An Expenditure on Health and Expectancy of Life Dynamics in Nepal: An Analysis With Uneven Linearity

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Abstract

Using yearly time-series data from 1995-2020, this research explores the asymmetric link between public health expenditure and life expectancy. Zivot unit-root testing and NARDL co-integration analysis were both used in this study's econometric approach; the former allowed for a single significant break in the model, while the latter took into account the presence of the structural break and analyzed the long-run asymmetric relationship. The study's findings show that public health spending as a percentage of GDP had a co-integrating connection, which means that negative shocks to this spending might lead to an increase in it and, in turn, a longer life expectancy. When the economy experiences negative shocks, not the positive ones, the government's response has to be proactive in raising health expenditure. Policymakers can use the study's findings as a reference for crafting a public health expenditure policy. This study has also made a novel contribution by applying nonlinearity and structural break unit-root tests, which were not tested in previous studies, to fill in the geographical gap that those studies had.

Keywords: NARDL, asymmetric link, public health expenditure, negative shocks, policymakers

***JEL Classification**: C32, I18, E32, H51, D78*

Introduction

In the Fiscal Year 2021/22 the government of Nepal has allocated an amount of USD 1.09 billion to the health sector; however, in the upcoming Fiscal Year 2022/23, the amount has been confined to USD 557.5 million due to the shrinkage in the Covid-19 allocations (Ministry of Finance [MoF], 2022). After the pandemic hit the world, several economies, including the Nepalese economy, faced an augmentation in health expenditure. Nevertheless, these expenditures have been playing a crucial role in enhancing the life expectancy of the population who dwell in the country. The improvement of the population's health is considered an important means of enhancing human capital, achieving sustainable development, reducing absolute and relative poverty, and thus improving the welfare of the nation (Boachie et al., 2018).

To such a decree, Hsiao and Heller (2000) asserted a poor linkage between the health sector and economic development. Many low-middle-income countries and even developing countries are found to be in disguise to realize the importance of the budget and were found to follow an ad hoc allocation of the budget in the health sector (Adhikari et al., 2002). With this, World Bank (WB, 2014) stated that the number of expenditures, incurred in the preparation of and improvements in the population's health, is regarded as health expenditures. Adhikari et al. (2002) asserted that the nation's health and economic development are highly correlated though it always stands difficult to differentiate which one is the real cause and effect in both. Good health is ostensible to contribute to sustainable development in the long run because it stands to be a major driving force of the nation's economy. To finance such economic development in the long run, the proportion of the health expenditure seems crucial to be financed by the government because public financing of healthcare is significant to address the equity issues in healthcare consumption and income redistribution (Boachie et al., 2018). Therefore, it can be seen that with augmented health spending by the government in developing countries especially lower-middle income nations with some measure of government intervention (Sachs, 2001). To this effect, it becomes incumbent on the government to become involved in improving the health of its people either directly or indirectly through policies (MoH, 2018; Boachie et al., 2018).

When referred to Adhikari et al. (2002) in the Nepalese context, the effective utilization of the allocated public health expenditure was not optimum two decades ago. Though the country tackled several political and developmental changes including the structural changes to date, the private expenditure on health is either expensive or unattainable to the remote sections of the country. To such a stipulation, agreeing to the report published by United Nation International Children Emergency Fund (UNICEF, 2018), Nepal’s health sector is seen to be making considerable progress in recent years. Several key Acts were passed to further an enabling environment (e.g., Public Health Service Act, Safe Motherhood & Reproductive Health Act, & Social Health Insurance Act). Provincial health directorates and offices were established, the Ministry of Health and Population and the Department of Health Services restructured, urban and community health facilities operationalized in all districts, and trachoma (a leading cause of blindness) was eliminated in Nepal. Progress on major outcomes, such as under-five mortalities, fertility, and stunting remain on track. The report entailed that Nepal is committed to achieving universal health care as well as the sustainable development goals (SDG) health targets (UNICEF, 2018).

An approximate 4.5 percent health expenditure is stated to be contributed to the gross domestic product in Nepal (WB, 2022). With this, the impact to be assessed on the life expectancy of the country is stated to be 71.4 years, according to the United Nation's World Population Prospects (UNDESS, 2022). The report, however, does not accompany the Covid-19 deviousness. The scenario can be entailed as a criterion for study as the health budget has been made more sophisticated and encompassing these days. Not only this, the government is keen on enhancing better health conditions and thus increasing the life expectancy of people for the achievement of a better SDG by 2030.

This study contributes to the literature in Nepal to study the time-series data to establish whether the health expenditure and the real GDP per capita and unemployment rate possess an asymmetric long-term relation with the major output of the life expectancy, or if there are some other factors affecting it. After that, the asymmetric analysis was done, and the model was best fitted with the residuals and diagnostic tests. Some of the issues unaddressed in the research in Nepal by Adhikari et al. (2002), such as the asymmetric relation, were not identified so far; the other socio-economic variables of the unemployment rate were not addressed and also; and life expectancy solely has not been addressed. However, this research encompasses new dynamics.

Literature Review

Hotchkiss et al. (1998) conducted research, on Household Health Expenditures in Nepal: Implications for Health Care Financing Form Using Representative Samples of Households, to investigate the level and distribution of the household out-of-pocket health expenditures. The results of the study indicated that households spend about 5.5 percent of the total household expenditures on health care and that household's account for 74 percent of the total level of funds used to finance the health economy. Likewise, rural households were found to spend more on health care than urban households, after controlling for the income status.

Adhikari et al. (2002) conducted a study on Nepalese health policies to assess the interrelationship between the health expenditure made by the government and economic development. The research used time-series data, used the health production function and the input-output model as the base model. The method of ordinary least squares—with either of the dependent variables as child mortality rate, infant mortality rate, and life expectancy rate—were used against the GDP at constant prices and the share of public health as a fraction of GDP as an independent variable. Due to the smaller sample size, the regression results were not convincing; however, the analysis of the national plans stated a strong positive relationship between the health of the nation and economic development.

Azomahou et al., (2009) made an attempt to use econometric technique for realizing the impact of life expectancy on economic growth. In their analysis, they employed non-parametric techniques for studying this relationship with data from eighteen countries for 1820–2005 period. It turned out that the relationship is convex at life expectancy below 65.3 and concave above this value. They also used a benchmark model that integrates perpetual youth with a learning by investing framework: this provides a distinctly increasing and concave path for life expectancy and economic growth. Furthermore, the paper considered two other models that deviate from the continual young assumption: concurrent earnings and probabilities of survival by age.

Bakelli (2016) undertook a research study on income inequality and health in China using panel data analysis. The study used the China Health and Nutrition Survey (CHNS) to address the question of whether income inequality has an impact on individuals' risks of having health problems in China. The study used the methodology of non-linear ARDL analysis to find the asymmetric effects. There was no difference with the previous studies with health measures, such as self-reported health or mortality rate, the study used physical functions to measure individual health. By analyzing panel data using county/city-level dummies and year fixed-effects, the study found that income inequality does not have a significant impact on individuals' risks of having health problems. This result is robust when changing between different indicators for income inequality.

Dayanikli et al, (2016) conducted research on the effect of GDP per capita on national life expectancy to assess the correlation among the variables. The technique of ordinary least squares, followed by a scatter plot, was employed. The regression was run on life expectancy as the dependent variable. Per capita real GDP and the share of public expenditure in GDP were used as the explanatory variables. The correlation between the per capita GDP, public health expenditure, and cross-country life expectancy, which was measured by birth were positive and the regression coefficients, were also statistically significant.

Boachie et al. (2018) conducted research on health outcomes to assess the relationship between public health expenditures and health outcomes. Time-series data from 1980 to 2014 was employed. Life expectancy was used as a dependent variable and private and public health expenditures as the explanatory variables. The ordinary least squares and the two-stage least squares estimators were employed for the analyses. The cost-effectiveness analyses were conducted. The public health expenditure was found increasing by 10% to avert 0.102-4.4, infant and under-five deaths in every 1000 live births while increasing life expectancy at birth by 0.77-47 days in a year. The research also revealed, though the health effect of income outweighs that of public health spending, that high (and rising) income inequality made government intervention necessary.

Bektas and Akman (2018) conducted a study on examining the role of health expenditures on economic growth to reinforce the human capital stock of a country that play an important role in growth and development. The study examined the role of health expenditures on economic growth in Turkey between 1975 and 2014. The real per capita gross domestic product (RPGDP) represented the economic growth, and real per capita health expenditure (RPHE) represented the health expenditures. The unit root tests, the Johansen co-integration test, and the Granger causality test were employed. After the Granger causality test was applied, it was concluded that there was a Granger causality in one direction from the *DRPHE* variable towards the *DRPGDP* variable—the causality that shows a long-term relationship between *RPGDP* and *RPHE*.

Chang and Zao (2021) explored the impact of income inequality on the health system coverage and whereas in emerging Asian economies using empirical evidence on asymmetric effects. The paper investigated the role of income inequality on the health status of the population for the period between 1991 and 2019. The findings pointed out that long-term effects of income differences were a cause of early mortality or lower life expectancy. Furthermore, the results showed that positive changes in income dispersion in these economies were positively related with life expectancy, indicating that negative changes in income dispersion were negatively related with life expectancy in these economies. It was also observed that the results were pretty robust irrespective of the econometric approach used – symmetric or asymmetric. The study concluded by calling on governments to factor the effect of their economic policies on income disparity in order to improve health.

Research Gap

The reviewed studies suggest advancement in the knowledge of the linkages between the health expenditures, economic development, and income distribution, and health results in various countries and settings. However, no attempt has been made to synthesize these findings for further investigation on how the health expenditure and the life expectancy of people in Nepal. Also no studies in Nepal has been done aiming to explore the nonlinear relationship assessing the structural break in both of the variables public health expenditures and life expectancy. Although some comparative works like Adhikari et al. (2002) and Hotchkiss et al. (1998) give some context to the Nepalese situation they do not use effective and sound methodological approaches that are used in Bakelli (2016) and Chang and Zao (2021) wherein nonlinear and asymmetric effects or panel analysis techniques were applied. The present study thereby opens the possibility for future research using other econometric techniques like the non-linear ARDL or Granger causality tests or Gregory Hansesn cointegration to examine the complex interactions of these variables in under-researched economies and time horizons.

Materials and Method

Data

This study, based on the annual time series data from 1995 to 2020, encompassed the data after the post-economic liberalization policy adopted in Nepal. The data merely encompassed the effect of the Covid-19 as the impact of the pandemic is yet to be seen on the variables taken. The life expectancy (LE) was employed as the dependent variable, which represents the national living age of the population under the average period in which the person was expected to remain biologically active. The Real GDP per capita (PCRGDP) was taken as the independent variable used to refer to the income per individual a year under constant prices. The share of public health expenditure on GDP (PHSGDP) was used to represent the fraction of GDP allocated to the public health expenditure. The Real GDP per capita was taken in terms of USD, and the public share of GDP was taken in terms of percentage whereas the life expectancy was taken in terms of the number of years. The unemployment rate was used to mean the percentage of the total population not employed at all. Due to the limitations of data, the sample size (*n*) could not be taken at a profuse amount. The data were simply taken from the Quarterly Review of the Nepal Rastra Bank (Central Bank) and from the annual reports released by the World Bank.

Model Specification

This study was replicated by slightly adjusting the model laid down by the conceptual equations for health production function, as mentioned by Filmer and Pritchett (1999) who used either of life expectancy, child mortality rate, or infant mortality rate as the dependent variable and the real GDP per capita, public health expenditure as a share of GDP, and unemployment rate as the independent variables. The *X* independent socioeconomic variables were employed to refer to the socioeconomic factors including either the adult literacy rate, unemployment rate, or inequality measurement (Gini coefficient). On the foundations of Filmer and Pritchett (1999), out of the three dependent variables, only one dependent variable, life expectancy, was taken under study so that the focus of the research would be on one dimension. The validity of the model taken for this study thus stands to have justified the rationale behind taking the necessary variables for the study. The model of the research mainly concentrated on the three explanatory variables and one dependent variable. Out of the three independent variables, only *PHDGSP* was taken as the variable for the study of the asymmetric relationship with the *LE*.

To capture the elasticities while correcting any skewness in the data and to address nonlinearity issues, the empirical version of the equation as stated by Filmer and Pritchett (1999) used the logarithmic form of the series. Aside from obtaining the elasticities directly, the logarithmic transformation helps to account for the nonlinear relationship between the regressand and the regressors. Further, it ensures results compatible with the previous studies (Boachie et al., 2018; Filmer & Pritchett, 1999). The model was formulated as

LE = f (PCRGDP, PHSGDP, UNR) …………………………… Equation (1)

The variables were converted into the log-linear form of base ten. *LE* was used to stand for Life Expectancy, *PCRGDP* for per capita real GDP, *PHSGDP* for public health expenditure share of GDP, and *UNR* for the unemployment rate.

To acknowledge the use of the indicator, life expectancy as a dependent variable has no strong meaning to reveal the actual health conditions of various segments of the population within the country, and the indicator has also been a secondary indicator for measuring the quality of life in many developing countries (Boachie et al., 2018). However, for the low middle-income country like Nepal, the general assumption is that countries with healthy populations will have low mortality and higher life expectancy (WB, 2017). This work adopted an inferential, time-series research design to initiate an analysis of the asymmetric connection of LE with variables like real GDP per capita, public health expenditure ratio, and the unemployment rate using the nonlinear ARDL approach proposed by Shin et al. (2014). Other techniques in the analysis were the long-run interest rate Johansen perfect bound test, coefficients from cointegration.

The decision to apply the nonlinear ARDL technique was inspired by the works of Bakelli (2016) and Chang and Zao (2021). Before applying this method, the time-series data were tested for unit roots using the Augmented Dickey-Fuller test and Phillips-Perron test (Enders, 2017), along with the Zivot and Andrews (1992) unit root test, which accounts for one structural break. According to Shin et al. (2014), the nonlinear ARDL approach is suitable when all variables in the study are either $I(1)$ or a combination of $I(0)$ and $I(1)$. For determining the appropriate lag length, Pesaran et al. (2001) recommended the use of the Akaike Information Criterion (AIC), and this study followed that recommendation, selecting the lag length with the lowest AIC value. This study is inspired by the econometric technique of non-linear analysis by Pokhrel and Adhikari (2022) and Dangal, Pokhrel, and Adhikari (2023).

To capture the effects of the asymmetry, nonlinear ARDL decomposed the variable share of health expenditure to GDP into two parts: the partial sum of positive change in public share of health expenditure to GDP, denoted by $PHSGDP^{+}$, and the partial sum of the negative change in public share of health expenditure to GDP, denoted by $PHSGDP^{-}$—both of them were used as separate regressors. The model for the long run using asymmetries was:

$$LE_t=\delta_t+PCRGDP+PHSGDP_t^{+}+PHSGDP_t^{-}+UNR+v_t \ldots\ldots\ldots\ldots\ldots Equation\ 2$$

Likewise, the nonlinear representation signifying the short-run and the long-run terms was represented the following in the equational layout.

$$\Delta LE_t=\delta_t+\Sigma_{i=1}^{p-1}\lambda_i\Delta LE_{t-1}+\Sigma_{i=1}^{q}\gamma_i^{+}\Delta PHSGDP_{t-i}^{+}+\ \Sigma_{i=1}^{q}\gamma_i^{-}\Delta PHSGDP_{t-i}^{-}+\ \Sigma_{i=1}^{q}\gamma_i\Delta PCRGDP_{t-i}+$$
$$\Sigma_{i=1}^{q}\ \gamma_i\Delta UNR_{t-1}+\rho LE_{t-i}+\phi^{+}PHSGDP_{t-i}^{+}+\phi^{-}PHSGDP_{t-i}^{-}+\ v_t\ldots\ldots Equation\ (3)$$

The subscript *i* represent number of lags taken for the study for the independent variables. ñ represents the long-term error correcting term. λ_i, $\gamma^{+}, and\, \gamma^{-}$ represent the coefficient for nonlinear, and similarly ρ, $\phi^{+}, and\, \phi^{-}$ are the nonlinear ARDL long-run coefficients with asymmetric terms. The Bounds test for the asymmetric long term cointegration was done in accordance with Fisher's (F test) (Narayan, 2004; Pesaran et al., 2001). The null hypothesis could be stated as $H_0: \rho = \phi^+ = \phi^- = 0$, and the alternative hypothesis would be $H_0: \rho \neq \phi^+ \neq \phi^- \neq 0$. Confirmation of cointegration occurs when the null hypothesis is rejected (Shin et al., 2014).

$$PHSGDP_t^+ = \Sigma_{j=1}^t \Delta\Delta PHSGDP_J^+ + \Sigma_{j=1}^t \max(\Delta X_j, 0)$$

$$PHSGDP_t^- = \Sigma_{j=1}^t \Delta PHSGDP_J^- + \Sigma_{j=1}^t \min(\Delta X_j, 0)$$

The long-run coefficient would be obtained by dividing the negative of the coefficient of $PHSGDP_t^+(\phi^+)$ by the coefficient of $LE_{t-1}(\rho)$ and also by dividing the negative of the coefficient of $PHSGDP_t^-(\phi^-)$ by the coefficient of $LE_{t-1}(\rho)$ (Shin et al., 2014). With this, the Wald test was assessed for the long-run asymmetry, to test the asymmetric coefficients as to whether they were statistically significant or not, stating the null hypothesis as $H_0: \frac{\phi^+}{\rho} = -\phi^-/\rho$ and alternative hypothesis as $H_0: \frac{\phi^+}{\rho} \neq -\phi^-/ñ$. When the null hypothesis was rejected the long-run asymmetry in the data under scrutiny was verified. In general, it revealed that how the elevation in the portion of PHSGDP affects the variables of LE differed from the way the decline in the portion of PHSGDP affected it (Pesaran et al., 2001).

After long-run asymmetry analysis, an asymmetric dynamic multiplier was conducted. The dynamic multipliers show how the LE_t adjusts to its new long-run equilibrium following the negative (*NEG)* or positive (*POS*) shock in LE_t. The cumulative dynamic multiplier effects of $PHSGDP_t^+$ and $PHSGDP_t^-$ on *LE* were calculated (Pesaran et al., 2001).

$$m_h^+ = \Sigma_{j=0}^h \frac{\Gamma LE_{t+j}}{\Gamma PHSGDP_t^+}, \; m_h^- = \Sigma_{j=0}^h \frac{\Gamma LE_{t+j}}{\Gamma PHSGDP_t^-}, \text{ for any h } = 0,1,2,\ldots$$

In case $h \to \infty$, then $m_h^+ \to -\phi^+/\rho$ and $m_h^- \to -\phi^-/\rho$.

After the final model had been defined, diagnostic and stability tests were undertaken on the asymmetric long-run model. Among these they employed autoregressive heteroscedasticity test, BG LM serial correlation test, Jarque-Bera normality test, CUSUM stability test and RAMSEY RESET functional stability test (Gujarati, 2003).

Results and Discussion

When using the NARDL model it was necessary to check for the unit roots of the variables used in the analysis. Moreover, it was pointed out by Shin et al. (2014) while conducting the nonlinear analysis, the variables should not be integrated of order I(2). For the dependent variable and the asymmetric variable used in the nonlinear analysis, the Zivot and Andrews (1992) test was performed.

The ADF tests revealed that *LE* was stationary and integrated of order of *I*(1) at constant, and *PHSGDP*, *PCRGDP*, and *UNR* were integrated of order of *I*(1) at constant or at constant plus trend. Likewise, the *PP* tests stated that *LE* and *UNR* became stationary at the order of integration at *I*(0) on constant or constant plus trend, and *PHSGDP* and *PCRGDP* were stationary at the integration of order *I*(1) at constant or constant plus trend.

Table 1

Results of ADF, PP, and ZA Test

		ADF t-stat	PP t-stat	ZA t-stat	Break Date
LE_t	Constant	-0.64	-63.82*	-6.99**	2004
	Constant Plus Trend	-5.67	-16.31*	-9.75**	2004
ΔLE_t	Constant	-5.91*	-6.78*		
	Constant Plus Trend	-2.69	0.06		
$PHSGDP_t$	Constant	-1.91	-1.90	-4.49	1999
	Constant Plus Trend	-1.89	-1.89	-4.14	1999
$\Delta PHSGDP_t$	Constant	-4.31*	-4.33*		
	Constant Plus Trend	-4.28*	-4.41*		
$PCRGDP_t$	Constant	2.67	1.09		
	Constant Plus Trend	-0.46	-2.47		
$\Delta PCRGDP_t$	Constant	-4.63*	-5.99*		
	Constant Plus Trend	-6.03*	-9.48*		
UNR_t	Constant	-3.43*	-3.38*		
	Constant Plus Trend	-3.31***	3.24***		
ΔUNR_t	Constant	-5.16*	-6.65*		
	Constant Plus Trend	-5.46*	-10.11*		

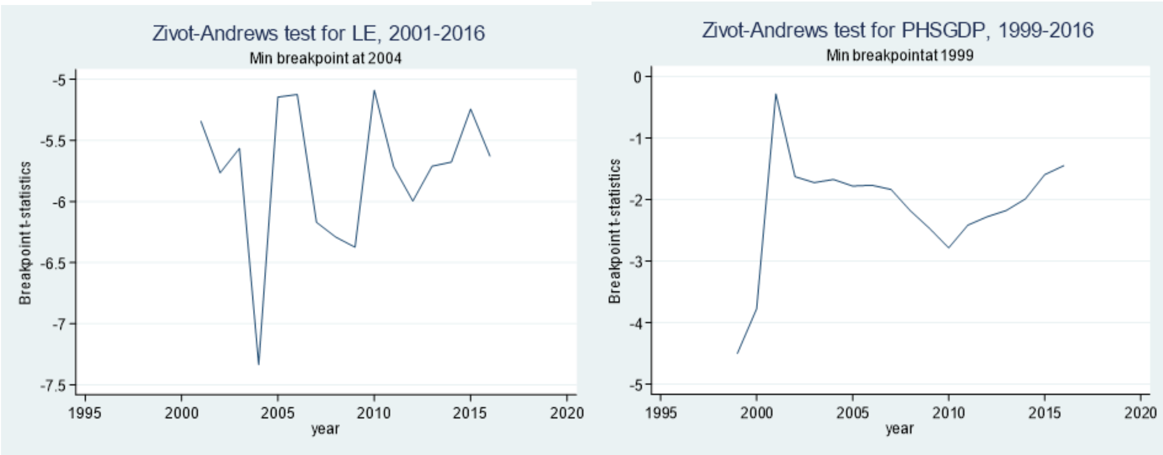
Note. ADF = Augmented Dicky Fuller Test; PP = Phillip Perron Test; ZA = Zivot Andrews Unit Root Test (one break); lag length on the basis of Schwarz Information Criterion (SIC). *,**,*** denotes significance level at 1%, 5%, and 10% respectively.

Likewise, the ZA test depicted a break in the *LE* in the year 2004. After 2004, the life expectancy steeply rose, as Figure 1 shows, because the government then launched a broad 5-year Nepal health sector program implementation plan (2004). This plan envisaged a wide vision of decreasing the child mortality rate, infant mortality rate, and the External Development Partners assisted projects to provide the important support for all external health care services areas both at the central and field levels. That support was closely co-coordinated with overall program needs (Ministry of Health and Population [MoHP], 2004).

In addition to this, the National Health Training Strategy (NHTS, 2004) was launched in 2004 that provided the training to the health professionals. It focused on overseeing all training need of Ministry of Health (then) through coordinated and complimentary efforts of all stakeholders, support partners, and private sector training resources under the stewardship of Ministry of Health (then) (MoHP, 2022). Likewise, when *PHSGDP* was inspected as portrayed in the Figure 1, it could be vividly seen that the share of public expenditure steeply declined after the year 1999, owing to the decrease in the total health expenditures after 1999 till 2003. The share of both government and private sector increased marginally, but the expenditures of both the official's donors and nongovernment organizations declined in the review period (World Health Organization [WHO], 2007).

Figure 1

The ZA Break Graph for LE and PHSGDP



The lag selection order of the model was based on Akaike information criterion (AIC) as suggested by Pesaran et al. (2001). The model with the least AIC was chosen for the study. Table 2 represents the model selection on the basis of least AIC value. Here top 5 models were taken under consideration.

Table 2

Model Selection Under AIC and BIC Criteria

S.N	Model	logL	AIC*	BIC*	HQ	Specification
1.	36	231.472	-19.345	-18.901	-19.233	ARDL (2, 1, 2, 0, 0)
2.	35	231.861	-19.292	-18.798	-19.168	ARDL (2, 1, 2, 0, 1)
3.	33	231.838	-19.291	-18.796	-19.166	ARDL (2, 1, 2, 1, 0)
4.	9	231.541	-19.264	-18.770	-19.140	ARDL (2, 2, 2, 0, 0)
5.	63	229.531	-19.263	-18.868	-19.164	ARDL (2, 0, 2, 0, 0)

Note. * represents the criteria for the model selection

By AIC and BIC model selection criteria, the optimal lag was estimated. There was no constant plus trend in the model. The lag with the lowest value for AIC was considered to be the best lag for the model that was being compared. Here 2 lags on the *LE*, 1 lag for *PCRGDP*, 2 lags for *PHSGDP_POS*, 0 lag for *PHSGDP_NEG*, and 0 lag for *UNR* were taken as the optimal lags, and the study was taken forward for the long-run cointegration analysis and for the study of the asymmetric behavior. The lags were found to be optimum because the optimality of its selection was backed up by the presence of no serial correlation and ARCH effects in the model. Further, the model with above optimum lags was also backed up by the significance of the functional stability Ramsey *RESET* test, *CUSUM* and *CUSUM* sum of squares test, and residuals tests. These tests are presented in Table 4 in detail.

The optimum model was applied to the bound tests on the basis of the Fisher's statistics on the nonlinear category; the stability was guaranteed by the significant *F* tests value as presented the Table 3.

Table 3

Bound Test (Long Run)

Test Statistic	Value	K
F- statistic	7.77689*	4
Critical bound values		
Significance	*I*(0) bound	*I*(1) bound
10%	1.90	3.01
5%	2.26	3.48
1%	3.07	4.44

Note. * significant at 1% level of significance

The bound tests showed significance at the 1% level, leading to the rejection of the null hypothesis (H_0: no long-run cointegration relationship exists) and acceptance of the presence of long-run cointegration. Both the upper and lower bounds were smaller than the F-stat values, indicating a stable long-run relationship. Following this, the short-run and long-run coefficients were evaluated, as shown in Table 4.

Table 4

Long Run/Short Run Coefficients

Variables	Coefficients	Standard Error	*t*-stat	*p*-value
Long Run				
LE(-1)*	-0.00228	0.00074	-3.08281	0.0081
PCRGDP(-1)	0.00099	0.00029	3.33620	0.0049
PHSGDP_POS(-1)	-0.00076	0.00026	-2.94622	0.0106
PHSGDP_NEG(-1)	0.00031	0.00008	3.83487	0.0018
UNR(-1)	0.00002	0.00004	0.44921	0.6602
Short Run				
D(*LE*(-1))	0.87108	0.02142	40.6529	0.0000
D(*PCRGDP*)	0.00045	0.00045	1.00300	0.3329
D(*PHSGDP_POS*)	-0.00021	0.00021	-1.05158	0.3108
D(*PHSGDP_POS*(-1))	-0.00076	0.00026	-2.94622	0.0106

Note. * denotes the long-run cointegration (coefficient is negative and statistically significant at 1% level of significance).

Table 4 depicts the long-run and short-run coefficients of the given model. The long-run cointegrating relationship was found significant at 1 % level of significance, signifying the economy was converging towards the equilibrium from its short-run disequilibrium. The positive and negative shocks to *PHSGDP* were found to be statistically significant at the long-run on 5% and 1% levels of significance, respectively. It was observed that both the positive and negative shocks seem to affect the dependent variable in long run, the positive shocks to affect negatively though. As far as the short run was concerned, the positive shock was seen to affect the dependent variable in a negative pattern. The long-run asymmetric coefficients were analyzed in Table 5.

Table 5

Long Run Asymmetric Coefficients

Variable	Coefficient	Std. Error	*t*-statistic	*p*-value*
PHSGDP_POS	-0.28841	0.05982	-4.82061	0.0003
PHSGDP_NEG	0.12137	0.03479	3.48857	0.0036

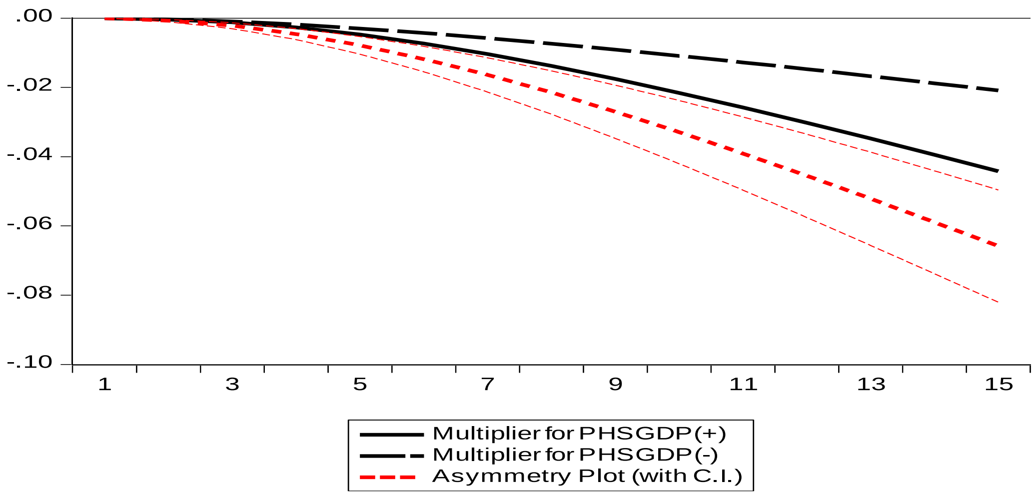
Note. * denotes significant at 1% level of significance

Table 5 represents the asymmetric coefficients in the long run. Due to the positive variations in the public health share in GDP, ceteris paribus, a one percent decrease in public health share increased the life expectancy by 0.28%. The result of the positive variation in public health share in GDP impacting to increase the life expectancy suggested that whenever there was a new policy positive to the health sector was introduced—no matter whether the government decreased the share of public health expenditure—the life expectancy continued to rise. The rise in life expectancy might be due to the factors that general people responded to the positive shocks and did not solely rely on the public health expenditure to lead a healthy and a disease-free life. Likewise, whenever there was a negative variation in the public health share in GDP, ceteris paribus, one percent increase in the public health share increased the life expectancy by 0.12%, implying that people were more stricken by the negative shocks and during that period the health share in GDP seemed crucial to increase the life expectancy. The case could be replicated in the recent case of the pandemic of Covid-19 as well. These both phenomena occurred in the long run.

After the analysis of the long-run asymmetric coefficients, the test of the long-run asymmetries of the coefficients was done with the help of the stepwise least squares in a unidirectional form (Shin et al., 2014). To test the stability of the coefficients Wald test mechanism was opted to impose the linear restrictions on the coefficients of the public share of GDP. The result of the Wald test was significant, signifying that the coefficients of *PHSGDP_POS* (-1) *and PHSGDP_NEG* (-1) were not to be linear; that is, the public share of GDP was showing asymmetric behavior. The *F*-statistic (14.99) and Chi-Square statistic (14.99) were both found significant at 1% level of significance. This null hypothesis of the symmetry in the long run was rejected, and the alternative hypothesis of long run asymmetry was thus accepted.

Figure 3

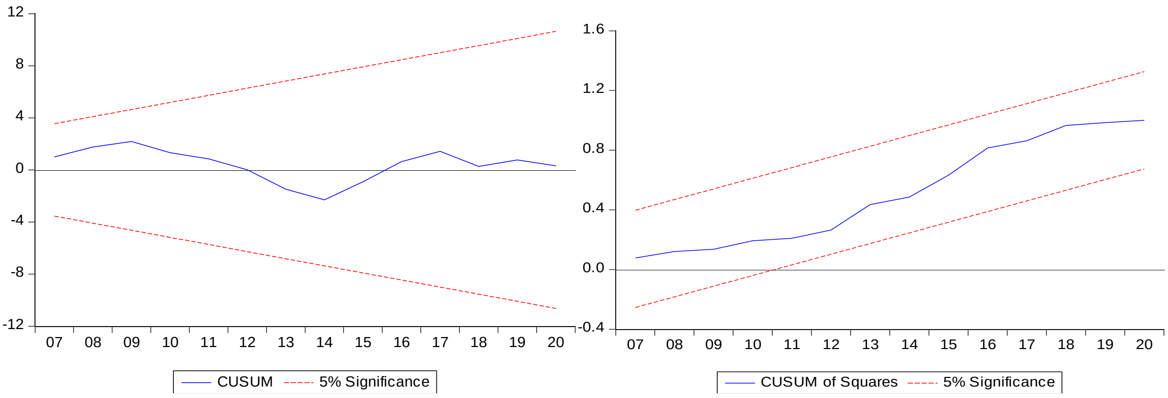
The Dynamic Asymmetric Multiplier



The results of the cumulative multipliers showed how the dependent variable reverts to a new long-run steady state after a unitary shock to the regressors, whether positive or negative. The dynamic multiplier analysis is illustrated in the context of Figure 3. Figure 3 depicts that the multiplier for the positive and negative shocks to public expenditure on health response negatively on the both ways. The response of the negative shock was less negative to that of the response of the positive shock. In the long run, the magnitude of the decrease of the multiplier due to the positive shock was larger than due to the decrease in the negative shock. In the same way, in the long run, the positive shock would have less impact as the asymmetry plot tend to move downwards. The positive and negative shocks beyond the 5% level reveal a symmetry in the long run, but in the very long run the effect of positive shocks would tend to fade away. The model was then tested with the stability diagnostic tests. Firstly, the *CUSUM* and *CUSUM* sum of squares test were carried out which eventually laid down to the following results.

Figure 4

CUSUM and CUSUM Sum of Squares Test



In diagnosing the residuals of the nonlinear ARDL model, the CUSUM and CUSUM of squares both showed that the model was stable in the long run because both the cumulative sums and total sums of squares of the recursive residuals were at 5 percent or lower.

Further, the *RAMSEY Reset* (regression equation specification test) was conducted to test whether the functional form of the model was correct in this case, that is, if the model possessed linearity, and *RAMSEY* model was also an indirect way of testing whether the regressors were significant or not (Shin et al., 2014). The null hypothesis (H_o: There is linearity in the model) was tested with the help of *F*-test statistic and *t*-test statistic. *F* statistic and *t* statistic were 1.2335 and 1.5216, both being significant (*p*-values more that 5 % - 0.2392). It was confirmed that the functional form of the model was correct and the model possessed non-linearity.

The residuals tests were performed to ensure whether the lag selected for the model was best fit. For this, Breusch Godfrey Lagrange multiplier serial correlation test, ARCH (auto regressive heteroscedasticity) test, and Jarque-Bera test for normal distribution were tested. The results are presented in Table 6.

Table 6

Residuals Test

Type	Chi-Square	p-value*	F-stat	p-value*	Jarque Bera	p-value*
BG serial correlation test	0.69658	0.7059	0.18789	0.8315	-	-
ARCH test	1.26244	0.2531	1.30624	0.2745	-	-
Jarque Bera test	-	-	-	-	1.95583	0.3761

Note. * denotes that the *p* values were insignificant above 10 % level.

The *p*-values of the all the test statistics of the BG serial correlation test, ARCH test, and Jarque Bera test for normality signified that the residuals out of the model possessed no serial correlation and the variance of the residuals was also constant along with the residuals were normally distributed.

Conclusions and Implications

Health expenditure in the country is likely to be a key factor in enhancing the competent manpower in an economy. The public share of health expenditure in GDP seems to affect life expectancy in the long run. This study has attempted to analyze the asymmetric behavior between the public health share on GDP and life expectancy with the engagement of the nonlinear auto-regressive distributed lag model (*NARDL*) to examine the long- and short-run asymmetric relationship simultaneously between the variables.

Conclusion

The results that emerge from the analysis of *NARDL* result depicted the asymmetric long-run relation between the life expectancy and public health expenditure share of GDP. Analyzing the results, this paper found that whenever a new policy that seemed positive to the health sector was introduced, no matter whether the government decreases the share of public health expenditure, the life expectancy continues to rise. The rise in the life expectancy seems to be due to the factors that general people respond to the positive shocks and do not rely solely on the public health expenditure to lead a healthy and a disease-free life, and people are also more stricken by the negative shocks. During this period the health share in GDP seems crucial to increase the life expectancy.

The error-correction term of nonlinear model appeared to be negative and statistically significant at 1% level, indicating the possibility of convergence towards equilibrium in each period by the captured adjustment parameter. The asymmetric dynamic multipliers would likely to state that in the long run the magnitude of the decrease of the multiplier due to the positive shock became larger than due to the decrease in the negative shock. In the same way, in the long run, the positive shock would have less impact as the asymmetry plot tend to move downwards.

In case of Nepal the result which indicate that life expectancy increases with positive health policies even in a situation of reduced public health expenditure highlighting the role of individual and community level responses. Yet negative change in health expenditure affect the sector more, thus showing its frailness. This underlines the importance of constant funding, and relevant policies to counterbalance several unfavorable impacts and maintain healthy changes apace.

Implications

The findings of the research study are consistent with those of the prior studies (Boachie et. al., 2018; Dayanikli et. al., 2016); however, this study appears to be one step ahead of this previous study (Adhikari et. al., 2002) because this study used nonlinearity followed by structural break unit-root tests—the tests, a new contribution, that have not been used so far. However, this research leaves these questions unresolved for future researchers: finding the nonlinear relationship with more than one structural break, using a larger sample size, and using other socioeconomic variables that impact the output of the model. In aggregate terms, the research seems to advise the Nepalese government that it would likely to be more focused on assessing the negative variations in the health expenditure and enhancing the health expenditure, assessing in parallel the new challenges in the health sector to increase life expectancy in the short and long run.

Limitations and Further Scope

This work has several limitations such as limited time frame, limited sample size of that has hindered the analysis to a small frame. However, the instruments used in the study while being effective may not capture the crux of health dynamics and relationship with the spending on public health. In general, the research is largely at macro level and therefore may not capture the kinds of fine details possible from the micro level analysis (using the micro econometric tools). Furthermore, the examination of socioeconomic factors and the impacts of different structural fractures was beyond the scope of enquiry of this research.

Future research can be extended by applying different methodological tools, namely, impact evaluations, using micro-econometric methods to compare effectiveness of health programs on individual and community levels. Extension of the empirical analysis to include many structural breaks and addition of more lead variables to the dataset could further enhance the credibility of the results. These interventions can improve understanding of health cost and lifespan when subjected to shifting health conditions.

Disclaimer: The opinions presented in this study are the subjective opinions of the researchers and do not reflect the official stance of the institution where they work.

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Appendix

Data Used in the Study

Year	Life Expectancy	Per Capita Real GDP (USD)	Public Health Expenditure share of GDP (%)	Unemployment rate (%)
1995	59.3	217.908	1.4	10.57
1996	60.0	232.471	1.4	10.56
1997	60.8	224.384	1.5	10.60
1998	61.5	227.407	2.5	10.61
1999	62.1	242.729	1.8	10.62
2000	62.6	258.780	1.4	10.62
2001	63.3	254.552	1.6	10.62
2002	63.3	261.294	1.7	10.66
2003	64.2	293.207	1.6	10.68
2004	64.8	327.831	1.6	10.68
2005	65.5	349.549	1.6	10.65
2006	65.9	410.072	2.1	10.66
2007	66.3	491.347	2.3	10.67
2008	66.4	496.523	2.8	10.65
2009	66.8	609.535	2.9	10.64

Year	Life Expectancy	Per Capita Real GDP (USD)	Public Health Expenditure share of GDP (%)	Unemployment rate (%)
2010	66.8	814.318	2.9	10.63
2011	67.3	808.241	3.3	10.65
2012	67.5	814.309	2.5	10.65
2013	68.0	824.144	2.2	10.67
2014	68.1	871.440	2.5	10.65
2015	67.5	887.612	2.1	10.66
2016	68.8	1039.025	2.1	10.68
2017	68.9	1176.696	1.5	10.66
2018	69.0	1203.836	1.3	10.63
2019	69.6	1166.629	1.3	10.58
2020	69.2	1276.810	2.1	13.16

Note. World Bank Data, NRB, and MoHP.