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<https://doi.org/10.1057/s41599-023-02005-1>

OPEN

Impact of urbanization and income inequality on life expectancy of male and female in South Asian countries: a moderating role of health expenditures

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Urbanization, income inequality and health expenditures are important factors of life expectancy. Urbanization and income inequalities are avoidable occurrences to tackle the health penalties. The objective of this study is to estimate the impact of urbanization and income inequality on the life expectancy male and female in six selected South Asian countries. To investigate the impact of urbanization and income inequality on life expectancy, eight econometric models are specified and estimated with recent panel data from 1997 to 2021. Based on the Hausman test, the random effect model is used for estimation. Life expectancy male and life expectancy female, respectively, are the dependent variables. Urbanization and income inequality are the independent variables, and health expenditure is the control variable. Further, the study finds the interaction effect of health expenditure with urbanization on life expectancy (male and female). Results explain that urbanization, income inequality and health expenditure have significant impacts on life expectancy in the case of both male and female. In both cases, life expectancy is negatively affected by urbanization and income inequality, whereas health expenditure has a positive impact on life expectancy. Health expenditures moderate the impact of urbanization on life expectancies of male and female with a small size effect. It explains that the negative impact of urbanization can be mitigated through health expenditures. The results of the study are robust. Based on the results of the study, policy-makers may suggest overcoming the problems of urbanization. It is a dire need to redistribute income in South Asian countries to achieve better health and improve life expectancy. More public health expenditures are required in these countries to provide more health facilities, especially in urban areas, to mitigate the impact of urbanization on life expectancy.

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Introduction

Better health facilities are needed by individuals all over the world, and countries of the world try to provide better health and health-related facilities to their individuals. The agenda of sustainable development goals (SDG) is a healthy life, and goal three is the health goal. It safeguards energetic lives and promotes welfare to people of all ages. SDG accentuates achieving the overall health goal (United Nations, 2022). Further, SDG goal five emphasizes gender equality and women empowerment in all respects, including health and education. Health is important to increase the production of a country. Nasreen et al. (2012) reflect health as a significant substance to boost earning capacity and self-respect of individuals. Health contributes to labor productivity increase. Musgrove (1993) defines a significant health role in poverty reduction, and it is the cause of long-term economic growth. Health is the absence of diseases. World Health Organization (WHO, 1984) defines health as a level for individual or group of individuals are able to grasp desires and satisfy needs to cope with the environment.

Health, education, income and dwellings/homes are the basic and important factors of economic growth in any country. Every country desires to improve Human Development Index (HDI) as it is an indicator of human development. It consists of three indices, including education, health and income. The aim of every country is to improve their living standard and make progress. Human Development Report (UNDP, 2019) explains elsewhere to understand the widespread variations in capabilities inside several countries. It recognizes the broadening gaps in boosted capabilities, for example, higher education admittance and life expectancy to seventy, further gaps in what people expect about lives and what we actually measure. European, East Asian, Latin American and Caribbean regions have the highest HDI. However, worse conditions prevail in sub-Saharan African and South Asian regions. Surprisingly, South Asian countries do not show a satisfactory level of human development, as HDI is the second lowest in these countries when compared with the world. The report also reveals that mental distress leads to prevent freedom and achievements. It is intensive that HDI dropped in ninety percent of countries during 2022 as compared to previous years.

United Nations (2019) estimates that the world's population in 2019 is coupled in urban areas is half of the population across the world. It is expected that this number will touch six billion by 2041. Dong et al. (2021) clarify that urbanization in China has a negative impact on health. Higher life expectancy indicates a healthier state of health. Analyzing the life expectancy in the case of South Asian countries, it is less as compared to other regions in the world. Under-five mortality was 17.90 out of 1000 in the Caribbean region in 2014, whereas this rate touches 55 in South Asian countries (World Health Organization, 2015). In spite of the fact that South Asian countries have made good progress in life expectancy, infant survival and childhood immunization from 2000 to 2007, it still does not fulfill the international standards. The health condition of Pakistani people is not good as compared to other countries. Pakistan Maternal Mortality Survey (PMMS, 2019) reports that life expectancy in Pakistan is 65.4 years at birth, whereas according to Pakistan Demographic Survey (PDS). According to Government of Pakistan, (2020), life expectancy in years at birth in Pakistan is 65 years in 2020; it is 64.5 years for males and is 65.5 years for females. However, data reflects that life expectancy is longer in Sri Lanka as compared to other South Asian countries.

Many studies find the factors of life expectancy, including urbanization, environment, industrialization, income inequality,

health expenditure, unemployment and other factors in different regions of the world. Few studies are devoted to exploring life expectancy in the South Asian region. Urbanization and income inequality in itself are avoidable phenomena to tackle the health penalties. Our study is unique in finding the impact of urbanization and income inequality on the life expectancy of male and female in South Asian countries. In literature, rare studies explore the impact of health inputs on the life expectancy of male and female both separately. Further, this study explores the interaction effect of health expenditure and urbanization on the life expectancy male and life expectancy female. The objectives of this study are: to estimate the impact of urbanization and income inequality on life expectancy (male and female) in South Asian countries and to find the moderating role of health expenditure with urbanization on the life expectancy (male and female) in these countries.

Literature review and hypothesis

Theoretical literature. Health is a significant factor in the human development index, and it is crucial for human capital as it enhances the productivity of labor. Grossman (1972) is the pioneer in contributing a theoretical framework for building a health model. The health production function is proposed to analyze the health conditions in any country. However, the health production function is alike and comparable to a traditional production function, which explains the technical relationship between inputs and outputs. A health production function shows the relationship between socio-economic and health inputs to health output. Jakovljevic et al. (2016) explain that the dependent variable in the health production function can be measured with health output, for example, life expectancy or mortality or death rate in the economy. The inputs may be the vector of socio-economic, demographic, environmental and nutrition factors, and health care and medical facilities and their costs in the economy. Olsen et al. (2013) use the production function to explain the performance quality in the case of primary health care in Denmark.

Empirical literature. Empirical literature explains the relationship between health output and health inputs. Researchers find that urbanization, income inequality, health expenditures including public and private, health facilities and their costs, unemployment, inflation, environment and pollution are the key determinants of life expectancy.

Life expectancy and income inequality. Empirical studies explain that income inequality is a significant factor in life expectancy. Amin (2001) and Nasreen et al. (2012) explain that there is a negative impact of income inequality on health. Adjaye (2004) specifies the negative impact of income inequality on health. Wilkinson and Pickett (2006) review 155 articles to watch income inequality and its impact on health. The results of reviewed articles explain that varied distribution of income results in bad health according to 88 reviews. However, 44 reviews display a positive and significant impact of income inequality on worse health. Thirty-seven articles do not show any impact of income inequality on health. Torre and Myrskylä (2011) explain that income inequality has an impact on the health in case of 21 developed countries of the world from 1975 to 2006. It is concluded that children's health can be improved through a reduction in income inequality. However, the results of the study found no impact of income inequality on the life expectancy of the people.

Nejadlabaf et al. (2013) estimate a negative impact of income inequality on the health in case of 22 developing countries from 1995 to 2008. Child (2013) discovers a positive relationship between income inequality and health. For this conclusion, 51 USA states were experimented over four censuses from 1980 to 2010. Baeten et al. (2013) also experimented link between income inequality and health in China. It is concluded that health gaps are linked to income inequality. The health of people can be improved with income. Hu et al. (2015) examine the relationship between income inequality and health status. Life expectancy and mortality are used as indicators of health status. This relationship has been experimented in 43 European countries. It is found that inequality in wealth distribution has a negative impact on the life expectancy of male and life expectancy of female. However, a positive relationship is explored between income inequality and mortality.

Heden (2015) explores the link between income inequality and health in the case of nineteen OECD countries. Results explain that income inequality has a significant impact on people's health. Further, socio-economic factors have an impact on life expectancy along with spending on health care, income and education. Herzer and Nunnenkamp (2015) evaluate the relationship between health and income inequality, including developed as well as developing countries, in the analysis. Results explain that income inequality incline to health improvements in the case of developed countries. However, in the case of developing countries, income inequality has a negative impact on life expectancy and a positive impact on infant mortality. Bhattacharjee et al. (2015) establish a link between income inequality and health expenditure in OECD countries. Results explain income inequality is linked to the poor health of the people during the periods of private regimes. However, income inequality is reduced during public regimes, which favors income growth in rich countries.

Recent studies explore the impact of income inequality on life expectancy. Chang and Gao (2021) analyze the short-run and long-run impacts of income inequality on life expectancy in emerging Asian countries. The findings of the study explain that life expectancy is decreased due to positive changes in income inequality. However, this relationship is positive in the long run in emerging Asian economies. Tibber et al. (2021) find the wide negative impacts of income inequality on health. Their study concludes that mental health is negatively associated with income inequality. Income inequality significantly leads to mental health complications. Qasim et al. (2020) explain that income inequality is harmful to human development. Nwosu and Oyenubi (2021) explore the impact of poverty and income inequality on health and conclude that poverty and income inequality are both significant contributors to health issues.

Hypothesis 1

H1a: Income inequality has a negative impact on the life expectancy of male in South Asian Countries.

H1b: Income inequality has a negative impact on the life expectancy female in South Asian Countries.

Life expectancy and urbanization. Urbanization is a process in which people move from rural areas to urban surroundings. Adjaye (2004) explains that health and income are basics for every individual. Health issues due to urbanization include improper nutrition, pollution, diseases, meager sanitation and housing. These issues ultimately shake the life expectancy in urban areas. Baeten et al. (2013) explain that better health conditions are observed in coastal and rural areas of China. Urbanization is not recommended for better health. Recent studies by Dong et al. (2021) explain health-related issues due

to industrialization and urbanization in China. With panel data estimation, it is concluded that carbon emissions are bad for health in the long term. It is estimated that a one percent rise in carbon emission increases 0.298 percent extra outpatients and 0.162 percent more inpatients; further, it damages inhabitants' health due to the rise in temperature. Industrialization and urbanization in China increase carbon emissions and ultimately pass it to health risks in urban areas.

Hypothesis 2

H2a: Urbanization has a negative impact on the life expectancy male in South Asian countries.

H2a: Urbanization has a negative impact on the life expectancy female in South Asian countries.

Life expectancy and health expenditures. The importance of health expenditures is recognized duly in the literature on empirical grounds and from established theories of health economics. Health expenditures not only directly treat health issues to expand life expectancy but also interact with urbanization to mitigate pollution hazards affecting the health of urban areas. Crémieux et al. (1999) discover the impact of public health expenditure on life expectancy in the case of Canada. Results explain that life expectancy is low and infant mortality is high in families that spend less amount of money on health. Gulis (2000) find that health spending is the key determinant of life expectancy. Findings are based on data from 156 countries. Further, Rahman et al. (2018) studied the impact of healthcare expenditure on health effects in 15 countries of the South Asian Association for Regional Cooperation-Association. Public and private health expenditures, along with total expenditures, have an impact on infant mortality, life expectancy at birth and crude death rate. The results explain that all three types of health expenditures significantly reduce infant mortality and death rates. Rana et al. (2018) investigated the link between health expenditure and health outcomes in case of 161 countries from developed as well as developing countries. Panel ARDL technique is used in this with data period of 1995 to 2014 with different income levels. The result explains that health expenditure impact on health outcomes is stronger in the case of low-income countries as compared to high-income countries.

Recently, Njoroge (2020) investigated a link between health expenditures and health outcomes in 18 Southern and East African countries. The generalized method of moments is used with data period from 2001 to 2017. It is concluded that health expenditure has a significant negative impact on mortality and maternal mortality and has a positive impact on the life expectancy at birth in these countries. Further, Ibukun (2021) explains the mechanism of health expenditures in the health system. It delivers funds to operate the health systems and plays a key role in the performance of the health sector through health outcomes and efficiency. Onofrei et al. (2021) explain the impact of public health expenditures on the health effect in the case of developing countries of the European Union. They establish that infant mortality and life expectancy at birth can be improved due to public health expenditures. Ibukun (2021) finds that governance is a mediator in the link between health expenditure and health outcomes. The empirical findings are based on panel data from 15 countries in West Africa during the time period from 2000 to 2018. The results of the study explain that health expenditure has a significant impact on infant mortality, under-five mortality and life expectancy. Uddin et al. (2023) estimate that the quality of an institution, financial development, and health expenditure have a positive impact on life expectancy, whereas emission of carbon, ecological footprints, mortality rate, and

population growth are the causes to reduce life expectancy in case of Asian countries.

Hypothesis 3:

H3a: Health expenditure has a positive impact on the life expectancy male in South Asian countries.

H3b: Health expenditure has a positive impact on the life expectancy female in South Asian countries.

Hypothesis 4:

H4a: Health expenditure moderates the relationship between urbanization and life expectancy male in South Asian countries.

H4b: Health expenditure moderates the relationship between urbanization and the life expectancy female in South Asian countries.

Methods

The study explores the impact of urbanization and income inequality on life expectancy (male and female) in selected South Asian countries using panel data from 1997 to 2021. Further, it finds the interaction impact of health expenditure and urbanization on the life expectancy of male and female. Six low-middle-income countries included in the analysis are India, Pakistan, Bangladesh, Sri Lanka, Nepal and Bhutan.

Variables and data sources. This study uses balanced panel data to find the impact of urbanization and income inequality on life expectancy. The sample includes panel data for six South Asian countries from 1997 to 2021. Data sources include world development indicators (WDI) and the standardized world income inequality database (SWIID). Life expectancy total, life expectancy female and life expectancy male are dependent variables. Life expectancy is a measure of health status as frequently used in the literature, for example, Hu et al. (2015) and Torre and Myrskylä (2011). Urbanization and income inequality are the independent variables and health expenditure is the control variable in this study. The Gini coefficient is used as an indicator of income inequality, for example, Gronqvist et al. (2012). Its value lies between zero and one. If the Gini coefficient is zero, it means equal distribution of income, and if the Gini coefficient is one, it means complete unequal distribution of income. The Gini coefficient is used to measure income inequality from zero to 100 scales by Herzer and Nunnenkamp (2015). They find equal income distribution when the Gini coefficient is zero and a fully unequal distribution in the case of the Gini coefficient is 100. Our study uses the Gini coefficient from zero to 100 scales. Urban population growth is used for urbanization. Current health expenditure per capita shows the health expenditures. Table 1 shows a brief description of the variables.

Model specification. Grossman (1972) introduces a health production function, and our empirical model is based on it. Mathematically, this function is shown as: $Y = f(X)$, where $Y =$ Health output, $f =$ denotes function, and $X =$ A vector of the individual inputs. The list of inputs may include education, consumption of goods, nutrient intake, individual and community assets, including land and environment (Fayissa and Gutema, 2005). This theoretical model is proposed to investigate a micro-level-based health production function. However, our study is related to macro-data; we replaced Y with life expectancy and vector X with income inequality, urbanization, health expenditure and the interaction of health expenditure with urbanization. Therefore, Grossman’s (1972) health production model is extended as: Life expectancy = f (income inequality, health expenditure, urbanization, health expenditure*health expenditure). At the stage of specification, the following six single equation econometric models are specified and estimated to find the impact of urbanization and income inequality on life expectancy.

$$Lema_{it} = \beta_0 + \beta_1 Gico_{it} + \beta_2 Urb_{it} + \beta_3 He_{it} + \mu_{it}$$

$$Lema_{it} = \beta_0 + \beta_1 Gico_{it} + \beta_2 Urb_{it} + \beta_3 He_{it} + \beta_4 He*Urb_{it} + \mu_{it}$$

$$Lefe_{it} = \beta_0 + \beta_1 Gico_{it} + \beta_2 Urb_{it} + \beta_3 He_{it} + \mu_{it}$$

$$Lefe_{it} = \beta_0 + \beta_1 Gico_{it} + \beta_2 Urb_{it} + \beta_3 He_{it} + \beta_4 He*Urb_{it} + \mu_{it}$$

Where: i is country and t is time period. $Lema_{it} =$ Life Expectancy, Male. $Lefe_{it} =$ Life Expectancy, Female. $Gico_{it} =$ Gini Coefficient. $Urb_{it} =$ Urbanization. $He_{it} =$ Health Expenditure. $He*Urb_{it} =$ It is the interaction of health expenditure and urbanization. $U_{it} =$ Error Term.

Model estimation. For panel data estimation in the econometric literature, fixed effect and random effect models are frequently used. The use of fixed effect and random effect models is based on number of time periods and cross section in the data set. If $N \leq 25$ and $T \leq 25$, then fixed effect or random effect models can be used. We have $N = 06$ and $T = 25$, which justifies to use fixed or random effect model. To understand the mathematics of fixed vs random effect model for panel data estimation, consider the regression model: $Y_{it} = \alpha_i + \beta X_{it} + u_{it} \dots (1)$; where i is country, t is time period and denoted as:

$i = 1, 2, 3 \dots, N$, and $t = 1, 2, 3 \dots, T$; other variables and parameters are explained as:

$Y_{it} =$ Life Expectancy (outcome variable for country i at time t).

$\alpha_i =$ Individual intercept for each country.

$\beta =$ It is a coefficient for a given country and shows β units change in life expectancy due to unit change in the explanatory variable. However, β will show % change in life expectancy due to

Table 1 Description of the variables and data sources.

Notation	Variables	Description	Data source
Leto	Life expectancy total	It is at birth in years.	World Development Indicators (WDI)
Lema	Life expectancy male	It is at birth in years.	World Development Indicators (WDI)
Lefe	Life expectancy female	It is at birth in years.	World Development Indicators (WDI)
Urb	Urbanization	Urbanization is shown with urban population growth (annual percentage).	World Development Indicators (WDI)
He	Health expenditure	It is current per capita health expenditure and measured in current US\$.	World Development Indicators (WDI)
Gico	Income inequality	It is Gini Coefficient to show income inequality. It is based on disposable income of households.	Standardized World Income Inequality Database (SWIID)

one % change in the explanatory variable if model is transformed into log form. It shows common effect across country controlling for individual heterogeneity.

X_{it} = It is a vector of explanatory variables for country i at time t .

Now suppose that $uit = \mu_i + \lambda_t + vit$;(2); where μ_i = unobservable individual (cross section) heterogeneity, λ_t = unobservable time heterogeneity and vit = random error term. These error components explain the assumption that components are fixed or random. We decided on fixed effects and random effects models. These models are explained in the next section.

F statistics is used to check the significance of the coefficients. Two tail P -values test explains the hypothesis that each coefficient is different from zero based on its t -value. A P -value lowers than 0.05 rejects the null and accepts the alternative hypothesis. We conclude that explanatory has a significant effect on the dependent variable (life expectancy) at a 95% significance level. F -test is used to find the overall significance of the estimated model. This test explains that all the estimated coefficients are jointly different than zero. The concluding remarks of the F -test explain that if $Prob > F$ is less than 0.05, then the overall significance of the model is fine. Panel data are useful to avoid omitted variable bias and to examine theories that predict parameter heterogeneity (Asteriou & Hall, 2007).

Fixed effect model. In the fixed effect model, the individual effect of a country is fixed and is not associated with explanatory variables; and time-invariant features of the country are unique. Each country's error term and constant are not correlated with the others as each country is different. It can be explained from equation (2) as if μ_i and λ_t are fixed parameters and vit is identically and independently distributed with zero mean and constant variance σ^2v , that is, $vit \sim IID(0, \sigma^2v)$, then equation (1) justify a fixed effects model. Here we have two models: (1) Least Squares Dummy Variable model and (2) Within-groups regression model. Many dummy variables are required for time and cross sections in the method of least squares dummy variable to capture the variation in intercept and slope, and it leads this approach unattractive and loss of degree of freedom. It is preferable to estimate a fixed effect model without dummy variables. We use the Q transformation of equation (1) as suggested by (Baltagi, 2005). In this method, mean values are subtracted from equation (1) to convert it into deviation form. Many studies use the fixed effect model, for example, Afzal et al. (2013).

Random effect model. In the random effect model, the individual effect of the country is a random variable and unrelated to explanatory variables in the model. It explains that the variance of individual effect is constant. From equation (2), if we assume that if μ_i and λ_t are random just as random error term vit . Further, assume that μ_i , λ_t and vit are all identically and independently distributed with zero mean and constant variance. Equation (1) will justify a random effect model. The $Cov(\mu_i, vit) = 0$, $Cov(vit, X_{it}) = 0$ and $Cov(\mu_i, X_{it}) = 0$. Generalized least squares and feasible generalized least squares are used to estimate the random effect model. The choice of these techniques depends on the shape of error. Judge et al. (1988) propose that random effect estimators are efficient if N is large and T is small, along with plotting the assumptions of the random effect model. Many studies used a random effect model, for example, Ahmad et al. (2023).

Hausman test. This test decides the appropriateness of fixed or random effect models for estimation. Null hypothesis explains that error terms are not correlated with regressors, and the

random effects model is recommended, otherwise the alternative hypothesis is accepted to use the fixed effects model. Null and alternative hypotheses are denoted as:

Null Hypothesis $H_0 : \beta_{RE} - \beta_{FE} = 0$ (Use random effect model)
 Alternative Hypothesis $H_a : \beta_{RE} - \beta_{FE} \neq 0$ (Use fixed effect model)

Final decision. However, the results of the Hausman test neither constitute a necessary condition nor a sufficient condition to run fixed versus random model. Finally, it is the researcher's decision to choose between fixed and random effect models. This conclusion may base upon the Hausman test, size of the data, number of units, number of observations per unit, level of correlation between the covariate and unit effect, and variation within unit in the independent variable relative to the dependent variable. Keeping in view all discussions of random vs fixed model, it is decided to use the random effect model. In the Hausman test, the P -value less than five percent does support to run a fixed effect model. We find that P -value is not less than five percent in all estimated models. Therefore, we use random effect model in this study.

Moderator variables. This study uses health expenditure as a moderator variable in the relationship between urbanization and life expectancy (male and female both). A moderator is a variable

Table 2 Summary statistics of variables.

Variable	Obs	Mean	Std. dev.	Min	Max
Lema	150	65.638	3.217	59.598	72.597
Lefe	150	69.703	4.716	61.315	80.111
He	150	47.486	37.553	8.362	162.108
Urb	150	2.928	1.442	0s.0474	6.957
Gico	150	39.737	5.068	33.00	48.700

Author's calculation.

Table 3 Country-wise mean life expectancy (years).

Life expectancy male					
Sr. #	Country			[95% conf. interval]	
1	India	65.292	0.584	64.137	66.447
2	Pakistan	62.392	0.253	61.891	62.894
3	Bangladesh	67.027	0.446	66.144	67.910
4	Sri Lanka	68.831	0.492	67.857	69.805
5	Nepal	64.410	0.498	63.425	65.395
6	Bhutan	65.874	0.677	64.536	67.212
Life expectancy female					
Sr. #	Country			[95% conf. interval]	
1	India	67.956	0.667	66.637	69.275
2	Pakistan	66.060	0.481	65.107	67.012
3	Bangladesh	69.873	0.707	68.475	71.270
4	Sri Lanka	77.480	0.417	76.655	78.305
5	Nepal	67.869	0.551	66.779	68.958
6	Bhutan	68.979	0.710	67.576	70.382
Life expectancy total					
Sr. #	Country	Mean	Std. Err.	[95% conf. Interval]	
1	India	66.556	0.618	65.334	67.779
2	Pakistan	64.112	0.362	63.396	64.829
3	Bangladesh	68.363	0.565	67.246	69.480
4	Sri Lanka	72.936	0.462	72.022	73.850
5	Nepal	66.162	0.536	65.103	67.222
6	Bhutan	67.318	0.700	65.934	68.702

Author's calculation.

Table 4 Correlation matrix.

	Lema	Lefe	Urb	Gico	He
Lema	1.000				
Lefe	0.901* (0.000)	1.000			
Urb	-0.488* (0.000)	-0.656* (0.000)	1.000		
Gico	0.348* (0.000)	0.531* (0.000)	-0.482* (0.000)	1.000	
He	0.740* (0.000)	0.775* (0.000)	-0.469* (0.000)	0.619* (0.000)	1.000

Author's calculation and * shows significance level at P = 0.05.

Table 5 Hausman test for life expectancy male.

	Fixed (b)	Random (B)	Difference (b-B)	S.E.
Urb	-0.814	-0.826	0.012	0.019
Gico	-0.486	-0.433	-0.053	0.044
He	0.0705	0.0704	0.0001	0.0004

Author's calculation.
 b = consistent under Ho and Ha; B = inconsistent under Ha, efficient under Ho.
 Test: Ho: difference in coefficients not systematic.
 $\chi^2(3) = (b-B)'[(V_b - V_B)^{-1}](b-B) = 1.59$ and Prob > $\chi^2 = 0.6626$; The value of Prob > $\chi^2 = 0.6668$ is not less than 0.05; The random effect model is accepted.

that can affect the strength or direction of the relationship between two variables. It is also known as an interactive variable. Jaccard et al. (1990) say that when the relationship between x and y depends on z, then the interaction effect occurs. Examples of moderator variables are in plenty in the field of social sciences. For example, education can act as a moderator in the relationship between technology and academic achievement. In the field of health, a moderator may explain the relationship between risk and life expectancy. Gender is a moderator in the relationship between smoking and lung cancer. Ahmad et al. (2021) find the firm size as a moderator in the relationship between ESG and the financial performance of firm. Ahmad et al. (2023) find the moderating role of ESG, corporate governance and firm size while estimating the impact of the global financial crisis on firm performance.

The effect size of the moderator can be measured as f^2 (Aiken and West, 1991), which is denoted as: $f^2 = (R^2_i - R^2_b)/(1 - R^2_i)$, where R^2_i = coefficient of determination of the interaction model and R^2_b = coefficient of determination of the basic model (without interaction). Cohen (1988) explains that effect sizes of 0.02, 0.15 and 0.35, respectively, are small, medium, and large. In the case of continuous variables, the effect size is very low (McClelland and Judd, 1993).

Robustness test. To check the robustness of the results, the three more econometric models are specified and estimated. In the first model, dependent variable is replaced with the life expectancy total. The explanatory variable, income inequality, is omitted in the second and third models, respectively. It is found that results are still significant in these three models. It explains that our results are robust.

Results and discussion

The summary statistics of variables are given in Table 2. This table explains that the mean value of life expectancy male and life expectancy female are, respectively, 65.6 and 69.7 years. The

mean value of urbanization growth is 2.92 percent annually, whereas per capita health expenditures are 47.48 dollars.

The detailed country-wise life expectancy is provided in Table 3. It explains that the mean life expectancy in Sri Lanka is 72.9 years, and it is the highest life expectancy in South Asian countries. The lowest life expectancy is found in Pakistan, which is 64.1 years.

The pairwise correlation coefficients of the variables are given in Table 4.

The values in brackets are the P-values of the correlation coefficient. All the coefficients are significant. The value of health correlation coefficients with life expectancy male and life expectancy female are respectively 0.740 and 0.775. It shows a high correlation among the variables.

Life expectancy male. This section explains the results of the regression model when life expectancy male is used as the dependent variable. The results of the Hausman test are demonstrated in Table 5. Based on the results of this test, the random effect model is suggested for estimation.

Results of model 1 and model 2 are provided in Table 6 when random effect generalized least regression is used. Here, the life expectancy male is the dependent variable.

Model 1 is without a moderator, and model 2 uses health expenditure as a moderator in the relationship between urbanization and life expectancy male. It is found that urbanization and income inequality has a negative impact on life expectancy, and this impact is significant. Per capita health expenditures have a positive and significant impact on life expectancy. Health expenditure significantly changes the direction of the relationship between urbanization and life expectancy. The interaction effect is found small and significant. It explains that the negative impact of urbanization can be reduced through health expenditures.

Life expectancy female

This section explains the results when life expectancy female is used as the dependent variable. The results of the Hausman test are demonstrated in Table 7. Based on the results of this test, the random effect model is suggested for estimation.

Table 8 explains the results of the random effect model using generalized least regression with and without moderator variable. It is found that urbanization and income inequality has a negative impact on life expectancy, and this impact is significant. Per capita health expenditure has a positive and significant impact on the life expectancy female.

Model 2 further explains the moderating role of health expenditure in the relationship between urbanization and life expectancy female. Health expenditure significantly moderates this relationship and explains that the negative impact of

Table 6 Random effects GLS regression (life expectancy male).

	Model 1				Model 2			
	Coef.	Std. err.	Z-value	P-value	Coef.	Std. err.	Z-value	P-value
Urb	-0.826	0.111	-7.41	0.000	-1.248	0.108	-11.51	0.000
Gico	-0.434	0.091	-4.75	0.000	-0.384	0.079	-4.86	0.000
He	0.070	0.004	17.28	0.000	0.024	0.006	3.57	0.000
He*Urb					0.025	0.003	7.80	0.000
Cons	81.951	3.720	22.03	0.000	80.529	3.257	24.72	0.000
For Model 1:	R ² Within = 0.792				Between = 0.088 Overall = 0.484			
	Wald chi2 = 543.28				Prob > chi2 = 0.0000			
For Model 2:	R ² Within = 0.856				Between = 0.004 Overall = 0.427			
	Wald chi2 = 832.36				Prob > chi2 = 0.0000s			
	Effect size = f ² = 0.099							

Author's calculation.

Table 7 Hausman test for life expectancy female.

	Fixed (b)	Random (B)	Difference (b-B)	S.E.
Urb	-1.171	-1.202	0.0312	0.0353
Gico	-0.339	-0.242	-0.0969	0.0794
He	0.069	0.069	-0.00001	0.0007

Author's calculation.

b = consistent under Ho and Ha; B = inconsistent under Ha, efficient under Ho; Test: Ho: difference in coefficients not systematic; chi2(3) = (b-B)'[(V_b-V_B)⁻¹](b-B) = 1.57 and Prob > chi2 = 0.667; The value of Prob > chi2 = 0.667 is not less than 0.05, random effect model is accepted.

urbanization can be reduced through health expenditures. In this case, the interaction effect is found moderate.

Comparison with other studies. In this section, results are compared with other studies. For example, Nasreen et al. (2012) conclude that life expectancy is negatively related to income inequality. The life expectancy is decreased by 0.65 years due to a one percent rise in income inequality. According to (Nejadlabaff et al. 2013), a reduction in income inequality by one percent can raise life expectancy by 0.0003 years. Haden (2015) explains that the Gini coefficient has a negative impact on the life expectancy female. The life expectancy female is reduced by 0.023 years due to a one percent increase in the Gini coefficient. Shmueli (2004) concludes that a one percent increase in the Gini coefficient reduces the life expectancy female by 0.171 years. Heden (2015) finds that a one percent rise in income inequality reduces the life expectancy male by 0.002 years. Hu et al. (2015) also find life expectancy male is negatively affected by income inequality. Dong et al. (2021) explain the negative impact of urbanization on health. Further, Bein et al. (2017) demonstrate a positive and strong relationship between health expenditure and life expectancy total. We explain the positive impact of these expenditures on life expectancy (male and female both).

Robustness of results. Three more models are provided in this section to check the robustness of the results. Life expectancy total is used as the dependent variable in the first model, and results are given in Table 9.

Our results are robust as we find that urbanization and income inequality has a negative impact on life expectancy,

and this impact is highly significant. Per capita health expenditure has a positive and significant impact on life expectancy. Further, the moderating role of health expenditure is confirmed in this relationship between urbanization and life expectancy.

We have estimated two more models by dropping out the income inequality from the vector of explanatory variables and their results are produced in Table 10. Model 1 explains the results of life expectancy male when used as the dependent variable and whereas model provides the information about life expectancy female when used as the dependent variable.

The results are robust as we find that urbanization and health expenditure in both models have a significant impact on life expectancy (male and female).

Conclusion and implications

This study explores the impact of urbanization and income inequality on life expectancy (male and female) in South Asian countries with the recent 25 years panel data from 1997 to 2021. The estimations of the study are based on the random effect-GLS model. Life expectancy male and life expectancy female are respectively used as dependent variables. Urbanization and income inequality are the independent variables, and health expenditure is the control variable. Further, the study finds the interaction effect of health expenditure with urbanization on life expectancy. Based on the mean value of life expectancy from 1997 to 2021, Sri Lanka achieved the highest life expectancy, and Pakistan is the lowest in this rank of South Asian countries. Regression results explain that urbanization and income inequality have a negative impact on life expectancy, and this impact is found to be significant. Health expenditures have a positive significant impact on the life expectancy male and life expectancy female. Further, health expenditures moderated the relationship between urbanization and life expectancy in both cases. The results of the study are found robust as experimented with three more econometric models.

Policy-makers may recommend solving the issues of urbanization in South Asian countries. Income inequality has a negative impact on life expectancy. It surges to redistribute income in South Asian countries to accelerate life expectancy. Government and health departments in South Asian countries are advised to allocate a health budget for the provision of health facilities, especially in urban areas, accordingly.

Table 8 Random effects GLS regression (life expectancy female).

	Model 1				Model 2			
	Coef.	Std. err.	Z-value	P-value	Coef.	Std. err.	Z-value	P-value
Urb	-1.203	0.166	-7.25	0.000	-1.812	0.169	-10.68	0.000
Gico	-0.242	0.130	-1.86	0.063	-0.097	0.105	-0.93	0.355
He	0.069	0.006	11.33	0.000	0.007	0.011	0.70	0.453
He*Urb					0.337	0.005	6.73	0.000
Cons	79.57	5.246	15.17	0.000	74.659	4.162	17.94	0.000
For Model 1:	R ² Within = 0.664 Wald chi2 = 287.52				Between = 0.726 Overall = 0.659 Prob > chi2 = 0.0000			
For Model 2:	R ² Within = 0.757 Wald chi2 = 419.47 Effect size = f ² = 0.282				Between = 0.385 Overall = 0.527 Prob > chi2 = 0.0000			

Author's calculation.

Table 9 Random effects GLS regression (life expectancy total).

	Model 1				Model 2			
	Coef.	Std. err.	Z-value	P-value	Coef.	Std. err.	Z-value	P-value
Urb	-0.986	0.133	-7.41	0.000	-1.511	0.129	-11.69	0.000
Gico	-0.338	0.107	-3.15	0.002	-0.252	0.089	-2.83	0.005
He	0.072	0.004	14.70	0.000	0.016	0.008	1.93	0.053
He*Urb					0.308	0.003	7.98	0.000
Cons	80.48	4.341	18.54	0.000	77.759	3.589	21.66	0.000
For Model 1:	R ² Within = 0.745 Wald chi2 = 420.90				Between = 0.475 Overall = 0.603 Prob > chi2 = 0.0000			
For Model 2:	R ² Within = 0.828 Wald chi2 = 663.97 Effect size = f ² = 0.236				Between = 0.151 Overall = 0.480 Prob > chi2 = 0.0000			

Author's calculation.

Table 10 Random effects GLS regression (life expectancy total).

	Model 1				Model 2			
	Coef.	Std. err.	Z-value	P-value	Coef.	Std. err.	Z-value	P-value
Urb	-0.904	0.118	-7.64	0.000	-1.247	0.165	-7.53	0.000
He	0.066	0.004	15.50	0.000	0.067	0.006	11.10	0.000
Cons	65.10	0.974	66.81	0.000	70.16	1.226	57.19	0.000
For Model 1:	R ² Within = 0.759 Wald chi2 = 447.50				Between = 0.420 Overall = 0.561 Prob > chi2 = 0.0000			
For Model 2:	R ² Within = 0.653 Wald chi2 = 280.41				Between = 0.750 Overall = 0.710 Prob > chi2 = 0.0000			

Author's calculation.

The agenda of future studies can explore the impact of pollution and environmental degradation on life expectancy in developed and developing countries.

Data availability

Data used in this study are collected from the World Development Indicators (WDI) and Standardized World Income Inequality Database (SWIID). These data sets are publicly available. The complete structured data set used may be supplied by the corresponding author upon request.

Received: 16 April 2023; Accepted: 28 July 2023;
Published online: 04 September 2023

References

Adjaye JA (2004) Income inequality and health: a multi-country analysis. *Int J Soc Econ* 31(1/2):195–207

Afzal M, Shafiq M, Ahmad N, Qasim HM, Sarwar K (2013) Education, poverty and economic growth in South Asia: a panel data analysis. *J Qual Technol Manag* 9(1):131–154

Ahmad N, Mobarek A, Roni NN (2021) Revisiting the impact of ESG on financial performance of FTSE350 UK firms: static and dynamic panel data analysis. *Cogent Bus Manag* 8(1):1900500

Ahmad N, Mobarek A, Raid M (2023) Impact of global financial crisis on firm performance in UK: moderating role of ESG, corporate governance and firm size. *Cogent Bus Manag* 10(1):2167548

Ahmad N, Shah FN, Ijaz F, Ghouri MN (2023) Corporate income tax, asset turnover and Tobin's Q as firm performance in Pakistan: moderating role of liquidity ratio. *Cogent Bus Manag* 10(1):2167287

Aiken LS, West SG (1991) *Multiple regression: testing and interpreting interactions*. Sage, Newbury Park

- Amin K (2001) Income distribution and health: a worldwide analysis. *Park Place Economist* 9(1):45–52
- Asteriou D, Hall S (2007) *Applied Econometrics: A Modern Approach*. Palgrave Macmillan, New York
- Baeten S, Van Ourti T, Van Doorslaer E (2013) Rising inequalities in income and health in China: who is left behind? *J Health Econ* 32(6):1214–1229
- Baltagi BH (2005) *Econometric analysis of panel data*, 3rd edn. John Wiley and Sons
- Bein MA, Unlucan D, Olowu G, Kalifa W (2017) Healthcare spending and health outcomes: evidence from selected East African countries. *Afr Health Sci* 17(1):247–254
- Bhattacharjee A, Shin JK, Subramanian C (2015) Health and income inequality: an analysis of public versus private health expenditure. *Int J Acad Res Bus Soc Sci* 5(8):11–19
- Chang S, Gao B (2021) A fresh evidence of income inequality and health outcomes asymmetric linkages in emerging Asian economies. *Front Public Health* 9:791960
- Child J (2013) Income inequality and health: is there an association? Undergraduate project, University of Nottingham (Econometric Project No. L13520)
- Cohen J (1988) Statistical power analysis for the behavioral sciences. Erlbaum, Hillsdale
- Crémieux PY, Ouellette P, Pilon C (1999) Health care spending as determinants of health outcomes. *Health Econ* 8(7):627–639
- Dong H, Xue M, Xiao Y, Liu Y (2021) Do carbon emissions impact the health of residents? Considering China's industrialization and urbanization. *Sci Total Environ* 758:143688
- Fayissa B, Gutema P (2005) Estimating a health production function for Sub-Saharan Africa (SSA). *Appl Econ* 37(2):155–164
- Government of Pakistan (2020) Pakistan demographic survey. Ministry of Planning, Development and Special Initiatives Pakistan Bureau of Statistics
- Gronqvist H, Johansson P, Niknami S (2012) Income inequality and health: lessons from a refugee residential assignment program. *J Health Econ* 31(4):617–629
- Grossman M (1972) On the concept of health capital and the demand for health. *J Polit Econ* 80(2):223–255
- Gulis G (2000) Life expectancy as an indicator of environmental health. *Eur J Epidemiol* 16:161–165
- Heden D (2015) Is income inequality an important health status determinant in the OECD? Master Essay, Lund University School of Economics and Management (NEKN06 No. 20142)
- Herzer D, Nunnenkamp P (2015) Income inequality and health: evidence from developed and developing countries. *Economics* 9(4):1–57
- Hu Y, Van Lenthe FJ, Mackenbach JP (2015) Income inequality, life expectancy and cause-specific mortality in 43 European countries, 1987–2008: a fixed effects study. *Eur J Epidemiol* 30(8):615–625
- Jaccard J, Helbig DW, Wan CK, Gutman MA, Kritz-Silverstein DC (1990) Individual differences in attitude behavior consistency: the prediction of contraceptive behavior. *J Appl Soc Psychol* 20(7):575–617
- Jakovljevic M, Groot W, Souliotis K (2016) Health care financing and affordability in the emerging global markets. *Front Public Health* 4:2
- Judge GG, Hill RC, Griffiths WE, Lutkepohl H, Lee TS (1988) *Introduction to the theory and practice of econometrics*. John Wiley, New York
- McClelland GH, Judd CM (1993) Statistical difficulties of detecting interactions and moderator effects. *Psychol Bull* 114:376–390
- Musgrove P (1993) Investing in health: the 1993 world development report of the world bank. *Bull Pan Am Health Organ* 27(3):284–286
- Nasreen S, Anwer S, Ahmad N (2012) Health status, income inequality and institutions: evidence from Pakistan economy. *Pakistan J Life Soc Sci* 10(2):139–144
- Nejadlabaf S, Hadian M (2013) Effect of inequality of income distribution on health status in selected countries using panel data analysis over the 1995 to 2008 period. *World Appl Sci J* 28:216–221
- Njoroge C (2020) Health expenditure and health outcomes in East and Southern Africa: does governance matter? *African Economic Research Consortium; Health Economics* (12). <https://publications.aercafricalibrary.org/xmlui/handle/123456789/1271>
- Nwosu CO, Oyenubi A (2021) Income-related health inequalities associated with the coronavirus pandemic in South Africa: a decomposition analysis. *Int J Equity Health* 20:21
- Olsen KR, Gyrd-Hansen D, Sørensen TH, Kristensen T, Vedsted P, Street A (2013) Organisational determinants of production and efficiency in general practice: a population-based study. *Eur J Health Econ* 14(2):267–276
- Onofrei M, Vatamanu A, Vintila G, Cigu E (2021) Government health expenditure and public health outcomes: a comparative study among EU developing countries. *Int J Environ Res Public Health* 18(20):10725
- Pakistan Maternal Mortality Survey (2019) Key indicators report. National Institute of Population Studies (NIPS), Islamabad and ICF, Rockville, p 2020
- Qasim M, Pervaiz Z, Chaudhary AR (2020) Do poverty and income inequality mediate the association between agricultural land inequality and human development? *Soc Indic Res* 151:115–34
- Rahman M, Khanam R, Rahman M (2018) Health care expenditure and health outcome nexus new evidence from the SAARC-ASEAN region. *Glob Health* 14:113
- Rana R, Alan K, Gow J (2018) Health expenditure, child and maternal mortality nexus; a comparative global analysis. *BMC Int Health Hum Rights* 18(1):1–5
- Shmueli A (2004) Population health and income inequality: new evidence from Israeli time-series analysis. *Int J Epidemiol* 33(2):311–317
- Tibber MS, Walji F, Kirkbride JB, Huddy V (2022) The association between income inequality and adult mental health at the subnational level—a systematic review. *Soc Psychiatry Psychiatr Epidemiol* 57(1):1–24
- Torre R, Myrskylä M (2011) Income inequality and population health: a panel data analysis on 21 developed countries (Working Paper No. 006). Max Planck Institute for Demographic Research, Rostock
- Uddin I, Azam KM, Tariq M, Khan F, Malik Z (2023) Revisiting the determinants of life expectancy in Asia—exploring the role of institutional quality, financial development, and environmental degradation. *Environ Dev Sustain*. <https://doi.org/10.1007/s10668-023-03283-0>
- United Nations Development Program (UNDP) (2019) Human development reports. <http://hdr.undp.org>
- United Nations (2022) Sustainable development goals report (2022). <https://unstats.un.org/sdgs>
- Wilkinson RG, Pickett KE (2006) Income inequality and population health: a review and explanation of the evidence. *Soc Sci Med* 62(7):1768–1784
- World Health Organization (1984) Health promotion: a discussion document on the concept and principles: summary report of the Working Group on Concept and Principles of Health Promotion, Copenhagen, 9–13 July 1984 (No. ICP/HSR 602 (m01)). WHO Regional Office for Europe, Copenhagen
- World Health Organization (2015) World health statistics 2015. World Health Organization. <https://apps.who.int/iris/handle/10665/170250>

Acknowledgements

The authors extend their appreciation to the Arab Open University for funding this research through research fund no. (AOURG-2023-001).

Author contributions

The corresponding author has a key role in structuring this article. However, all authors have a significant role in completing the article.

Competing interests

The authors declare no competing interests.

Ethical approval

This study is not related to human participants performed by any of the authors.

Informed consent

This study does not contain any study with human participants performed by any of the authors.

Additional information

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