# Causal Linkage Between Health Expenditure, Economic Growth, and Life Expectancy: A Study of India

**Avinash Kaur***

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**Abstract**

*The study attempted to explore causality between Public Health Spending, Economic Growth, and Life Expectancy in India for the period 1981-82 to 2015-16. Gross Domestic Product did not granger cause Life expectancy, while Life expectancy granger caused the Gross Domestic Product indicating that there existed a unidirectional relationship between GDP and LEXP. On the other hand, Government health expenditure did not granger caused life expectancy and similarly, life expectancy did not granger cause government health expenditure confirming there is no causality between government health expenditure and life expectancy. In the same manner, government health expenditure did not granger cause gross domestic product, while gross domestic product granger cause government health expenditure (at 10 percent) demonstrating unidirectional causality between government health expenditure. The study concluded it is necessary on the part of the government that to achieve the desired economic growth, adequate funds should be allocated to the health sector.*

**Keywords:** *Health, Life Expectancy, India, Economic Growth, Government Health Expenditure.*

## INTRODUCTION

In recent years, the inter linkage between health expenditure and economic growth has gained the attention of researchers. Many studies focusing on the relationship between health expenditure and economic have been conducted at different times in different countries.

* Assistant Professor Department of Commerce, Punjabi University, Patiala
Email: Sidhu.Avinash@yahoo.com

It is rightly said that "Health is Wealth". The health of people is interlinked with economic growth and both have a positive significant association between them. The countries which are allocating adequate funds to the health sector are found more developed as compared to others. The importance of health expenditure has been documented as a key determinant of growth. In 2001, the World Health Organization highlighted a 10 percent increase in Life Expectancy at birth would result in a 0.35 percent increase in the rate of economic growth. The health of the population is the primary factor driving economic growth. Thus, the countries which want to successfully develop have to spend a fair proportion of total expenditure on the health sector. The World Bank in its report in the year 1998 highlighted that improvement in life expectancy is strongly associated with the per capita income. Life expectancy is considered as the foremost key indicator of the health of the population and economic growth of a country. Thus, the increase in life expectancy will result in per capita income, which ultimately would bring economic growth.

In 2005, the World Health Organization recommended that the total health spending, including both the government and private spending, should amount to at least a minimum of $54 per person. When a person is healthy, life expectancy increases, and this also promotes his savings and investments and there is also the opportunity for healthy individuals to find better means to benefit from these investments they have made as suggested by (Serdar, 2015).

According to WHO (2005), 50 % of economic growth differentials between developed and developing nation is attributable to ill-health and low life expectancy. Some economists believe the increase in life expectancy would boost the efficiency of the total production factor and finally leads to economic growth.

Numerous studies have revealed a strong positive association between mortality rates and socioeconomic status. Preston (1975) attempted to examine the relationship between per capita income and health status of the population as measured by life expectancy using cross country data. The results revealed there existed a positive relationship between income and health status. Bhargavam (2001) revealed a positive association between life expectancy and economic growth. Lustig (2006) explored that population health is approximately responsible for one-third of long term economic growth. Lorentzen, Mcmillan, and Wacziarg (2008) undertook and revealed that higher life expectancy leads to prompt economic growth. Cervellati and Sunde (2009) also observed that a sufficiently high life expectancy is ultimately the trigger of the transition to sustained income growth.

The paper is organized into five sections. Section I is related to the introductory part;

the next section is about the literature review. Section III provides the data and methodology. Section IV centers on the empirical analysis and the last section i.e Section V deals with the conclusion and policy implications of the study.

## LITERATURE REVIEW

**Mehrara et al (2012)** examined the linkage between health expenditure and economic growth in the Middle East and North Africa countries. The study found that health expenditure and economic growth have a positive significant association between them. The study concluded that the proportion of health expenditure to total Gross Domestic Product diminishes with Gross Domestic Product. **Ogungbenle et al (2013)** examined the causality between life expectancy, Public Health Expenditure, and Economic Growth in Nigeria. The results revealed that there existed no bi-directional causality between life expectancy & public health spending and also between life expectancy and economic growth in Nigeria. The study further observed the existence of bidirectional causality between public health spending and economic growth in Nigeria. **Maduka et al (2016)** examined the causality between health expenditure, health outcomes, and economic growth in Nigeria. The results revealed that however, government health expenditure did not directly influence economic growth; but still it indirectly impacts economic growth through the health outcomes- Mortality Rate and Life Expectancy. **Hami (2016)** examined the linkage between life expectancy and economic growth in Iran for the period from 1966 to 2013. The study found that there existed a positive significant relationship between economic growth and life expectancy in Iran during the study period. **Nwani and Kelikume (2019)** investigated the relationship between public health expenditure, health status, and growth. The study found that there existed no causality between public health expenditure and health status; and also between health status and economic growth, no causality has been observed. **Murunga et al (2019)** investigated the relationship between health expenditure and health outcomes in Kenya. The study found health expenditure had an average impact on health outcomes. The study suggested that adequate budgetary allocations should be made to the health sector for overall growth. **Sarpong et al (2020)** attempted to study the effect of health on long-run economic growth in 35 Sub-Saharan African countries for the period 1997-2016. The results revealed that health has a significant positive effect on economic growth in Sub-Saharan African countries.

## DATA AND METHODOLOGY

The study aims to determine the causal linkage between economic growth (Gross

Domestic Product), government health expenditure, and life expectancy in India for the period 1981-82 to 2015-16. The data used for the study have been collected from various issues of Economic Survey of India, Handbook of Statistics on Indian Economy published by Reserve Bank of India, Mumbai, and Health & Family Welfare Statistics. For the study the following techniques are applied:

**Stationary Test**

It is observed in the literature that most of the time series variables have unit roots and regressing non-stationary variables in the model may result in spurious regression (Granger, 1986). Thus, in this study unit root test has been conducted on selected variables to check the stationary status of the selected variables. For the study, the Philip Perron unit root test has been used.

**Vector Autoregressive Model**

VAR is applied because the variables were not co integrated i.e. long-run relationships did not exist among the variables. For the analysis of time series data, which includes more one variable (multivariate time series) the Vector Autoregressive is used (VAR). The technique also has the advantage of being easy to understand, generally applicable, and easily extended to non-linear specifications and models that may contain endogenous right-hand-side variables (Philips, 1987). Peseran et al (2001) assert that this technique allows a mixture of 1[1] and 1[0] variables as regressors, that is the order of integration of relevant variables may not necessarily be the same. The following model is proposed for the VAR model:

$$LnGDP_t = \beta 1i_{t-n} + \beta_{2i\ t-n} + \epsilon_{1t}$$

$$LnGHEXP_t = \lambda_{1i} LnGDP_{t-n} + \lambda_{2i} LnIMR_{t-n} + \epsilon_{2t}$$

$$LnIMR_t = \phi_{1i} LnGDP_{t-n} + \phi_{2i\ t-n} + \epsilon_{3t}$$

Where LnGDP stands for Natural Logarithm of Public Expenditure

LnGHEXP= Natural Logarithm of Gross Domestic Product

LnIMR stands Natural Logarithm of Infant Mortality Rate

$\beta$, $\lambda$, and $\phi$ are the coefficients of the variables

$\epsilon_{1t,}\ \epsilon_{2t}$ & $\epsilon_{3t}$ denotes Error terms

### Impulse Response Function

VAR model is well known for investigating shocks transmission among variables. An Impulse Response Function of the VAR traces the consequence of one shock to one of the innovations on current and future values of the endogenous variables. The impulse response Function method is used to determine the response of an endogenous variable toward a shock from other variables.

### Variance Decomposition

Variance Decomposition makes information accessible about the relative significance of each random innovation in affecting the variables in the VAR. Thus, the variance decomposition provides information about the relative importance of each random innovation in affecting the variables in the VAR.

## EMPIRICAL ANALYSIS

Table 1 depicts the results of the unit root test. It is observed from the results that life expectancy (LEXP) is stationary at level, however; the variables Gross Domestic Product (LGDP) and Government Health Expenditure (LGHEXP) are non-stationary at the level. on the other hand, both these variables are stationary after the first and second differences. Thus, the Gross Domestic Product (LGDP) is integrated of order one; whereas Government Health expenditure is integrated of order two.

**Table 1: Unit Root Tests:**

| Phillips Perron Test | | | | |
|---|---|---|---|---|
| **Variables** | **Critical Value** | **t-statistic** | **Prob.** | **Order of integration** |
| LGDP | -3.098738 | -2.954021 | 0.0364 | I(2) |
| LGHEXP | -8.069363 | -2.615817 | 0.0000 | I(1) |
| LEXP | -7.993485 | -2.957110 | 0.0002 | I(0) |

Source: Author's Computation.

Since it is observed from the above table that all the variables are integrated at different levels, this is a clear indication that co-integration has not met. Therefore, vector autoregressive has been used.

**Vector Autoregressive Method**

To check the appropriateness of the VAR in the sense of whether VAR is stable, i.e. all roots have values less than one and lie inside the unit circle, stability tests have been used. The test of Autocorrelation LM and White Heteroscedasticity with No Cross Terms have been applied for testing autocorrelation (see Appendix). The results of these tests reveal that the residuals are not serially correlated and are homoscedastic, which ultimately proves that the estimated parameters of the model are precise.

The overall goodness of fit statistics for these equations is quite impressive. The coefficient of determination ($R^2$) for economic growth is 0.999. The result indicates the regressors in the equation are responsible for about 99.9 percent of the systematic variations in economic growth.

**Table 2**
**Vector Autoregressive**

| | LGDP | LGHEXP | LEXP |
|---|---|---|---|
| LGDP(-1) | 1.293279 | -0.347260 | 0.996463 |
| | (0.15819) | (0.69461) | (6.47845) |
| | [ 8.17534] | [-0.49994] | [ 0.15381] |
| LGDP(-2) | -0.452565 | 0.576682 | 1.577921 |
| | (0.14503) | (0.63682) | (5.93941) |
| | [-3.12049] | [ 0.90557] | [ 0.26567] |
| LGHEXP(-1) | 0.032158 | 1.003126 | 0.387669 |
| | (0.03921) | (0.17217) | (1.60580) |
| | [ 0.82013] | [ 5.82630] | [ 0.24142] |
| LGHEXP(-2) | -0.004326 | -0.252527 | 0.163453 |
| | (0.03824) | (0.16790) | (1.56594) |
| | [-0.11313] | [-1.50405] | [ 0.10438] |

| | | | |
|---|---|---|---|
| LEXP(-1) | 0.004591 | 0.008067 | 0.474887 |
| | (0.00486) | (0.02135) | (0.19915) |
| | [ 0.94414] | [ 0.37781] | [ 2.38452] |
| LEXP(-2) | 0.011862 | -0.002897 | 0.083904 |
| | (0.00505) | (0.02215) | (0.20661) |
| | [ 2.35127] | [-0.13078] | [ 0.40610] |
| C | -0.090564 | -0.823417 | 10.05230 |
| | (0.11827) | (0.51932) | (4.84353) |
| | [-0.76574] | [-1.58558] | [ 2.07541] |
| R-squared | 0.999758 | 0.995989 | 0.992756 |
| Adj. R-squared | 0.999702 | 0.995063 | 0.991084 |
| Sum sq. resids | 0.002250 | 0.043385 | 3.773985 |
| S.E. equation | 0.009303 | 0.040849 | 0.380990 |
| F-statistic | 17908.26 | 1076.031 | 593.8452 |
| Log likelihood | 111.4632 | 62.63847 | -11.04677 |
| Akaike AIC | -6.331103 | -3.372029 | 1.093743 |
| Schwarz SC | -6.013662 | -3.054588 | 1.411184 |
| Mean dependent | 6.265666 | 3.459667 | 62.42727 |
| S.D. dependent | 0.539148 | 0.581392 | 4.034869 |

| | |
|---|---|
| Determinant resid covariance (of adj.) | 1.57E-08 |
| Determinant resid covariance | 7.66E-09 |
| Log-likelihood | 167.8703 |
| Akaike information criterion | -8.901229 |
| Schwarz criterion | -7.948906 |

Source: Author's Computation.

**Table 3**
**VAR Probability Values for the Coefficients**

| | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C(1) | 1.293279 | 0.158193 | 8.175345 | 0.0000 |
| C(2) | -0.452565 | 0.145030 | -3.120487 | 0.0025 |
| C(3) | 0.032158 | 0.039211 | 0.820129 | 0.4146 |
| C(4) | -0.004326 | 0.038238 | -0.113130 | 0.9102 |
| C(5) | 0.004591 | 0.004863 | 0.944143 | 0.3480 |
| C(6) | 0.011862 | 0.005045 | 2.351267 | 0.0212 |
| C(7) | -0.090564 | 0.118271 | -0.765740 | 0.4461 |
| C(8) | -0.347260 | 0.694610 | -0.499935 | 0.6185 |
| C(9) | 0.576682 | 0.636815 | 0.905573 | 0.3680 |
| C(10) | 1.003126 | 0.172172 | 5.826302 | 0.0000 |
| C(11) | -0.252527 | 0.167898 | -1.504052 | 0.1366 |
| C(12) | 0.008067 | 0.021353 | 0.377808 | 0.7066 |
| C(13) | -0.002897 | 0.022152 | -0.130785 | 0.8963 |
| C(14) | -0.823417 | 0.519316 | -1.585581 | 0.1169 |
| C(15) | 0.996463 | 6.478452 | 0.153812 | 0.8782 |
| C(16) | 1.577921 | 5.939412 | 0.265670 | 0.7912 |
| C(17) | 0.387669 | 1.605805 | 0.241417 | 0.8099 |
| C(18) | 0.163453 | 1.565940 | 0.104380 | 0.9171 |
| C(19) | 0.474887 | 0.199154 | 2.384525 | 0.0195 |
| C(20) | 0.083904 | 0.206610 | 0.406099 | 0.6858 |
| C(21) | 10.05230 | 4.843527 | 2.075409 | 0.0412 |
| Determinant residual covariance | | 7.66E-09 | | |

Source: Author's Computation.

From the table 3, it is observed in the case of the economic growth equation, that the coefficient one year lagged value of a government of health expenditure is positive but insignificant in determining the changes in economic growth, whereas the coefficient of two years lagged value of a government of health expenditure is negative and insignificant at 1 percent level. On the other hand, the coefficient of one year lagged value of life expectancy

is positive but significant in determining the changes in economic growth, however, the coefficient of two years lagged value of life expectancy is positive and significant at 1 percent level. The coefficient of one year lagged value of economic growth is positive and significant; while the two-year lagged value of economic growth is negative and insignificant.

**Table 4**
**Pair wise Granger Causality Test**

| Null Hypothesis: | Obs | F-Statistic | Prob. |
|---|---|---|---|
| LGDP does not Granger Cause LEXP | 33 | 2.22848 | 0.1264 |
| LEXP does not Granger Cause LGDP | | 4.83200 | 0.0157 |
| LGHEXP does not Granger Cause LEXP | 33 | 1.44684 | 0.2524 |
| LEXP does not Granger Cause LGHEXP | | 1.53763 | 0.2325 |
| LGHEXP does not Granger Cause LGDP | 33 | 0.16050 | 0.8525 |
| LGDP does not Granger Cause LGHEXP | | 2.61708 | 0.0908 |

Source: Author's Computation

From table 4, it can be deduced Gross Domestic Product did not granger cause Life expectancy, while Life expectancy granger caused the Gross Domestic Product indicating that there existed a unidirectional relationship between GDP and LEXP. On the other hand, Government health expenditure did not granger cause life expectancy and similarly, life expectancy did not granger cause government health expenditure confirming there is no causality between government health expenditure and life expectancy. In the same manner, government health expenditure did not granger cause gross domestic product, while gross domestic product granger causes government health expenditure (at 10 percent) demonstrating unidirectional causality between government health expenditure.

**Impulse Response Function**

(1) A standard deviation change (shocks) in Gross Domestic Product (LGDP) shows a positive response due to its shock.

(2) A standard deviation change (shocks) in Gross Domestic Product (LGDP) to

government Health expenditure (LGHEXP) shows that a shock in government health expenditure will result in a positive response by economic growth (GDP).

(3) A standard deviation change (shocks) in Gross Domestic Product (LGDP) due to shock in life expectancy (LEXP) depicts that Gross Domestic Product responds positively to innovation in life expectancy.

(4) A standard deviation change (shocks) in government health expenditure to gross domestic product shows a positive response in government health expenditure due to variation in gross domestic product.

(5) A standard deviation change from government health expenditure to government health expenditure depicts the positive response to its shock.

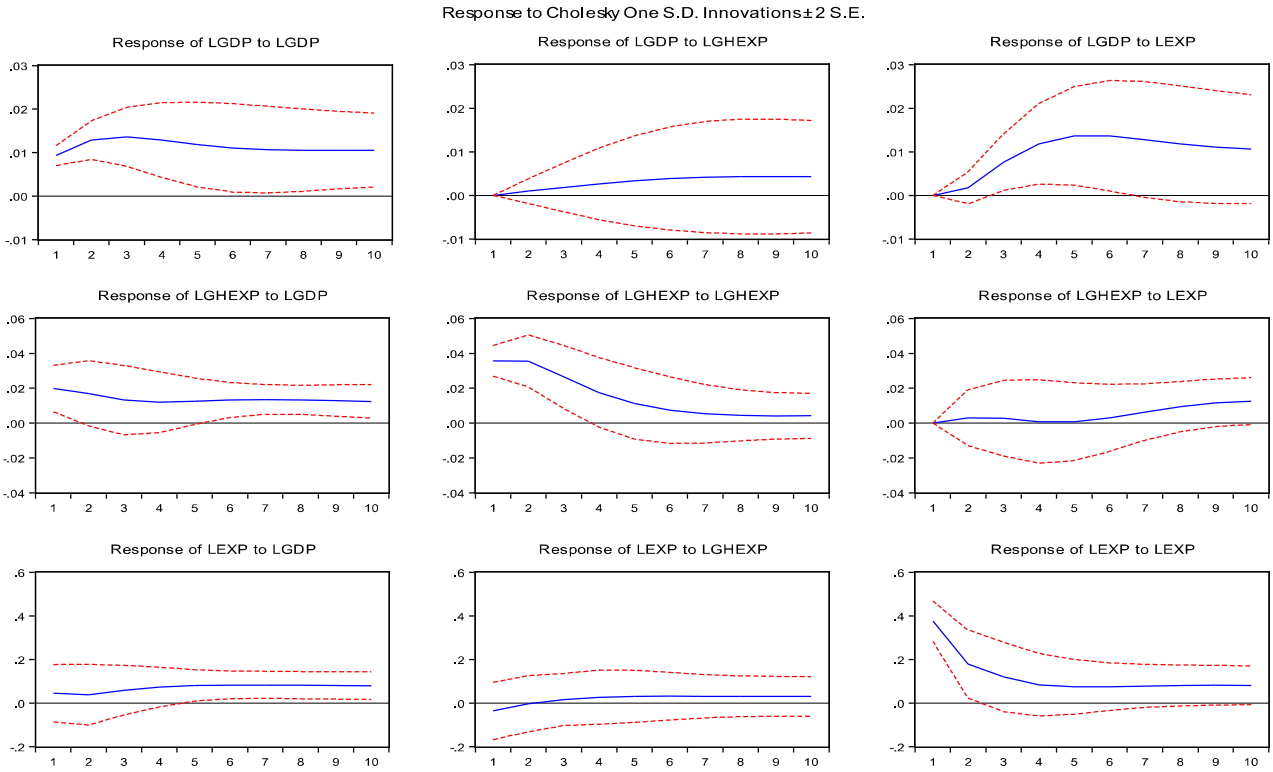
(6) A standard deviation change from government health expenditure to life expectancy was initially around zero equilibrium but gradually increased after the 6th period.

(7) A standard deviation change from life expectancy to the gross domestic product produced a stable effect on life expectancy throughout the period.

(8) A standard deviation change from life expectancy to government health expenditure indicates that life expectancy responds positively to innovation in government health expenditure in India.

(9) A standard deviation change from life expectancy to life expectancy shows a positive reaction of life expectancy to its shock.

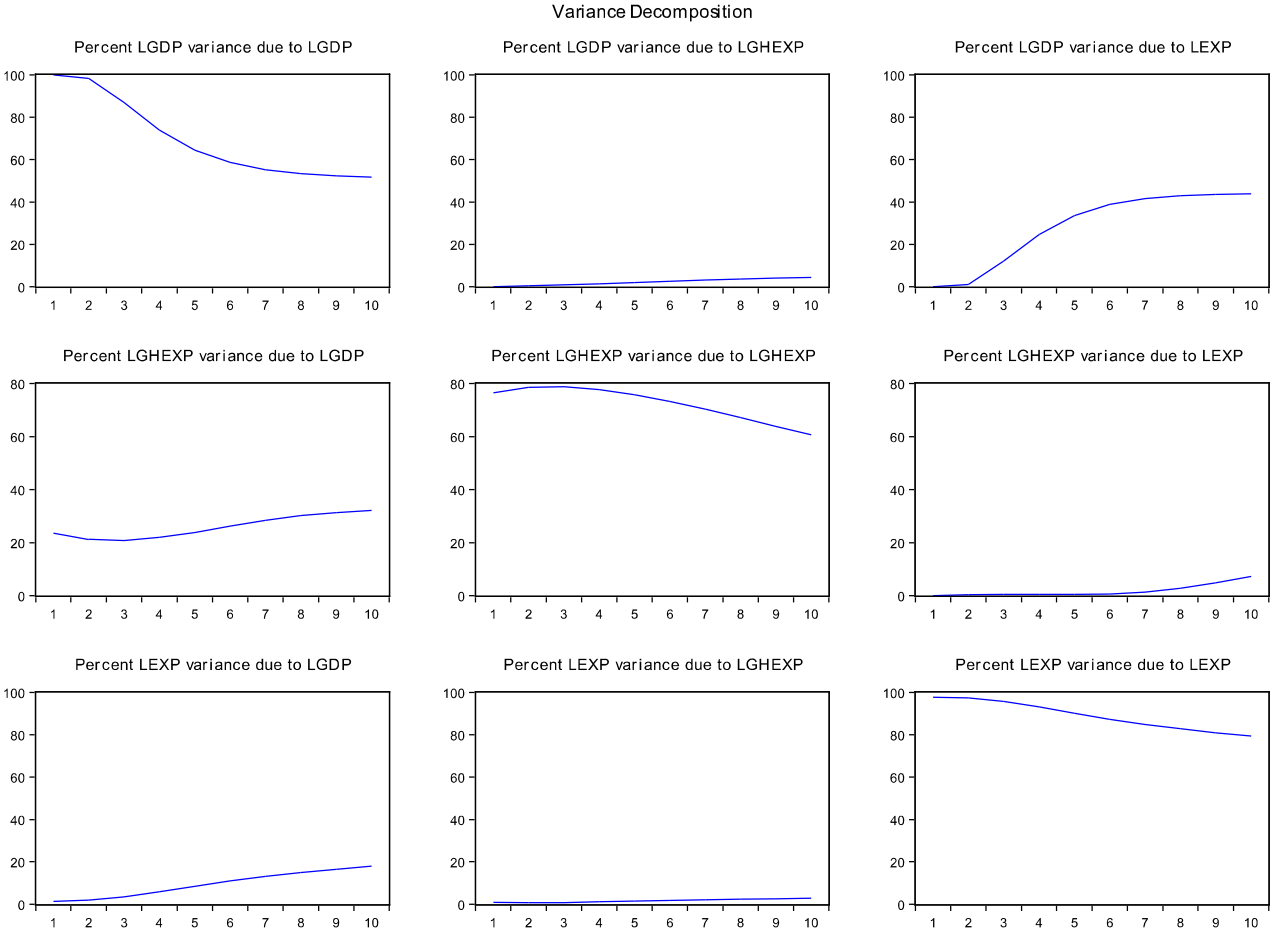
Figure 1




## Variance Decomposition

It can be observed from the graphs that fundamental shocks to Government Health expenditure account for small variations in economic growth (LGDP). The proportion ranges from 0.37% to 4.35% during the periods of the forecast. However, the variance decomposition of economic growth to shocks in Life Expectancy (LEXP) exhibits about 44 percent variation. This indicates that Life Expectancy predominantly determines variations in economic growth. The variance decomposition of Government Health expenditure reveals that the Gross Domestic Product account for about 32 percent variation in Government Health Expenditure; on the other hand, Life Expectancy account for about 7 percent variation in Government Health expenditure. The results suggest that the variation in GDP plays an important role in determining the extent of government health expenditure in India. On the other hand, the variance decomposition of Life Expectancy revealed that gross domestic product accounts for 18 percent variation in life expectancy, while government health expenditure accounts for 3 percent variation. The results suggested that life expectancy is more influenced by variation in the gross domestic product as compared to government health expenditure.

Figure 2




## CONCLUSION AND POLICY IMPLICATIONS

The present paper aimed to examine the relationship between government health expenditure, life expectancy, and economic growth in India. The Vector Autoregressive Method is applied to determine the causality among the selected variables. Furthermore, Impulse Response Function and Forecast Error Variance Decomposition are also applied to examine the effects of innovations of the endogenous variables to each other. The results revealed that life expectancy has positive and significant effect on economic growth in India during the study period. However, the result of government health expenditure was found to be mixed. The study further found that Gross Domestic Product did not granger cause Life expectancy, while Life expectancy granger caused the Gross Domestic Product indicating that there existed a unidirectional relationship between GDP and LEXP. On the other hand, Government health expenditure did not granger cause life expectancy and similarly, life expectancy did not granger cause government health expenditure confirming

there is no causality between government health expenditure and life expectancy. In the same manner, government health expenditure did not granger cause gross domestic product, while gross domestic product granger causes government health expenditure (at 10 percent) demonstrating unidirectional causality between government health expenditure. Therefore, it is necessary on the part of the government that to achieve the desired economic growth, adequate funds should be allocated to the health sector.

It is need of the hour that policymakers should pay proper attention to the health sector in order to achieve economic growth ultimately. As, it is evident from the results that life expectancy has positive and significant effect on economic growth of the India; so it is required on the part of the government to sanction adequate budget to the health sector. For developing economies, the policy implication is that continued investment in human capital in the form of health and education would contribute to the economic growth of a nation.

## REFERENCES

Anyanwu, J. and A. E. Erhijakpor (2007). *Health Expenditures and Health Outcomes in Africa.* Delta State University Economic Research Working Paper No. 91.

Bloom, D., D. Canning, J. Sevilla (2004). *The Effect of Health on Economic Growth: A Production Function Approach.* Harvard School of Public Health, Boston, MA, USA. World Development 32 (1), 1–13.

Bokhari, F., Y. Gai, P. Gottret (2006). *Government Health Expenditures and Health Outcomes.* Department of Economics, Florida State University.

Day, K. and T. Julie (2005). *Health Spending, Health Outcomes, and Per Capita Income in Canada: A Dynamic Analysis*, Working Paper 2005-07 (Department of Finance, Canada), June

Deluna, R., and Peralta, T.F. (2014). *Public Health Expenditures, Income, and Health Outcomes in the Philippines*. MPRA Paper No. 60115,

Ecevit, E. (2013). The impact of life expectancy on economic growth: Panel co-integration and causality analyses for OECD countries. The International Journal of Social Sciences, 16(1), 1–14.

Malik, G. (2006). *An Examination of the relationship between Health and Economic Growth*. Indian Council for Research on International Economic Relations, New Delhi Working

Papers, 185.

Mehrara, M. (2011). Health Expenditure and Economic growth: An ARDL Approach for the Case of Iran. *Journal of Economics and Behavioral Studies*, *3*(4), 249-256.

Mishra, P. K., & Mishra, S. K. (2015). The Triangulation Dynamics between Education, Health, and Economic Growth in India. *The Journal of Commerce*, *7*(2), 69.

Mohapatra, S. (2017). Economic growth, public expenditure on health and IMR in India: An econometric investigation of causal linkages. *International Journal of Social Economics,* 44 (12), 2002-2018.

Murunga, J., Mogeni, E.G. & Kimolo, D.N.(2019). Public Health Spending and Health Outcomes in Kenya. *European Scientific Journal,* 15(1), 125-138.

Nixon, J., Ulmann, P.(2016). The relationship between health care expenditure and health outcomes. The *European Journal of Health Economics,* **7,** 7–18.

Nwani, S.E., and Kelikume, I.(2019). Causal Linkage amongst Public Expenditure on Health, Health Status, and Growth: New Empirical Evidence from Toda- Yamamoto Approach for Nigeria. *Journal of Scientific Research and Reports*, 24(3), 1-13.

Ogunjimi, J., and Adebayo, A. (2018). *Health Expenditure, Health Outcomes, and Economic Growth in Nigeria.* MPRA Paper No. 94989.

Qadri, F.S., and Dr. A. Waheed (2011). *Human Capital and Economic Growth: Time Series Evidence from Pakistan.* MPRA Paper No. 30654.

Rengin, A. K. (2012). The Relationship Between Health Expenditure and Economic Growth: Turkish case, *International Journal of Business Management and Economics Research*, 3(1), 404-409.

Sarpong, B., Edward, N.A., and Owoo, N.S. (2020). *Health and Economic Growth Nexus: Evidence from Sub-Saharan African Countries*, Global Business Review, 21(2), 328-347.

Scheffler, R. M. (2004). *Health Expenditure and Economic Growth: An International Perspective.* Occasional Papers on Globalisation, University of South Florida.

Schultz, T. P. (1999). Health and schooling investments in Africa. *Journal of Economic Perspectives*, 13, 67-88.

Serdar, K. (2015). Government Health Expenditures and Economic Growth: A Feder–Ram

Approach for the Case of Turkey. *International Journal of Economics and Financial Issues*. 5(2), 441-447.

Shafi, R., & Fatima, S. (2019). Relationship between GDP, Life Expectancy, and Growth Rate of G7 Countries. *International Journal of Sciences*, 8(06), 74–79.

Sharma, R. (2018). Health and Economic Growth: Evidence from dynamic panel data of 143 years. *PLoS ONE* ,13(10) .

Strauss, J., and D. Thomas (1998). Health, nutrition and economic development, *Journal of Economic Literature,* 36, 766-817.

Swan, T. W. (1956). Economic Growth and Capital Accumulation, *Economic Record*, 32(2), 334-361.

World Bank (1993). Investing in Health: World Development Report. Washington, D.C.

World Health Organization (2005). World Health Development Indicators. Washington, DC

World Health Organization (1999). WHO on Health and Economic Productivity*, Population and Development Review* 25(2), 396-401.

Yakub, J., Ojapinwa, T., and Rukayat, Y. (2012). Public Health Expenditure and Health Outcomes in Nigeria: The Impact of Governance. *European Scientific Journal*, 8(13), 189-201.

## APPENDIX

### VAR Stability condition check test

Roots of Characteristic Polynomial
Endogenous variables: LGDP LGHEXP LEXP
Exogenous variables: C
Lag specification: 1 2
Date: 07/11/20 Time: 19:11

| Root | Modulus |
|---|---|
| 0.991064 | 0.991064 |
| 0.543596 - 0.342482i | 0.642488 |
| 0.543596 + 0.342482i | 0.642488 |
| 0.430137 - 0.201951i | 0.475186 |
| 0.430137 + 0.201951i | 0.475186 |
| -0.167236 | 0.167236 |

No root lies outside the unit circle.
VAR satisfies the stability condition.

### VAR Residual Portmanteau Tests for Autocorrelations

Null Hypothesis: no residual autocorrelations up to lag h
Date: 08/18/20 Time: 16:08
Sample: 1 35
Included observations: 33

| Lags | Q-Stat | Prob. | Adj Q-Stat | Prob. | df |
|---|---|---|---|---|---|
| 1 | 1.577866 | NA* | 1.627175 | NA* | NA* |
| 2 | 10.20064 | NA* | 10.80626 | NA* | NA* |
| 3 | 18.66344 | 0.0282 | 20.11533 | 0.0172 | 9 |
| 4 | 27.20726 | 0.0752 | 29.83762 | 0.0391 | 18 |
| 5 | 33.59353 | 0.1782 | 37.36429 | 0.0885 | 27 |
| 6 | 37.58217 | 0.3966 | 42.23930 | 0.2194 | 36 |

| | | | | | |
|---|---|---|---|---|---|
| 7 | 42.38241 | 0.5835 | 48.33190 | 0.3399 | 45 |
| 8 | 48.99041 | 0.6675 | 57.05447 | 0.3622 | 54 |
| 9 | 55.91424 | 0.7246 | 66.57473 | 0.3550 | 63 |
| 10 | 60.40283 | 0.8333 | 73.01488 | 0.4444 | 72 |
| 11 | 70.05510 | 0.8021 | 87.49328 | 0.2914 | 81 |
| 12 | 73.83850 | 0.8916 | 93.43863 | 0.3811 | 90 |

*The test is valid only for lags larger than the VAR lag order.
df is degrees of freedom for the (approximate) chi-square distribution

**VAR Residual Serial Correlation LM Tests**

VAR Residual Serial Correlation LM Tests
Null Hypothesis: no serial correlation at lag order h
Date: 08/18/20 Time: 16:09
Sample: 1 35
Included observations: 33

| Lags | LM-Stat | Prob |
|---|---|---|
| 1 | 4.773524 | 0.8536 |
| 2 | 11.96039 | 0.2156 |
| 3 | 10.76888 | 0.2919 |
| 4 | 9.447395 | 0.3970 |
| 5 | 6.077848 | 0.7321 |
| 6 | 4.720522 | 0.8580 |
| 7 | 4.267002 | 0.8930 |
| 8 | 6.472369 | 0.6919 |
| 9 | 7.891867 | 0.5451 |
| 10 | 6.330758 | 0.7064 |
| 11 | 11.24212 | 0.2595 |
| 12 | 5.079777 | 0.8273 |

Probs from chi-square with 9 df.

**VAR Residual Normality Tests**

Orthogonalization: Cholesky (Lutkepohl)
Null Hypothesis: residuals are multivariate normal
Date: 08/18/20 Time: 16:09
Sample: 1 35
Included observations: 33

| Component | Skewness | Chi-sq | df | Prob. |
|---|---|---|---|---|
| 1 | 0.519007 | 1.481528 | 1 | 0.2235 |
| 2 | 0.177440 | 0.173167 | 1 | 0.6773 |
| 3 | 0.810645 | 3.614300 | 1 | 0.0573 |
| Joint | | 5.268995 | 3 | 0.1531 |

| Component | Kurtosis | Chi-sq | df | Prob. |
|---|---|---|---|---|
| 1 | 3.390310 | 0.209471 | 1 | 0.6472 |
| 2 | 2.693185 | 0.129436 | 1 | 0.7190 |
| 3 | 7.712415 | 30.53443 | 1 | 0.0000 |
| Joint | | 30.87333 | 3 | 0.0000 |

| Component | Jarque-Bera | df | Prob. |
|---|---|---|---|
| 1 | 1.690999 | 2 | 0.4293 |
| 2 | 0.302602 | 2 | 0.8596 |
| 3 | 34.14873 | 2 | 0.0000 |
| Joint | 36.14233 | 6 | 0.0000 |

**Variance Decomposition**

| Variance Decomposition of LGDP: Period | S.E. | LGDP | LGHEXP | LEXP |
|---|---|---|---|---|
| 1 | 0.009303 | 100.0000 | 0.000000 | 0.000000 |
| 2 | 0.016008 | 98.45696 | 0.376183 | 1.166859 |
| 3 | 0.022423 | 87.00366 | 0.844639 | 12.15170 |
| 4 | 0.028538 | 73.96798 | 1.368035 | 24.66399 |
| 5 | 0.033937 | 64.43367 | 1.934604 | 33.63173 |
| 6 | 0.038415 | 58.57531 | 2.525082 | 38.89961 |
| 7 | 0.042085 | 55.22817 | 3.095678 | 41.67616 |
| 8 | 0.045173 | 53.37536 | 3.603202 | 43.02144 |
| 9 | 0.047883 | 52.34411 | 4.024005 | 43.63189 |
| 10 | 0.050351 | 51.73056 | 4.356707 | 43.91273 |

| Variance Decomposition of LGDP: Period | S.E. | LGDP | LGHEXP | LEXP |
|---|---|---|---|---|
| 1 | 0.040849 | 23.56694 | 76.43306 | 0.000000 |
| 2 | 0.056834 | 21.14488 | 78.56933 | 0.285784 |
| 3 | 0.064075 | 20.84205 | 78.74228 | 0.415675 |
| 4 | 0.067505 | 21.91116 | 77.69901 | 0.389839 |
| 5 | 0.069567 | 23.84624 | 75.77504 | 0.378722 |
| 6 | 0.071260 | 26.17683 | 73.28792 | 0.535253 |
| 7 | 0.073003 | 28.38298 | 70.35881 | 1.258214 |
| 8 | 0.074938 | 30.10714 | 67.11568 | 2.777180 |
| 9 | 0.077024 | 31.29472 | 63.82006 | 4.885219 |
| 10 | 0.079138 | 32.09190 | 60.73602 | 7.172079 |

| Variance Decomposition of LGDP: Period | S.E. | LGDP | LGHEXP | LEXP |
|---|---|---|---|---|
| 1 | 0.380990 | 1.374684 | 0.907455 | 97.71786 |
| 2 | 0.422622 | 1.932949 | 0.743911 | 97.32314 |
| 3 | 0.443436 | 3.539481 | 0.804850 | 95.65567 |
| 4 | 0.457909 | 5.866117 | 1.093864 | 93.04002 |
| 5 | 0.471865 | 8.450736 | 1.450274 | 90.09899 |
| 6 | 0.486015 | 10.90329 | 1.786038 | 87.31067 |
| 7 | 0.500239 | 13.05628 | 2.078080 | 84.86564 |
| 8 | 0.514239 | 14.89632 | 2.331323 | 82.77235 |
| 9 | 0.527780 | 16.47531 | 2.555401 | 80.96929 |
| 10 | 0.540748 | 17.85395 | 2.757245 | 79.38881 |
| Cholesky Ordering: LGDP LGHEXP LEXP | | | | |