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Cancer prevalence, health expenditure and economic output: Panel econometric application*

Kanser prevalansı, sağlık harcaması ve ekonomik çıktı: Panel ekonometrik bir uygulama

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ABSTRACT

Introduction and Objectives: From countries' perspective, chronic diseases, such as cancers, cardiovascular disease, reduce life expectancy and ultimately economic productivity, thus depleting the quality and quantity of countries' labour force. This may result into lower national output in national income. Moreover, diseases also have an increasing effect on health expenditures. This effect is higher for chronic noncommunicable diseases. Because noncommunicable diseases are often complex cases that require long-term, continuous care. The aim of this study is to investigate the effect of cancer disease on economic output and health expenditure. **Methods**: The effect of cancer on health expenditures was analyzed with the static panel regression equation, and the effect on economic output using the dynamic model. Data in empirical analysis was obtained from the World Bank, Global Health Data Exchange-GHDx database, International Monetary Fund and UNESCO Institute for Statistics (2019) database. STATA 13.0 is used for all estimations. **Results**: The increase in cancer prevalence has a negative effect on economic output for the period between 2000 and 2017 in OECD countries. It was also concluded that the increase in cancer prevalence has a positive effect on total and public health expenditure per capita in OECD countries between 2004 and 2017. **Conclusions**: Noncommunicable diseases, such as cancer, emerge as a global social problem. Multi-stakeholder action plans should be developed in partnership with national and international organizations in order to prevent the increase of non-communicable diseases in the society.

Key Words: Health Economics, Non-Communicable Diseases, Cancer, Panel Data.

Anahtar Kelimeler: Sağlık Ekonomisi, Bulaşıcı Olmayan Hastalıklar, Kanser, Panel Veri

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ÖZ

Giriş ve Amaç: Ülke bakış açısından, Kanser ve kardiyovasküler hastalıklar gibi kronik hastalıklar, yaşam beklentisini ve nihayetinde ekonomik üretkenliği azaltmakta, böylece ülkelerin işgücünün niteliğini ve niceliğini tüketmektedir. Bu durum milli gelirde daha düşük ulusal çıktıya neden olmaktadır. Ayrıca hastalıklar sağlık harcamalarını artırıcı bir etkiye sahiptir. Bu etki kronik bulaşıcı olmayan hastalıklarda daha fazladır. Çünkü bulaşıcı olmayan hastalıklar genellikle uzun süreli, sürekli bakım gerektiren karmaşık vakalardır. Bu çalışmanın amacı, kanser hastalığının ekonomik çıktı ve sağlık harcamaları üzerindeki etkisini araştırmaktır. **Metot**: Kanserin sağlık harcamaları üzerindeki etkisi statik panel regresyon modeli, ekonomik çıktı üzerindeki etkisi ise dinamik panel model kullanılarak analiz edilmiştir. Ampirik analizdeki veriler Dünya Bankası, Global Health Data Exchange-GHDx veri tabanı, Uluslararası Para Fonu ve UNESCO İstatistik Enstitüsü (2019) veri tabanından elde edilmiştir. Tüm tahminler için STATA 13,0 kullanılmıştır. **Bulgular**: OECD ülkelerinde 2000-2017 yılları arasındaki dönemde kanser prevalansındaki artışın ekonomik çıktı üzerinde olumsuz etkisi vardır. Ayrıca 2004-2017 yılları arasında OECD ülkelerinde kanser prevalansındaki artışın toplam ve kişi başına düşen kamu sağlık harcamaları üzerinde arttırıcı etkisi olduğu sonucuna ulaşılmıştır. **Sonuç**: Kanser gibi bulaşıcı olmayan hastalıklar küresel bir sosyal sorun olarak karşımıza çıkmaktadır. Toplumda bulaşıcı olmayan hastalıkların artmasını önlemek için ulusal ve uluslararası kuruluşlarla ortaklaşa çok paydaşlı eylem planları geliştirilmelidir.

INTRODUCTION

Chronic non-communicable diseases (CNCDs) are defined as non-communicable conditions that affect people in the long term, account for the vast majority of morbidity and mortality and responsible for a notable economic burden in countries (1). CNCDs are a condition that has a prolonged course, that does not resolve spontaneously, and for which a complete cure is rarely achieved. They encompass a broad range of conditions, including cardiovascular disease, diabetes, cancers, chronic respiratory disease, mental-health problems and musculo–skeletal disorders (2). The four main CNCDs are cardiovascular diseases, cancers, diabetes and chronic lung diseases for deaths on globally. The leading causes due to the CNCD in 2016 were cardiovascular diseases (17.9 million deaths, or 44% of all deaths), cancers (9.0 million, or 22% of all deaths), and respiratory diseases, including asthma and chronic obstructive pulmonary disease (3.8 million of 9% of all deaths). Diabetes caused another 1.6 million deaths (3).

Along with mortality effects, CNCDs, including cancers, have morbidity efffect on globally. For instance, CNCDs account for 62% of the healthy life years lost – (Disability Adjusted Life Years) DALYs – worldwide. On the other hand, CNCD causes substantial morbidity worldwide and accounts for one-third of DALYs in low-income countries and for nearly two-thirds in middle income countries. In Africa, even where CNCD-related morbidity is lowest, these conditions still account for 21 per cent of DALYs. At a globally level the largest disease burden in 2017 comes from cardiovascular diseases which account for 15 percent of the total. This is followed by cancers (9 percent); neonatal disorders (7 percent); muscoskeletal disorders (6 percent); and mental and substance use disorders (5 percent) (4).

According to the WHO- World Health Organization-, the rise of CNCDs, including cancers, has been driven by primarily four major risk factors: tobacco use, physical inactivity, the harmful use of alcohol and unhealthy diets. Moreover, the epidemic of CNCDs poses devastating health consequences for individuals, families and communities, and threatens to overwhelm health systems. The socioeconomic costs associated with CNCDs make the prevention and control of these diseases a major development imperative for the 21st century (5).

From countries' perspective, chronic diseases, such as cancers, cardiovascular disease, reduce life expectancy and ultimately economic productivity, thus depleting the quality and quantity of countries' labour force. This may result into lower national output in national income (6). Suhrcke, Võrk and Mazzuco have stated that there is four link channels from the health to economic outcomes. These are enhanced labour productivity, greater labour supply, education and training fostering higher skills, and more savings available for investment in physical and intellectual capital (7).

It is known that the prevalence and increase of non-communicable diseases in society has negative externalities in human, social and economic fields; it is recognized that these diseases play a role in reducing economic productivity and increasing economic poverty. Diseases are both quantitatively and qualitatively corrosive to the labor stock. In this context, diseases cause significant loss of income and output by reducing human capital stock and labor productivity (8). In addition to loss of income and output, diseases also have an increasing effect on health expenditures. This effect is higher for chronic noncommunicable diseases. Because noncommunicable diseases are often complex cases that require long-term, continuous care. In this study, from this point of view, the effect of cancer, which is one of the non-communicable diseases, on economic output and health expenditures was investigated at macro perspective.

The findings from the empirical studies generally reveal a strong positive correlation between health and economic level both micro and macro perspective. Countries with better health status tend to have higher incomes than countries with worse health status (9). Also, it is true that life expectancy is higher and infant mortality lower in richer countries than in poorer countries (10). On the other side, health status of a country's population is an intrinsic and constituent indicator of the level of development of the country. For instance, UNDP's Human Development Index (HDI) is an average of the health, education, and economic status of a country (11). However, the relationships between health and economic output or economic growth are difficult to assess. The direction of the causality is often questioned and the subject of a vigorous debate. For some authors, diseases or poor health has contributed to poor growth performances especially in low-income countries. For other authors, the effect of health on growth is relatively small, even if one considers that human capital accumulation needs also health investments (10). With this aspect, it is hoped that the study will contribute to the literature. Also, in studies examining the relationship between health and economy, the most frequently used variables as health status indicators are life expectancy at birth and infant mortality rate (12). While studies on the economic effects of diseases focused on the effects of infectious diseases such as HIV/AIDS, studies investigating non-communicable diseases such as cancer, obesity and cardiovascular diseases have started to increase in only recent years. This study will also contribute to the literature in terms of seeing the impact of cancer, which has a significant burden on the disease burden of societies, on health expenditures and economic output.

MATERIALS AND METHODS

In this study, the effect of cancer on economic output and health expenditures was analyzed with the help of panel econometric models. To achieve this, a comparison of countries with different health systems and different health structures will be made. In this way, it will be seen whether there are effects due to the structural characteristics of the countries.

Panel data analysis is basically a combination of cross-section data and time series analysis. For this reason, in panel data models, both time and cross section, in other words, unit size coexist. However, in the analysis of panel data models, it generally focuses on cross-sectional variation or heterogeneity (13).

In its most general form, the panel data model is shown as follows;

$$Y_{it} = \beta_{0it} + \beta_{1it}X_{1it} + \beta_{2it}X_{2it} + ... + \beta_{kit}X_{kit} + u_{it}$$

$$i=1......N,\ t=1......T$$

The model used in empirical analysis is the model developed by Suhrcke and Urban (2010) to measure the morbidity effect of diseases to the model adapted to measure the impact of cardiovascular diseases on economic growth. Investigation of the relationship between cancer and economic output will be done using dynamic panel data models. Accordingly, based on the data of Suhrcke and Urban (2010), the model created to investigate the determinants of gross national product, in other words, economic output in OECD countries;

$$ly_{it} = \beta_0 + \beta_1\, ly_{it-1} + \beta_2\, lcan_{it} + \beta_3 fer_{it} + \beta_4\, mor_{it} + \beta_5\, inv_{it} + \beta_6\, tr_{it} + \beta_7\, edu_{it} + u_{it}$$

Here; "ly" is logarithm of real gross domestic product (GDP) per capita calculated according to purchasing power, "yt-1" is the logarithm of the previous period value of the real gross domestic product per capita calculated according to purchasing power, "lcan" is logarithm of the prevalence value of cancer, "fer" is fertility rate, "mor" is mortality rate, "inv" is the share of total investments in GDP, "tr" is total trade capacity, "edu" is expected schooling year, "u" is error term, "i" is OECD countries (panel unit size) and "t" is years (panel time dimension).

Many topics discussed in the economic literature are dynamic. That is, the value is affected by the previous period value. Economic growth is also in this structure. For this reason, while investigating the effect of cancer on economic output, dealing with dynamic models rather than static models is important for the reliability of the findings. For this purpose, the results of the analysis will be presented using the Arellano-Bond Generalized Moments Method (GMM) estimator, which is widely used and popular in the dynamic panel literature. The data set covers the period from 2000 to 2017 for 36 OECD countries. Data in empirical analysis was obtained from the World Bank, Global Health Data Exchange-GHDx database, International Monetary Fund and UNESCO Institute for Statistics (2019) database. STATA 13.0 was used for all estimations.

In addition to loss of income and output, diseases also have an increasing effect on health expenditures. This effect is expected to be higher in non-communicable chronic diseases such as cancer. Usually cancer diseases are complex cases that require long-term, continuous care. In the estimation, health expenditures were modeled as total per capita health expenditure, total public health expenditure per capita and total out-of-pocket health expenditure per capita, and the effects of these diseases on public, private and total health expenditures were examined separately. In this way, it will be interpreted in what way cancer affect health expenditures.

In order to analyze empirically the impact of cancer on health expenditures, the determinants of health expenditure model developed by Xu et al were used. According to the model, health expenditures were generally related to income, structure of society (old age, education, etc.), development of health technologies, characteristics of the health system, and community disease pattern (14). The equations for the models created to examine the effects of cancer on health expenditures are as follows;

$$lthe_{it}=\Theta_0+\Theta_1 lcan_{it}+\Theta_2 income_{it}+\Theta_4 age_{it}+\Theta_5 ss_{it}+\Theta_6 edu_{it}+u_{1it} \quad (1)$$

$$lgov_{it}=\gamma_0+\gamma_1 lcan_{it}+\gamma_2 income_{it}+\gamma_4 age_{it}+\gamma_5 ss_{it}+\gamma_6 edu_{it}+u_{2it} \quad (2)$$

$$lgov_{it}=\psi_0+\psi_1 lcan_{it}+\psi_2 income_{it}+\psi_4 age_{it}+\psi_5 ss_{it}+\psi_6 edu_{it}+u_{3it} \quad (3)$$

Here; "lthe" is logarithm of total health expenditure per capita calculated according to purchasing power parity, "lgov" is logarithm of total government health expenditure per capita, "loop" is logarithm of total out of pocket health expenditure per capita, "income" is the level of revenue per capita calculated according to purchasing power parity, "age" is the proportion of individuals over 65 in the society, "lcan" is logarithm of cancer prevalence, "edu" is expected schooling year (education), "ss" is the share of public expenditures in total health expenditures representing the health system structure, "u" is error term, "i" represents the panel unit size of OECD countries, "t" represents years, that is the panel time dimension.

Analyzes covering the period 2004-2017 were conducted for 36 OECD countries in the sample in order to examine the impact of cancer on health expenditures. The reason for using this period range is not to work with an unbalanced panel in the model.

RESULTS

Using the static panel data methodology, the effect of cancer prevalence on health expenditures between

2004 and 2017 in 36 OECD countries was expanded by extending the model of Xu et al. (2011), and the fixed effects were estimated using the panel regression method and the Discroll and Kray robust standard errors estimator. The reason for using fixed effects model as estimation method is the results of LR, F and Hausman tests. Also, I used dynamic panel data method to estimate the effect of cancer prevalence on economic output between 2000 and 2017 in 36 OECD countries. The reason for using dynamic model as estimation method is economic theory.

First, in Table 1, dynamic model Arellano-Bond GMM estimator results are presented using robust standard errors.

Before the interpretation of the panel regression estimation results obtained in the analysis with the Generalized Moments Method (GMM), it is important to perform some consistency tests for the model. Three different tests were used for consistency. The Wald Chi2 test that tests the significance of the variables in the model as a whole, the Sargan test that tests the validity of the tools used in the model, and the Arellano-Bond (AB) autocorrelation tests that show whether the model has an autocorrelation problem.

The model is statistically significant as a whole, according to the Wald test results. In addition, the relationship between instrument variables and error terms was tested with the Sargan test and it was concluded that the instrument variables were valid. The results of AR (1) shows that there is autocorrelation and AR (2) tests show that there is no autocorrelation problem as expected. When the obtained test results are evaluated collectively, it is concluded that the panel regression estimation results can be interpreted properly. The small sample correction suggested by Windmeijer (2005) was made in the GMM estimates. As excessive vehicle use leads to deviating results, it is accepted as a rule of thumb that the number of vehicles should not exceed the number of units in GMM estimates. The Д sign indicates that the number of vehicles is therefore limited. The descriptive statistical results of the models also show that there is no problem in the estimation of the models.

First of all, it is seen that all of the variables that are determinants of output are significant at 10% confidence levels and the coefficients are consistent with expectations. The coefficient of the logarithm of the prevalence value, which is the proxy indicator of cancer, was found to be statistically significant at the 5% confidence level in the probability value calculated with robust coefficients. The coefficient of cancer prevalence was obtained as negative and significant. Accordingly, if the prevalence of cancer among non-communicable diseases decreases in the society, economic output is

Table 1. Arellano-Bond Robust Standard Errors GMM Estimator Results

Arellano-Bond dynamic Model Prediction Group Variable: Countries Time: Years (2000-2017) Vehicle Variable Number: 35 Д				**Number of Observations**	504	
				Number of Groups	36	
				Wald Test	1255.93	
				p	0.0000	
Ly	**Coefficient**	**Std error**	**z**	**p**	**%95 Confidence Interval**	
l_{yt-1}	0.572***	0.042	13.53	0.000	0.489	0.655
l_{yt-2}	0.011	0.040	0.29	0.769	-0.067	0.090
l_{yt-3}	0.231***	0.048	4.79	0.000	0.136	0.326
Lcan	-0.207**	0.101	-2.04	0.041	-0.407	-0.008
Fer	-0.091**	0.029	-3.11	0.002	-0.149	-0.033
Mor	0.026***	0.006	4.13	0.000	0.013	0.038
Inv	0.009***	0.001	10.1	0.000	0.006	0.0107
Tr	0.002***	0.001	4.97	0.000	0.001	0.002
Edu	0.017**	0.001	2.38	0.017	0.003	0.0317

GMM: L(2/3).ly
Standard Equation LD.ly D.lcan D.fer D.mor D.inv D.tr D.edu
Sargan Test Statistic: 34.25435
P for Sargan: 0.1287
AR(1): -2.7686 ve p:0.0056***
AR(2): -0.41724 ve p:0.6765

affected positively. When other determinants of output are examined, one of the factors determining the value of output at time t is its value in t-1 period. The coefficient of Yt-1 variable in the model is statistically significant at 1% confidence level, with a positive sign. This situation shows that there is a positive relationship between the income level of the previous period and the income level of this period. Another variable of output is the birth rate. The "fer" variable was included in the model as an indicator of birth rate, and the coefficient of this variable was found to be significant and negative at the 5% confidence level. If the birth rate increases in the society, output is negatively affected.

Another variable of output is investments. The "inv" variable was included in the model as an investment indicator, and the coefficient of this variable was found to be positive at 1% confidence level. This shows that if the total investments of the country increase, the output is positively affected from this as expected. Another variable of output is the country's trade capacity. The "tr" variable was included in the model as the trade indicator and the coefficient of the trade variable was found to be positive at the 1% confidence level. This situation shows that if the total trade capacity of the country increases, as expected, the output is positively affected. The last determinant of output in the model was the education variable, which indicates the human capital capacity, and the logarithm of the expected education year variable was added to the model as "edu". The coefficient of education variable was found to be positive at the 0.01 confidence level. This situation shows that if the education level of the country increases, the output is positively affected from this as expected.

For the effect of cancer on health expenditures, the static fixed effects model was used as the estimator for the group. However, according to the presumption tests of the Wald Test, Pesaran CD test and LBI-DW test performed in the established models, there are deviations from all three assumptions in all three models. Therefore, the final model prediction results are estimated with the Driscoll-Kray robust standard errors estimator. The estimation results are as in the Table 2 below.

According to the results of Model-1 examining the effect of cancer on health expenditures according to the estimation results made by considering the varying variance, inter-unit correlation and autocorrelation problem, there is a positive relationship between all variables and health expenditure. All coefficients have a positive sign. A statistically significant positive relationship at the level of 10% was found between the logarithm of the cancer prevalence value and the logarithm of the total health expenditure per capita. Accordingly, 1% increase in cancer prevalence increases the total health expenditure per person by 0.80%.

Table 2. Results with Driscoll-Kray Standard Errors-Cancer

Model 1- Dependent Variable: lkbsh Estimation Method: Fixed Effects Within-Group Estimator- Robust Standard Errors Group Variable: Countries R-sq: within = 0.7992 Number of Observations: 504 Number of Groups: 36				**Model 2-** Dependent Variable: lgov Estimation Method: Fixed Effects Within-Group Estimator- Robust Standard Errors Group Variable: Countries R-sq: within = 0.8271 Number of Observations: 504 Number of Groups: 36			**Model 3-** Dependent Variable: loop Estimation Method: Fixed Effects Within-Group Estimator- Robust Standard Errors Group Variable: Countries R-sq: within = 0.3547 Number of Observations: 504 Number of Groups: 36		
Variable	**Coef.**	**t**	**p**	**Variable**	**Coef.**	**p**	**Variable**	**Coef.**	**p**
Lcan	0.804* (0.403)	1.99	0.068	.804*** (0.392)	2.05	0.061	0.858 (0.507)	1.69	0.115
Income	0.001*** (0.000)	3.83	0.002	.00*** (0.000)	3.61	0.003	0.000** (0.000)	2.26	0.042
Edu	0.028*** (0.003)	7.51	0.000	.0405*** (0.004)	8.52	0.000	-0.010 (0.013)	-0.77	0.457
Age	0.093*** (0.004)	21.34	0.000	.103*** (0.004)	25.56	0.000	0.048*** (0.013)	3.52	0.004
Ss	0.011*** (0.002)	4.01	0.001	.0170*** (0.002)	6.3	0.000	-0.011** (0.004)	-2.74	0.017
Constant	378.071*** (0.2963796)	12.76	0.000	2.925*** (0.266)	10.96	0.000	4.960*** (0.696)	7.12	0.000
F	299.77***			F	318.05***		F	4.14**	
P	0.000			p	0.000		p	0.018	

*Robust standard errors were used in the estimation. Values in parentheses indicate standard errors. *, ** and *** represent significance at the 0.10, 0.05, and 0.001 level, respectively.*

Another variable in the model is the "income" variable, which represents the income level. The relationship between per capita income level calculated according to purchasing power parity and total health expenditure per capita calculated according to purchasing power parity is statistically significant at 1% level. The fact that the coefficient is positively signed and significant reveals that the level of income increases health expenditures. This situation is consistent with theoretical expectation. The third independent variable in the model is the proportion of the population over the age of 65, representing the demographic structure of the society. This variable is included in the model as "age". The relationship between the proportion of the population aged +65 in the total population and the total amount of health expenditure per person calculated according to purchasing power parity is statistically significant at the level of 1%. The fact that the coefficient is positive and significant reveals that aging increases health expenditures. This situation is in line with the theoretical expectation. The relationship between education variable in Model 1 and total health expenditure per capita calculated according to purchasing power parity is statistically significant at 1% level. Education variable is included in the model as "edu" and has a positive coefficient. Accordingly, the increase in the expected schooling year, which is the proxy indicator of the education variable, positively affects the total health expenditures. This situation is in line with the theoretical expectation. The last explanatory variable in Model 1 is the share of public expenditures in total health expenditures, which represents the structure of the health system in terms of financing. This variable is included in the model as "ss". The sign of this variable is positive and statistically significant at the 1% level. Increasing the share of public expenditures in total health expenditures increases the total health expenditure per capita.

According to the results of Model-2, which examines the effect of cancer on total public health expenditure per capita, there is a positive relationship between all variables and health expenditure. A statistically significant positive relationship at the level of 10% was found between the logarithm of the cancer prevalence value and the logarithm of the total public health expenditure per capita. Accordingly, a 1% increase in cancer prevalence increases the total public health expenditure per person by 0.80%. The relationship between per capita income level calculated according to purchasing power parity and total public health expenditure per capita calculated according to purchasing power parity is statistically significant at 1% level. The fact that the coefficient is positively signed and significant reveals that the income level increases public health expenditures. This situation is consistent with theoretical expectation. The third independent variable in Model 2 is the ratio of the population over the age of +65, representing the demographic structure of the society. The relationship between the proportion of the population aged +65 in the total population and the total amount of public health expenditure per capita is statistically significant at the level of 1%. The fact that the coefficient is positively signed and significant reveals that aging increases public health expenditures. The relationship between education variable in Model 2 and the total amount of public health expenditure per capita is statistically significant at 1% level. Accordingly, the increase in the expected schooling year, which is the proxy indicator of the education variable, increases the total public health expenditures. The last explanatory variable in Model 2 is the share of public expenditures in total health expenditures, which represents the structure of the health system in terms of financing. The sign of this variable is positive and statistically significant at the 1% level. Increasing the share of public expenditures in total health expenditures increases the amount of total public health expenditure per capita.

According to the results of Model-3, which examines the effect of cancer on total out-of-pocket health expenditure per person, a statistically significant relationship was not found between the logarithm of the cancer prevalence value and the logarithm of the total OOP health expenditure per capita. The relationship between per capita income level calculated according to purchasing power parity and total out-of-pocket health expenditure amount is statistically significant at 5% level. The fact that the coefficient is positively signed and significant reveals that the income level increases out-of-pocket health expenditures. Another independent variable in Model 3 is the ratio of the population over the age of +65, representing the demographic structure of the society. The relationship between the proportion of the population aged +65 in the total population and the total amount of public health expenditure per capita is statistically significant at the level of 1%. The fact that the coefficient is also positively signed and significant reveals that aging increases out-of-pocket health expenditures. The relationship between education variable in Model 3 and total out-of-pocket health expenditure per person is not statistically significant. The last explanatory variable in Model 3 is the share of public expenditures in total health expenditures, which represents the structure of the health system in terms of financing. The sign of this variable is negative and statistically significant at the 5% level. Increasing the share of public expenditures in total health expenditures decreases the amount of total OOP health expenditure per capita.

When comparing the results of Model-1, Model-2 and Model-3, which examines the effect of cancer prevalence on different health expenditure indicators, the logarithm of the cancer prevalence has effect on the logarithm of the total amount of health expenditure per capita by purchasing power parity and on the logarithm of the total amount of public health expenditure per capita. However, it was concluded that there was no significant relationship between the logarithm of the cancer prevalence and the logarithm of the per capita out-of-pocket health expenditure.

DISCUSSION AND CONCLUSION

The effects of diseases on the economy can be examined in two dimensions as macro and micro effects. Macro effects are losses in national income through the erosion of the human capital stock or a decrease in the quality and quantity of labor supply as a result of economic output and an increase in mortality / morbidity rates of diseases. Microeconomic effects of diseases refer to their effects on microeconomic decision-making units such as individuals (households) and firms (15). Another effect of diseases on the economy is through health expenditures. Studies in the literature suggest that non-communicable diseases cause higher health expenditure. In this study, with the help of static and dynamic panel models, the effect of cancer on economic output and health expenditures is focused. The contribution of the study to the literature is that the economic effect of disease patterns will be examined by using the prevalence variable instead of mortality in the model. The reason for this situation is that deaths caused by long-term diseases such as cancer occur mostly after withdrawal from the workforce and health expenditures for these diseases are high from the beginning. In addition, the model has the capacity to examine more than one country in more than one period and present a result that is free from unit or time effects. Therefore, more realistic results have been obtained in estimating the economic impact of diseases. The effect of cancer on economic output was investigated by dynamic panel output regression equation with the help of annual data for the period 2000-2017 for OECD countries. The reason why trade capacity and investments are included in the model that examines the effect of the disease on economic output is that these variables are determinants of economic output in the economic literature. In addition, an education variable was added to the model. The reason for this is to be able to measure the impact of human capital on output. Mortality and birth rate were added to the model, which are health variables that are indicators of important human capital together with education. The reason why these variables are included in the model is that the death rate will affect the economic output due to its effect on the labor force, and similarly, the birth rate will affect the economic output through the labor supply and income share. In addition, cancer prevalence was added to the model to focus on the impact of diseases on output. Undoubtedly, there are many variables that determine economic output in a country. For example, factors such as structural reforms, confidence, stability, availability of labor, employment, and investment capacity may also have an impact on output. However, this study focused more on the effect of human factors on output. In future studies, it may be suggested to establish larger models that also examine these factors. According to the established model, it was concluded that the increase in cancer prevalence has a negative effect on economic output in OECD countries. The effect of cancer on health expenditure was investigated by static panel regression equation with the help of annual data for the period 2004-2017 for OECD countries. Undoubtedly, health expenditures are affected by many factors besides invastigaed variables, income aging, education, health systems characteristics and disease patern. For example, there are findings in recent studies that obesity rates have an effect on health expenditures. However, in the study, a single disease group was included in the model in order to focus on cancer as a disease pattern. Also the reason why these variables are included in the model is that income, education and aging are the variables most associated with health expenditures and the effect of health system structure on expenditure is also desired to be observed. According to the established model, it was concluded that the increase in cancer prevalence has a positive effect on total and public health expenditure per capita in OECD countries.

There has been an increase in the number of studies on the economic effects of diseases in the literature in recent years. Similar results were obtained in studies in the literature. For example, in a systematic review conducted by Vandenberghe and Albrecht in 2019, it was concluded that non-communicable diseases both led to an increase in health expenditures. Schmid concluded that the direct medical costs of treating cardiovascular diseases in Germany have a high financial impact on the German health system (16-17).

In 1992, Mankiw, Romer, and Weil expanded the Solow growth model by including the human capital phenomenon, and later in 1995 Knowles and Owen (1995) expanded human capital by including the health element in the model as well as the education. Studies examining the effects of health and diseases have emerged. While studies on the economic effects of diseases focused on the effects of infectious diseases such as HIV / AIDS, studies investigating non-communicable diseases such as cancer, obesity and cardiovascular diseases have started to increase in recent years. Studies have generally found the negative economic effects of the diseases. For example, Tandon examined the macroeconomic impact of HIV / AIDS in the Asia and Pacific region with a panel regression model using the solow growth model in 2005 and found that increased HIV prevalence had a negative impact on health capital and economic growth (11). Similarly, Cuddington calculated in his study in 1993 that if AIDS is not stopped, Tanzania will decrease its GDP significantly in 2010 and cause per capita income levels to decrease (18). Dixon et al examined the impact of the HIV epidemic on economic growth performance in 41 African economies between 1960 and 1999 with the help of panel data models and showed that the impact of the epidemic was in line with normal economic expectations for African countries where the impact of the HIV epidemic was relatively low (19). Suhrcke and Urban investigated the effect of mortality of cardiovascular diseases on economic growth by income groups in their study in, in which they examined the effect of mortality rate of cardiovascular diseases on economic growth. According to the result of the dynamic panel data model they established, they found that although this disease did not have a significant effect on economic growth in low and middle income groups, it had a strong negative effect on growth rates in high income groups (20). The findings of Suhrcke's and Urban's study are similar to those of this study. Muka et al. In the review studies examined the economic effects of noncommunicable diseases at a macroeconomic level, they stated that noncommunicable diseases such as cancer will increase over time and create a significant financial burden on the budget and welfare (21). Torun, in 2017, investigated the direct and indirect costs of cancer in Turkey. According to the analysis, it was concluded that cancer negatively affects economic development in terms of both reducing investment opportunities in other sectors and decreasing income level by decreasing labor productivity. However, Torun also revealed that if the policies against cancer are successful, GDP will increase by 0.01% (15). Bloom et al examined the economic costs of noncommunicable diseases, including cancer, in the Chinese and Indian economy in 2013 within the framework of the Epic Model. According to the analysis, the cost of five main noncommunicable diseases was calculated as USD 27.8 trillion for China and USD 6.2 trillion for India (in 2010 USD) (22). Mahal et al analyzed the economic burden of cancer on Indian households in 2013 using data from approximately 74.000 household health and morbidity surveys. They concluded that cancer reduces the labor force participation rate of households and that the share of income from health expenditures is higher than that of other households (23). Similarly, this study concluded that cancer negatively affects economic output and also increases health expenditures. When the effect of cancer on health expenditures was examined separately according to the ownership of health expenditures, it was seen that cancer prevalence increased total health expenditure and public health expenditure per capita according to purchasing power parity, but did not have a significant effect on per capita OOP health expenditure. This situation can be explained by the fact that health expenditures made due to cancer are covered mostly by public financing.

Noncommunicable diseases, such as cancer, emerge as a global social problem. These diseases adversely affect economic and social development and also deepen the inequalities of opportunity between countries and regions due to the inequality of resources. In this respect, they are seen as a public health problem. Collaboration and determination at global, regional and national levels are needed to eliminate these risks and threats. Scientific studies show that non-communicable disease burdens can be prevented, especially with action plans to reduce risk factors, and financial risks can be greatly reduced with cost-effective preventive measures as well as disease prevention and control interventions. At this point, the health economics discipline may have important contributions. Determination of priority activity areas with scientific methods and realization of simultaneous prevention, cost-effective treatment and control practices are some of these areas of contribution. In this context, multi-stakeholder action plans have been developed in partnership with national and international organizations in order to prevent the increase of non-communicable diseases in the society in recent years. Prevent noncommunicable diseases by improving key risk factors such as tobacco use, harmful alcohol use, physical inactivity and unhealthy diet, strengthening the health system response to noncommunicable diseases and risk factors, and assessing progress in prevention and control by monitoring trends and determinants of noncommunicable diseases. It is important to work towards. Otherwise, as stated by the United Nations, non-communicable diseases, which are defined as one of the most important health problems in the 21st Century, will have destructive effects on the health capacity of countries as well as socially and economically.

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Conflict of Interest

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Availability of data and material

Data is open access.

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