



International Journal of Environment and Sustainable Development

ISSN online: 1478-7466 - ISSN print: 1474-6778

<https://www.inderscience.com/ijesd>

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DOI: [10.1504/IJESD.2022.10052100](https://doi.org/10.1504/IJESD.2022.10052100)

Article History:

Received:	10 May 2022
Accepted:	21 October 2022
Published online:	20 December 2023

Impact of environmental and economic determinants on life expectancy: a sustainable development exploration in Sino-Pak from 1965 to 2020

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Abstract: This study comparatively examines the impact of environmental, economic, and fiscal determinants on health well-being (life expectancy-LE) and social development in Sino-Pak. The present study uses LE at birth to proxy health well-being and the dependent variable. At the same time, carbon dioxide emissions (CO₂) and gross domestic product per capita (GDPpc) as independent variables from 1965-to-2020, and current health expenditures per capita (CHE) is moderator variable from 2000-to-2020. OLS Statistics and graphical demonstrations show that CO₂ emissions negatively affect the LE in Sino-Pak throughout the selected period while GDPpc has improved the LE in both countries. Adding a moderator role shows that CHE has played a promising role in China compared to Pakistan for life quality and Sustainable Development Goal 03. The study concludes that the Pakistan Government should adopt effective fiscal and administrative policies from China for better implementations and effective health well-being to achieve the SDG.

Keywords: carbon dioxide emissions; CO₂; current health expenditures per capita; CHE; gross development product per capita; GDPpc; sustainable development; life expectancy.

Reference to this paper should be made as follows: Abbas, H.S.M., Azhar, A. and Gul, A.A. (2024) 'Impact of environmental and economic determinants on life expectancy: a sustainable development exploration in Sino-Pak from 1965 to 2020', *Int. J. Environment and Sustainable Development*, Vol. 23, No. 1, pp.40–56.

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1 Introduction

Quality of Life is an integral part of human development. Health quality, ultimate educational attainment, and living conditions have been considered. Where developed states enjoy a quality of life with full swings, developing and under-developed countries struggle to achieve a standard of living (Tahir, 2020; UNDP, 2020). As mentioned earlier, health condition is an essential part of the quality of life; various factors affect health conditions, e.g., Administrative and health reforms, fiscal policies, environmental determinants, and economic conditions. Life expectancy (LE) at birth is a vital indicator of human development and hardcore debate globally, especially in low-middle income countries affected by various economic, environmental, and fiscal attributes, and can be mitigated through prudent policy measures.

Climate change and pollution are significant environmental determinants that impact health conditions and quality of life. High concentrations of carbon dioxide (CO₂) and Greenhouse gases (GHG) Emissions affect the life span by affecting the respiratory system and human skin. Amuka et al. (2018) examined that air pollution does not affect LE in developing countries. However, in a recent study by Abbas et al. (2021b), people exposed to air pollution are vulnerable to respiratory diseases (e.g., COVID-19), which affect their LE They further analysed that some other factors (economic and social) affect and promote LE and air pollution (Dixon, 2021).

Economic stability and development may accelerate LE and health conditions despite various health deterioration factors. Growth in people's income capacity helps them better cope with environmental and natural health calamities (Wang et al., 2020; Abbas et al., 2021a). The income per capita supports the people in approaching a better healthcare system, access to medicines, and hiring qualified health practitioners. Moreover, it also provides education, sanitation systems, and awareness for healthy living. It examined that a healthy and progressive economic system affects health conditions and well-being and vice versa. According to human development index (UNDP, 2020), most states with high income per capita have very high social development and health outcomes compared to developing and least developed countries. Abbas et al. (2020) stated that developed countries have high health fiscal policies that have improved their social and health conditions and do not compromise.

Fiscal policies and implementations promote social development and well-being (Meheus and McIntyre, 2017). However, developing countries have fragile policy-making and implementations, which make their social status fragile. Public health spending positively enhances health outcomes by accessing health practitioners' medicines, infrastructure, training, and expertise. Wang et al. (2020) and Shah et al. (2021) examined that public health spending helps improve health services and vice versa. Simultaneously, some institutional malpractices and decision-making hinder ineffective outcomes if health spending has not progressed. A better health spending system provides on-time health services, advanced treatment for communicable and non-communicable diseases within a state, and trained and professional healthcare staff services, affecting health outcomes and quality of life.

Considering the impact of environmental, economic, and fiscal determinants on the health condition of the public, this has been designed accordingly. It has been witnessed that developing countries are more prone to health and other social shortcomings than developed countries (Amuka et al., 2018). Following the Amuka et al. (2018) findings and research, this study applied the model to Asia's two strategic and economic partners (China and Pakistan). Ullah et al. (2021a) examined the comprehensive studies and state issues in Sino-Pak to help regional and sustainable development. Moreover, by the IMF (2020) economic progressive report, Sino-Pak economic development has mixed effects on the respective countries' social development. In social sciences, economic, fiscal, and environmental dynamics and policy outcomes have long-lasting impacts that need to be studied and analysed (Coglianese and Starobin, 2020).

Guo et al. (2021) analysed that environmental policies are critical issues for China that affect their economic and social well-being that need to be revised. Recent studies by Yang and Geng (2022), Shah et al. (2021), Ullah et al. (2021a, 2021b), Das and Das (2022), Sheraz et al. (2021), Zaman et al.(2021), and Alam et al. (2021) also discussed the global, regional, China, Pakistan, and India's perspective on social, economic, and environmental determinants on health quality which made this study more essential in

regional level respectively. Another recent survey by Telch and Appe (2022) explored the factors affecting human development in cross-section developing countries by considering environmental, economic, and policy attributes. However, fiscal determinants have not been discussed by them.

Based on the importance of the variables and state progression, this study has raised the following research questions to be examined in the result and analysis section of the paper. How does carbon dioxide affect health conditions (LE)? How does income influence health conditions (LE)? What is the role of fiscal policy (health expenditures) on health conditions (LE)? The rest of the paper structure is as follows: section two with a literature review; section three explains the data selection and appropriate methodology. Section 4 describes the findings and relevant discussion, while Section 5 concludes the paper with appropriate recommendations. Moreover, a few study limitations and future study directions are also discussed at the end of this paper.

2 Literature review

The quality of life and health well-being are the fundamental determinants of social development. Moreover, this social development can be accessed through various indicators, e.g., life longevity, education attainment, and a better standard of living. Various natural and human-made determinants affect LE. Barlow and Vissandjie (1999) analysed the determinants of LE in 1990 through various World Bank and United Nations sources that can impact life longevity, e.g., income per capita, sanitation system, climatic factors, and human activities. LE is one of the UNDP's top three human development parameters. It shows that LE is considered a vital indicator of the quality of life and health improvement factor that coincides with the SDGs.

Wang et al. (2014) examined the impact of air pollution on China's LE through geographical and stepwise regression analysis. They investigated that those areas with better air quality have a higher life longevity ratio than air quality deteriorated areas. A similar study in Oman by Ali and Ahmad (2014) stated that CO₂ emission had a mixed positive effect on LE in the long run while a significant adverse impact on LE in the short run. However, a panel study of 136 countries from 2002 to 2010 examined that CO₂ emission has not been a significant factor that adversely affects LE; instead, socio-economic variables influence LE (Monsef and Mehrjardi, 2015).

Ali and Audi (2016) examined the nexus of CO₂ emissions and life longevity in Pakistan from 1980 to 2015 through autoregressive distributed lag (ARDL) approach. They stated that along with income inequality, CO₂ emission negatively affects LE in Pakistan. Ahmad et al. (2018) conducted a parallel study in China from the 1960 to 2015 dataset through the ARDL approach. They endorsed the findings of earlier studies and found that in the long run, CO₂ emission negatively affects human health and life longevity, which can be tackled through effective climate and health policy reforms. Amuka et al. (2018) also investigated the impact of CO₂ emissions on Nigeria's LE from 1976 to 2013 through OLS-linear regression (OLS). However, their study stated that CO₂ emissions have not significantly affected life longevity in Nigeria. They further state that some socio-economic and fiscal measures significantly affect the health of environmental determinants.

In contrast, Amuka et al. (2018), Nkulu and Edeme (2019) examined the impact of CO₂ emission impact on the life span in Nigeria from 1960 to 2017 and found that CO₂

emission from solid fuel consumption negatively affects the health of the people and should be dealt with effectively by African Union policy reform. Wu et al. (2020) in China from 2013 to 2017, and Rjoub et al. (2021) recently tested the CO₂ emissions and LE nexus in Turkey from 1960 to 2018. They examined CO₂ emissions and called for serious policy reforms in Turkey and China to safeguard public health from environmental degradation. They further suggested that through effective policy-making government should protect climate change and public well-being for sustainable development and sustain the economic progression without disturbing the environment.

Besides the negative effect of CO₂ emission on LE, economic growth on income per capita substantially improved the LE ratio and reduced premature mortality. Sen (2011) compared income per capita on health outcomes between India and China. The study stated that gross domestic product (GDP) per capita helped china in reducing poverty and improved social development such as education, health, and standard of living, which is far more progressive than other regional developing countries. Hassan and Kalim (2012) in Pakistan examined the GDP per capita impact and stated that it improved the quality of life, which needs to be tackled carefully by the government. However, Ali and Ahmad (2014) on Pakistan and Wang et al. (2015) on China studied the impact of per capita income on life longevity. They found that per capita income has mixed results in the various regions of the states and not more evident results in other socio-economic determinants of quality of life.

Furthermore, Shahbaz et al. (2016) empirically tested that economic misery deteriorated the health outcomes in Pakistan from 1972 to 2012. Delavari et al. (2016) tested the GDP per capita impact on LE in Iran from 1985 to 2013 through OLS estimation. They found that GDP per capita substantially positively impacted LE in Iran, while environmental degradation has not been a significant health deterioration determinant in Iran. Another study in Turkey by Şentürk and Amjad (2021) examined the GDP per capita and economic development on LE with gender specification from 1971 to 2017 through ARDL. They stated that male LE is significantly improved through income per capita compared to females in Turkey. Luo and Xie (2020) showed their findings in China on economic growth and LE from 1968 to 2012. They argued that despite economic growth, china's health gain stagnation is due to income inequality in poor and wealthier regions. Equal income distribution can improve LE in poorer states and the state's national health. They further stated that effective government policies and service justice could positively affect health outcomes.

An effective government measures access through public spending and policy-making, improving a state's social development and service delivery. Siddiqui et al. (1995) examined the determinants of health services and found that Health expenditure is vital in improving health outcomes in Pakistan. Kim and Lane (2013) studied the effect of health expenditures on LE in 17 developed panel OECD countries from 1973 to 2000 through a mixed-effect model. They concluded that health expenditures have positively impacted LE at birth while negatively affecting infant mortality in developed states that need to be tackled through health reforms. Another panel study of 175 countries has conducted by Jaba et al. (2014) from 1995 to 2010 through a fixed-effect model. They examined the health expenditures (Input) and LE (Output) relation and found that health expenditures significantly impacted LE. However, its impact has mixed effects from region to region based on income category. A similar study was also conducted in European states by difference-in-difference (DID) and data envelopment analysis (DEA) from 1989 to 2012 (Jakovljevic et al. 2016).

A recent study in BRICS (Brazil, Russia, India, China, and South Africa) stated that emerging economies have a positive impact on health spending on health outcomes; however, its impact on others might be harmful and put pressure to forego the spending in those sectors (Jakovljevic et al., 2019) and can mitigate the negatively through mutual assistance among BRICS states. A policy perspective in Pakistan by Ahmad et al. (2019) argued that the government of Pakistan should focus on improving health spending on health infrastructure and facilities to improve LE. Ali et al. (2020) in Pakistan from 1982 to 2016 and Tahir (2020) in China from 1970 to 2015 examined the health spending impact on health outcomes through the ARDL approach. They discussed that sufficient health spending on healthcare facilities and infrastructure and the grooming of healthcare professionals substantially impacted health outcomes; however, adding other socio-economic and environmental determinants can affect spending on life longevity.

3 Methodology

Following the Amuka et al. (2018) outcome in Nigeria, this study tested the impact of CO₂ emission as an independent variable on LE in Sino-Pak in a comparative way. Moreover, this study employed the economic impact of better income conditions, GDP per capita (GDPpc), and a few other independent variables on LE. The present study used 1965–2020 to analyse and progress over five decades. Due to data limitations in health spending, a moderating role of current health expenditures (CHE) per capita has been taken from 2000 to 2020. All the variables have been extracted from the world development indicators (WDI) issued by the World Bank for data authenticity and reliability.

Furthermore, this study has applied the ordinary least square (OLS) regression test. For data robustness, Augmented Dickey-Fuller (ADF) tests for unit root, variance inflation factor (VIF) test for multicollinearity, and Breusch-Pagan/Cook-Weisberg test for heteroskedasticity has been applied (Delavari et al., 2016; Amuka et al., 2018; Nkulu and Edeme, 2019; Wu et al., 2020; Ali et al. 2020; Tahir, 2020). The present study examined the study directions in two phases for study innovation. Moreover, there is a rich literature on China and Pakistan individually regarding health conditions. However, a comparative analysis of Sino-Pak has not been conducted yet to the best of researchers’ knowledge, making this study novel and interesting. A descriptive and graphical investigation of Sino-Pak’s LE and independent and moderating variables has been conducted in the first phase. In the second phase, an econometric estimation is applied with the direct impact of independent variables on LE and moderating role of CHE on LE.; after that, a complete model examination is also conducted individually of Sino-Pak.

3.1 Econometric equation

$$LE = \int (CO_2, GDPpc, CHE)$$

- Direct model

$$LE = \beta_0 + \beta_1(CO_2)\mu, \tau + \beta_2(GDPpc)\mu, \tau$$

- Moderating model

$$LE = \beta_0 + \beta_1(CO_2)\mu, \tau + \beta_2(GDPpc)\mu, \tau + \beta_3(CHE)\mu, \tau$$

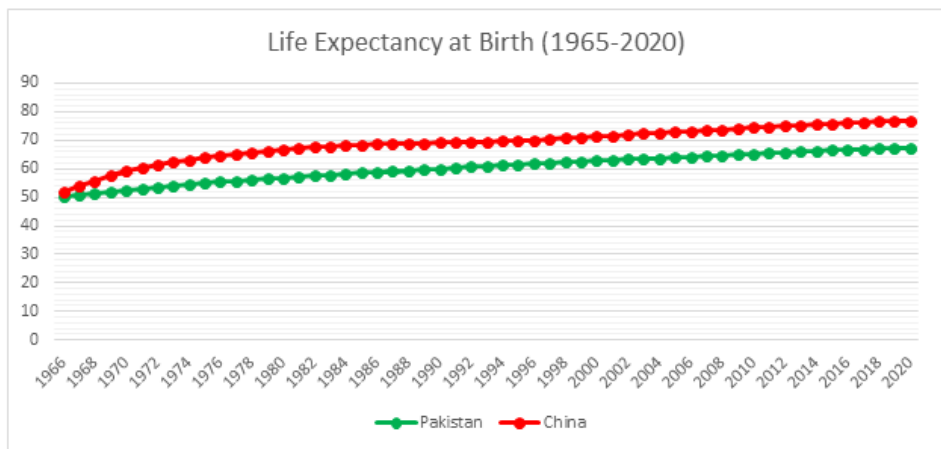
4 Results and analysis

4.1 Descriptive and graphical estimation

4.1.1 Life expectancy at birth (Years)

Figure 1 depicts the LE at Birth (a proxy of health conditions) in Sino-Pak for the last five decades (1965–2020). It shows that China's LE tends to be shown in better statistics than in Pakistan. However, Pakistan LE has shown a continuous upward trend in the last five decades, whereas Chinese LE showed a slight downward trend in the 90s. Nevertheless, as Figure 1 illustrates, since 2000, China's LE has shown an upward trend that shows better health conditions than its allied Pakistan. In the last 54 years, Pakistan has improved LE from 49 to 67 years, while China has enhanced from 49 to 76.

Figure 1 A comparison life expectancy trends in SINO-PAK (see online version for colours)



Note: In Y-Axis age and in X-axis years (time) displaced.

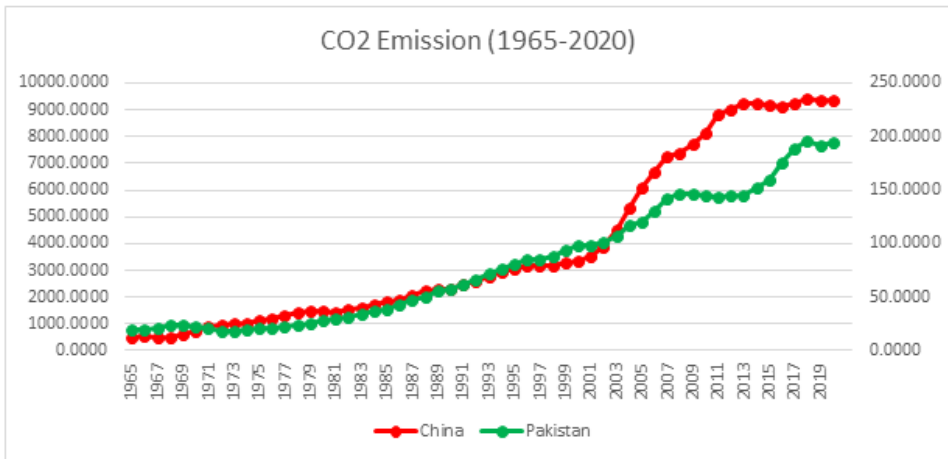
Source: world development indicator (WDI)

Source: world development indicator (WDI). in y-axis health expenditures per capita taken in USD and in X-axis years has taken

4.1.2 Carbon dioxide emissions

Figure 2 shows the environmental conditions of China and Pakistan from (1965 to 2020). From 1965 to 2000, China and Pakistan faced ecological deterioration. However, since 2001, a high upward trend of environmental deterioration has been observed in China due to increased industrial growth and global integration. On the other hand, despite various industrial development and effective policy-making, China's CO₂ emissions pollute the climate considering its size. Pakistan has also been polluting the environment, which needs an effective policy decision to implement and control climate change.

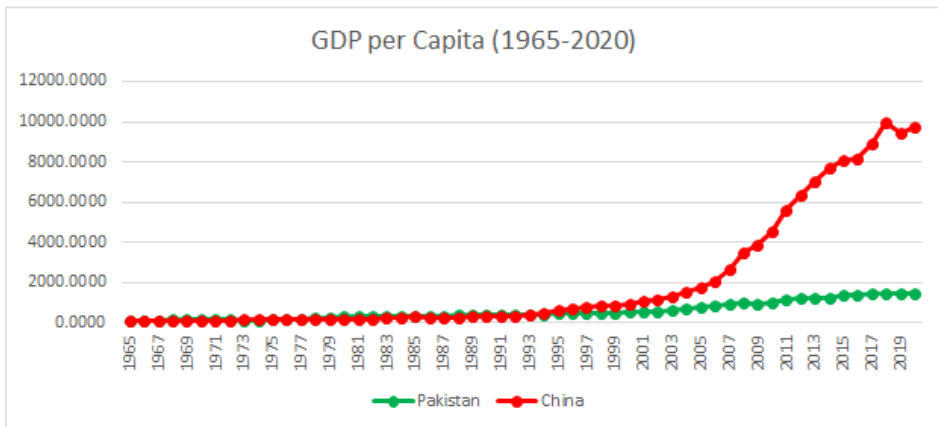
Figure 2 A comparison CO₂ emissions trends in Sino-Pak (see online version for colours)



Note: In primary Y-axis it shows CO₂ emissions in china and secondary Y-axis shows CO₂ emissions in Pakistan and both are in metric ton per capita, while X-axis shows the years (time).

Source: World energy statistics

Figure 3 A comparison GDP per capita in Sino-Pak (see online version for colours)



Source: World development indicator (WDI). in Y-axis GDP per capita taken in USD and in x-axis years has taken

4.1.3 GDP per capita

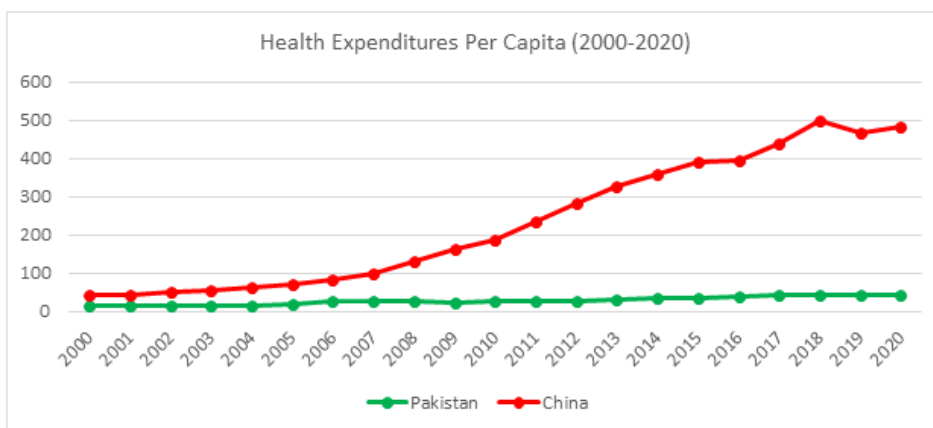
The income per capita is a vital instrument for quality of life. It helps improve education, health, and other ingredients of life quality. Figure 3 shows that increasing GDPpc has helped the quality of life in China and Pakistan. It depicted that per capita income had not significantly improved Sino-Pak. However, since 2001 a significant upward trend in per capita income has been shown in China, improving life quality. In contrast, Pakistan’s per capita income has been upward, but little progress. In the last 54 years, Pakistan has

improved its GDP per capita from \$89 to \$1,482, while China has enhanced it by \$98 to \$9,976.

4.1.4 CHE per capita

In contrast to Figures 2 and 3, CO₂ emissions and GDP per capita positively influenced China and Pakistan's life quality. Figure 4 shows the health expenditures' impact on LE from 2000 to 2020. Pakistan's fiscal measures have not shown much progress, which did not impact life quality. Despite the adverse effects of environmental deterioration, health expenditures per capita have not improved, so LE is not showing as much progress as it should be. In comparison, China has shown tremendous improvement with excellent policy decisions, which reflected its LE As per statistics, Pakistan has demonstrated CHE per capita \$15–\$42 in 19 years. On the other hand, China has improved by \$42–\$501 per capita.

Figure 4 A comparison of health expenditures per capita in Sino-Pak (see online version for colours)



4.2 Econometric estimation

4.2.1 Correlation matrix

Table 1 describes the correlation matrix of Sino-Pak comparatively. It shows that CO₂ emission positively correlated to LE with a 99% significant interval and high co-efficient value in Pakistan compared to China. At the same time, GDPpc also has a 99% confidence interval and high co-efficient value in Pakistan. However, CHE has a high co-efficient value in China compared to Pakistan. All values in Sino-Pak are positively correlated with LE with a 99% confidence interval.

4.2.2 VIF for multicollinearity test

A statistical estimation problem arises due to the high correlation value, which is likely to be a multicollinearity issue. However, a higher value is a sign of good correlation results, but to avoid multicollinearity, a statistically robust VIF test has been applied in Table 2. A threshold VIF value should be less than 10 to reject the multicollinearity in the data. Results show that despite having high correlation statistics, there is no multicollinearity issue in the data.

Table 1 Correlation matrix

<i>Variables</i>	<i>LE</i>	<i>CO₂</i>	<i>GDPpc</i>	<i>CHE</i>
<i>Sino</i>				
LE	1.0000			
CO ₂	0.8004***	1.0000		
GDPpc	0.8539***	0.9849***	1.0000	
CHE	0.9654***	0.8638***	0.9392***	1.0000
<i>Pak</i>				
LE	1.0000			
CO ₂	0.9293***	1.0000		
GDPpc	0.8790***	0.9649***	1.0000	
CHE	0.9504***	0.9675***	0.9643***	1.0000

Note: Standard errors in parentheses, *** p < 0.01, ** p < 0.05, * p < 0.1.

Source: Authors' estimation

Table 2 VIF test statistics

<i>Variables</i>	<i>VIF</i>		<i>1/VIF</i>	
	<i>Sino</i>	<i>Pak</i>	<i>Sino</i>	<i>Pak</i>
CO ₂	6.4700	9.8500	0.1546	0.1015
GDPpc	6.4700	9.4300	0.1546	0.1060
CHE	6.1200	9.1100	0.1634	0.1098
Mean VIF	6.3533	9.4633		

Note: A VIF's value above 10 shows the multicollinearity.

Source: Authors estimation

4.2.3 Augmented Dickey-Fuller test for unit roots

For checking the stationarity in the data, a critical pre-estimation test, the ADF test for unit root, has been applied in Table 3. Statistics show that LE and CO₂ are stationary at the level form in Sino-Pak while GDPpc is stationary at the first difference in Sino-Pak. However, CHE is stationary at the level form in Pakistan and stationery at the first difference in China.

Table 3 ADF tests statistics of unit root

Variables	Level		ADF		5% Critical value		Difference		P-value	
	Sino	Pak	Sino	Pak	Sino	Pak	Sino	Pak	Sino	Pak
LE	Level	Level	-13.820	-15.587	-2.928	-2.928	I(0)	I(0)	0.000	0.000
CO2	Level	Level	-3.543	-4.123	-3.500	-3.498	I(0)	I(0)	0.035	0.005
GDPpc	Level	Level	-5.417	-6.278	-2.928	-2.928	I(1)	I(1)	0.000	0.000
CHE	Level	Level	-3.348	-3.192	-3.000	-3.000	I(1)	I(0)	0.000	0.020

Source: Authors' estimation

4.2.4 Regression analysis for life expectancy at birth (LE)

After performing the pre-diagnostic tests of the data, Table 4 presents the baseline regression analysis of the study. The regression results show the direct impact of CO₂ and GDPpc from (1965 to 2020) on LE's direct influence. According to the statistics, CO₂ emission negatively impacted LE, with a 99% confidence interval in China. It further states that CO₂ emission has also affected the LE in Pakistan; however, its impact is not as significant as in China. It further noted that a high co-efficient value of constant shows that some other factors affect the LE in China, which reduces the overall impact of the model but still shows a significant value and supports the study objective. Overall, the direct effects of CO₂ emissions and GDPpc have a high R-square value in Pakistan, 0.931, higher than that of China, 0.784, which backed the study objective. The second section of regression estimation, a moderating variable of Current health expenditure per capita, has been introduced. Statistics show that CHE has positively impacted LE in Sino-Pak with a 99% confidence interval. However, CHE moved LE better in China with an R-square value of 0.932 than in Pakistan with 0.903.

Table 4 OLS regression statistics

<i>Variables</i>	<i>Direct impact</i>		<i>Moderating</i>		<i>Complete model</i>	
	<i>Sino</i>	<i>Pak</i>	<i>Sino</i>	<i>Pak</i>	<i>Sino</i>	<i>Pak</i>
CO ₂	-0.000*** (0.001)	-0.000 (0.000)			0.000*** (0.000)	-2.150 (3.448)
GDPpc	21.710*** (3.737)	0.120*** (0.013)			-0.000* (0.000)	7.730*** (1.815)
CHE			0.010*** (0.001)	0.140*** (0.011)	0.020*** (0.005)	0.040 (0.027)
Constant	18.410** (7.554)	1.470*** (0.029)	71.990*** (0.173)	61.250*** (0.316)	69.840*** (0.262)	45.440*** (5.067)
Observations	56	56	21	21	21	21
R-squared	0.784	0.931	0.932	0.903	0.992	0.964

Note: Standard errors in parentheses, *** p < 0.01, ** p < 0.05, * p < 0.1.

Source: Authors' estimation

The final section of the study shows that CO₂ emissions from 2000 to 2020 had no significant impact on LE in Pakistan, although it affected the health but not as effective, while CO₂ emissions in China strangely helped China in better LE, which had been affected the health condition for last three decades. It might be due to better environmental policies and pleasant climate strategies. On the other hand, GDPpc shows better results in Pakistan, with a 99% significant impact on LE for improving life quality. At the same time, China's GDPpc has demonstrated a negative impact since 2000, which means that due to high industrialisation and economic activities in the last two decades, a substantial adverse effect of GDPpc with a 90% significant value has impacted LE. In the end, CHE shows a strong positive impact on LE in China with a 99% considerable value that overcomes the adverse effects on LE by the other health deterioration determinants. However, CHE has not shown a significant impact in the presence of other hampering and accelerating determinants of health outcomes. The regression results show that China

leads to a better r-square value of 0.992 in a complete model than Pakistan's 0.962. Moreover, to rely on the results and regression assumption, a heteroskedasticity test has been applied in Table 5, which should be constant variances. In rejecting the null hypothesis of heteroskedasticity in the data, a p-value should be more significant than 5% satisfying through Table 5, showing no heteroskedasticity in the data.

Table 5 Breusch-Pagan/Cook-Weisberg test for heteroskedasticity

<i>Breusch-Pagan/Cook-Weisberg test for heteroskedasticity</i>	
<i>Ho: Constant variance</i>	
<i>Variables: fitted values of life expectancy at birth (Years)</i>	
<i>Sino</i>	<i>Pak</i>
Chi2(1) = 1.13	Chi2(1) = 2.06
Prob > chi2 = 0.7204	Prob > chi2 = 0.1510

Note: A probability below 5% reject the null hypothesis of heteroskedasticity.

Source: Authors' estimation

5 Discussion

Environment deterioration causes various climatic and health issues; on the other hand, income per capita improves life and well-being (Barlow and Vissandjie, 1999). In this study, a run CO₂ emission impact on LE negatively results in Sino-Pak. However, China's economic process has been polluting the air quality significantly, but it also improved the income per capita substantially better than Pakistan. In the previous studies by Wang et al. (2014), Ali and Audi (2016), and Ahmad (2018), the perspective of Pakistan and China categorically showed similar results in different time frames. However, none of the previous studies made a comparative analysis of Sino-Pak on this perceptive yet except Sen (2011), which examined the comparative discussion of China and India on income impact on health outcomes.

Furthermore, the adverse effect of environmental deterioration can be mitigated or controlled by socio-economic and fiscal measures. The present study added a moderator role of health expenditures per capita on LE in Sino-Pak since the inception of MDGs. The results show that health spending made a very influential impact on life longevity in China and through effective policy-making influence of CO₂ also changed from an adverse to a positive effect on LE in China, which overall had a favourable impact on health outcomes in China as studied by Tahir (2020). However, GDP per capita negatively impacted LE in the presence of a socio-economic issue, which backed the study findings of Luo and Xie (2020) on China.

On the other hand, health spending's impact on Pakistan's health outcomes does not show progressive output. The previous studies by Ahmad et al. (2018) and Ali et al. (2020) on Pakistan focused on the effective utilisation of health spending for better health outcomes and empirically tested the significant impact of LE. However, the present study explored that health spending in Pakistan does not significantly impact LE; instead, income per capita can substantially impact LE in Pakistan. Furthermore, it showed that the public relied on private health spending and facilities compared to public spending in Pakistan. Based on the moderator's impact on LE studies by Delavaris et al. (2016) in

Iran, Amuka et al. (2018) in Nigeria, and Rjoub et al. (2021) in turkey showed similar results in CO₂ emissions, GDP per capita, and health spending on LE. However, a comparative analysis of Sino-Pak makes this study interactive and novel in this perspective.

6 Conclusions and study recommendations

The present study aimed to examine the role of CO₂ and GDPpc on LE in Sino-Pak, from 1965 to 2020. Moreover, considering Sustainable Development Goal 03. c, CHE has been considered a moderator from 2000 to 2020 (due to data availability limitation). Therefore, an econometric estimation and descriptive and graphical examination have been applied in the last five decades of analysis. As a result, it showed that CO₂ emissions had negatively affected the LE in Sino-Pak, GDPpc positively enhanced the life quality, and accessibility improved the LE in both states. However, due to state and demographic size, China has been more affected by the CO₂ emissions, but its GDPpc continuously improved the quality of life compared to Pakistan.

The study concludes that CHE has been a promoting factor of LE in Sino-Pak since establishing the Millennium Development Goals (MDGs 2000) and has improved LE in both countries. However, CHE shows favourable health conditions in China due to better fiscal policies and government effectiveness. However, due to better policies, CO₂ emission has shown a positive relationship with life longevity in China; although it affects the LE in Pakistan, it is not a significant factor, as per Table 4. Simultaneously, GDPpc has not been a life longevity factor in China since 2000, while it has improved the life quality in Pakistan, which positively affects the LE. On the other hand, CHE positively improved the LE in Sino-Pak; however, CHE shows significant results in China and supports improving life longevity compared to Pakistan.

The government of Pakistan needs effective strategic measures in the health sector from china which should be implemented in Pakistan for better health outcomes and to achieve the S.D. of health and well-being. Along with fiscal and reasonable governance assistance, effective environmental clearance policies also needed to be adopted in Pakistan, affecting health outcomes and longevity. Pakistan needs to implement effective health reforms in the state, just like china (health reforms 2009), that improve the quality of health and life in achieving the SDG by 2030. Along with the above conclusion and recommendations, a couple of suggestions for practitioners are mentioned below:

- CO₂ emission has negatively affected LE in China compared to Pakistan, which needs to be improved with effective environmental policies.
- China's GDP per capita improved the LE much better than Pakistan, which must be triggered for policy experts in Pakistan to allocate health funds in the right direction followed by China.
- China and Pakistan's economic policies should be coherent with environmental and health outcomes to achieve sustainability.

Apart from the above statistics, discussion, conclusions, and recommendations, this study suggests that developing countries should focus on green environmental policies to improve the state's life outcomes and provide adequate health expenditures and economic activities. In achieving SDG 2030, developing countries should work jointly to make the

world prosperous. This Sino-Pak study highlights an essential aspect from the developing world's perspective and deals with two of the most populous countries where LE at birth, referencing SDG 03, must be dealt with tactfully to accomplish SDG 2030.

For future studies and CHE, other health-driving measures such as out-of-pocket health expenditures, government consumption expenditures, and the impact of urbanisation on health outcomes can be examined. In addition, the health outcomes measures such as accessibility and quality of health instead of LE can also be an excellent approach for future study. Moreover, regional integration through economic and social integration can affect health outcomes and make future studies more exciting and impactful.

References

- Abbas, H.S.M., Gillani, S., Ullah, S., Raza, M.A.A. and Ullah, A. (2020) 'Nexus between governance and socioeconomic factors on public service fragility in Asian economies', *Social Science Quarterly*, Vol. 101, No. 5, pp.1850–1868.
- Abbas, H.S.M., Xu, X. and Sun, C. (2021a) 'Role of foreign direct investment interaction to energy consumption and institutional governance in sustainable GHG emission reduction', *Environmental Science and Pollution Research*, Vol. 28, No. 40, pp.56808–56821.
- Abbas, H.S.M., Xu, X., Sun, C., Ullah, A., Gillani, S. and Raza, M.A.A. (2021b) 'Impact of COVID-19 pandemic on sustainability determinants: a global trend', *Heliyon*, Vol. 7, No. 2, p.e05912.
- Ahmad, M., Ur Rahman, Z., Hong, L., Khan, S., Khan, Z. and Naeem Khan, M. (2018) 'Impact of environmental quality variables and socio-economic factors on human health: empirical evidence from China', *Pollution*, Vol. 4, No. 4, pp.571–579.
- Ahmed, M.E. and Khan, M.J. (2019) *Relationship between Health Expenditures and Life Expectancy Paka Pakistan* [online] <https://www.pide.org.pk/pdf/HealthEconomics/Policy/HE-Policy-Brief-7.pdf> (accessed 10 April 2021).
- Alam, M.M., Hossain, M.S., Islam, N., Murad, M.W. and Khan, N.A. (2021) 'Impacts of health and economic costs on street children working as waste collectors in Dhaka City', *International Journal of Environment and Sustainable Development*, Vol. 20, No. 1, pp.29–50.
- Ali, A. and Ahmad, K. (2014) *The Impact of Socio-Economic Factors on Life Expectancy for the Sultanate of Oman: An Empirical Analysis* [online] <https://mpra.ub.uni-muenchen.de/id/eprint/70871>.
- Ali, A. and Audi, M. (2016) *The Impact of Income Inequality, Environmental Degradation and Globalization on Life Expectancy in Pakistan: an Empirical Analysis* [online] <https://mpra.ub.uni-muenchen.de/id/eprint/71112>.
- Ali, M., Gilani, D.Q. and Ul Abidin, A. (2020) 'Public health care and government health expenditures in Pakistan', *Journal of Economic Impact*, Vol. 2, No. 3, pp.93–98.
- Amuka, J.I., Asogwa, F.O., Ugwuanyi, R.O., Omeje, A.N. and Onyechi, T. (2018) 'Climate change and life expectancy in a developing country: evidence from greenhouse gas (CO₂) emission in Nigeria', *International Journal of Economics and Financial Issues*, Vol. 8, No. 4, p.113.
- Barlow, R. and Vissandjee, B. (1999) 'Determinants of national life expectancy', *Canadian Journal of Development Studies/Revue Canadienne D'études du Développement*, Vol. 20, No. 1, pp.9–29.
- Coglianesi, C. and Starobin, S.M. (2020) 'Social science and the analysis of environmental policy', *Review of Policy Research*, Vol. 37, No. 5, pp.578–604.
- Das, T. and Das, D. (2022) 'Does the augmentation of monetary and non-monetary factors prerequisite for the improvement of health outcomes? Evidence from the Indian states', *The International Journal of Health Planning and Management*, Vol. 37, No. 2, pp.1131–1156.

- Delavari, S., Zandian, H., Rezaei, S. et al. (2016) 'Life expectancy and its socio-economic determinants in Iran', *Electronic Physician*, Vol. 8, No. 10, p.3062.
- Dixon, A. (2021) 'Why we need to face up to the ageing population?', *Health Economics, Policy and Law*, Vol.16, No. 4, pp.379–382.
- Guo, S., Song, Q. and Qi, Y. (2021) 'Innovation or implementation? Local response to low-carbon policy experimentation in China', *Review of Policy Research*, Vol. 38, No. 5, pp.555–569.
- Hassan, M.S. and Kalim, R. (2012) 'The triangular causality among education, health and economic growth: a time series analysis of Pakistan', *World Applied Sciences Journal*, Vol. 18, No. 2, pp.196–207, doi: <http://hdl.handle.net/123456789/562>.
- IMF (2020) 'Fiscal monitor 'policies to support people during the COVID-19 pandemic' April 2020', *International Monetary Fund*.
- Jaba, E., Balan, C.B. and Robu, I-B. (2014) 'The relationship between life expectancy at birth and health expenditures estimated by a cross-country and time-series analysis', *Procedia Economics and Finance*, Vol. 15, No. 1, pp.108–114, [https://doi.org/10.1016/S2212-5671\(14\)00454-7](https://doi.org/10.1016/S2212-5671(14)00454-7).
- Jakovljevic, M., Timofeyev, Y., Ekkert, N.V. et al. (2019) 'The impact of health expenditures on public health in BRICS nations', *Journal of Sport and Health Science*, Vol. 8, No. 6, p.516.
- Jakovljevic, M.B., Vukovic, M. and Fontanesi, J. (2016) 'Life expectancy and health expenditure evolution in Eastern Europe—DiD and DEA analysis', *Expert Review of Pharmacoeconomics and Outcomes Research*, Vol. 16, No. 4, pp.537–546.
- Kim, T.K. and Lane, S.R. (2013) 'Government health expenditure and public health outcomes: a comparative study among 17 countries and implications for U.S. health care reform', *American International Journal of Contemporary Research*, Vol. 3, No. 9, pp.8–13.
- Luo, W. and Xie, Y. (2020) 'Economic growth, income inequality and life expectancy in China', *Social Science and Medicine*, July, Vol. 256, p.113046.
- Meheus, F. and McIntyre, D. (2017) 'Fiscal space for domestic funding of health and other social services', *Health Economics, Policy and Law*, Vol. 12, No. 2, pp.159–177.
- Monsef, A. and Mehrjardi, A.S. (2015) 'Determinants of life expectancy: a panel data approach', *Asian Economic and Financial Review*, Vol. 5, No. 11, p.1251.
- Nkalu, C.N. and Edeme, R.K. (2019) 'Environmental hazards and life expectancy in Africa: evidence from GARCH model', *SAGE Open*, Vol. 9, No. 1, DOI: 2158244019830500.
- Rjoub, H., Odugbesan, J.A., Adebayo, T.S. and Wong, W-K. (2021) 'Investigating the causal relationships among carbon emissions, economic growth, and life expectancy in Turkey: evidence from time and frequency domain causality techniques', *Sustainability*, Vol. 13, No. 5, p.2924.
- Sen A. (2011) *Quality of life: India vs. China*, *The New York Review of Books*, Vol. 12, No. 12, p.2, The New York Review of Books, Pratiche Trust Kolkata, India.
- Şentürk, İ. and Amjad, A.L.İ. (2021) 'Socioeconomic determinants of gender-specific life expectancy in Turkey: a time series analysis', *Sosyoekonomi*, Vol. 29, No. 49, pp.85–111.
- Shah, M.H., Wang, N., Ullah, I., Akbar, A., Khan, K. and Bah, K. (2021) 'Does environment quality and public spending on environment promote life expectancy in China? Evidence from a nonlinear autoregressive distributed lag approach', *The International Journal of Health Planning and Management*, Vol. 36, No. 2, pp.545–560.
- Shahbaz, M., Loganathan, N., Mujahid, N., Ali, A. and Nawaz, A. (2016) 'Determinants of life expectancy and its prospects under the role of economic misery: a case of Pakistan', *Social Indicators Research*, Vol. 126, No. 3, pp.1299–1316.
- Sheraz, M., Deyi, X., Ahmed, J., Ullah, S. and Ullah, A. (2021) 'Moderating the effect of globalization on financial development, energy consumption, human capital, and carbon emissions: evidence from G20 countries', *Environmental Science and Pollution Research*, Vol. 28, No. 26, pp.35126–35144.
- Siddiqui, R., Afridi, U., Haq, R. and Tirmazi, S.H. (1995) 'Determinants of expenditure on health in Pakistan [with comments]', *The Pakistan Development Review*, Vol. 34, No. 4, pp.959–970.

- Tahir, M. (2020) 'Trade and life expectancy in China: a cointegration analysis', *China Economic Journal*, Vol. 13, No. 3, pp.322–338.
- Telch, F. and Appe, S. (2022) 'How can countries improve human development? Four distinct national planning strategies and the challenges for human development ahead', *Development Policy Review*, Vol. 40, No. 2, p.e12561.
- Ullah, A., Pinglu, C., Ullah, S., Abbas, H.S.M. and Khan, S. (2021a) 'The role of E-Governance in combating covid-19 and promoting sustainable development: a comparative study of China and Pakistan', *Chinese Political Science Review*, Vol. 6, No. 1, pp.86–113.
- Ullah, A., Pinglu, C., Ullah, S. and Elahi, M.A. (2021b) *A Pre Post-COVID–19 Pandemic Review of Regional Connectivity and Socio-Economic Development Reforms: What Can Be Learned by Central and Eastern European Countries From the China-Pakistan Economic Corridor*, Vol. 24, No. 2, pp.23–43.
- Ullah, I., Rehman, A., Khan, F.U., Shah, M.H. and Khan, F. (2020) 'Nexus between trade, CO₂ emissions, renewable energy, and health expenditure in Pakistan', *The International Journal of Health Planning and Management*, Vol. 35, No. 4, pp.818–831.
- UNDP (2020) *Human Development Report 2019*, New York, United States of America.
- Wang, L., Li, Y., Li, H. et al. (2014) 'A study of air pollutants influencing life expectancy and longevity from spatial perspective in China', *Science of the Total Environment*, Vol. 487, pp.57–64, <https://doi.org/10.1016/j.scitotenv.2014.03.142>.
- Wang, S., Luo, K., Liu, Y. et al. (2015) 'Economic level and human longevity: spatial and temporal variations and correlation analysis of per capita GDP and longevity indicators in China', *Archives of Gerontology and Geriatrics*, Vol. 61, No. 1, pp.93–102.
- Wang, Z., Asghar, M.M., Zaidi, S.A.H. et al. (2020) 'The dynamic relationship between economic growth and life expectancy: contradictory role of energy consumption and financial development in Pakistan', *Structural Change and Economic Dynamics*, June, Vol. 53, pp.257–266, <https://doi.org/10.1016/j.strueco.2020.03.004>.
- Wu, Y., Wang, W., Liu, C., Chen, R. and Kan, H. (2020) 'The association between long-term fine particulate air pollution and life expectancy in China, 2013 to 2017', *Science of The Total Environment*, Vol. 712, p.136507, <https://doi.org/10.1016/j.scitotenv.2020.136507>.
- Yang, X. and Geng, L. (2022) 'An integrated analysis of social, economic, and environmental indicators' effects on public health and health inequality globally: from the perspective of vulnerability', *Social Indicators Research*, DOI: 10.1007/s11205-022-02877-x.
- Zaman, M., Pinglu, C., Hussain, S.I., Ullah, A. and Qian, N. (2021) 'Does regional integration matter for sustainable economic growth? Fostering the role of FDI, trade openness, I.T. exports, and capital formation in BRI countries', *Heliyon*, Vol. 7, No. 12, p.e08559.