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ORIGINAL ARTICLE

Predictors of life expectancy at birth in Türkiye: A longitudinal study

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Abstract

Objective: The aim of this study is to examine the impact of social, behavioral, economic, and healthcare system-related factors on life expectancy at birth in Türkiye.

Methods: Enrollment rate in tertiary education, tobacco consumption gram per capita, out-of-pocket payments (OOPHE), and Gross Domestic Product (GDP) per capita were included as predictors. The data were obtained from the database of the Organisation for Economic Co-Operation and Development (OECD), World Bank, and Health Statistics Yearbooks published by the Ministry of the Health in Türkiye for 2000-2019. Johansen Cointegration test was used to define the existence of the long-run statistical relationship between life expectancy at birth and the predictors.

Results: Enrollment rate in tertiary education, GDP per capita, and out-of-pocket payments are positively associated with life expectancy, while tobacco consumption gram per capita has a negative association. It has been concluded that short-term deviations from the equilibrium, using an error correction model, will reach long-term equilibrium approximately one year later. Granger causality test and the estimation result revealed that enrollment rate in tertiary education, tobacco consumption, out-of-pocket health expenditure, and GDP per capita are the short-term and long-term determinants of life expectancy at birth.

Conclusion: This study provides important evidence for policymakers to allocate resources to the social, behavioral, healthcare-related, and economic determinants of health status to increase life expectancy. In addition, the determination of out-of-pocket payments have a positive relationship with life expectancy gives a clue about the need to make more efforts regarding the economic accessibility of healthcare services in the Turkish health system.

Keywords: Life Expectancy, Health Economics, Health Management, Johansen Cointegration Analysis

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INTRODUCTION

People naturally seek to be healthy and live longer. Historically, people have made an intense effort to improve their health. In order to improve health, it is necessary to understand the factors that affect health status.[1,2] There are many factors that affect the state of being healthy. These factors, which are expressed as determinants of health, have been discussed in a wide framework. Blum (1974) provided a basic framework for this issue and proposed the determinants of the health model. According to this model, the factors that affect health status are basically genetics, environment, behaviors, and health services. These factors are surrounded by population, cultural system, mental health, ecological balance, and natural resources.[3] In the Dahlgren-Whitehead model, which was later defined as the "rainbow model" and proposed in 1991, environmental conditions are emphasized more as determinants of health.[4] More recently, Exworthy (2008) categorized the determinants of health as social, economic, healthcare services accessibility, and behavioral factors.[5] Today, in addition to the factors in these models, the social determinants of health are defined by the World Health Organization (WHO) as "non-medical factors that affect health". These factors consist of the conditions in which people are born, grow, work, live, and age.[6] Studies in the literature have provided evidence that social factors, along with other factors, are among the strong determinants of health. It has been determined that social factors, including socioeconomic factors, have a significant impact on many health outcomes in different settings and populations.[7]

Examining and investing in these factors, known as "determinants of health", is extremely important in terms of health promotion. In a study, it was determined that Gross Domestic Product (GDP), unemployment, nitrogen oxide per capita, tobacco consumption, sugar consumption, oil consumption, and the number of physicians per thousand people, which are among the determinants of health, are associated with life expectancy at birth, while GDP and alcohol use are associated with mortality.[1] Gisselmann (2005) found that low maternal education level is associated with low birth weight and infant mortality.[8] Jeong et al. (2007) suggested that healthy lifestyle behaviors are important in improving health outcomes.[9] Nixon and Ulmann (2006) concluded that health expenditures were related to health outcomes.[10] Owusu et al. (2021) stated that health expenditures in low- and middle-income countries would potentially reduce maternal and infant mortality.[11] Ali and Bibi (2017) determined that women's education, family planning and health services, and access to food have an impact on the survival rate under the age of five.[12]

Ho and Hendi (2018) suggested life expectancy at birth as "the most important indicator of a country's well-being".[13] Life expectancy at birth is defined as the average number of years a person would still live at birth. It is stated that it is an important indicator for evaluating the economic and social development of a country or region.[14] The average life expectancy in a country is under the influence of various economic, social, and environmental factors in that country.[15] In a study of 15 European countries, it has been determined that education level and life expectancy are related. On the other hand, smoking, low income, and high body weight

are associated with lower life expectancy.[16] In a study conducted in Türkiye, it was revealed that general education level, purchasing power, and economic development have an effect on life expectancy.[2] Bagus Wirayuda et al. (2022) concluded that sociodemographic, macroeconomic, and health factors affect life expectancy.[17]

Considering that the health services sector is growing rapidly and the costs related to health and insurance are increasing, examining the determinants of life expectancy for countries emerges as a very important issue.[15] Examining these determinants can provide policymakers with the necessary evidence for optimal resource allocation for optimal health outcomes. Therefore, this study attempted to examine the impact of enrollment in tertiary education as a social determinant, tobacco consumption gram per capita as a behavioral determinant, out-of-pocket payments as a healthcare services accessibility determinant, and GDP per capita as an economic determinant on life expectancy at birth.

METHODS

Data

The dependent variable is defined as the life expectancy at birth in this study. The determinants of life expectancy were examined in four main categories based on the model of social determinants of health which was formed by Exworthy in 2008.[5] These are social, economic, healthcare services accessibility, and behavioral factors.

In social factors, the enrollment rate in tertiary education was chosen to be included in the model. In Türkiye, compulsory education is for 12 years including primary and secondary education. That is why the effect of higher education was examined in this mode. To evaluate the effect of economic conditions, gross domestic product (GDP) per capita was chosen. Healthcare services-related factors were considered in terms of health financing policies. WHO has been highlighting the importance of financing, especially universal health coverage, in accessibility to healthcare for a very long time.[18] Many studies have used health expenditure as a percentage of GDP, health expenditure per capita, or public health expenditure and reported significant results.[19-21] However, to consider financial accessibility, in this study, out-of-pocket health expenditure was included in the model. Because, in universal health coverage, it provides clearer evidence on financial accessibility. Finally, to include the effect of behavioral factors, tobacco consumption gram per capita was chosen.

The data were obtained from the database of the Organisation for Economic Co-Operation and Development (OECD), World Bank, and Health Statistics Yearbooks published by the Ministry of the Health in Türkiye for 2000-2019.

Descriptive statistics of the model are summarized in Table 1.

Table 1. Descriptive statistics of the variables (2000-2019, Türkiye)

	LE	GDP	HE	OOPHE	TC
Mean	75.080	2.063	29.620	18.685	1367.765
Median	74.200	1.990	31.740	17.350	1330.950
Maximum	78.600	5.730	45.640	28.600	1817.000
Minimum	71.100	-3.270	12.560	14.100	1021.000
Std. Dev.	2.700	2.063	11.934	3.479	280.310
Skewness	0.095	-0.487	-0.155	1.284	0.159
Kurtosis	1.404	3.629	1.421	4.318	1.405
Observations	20	20	20	20	20

Accordingly, the mean of life expectancy (LE) at birth was 75.08 years, and the minimum

and maximum values during the period 2000-2019 were 71.10 and 78.60 years, respectively. Additionally, the mean of GDP per capita was 2.063 dollars. The means of enrollment rate in tertiary education (HE) and share of out-of-pocket health expenditure (OOPHE) in total health expenditure and tobacco consumption gram per capita (TC) were 29.620, 18.685, 1367,765 respectively.

Model specification

In this study, the effects of socioeconomic and health-related factors on life expectancy in Turkey were analyzed. The sample size and power calculations for the study were conducted using a two-sample t-test. The assumptions for the analysis are as follows:

The difference in life expectancy between the two groups is 5 years (delta = 5). This effect size has been calculated within the framework of values recommended by Cohen (1988),[22] thus it is considered practically significant. The standard deviation for both groups is set at 10 (sd = 10). The analysis was performed with a Type I error rate (alpha) of 0.05 and a power level of 0.80. The power analysis determined that a sample size of 64 per group is recommended. This results in a total of 128 participants. This sample size is considered sufficient to achieve statistically significant results by controlling for the determined effect size and error level. All statistical analyses conducted in this study were performed using EViews 13 software.

In order to employ the cointegration and causality test, it is compulsory to examine the unit root test on the time series macro-variables in our sample. This is because most macroeconomic time series have unit roots and estimates with non-stationary series often cause spurious regression results. In literature, the common unite root tests in order the check the stationary or non-stationary are Augmented Dickey-Fuller (ADF), Phillips Perron (PP), Kwiatkowski–Phillips–Schmidt–Shin (KPSS), and Ziwot Andrews tests. So for this study, The Phillip-Perron unit root test is adopted for this purpose. Augmented Dickey-Fuller, and Phillips Perron tests were employed to check stationarity in the series, respectively.

In this study, Johansen Cointegration test was used as the methodology to define the existence of the long-run statistical relationship between health status (life expectancy at birth) and its socioeconomic factors (enrollment rate in tertiary education), behavioral factors (tobacco consumption grams per capita), economic indicator (GDP per capita growth –annual %) and healthcare services factors (out-of-pocket health expenditure in total health expenditure) for Türkiye between 2000-2019. The method involves cointegration and the estimation of the Vector Error Correction Model (VECM) in order to define the time series behavior. Cointegration between first-order integrated series by Engle and Granger (1987), who investigated the relationship, revealed the one-way cointegration relationship. Johansen and Juselius's (1990) approach, which brings a multi-equation approach and allows more than one cointegration relationship to be revealed, defines a cointegration relationship as a vector.[23] In order to test the long-term equilibrium relationship between the series with cointegration analysis, the most important issue to be considered is that the series should be integrated at the same degree.[24] The Johansen cointegration approach consists of two parts. Firstly,

whether the series is stationary or not is examined using the unit root test. Secondly, the lag length criteria will be determined to perform the Johansen cointegration Test.

The Linear Model was specified as below:

$$LE=\alpha_0+\alpha_1 GDP+ \alpha_2 OOPHE+ \alpha_3 HE+ \alpha_4 TC+u_t \quad (1)$$

Equation 1 was estimated using life expectancy as a dependent variable.

Where, health status: life expectancy at birth-LE, socioeconomic factors: enrollment rate in tertiary education-HE, behavioral factors: tobacco consumption grams per capita -TC, healthcare services factors: share of out-of-pocket health expenditure in total health expenditure - OOPHE and economic indicator (GDP per capita growth –annual %)- GDP.

Before proceeding to the cointegration test, the Vector Error Correction Model (VECM) was estimated for the variables used in the model. Among the models that demonstrated a cointegration relationship between the series, lacked autocorrelation or heteroscedasticity issues, and had normally distributed residuals, the model with the lowest AIC and SIC values was selected.

In the current study, the Johansen Cointegration test has been used to define the long-term statistical relationships between the series. The results of the cointegration test have laid the groundwork for the application of the Vector Error Correction Model (VECM) and Granger causality test. The results of all these analyses are presented below in order.

RESULTS

In this section, summaries of the tests and analyses conducted, and the findings obtained are explained in detail. It begins with the results of the unit root tests.

Table 2. Unit Root Test Results

	ADF				PP			
	Level		1* Difference		Level		1* Difference	
Series	Constant	Trend	Constant	Trend	Constant	Trend	Constant	Trend
LE	-0.807	-2.16	-4.29***	-4.17**	-0.78	-2.15	-4.29***	-4.17**
GDP	-3.93	-4.55	-6.51***	-6.30***	-3.92	-4.54	-14.20***	-13.68***
HE	-0.91	-0.90	-3.56**	-3.63**	-0.91	-1.07	-3.55**	-3.62**
OOPHE	-2.92	-3.068	-3.53**	-3.31*	-2.48	-3.18	-3.90***	-3.43*
TC	-1.61	-2.30	-2.86*	-3.27**	-1.55	-0.61	-2.81*	-3.37**

* Stationary at the 10 per cent level. ** Stationary at the 5 per cent level.*** Stationary at the 1 per cent level

The findings of the ADF and PP tests results in Table 2 showed that life expectancy at birth, GDP per capita, out-of-pocket health expenditure, enrollment rate in tertiary education, and tobacco consumption are not stationary at level. On the other hand, after taking the first differences of the series, they became stationary providing that all the variables used in the model are integrated order (1). Maximum lag length in unit root analysis is determined according to the SIC information criterion.

It has been determined that there is a cointegration relationship between the series in the estimated VECM model, there is no autocorrelation problem[1], no heteroscedasticity[2], and the residues are

1. LM test results for model 1: Lag (1) prob: 0.941>0.01; Lag (2) prob: 0.372>0.01
2. Heteroskedasticity for model (1) ki-kare prob: 0.465>0.01
3. Jarque-Bera test for model (1) prob: 0.315>0.01

normally distributed[3]. However, Johansen (1988) recommends a trace test and maximum eigenvalue test to determine the number of cointegration vectors.[25] It emphasizes that these calculated test statistics should be compared with the critical values obtained. From this point of view, it is determined whether the variables are cointegrated (long-term) by comparing the statistical values calculated with the critical values.[26] The results of the cointegration test are shown in Table 3.

Table 3. Johansen Cointegration Test

		Model 1		
Hypotheses	**Eigen Value**	**Trace Statistic**	**Critical Value**	**Prob**
	0.95***	101.84	69.82	0.00
	0.73**	49.09	47.86	0.04
	0.63	25.79	29.80	0.14
	0.26	7.95	15.49	0.47
	0.14	2.65	3.84	0.10
Hypotheses	**Eigen Value**	**Max-Eigen Statistic**	**Critical Value**	**Prob**
	0.95	52.75	33.88	0.00
	0.73	23.30	27.58	0.16
	0.63	17.83	21.13	0.14
	0.26	5.31	14.26	0.70
Ho:r≤5	0.14	2.65	3.84	0.10

***denotes 0.01 significance level; **denotes 0.05 significance level; *denotes 0.10 significance level.

Model 1 showed that trace tests, and max eigen statistic 2 and 1 cointegrating equation at 1 and 5 percent significance level, respectively. Therefore, it can be said that the variables affect each other in the long run. Within the framework of these basic criteria, the VEC (1) model, which was estimated with the help of model 3 proposed by Johansen, was estimated as the most appropriate model. Finding the cointegration relationship shows that the short-term deviation tendencies of the variables from equilibrium can be handled within the framework of the vector error correction model.

Table 4. VECM Prediction Results

Model 1	
Lon Term Equation	
Constant	**75.807**
GDP(-1)	**0.212 (-7.25)*** **
HE(-1)	0.129 (-10.55)***
OOPHE (-1)	0.073 (-3.98)***
TC(-1)	**-0.005 (8.851)*** **
Short Term Equation	
$VECT_t$	**-1.104 (-3.108)*** **

***denotes 0.01 significance level; **denotes 0.05 significance level; *denotes 0.10 significance level.

The estimation of long and short term results of the model in which life expectancy is the dependent variable and the other variables in models are independent are given in Table 5. As seen in this table, the error correction coefficients of the model are negative and statistically significant. This indicates that the

error correction mechanism is functioning for the equation. The imbalance that occurs in one period is corrected in the next period. The long-term relationship is consistent in the model established in the relevant period. In the long run, when there is a deviation from the equilibrium, it means that it will return to balance again. Short-term life expectancy fluctuations (1/1.104) can be corrected in less than 1 year and reach long-term equilibrium again.

Long run equation model 1

$$Le=75.807+0.129\ HE+0.212GDP+0.073OOPHE-0.005TC \quad (2)$$

Table 4 and equations 2 show that one-unit increase in GDP per capita growth and out-of-pocket health expenditure in total health expenditure in the long run, increases life expectancy at birth by 0.212 and 0.073 respectively. The long-run effect of enrollment rate in tertiary education is positive and significant on life expectancy at birth. The long-run effect of tobacco consumption is negative on life expectancy at birth. Finally, the long- and short-term causality relationships between the series regarding the model estimation results of Granger block exogeneity are shown in Table 5.

Table 5. Long and Short Term Causality Analysis

Equations	Short Term (Chi Square Analyze)	Long Term (Chi Square Analyze)
	14.204*** (prob:0.0067)	-3.108***
D(GDP)	12.600*** (prob:0.0004)	
D(HE)	3.052* (prob:0.0806)	
D(OOPHE)	0.018 (prob:0.8931)	
D(TC)	3.730** (prob:0067)	

***denotes 0.01 significance level; **denotes 0.05 significance level; *denotes 0.10 significance level.

Following the cointegration test, a causal relationship between life expectancy and its determinants was examined using the block exogeneity Wald test based on VECM. In the short term, enrollment rate in tertiary education, tobacco consumption, out-of-pocket health expenditure, and GDP per capita were found to have a causal effect on life expectancy at birth. These variables on life expectancy are the cause in the long run and the short run. Accordingly, the findings have pointed out that there is a causal relationship between life expectancy and GDP per capita with a probability of 0.0004 at 1% significance. On the other hand, out-of-pocket health expenditure is found to have no causal effect on life expectancy at birth at 0.01, 0.05, or 0.10 significance levels.

DISCUSSION

For decades, many researchers have focused on quantifying the contribution of different factors to health status. This effort is simply related to the motivation of determining areas in which resources must be allocated to improve health status indicators.[27] The WHO Global Commission on Social Determinants of Health (SDH) has also addressed the social factors as leading determinants of health status.[28] This study aimed to investigate the relationship between health status and its determinants in Türkiye. Results showed that enrollment rate in tertiary education, GDP per capita, and out-of-pocket payments are positively associated with life expectancy, while tobacco consumption gram per capita has a negative association. The factor with the highest effect was GDP per capita which is followed by higher education, OOP, and tobacco consumption. All variables have explained the 65% of variance in life expectancy. These

findings support the idea that socio-economic factors are important determinants of health status in Türkiye.

Health status and its determinants were also measured by many papers in the literature using different indicators. The finding of positive effects of GDP per capita, and education on life expectancy in the current study is similar to previous studies in the literature. A study conducted on 28 European Union countries which is identical to our study found that GDP per capita and attained education level were significant predictors of life expectancy.[14] The findings of the current study are also parallel to an extensive panel data analysis of OECD countries which had life expectancy at birth, adjusted mortality, infant mortality, and potential years of life lost as dependent variables (health status) while 19 factors related to socio-economic, physical environmental, health behavior and health services were included as determinants. The results verified that life expectancy was significantly related to determinants such as income, employment, tobacco and alcohol consumption, and the number of doctors.[1] The finding of the current study on the negative association between life expectancy and tobacco consumption has been also verified in this study. A study conducted in Spain has reported a unidirectional and positive causal relationship between per capita income, rate of hospital beds, medical staff-nurses, and life expectancy.[29] A study conducted in Iran is identical to the findings of the previous finding as it shows significant positive effects of GDP per capita, number of doctors, and urbanization. Also, the finding on the importance of literacy in predicting life expectancy in the mentioned study was also supported by the verified positive effect of education on life expectancy in the current study.[30] A study focused on the Asia/Pacific area has used GDP per capita, health expenditure per capita, unemployment rate, and exchange rate as predictors in the model. Some results of the study contradicted to many other studies in the literature and the current study as it has shown a negative relationship between health expenditure and life expectancy.[31] Some studies also provided significant contributions to this topic in Türkiye. A study used many factors' effects on life expectancy such as health expenditures, food availability, smoking, etc.[15] Şentürk and Ali (2021) reported significant effects of education, fertility rates, purchasing power, and environmental degradation on gender-specific life expectancy in Türkiye.[2] These findings are identical to the findings of the current study, considering the positive effect of education and purchasing power on life expectancy. Gulcan (2020) also investigated the determinants of life expectancy in Türkiye and used GDP per capita, CO2 emission, and urbanization as predictors.[35] However, the results showed a long run relationship only between urbanization and life expectancy which contradicts the current findings.

The finding of the positive causal relationship between out-of-pocket health expenditure and life expectancy requires more attention because it is a distinctive and controversial issue in the health systems. There are also some other studies which examined the association between out-of-pocket health expenditure and life expectancy. Some of these studies reported contradicting findings while some were identical to the current study. Ranabhat et al. (2018) reported a negative relationship between out-of-pocket payments[32] while Roffia et al. (2022) found

the same as in the current study that OOP payment was positively associated with life expectancy.[33] Owumi and Eboh (2022) also found that increasing out-of-pocket health expenditure can lead to an enhancement in life expectancy supporting the current study's findings.[34] Considering its significant effect, it can be inferred that out-of-pocket payments are still a prominent way of accessing needed healthcare services. The share of out-of-pocket health expenditure in the model gives a hint about financial accessibility to healthcare services which seems to be still a prominent issue in the Turkish healthcare system. Out-of-pocket payments seem to be an enabler for some people in order to obtain proper medical services. This may be a booster of general health status. However, it can also be a barrier to some people who need medical services.

CONCLUSION

Considering the positive effect of socio-economic factors such as education and income, this study acclaims that investing in the areas which can improve employment rates, purchasing power, food and accommodation availability, education, etc. can enhance the health status of the population. Tobacco consumption was negatively associated with life expectancy. Campaigns towards cigarette cessation can still be beneficial to improve life expectancy in Türkiye. The positive effect of OOP payments can be caused by the people who get proper medical services by paying out-of-pocket. This can be considered a challenge in the health system. Increasing out-of-pocket payments may at some point limit individuals' access to health services and cause inequalities in access. Considering that the positive association found in the present study may be due to some confounding factors, it is recommended that future studies re-examine the effect of this variable on life expectancy. Therefore, policies to reduce out-of-pocket payments while enhancing financial accessibility to healthcare services should be considered. However, there is still a need for further research to discover the causes of this finding.

The study contributes to the literature by providing information on different predictors of life expectancy, especially the effect of out-of-pocket expenditures in Türkiye. The study has several strengths. The selected determinants were from four major factor groups as social, economic, behavioral, and health services. This holistic perspective enabled the researchers to compare the different effects of the determinants. Second, taking the OOP into consideration as a variable related to financial access level to healthcare is kind of an innovative way. There are limited studies exploring the causality between these payments and life expectancy. The finding of the positive effect of OOP may be a special topic for further studies to be more deeply explored. Lastly, the study covered the data of the last two decades. Data for twenty years is an important factor in terms of the strength of the causality.

This study is also not without limitations. The study used life expectancy as the indicator of health status. Many other indicators such as infant and maternal mortality rates may be considered as health status indicators. One of the constraints related to this limitation was the availability of reliable data. Lack of data and multicollinearity also for many other variables for the analysis horizon deterred the authors from including many possible

explanatory variables in the model. Future studies may consider adding a wider array of variables on social, economic, behavioral, and healthcare services related factors to determine their effects on health status in Türkiye.

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