The nexus between health status and health expenditure, energy consumption and environmental pollution: Empirical evidence from SAARC-BIMSTEC regions

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Abstract

Background: The COVID-19 pandemic has highlighted the need for the betterment of health status, while also considering health expenditure, energy, and environmental issues. This paper examines the nexus between health status and health expenditure (both public and private), energy consumption and environmental pollution in the SAARC-BIMSTEC region.

Methodology: We utilized the panel autoregressive distributed lag (ARDL) model, heterogeneous panel causality test, cross sectional dependence test, cointegration test and Pesaran cross sectional dependent (CADF) unit root test for obtaining estimated results from data over 16 years (2002-2017).

Results: Our results authorize the cointegration among the variables used, where energy consumption, public and private health expenditure and economic growth have positive and statistically significant effects and environmental pollution has both negative and significant effects on the health status of these regions in the long-term, but no panel wise significant impact is found in the short-term. Two-way causal relationships between health status and environmental pollution, public and private health expenditure, economic growth and sanitation facilities, and a one-way causality running from energy consumption to health status are presented.

Conclusions: The improved health status in the SAARC-BIMSTEC region needs to be protected by articulating the effective policies on both public and private health expenditures, environmental pollution, energy consumption, and economic growth. The attained results are theoretically and empirically consistent, and have important policy implications in the health sector.

Keywords: Health status; energy consumption; environmental pollution; health expenditure; panel ARDL.

JEL codes: I10, I15, I18, C23

1. Introduction

In 2015 the United Nations (UN) proposed Sustainable Development Goals (SDGs) to be achieved by 2030, citing good health and well-being as among its principal targets, incorporating affordable and clean energy, pure water and sanitation to improve the health of people, no matter where they live (Goal-3, 6 and 7, UN, 2015; WHO, 2018). Good health is a fundamental human right; however, recent and previous pandemics and epidemics have highlighted a need to re-think a number of health-related issues globally. The world is now experiencing a huge toll on health as well as a massive death toll due to ignorance and lack of proper consideration of various health related factors like energy, environment, public and private health expenditures, hygiene, and sanitation. In many areas, health facilities have been found to be wanting, exacerbating those health related issues. Therefore, ensuring better health facilities for all people in order to build a safer world has now become a prime policy goal across the globe. The challenges resulting from COVID-19 have made the implementation of these goals imperative.

In the SAARC-BIMSTEC region, health status, health expenditures, energy use, environment and economic growth are essential considerations that require prioritization. This region comprise of ten emerging countries[1] covering geographical areas of 5,935,573.999 square kilometres with a population is 1959.45 million, many of whom are living in poverty (average rate 20.54% approximately), where awareness of health issues is low and therefore requires serious attention (WDI, 2020). In 2017, the average life expectancy at birth in this region was 71.18 years, the highest belonging to Thailand (76.68 years) and the lowest belonging to Afghanistan (64.13 years) (WDI, 2020). The average public and private health expenditures in 2017 were 38.27% and 55.15% respectively, out of total current health expenditures (5.05% of GDP) in this region, which is an insignificant amount when placed into context (WDI, 2020). The average economic growth of this region in early 2017 was 5.63% which improved over the year. Increased industrialization and urbanization may have played a critical role in this improvement (WDI, 2020). In terms of energy utilization and carbon discharges in this region, the average per capita energy intake and CO_2 emissions in 2017 were 697.61 kg of oil equivalent and 1.36 metric tons (WDI, 2020; BP, 2019; Knoema, 2020).

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[1] The SAARC-BIMSTEC countries are Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, Sri Lanka, Myanmar and Thailand.

The key objectives of this study are:

i. To identify the impact of health expenditure (public and private), carbon emissions, energy consumption, sanitation facilities, and economic growth on health status in the SAARC-BIMSTEC region.
ii. To detect the long-term and short-term associations, causality and dynamics among health status, health expenditure (public and private), carbon emissions, energy consumption, sanitation facilities, and economic growth.

Previous studies have made an effort to assess and derive the most important factors relating to health and its nexus with the other elements that have been previously mentioned. Factors affecting health status are various. In this study, we will review the past literature in the context of our research objectives.

Various researchers (Deshpande et al. (2014), Jaba et al. (2014), Duba et al. (2018), Bousmah et al. (2016), Becchetti et al. (2017), among others) have noted the increased health expenditure that benefits health indicators like life expectancy, infant and child mortality rate, and crude death rate. Deshpande et al. (2014) pointed out the significant positive effect of health care expenditure on life expectancy in developed countries due to well-judged spending but the insignificant impact in developing countries because of lack of focus on quality rather than quantity of expenditure in 181 countries, taking data from 2011 (used closest statistic from 2008-2011, if 2011 data was unavailable). Similarly, Jaba et al. (2014) identified the positive impact of health expenditure on life expectancy in 175 countries from the data of 1995-2010 where panel data estimation technique was applied. They also obtained significant country effects and important differences among the countries. In the same way, Duba et al. (2018) ascertained the positive effect of health care expenditure on life expectancy at birth for both male and female, where the fixed effect model was used for 210 countries and regions over the period from 1995-2014.Bousmah et al. (2016) provided evidence that health expenditure positively affects health outcomes in the presence of high institutional quality in the context of 18 Middle Eastern and North African (MENA) countries for the period from 1995–2012, although they considered health expenditure to be a necessary but not sufficient requirement for better health status. Becchetti et al. (2017) also identified the significant influence of health expenditure on reducing chronic diseases, which results in lengthening life expectancy in the data of 13 countries with the instrumentation of parliament political composition.

In contrast, a number of researchers found unclear or insignificant relationships between health expenditure and health indicators (see Rahman et al. (2018), Jiang et al. (2018), and Tran et al. (2017), among others). In this context, Rahman et al. (2018) conducted a study on health care expenditure and health outcomes nexus in the SAARC-ASEAN regions for the data period of 1995-2014. They employed fixed effects, random effects and generalized method of moments (GMM) approaches, where they identified the positive impact of health expenditure on crude death rate and infant mortality rate but no significant impact on life expectancy at birth. Tran et al. (2017) found that health care expenditure did not improve health and advocated reallocating public health expenditure from medical expenditures to social programs in the USA to raise life expectancy and reduce death. Jiang et al. (2018) found a varying effect of health care spending on life expectancy due to the heterogeneity of social development across the 31 provinces of the China over the period 2000-2010 by employing geographically weighted regression analysis. Similarly, Hitiris and Posnett (1992), did not clearly observe any nexus between health expenditures and the length of life in case of the OECD from a sample of 560 pooled time-series and cross-section observations. Barlow and Vissandjee (1999) identified per capita health expenditure as a weak determinant whereas literacy, per capita income, and access to safe water supplies were identified as strong positive determinants on life expectancy from the multivariate cross-national analysis of 1990.

Ongoing debates show that there are conflicting opinions on whether emphasis should be on public or private health expenditure for ensuring better health facilities. In this context, Ray and Linden (2019) found a positive effect of public health expenditure but a negative effect of private health expenditure on the life expectancy at birth for 195 countries for the data period of 1995-2014 where they used generalized method of moments (GMM) estimation technique. Rezapour et al. (2019) also revealed that public health expenditure had a significant impact but private health expenditure had little or no significant impact on life expectancy in the context of three groups of selected middle or high income countries where the data of 2000-2015 are considered for using the panel regression model. Similarly, Aísa et al. (2014) found a higher impact of public health expenditure but a lower impact on life expectancy in the OECD countries over the period 1980-2000, while using cross-country fixed effects multiple regression analysis. Golinelli et al. (2017) revealed that higher public health expenditure lowered the mortality rate in Italy over the period 1999-2013; they applied a pooled cross-sectional time series study. On the other hand, employing ordinary least squares (OLS) regression, Nkemgha et al. (2020) identified the positive and statistically significant influence of private health expenditure but no significant impact of public health expenditure on life expectancy in Cameroon during 1980-2014; they also obtained the bidirectional and unidirectional causal links of private and public health expenditure, respectively. Similarly, while conducting a study in 31 European countries for the data period of 2014-2014, van den Heuvel and Olaroiu (2017) found that although public health expenditure is not a key determinant of life expectancy, but the social protection expenditures are important factors. A simple linear regression model was used for the study. Many other researchers pointed out the positive role of both public and private health care expenditures on health status. For example, Novignon et al. (2012) presented the strong positive link of both public and private health care expenditure with life expectancy, although public health spending had comparatively greater influence in case of 44 countries in sub-Saharan Africa using the panel data of 1995-2010 from the fixed and random effects panel regression models. Akinci et al. (2014) also found that both the public and private health expenditures reduced the maternal mortality rate, the under-five mortality rate, and the infant mortality rate in the MENA region because of effective government and private health spending on health care during 1990-2010. These findings were achieved with the aid of pooled ordinary least regression, random effects, and Hausman-Taylor instrumental variable models. Thus the inconclusive interconnection between health expenditure and health status demands further investigation.

Energy is the life blood of the modern world, ensuring better living for people by making technological amenities available, and providing sophisticated and improved medical facilities. Energy consumption is another important factor that warrents investigation. Recently, a number of researchers (Shobande, 2020; Hanif 2018; Youssef et al., 2016; Jorgenson et al., 2014; among others) have tried to ascertain the link between health status and energy consumption. Shobande (2020) discovered that energy consumption reduced and carbon emission increased child mortality in 23 African countries over the period 1999-2014.The findings were based on the baseline pooled OLS and system-generalized method of moments (GMM) estimators. Examining this concept in more detail, Hanif (2018) found that non-renewable energy consumption adversely affected life expectancy by raising the mortality rate, while renewable energy consumption reduced the mortality rate and extended life expectancy in 34 Sub-Saharan African countries where system- generalized method of moment (GMM) analysis was used over the period of 1995-2015. In the same way, using the bootstrap panel analysis of causality, Youssef et al. (2016) found a strong link between health and energy consumption in Africa, where in some African countries they found unilateral causality between energy use and life expectancy, and under-5 child mortality from the data of 1971-2010 . Furthermore, Jorgenson et al. (2014) employed longitudinal analysis techniques and found that declining energy intensity and increasing energy efficiency improved human well-being in the 12 Central and Eastern European (CEE) countries for the period of 1992-2010 . Thus, further investigation on the link between energy consumption and health status is required for correct policy initiatives.

The effect of environmental pollution on health is now becoming another key concern, and some research relates clearly to this vital issue (see Balan, 2016; Ali and Audi, 2016; Nathaniel and Khan, 2020; Duba et al., 2018; Amuka et al., 2018; Monsef and Mehrjardi, 2015; Mutizwa and Makochekanwa, 2015; and Sinha, 2014; among others). Applying panel least squares method, Balan (2016) found the negative impact of CO_2 emissions on life expectancy at birth in 25 EU countries covering the period 1995-2013. Similarly, Ali and Audi (2016) conducted a study on the effect of income inequality, globalization and environmental degradation proxied by CO_2 in Pakistan, covering the period 1980-2015. Using the auto regressive distributive lag (ARDL) model they ascertained the significantly negative impact of environmental degradation on life expectancy. Nathaniel and Khan (2020) investigated the link between health financing, CO_2 emissions and life expectancy in Nigeria. Applying Bayer and Hanck's cointegration test for the data period 1970-2014, they found cointegration among variables but identified an insignificant negative impact of CO_2 emissions on life expectancy at birth. Similarly, by applying fixed effects and random effects models, Duba et al. (2018) discovered an insignificant effect of CO_2 emissions on average life expectancy at birth in 210 countries and territories, . Mutizwa and Makochekanwa (2015) conducted a study on the impact of environmental factors on health status in 12 countries of Southern African Development Community (SADC) during the period 2000-2008, where they considered CO_2 emissions per capita, access to improved water source, and access to improved sanitary facilities to measure environmental quality, and annual infant mortality rate to measure health status. By employing fixed effects and random effects regression analysis they found that two environmentally related variables: access to water and sanitary facilities, had significant effects on reducing infant mortality whereas CO_2 emissions had an insignificant effect.

On the other hand, Matthew et al. (2020) obtained a significantly positive impact of CO_2 emissions on life expectancy in West Africa from the data period of 2000-2018 by applying two stages least squares econometric techniques. Monsef and Mehrjardi (2015) found an insignificant positive impact of CO_2 emissions on life expectancy in 136 countries covering the period 2002-2010. Similarly, Amuka et al. (2018) employed ordinary least square (OLS) techniques and also found an insignificant positive linkage between CO_2 emissions and life expectancy in Nigeria over the period of 1995-2013. In addition, Sinha (2014) found a bidirectional causal association between CO_2 emissions and infant mortality rate in India which validated the feedback causality. Therefore, the study relating to the interconnection between environment and health status is appealing and deserves more thorough investigation.

From the exploration of the above mentioned literature, it has been observed that the results are unconvincing and not encouraging to the expression of any appropriate policy initiatives towards ensuring better health status for the people. Moreover, the combined consideration of both public and private health expenditures, energy consumption and environmental pollution on health status is absent in most of the literature, especially in the SAARC-BIMSTEC region. Therefore, this study will fill the existing gaps and provide an expedient way of probing the impact of health expenditure, energy consumption and environmental pollution on health status and the articulation of proper policy implications.

2. Methods

2.1. Theoretical or empirical rationale for choosing the variables

The theoretical justification for this study may be linked with various well-known theories e.g. human capital theory suggested by Gary S. Becker (1964) (Shobande, 2020; Breton, 2014; Na, 2012); the health care model recommended by Grossman (Shobande, 2020; Novignon et al., 2012; Grossman, 1972); and the inclusion of human capital in the neoclassical endogenous growth model by Romer (1996) (Novignon et al., 2012; Romer, 1996).

The empirical rationale for selecting our variables is mainly on the basis of the data availability, and past and existing literature. We have accessed the data on the variable life expectancy at birth to determine health status following Lichtenberg (2014), Rahman et al. (2018), Ray and Linden (2019), Nkemgha et al. (2020), and others; public and private health expenditures are considered following Jaba et al. (2014), Duba et al. (2018), Rahman et al. (2018), and others; energy consumption in the line of Shobande (2020), Hanif (2018), Youssef et al. (2016), Jorgenson et al. (2014) among others; the carbon emissions to denote environmental pollution in the line of Nathaniel and Khan (2020), Duba et al. (2018), Amuka et al. (2018), Sinha (2014) among others; per capita GDP as a proxy of economic growth following Rahman et al. (2018), Shobande (2020), and others, and the sanitation facilities following Rahman et al. (2018) and Novignon et al. (2012) among others.

The rationale for selecting the variables is that: (i) a combination of public and private health expenditures ensure better health status; (ii) energy consumption creates enough facilities to obtain good health status; (iii) excessive carbon emissions are detrimental to better health outcomes; (iv) economic growth offers improved amenities for safeguarding health status; and (v) effective sanitation facilities contribute to improved health status.

The identification of our variable is as follows:

HS: Health status

PUH: Public health expenditure

PVH: Private health expenditure

ENC: Energy consumption

CO_2: Carbon emissions

PerGDP: Per capita gross domestic product

SAN: Sanitization facilities

2.2. Variables and data

To conduct our study we have utilized the health status as a dependent variable; as a proxy of this, variable life expectancy at birth is used. The independent variables are public and private health expenditures, carbon emissions, energy consumption, sanitation facilities, and economic growth. Both of the public and private health expenses are taken as a percentage of current health expenditures; energy consumption is considered to be a per capita oil equivalent, and the carbon emissions variable is taken as metric tons per capita. As the proxy variable for economic growth the per capita gross domestic product (GDP) is used, and the sanitation variable is considered as the usage of at least basic sanitation by the population (% of total population).

In this study, we used data provided by the World Development Indicator from the World Bank for the years 2002-2017. However, due to the lack of data of energy use in case of Afghanistan, Bhutan and the Maldives, we have taken figures from the data (2002-2017) of Knoema's (2020) data world atlas. For all other countries beyond WDI, carbon emission and energy consumption data for the period of 2015-2017 are collected from Knoema's (2020) data world atlas and BP (2019) statistical review. For our estimation, we have used two well-known statistical software packages, STATA-16 and E-views-10.

The model used for empirical estimation is depicted below:

HS = f (PUH, PVH, ENC, CO2, PerGDP, SAN) (1)

After converting all the variables of the equation (1) into natural logarithmic form, we will obtain the elasticity of every variable from the coefficient values. Therefore, the equation (1) can be depicted as:

$$\mathrm{LNHS_t} = \alpha + \beta_1\mathrm{LNPUH_t} + \beta_2\mathrm{LNPVH_t} + \beta_3\mathrm{LNENC_t} + \beta_4\mathrm{LNCO2_t} + \beta_5\mathrm{LNPerGDP_t} + \beta_6\mathrm{LNSAN_t} + +\mathcal{E}_t \quad (2)$$

Where, α is the intercept, and β_1, β_2, β_3, β_4, β_5, β_6 are coefficients and $\mathcal{E}_t$ is the error term.

2.3 Econometric approach

In this study we applied various econometric techniques for the purpose of estimation. We employed the following tests: a cross-sectional dependence test to observe the shock effect; Pesaran's (2007) CADF panel unit root test to confirm the stationarity of variables; the Pedroni (1999, 2004) and Kao (1999) cointegration tests to measure the equilibrium association; the panel pooled mean group (PMG) or panel ARDL method to estimate the long and short term equilibrium effects; and Dumitrescu and Hurlin's (2012) heterogeneous panel causality to discover the direction of causality.

2.3.1 Cross-sectional dependence

Cross-sectional dependence of the variables may appear due to the prevalence of analogous geographic, economic, historical, ethnic and political jolts; hence these jolts should be checked before the detection of the unit root. In this study we have utilized four renowned cross-sectional dependency tests: Breusch and Pagan (1980) BP LM, Pesaran (2004) scaled LM, Pesaran (2004) CD, and Baltagi et al. (2012) biased-corrected scaled LM.

To examine the cross-sectional dependence among the panel data the below model is suggested by Breusch and Pagan (1980):

$$CD_{BP} = \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \widehat{p_{ij}}^2$$

To overcome the limitations of the above, Pesaran (2004) develops the following LM statistics:

$$CD_{LM} = \sqrt{\frac{1}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} (\widehat{p_{ij}}^2 - 1)$$

Pesaran (2004) recommends that if the cross-sectional size is greater than the time dimension, the following test statistic can be used instead.

$$CD = \sqrt{\frac{2T}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \widehat{p_{ij}}^2$$

From the simple asymptotic bias correction, the scaled LM test as recommended by Baltagi et al. (2012) is:

$$CD_{BC} = \sqrt{\frac{1}{N(N-1)} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} (\widehat{p_{ij}}^2 - 1)} - \frac{N}{2(T-1)}$$

Where $\widehat{p_{ij}}$ specifies a correlation among the errors. In this test the null hypothesis is H_0: no cross-sectional dependence whreas the alternative hypothesis is H_1: cross-sectional dependence.

2.3.2 Panel unit root test

Detection of unit root in the series of variables is essential to estimate it in the PMG or panel ARDL model. In this regard we have used the cross-sectional augmented Dickey-Fuller (CADF) test because of the consideration of cross-sectional panel data following the methodology of Pesaran (2007) under the following equation:

$$\Delta x_{it} = \alpha_i + p_1 x_{it-1} + \delta_1 \bar{x}_{t-1} + \sum_{j=0}^{n} \eta_{ij} \Delta \bar{x}_{it-1} + \sum_{j=0}^{k} \Psi_{ij} \Delta x_{it-1} + \varepsilon_{it}$$

Where, $\bar{x}_{t-1}$ and $\Delta \bar{x}_{it-1}$ indicate the cross-sectional averages of lagged levels and first difference individual series respectively.

2.3.3 Co-integration test

For co-integration among the variables, a residual based cointegration test as advised by Pedroni (1999, 2004) has been employed on the basis of two varieties: panel test and group test. The panel test has four statistics under the within dimension: panel PP, panel rho, panel v and panel ADF, whereas the group test has three statistics under the between dimension: group PP, group rho and group ADF. It is considered that the mentioned statistics are standard, normally and asymptotically distributed residuals based on the following long-term model:

$$Y_{it} = a_i + \zeta_i + \sum_{j=1}^{m} \Psi_{ji} X_{jit} + \varepsilon_{it}$$

The construction of the appraised residuals is as under:

$$\varepsilon_{it} = p_i \varepsilon_{it-1} + u_{it}$$

The comparison is made based on the maximum likelihood panel cointegration statistics considering no co-integration among the variables as the null hypothesis. The cointegration system for panel data recommended by Pedroni (1999, 2004) is as follows:

$$Y_{it} = a_i + \Psi X_{it} + \varepsilon_{it}$$

We have also used another co-integration test to observe homogenous nexus as suggested by Kao (1999) under two types of test: the Dickey-Fuller and the Augmented Dicky Fuller, where no co-integration among the variables as the null hypothesis is assumed.

2.3.4 Pool mean group or panel ARDL estimation

To identify the dynamic nexus between health status and public and private health expenditures, carbon emissions, energy consumption, sanitation facilities, and economic growth, we have utilized the pool mean group (PMG) or panel autoregressive distributed lag (ARDL) method under the following equation:

$$\Delta(Y_{i)t} = \sum_{j=1}^{p-1} \eta_j^i \Delta(Y_{i)t-1} + \sum_{j=1}^{q-1} \rho_j^i \Delta(X_{i)t-1} + ₼^i[(Y_{i)t-1} - \{\Psi_0^i + \Psi_0^i (X_{i)t-1}\}] + \varepsilon_{i,t}$$

Where, Y is the health status. X is the set of explanatory variables comprising public and private health expenditures, energy use, CO_2 emissions, economic growth, and sanitation facilities. The short-term coefficients of dependent and independent variables are symbolized respectively by η and ρ, where the long-term coefficients are denoted by Ψ. The speed of adjustment towards long-term affiliation is denoted by ₼, and the time-varying error term by ε . We have used the subscript i to determine country and t for time. The long-term growth regressions are shown within the square brackets.

2.3.5 Heterogeneous panel causality test

To perceive the short-term bivariate causal association among the variables we have adopted the Dumitrescu and Hurlin (2012) heterogeneous panel causality test that considers the cross-sectional dissimilarities under the following model:

$$y_{it} = a_i + \sum_{j=1}^{J} \eta_i{}^{J}\, y_{i,t-J} + \sum_{j=1}^{J} \rho_{i\ i}^{J}\, x_{i,t-J} + \varepsilon_{i,t}$$

The $x_{i,t}$ and $y_{i,t}$ denote the observations of two stationary variables of individual i in period t, j exposes the lag length, $\eta_i{}^{(J)}$displays the autoregressive parameter, and $\rho_i^{(J)}$ designates the regression coefficient varying within the groups. The identical lag order J for all individuals is considered so that the panel may be balanced. It is a fixed coefficient, normally distributed and permits the case of heterogeneity.

This test assumes no causality as the null hypothesis and the existence of causality between variables as the alternative hypothesis, as under:

H_o : $K_i = 0$ Ч$_I$ =1, …*N*

H_1 : $K_i = 0$ Ч$_I$ =1, …,*N₁*

$K_i \pm 0$ Ч$_I$ =$N_1 + 1, N_1 + 2, \ldots, N$

Here, N_1 represents the unknown parameter that fulfils the condition $0 \leq N_1 /N < 1$. The ratio of N_1/N ought to be lower than 1, because $N_1 = 0$ indicates causality for all individuals in the panel, whereas, $N_i = N$ means no causality, so that we failed to reject the null hypothesis.

3. Results

3.1 Descriptive statistics

In Table-1, the results of the descriptive statistics of our considered variables are displayed in natural logarithmic form. We have found that the mean, median, maximum, minimum, and standard deviation values of the health status are 4.224, 4.218, 4.361, 4.039, and 0.076 respectively. The mean values of public health expenditure, private health expenditure, energy consumption, CO_2 emissions, per capita GDP, and sanitation facilities are, consecutively, 3.263, 3.966, 6.080, -0.398, 7.289, and 4.016, and their standard deviations are, consecutively, 0.827, 0.494, 1.032, 1.093, 0.893, and 0.431.

Table 1: Descriptive statistics

	LNHS	LNPUH	LNPVH	LNENC	LNCO2	LNPERGDP	LNSAN

Mean	4.224	3.263	3.966	6.080	-0.398	7.289	4.016
Median	4.218	3.231	4.221	6.120	-0.406	7.060	4.055
Maximum	4.361	4.336	4.455	7.700	1.530	8.963	4.599
Minimum	4.039	-0.115	2.661	2.979	-3.259	5.800	2.989
Std. Dev.	0.076	0.827	0.494	1.032	1.093	0.893	0.431
Observations	160	160	160	160	160	160	160

Note: All the variables are converted into the natural logarithm form.

3.2 Cross-sectional dependence test results

We have reported the values of four types of cross-sectional dependence tests and their probabilities in Table 2. All the variables except public health expenditure have confirmed the significance in all four tests, which has assured three tests. From the Table-2 we can observe that the probability values of our studied variables are at different levels and can therefore reject the null hypothesis of cross-sectional independence.

Table 2: Cross-sectional dependence test results

Variables	Breusch-Pagan LM	Pesaran scaled LM	Bias-corrected scaled LM	Pesaran CD
LNHS	705.850*** (0.000)	69.600*** (0.000)	69.326*** (0.000)	26.566*** (0.000)
LNPUH	171.068*** (0.000)	13.289*** (0.000)	12.955*** (0.000)	-0.888 (0.374)
LNPVH	213.210*** (0.000)	17.731*** (0.000)	17.798*** (0.000)	-1.942* (0.052)
LNENC	261.927*** (0.000)	22.866*** (0.000)	22.533*** (0.000)	9.781*** (0.000)
LNCO2	337.622*** (0.000)	30.845*** (0.000)	30.512*** (0.000)	16.745*** (0.000)
LNPERGDP	640.482*** (0.000)	62.769*** (0.000)	62.436*** (0.000)	25.257*** (0.000)
LNSAN	714.776*** (0.000)	70.601*** (0.000)	70.267*** (0.000)	16.056*** (0.000)

Note: ***, **, and * denote significance level at 1%, 5% and 10%, respectively. Figures in the parentheses are probabilities

3.3 Unit root test results

To detect the presence of the unit root we have employed the cross-sectional ADF unit root test (CADF) as per the methodology of Pesaran (2007), due to the contemplation of the cross-sectional dependence issue. By applying the constant only we have found that the LNHS, LNPUH, and LNSAN have no unit root at level, where the LNENC, $LNCO_2$, LNPVH, LNPERGDP have unit root at level but no unit root at their first difference (Table-3). As per the methodology of Pesaran et al. (2001), we may utilize the ARDL model in case the series has no unit root or stationary at level I(0), at first difference I(1) or both, but none may be stationary at secondary difference I(2).

Table 3: Unit root test results

Variables	Constant				Order of Integration
	Level	p-value	1st difference	p-value	
LNHS	-5.248***	0.000	-2.229*	0.066	I(0)
LNENC	-1.840	0.368	-3.272***	0.000	I(1)
$LNCO_2$	-1.578	0.680	-3.381***	0.000	I(1)
LNPUH	-2.399**	0.020	-3.772***	0.000	I(0)
LNPVH	-2.047	0.165	-3.313***	0.000	I(1)
LNPERGDP	-1.374	0.863	-2.955***	0.000	I(1)
LNSAN	-3.189***	0.000	-2.335**	0.035	I(0)

Note: ***, **, and * denote significance level at 1%, 5% and 10%, respectively.

3.4 Cointegration test results

To investigate the prevalence of the long-term nexus between health status and health expenditure (both public and private), energy consumption, environmental pollution, economic growth, and sanitation we have taken the assistance of two kinds of panel cointegration tests as proposed by Pedroni (1999, 2004) and Kao (1999). Both tests have assured the existence of long-term cointegration among our studied variables, and are therefore suitable to evaluate the parameters of the dynamic error correction model by applying the panel ARDL model or the PMG method (Table-4).

Table 4: Pedroni and Kao panel cointegration test results

Pedroni cointegration test				
Estimates	Statistic	Prob.	Weighted Statistics	Prob.
Alternative hypothesis: common AR coefficients (within-dimension)				
Panel v-Statistic	-0.837	0.799	0.347	0.3642

Panel rho-Statistic	3.456	0.999	2.644	0.996
Panel PP-Statistic	0.522	0.699	-1.614*	0.053
Panel ADF-Statistic	-1.821**	0.034	-2.554***	0.005
Alternative hypothesis: individual AR coefficients (between-dimension)				
Group rho-Statistic	3.843		0.999	
Group PP-Statistic	-3.082***		0.001	
Group ADF-Statistic	-2.995***		0.001	
Kao cointegration test				
Statistic	t-statistic		Prob.	
ADF	-3.593***		0.000	

Note: ***, ** and * denote significance level at 1%, 5% and 10%, respectively.

3.5 The results of Panel ARDL estimation

From the model of PMG or panel ARDL(1,1,1,1,1,1,1) and applying Akaike information criterion in the case of constant (level) case-II we found the long-term and short-term association among our studied variables (Table-5). We observed that the coefficients of the public and private health expenditures and energy consumption are, respectively, 0.014, 0.030, and 0.027, which are positive and statistically significant at 1% level. The coefficient of environmental pollution proxied by CO2 is -0.085 which is negative and statistically significant at 1% level. The coefficients of economic growth and sanitation facilities are 0.029 and 0.018, where the former is statistically significant at 5% level but the latter is insignificant. The coefficient of error correction term (COINTEQ01) is -0.034, which is negative and statistically significant even at 1% level assuring long-term cointegration among the considered variables. However, in the short-term we found that neither variable is statistically significant, which denotes that the fruit of the above variables on health status cannot be found instantaneously and will have to wait for the long term

Table 5: PMG or panel ARDL results

Variable	Coefficient	Std. Error	T-Statistic	Prob.
Long Term				
LNPUH	0.014***	0.005	2.691	0.009
LNPVH	0.030***	0.011	2.821	0.006
LNENC	0.027***	0.009	3.095	0.003

LNCO2	-0.085***	0.024	-3.568	0.001
LNPERGDP	0.029**	0.012	2.368	0.021
LNSAN	0.018	0.069	0.261	0.795
Short Term				
COINTEQ01	-0.034***	0.012	-2.848	0.0057
D(LNPUH)	-0.001	0.001	-0.702	0.485
D(LNPVH)	-0.005	0.004	-1.240	0.219
D(LNENC)	0.0004	0.0004	1.021	0.311
D(LNCO2)	0.003	0.002	1.616	0.110
D(LNPERGDP	-0.007	0.004	-1.604	0.113
D(LNSAN)	-1.122	1.019	-1.101	0.274
Constant	0.124**	0.048	2.587	0.0117

Note: ***, **, and * denote significance level at 1%, 5% and 10%, respectively.

3.6 Country specific short-term test results

The outcomes of the country specific tests in the short-term are displayed in Table-6. The findings are mixed which are analysed in the discussion section.

Table 6: Short-term country specific results of all sample countries

Country	COINTEQ01	LNPUH	LNPVH	LNENC	LNCO2	LNPERGDP	LNSAN	Constant
Afghanistan	0.012***	-0.001***	0.001***	0.00***	0.001***	0.001***	0.523***	-0.055***
Bangladesh	-0.03***	-0.003***	-0.016***	0.001***	0.006***	0.018***	0.035**	0.098***
Bhutan	0.0121***	0.005***	-0.0002***	0.003***	-0.0001***	-0.002***	0.877***	-0.052***
India	-0.080***	0.003***	0.009***	-0.001***	0.002***	-0.010***	-0.089***	0.302***
Maldives	-0.058***	0.001***	-0.001***	-0.001***	0.002***	-0.001***	0.0217***	0.218***
Nepal	-0.006***	-0.0002***	-0.001***	-0.000***	0.0002***	-0.001***	0.057***	0.024***
Pakistan	-0.066***	0.000***	-0.002***	0.000***	-0.002***	-0.014***	-0.098***	0.241***
Sri Lanka	-0.090***	-0.004***	-0.032***	0.002***	0.017***	-0.036***	-6.245	0.378***
Myanmar	-0.020***	0.0003***	0.002***	-0.0004***	0.001***	-0.018***	-7.951*	0.032***
Thailand	-0.014***	-0.010***	-0.006***	-0.001***	0.002***	-0.008***	1.689**	0.051***

Note: ***, **, and * denote significance level at 1%, 5% and 10%, respectively.

3.7 Results of the panel causality test of Dumitrescu and Hurlin (2012)

In Table-7 the Dumitrescu and Hurlin (2012) panel causality outcomes are shown by w-statistic and corresponding probability. In this study, we have observed the bidirectional causality between health status, and health expenditures (both public and private), carbon emissions, economic growth, and sanitation facilities, but unidirectional causality emanating from the energy use to health status.

Table 7: Causality test results

Null Hypothesis:	W-Stat.	Prob.	Decision
LNPUH does not cause LNHS	3.495***	0.000	LNPUH ↔ LNHS (bidirectional causality)
LNHS does not cause LNPUH	2.783**	0.012	
LNPVH does not cause LNHS	3.786***	0.000	LNPVH ↔ LNHS (bidirectional causality
LNHS does not cause LNPVH	2.454**	0.046	
LNENC does not cause LNHS	5.315***	0.000	LNENC→ LNHS (unidirectional causality)
LNHS does not cause LNENC	1.623	0.501	
LNCO2 does not cause LNHS	9.660***	0.000	LNCO2↔ LNHS (bidirectional causality)
LNHS does not cause LNCO2	3.265***	0.000	
LNPERGDP does not cause LNHS	9.837***	0.000	LNPERGDP ↔LNHS (bidirectional causality)
LNHS does not cause LNPERGDP	3.094***	0.003	
LNSAN does not cause LNHS	19.951***	0.000	LNSAN ↔ LNHS (bidirectional causality)
LNHS does not cause LNSAN	37.283***	0.000	

Note: ***, **, and * denote significance level at 1%, 5% and 10%, respectively.

4. Discussion

Previous studies that considered health status were largely inconclusive and thus, were of no help in formulating cohesive policies in the health sector. The differences of opinion may be due to the variety of methodologies, regions, countries, variables, and data, which create an enigmatic nexus between related variables and health status, creating the opportunity for further investigations for formulating and executing proper policy strategies. In this regard our study is an effort to identify the decisive impact of health expenditure (both public and private), energy consumption and environmental pollution on health status by utilizing various voguish econometric tools in the case of the panel of SAARC-BIMSTEC countries.

Our main findings(see Table-5) portray that, the public and private health expenditures increase health status in the studied region due to the broader health care facilities in the long-term, whereas carbon emissions (CO_2) adversely affects human health by generating environmental pollution. On the other hand, balanced and sustained economic growth and environmentally friendly energy consumption increase the human life by providing the stimulus of utilizing modern medical technologies and facilities in this region. These findings are pragmatic and rational, and have notable empirical significance in the health sector.

Regarding the country-specific short term results in Table-6 (Section 3.6), the negative effect of health care expenditure in various countries may be due to the inefficiency of spending in the health sectors and rampant corruption in health financing. The positive consequence of CO_2 emissions on the health status of people in some countries may be due to the externality effect of economic development which may generate huge income at the cost of the environment and people may be able to afford better food and housing, but in the long-term they may affect people's health negatively. For some countries the negative coefficients of energy consumption, economic growth and sanitation facilities in the short-term may be due to the immediate adverse impact of these variables by creating pressure on the cost, environment and inefficient utilization of energy and sanitation.

The major contributions of this study are: (i) this is the first study in the literature, to the best of our understanding, that investigates the effects of public and private health expenditures, energy consumption, carbon emissions, economic growth, and sanitation facilities on health status in the context of SAARC-BIMSTEC regions; (ii) this work employs the latest available and inclusive data covering the period of 16 years (2002-2017); (iii) the results are attained by employing various erudite econometric tools e.g. cross-sectional dependence test, CADF panel unit root test, Pedroni and Kao test, Pool Mean Group (PMG) or panel autoregressive distributed lag (ARDL) method, Dumitrescu and Hurlin causality test; and (vi) the outcomes will provide guiding principles for policy makers to ensure improved health status by espousing massive health expenditures (public and private), lower carbon emissions and energy consumption, and effective economic growth policies.

5. Conclusion and policy implications

This paper explored the nexus between health status and health expenditures (both public and private), energy consumption and environmental pollution in the SAARC-BIMSTEC region. Using annual data from 2002-2017, we have utilized the panel autoregressive distributed lag (ARDL) model, heterogeneous panel causality test, cross sectional dependence test, cointegration test and Pesaran cross sectional dependent (CADF) unit root test to estimate the findings. The acquired results authorize the cointegration among the variables used: public and private health expenditure, energy consumption, and economic growth have positive and statistically significant influence, and environmental pollution has negative and significant effect on the health status of the region in the long-term, but no panel wise significant impact is revealed in the short-term. A two-way causal nexus between health status and environmental pollution, public and private health expenditure, economic growth and sanitation facilities, and a one-way causality running from energy use to health status have also been found. The attained results are theoretically and empirically consistent, and have significant policy implications in the health sector. The policy implication of the findings is: the better and improved health status required to be safeguarded by enunciating the effective policies on both public and private health expenditures, environmental pollution, energy consumption, and economic growth. In this context the following recommendations should be stressed:

i. *Public-private health expenditure policy mix:* In order to ensure better health care facilities, a flexible and affordable health expenditure policy combining public and private initiatives is needed. Establishing a large number of hospitals, supplying a good number of efficient doctors, nurses, and medical equipment and arranging modern health care facilities and better diagnosis instruments –all are essential to guarantee better health. All will be sustainable by the use of an adequate, corruption free and appropriate public-private health expenditure policy mix.

ii. *Efficient energy policy*: Energy provides the impetus of efficient economic growth which also affects the health status of the people through different channels. By improved living standards, supplying adequate electricity, facilitating manufacturing new drugs, delivering different health related facilities through different ways, energy plays a crucial role in the modern health sector. In this regard the negative externality of energy production is also a matter of concern because different diseases are spread through environmental pollution. Therefore, an efficient, affordable, reliable, modern energy policy is urgently required by emphasizing the use of clean and renewable energy in the region.

iii. *Reducing environmental pollution*: Environmental pollution affects human health adversely by generating different viruses and bacteria, which are responsible for various diseases like bronchitis, heart problems, lung problems, and flu related diseases like COVID-19 and many other potentially fatal conditions. In this regard a green environment ensuring by the reduction of CO_2 emissions should be encouraged. Proper policy regarding the clean energy, green development, and reforestation activities may curb environmental pollution and foster longevity.

iv. *Health friendly economic growth policy reforms*: Economic growth and development enables people to earn more and benefit from more modern health facilities; however, the negative external effect of growth activities (increased pollution) may be detrimental to public health. In this context, sustainable, and smart health friendly economic growth policy reforms will be helpful to increase people's life spans throughout the world, and more particularly in the countries that have been mentioned above.

Declarations:

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Availability of supporting data

Data used in this study are collected from the World Development Indicator (WDI, 2020) of the World Bank, Knoema's (2020) data world atlas, and BP (2019) statistical review.
The complete structured data set used for the study may be supplied by the corresponding author on reasonable request.

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Authors' contributions

MMR contributed in conceptual and methodological development, variable selection, result analysis, writing the abstract, polishing and editing, improving the quality of the manuscript, and overall careful supervision. KA wrote the study plan, literature review, data collection, main sections of the paper, econometric estimation, and data and result analysis, undertaking the responsibility of corresponding author of this paper.

Ethical Approval and Consent to participate

Not applicable.

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Competing interests

The authors declare that they have no competing interest.

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