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RESEARCH PAPER

Public Health Expenditure, Human Capital, and Economic Growth in South Asia: Panel Data Evidence

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ABSTRACT

This study examines the long-run relationship between public health expenditure, human capital, and economic growth in South Asian economies from 1995–2024. Public health spending is a key policy instrument for human capital formation, which plays a central role in sustaining economic growth. South Asia faces persistent health and development challenges, making this relationship policy relevant. Using balanced panel data for seven countries, the study applies panel unit root tests, Pedroni panel cointegration tests, Granger causality analysis, and long-run estimators including FMOLS, panel OLS, and DOLS. Economic growth is measured by GDP per capita, while human capital is proxied by HDI, labor force participation, life expectancy, and infant mortality. The findings confirm a stable long-run cointegrating relationship. Public health expenditure and key human capital indicators exert a positive and significant impact on economic growth. Short-run causality runs from growth to health expenditure. Policymakers should ensure sustained and efficient public health investment to strengthen human capital and support long-term growth.

KEYWORDS Public Health Expenditure, Human Capital, Economic Growth, Panel Cointegration, FMOLS, South Asia

Introduction

The health of a nation is an important measure of its quality of life due to the dependence on labor productivity upon the state of wellbeing and the progress of workers. Hence, government health spending is critical to human capital formation. The role of health in raising Gross Domestic Product (GDP) is well acknowledged (Iftikar, & Ali, 2024; Rahman et al., 2018). The South Asia is home to some of the most severe health disparities and some of the greatest economic inequities in human history. Although considerable research has been developed on health inequalities, less attention has been given to the questions of responses to those inequities among South Asian policymakers (Wasim, et.al., 2023; Pandi et.al., 2024; Khan & Khattak.2022). Human capital is an important factor in sustainable economic growth (SEG). According to growth theory, human capital consisting of health, education, training and migration makes labor more productive (Akram, et, al., 2008). Better aspects of health and education in particular, are necessary for an economy to progress in the long run (ceteris paribus) with per capita incomes growth, an assumption consistent with the neoclassical growth model (Canning & Pedroni, 2008). Other prior empirical research also shows that variations in growth of public health spending are largely explained by differences in GDP per capita growth across developing countries (Newhouse, 1977). Public health expenditures in South Asia are often accompanied by substantial out-of-pocket health spending. For example, even though public health expenditure remains a small proportion of total health spending in many South Asian countries, individuals still have to seek help from private providers when government facilities are inadequate (Zaidi et al., 2017). Recent research also corroborates these findings, even control variables such as life expectancy and mortality still matter in the case of South Asia (Dhungana, et, al., 2024; Wasim, et al., 2023). The relationship between public health expenditure and economic growth is a two-way causality relationship. As in the Schumpeterian tradition, health and

other kinds of human capital as well as physical capital impact per capita GDP through both increasing resource productivity and technological change. On the other hand, economic growth also allows for ameliorations of nutritional status, sanitation and medical technology, resulting in lower mortality rates (Gerdtham & Jönsson 2000; Dhungana et al., 2024). For instance, recent studies demonstrate in the long-run and equilibrium exist between health expenditure and economic growth in India with causality varying across states according to improvement in their index of health achievement. However, despite its significance, the health system in South Asia has been beset by a number of challenges including skewed allocation of funds for healthcare delivery, quality concerns in public sector hospitals and political interference on efficiency (Adeel, 2016; Pandi, et al., 2024). Public hospitals are usually not well-equipped, and most medical personnel opt for private practice due to attractive salaries and working conditions (Adeel 2016). In this regard, the objective of the present study is to investigate long term relationship between public health expenditure and economic growth in South Asia through panel Cointegration techniques. Grounded on the health-driven growth theory, it examines whether higher public health spending has a long run effect on economic growth. By extending the time horizon and using more recent data (1995–2024), the study adds to the literature in several respects: it supplies updated empirical evidence of South Asian economies, examines long-run causality and scale effect, filling gaps found in previous contributions which included earlier years only, one country or lacked recent control variable.

Literature Review

The human capital-economic growth relationship has been extensively analyzed, and ample empirical evidence indicates that health and education investments are associated with enhanced economic performance. A number of studies have examined the relationship between public health spending and growth in income over the last two decades, especially in developing regions like South Asia where health financing is a critical policy issue.

Health Expenditure and Economic Growth

Health spending is an important factor to determine the accumulation of human capital and productivity. Former works (e.g., Gyimah-Brempong, & Wilson, 2004) have shown that there is a positive relationship between investment in health capital (proxied by health expenditure and child mortality rates) and per capita income growth. Likewise, Schultz, (2005) stressed that better nutrition and the overall health status of adults generate increased factor productivity and income for the worker which helps promote long-run economic growth. Lorentzen, et, al., (2008) have examined the impact of adult mortality on economic performance and their result showed that higher mortality rates impede growth by shortening planning horizons and lowering education and physical capital investment. Jamison, et al., (2005) also reported that health advancements alone accounted for nearly 11% of economic gains in poor nations, supporting that investment in health and investment in education are symbiotic forces for prosperity. These relationships continue to be supported by recent empirical research. For instance, Rahman, et, al., (2018) and Wasim, et, al., (2023) provided very high evidence for the positive effect of public health spending on GDP growth in South Asia.

International Evidence on Health Spending

Internationally, the nexus between health spending and economic growth has also been widely investigated. Anderson, & Frogner, 2008) had earlier found that despite the United States' consistently higher levels of health care spending per capita than those of other OCED nations outcomes were not commensurately better which is consistent with findings demonstrating how difficult it can be to translate spending into performance. Mohan and Mirmirani (2007) and Baltagi and Moscone (2010) brought out structural,

institutional factors, indicating efficiency and governance affect the way health investment impact outcome. More recently, studies have used more sophisticated econometric techniques to test the impact of different types of health expenditures (public versus private) on growth. For example, Jaba, et, al., (2014) discovered that health spending per capita and life expectancy are associated with a group of 175 countries. Also have found a positive effect of public health spending in OECD countries on the indicator "health", which increases labor productivity and income. Updated analysis by Dhungana, et., al., (2024) found that improvements in longevity and declines in infant mortality are both large channels through which health investment stimulates growth in South Asia. In a similar vein, Pandi, et, al., (2024) also found that public investment in health infrastructure and preventive care has long run implications on GDP per capita.

Health Inequality and Policy Response in South Asia

Readmission-centered South Asian nations continue to encounter persistent health inequities and inefficiencies in public health spending. Zaidi, et, al., (2017) noted how disproportionate allocation of resources and the lack of insurance coverage have widened disparities in access to care. Newer evidence from Iftikar, & Ali, (2024) suggests that despite increases in government expenditure on health, the region remains highly dependent on out-of-pocket payments which constrain the equitable dividends of public investments. Political factors, governance issues and dominance of private medical practice in South Asian health system also restrict public health performance (Adeel, 2016; Wasim, et, al., 2023; Khan, et. al., 2022). Such "leakage" is a problem that reduces the impact of health investment on economic gain. Although there are many studies on health–growth nexus, few studies have empirically investigated the Cointegration and causality relation between public health expenditure and economic growth in case of South Asian countries. The vast majority of earlier studies considered summary measures of health without differentiating between short- and long-term movements or accounting for cross-country variation. The current study adds to this gap by using Panel Cointegration and Granger causality techniques to new data that extends from 1995 to 2024, shedding more light on how the investment in health impacts sustainable economic growth with different within region effects.

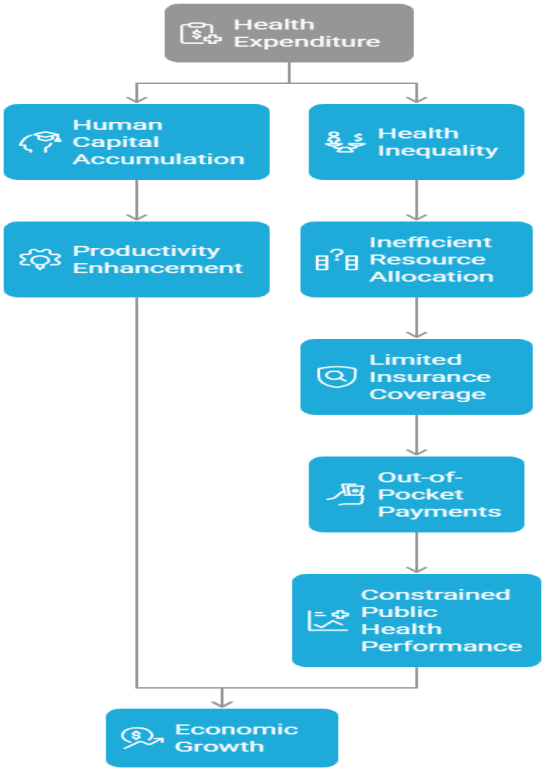

Figure 1: Theoretical Framework

Figure 1 Mapping the theoretical framework Figure 1 presents a theoretical framework that maps out the mechanisms through which public health expenditure may affect economic growth, both with respect to its productive function via human capital accumulation and constraints due to health inequality as well as inefficiency. The pinnacle of the framework is public health expenditure, which reflects government investment in health systems, infrastructure and services. Higher public health spending does double duty in driving economic outcomes. On the plus side, expenditures in public health lead to human capital accumulation through better health of population, raised longevity and increased labour force activity. A healthy population is a more productive population, with fewer lost workdays to sickness and better opportunities for investments in education and skills. This results in increase in efficiency, one of the fundamental determinants of economic growth most especially output and income levels.

On the other hand, the framework also indicates a constraint channel in light of health disparity. While resources in public health are inefficiently allocated, segments of the population get little insurance cover and households end up having to pay a great deal out-of-pocket for healthcare. High payments at the point-of-service can lower disposable incomes, heighten susceptibility to poverty, and restrict access to quality health care. These effects lead to a limited performance of public health and attenuate the overall efficiency gains from spending on health, hence lowering its growth promoting effect. The approach thus stresses the fact that public health spending does not automatically lead to economic growth. Its efficacy is determined by the efficiency with which resources are spent and whether health inequalities are narrowed. When health budgets enhance human capital and reduce inequality, they underpin sustainable economic growth. But if inefficiencies and access disparities remain, the growth benefits of public health spending are much reduced. The framework offers a conceptual rationalisation for the empirical investigation that has been undertaken in this paper and shows why public health spending, indicators of human capital and institutional effectiveness are important drivers of long-run growth in South Asian countries.

Material and Methods

The present study uses panel data (1995–2024) to empirically analyses the role of public health expenditure, human capital and economic growth in some selected South Asian countries. The panel consists of seven countries Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka making a well-balanced dataset for panel regression analysis. Secondary annual statistics are collected from recognized international sources to maintain reliability and comparability. GDP per capita (as a proxy for economic growth), labor force

participation, life expectancy, and infant mortality rate are from the World Development Indicators. Data on HDI, which is the summary measure of human capital development, and public health expenditure as percentage of GDP are retrieved from UNDP and OWID, respectively. Below in table 1 are further details of all the variable.

Table 1
Description of Variables Used in the Conceptual Framework

Variable Category	Variable Name	Symbol	Measurement / Proxy	Expected Effect on Economic Growth	Theoretical Justification
Dependent Variable	Economic Growth	GDP	GDP per capita (current US$)	—	Standard measure of economic performance and income level
Key Independent Variable	Public Health Expenditure	PHE	Government health expenditure (% of GDP)	Positive (+)	Higher public health spending improves population health, productivity, and human capital
Human Capital Variables	Human Development Index	HDI	Composite index (health, education, income)	Positive (+)	Captures overall human capital accumulation and development
	Labor Force Participation	LF	Labor force participation rate (%)	Positive (+)	Higher participation reflects greater productive capacity
	Life Expectancy	LE	Life expectancy at birth (years)	Positive (+)	Healthier populations are more productive and economically active
Health Outcome Variable	Infant Mortality	IM	Infant deaths per 1,000 live births	Negative (−)*	Higher infant mortality reflects poor health conditions and lower human capital quality

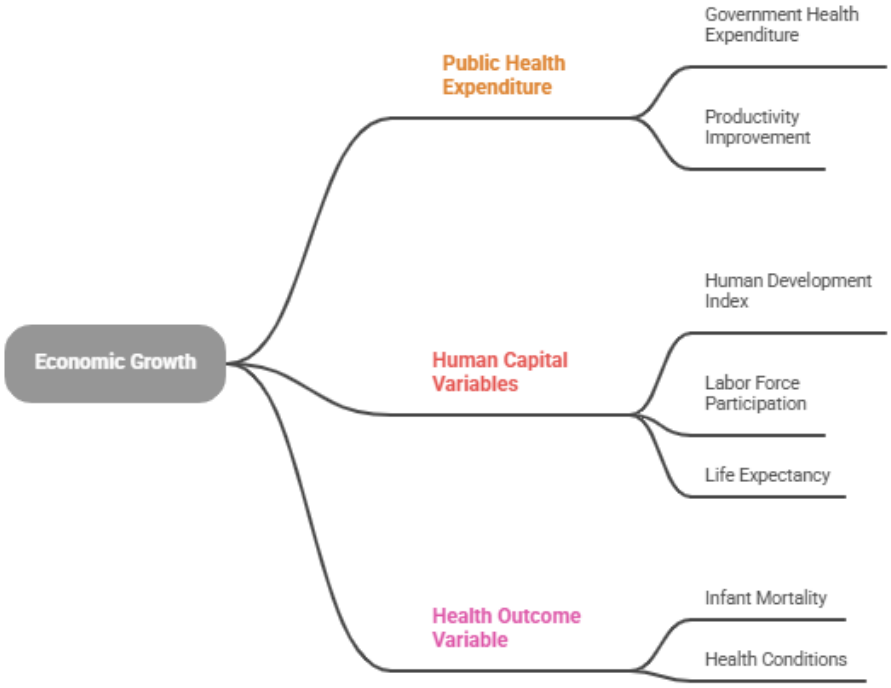

Figure 2: Conceptual Framework

The conceptual model is presented in Figure 2 which illustrates the direction of flow on public health expenditure and how it affects economic growth through enhance human capital and health outcomes. An expansion in government investment on health contributes to improved access (quality) of health care, productivity and human development captured through indices such as HDI, labor force participation and life expectancy. Lower rates of infant mortality, in turn, suggest better population health and more effective health systems. Together, these channels enhance labor productivity and the accumulation of human capital that serves as engine for lasting economic growth. And effective investment in public health is an essential part of supporting long-run economic growth.

According to this analytical model, the dependent of the dependent variable exerting influence over economic growth is represented by GDP per capita. The independent variables are public health spending, human development index (HDI), labor force participation, life expectancy and infant mortality. Following theoretical and empirical literature, all explanatory variables are predicted to have statistical significant effects on economic growth. Therefore, the functional form of the predictive model is given as:

$$GDP_{it} = \beta_0 + \beta_1 PHE_{it} + \beta_2 HDI_{it} + \beta_3 LF_{it} + \beta_4 LE_{it} + \beta_5 IM_{it} + \varepsilon_{it} \quad \text{Eq(1)}$$

Where:

GDP_{it} = GDP Per Capita (proxy for economic growth)
PHE_{it} = Public Health Expenditure
HDI_{it} = Human Development Index
LF_{it} = Labor Force
LE_{it} = Life Expectancy
IM_{it} = Infant Mortality
ε_{it} = Random error term

The model is calculated to evaluate how differences in public health expenditure impact economic growth across countries and over time. A variation in public health expenditure (PHE_{it}) is predictable to produce a comparative change in GDP per capita as

characterized by the coefficient β_1, which detentions the border line effect of health investment on economic performance. The above model employs an Ordinary Least Squares (OLS) regression framework to estimation the linear relationship between the dependent and independent variables. The main objective is to study the impact of public health expenditure (PHE) on economic growth (GDP per capita), while guiding for other explanatory variables, with the Human Development Index (HDI), labor force participation, life expectancy, and infant mortality. This method aligns with well-known econometric works highlighting the significance of health-related asset in fostering sustainable economic development (Baltagi, & Moscone, 2010; Mathews, & Hu, 2007; Wasim, et, al., 2023).

Panel Unit Root Testing

Before performing the panel Cointegration analysis, we need to check for stationarity in variables to prevent the possibility of spurious regression. As Canning and Pedroni (2008) point out, panel data sets with relatively long time dimensions can be considered to possess a time-series dimension and it is therefore necessary to test for the presence of unit roots. Most of macroeconomic variables are non-stationary in nature and not controlling for them would result in erroneous statistical interpretations (Maddala & Wu, 1999; Levin, et, al., 2002; Pesaran, 2007).

This study uses panel unit root tests to check the order of integration of the variables. Precisely, the Levin–Lin–Chu (LLC) and Im–Pesaran–Shin (IPS) panel unit root tests are used. The LLC test assumes that there exists a common unit root process across cross-sections, but individual fixed effects and serial correlation are allowed. However, as noted Choi, (2001) the LLC test may have little power when applied to small samples. In order to control for this issue, we also used the IPS test to allow for heterogeneities in the autoregressive coefficients across cross-section and presents superior performance in small sample panels.

The general specification of the panel unit root test is given as:

$$\Delta x_{it} = a_i + \beta_i x_{i,t-1} + \sum_{j=1}^{pi} \beta_{ij} \Delta x_{i,t-j} + \mu_{it} \quad \text{Eq (2)}$$

where i means the cross-sectional units (countries), t denotes the time period, x_{it} is the variable under concern, p_i is the optimal lag length, and μ_{it} is the error term.

On behalf of equally LLC and IPS tests, the null hypothesis (H_0) take up the existence of a unit root (i.e., the series is non-stationary), although the alternate hypothesis (H_1) indicates stationarity. In the LLC framework, the alternate hypothesis accepts a common autoregressive parameter (β<0), while the IPS test lets for heterogeneous autoregressive coefficients through panel units.

The study draws on the augmented Dickey–Fuller (ADF) context, which estimations the stationarity of variables by means of first differences, lagged level terms, and optional trend mechanisms. The ADF requirement can be stated as:

$$\Delta X_t = \alpha\, \beta X_{t-1} + \sum_{1=1}^{m} \gamma_i\, \Delta X_{t-1} + \varepsilon_t \quad \text{Eq (3)}$$

wherever Δ means the first-difference operative, m is the optimal lag length, and ε_t is a white-noise error term.

If the null of unit root is rejected, it indicates that series was stationary. On the other hand, rejecting the null hypothesis implies non-stationarity. The evidence of the panel unit root tests informs our choice of econometric method and whether to perform a panel Cointegration analysis.

Panel Cointegration Tests

Once the stationarity of variables is determined, we can then investigate whether there's a long-run equilibrium relationship between them. The Panel Cointegration tests are applied to test the exist of a stable long-run relation among dependent variable and its determinants despite having short run fluctuations. Cointegration describes that deviations from long-run equilibrium are short lived and an adjustment process exists to bring the system back into balance.

Since all the variables in this study are I(1) Cointegration panel testing is used. The analysis is based on Pedron's (1999, 2004) panel Cointegration tests which permit heterogeneity in both the intercepts and slope coefficients across cross-section units. These tests allow for both within- and between-dimension panel statistics, thus ensuring powerful evidence of Cointegration in heterogeneous panels.

Using panel Cointegration techniques, the study captures short-run dynamics as well as long run relationships between public health expenditure, indicators of human capital and economic growth. This is also very much in line with the prior evidence from empirical literature which highlights the significance of differentiating between short- and long-term effects while examining health–growth nexus (Akram, et, al., 2008).

Cointegration Theory

Toward officially clarify the Cointegration framework, reflect a vector autoregressive (VAR) model of direction p:

$$Y_t = A_1\, Y_{t-1} + A_2\, Y_{t-2} \ldots + A_P\, Y_{t-\mathrm{P}} + BX_t + \varepsilon_t \quad \text{Eq (4)}$$

wherever Y_t is a k-dimensional vector of non-stationary I(1) variables, X_t is a vector of deterministic variables, and ε_t is a vector of white-noise disturbances.

This VAR illustration can be reparametrized into a Vector Error Correction Model (VECM) as follows:

$$\Delta \mathrm{Y_t} = \Pi \mathrm{Y_{t-1}} + \sum_{\mathrm{n=1}}^{\mathrm{P-1}} \Gamma_{\mathrm{i}}\, \Delta \mathrm{Y_{t-i}} + \mathrm{BX_t} + \varepsilon_{\mathrm{t}} \quad \text{Eq (5)}$$

Where.

$$\Pi = \sum_{\mathrm{i=1}}^{\mathrm{P}} \mathrm{A_i} - \mathrm{I}, \Gamma_{\mathrm{i}} = -\sum_{\mathrm{j=i+1}}^{\mathrm{P}} \mathrm{A_j} \quad \text{Eq (6)}$$

Allowing to the Granger Illustration Theorem, if the matrix Π has concentrated rank (r<kr), it can be disintegrated into two matrices α and β, such that Π = αβ′. The matrix β contains the Cointegration vectors that signify long-run equilibrium relations among the variables, although α detentions the rapidity of change limits that designate how fast deviations from equilibrium are modified (Granger, 1988).

The rank r denotes the quantity of Cointegration relationships in the method. The Johansen Cointegration procedure is used to estimation these relations by testing the rank of the Π matrix within an unrestricted VAR framework (Dejemeppe, 2005). The existence of Cointegration validates the estimate of long-run coefficients by means of methods such as Fully Modified Ordinary Least Squares (FMOLS) and Dynamic Ordinary Least Squares (DOLS).

Results and Discussion

In this section the empirical findings of the panel data (Bangladesh, Bhutan, India, Maldives, Nepal Pakistan and Sri Lanka) are presented and discussed. The analysis process starts with the calculation of descriptive statistics to present a summary table describing the main features of data and correlation indicator to evaluate both strength and direction between variables. Granger causality tests are then performed to investigate the predictive direction of the relationships. Pre-estimation, panel unit root tests are used to ascertain the order of integration of variables and to confirm that the econometric techniques we use are appropriate. At 5 percent level of significance, we find that all the variables are non-stationary at levels but stationary after first difference i.e. they become I(1). With this order of integration, Panel Cointegration methods are considered appropriate when exploring long- run relationships. Thus, the study uses a complete set of panel Cointegration approaches which include Pedroni panel Cointegration tests as well as long-run estimators such as Fully Modified Ordinary Least Squares (FMOLS), Panel Ordinary Least Squares (OLS) and Dynamic Ordinary Least Square (DOLS). Estimation procedure The above techniques provide a robust semiparametric estimate of the long-run coefficients, controlling for heterogeneity and potential endogeneity across countries.

Descriptive Statistics

Summary statistics for all empirical variables are displayed in Table 2, which contains the mean, median, maximum, minimum and standard deviation of each variable. The panel is annual and includes seven South Asian countries (Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka) over the period 1995–2024 which produces a balanced panel of 210 observations for each variable

Table 2
Descriptive Statistics

Variables	Mean	Median	Maximum	Minimum	Std. Dev	Obs
GDP Per Capita	1746.56	982.02	102240	203.98	2021.30	210
PHE	2.39585	1.5677	10.800	0.2657	2.1361	210
HDI	0.56573	0.5570	0.7800	0.3963	0.0974	210
Labor Force	61.6939	57.625	86.265	49.220	10.863	210
Life Expectancy	67.9768	67.628	78.627	56.636	5.0215	210
Infant Mortality	43.0738	40.950	97.400	6.4000	24.025	210

The descriptive statistics reveal huge country and time differences. The dependent variable, GDP per capita (current US dollar) has mean level of 1746.56 and high level of standard deviation (2021.30), indicating substantial disparity in income levels across South Asian economies during study period. Public health expenditure (PHE) as a percentage of GDP, on average is 2.40 percent implying that the public spending on health in the region is low with huge cross-country disparities. The average HDI value of 0.566 reflects moderate levels of human development in the sampled countries. Labor force participation rates average 61.69%, and life expectancy averages 67.98 years, which present that the population health has achieved a certain improvement over time. On the other hand, infant mortality is characterized by a thick tail with larger dispersion; it also has a higher mean value of 43.07 per thousand live births which shows that disparities and health problems are still afflictive among countries in the region. The descriptive statistics suggest that there exists considerable heterogeneity in levels of economic activity, health expenditure and human capital indicators across the South Asian countries, thus providing a rationale for applying panel econometric procedures on the data.

Granger causality test

The direction of causality between public health expenditure, the human capital indicators and economic growth is tested using the Granger causality test in South Asian countries. The test determines if previous values of a variable are useful in predicting another. So, the null hypothesis is no Granger-causality between series and an alternative hypothesis of a one- (or two) sided causality. The pairwise Granger causality tests use two

lags and are estimated with the annual panel data of seven South Asian countries over 1995–2024, resulting in a balanced panel of 7 × 30 = 210 observations. The main results are summarized in Table 3.

Table 3
Granger Causality Tests
(Sample period: 1995–2024; Number of observations: 210; Lag length: 2)

Null Hypothesis	F-Statistic	Prob.	Type of Causality	Decision
Public health expenditure does not Granger-cause GDP per capita	1.81738	0.14680	No causality	Accept
GDP per capita does not Granger-cause public health expenditure	2.72211	0.04670	Unidirectional	Reject
HDI does not Granger-cause GDP per capita	0.94477	0.42090	No causality	Accept
GDP per capita does not Granger-cause HDI	2.90345	0.03710	Unidirectional	Reject
Life expectancy does not Granger-cause GDP per capita	2.69337	0.04850	Unidirectional	Reject
GDP per capita does not Granger-cause life expectancy	3.48826	0.01750	Unidirectional	Reject
Labor force does not Granger-cause life expectancy	4.82969	0.00310	Unidirectional	Reject
Remaining null hypotheses	—	>0.05	No causality	Accept

Note: Significance is evaluated at the 5 percent level. Decision rule: Reject H_0 if $p\text{-}value < 0.05$.

The findings imply a one-way causal linkage of GDP per capita to public health spending, and that economic growth stimulates larger public outlays on health. But per capita public health spending does not Granger-cause GDP per capita in the short run. All these indicate the fact that better economic performance paves way for gains in public health investment. Initially, it's income-pushed characteristic of South Asian health spending. As for the human capital variables, the empirical results indicate that there is a one-way causality running from per capita GDP to Human Development Index (HDI) suggesting that economic development influence on level of overall human development. By contrast HDI does not Granger-cause GDP per capita, indicating that the effects of growth in human development are long-term rather than short-run dynamics. The Granger causality further confirms one-way causation from life expectancy to GDP per capita and vice versa, suggesting that there exists a mutually reinforcing relationship between economic growth and population health. This observation is consistent with the argument that healthier population promotes economic growth, just as higher income leads to improvements in health. For the labor force, demand from Granger causes life expectancy and not vice versa indicating that labor market is influencing-pull factor for health of population. Nevertheless, in the short run we find no causal relationship between labor force participation and GDP per capita. The Granger causality analysis shows that, in the short run, public health expenditure and human development are mainly driven by economic growth; by contrast, the impacts of health standard and human capital variables on economic growth are stronger via long-run channels from the results of panel Cointegration and FMOLS.

Panel Unit Root Test

Panel Unit Root Test Results Table 4 presents panel unit root test results. Unit root tests are performed before estimating the long-run relationships in order to check that variables are of different orders of integration, and to prevent the possibility of spurious regression. Stationarity is especially critical in panel data analysis, as non-stationary process can produce faulty and spurious inferences. Using the Levin–Lin–Chu (LLC) panel unit root test on annual panel data for seven South Asian countries during 1995 and 2024 we have a balanced sample of 210 observations. Tests are conducted in levels and first differences with both intercept alone and intercept and (in model.) linear time trends. The fact that the null hypothesis of a unit root cannot be rejected for GDP per capita and for all

explanatory variables implies that they are non-stationary at levels. But taking first differences, we reject the null hypothesis for all variables in standard significance levels as they become stationary. Generated by Getz (1999). This also provides evidence that all variables are of order one, I(1).

Table 4
Panel Unit Root Test Results (Levin–Lin–Chu)

Variable	Level Statistic	Prob.	1st Difference Statistic	Prob.	Decision
GDP Per Capita	6.8961	1.0000	-2.1896	0.0114	I(1)
PHE	1.1688	0.8788	-13.055	0.0000	I(1)
HDI	5.3584	1.0000	-2.4138	0.0079	I(1)
Labor Force	0.0228	0.5091	-4.8278	0.0000	I(1)
Life Expectancy	-1.2930	0.0980	-6.6184	0.0000	I(1)
Infant Mortality	-3.6031	0.1802	-7.1986	0.0000	I(1)

Note: Significance levels are 1%, 5%, and 10%.

To consider any potential cross-sectional dependence, we conduct additional and different Diagnostic tests following (Pesaran 2007). The findings suggest the existence of cross-sectional dependence at levels but not when first differenced. This can be taken as an evidence of robustness of the panel unit root results against cross-sectional dependence and justifying the later use of panel Cointegration methodology. The results reported show that all the variables are integrated of the same order, I(1). This common integration order provides significant motivation for having recourse to panel Cointegration analysis, which could be employed to test whether there is a long-run equilibrium relationship between public health expenditure, human capital indicators and economic growth in case of South Asia.

Panel Cointegration Test

The objective of the panel Cointegration test is to investigate whether there exists a stable long-run equilibrium relationship between public health expenditure, human capital proxies, and economic growth within South Asia. While they may dance around in the short-run, Cointegration suggests that they travel together over the span of time and should eventually return to their long-run mean. Since all the variables are found to be integrated of order one, I(1), in accord with the panel unit root tests it is suitable and crucial to conduct a panel Cointegration. This study employs the Pedroni (1999, 2004) residual-based panel Cointegration tests, which accounts for heterogeneity across cross-sectional units in terms of both intercepts and slope coefficients. These tests are particularly appropriate for panels of moderate size and yield more than one test statistics categorized into within-dimension (panel) and between-dimension (group) statistics. The within-dimension statistics aggregate information from across countries, while the between-dimension statistics permit country-by-country dynamics. In addition, the Pedroni Cointegration method acts as a support for adjusting long-run coefficients with Fully Modified Ordinary Least Squares (FMOLS) and Dynamic Ordinary Least Squares (DOLS) estimators (Pedroni, 2001,2001). These estimators adjust for endogeneity as well as serial correlation, and provide asymptotically unbiased and efficient long-run parameter estimates.

Table 5
Pedroni Panel Cointegration Test Results

Pedroni Residual Cointegration Test	Statistic	Prob.	Statistic	Prob.
Within-dimension (Panel Statistics)				
Panel v-Statistic	1.15365	0.87570	2.91141	0.99820
Panel rho-Statistic	1.45047	0.92650	1.70150	0.95560
Panel PP-Statistic	8.40233	0.00000	9.59364	0.00000
Panel ADF-Statistic	3.59048	0.00020	4.86020	0.00000
Between-dimension (Group Statistics)				

Group rho-Statistic	2.76702	0.99720	—	—
Group PP-Statistic	12.04920	0.00000	—	—
Group ADF-Statistic	3.58533	0.00020	—	—

Note: Significance levels are 1%, 5%, and 10%.

The findings reported in Table 5 give strong evidence of Cointegration between the variables. All T-statistics including the panel PP- statistic and panel ADF - statistic as well as Group PP-Statistic and group ADF - Statistic are significantly different from zero at the 1 level, which implies rejection of null hypothesis of no Cointegration. While certain statistics like the panel v-statistic and rho-statistics are not, Pedroni (2004) suggests that if most of the tests reject the null hypothesis then we can conclude existence of Cointegration. The results reveal the presence of long-run Cointegration relationship between public health spending, human capital statistics and economic growth in South Asia. This verifies that the variables are Cointegrated despite short-run deviations and justices our estimation of long-run parameter using panel FMOLS, panel OLS and DOLS estimates in the next section.

Panel Regression Results

The study utilizes three panel regression estimators namely the Fully Modified OLS (FMOLS), Panel OLS and Dynamic OLS to determine the long-run relationship between public health spending, human capital indicators and economic growth. They are suitable for the Cointegrated panel and have been employed in obtaining non-biased and efficient long-run parameter estimators. The FMOLS estimator (Phillips and Hansen 1990) is robust to both endogeneity and serial correlation in Cointegrated systems. Saikkonen (1991) and Stock and Watson (1993), DOLS estimator extended by adding the leads and lags of the differenced regressors). Panel OLS estimates are also presented for comparison. All estimations are done in Eviews, and we used the usual routine for Cointegrated panel regression analysis. The regression estimates are shown in Table 6. The predicted models have a very high level of explanatory power (the R-squared and adjusted R-squared are large) which indicates that much of the variability in GDP per capita can be attributed to public health expenditure and human capital variables.

Table 6
Panel Regression Results (FMOLS, Panel OLS, and DOLS)

Variables	FMOLS	Panel OLS	DOLS
	Coefficient (Prob)	Coefficient (Prob)	Coefficient (Prob)
Public Health Expenditure (PHE)	159.2327 (0.0000)	601.9155 (0.0000)	596.7034 (0.0008)
Human Development Index (HDI)	26098.33 (0.0000)	9476.988 (0.0001)	24656.96 (0.0098)
Labor Force	182.3442 (0.0000)	17.27122 (0.0527)	587.4536 (0.0003)
Life Expectancy	186.5659 (0.0000)	337.3815 (0.0000)	-127.0763 (0.5562)
Infant Mortality	89.22237 (0.0000)	70.23118 (0.0000)	78.18974 (0.0410)
R-squared	0.936733	0.86745	0.99986
Adjusted R-squared	0.931603	0.86251	0.99740
Long-run Variance	114346.4	—	212.572
Durbin–Watson Stat	—	2.25037	—

Note: Significance levels are 1%, 5%, and 10%.

The outcomes suggest that public health expenditure indeed has a positive and statistically significant impact on GDPPC under all three estimated approaches, further emphasizing the role of health investment in fostering long-run economic growth in South Asia. The HDI also has a significant and positive relationship with economic growth in all specifications, thus indicating the centrality of human capital to better macroeconomic performance. The labor force variable has a positive and significant effect on the GDP per capita in FMOLS and DOLS, this effect is only marginally significant in panel OLS. This

indicates that the involvement of the labor market has an impact on economic growth, especially when long-run dynamics and endogeneity are taken into account.

Life expectancy has a positive statistically significant association with GDP per capita in FMOLS and panel OLS estimations, while it is negative and insignificant in the DOLS estimation. This diversity across models might be generated by contrasts between the short-run adjustment dynamics captured by DOLS and is an indication that growth effects of health operate principally through long-run channels. The infant mortality coefficient is significant in all three models. Although the positive sign should be taken with a grain of salt, it probably captures the structurally and transitionally generated dynamics in South Asian economies, not direct causality. This finding emphasizes interpretation of health effects found on a particular health-related outcome sometime necessitating consideration of ceteris paribus assumptions that are more broadly demographic and development based. Of the three estimators, FMOLS offers the most trustworthy long-run estimates for Cointegrated panel data and it is therefore highlighted in our discussion of overall conclusions. The positive and statistically significant coefficients of these variables suggest existence of long-run positive relationships between the level of GDP per capita and public health expenditure, life expectancy and literacy rate in South Asian countries.

Discussion

The empirical evidence of the present study validates a long-run association among public health expenditure, human capital and economic growth in South Asian countries. The outcomes from the panel Cointegration and long-run regression methods validate that public health expenditure as well as major human capital indicators facilitate economic growth in the long-run span. These results are also very much in line with both theory and previous empirical evidence elsewhere in the health–growth literature. The favorable and statistically significant effect of investment in the public health sector on GDP per capita under each long-run estimator (FMOLS, Panel OLS and DOLS) gives additional weight to the notion that health spending promotes economic growth through rising labor productivity and quality of human capital. This result supports those of Baltagi and Moscone (2010) that indicate a robust long-run relationship between health expenditure and income in OECD countries, as well as Akram, et, al., (2008) who show that health gains have a positive impact on long-run economic growth in developing countries. Likewise, Wasim, et, al., (2023) explain that greater public health spending fosters economic growth by enhancing labor productivity and mitigating health-related losses of productivity.

The significant positive relationship between the Human Development Index (HDI) and economic growth noted in this study provides additional support for the human capital–induced growth hypothesis. As HDI is intended to be a proxy of human capital, it measures various aspects of development such as health, education and standard of living. The findings are consistent with previous studies such as Piabuo and Tieguhong (2017) and Mathew and Hu (2007) who claim that long term economic growth in developing countries is significantly influenced by human development investments. Given the importance of HDI in all estimates, the various approaches to estimation underscore the view that economic growth in South Asia is strongly associated with more general improvements in human welfare and not just with physical capital accumulation.

The results of the labor force variable point to its positive and significant role in promoting economic growth, especially with FMOLS and DOLS estimations. This finding accords with endogenous growth theory, which emphasizes the role of quality and quantity of labor as drivers of economic development. Canning and Pedroni (2008) provide similar evidence, the authors find that human capital stock and labor-related infrastructure matter for maintaining long-run growth. Indeed, the relatively stronger estimate of significance in Panel OLS highlights the need to adopt Cointegration based estimators which will control for endogeneity and long run dynamics.

The life expectancy-life expectancy elasticity is positive and statistically significant in the FMOLS as well as panel OLS estimates, which implies that better population health increases income in the long run. This result supports the health-led growth theory and confirms previous empirical evidence on the positive effect of health-status on productivity and economic growth. The small magnitude of the coefficient in the DOLS model, however, indicates that the income effects on life expectancy could work with a country-specific lagged pattern and is stronger for long-run relations than for short-run corrections. This finding is consistent with the perspective that improvements in health affect growth by cumulative as opposed to immediate changes in output.

The positive and significant value of infant mortality in all models should be taken with some caution. Although infant mortality is normally expected to have a negative relationship with economic growth, South Asia's positive sign in the current analysis may inadvertently capture some of the structural and transition features of South Asian economies including demographic transformations, poorly performing health systems, and disparities between countries. The findings are congruent with those from previous studies in the developing world and other research in terms of demographic variables representing an intermediate level, rather than a direct cause. This highlights the need for careful interpretation of health indicators in developing-country panels.

The Granger causality evidence further supports the long-run results by showing that in the short run economic growth Granger causes public health expenditure and not vice versa. This finding adheres to the income-driven health spending theory, on which it is argued that relatively higher incomes help the government invest more on health sectors. These results are in line with those of Baltaghi and Moscone (2010) and other studies that find evidence of bidirectional or growth-induced causality from income to health spending. Crucially, along with Cointegration linking variables together, it provides evidence that, health expenditure does not cause economic growth in short run (realized through the value of = 0.21) but also implied that it has a significant effect and very well determine long-run cause conjuncture or prompt to achieve sound and healthy economic fifteen years' period.

The empirical evidence of this study validates the existence of long-run virtuous cycle relationship between investment in public health, human capital accumulation and economic growth in South-Asia. Economic growth creates fiscal space and allows increased spending on health, at least in the short term, but consistent public investment in health and human development are necessary for long-term economic prosperity. These results support the idea that health spending may be interpreted as productive investment and not only a social expenditure, especially in developing areas with important human capital restrictions.

Conclusion

The long-run relationship between public health expenditure, human capital and economic growth in the South Asian countries was investigated in this study for the period: 1995–2014. The paper finds robust empirical evidence on the role of public health investment and human capital formation in driving economic performance in the region, using panel unit root tests, Pedroni panel Cointegration approaches and long run estimators including FMOLS, panel OLS and DOLS. The empirical results confirm the presence of a long-run stable equilibrium relationship between public health expenditure and economic growth. The findings suggest that public health spending significantly influences GDP per capita and the growth of spending on health contributes to economic growth by enhancing the quality and productivity of human capital. These results are in line with the general literature indicating health investment as a fundamental driver of human capital accumulation and long term development.

Moreover, the findings show that human capital proxied by the Human Development Index (HDI), labor force participation rate and life expectancy, has a long-run positive impact on economic growth. This supports the notion that gains in health and human development are essential in sustaining economic growth through increased labor productivity and lower health-related inefficiencies. Infant mortality is statistically significant, but its coefficient must be interpreted carefully as it likely addresses more general structural and demographic phenomena rather than a direct cause-effect. The Granger-causality test also concludes that public health expenditure increases (decreases) are triggered by economic growth in the short-run and non-causal relationship is found between both variables in long-run; it indicates that increasing levels of incomes allow the governments to direct more funds into the health sector. This result indicates the existence of a feedback effect between economic growth and health investment, rather than one-way causality, that is to say between on one hand the growth which in turn sustains expenditure in health context and one the other side change in health level will induce long run growth. These are in line with the theoretical understanding of beneficial reinforcing dynamics between income, health and productivity (Khan, et al., 2024.

Recommandations

From the policy point of view, these findings imply that public spending in health is more an investment than a consumption. Governments in South Asia should accord priority to enhanced and consistent public expenditure on health, particularly those interventions that build human capital like preventive care, maternal and child health services and investments in the country's health infrastructure. Greater access to high quality care can increase productivity at work and drive long-term growth. Yet, more spending alone might not be enough. (governance and efficient resource allocation) to their ability (effectiveness of public health expenditure, Khan, et al., 2022). Policymakers may want to concentrate on improving governance of the health sector, reducing inefficiencies and ensuring that public spending supports high-impact health interventions. Preventing regional health inequalities and minimizing dependence on out-of-pocket health expenditures are also important for equity and for optimizing the growth effects of investing in health. Second, policies that are coordinated and combine health, labor market, and human development measures will tend to have a higher pay-off. Investments in health could be supplemented with policies enhancing labor force participation, education and skill development that would strengthen the human capital channel of impact of spending on health on growth.

Although the study offers a broad long-term analysis for South Asia, one possible extension is by deconstructing public health expenditure into preventive and curative components, looking at country specific dynamics of public health expenditure or including measures of institutional quality and governance. Such extensions would lead to a better understanding of how investment in public health can be harnessed to pave the way for sustainable development in developed areas of the world.

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