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ASYMMETRY OF PRIVATE EXPENDITURE ON HEALTHCARE ON LIFE EXPECTANCY IN USA

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Abstract

In this paper, author examined the short run and long run nonlinear relation between private health expenditure and life expectancy in USA during 1960-2023 and tested asymmetric impacts by applying NARDL model taking data from the World Bank and from NBER. It found that there are both short and long asymmetries. The positive changes from cumulative dynamic multiplier of private expenditure on life expectancy have positive impact and negative changes have negative impact which are significant. The positive response and negative response converged to long run limits where the former is upward and the latter is downward. The asymmetry is upward moving and became stationary above the equilibrium level within the limits of confidence interval.

Keywords: life expectancy, private health expenditure, Asymmetry, NARDL, positive changes, negative changes, cumulative dynamic multiplier

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INTRODUCTION

Public health is an ingredient of increasing productivity, human capital and promotes growth and social development. It also stimulates innovations and skill development. Generally, it also pushes the social welfare function to the upward stages. If investment in public health increases, then the indicators of health outcomes will surely increase. Both private and government investment have great role to improve health outcomes. In USA, the private expenditure on healthcare has been catapulting along with government spending on health in the decentralized manner.

US Public Health National Center for Innovations fundamentally initiated to protect and promote the health of all people in all communities in USA in order to maintain SDGs for 2030 in which advisory committee proposed to promote, strengthen, and evaluate the nation's efforts to improve the health and wellbeing of the people that can dwindle health disparities, achieve health equity and attain health literacy (Kent State,2024).

Now, USA spends on healthcare about 17.8% of GDP in 2021 which is the highest in the world and twice than that of OECD countries. Per capita healthcare expenditure in USA is twice than the Germany and four times that of South Korea. On the other hand, life expectancy at birth of USA was 77 years in 2020 which is lower than the average of OECD countries where life expectancy at birth of the general citizens of USA is much higher than the racial and ethnic groups (The Common Wealth Fund,2023).

In this situation, the White House (2025) passed an order on "Make Our Children Healthy Again Strategy" which is to be completed its implementation within 180 days where USA planned to strategic increase in life expectancy at birth to 82.6 years.

There is a positive correlation between health expenditure and life expectancy at birth which was empirically verified by innumerable research studies in developed or developing countries. There are many asymmetries of public or private expenditure on healthcare which can change the dimensions and degrees of health outcome. The quality and quantity of private expenditure on healthcare vary from country to country and change from time to time for which the asymmetric impacts emerged in the indicators of health outcomes. In this paper, the asymmetric impacts of private expenditure on healthcare upon the life expectancy at birth in USA during long period of time from 1960 to 2023 will be examined through Non-Linear Auto Regressive Distributed Lag model.

Literature review

In OECD countries during 2005 to 2018, it was found that health expenditures positively affect the national life expectancy by applying GMM model with fixed effect method among health expenditure, GDP per capita and productivity, population, infant mortality rates, potential years of life lost, deaths from cancer and the suicide rate respectively (Morina et al.,2022). A panel data regression among 8 East African countries from 2000 to 2014 revealed that health care expenditure and life expectancy were positively related while female life expectancy had stronger effect than the male (Bein et al.,2017). A panel data regression among 175 countries grouping into geographical and income categories during 1995-2010 to examine the impact of health expenditure and life expectancy and found that the relation is positive where lower middle-income group is the highest beneficiary while high income group is the lowest beneficiary (Jaba et al.,2014). Using the Grossman Model in a fixed effect regression technique from 2010 to 2017 in globally 217 countries and found a significant positive impact on health outcomes from public health expenditure. Moreover, life expectancy at birth has significant positive impact from the increase in private health expenditure. If one per cent rise in health expenditure then male life expectancy will increase by 2.735% and female life expectancy will increase by 2.356% respectively (Thomas,2020). Wanjiku (2023) examined the econometric relationship between health expenditure and four fundamental health outcomes such as Infant Mortality Rate, under 5 Mortality Rate, Maternal Mortality Rate, and Life Expectancy among 63 countries grouping into 12 low, 17 middle and 34 high-income countries during 2000-2019 and found strong positive impacts among them where impact on life expectancy varies marginally in various income group of countries. Nguyen, Nguyen, and Luc (2023) used fixed effect panel regression model in low- income groups of Vietnam on health spending and health outcomes and found that there is weaker correlation between higher health spending and better health outcome.

In Saudi Arabia and Nigeria during 2000-2016, the short run and long run causalities were found among economic growth, life expectancy at birth and health expenditure after applying the ARDL, ECM and Granger causality models where life expectancy was shown as directly related with the health expenditure (Akinwale,2021). Panel fixed effect regression analysis among 15 countries in ASEAN and SAARC during 1995–2014 between the variables of public health expenditure, private health expenditure, GDP per capita, improved sanitation, life expectancy at birth, crude death rate and infant mortality rate revealed that health expenditure influenced positively on life expectancy where impact of private health expenditure was higher than the public health expenditure. Other factors had significant positive effects in health outcomes (Rahman et al.,2018). There is a long run association between health expenditure, life expectancy and renewable anergy in China during 2000Q1-2020Q4 where life expectancy had positive relation with increase in health expenditure which induced positively on renewable energy consumption. The results were observed by applying VECM model (Liu & Zhong,2022). Anwar et al.

(2023) examined 38 OECD countries during 1996-2020 by using GMM model with panel fixed effect method and found that a 1% hike in government health expenditures would increase life expectancy by 0.008% and reduce infant mortality by 0.21% significantly.

Objectives

The paper tries to examine the asymmetric impact of personal expenditure on healthcare on the life expectancy at birth in USA from 1960 to 2023 considering life expectancy as public health outcome indicator and personal expenditure on health is its one of the basic determinants. The changes of these two indicators are not uniform and their relationship changes asymmetrically.

Source of Data & Methodology

The data on life expectancy at birth of USA from 1960 to 2023 were collected from the World Bank. The data on private expenditure on healthcare in US$ from 1960 to 2023 were taken from NBER, USA.

The Nonlinear Autoregressive Distributed Lag model and its asymmetry estimations and cumulative dynamic multiplier effects were done by applying Shin et al. (2014) model. The Dicky and Fuller (1979) model was used for conducting unit root test. The serial correlation and heteroscedasticity tests were done by applying Breusch-Pagan model (1979). Page (1954) model was applied for stability test.

The results and discussions

The level series of life expectancy at birth (x) in USA during 1960-2023 contains unit root and is non-stationary because unit root test showed that ADF=-0.5057 whose probability is 0.9807 as against tabulated ADF=-3.452 at 5% level while the first difference series contains no unit root and is stationary because ADF=-6.366 whose probability is 0.0000 which is greater than the tabulated value. Moreover, the level series of private expenditure on healthcare in USA (z) during 1960-2023 contains unit root since ADF=-3.3316 whose probability p=0.0705 which is less than the tabulated ADF=-3.482 at 5% level while the first difference series has no unit root because calculated ADF=-6.0349 whose probability is p=0.0000 which is greater than the tabulated ADF at 5% level, thus it is stationary.

The estimated non-linear auto-regressive distributed lag model between life expectancy at birth and personal expenditure on healthcare in USA during 1960-2023 states that the positive changes of personal expenditure on healthcare at t period have negative impact on the life expectancy at birth at t period which is not significant while its positive impacts at t-1 & t-2 periods are significant at t-2 period only. On the other hand, the negative changes of personal expenditure on healthcare at t period have significant positive impact on the life expectancy at birth at t period ,and even, it had significant negative impacts at t-1 & t-2 periods respectively. The life expectancy at birth at t period is significantly positively related with its previous period. The trend coefficient is negative and insignificant. The estimated model is highly significant where AIC is minimum (Table 1).

Table 1: *NARDL estimate*

Variable(dependent=x_t)	Coefficient	Standard Error	t-Statistic	Probability
x_{t-1}	0.809409	0.055912	14.47647*	0.0000
z_t^+	-0.117910	0.100406	-1.174336	0.2456
z_{t-1}^+	0.014978	0.149418	0.100244	0.9205

z_{t-2}^{+}	0.208063	0.109077	1.907488**	0.0620
z_{t}^{-}	0.492822	0.074132	6.647926*	0.0000
z_{t-1}^{-}	-0.241953	0.109798	-2.203622*	0.0320
z_{t-2}^{-}	-0.405745	0.082582	-4.913222*	0.0000
C	13.50428	3.977356	3.395291*	0.0013
@trend	-0.019307	0.017406	-1.109229	0.2724

R^2=0.994, F=1122.08*, DW=1.95, AIC=0.039, loglikelihood=7.787, n=61, ARDL (1,2,2), maximum 4 lag in auto-selection among 100 models, *=significant at 5% level, **=significant at 10% level.
Source-Calculated by author

The estimated error correction model implies that the increment of life expectancy at birth is negatively related with its one period lag significantly in the long run. The positive changes of personal expenditure on health care at lag 1 are positively related with life expectancy at birth which is significant at 5% level and the negative changes of personal expenditure on health care are negatively related with life expectancy at birth significantly at t period in the long run. On the other hand, in the short period, positive changes of incremental personal expenditure on health care at period t and t-1 are negatively related with incremental life expectancy at birth where t-1 period is significant while negative changes of incremental personal expenditure on health care at period t and t-1 are positively related with incremental life expectancy at birth at t period significantly. The cointegrating coefficient is significant and convergent which states that it is converging at the rate of 19% per annum towards equilibrium.

Table 2: *Error correction model*

Variable (dependent= $d(x)_t$	Coefficient	Standard Error	t-Statistic	Probability
C	13.50428	3.977356	3.395291*	0.0013
@Trend	-0.019307	0.017406	-1.109229	0.2724
x_{t-1}	-0.190591	0.055912	-3.408761*	0.0013
z_{t-1}^{+}	0.105131	0.050491	2.082163*	0.0423
z_{t-1}^{-}	-0.154875	0.078966	-1.961304**	0.0552
$d(z)_{t}^{+}$	-0.117910	0.100406	-1.174336	0.2456
$d(z)_{t-1}^{+}$	-0.208063	0.109077	-1.907488**	0.0620
$d(z)_{t}^{-}$	0.492822	0.074132	6.647926*	0.0000
$d(z)_{t-1}^{-}$	0.405745	0.082582	4.913222*	0.0000
CointEq(-1)*	-0.190591	0.032860	-5.800068*	0.0000

R^2=0.681, F=19.225*, DW=1.905, AIC=-0.0258, loglikelihood=7.787, n=61, ARDL (1,2,2), ,*=significant at 5% level, **=significant at 10% level, d=first difference.
Source-Calculated by author

The Bounds test revealed that F=10.798, which is greater than the critical values of I (0) and I (1) at 10%,5% and 1% levels of significance which implies that there is long run cointegration and there is no obstacle to apply NARDL estimates (Table 3).

Table 3: *Bounds Test*

F stat (2), (n=61)	10% level of significance	5% level of significance	1% level of significance
I (0)	4.35	5.13	7.01

I (1)	5.25	6.17	8.23

Source-Calculated by author

In NARDL estimation of the asymmetry of private expenditure on health care of USA on life expectancy at birth during 1960-2023 states that in the long run, increment of life expectancy is negatively associated with life expectancy of the previous period significantly whereas in case of long run asymmetry, positive changes of cumulative dynamic multiplier of private expenditure on healthcare at lag 1 are positively related with incremental life expectancy significantly while negative changes of it are inversely related with life expectancy at lag 1 significantly. On the other hand, in the short run, positive changes of incremental cumulative dynamic multiplier of private expenditure on healthcare at level are negatively related with increment of life expectancy at level insignificantly whereas negative changes of increment of cumulative dynamic multiplier of private expenditure on healthcare at level are significantly positively associated with increment of life expectancy at level. Moreover, in case of short run asymmetric impact, negative changes of increment of cumulative dynamic multiplier of private expenditure on healthcare at lag 1 are significantly positively associated with increment of life expectancy at level. The trend is downward but insignificant. The model is highly significant with minimum AIC (Table 4).

Table 4: *Asymmetric impacts*

Variable($d(x)_t$=dependent)	Coefficient	Standard Error	t-Statistic	Probability
Long-run				
x_{t-1}	-0.190591	0.055912	-3.408761*	0.0013
Asymmetric				
$cdmz^{+}_{t-1}$	0.105131	0.050491	2.082163*	0.0423
$cdmz^{-}_{t-1}$	-0.154875	0.078966	-1.961304**	0.0552
Short-run				
$d(cdmz)^{+}_{t}$	-0.117910	0.100406	-1.174336	0.2456
$d(cdmz)^{-}_{t}$	0.492822	0.074132	6.647926*	0.0000
$d(cdmz)^{+}_{t-1}$	-0.208063	0.109077	-1.907488**	0.0620
Asymmetric				
$d(cdmz)^{-}_{t-1}$	0.405745	0.082582	4.913222*	0.0000
C	13.50428	3.977356	3.395291*	0.0013
Tren	-0.019307	0.017406	-1.109229	0.2724
COINTEQ	-0.190591	0.032860	-5.800068*	0.0000

R^2=0.681, F=13.88*, DW=1.95, AIC=0.0397, loglikelihood=7.787, *=significant at 5% level, **=significant at 10% level, ARDL (1,2) with maximum 4lags., n=61, cdm=cumulative dynamic multiplier, d=first difference, c=constant.
Source-Calculated by author

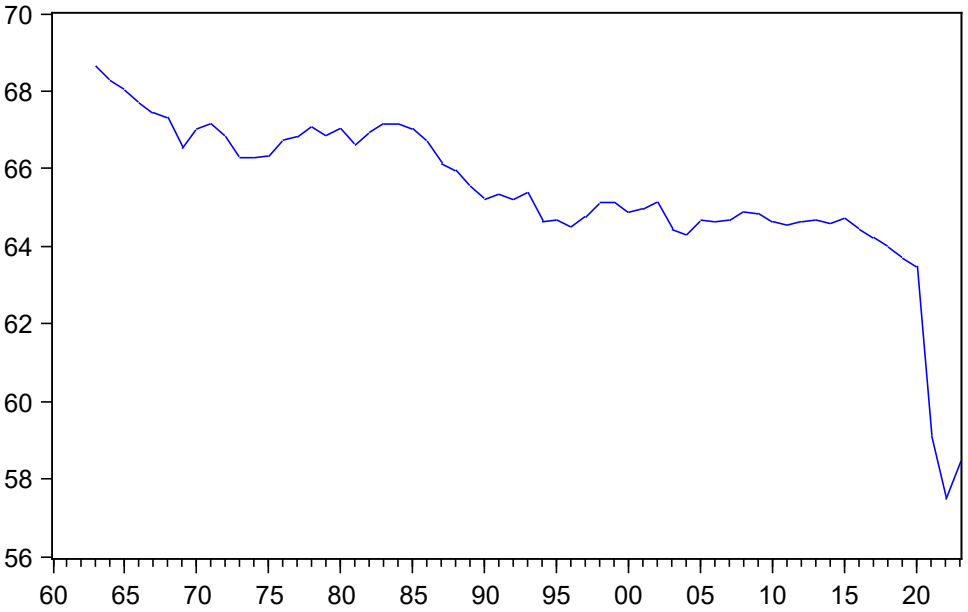
The estimated cointegrating equation implies that the positive changes of cumulative dynamic multiplier of private expenditure on health care at lag 1 are positively associated with life expectancy at lag 1 significantly in the long run while negative changes of cumulative dynamic multiplier of private expenditure on health care at lag 1 are negatively associated with life expectancy at lag 1 insignificantly. The cointegration

equation is convergent and it is converging towards equilibrium at the speed of adjustment of 19% per annum significantly.

CE=-0.190519x_{t-1}-(0.5516$cdmz^{+}_{t-1}$-0.8126$cdmz^{-}_{t-1}$)
(-5.80)* (2.34)* (-1.42)
Where CE=cointegrating equation, *=significant at 5% level, cdm=cumulative dynamic multiplier

The cointegration relationship is depicted in Figure 1 which is converging significantly towards zero.

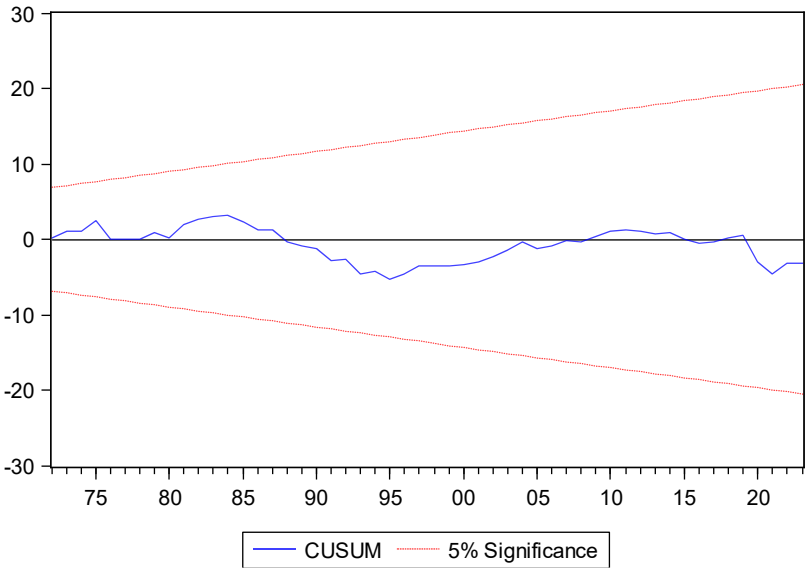
Figure 1: *Cointegration equation*



Source-Plotted by author
The model has no problem of serial correlation as observed from Breusch-Godfrey Serial Correlation LM Test (1979) for residuals where F (2,50) =0.0247(p=0.9756) and nR^2=0.06023(probability of Chi-square (2) =0.9703) which is accepted for no serial correlation at null hypothesis H0.
Again, the model has no problem of heteroscedasticity as observed from Breusch-Pagan-Godfrey heteroscedasticity test (1979) for residuals where F (8,52) =1.0556(p=0.4081) and nR^2=8.5227(probability of Chi-square (8) =0.3841) which are accepted for no heteroscedasticity at hull hypothesis.

The residuals are not normally distributed since Jarque Bera=23.131(p=0.0000) which is not accepted for normality.
The model is shown stable because the stability test of Page (1954) confirmed that the CUSUM line passes through ±5% significant level which is depicted in Figure 2 below.

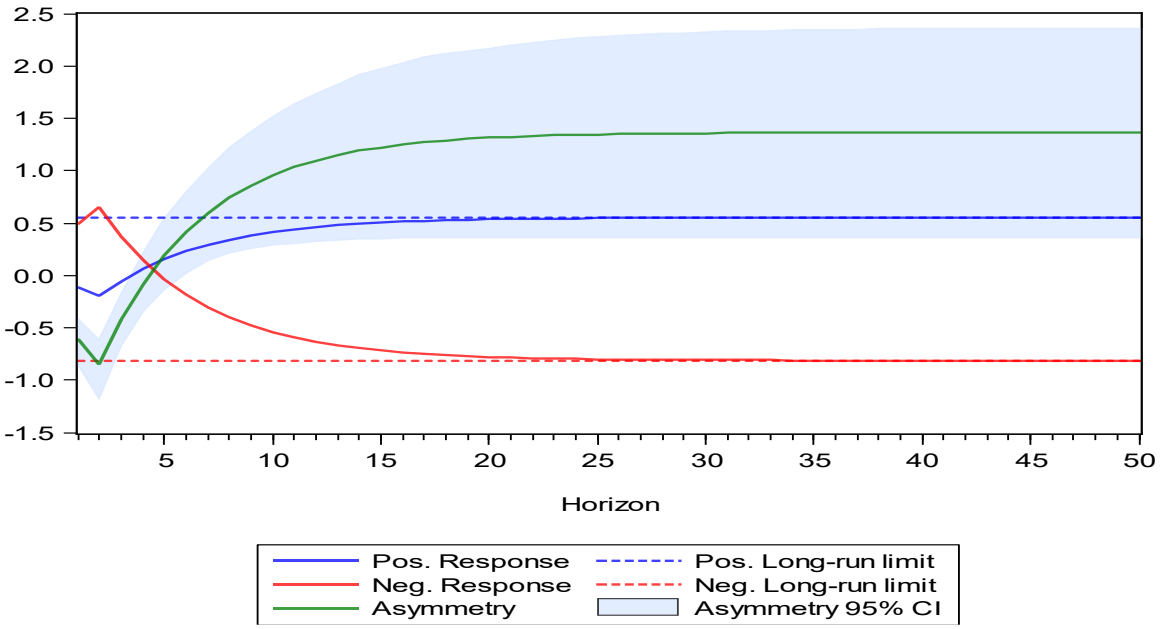
Figure 2: *Stability test*



Source-Plotted by author

The positive response from cumulative dynamic multiplier of private expenditure on healthcare on life expectancy in USA from 1960 to 2023 has been increasing upward and converged to positive long run limit which is above the equilibrium line but passed inside the confidence interval. On the other hand, the negative response from cumulative dynamic multiplier of private expenditure on healthcare on life expectancy has been declining and converged towards negative long run limit which is below the equilibrium level but went away outside the confidence interval. Thus, the asymmetric impact started upward trending and then became stationary at far above the equilibrium line as well as above the positive long run limit within the confidence interval. All these impacts have been depicted in Figure 3

Figure 3: *Asymmetry*



Source-Author's own

The symmetry test revealed that both the long run and short run F statistic, t-statistic and Chi-square statistic are rejected for H0= coefficient is symmetric at 5% significant level which are shown in Table 5 below.

Table 5: *Symmetry test*

Variable	Statistic	Degree of freedom	Value	Probability
Long run,z_t	t-statistic	52	3.594135	0.0007
	F-statistic	(1, 52)	12.91780	0.0007
	Chi-square	1	12.91780	0.0003
Short run, z_t	t-statistic	52	6.420894	0.0000
Symmetry by sum	F-statistic	(1, 52)	41.22787	0.0000
	Chi-square	1	41.22787	0.0000

Source-Calculated by author

Limitations and future scope

In this paper, only one indicator of public health and only one independent variable of outcome of public health were considered in explaining the asymmetry impact in USA during 1960-2023.There are many indicators of public health and many indicators of the health outcome. So, researchers have enough scopes of future study on these issues. Even, panel data on asymmetry analysis of public health are open to study.

DISCUSSIONS AND POLICY ISSUES

In the short run, negative changes of cumulative dynamic multiplier of private health expenditure have significant positive impact on life expectancy in USA. Its causes should be explored on conducting policy issues on the right direction. Although, in the long run, positive changes and negative changes of cumulative dynamic multipliers of private health expenditure produced both positive and negative impacts on life expectancy which are obvious and policy makers encourage private investors to hike investment on healthcare. Similarly, in cointegrating relation, positive changes of cumulative dynamic multiplier of private health expenditure induced positively on life expectancy significantly which can encourage investors while insignificant negative impact on life expectancy by negative changes of cumulative dynamic multiplier of private health expenditure will discourage investors. Thus, the asymmetry is upward although stationary in the long run. The identification of negative impacts is necessary. Social determinants of public health outcome like inequality and poverty should be emphasized for amelioration, even, the availability of healthy foods, sustainable health system, increasing demographic dividends, and higher government allocations should be given more priority. Recently, Biden-Hariss administration emphasized on medical insurance adding 6.3 million people under the coverage since 2020 where uninsured adults aged 18-64 have declined from 14.5% in late 2020 to 11% in early 2023 and uninsured children aged 0-17 declined from 6.4% to 4.2% during the same period (Smith,2023). Michaud et al. (2025) expressed that Trump administration cut public health funding massively discarding support on the programs relating to diversity, equity and inclusion and racial inequities because of decentralized public health system in USA. The American Medical Association (2024) wanted to enforce law to enact the public health awareness programm on various preventive measures for diseases through internet and social media because more than 94% of the youths of USA took help from internet and social media for healthcare protection in recent years.

CONCLUSIONS

The paper concludes that in the long run, life expectancy is affected positively by positive changes of private health expenditure which is significant. On the other hand,in the short run, it has insignificant positive impact while negative changes of private health expenditure have both significant positive and negative effects on life expectancy in USA during 1960-2023.There is short run asymmetry from negative changes of incremental cumulative dynamic multiplier of private health expenditure on incremental life expectancy which is positive and significant. On the other hand, long run asymmetry from positive changes of cumulative dynamic multiplier of private health expenditure is negatively affected on life expectancy while negative changes affected negatively on life expectancy significantly. The cointegrating equation is convergent and significant. It is converging towards equilibrium at the speed of adjustment of 19% per annum significantly. Both positive response and negative response from cumulative dynamic multiplier of private expenditure on healthcare on life expectancy have converged to long run limits where negative responses declined but positive responses are upward. The asymmetry line is also upward moving and converged towards stationary level above the equilibrium line within the limits of the confidence interval. This NARDL model is stable without serial correlation and heteroscedasticity problems but did not follow normality. Of late, US president policy of "Make Our Children Healthy Again Strategy" emphasized to increase life expectancy at birth of USA to 82.6 years.

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