OPERATIONS RESEARCH AND DECISIONS
No. 4 2021
DOI: 10.37190/ord210404

A PANEL DATA ESTIMATION OF THE DETERMINANTS OF LIFE EXPECTANCY IN SELECTED SAARC COUNTRIES

NUSRAT JAFRIN[1,2*], MUHAMMAD MEHEDI MASUD[1,3]
ABU NASER MOHAMMAD SAIF[4,5], MASNUN MAHI[1], MORIAM KHANAM[6]

[1]Faculty of Business and Economics, Universiti Malaya, Kuala Lumpur, Wilayah Persekutuan 50603, Malaysia

[2]Department of Population Sciences, Faculty of Social Sciences, University of Dhaka, Bangladesh

[3]Department of Business Administration, Daffodil International University, Dhaka, Bangladesh

[4]School of Business and Economics, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia

[5]Department of Management Information Systems, Faculty of Business Studies, University of Dhaka, Nilkhet Rd., Dhaka 1000, Bangladesh

[6]Institute of Health Economics, University of Dhaka, Nilkhet Rd., Dhaka 1000, Bangladesh

The precarious and decisive dynamics concerning the health of the population of South Asian Association for Regional Cooperation (SAARC) countries has called for further inquiry into the determinants of life expectancy (LE) in this region. Hence, the current paper employs the panel data estimation methods to analyse the economic, social, demographic, environmental, and technological factors influencing LE in five SAARC countries. These countries (Bangladesh, India, Pakistan, Nepal, and Sri Lanka) are selected as they are favoured by the country similarity theory and other identical contexts. Available secondary data from 2000 to 2016 were obtained from the World Bank and UNDP databases for the specfic countries. The results reveal that the mean year of schooling and sanitation services are significant positive predictors of life expectancy at birth (LEAB). However, the total fertility rate, urban population, and CO_2 emissions negatively influence life expectancy. Furthermore, the impact of health expenditure on life expectancy is significant but negative, which is unconventional. On the other hand, other independent variables, such as GDP, gross capital formation, internet usage, and mobile cellular subscription turn out to be insignificant predictors of LEAB. Our aggregate findings reveal some common factors on which the governments of SAARC countries can collaborate to improve the LEAB of the region while identifying some idiosyncratic factors that require tailored attention of the governments and policymakers of the respective nations.

Keywords: *life expectancy, economic, social, demographic, environmental, technological, SAARC countries*

[*]Corresponding author, email address: nusrat_dps@du.ac.bd
Received 1 October 2021, Accepted 30 November 2021

1. Introduction

The number of years that a newborn is anticipated to live provided that the mortality patterns remain the same throughout the infant's lifetime is known as life expectancy at birth [8, 65]. In evaluating the health status of the population in developed and developing nations, life expectancy (LE) is commonly considered [29]. It is also used as a synthetic parameter in the assessment of the economic and social advancement of a country or region [16, 8, 6, 29]. Generally, international organisations extensively use life expectancy at birth (LEAB) as an overall indicator of the development of a nation [5]. Health is one of the most vital assets of human beings and its degradation or incomplete development can result in physical and emotional weaknesses that impair the full utilisation of human capabilities [44]. By and large, the impact of health status and expected lifespan on overall economic growth is well recognised due to several dynamics. First of all, healthy individuals who are energetic, creative, and mentally strong can easily enhance their income levels. Second of all, healthy populations support economic development through increased savings and their longevity spurs post-retirement investment. Lastly, as compared to the less healthy population, healthier people tend to invest more in knowledge, skills and expertise which raises their earning power and promotes rapid economic progress [49]. Consequently, sustainability, improvement, and refinement of the health status of a population have been deliberated as key strategies for sustainable development in developing economies [6].

In recent decades, LEAB has received global attention, with the discovery of disparity in LE particularly between developed and developing nations [8, 43, 37]. For instance, a 19-year gap exists in the LEAB between low and very high human development countries [60]. This disparity is believed to have its roots in different socio-economic backgrounds of various social constellations, such as poverty status and living arrangements. In other words, the socio-economic and environmental aspects have an independent and interactive impact on LE levels [8, 43]. Moreover, high inequalities in life expectancy exist within developing and developed countries [60]. It is noteworthy that LEAB is a continuous parameter that varies over time, implying that the country with the highest (frontier) LEAB changed several times [35].

SAARC countries, also known as South Asian nations, have been experiencing demographic, epidemiologic, and socioeconomic changes over the last few decades [23, 17, 51, 10]. This region constitutes a large portion of the world's population, and its LE (see Fig. 1), which has been increasing over the last decades [62], has drawn the attention of many public health experts. As shown in Fig. 1, Sri Lanka and Maldives have higher LEAB, while Bangladesh, India, Pakistan, Nepal, and Bhutan have almost similar LEAB from 2000 to 2016. Afghanistan has been reported with the lowest LEAB during the period. However, overall, the LEAB of the eight SAARC nations has increased over time, which may have resulted from the substantial declines in early deaths or disabilities from contagious diseases [55]. In addition, economic transition, urbanisation, and lifestyle changes also contribute to the improved LEAB [62].

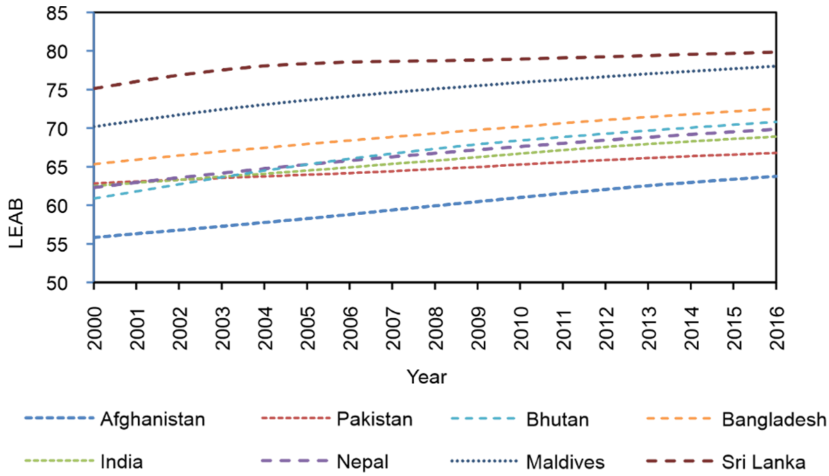

Fig. 1. LEAB for SAARC countries during the period 2000–2016.
Source: World Development Indicators 2019

Despite the multiplicity in their geographical, language, and political arrangements, countries such as Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka encounter almost similar health challenges [51, 55]. For instance, in this region, there remain some transmittable diseases, maternal health and nutritional deficiencies that contribute to disease burdens [55]. Furthermore, due to the demographic and epidemiologic transition patterns in the region, non-communicable diseases (NCDs) such as pre-diabetes, metabolic syndrome, diabetes, cardiovascular disease, along with mental health disorders are gradually becoming a threat to the region's population health [62, 55, 23, 17].

It is, therefore, decisive to ascertain the dynamics contributing to the better health of the population for further sustainable development in the SAARC region. Besides, previous studies [48, 17, 23, 55] conducted in SAARC or South Asian region were not focused on the determinants of life expectancy. Hence, this paper undertakes the panel data estimation methods to analyse the determinants of LE in the selected five nations[1] of the South Asian region. The conceivable social, economic, environmental, demographic, and technological determinants of LEAB were collectively considered in a single model of life expectancy.

[1]The rationales behind choosing the five countries are illustrated in Section 3.

2. Review of literature

Several studies having been conducted to this date determine the factors of life expectancy in various countries and regions. For instance, the socio-economic bases of LE in 91 developing states are examined by Kabir [30], and it is discovered that per capita earning, education level, health expenditures, access to safe drinking water, and urbanisation have a statistically insignificant impact on the LE in developing countries. Thus, the paper advocated that nations should design guidelines and strategies to enhance physicians' readiness to save lives while decreasing adult illiteracy and undernourishment to improve their life expectancies. On the other hand, Barlow and Vissandjee [5], through a multivariate cross-national analysis in 1990, reveal that knowledge, per capita income, and access to safe drinking water have positive and significant effects on LE. Moreover, while this paper highlights productiveness and humid climate settings as having negative significant effects, per capita spending on health and degree of urbanisation are considered relatively weak elements of life expectancy.

Rizzo [49] examines numerous socioeconomic elements of LE in 34 low-income nations and discovers that subsidised health expenditures, access to basic health facilities, predominance of HIV, urbanisation, education, and sex are significant measures promoting life expectancy, while foreign aids, corruption, and undernourishment are found to be immaterially connected to life expectancy. Monsef and Mehrjardi [44] examine the factors of LEAB in 136 countries from 2002 to 2010 using panel data techniques and discover that unemployment and inflation affect LEAB deleteriously, as opposed to gross capital formation and gross national income. Besides, urbanity is found to lower LEAB, while CO_2 emission has an insignificant effect.

In Iran, the LEAB is found to be positively and significantly affected by the GDP per capita, the number of physicians per 10 000 inhabitants, the extent of literacy and the availability of food from 1985 to 2013. It is also discovered that the total fertility ratio had a negative and significant impact on the LEAB. In contrast, the effects of the degree of urbanisation, CO_2 emission, and inflation rate on LEAB are found to be insignificant [15]. In Turkey (from 1965 to 2005), nourishment, food accessibility, and health expenditures were identified as the key positive elements for longevity, while smoking appears to be the prime cause of mortality [21]. A study conducted in Nigeria from 1980 to 2011 highlights that orthodox socio-economic variables such as per capita income, schooling, and government expenditures on health has an insignificant effect on LEAB, as opposed to unemployment and nominal exchange rates, which affect the expectancy of life [53]. Ali and Ahmad [1] probe the impact of food production, schooling, inflation, population growth, per capita earnings, and CO_2 emissions on the LE of Omanis from 1970 to 2012. The outcomes suggest that food production and school enrolment against population growth have a positive and significant influence on the expectancy of life. However, the impact of CO_2 emissions varies between the short and long run, as the relationship between CO_2 emissions and life span in Oman is found to be significant and negative in the short run, but positive and insignificant in the long run.

A paper exploring the countrywide data of 31 European nations reveals that the social protection expenditure, not the healthcare expenditure, is the prime element of LEAB [61]. Citizens of countries that expend a high percentage of their GDP on social protection and have fewer restorative beds and low infant mortality exhibit a substantially longer life expectancy [61]. Also, Zare, Gaskin, and Anderson [66] highlight that spending on healthcare significantly enhances LE in Economic Co-operation and Development (OECD) countries from 1985 to 2010. The outcome of the paper also indicates that the GDP per capita, labour efficiency, years of schooling, and percentage of GDP spendings allocated for public services are vital factors influencing life expectancy, while political factors have only a minor effect. It is also discovered that expectancy of life is reduced by smoking and high daily calorie ingestion [66]. Moreover, Jaba, Balan, and Robu [27] report a significant connection between the health outlays and LE in 175 countries from 1995 to 2010 using panel data analysis.

Kerdprasop and Kerdprasop [32] examined the life expectancy in ASEAN countries from 1990 to 2015 and identified the proportion of forest region and GDP growth as being the key elements promoting life expectancy in Cambodia; the proportion of arable land, GDP growth and the extent of CO_2 emissions in Lao PDR; CO_2 emission in Thailand; and CO_2 emissions, HDP growth and forest area in Vietnam. In the eastern Mediterranean region, it was observed that the income per capita, education index, food accessibility, the extent of urbanization and employment ratio were the indicators of health status [6].

Bilas, Franc, and Bošnjak [8] explored the bases of LEAB in 28 European Union countries from 2001 through 2011. The authors highlighted that the GDP per capita and level of education were significant factors affecting LEAB, while the impact of population growth, GDP growth, and enrolment rates for higher education were insignificant. The substantial forecasters of LE in the 91 low and lower-middle-income countries in 2012 were HIV dominance rate, total fertility rate, mean year of schooling, and GNI per capita [42].

Husain [26] discovered that the enhancement of levels of literacy in developing countries increased LE at a persistent rate. Health expenses and per-capita calorie ingestion have a substantial positive impact on LE, while a significant and negative connotation was discovered between fertility and LE. Rogers and Wofford [50] investigated the factors of LE in 95 less-developed countries using socioeconomic development indicators such as urbanization, industrialization, and education as well as public health parameters such as access to safe water, number of available physicians and satisfactory level of nutrition. The outcome advocated that socioeconomic factors and public health indicators unswervingly affect the LE in LDCs, with the socioeconomic variables being more dominant.

A study examined the longitudinal contributions of GDP, literacy rate of adults aged 15 years and above, the fraction of malnourished individuals in the population and political elements to the LE in 119 less-developed countries (LDCs) between 1970 and 2004 [37]. The outcome suggested that the life expectancy in LDCs increases over time and is linked to all four factors. The political system had the least effect on the augmented LE at the onset, but became noteworthy and continued to rise; on the other hand, the impact of other socioeconomic factors got stronger but recurrently declined over time [37]. Another study led by Mondal et al. [43] scrutinized the relationship between socio-demographic and health factors and LE in 48 least-developed countries (LDCs). The result identified death rate, infant mortality rate, physicians' availability and gross national income per capita as the major predictors of LE in these nations. Hassan et al. [22] revealed that health expenses, GDP, education index, improved water coverage and improved sanitation have a positive relationship with LE in 108 developing nations from 2006 to 2010.

The linkage between environment and health is unprecedented, and numerous researchers, predominantly environmental epidemiologists, have been working on this topic for a long time at international and local levels [20]. However, Gulis [20] observed that literacy as a reflection of the social environment and access to safe drinking water as a depiction of the natural environment are the two major variables influencing LE in the multivariate linear regression model. The study by Mariani, Pérez-Barahona, and Raffin [40] probed the relationship between LE and the environment, and the findings proposed that LE and environmental dynamics can be jointly determined. From 2003 to 2010, it was discovered that air quality might have contributed extensively to the LE in 113 major cities, covering all provinces in China [63]. Bai et al. [4] scrutinized the variation in LE among countries that fall under the Belt and Road (B&R) initiative and explored the influence of economic progress on their LE from 2000 to 2014. Bai et al. [4] observed that the unemployment rate was positively associated with LE only in countries that are in the top LE quantiles; whereas, the GDP growth and inflation were negatively related to LE in nations that are in the lowest LE quantiles for men, but not for women. Overall, the LE continued to grow in the B and R nation-states, while the extent of the rise was found to be mixed [4].

In our society, the use of internet plays a significant role as a medium of communication [24]. It has become a medium of knowledge creation and also a sharing platform acting as an intermediary between LE and economic progression [2]. To corroborate this, the study led by Alzaid et al. [2] identify a positive relationship between internet usage and the LE of individuals. Moreover, the economic state of a country has a direct and indirect effect on LE, since it can be influenced by internet usage. Singh et al. [56] also identify a correlation between hi-tech advancement and LE. Their study investigates the consequences of internet-related facilities (broadband, mobile phone and Internet security) on LE based on panel data of sixteen Asian countries from 2009 to 2014.

The outcome advocates that each of the three factors has a somewhat positive relationship with LE, which conforms to the interpretations of the current literature [36].

As based on the existing literature, the elements of LEAB can be categorised into social economic, demographic, and environmental dimensions [41, 44]. Furthermore, the technological factor has become a crucial element in recent years. Although some studies examine the determinants of LEAB in developing nations, there is a dearth of literature in this field, especially for SAARC countries. In this respect, this study examines the relationship between LEAB and selected economic, social, environmental, demographic, and technological factors, using the panel data method due to its discerning statistical properties and the least-squares method to run the regression [47, 3]. We expect the effects of these factors on LEAB to conform with that of the existing literature.

3. Data and methods

Grossman [18] developed a model for health production, given that health represents a long-lasting capital stock that yields an output of healthy time. Generally, the health production function is a useful tool for estimating the health status of a nation, and contains some inputs and outputs. For instance, LEAB or morbidity is considered as the output of the health production function, while inputs include healthcare, education, environment, lifestyle, medical and health expenditures, and genetic factors [1]. Therefore, the LEAB is the most used variable in the characterisation of health output and represents a broad measure of a nation's health status [44, 21, 16].

In line with the methods and procedures of the existing literature [18, 16, 21, 44, 1, 22], this paper considers the model which captures the influence of economic, social, demographic, environmental, and technological factors on the LEAB in SAARC countries:

$$\mathrm{LEAB} = f\,(GDP, GCF, HE, MYS, TFR, UP, CO_2, SAN, IUP, MS) \tag{1}$$

where LEAB is the life expectancy at birth, *GDP* – the gross domestic product and *GCF* – the gross capital formation. Also, *HE, MYS, TFR*, and *UP* represent the health expenditure, mean years of schooling, total fertility rate, and urban population, respectively. The CO_2 means $\mathrm{CO_2}$ emissions, *SAN* denotes the sanitation services, *IS* is the internet usage, and *MC* indicates the mobile cellular.

As based on the above model, the current study developed the conceptual framework for the determinants of LEAB (Fig. 2).

To investigate the economic, social, demographic, environmental, and technological determinants of LEAB in the SAARC region, we use the panel data method and obtain the available yearly data (from 2000 to 2016) of all variables for Bangladesh, India, Nepal, Pakistan, and Sri Lanka. These five nations were chosen because they share a similar level of development [45, 58] as stated and argued in the country's similarity theory [38, 52]. However, according to the World Bank [64], Afghanistan and Maldives are classified as low-income and upper-middle-income countries, respectively. As a lower-middle-income country, Bhutan has the second-lowest population with the second-lowest territory in terms of land area among the eight countries [65]. Besides, data availability also permits the researchers to include Bangladesh, India, Pakistan, Nepal, and Sri Lanka as the most applicable countries for current research.

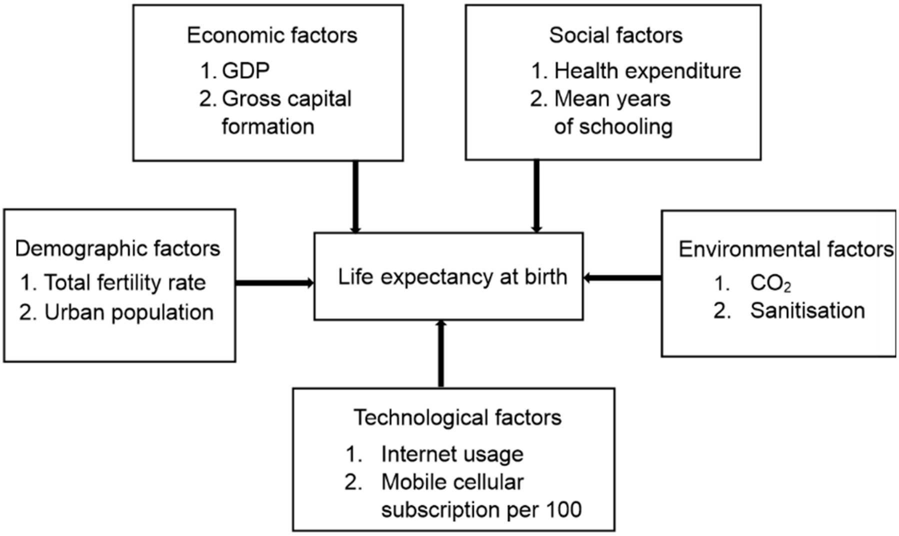

Fig. 2. Determinants of LEAB

The datasets are collected from the World Bank and United Nations Development Programme (UNDP). Using the pooled OLS method, the following model is specified for empirical investigation:

$$\begin{aligned} \text{LEAB}_{it} = a + \beta_1 GDP_{it} + \beta_2\, GCF_{it} + \beta_3\, HE_{it} + \beta_4\, MYS_{it} + \beta_5\, TFR_{it} \\ + \beta_6\, UP_{it} + \beta_7 CO_{2it} + \beta_8 SAN_{it} + \beta_9\, IUP_{it} + \beta_{10}\, MS_{it} + \varepsilon_{it} \end{aligned} \tag{2}$$

where i and t indicate the individual country and time, respectively. The LEAB is the dependent variable in our study. Along with the dependent variable, other variables and their pertaining definitions are presented in Table 1.

Table 1. Description of variables

Variable	Meaning	Definition	Source
LEAB	life expectancy at birth total, years	the expected lifespan (in years) of a new-born provided that the mortality patterns remain the same throughout the infant's lifetime	1
GDP	GDP growth, annual %	the annual percentage growth rate of a country's GDP calculated in constant (2010 USD) local currency	
GCF	gross capital formation, % of GDP	net changes in the inventories, plus outlays on addition to the fixed assets of a country	
HE	current health expenditure, % of GDP	the annual percentage value of a country's health expenditure (i.e., healthcare goods plus services) in a year to its GDP	
MYS	mean years of schooling, years	the average duration schooling (in years) received by a person (25 years and above) in his or her lifetime; the average expected duration of schooling (in years) of a child at the school--entry age provided that the age-specific enrolment patterns and rates remain the same throughout the child's life	2
TFR	fertility rate, total, births per woman	number of children that would be born to a woman provided that she remains alive till the end of her childbearing years and bear children following age-specific fertility rates of the specified year	1
UP	urban population, % of total	people living in urban areas as defined by national statistical offices	
CO_2	CO_2 emissions, metric tons per capita	the per capita CO_2 produced (in metric tons) through gas flaring and consumptions of solid, liquid and gas fuels	
SAN	population using at least basic sanitation services, %	the proportion of household in a population (in percentage) with improved personal sanitation facility in which excreta are safely disposed of in site or treated off-site	2
IUP	individuals using the internet, % of the population	the proportion of total population (in percentage) with access to internet in the last three months, from any location and in any medium (ie, computer, mobile phone and others)	1
MS	mobile cellular subscriptions, per 100 people	total number of users (per 100 people) of mobile cellular subscriptions that offer voice communications, excluding data cards, USB modems, public mobile data services, private trunked mobile radio, telepoint, radio paging, and telemetry services	

1 – World Bank, 2 – United Nations Development Programme.

4. Results

4.1. Descriptive statistics

The descriptive statistics (Table 2) shows the features of all variables that are used in this paper. Specifically, it presents the total number of observations, the mean values, standard deviations, the minimum values and maximum values for each variable.

In our sample, all variables have a total of 85 observations, and the average LEAB of the countries is 68.92, with a minimum and maximum of 62.28 and 79.83, respectively. The range between the minimum and the maximum value of LEAB indicates the presence of a moderate variation in the LEAB of the SAARC countries. On the other hand, varied characteristics of the explanatory variables are observed in the study.

Table 2. Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
LEAB	85	68.921	5.317	62.288	79.835
GDP		5.078	2.04	–2.244	9.004
GCF		27.322	7.415	14.121	41.951
HE		3.494	0.977	1.987	6.294
MYS		5.712	2.616	2.4	11
TFR		2.913	0.784	2.027	5.037
UP		25.685	7.489	13.397	36.234
CO_2		.684	0.443	0.098	2.01
SAN		39.918	11.185	15	59
IUP		6.875	6.577	0.071	25.8
MS		39.883	36.177	0.043	122.72

It is noted that economic factors such as *GDP* and *GCF* exhibit substantial variation. Some countries experience negative economic growth (–2.244%), with the capital formation varying between 14.121 and 41.951% during the period of analysis. As compared to economic factors, the sample countries differ less markedly in the social aspect. Also, the mean values of the social factors (*HE* and *MYS*) denote that countries spend approximately 3.494% of their revenue on health services. At the same time, the students spend roughly 5.712 years in the formal education system on average. Besides, it is observed that the countries only slightly differ demographically in terms of fertility rates. However, there is a noticeable difference in the population's geographic distribution–people living in urban areas vary between 13.397% and 36.234%, with a mean value of 25.685%. Similarly, the sample countries show a somewhat comparable environmental scenario, with a slight variation in the level of CO_2. Nevertheless, the countries depict a distinctly contrasting scenario in terms of basic sanitation levels given the minimum and maximum values of 15 and 59%, respectively, and an average value of 39.918%. While other factors show comparable results, we discover that the sample countries mostly differ in terms of their technological advancements. In particular, the usage of mobile phone subscriptions experience rapid growth during the period of analysis; the highest value of 122.72 for the variable MS signifies the existence of over 100 registered subscriptions per 100 people in some countries. Moreover, internet usage witnesses a notable rise, as the value of IUP ranges from 0.071 to 25.8%. However, the average use remains relatively low, with the variable having a mean value of 6.875%.

The correlation matrix (Table 3) indicates that the LEAB has a positive correlation with the *GDP*, *GCF*, *HE*, *MYS*, *SAN*, *IUP*, and *MS*. On the other hand, LEAB is negatively associated with *TFR*, *UP*, and CO_2. It also depicts that none of the correlation coefficients exceeds 0.80, indicating that multicollinearity is not a serious issue in this model [30].

Table 3. Correlations matrix

	LEAB	*GDP*	*GCF*	*HE*	*MYS*	*TFR*	*UP*	CO_2	*SAN*	*IUP*	*MS*
LEAB	1.000										
GDP	0.022	1.000									
GCF	0.244	0.376	1.000								
HE	0.173	–0.226	0.494	1.000							
MYS	0.800	0.051	0.152	0.101	1.000						
TFR	–0.696	–0.198	–0.694	–0.350	–0.529	1.000					
UP	–0.413	0.237	–0.310	–0.686	–0.259	0.410	1.000				
CO_2	–0.016	0.292	0.181	–0.121	0.244	0.036	0.545	1.000			
SAN	0.473	0.027	0.118	0.031	0.424	–0.286	0.222	0.365	1.000		
IUP	0.368	0.103	0.304	0.157	0.327	–0.329	0.146	0.428	0.800	1.000	
MS	0.504	0.048	0.330	0.147	0.416	–0.462	0.790	0.322	0.789	0.780	1.000

According to Kleinbaum et al. [34], a variable is supposed to be highly collinear when the value of variance inflation factor (VIF) is more than 10. This situation creates the problem of multicollinearity [30]. However, the VIF values of all independent variables in our study do not exceed the threshold level of 10, indicating the absence of multicollinearity issue in the model as shown in Table 4.

Table 4. Variance inflation factor

Variable	*MS*	*IUP*	*SAN*	*UP*	*GCF*	*TFR*	CO_2	*HE*	*MYS*	*GDP*	Mean *VIF*
VIF	7.228	7.217	6.762	6.506	4.620	4.317	3.843	3.614	3.525	1.713	5.221
1/*VIF*	0.138	0.139	0.148	0.154	0.216	0.232	0.260	0.277	0.284	0.584	0

4.2. Results of the pooled OLS and random effects

Findings from the pooled OLS and the random-effect model are presented in Table 5. The selection of the exact model was favoured by the Breusch and Pagan Lagrangian multiplier (LM) test. The pooled OLS model assumes the absence of correlation between the error terms and the absence of difference between the cross-sectional and time series [22].

H0: $\sigma 2_{\lambda} = 0$ (pooled OLS model is preferred),
Ha: $\sigma 2_{\lambda} > 0$ (random effect is preferred).

As shown in Table 5, the null hypothesis is accepted because the *p*-value is 1.000; consequently, the pooled OLS is more appropriate in this study. Table 5 also shows the determinants of LEAB in the selected SAARC nations. The R-squared value is 0.90, indicating that 90% variation in the dependent variable can be explained by all independent variables.

The results indicate that *MYS* and *SAN* have a significant positive impact on the LEAB at 1% level of significance. The results imply that an increase in the mean year of schooling and sanitation services will increase the LEAB. Furthermore, *TFR*, *UP*, and CO_2 negatively and significantly affected the LEAB at a 1% level of significance.

Table 5. Results of the pooled OLS and random effects (RE)

Variable	OLS	RE
GDP	0.0225	0.0225
	(0.0406)	(0.0497)
GCF	8.58×10^{-5}	8.58e–05
	(0.0215)	(0.0225)
HE	–0.489***	–0.489***
	(0.173)	(0.151)
MYS	1.561***	1.561***
	(0.0545)	(0.0556)
TFR	–1.335***	–1.335***
	(0.253)	(0.205)
UP	–0.0831***	–0.0831***
	(0.0300)	(0.0264)
CO_2	–2.611***	–2.611***
	(0.362)	(0.343)
SAN	0.0750***	0.0750***
	(0.0182)	(0.0180)
IUP	–0.00144	–0.00144
	(0.0271)	(0.0316)
MS	0.00712	0.00712
	(0.00568)	(0.00680)
Constant	66.13***	66.13***
	(1.824)	(1.612)
Breusch–Pagan LM test for RE (*p*-value)		1.000
Observations	85	
R-squared	0.904	

Robust standard errors are indicated in parentheses. The asterisks *** denote the level of significance at the 1% level.

These findings suggest that a decrease in the total fertility rate, urban population and CO_2 emissions will lead to an increase in the LEAB. However, *HE* has a negative and significant impact on the LEAB at 1% level of significance, which is unconventional. The impact of other independent variables such as the GDP, GCF, IUP, and MS on the LEAB are found to be of no statistical significance.

5. Discussion

This study analyses the determinants of LEAB in the selected SAARC countries from 2000 to 2016, using panel data estimation. Findings from the pooled OLS analysis indicate that economic variable such as the GDP growth rate does not significantly influence the LEAB in Bangladesh, India, Pakistan, Nepal, and Sri Lanka. These results are consistent with those reported by Bilas et al. [8]. While the LEAB of a nation can be influenced by GDP, it is also important to determine how the actual amount of GDP is utilised [14]. Moreover, income inequality across countries remains an important factor influencing LE [7]. However, it has been discovered that rising incomes and personal well-being have an inverse relationship, implying that economic growth hampers people's well-being across the world [28]. The gross capital formation is an insignificant variable having zero influence on LEAB; this is in contrast to the findings of Monsef and Mehrjardi [44], which reported a significant effect of gross capital formation on LEAB. Thus, constructive policies and instruments are needed to influence the economic environment towards an enhanced LE in these nations.

Both social variables (health expenditure and mean year of schooling) were found to exhibit a significant effect, albeit in a different direction. For instance, health expenses negatively influence the LEAB, implying that an increase in health expenditure will result in a decrease in LEAB. This finding is consistent with the study of Kabir [30]. In contrast, a study conducted by Rahman et al. [48] finds that diet, lifestyle, and education rather than healthcare expenditure have significant impacts on LEAB in the SAARC-ASEAN region. Also, Barlow and Vissandjee [5] discover that the per capita health expenditure has a mild effect on the LEAB. This observation could be attributed to the lower health budget allocation of these nations. For example, in 2018, the budgetary allocations for health in Bangladesh, India, Pakistan, Sri Lanka, and Nepal are 0.8, 1.4, 0.9, 2, and 2.3%, respectively, [12]. The allocations are lower as compared to the global average standard [57]. Moreover, due to the low public expenditure on healthcare, these nations suffer from a lack of medicines, equipment and medical staff, particularly in the rural and sub-urban areas [57].

In our model, the mean year of schooling positively influences the LEAB, which is supported by previous studies [42, 26]. Educated individuals are more cautious about their health, resulting in their adoption of a healthy lifestyle for improved longevity.

However, Kabir [30] discovers that education is statistically insignificant and has no influence on the LE in developing countries. Another study conducted in European Union countries by Bilas et al. [8] finds a negative impact of educational attainment on LE. In justifying the result, the researchers explain that educated people usually perform more complex and responsible tasks for longer working hours, which could lead to more stress and less physical activity [8]. However, it is also important to account for the accurate classification of literacy [49], as further studies can be undertaken with the different categories of education levels to determine the in-depth effects of education on LE.

In our panel data estimation, both demographic variables (total fertility rate and urban population) negatively affect the LEAB in the five nations of the SAARC region. This suggests that an increase in the total fertility and urban population will result in a decline in the LEAB. These findings are consistent with the studies of Rizzo [49], Monsef and Mehrjardi [44], Mondal and Shitan [42], and Delavari et al. [15]. The highlighted countries in this research domain are in a demographic dividend phase; hence, these nations experience lower fertility and mortality rates, and a higher LEAB. Moreover, during the demographic dividend phase, people's attitudes towards life change [10, 9]. The impact of urbanisation on LE is very important for developing countries, as urbanisation helps urban citizens of developing nations attain improved healthcare, quality education and other enriched socio-economic facilities. All these have a positive impact on health status [30]. However, it is also essential for developing nations to maintain the quality of urban life for a favourable effect on their LE. For instance, Rogers and Wofford [50] observe that urbanisation is less influential in predicting LE owing to the unhealthy condition of cities in developing countries.

Carbon emission (CO_2) is discovered to have a significant negative influence on the LEAB in this study; this is supported by Kerdprasop and Kerdprasop [32]. On the contrary, Monsef and Mehrjardi [44], Ali and Ahmad [1] discover CO_2 emissions to be of no significance to LE. Generally, the adverse effects of climate change on human lifestyle, food production and human health can threaten the average lifespan, particularly in developing nations. Recently, developing nations suffer from air pollution, which ultimately affects the health status of the people. As compared to developed nations, massive unplanned urbanisation and rapid industrial development cause air pollution in developing countries [39]. However, the other environmental factor (i.e., sanitation service) has a positive and significant influence on the life expectancy at birth, which is consistent with other studies [49, 22]. A possible explanation is that improved sanitation plays a significant role in reducing the burden of diseases and mortality rates, thereby enhancing the longevity of the population in a country or region [54]. Thus, the developed countries invest more in water and in sanitation systems to maintain good health status as well as environmental quality [22]. Recently, South Asian countries have achieved remarkable progress in sanitation following their renewed effort towards improved sanitation services. As an instance, the rate of open defecation reduced by over 30% in

India, Bangladesh, Nepal, and Pakistan. Despite the progress, a large number of people (610 million) still practise open defecation in South Asia, constituting over 60% of the global burden [57].

In this paper, neither the use of the Internet nor mobile phone has a significant effect on the LEAB, which is inconsistent with the existing literature [2, 36]. Generally, the proliferation of e-Health through the Internet for the patients' medical management, personalised healthcare management, and intelligent observation systems can improve health outcomes [11]. However, the insignificant impact of these variables signifies the infrequent use of the Internet or mobile for health-related activities in these mentioned nations; in other words, these less-developed nations still struggle to grip the benefits of healthcare facilities through the Internet [13]. While technology is fast-evolving with several potential impacts on health, its adoption in developing economies is lesser as compared to the developed nations [60]. Countries like Bangladesh and Pakistan are experiencing challenges in the utilisation of e-health facilities basically from the end--users' perspectives [33, 25]. Similar findings are reported, with the non-acceptance of m-healthcare services that are supported by mobile devices in these South Asian countries [19, 31].

6. Conclusion and policy implications

This study examines selected macro determinants of life expectancy at birth in Bangladesh, India, Pakistan, Nepal, and Sri Lanka from 2000 to 2016. The Panel data estimation indicates that social, demographic, and environmental factors mostly influence the LEAB in these five countries, while the economic and technological factors insignificantly influence the LEAB. As based on the findings, this research article draws specific policy implications for the studied countries to improve their health outcomes through augmented LEAB. Although the countries perform well in terms of GDP growth and per capita income, their life expectancy is comparatively lower. To address this, in line with the achievement of sustainable development goal 3, the respective government should not only ensure budgetary allocation for the health sector but also supervise the expenditure of apportioned funds. Likewise, despite their technical acquaintance, people still fail to utilise technology for different health-related services that will lead to superior life expectancy. Consequently, there is a call for SAARC countries to develop their infrastructure to leverage technology for the augmented life expectancy.

Generally, developed nations invest more in their health, education, environment, and sanitation, all of which have a positive impact on LEAB [1]. SAARC nations can also emulate similar development paths. Historically, these nations suffer from a lack of evidence-based policies and social accountability [51] that depicts a fragile situation in the overall health sector. Hence, an urgent and effective policy reformulation is required to reduce inequalities in the health sector and consequently achieve a sustainable life expectancy for the nationals of SAARC countries.

While this study has contributed important practical knowledge, it is not bereft of some limitations. First, the current research covers a short period of observations. Second, due to the lack of available and analogous data, we were unable to include all countries of the SAARC region as well other variables such as adult literacy, number of physicians, smoking and alcohol intake in our model. Lastly, few missing values were exposed through extrapolation, which could slightly affect the results of the study.

References

[1] ALI A., AHMAD K., *The impact of socio-economic factors on life expectancy in sultanate of Oman. An empirical analysis*, Middle-East J. Sci. Res., 2014, 22 (2), 218–224.

[2] ALZAID A., KOMAL K., AL-MARAGHI A., ALSULAMI M., *Examining the relationship between the internet and life expectancy*, 24th International Business Information Management Association Conference Crafting Global Competitive Economies, Milan, Italy, 2020, 1142–1151.

[3] ANDO T., BAI J., *Clustering huge number of financial time series. A panel data approach with high-dimensional predictors and factor structures*, J. Am. Stat. Assoc., 2017, 112 (519), 1182–1198.

[4] BAI R., WEI J., AN R., LI Y., COLLETT L., DANG S., WANG Y., *Trends in life expectancy and its association with economic factors in the belt and road countries – evidence from 2000–2014*, Int. J. Environ. Res. Publ. Health, 2018, 15 (12), 2890.

[5] BARLOW R., VISSANDJEE B., *Determinants of national life expectancy*, Can. J. Dev. Stud., 1999, 20 (1), 9–29.

[6] BAYATI M., AKBARIAN R., KAVOSI Z., *Determinants of life expectancy in Eastern-Mediterranean region. A health production function*, Int. J. Health Pol. Manage., 2013, 1 (1), 57–61.

[7] BECKER G.S., PHILIPSON T.J., SOARES R.R., *The quantity and quality of life and the evolution of world inequality*, Am. Econ. Rev., 2005, 95 (1), 277–291.

[8] BILAS V., FRANC S., BOŠNJAK M., *Determinant factors of life expectancy at birth in the European Union countries*, Coll. Antr., 2014, 38 (1), 1–9.

[9] BLOOM D.E., FINLAY J.E., D*emographic change and economic growth in Asia. Asian economic policy review*, 2009, 4 (1), 45–64.

[10] BLOOM D., CANNING D., SEVILLA J., *The demographic dividend: A new perspective on the economic consequences of population change*, Rand Corporation, 2003.

[11] CAR J., TAN W.S., HUANG Z., SLOOT P., FRANKLIN B.D., *eHealth in the future of medications management: personalisation, monitoring and adherence*, BMC Med., 2017, 15 (1), 73.

[12] CHAITY A.J., *Budget allocations for health, education continue to shrink*, Dhaka Tribune, 2018, June 29. Retrieved September 10, 2020, from: https://www.dhakatribune.com/bangladesh/2018/06/29/ budget-allocations-for-health- education-continue-to-shrink

[13] CHO Y.M., LEE S., ISLAM S.M.S., KIM S.Y., *Theories applied to m-health interventions for behavior change in low-and middle-income countries: a systematic review*, Telemed. e-Health, 2018, 24 (10), 727–741.

[14] DEATON A., *Health in an age of globalization*, [In:] S. Collins C. Graham (Eds.), *Brookings Trade Forum*, The Brookings Institution, Washington, DC, 2004, 83–130.

[15] DELAVARI S., ZANDIAN H., REZAEI S., MORADINAZAR M., DELAVARI S., SABER A., FALLAH R., *Life expectancy and its socioeconomic determinants in Iran*, Electr. Phys., 2016, 8 (10), 3062–3068.

[16] FAYISSA B., GUTEMA P., *Estimating a health production function for Sub-Saharan Africa (SSA)*, Appl. Econ., 2005, 37 (2), 155–164.

[17] GOPALAN H.S., MISRA A., JAYAWARDENA R., *Nutrition and diabetes in South Asia*, Eur, J. Clin. Nutr., 2018, 72 (9), 1267–1273.

[18] GROSSMAN M., *On the concept of health capital and the demand for health*, J. Pol. Econ., 1972, 80 (2), 223–255.

[19] GUDLAVALLETI V.S.M., *Challenges in accessing health care for people with disability in the south Asian context. A review*, Int. J. Environ. Res. Publ. Health, 2018, 15 (11), 2366.

[20] GULIS G., *Life expectancy as an indicator of environmental health*, Eur. J. Epidem., 2000, 16 (2), 161–165.

[21] HALICIOGLU F., *Modeling life expectancy in Turkey*, Econ. Model., 2011, 28 (5), 2075–2082.

[22] HASSAN F.A., MINATO N., ISHIDA S., NOR N.M., *Social environment determinants of life expectancy in developing countries. A panel data analysis*, Global J. Health Sci., 2017, 9 (5), 105–117.

[23] HILLS A.P., ARENA R., KHUNTI K., YAJNIK C.S., JAYAWARDENA R., HENRY C.J., MISRA A., *Epidemiology and determinants of type 2 diabetes in south Asia*, Lancet Diab. Endocrin., 2018, 6 (12), 966–978.

[24] HOQUE M.R., SAIF A.N.M., ALBAR A.M., BAO Y., *Adoption of information and communication technology for development. A case study of small and medium enterprises in Bangladesh*, Inf. Dev., 2016, 32 (4), 986–1000.

[25] HUQ S.M.M., *Health sector in Bangladesh*, [In:] A. Banik (Ed.), *Trade in Health Services in South Asia*, Springer, Singapore 2020, 21–61.

[26] HUSAIN A.R., *Life expectancy in developing countries. A cross-section analysis*, Bangl. Dev. Stud., 2002, 28 (1/2), 161–178.

[27] JABA E., BALAN C.B., ROBU I.B., *The relationship between life expectancy at birth and health expenditures estimated by a cross-country and time-series analysis*, Proc. Econ. Fin., 2014, 15, 108–114.

[28] JEFF G., *The relationship between GDP and life expectancy isn't as simple as you might think*, 2016, October 18. Retrieved August 30, 2020, from: https://www.weforum.org/agenda/2016/10/the-relation ship-between-gdp-and-life-expectancy-isnt-as-simple-as-you-might-think

[29] JIANG J., LUO L., XU P., WANG P., *How does social development influence life expectancy? A geographically weighted regression analysis in China*, Publ. Health, 2018, 163, 95–104.

[30] KABIR M., *Determinants of life expectancy in developing countries*, J. Dev. Areas, 2008, 41 (2), 185–204.

[31] KARAGEORGOS G., ANDREADIS I., PSYCHAS K., MOURKOUSIS G., KIOURTI A., LAZZI G., NIKITA K.S., *The promise of mobile technologies for the health care system in the developing world. A systematic review*, IEEE Rev. Biomed. Eng., 2018, 12, 100–122.

[32] KERDPRASOP N., KERDPRASOP K., *Association of economic and environmental factors to life expectancy of people in the Mekong basin*, [In:] Proc. 12th IEEE Conference on Industrial Electronics and Applications (ICIEA), IEEE, Siem Reap, Cambodia, 2017, June, 1984–1989.

[33] KHAN J.Z.I., *Expected challenges in e-health implementation. A case of rural hospitals in Pakistan*, Master's Thesis, Örebro University, 2019. Retrieved November 20, 2020, from: https://www.divaportal. org/smash /get/diva2:1338730/FULLTEXT01.pdf

[34] KLEINBAUM D.G., KUPPER L.L., MULLER K.E., *Applied regression analysis and other multivariate methods*, 2nd Ed., PWS-KENT, Wedsworth, Inc., Boston, Massachusetts, 1988.

[35] KONTIS V., BENNETT J.E., MATHERS C.D., LI G., FOREMAN K., EZZATI M., *Future life expectancy in 35 industrialised countries: projections with a Bayesian model ensemble*, The Lancet, 2017, 389 (10076), 1323–1335.

[36] LEE C.W., KIM M.S., *The relationship between internet environment and life expectancy in Asia*, Rev. Int. Bus. Econ. Res., 2019, 8 (2), 70–80.

[37] LIN R.T., CHEN Y.M., CHIEN L.C., CHAN C.C., *Political and social determinants of life expectancy in less developed countries. A longitudinal study*, BMC Public Health, 2012, 12 (1), 85.
[38] LINDER S.B., *An essay on trade and transformation*, Wiley and Sons, New York 1961.
[39] MANNUCCI P.M., FRANCHINI M., *Health effects of ambient air pollution in developing countries*, Int. J. Environ. Res. Publ. Health, 2017, 14 (9), 1048.
[40] MARIANI F., PÉREZ-BARAHONA A., RAFFIN N., *Life expectancy and the environment*, J. Econ. Dyn. Control, 2010, 34 (4), 798–815.
[41] MARTÍN CERVANTES P.A., RUEDA LÓPEZ N., CRUZ RAMBAUD S., *A causal analysis of life expectancy at birth. Evidence from Spain*, Int. J. Environ. Res. Publ. Health, 2019, 16 (13), 2367.
[42] MONDAL M.N.I., SHITAN M., *Impact of socio-health factors on life expectancy in the low and lower middle-income countries*, Ir. J. Publ. Health, 2013, 42 (12), 1354–1362.
[43] MONDAL M.N.I., ULLAH M.M.M.N., ISLAM M.R., RAHMAN M.S., KHAN M.N., AHMED K.M., *Socio-demographic and health determinants of inequalities in life expectancy in least developed countries*, Int. J. Mater. Child Health AIDS (IJMA), 2015, 4 (1), 57–66.
[44] MONSEF A., MEHRJARDI A.S., *Determinants of life expectancy. A panel data approach*, Asian Econ. Fin. Rev., 2015, 5 (11), 1251–1257.
[45] MURSHED M., ABBASS K., RASHID S., *Modelling renewable energy adoption across south Asian economies. Empirical evidence from Bangladesh, India, Pakistan and Sri Lanka*, Int. J. Fin. Econ., 2021, 26 (4), 5425–5450.
[46] MURSHED M., CHADNI M.H., FERDAUS J., *Does ICT trade facilitate renewable energy transition and environmental sustainability? Evidence from Bangladesh, India, Pakistan, Sri Lanka, Nepal and Maldives*, En., Ecol. Environ., 2020, 5 (6), 470–495.
[47] PESARAN M.H., *Testing weak cross-sectional dependence in large panels*, Econ. Rev., 2015, 34 (6–10), 1089–1117.
[48] RAHMAN M.M., KHANAM R., RAHMAN M., *Health care expenditure and health outcome nexus. New evidence from the SAARC-ASEAN region*, Global. Health, 2018, 14 (1), 1–11.
[49] RIZZO T., *A panel data study of the determinants of life expectancy in low-income countries*, 2019. Honors Thesis, Bryant University, Retrieved November 20, 2020, from: https://digitalcommons.bryant. edu /cgi/viewcontent.cgi?article=1029context=honors_economics
[50] ROGERS R.G., WOFFORD S., *Life expectancy in less developed countries: Socioeconomic development or public health?*, J. Biosoc. Sci., 1989, 21 (2), 245–252.
[51] SADANA R., D'SOUZA C., HYDER A.A., CHOWDHURY A.M.R., *Importance of health research in South Asia*, Bmj, 2004, 328 (7443), 826–830.
[52] SATTINGER M., *Trade flows and differences between countries*, Atl. Econ. J., 1978, 6 (2), 22–30.
[53] SEDE P.I., OHEMENG W., *Socio-economic determinants of life expectancy in Nigeria (1980–2011)*, Health Econ. Rev., 2015, 5 (1), 2.
[54] SELCK T.J., DECKARM R., *Income, democracy, and public policy. The effects of improved sanitation on life expectancy*, J. Water, Sanit. Hyg. Dev., 2015, 5 (3), 525–529.
[55] SIEGEL K.R., PATEL S.A., ALI M.K., *Non-communicable diseases in South Asia. Contemporary perspectives*, Brit. Med. Bull., 2014, 111 (1), 31–44.
[56] SINGH A., KUMAR K., WADHWA J.K., PALAKKANDY A., *Effect of life expectancy on technological development*, Tech. Soc. Sci. J., 2020, 5, 225–237.
[57] *South Asia Alliance for Poverty Eradication (SAAPE), Growing inequality in South Asia*, South Asia Inequality Report 2019, Kathmandu, Nepal. Retrieved August 30, 2020, from: https://www.globaltaxjustice.org/sites/default/files/South%20Asia%20Inequality%20Report%202019.pdf
[58] SUTRADHAR S.R., *The impact of remittances on economic growth in Bangladesh, India, Pakistan and Sri Lanka*, Int. J. Econ. Pol. Stud., 2020, 14 (1), 275–295.

[59] *United Nations Development Programme (UNDP), Human Development Data*, 2018. Retrieved August 30, 2020, from: http://hdr.undp.org/en/data
[60] *United Nations Development Programme (UNDP), Human Development Report 2019*, New York. Retrieved September 10, 2020, from: http://hdr.undp.org/en/2019-report
[61] VAN DEN HEUVEL W.J., OLAROIU M., *How important are health care expenditures for life expectancy? A comparative, European analysis*, Journal of the American Medical Directors Association, 2017, 18 (3), 276.e9e–276.e12.
[62] WALKER I.F., GARBE F., WRIGHT J., NEWELL I., ATHIRAMAN N., KHAN N., ELSEY H., *The economic costs of cardiovascular disease, diabetes mellitus, and associated complications in South Asia*. *A systematic review*, Value Health Reg. Iss., 2018, 15, 12–26.
[63] WANG C., ZHOU X., CHEN R., DUAN X., KUANG X., KAN H., *Estimation of the effects of ambient air pollution on life expectancy of urban residents in China*, Atm. Environ., 2013, 80, 347–351.
[64] World Bank, *World Development Indicators*, 2018. Retrieved October 29, 2020, from: https://data.worldbank.org/?locations=AF-XM-MV-XT
[65] World Bank, *World Development Indicators*, 2019. Retrieved August 30, 2020, from: https: //data.worldbank.org/
[66] ZARE H., GASKIN D.J., ANDERSON G., *Variations in life expectancy in Organization for Economic Cooperation and Development countries 1985–2010*, Scand. J. Publ. Health, 2015, 43 (8), 786–795.