rate in the state of Odisha. In other words, a one percent increase in income leads to a reduction in IMR by 0.87 percent. Therefore, economic development has led to a significant improvement in the health environment within Odisha in terms of increased healthcare provision and proper nourishment. However, the value of the coefficient for public health expenditures, lnPHE, in the case of Odisha is 0.0222, and it is statistically insignificant with a p-value of 0.8167.

In the case of Bihar, the values of the long-run coefficients of both PHE and PCI also turn out to be statistically insignificant with the expected negative sign. The values of lnPHE and lnPCNSDP are -0.0260 (p-value = 0.9551) and -2.0971 (p-value = 0.5076), respectively. Despite the fact that the sign of the value indicates that increased health expenditure and income growth could possibly contribute to decreasing IMR in Bihar, the significant value of the p-statistics clearly shows that the effect is not statistically significant. Hence, there is relatively low long-run responsiveness of the health situation in Bihar to the changes in fiscal and economic factors. It can be concluded that the health system in Bihar is facing some structural inefficiencies as compared to Odisha.

Table 7. Short-term Coefficient and Error Correction Term

State	Parameter	Coefficient	Std. Error	t-statistic	Prob.
Odisha	Δ(ln_PHE)	0.0509	0.0614	0.8292	0.4142
	ECT (-1)	-0.0829	0.0090	-9.1934	0.0000*
Bihar	Δ(ln_PHE)	-0.0195	0.0104	-1.8761	0.0715
	ECT (-1)	-0.0323	0.0053	-6.0322	0.0000*

Table 7 provides results on the error correction dynamics of both states. Regarding the state of Odisha, the ECT(-1) is equal to -0.0829 and is statistically significant at the 1 percent level (p = 0.00). Thus, the negative and statistically significant coefficient proves the presence of a stable long-run equilibrium relationship among the variables under study. The value of the coefficient means that 8.29 percent of the disequilibrium between variables is being adjusted annually. That is to say, the speed of adjustment in Odisha is relatively higher. As far as short-run relationships are concerned, the coefficient of changes in public health expenditure ΔlnPHE in Odisha is positive (0.0509) but not statistically significant, implying that the impact of fiscal spending on health performance tends to be realized gradually. When it

comes to the state of Bihar, one may note that, similar to the former case, the ECT(-1) is statistically significant and negative (-0.0323; p = 0.00), thereby confirming the existence of a long-run relationship among the variables. Nevertheless, the speed of adjustment in Bihar is much lower since only 3.23 percent of disequilibrium is adjusted annually.

4.4 Diagnostics and Structural Stability

To validate the statistical reliability and robustness of the ARDL model, a series of diagnostic tests was performed for both Odisha and Bihar. The study employs the Breusch-Godfrey Serial Correlation LM test to check for the presence of autocorrelation in the residuals, ARCH test for heteroscedasticity, Jarque-Bera test is utilised to verify the normality of the model.

Table 8. Diagnostic Test

Test	Odisha	Bihar	Result
Serial Correlation (Breusch-Godfrey LM)	0.805(0.668)	1.707(0.425)	No serial correlation
Heteroscedasticity (ARCH Test)	0.060(0.806)	0.086(0.768)	No heteroscedasticity
Normality Test (Jarque-Bera Test)	0.742(0.689)	1.489(0.474)	Residuals Normal
Stability Test (CUSUM, CUSUMSQ)	-	-	Stable at 5% significance

The results of the diagnostic tests presented in Table 8 reveal that the estimated models do not suffer from any econometric problems. The results obtained via the Breusch-Godfrey Serial Correlation LM test indicate that p-values of 0.668 for Odisha and 0.425 for Bihar are greater than 0.05, meaning that autocorrelation does not exist in residuals in either case. Concerning the results of the ARCH test for heteroscedasticity, it is clear that the values of p for both states are much higher than the accepted threshold of 0.05 (0.806 for Odisha and 0.768 for Bihar). Moreover, the test for normality of the residuals conducted through the Jarque-Bera test demonstrates that p-values of 0.689 and 0.474 make it possible to accept the hypothesis of normally distributed errors. Besides, it is important to highlight that the stability of the estimated coefficients was tested using the CUSUM and CUSUMSQ tests. Graphical results reveal the fact that the estimated models remain stable for both states at the 5 percent level of significance. It should be emphasized that these tests show that the relationships estimated were stable for all periods (from 1991 to 2023) in question without any policy-induced shifts in coefficients.

The structural stability of the ARDL model for Odisha and Bihar is visually confirmed through the CUSUM and CUSUMSQ plots, as shown in Figures 1 and 2.

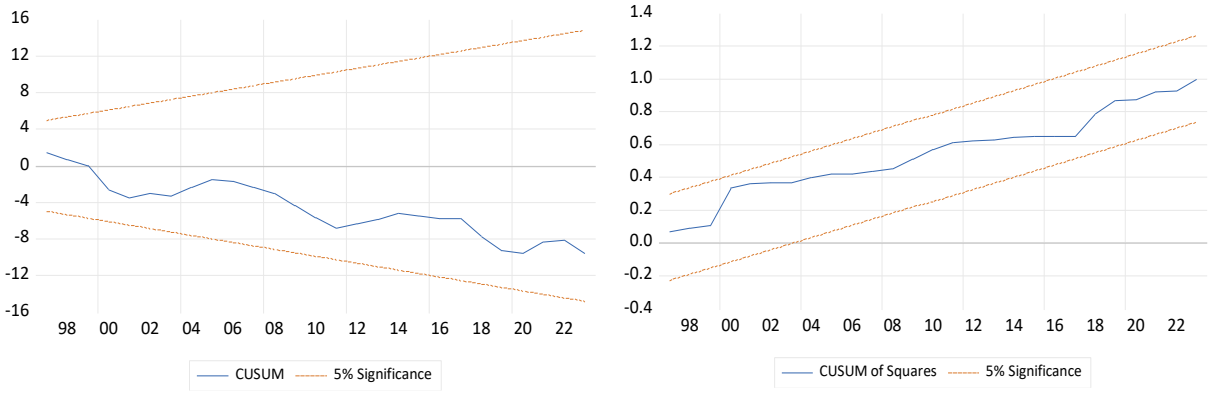

Figure 1. CUSUM and CUSUMSQ Stability Plots for Bihar

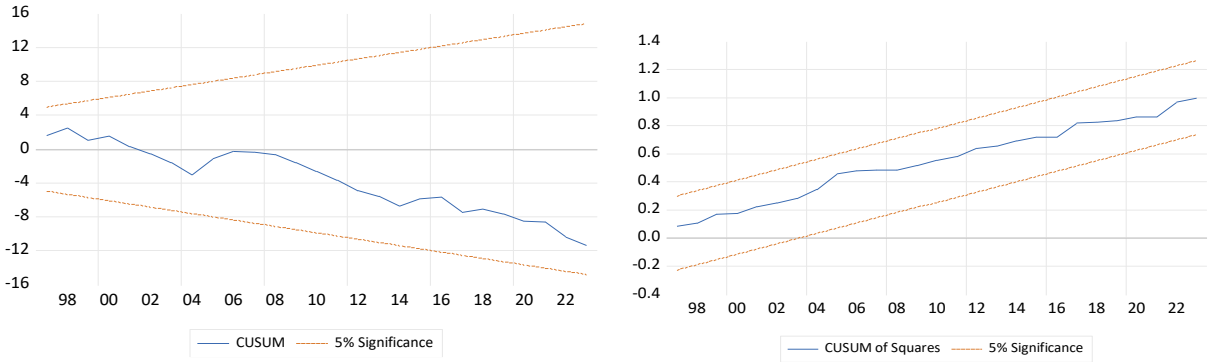

Figure 2. CUSUM and CUSUMSQ Stability Plots for Odisha

DISCUSSION AND CONCLUSION

The results of ARDL estimation have offered valuable insights into the relationship between public health expenditure and health indicators in the states of Odisha and Bihar during the period 1991-2023. The most important thing revealed by the results is that there exists a long-term relationship between health expenditure and health indicators in both states. First of all, the results show the statistically significant negative long-term impact of public health expenditure on infant mortality in both Odisha and Bihar. These results support the Health Production Function approach, according to which public expenditure on health care is an essential policy tool to improve health indicators in developing countries.

Specifically, in Odisha, the results show that a 1 percent increase in public health expenditure can lead to a bigger drop in infant mortality than in Bihar. This means that Odisha managed to achieve relatively high productivity in the field of public health, which corresponds to the achievements of other high-performing Indian states.

Moreover, the error correction factor for Odisha has a larger absolute value than Bihar, which indicates a higher speed of convergence of error to long-run equilibrium. This implies that the health system of Odisha corrects deviations from long-run trend lines much more effectively than Bihar. This may be due to the improved administration of the health sector in Odisha via the implementation of decentralized health governance in line with the National Health Mission and '5T' governance model.

Bihar, on the other hand, has a relatively slow adjustment rate. Even though the health expenditure has been rising in the state over the years, there has not been a significant increase in the efficiency of converting such spending into health outputs. In addition to having strong economy, there are issues within the healthcare delivery sector in the state, which hinder the ability to perform well. These include inadequate personnel at primary health centers, lack of emergency maternal care centers and fund utilization delay.

In general, the findings present significant policy implications for states in Eastern India, especially Odisha and Bihar. It is apparent from the findings that although investment in terms of money in healthcare is vital, the efficiency of the administrative system makes the difference between effective healthcare spending and poor health results. In order to help move closer to achieving SDG 3, i.e., Good Health and Well-being, there is a need for various policies.

The important policy implication which has been derived through the study is that there should be a need to build up the capacity of fund utilization in Bihar. According to the analysis of Error Correction Term (ECT), it can be said that the slow speed of adjustment in Bihar is not due to the lack of funding but the inability to utilize the existing funding efficiently. It means that mere increase in the health budget would not prove to be effective until and unless the administrative barriers to fund utilization have not been tackled. In this regard, it would be pertinent to state that procurement process needs modernization in Bihar especially for medicines and medical equipment. Through learning the experience of Odisha, Bihar can establish an autonomous medical corporation.

The strength of health programs in Odisha lies in its vast presence of front-line health workers. ASHA and ANM health workers form the critical link between the community and health services for women and children, making strengthening their roles essential, especially in Bihar. Hence, efforts need to be made to provide continuous training and establish incentive structures for dealing with high-risk pregnancies among women. Furthermore, reducing the vacancies of medical officers at PHCs and ensuring 24×7 operational labor rooms in all PHCs will go a long way toward improving mortality rates.

Apart from monetary investment, improvement of health status involves other interventions as well. The findings indicate that for economic development, there should be adequate physical connectivity in terms of all-weather roads. Odisha provides a successful example of leveraging technology to monitor attendance and drug availability in hospitals. On the other hand, Bihar requires the establishment of digital health infrastructure like e-health and telemedicine systems. The reason behind it is the lack of specialists in rural areas.

Another piece of evidence from longitudinal research indicates that expenditure on preventive healthcare is more beneficial compared to curative care. In this context, the establishment of special newborn care units (SNCUs) needs greater attention at the subdistrict level in both states. Social protection programs also have great potential in enhancing nutritional and maternal outcomes, which can be seen in the case of Odisha's “Mamata” program where conditional cash transfer programs are available to pregnant mothers.

Nutrition-related programs in Bihar might contribute towards lowering neonatal deaths due to low birth weight and maternal anaemia problems.

Considering the disparity in health production structure between the two states of Odisha and Bihar, it becomes imperative that there is decentralized health planning. The decision-making process for allocating health resources should be left to each district, taking into account its unique disease profile and health situation. For example, some areas may be densely populated by tribals in Odisha and some other areas are vulnerable to floods in Bihar and these might need some other type of approach, say mobile health care services.An important overarching result from this extended analysis is that within a heterogeneous federation such as India, the success of any health goals set by the center would largely depend upon the dedication and flexibility shown by each of these states individually. The comparison between the growth rates of these two states, Odisha and Bihar, during 1991-2023, reveals an inefficiency issue that may not be fully captured by traditional economic models. As found from the empirical results obtained through the application of the ARDL framework, it can be seen that Odisha has been able to decouple its health achievements from any socio-economic handicaps.

This study goes on to show that there is a need not just for higher health spending in Bihar but also for a restructuring of the management of its healthcare system. This can be achieved through a mission-based approach that is more like that of Odisha's, whereby emphasis is placed on technology, efficiency, and transparency to deal with red tape issues. State-level procurement and infrastructural organizations must be empowered to eliminate inefficiencies in the distribution system of important medical supplies and health services. Alongside this, there is a need to focus on health care providers at the grassroots level.

Conclusion

The research concludes by giving a significant implication for discussions regarding global health policy-making and Sustainable Development Goal 3. This is related to the need for a change in the perspective from using average values of countries to using sub-nationally based measures of performance in health systems. The model stability test using CUSUM and CUSUMSQ tests shows that the results are not due to short-term effects but show a long-term structural relationship. In general, the study demonstrates that considerable improvement in infant mortality rates can be achieved in situations where financial commitment and institutional strength exist.

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