MARMARA UNIVERSITY
INSTITUTE FOR GRADUATE STUDIES
IN PURE AND APPLIED SCIENCES

FORECASTING OF HEALTH EXPENDITURES AND DETERMINING ITS INDICATORS

TUĞÇE İŞSEVER

Ph.D. THESIS

Department of Industrial Engineering

Thesis Supervisor

Prof. Dr. Bahar SENNAROĞLU

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ACKNOWLEDGEMENT

First of all, I would like to express my endless thanks and gratitude to my advisor Prof. Dr. Bahar SENNAROĞLU, who helped me in every aspect throughout my thesis study, contributed and supported me during my thesis journey.

I would like to thank the members of the thesis committee, Assoc. Prof. Dr. Cem Çağrı DÖNMEZ and Assoc. Prof. Dr. Adnan ÇORUM, who contributed to and supported my thesis with their valuable feedback.

Finally, I express my gratitude to my beloved parents, Prof. Dr. Halim İŞSEVER and Neşe İŞSEVER, who supported and encouraged me at every stage of my life and provided every support throughout this long journey.

May, 2024 **Tuğçe İŞSEVER**

TABLE OF CONTENT

ÖZET

SAĞLIK HARCAMALARININ TAHMİNİ VE GÖSTERGELERİN BELİRLENMESİ

Sağlık harcamaları OECD ülkeleri için ekonomik kaygılardan biri olarak değerlendirilmektedir. Günümüzde tüm dünyada sağlık harcamalarının artmasıyla birlikte ülkeler, bu harcamaları tahmin etme ve bütçe planlama çalışmaları yapmaktadır. Artan sağlık harcamaları nedeniyle tahminler önem kazanmakta ve en doğru ve uygulanabilir yöntemin bulunması için çalışmalar yapılmaktadır. Harcamaların doğru tahmin edilmesi ekonomik sürdürülebilirliğe ve bütçe planlamasına katkı sağlar.

Çalışmanın ilk bölümünde OECD ülkelerinin sağlık harcamalarını etkileyen değişkenleri belirlemek için Ki-Kare Otomatik Etkileşim Tespiti (CHAID) karar ağacı tekniği kullanılmıştır. CHAID karar ağacını oluşturmak için ekonomik, demografik ve sağlık kategorilerinde toplam on beş değişken seçilmiştir.

CHAID analizi sonucunda cari sağlık harcamaları üzerinde etkili olan beş değişken tespit edilmiştir: kişi başına düşen gayri safi yurt içi hasıla, doğumda beklenen yaşam süresi, ölüm oranı, cepten yapılan harcamalar ve doğurganlık oranı. Otuz yedi OECD ülkesi, cari sağlık harcamaları açısından karar kurallarına göre on bir gruba ayrılmaktadır. Ülkelerin sağlık harcamalarının öngörülen değerleri ile gerçek değerleri arasındaki korelasyon katsayısının yüksek değeri, iyi tahmin performansını göstermektedir. Ayrıca, belirlenen etkili değişkenleri açıklayıcı değişkenler olarak kullanarak oluşturulan regresyon modelleri iyi bir tahmin doğruluğu sağlamıştır.

Çalışmanın ikinci bölümünde, Box-Cox dönüşümünün OECD ülkelerinin sağlık harcamalarını tahmin etmeye yönelik tahmin yöntemlerinin performansları üzerindeki etkileri incelenmiştir. Hem orijinal veriyi hem de dönüştürülmüş verileri kullanarak 37 OECD ülkesinin sağlık harcamaları verileri üzerinde Holt'un yöntemi, Otoregresif Entegre Hareketli Ortalama (ARIMA) ve Sinir Ağı Otoregresyon (NNAR) modelleri kullanılmıştır. Tahmin yöntemlerinin performanslarının Ortalama Mutlak Yüzde Hata ile karşılaştırılmasına dayanan sonuçlar incelendiğinde, ARIMA'nın orijinal veya dönüştürülmüş veriler kullanılsın veya kullanılmasın diğer yöntemlerden daha iyi performans gösterdiğini gösterdi; NNAR'ın performansı güç dönüşümüyle artarken Holt'un yönteminin performansı logaritmik dönüşümle arttı.

ABSTRACT

FORECASTING OF HEALTH EXPENDITURES AND DETERMINING ITS INDICATORS

Health expenditures are considered one of the economic concerns for OECD countries. Today, with the increase in health expenditures all over the world, countries are working on predicting these expenditures and planning budgets. Due to the increasing health expenditures, the predictions become important and studies are carried out to find the most accurate and applicable method. Accurate prediction of expenditures contributes to economic sustainability and budget planning.

In the first part of the study, the Chi-Square Automatic Interaction Detection (CHAID) decision tree technique was used to determine the variables affecting the health expenditures of OECD countries. A total of fifteen variables in the economic, demographic, and health categories were selected to create the CHAID decision tree.

As a result of the CHAID analysis, five variables that have an impact on current health expenditures were identified: gross domestic product per capita, life expectancy at birth, mortality rate, out-of-pocket expenses, and fertility rate. Thirty-seven OECD countries are divided into eleven groups according to decision rules in terms of current health expenditures. The high value of the correlation coefficient between the predicted values and actual values of countries' health expenditures indicates good forecasting performance. Additionally, regression models created using the identified influential variables as explanatory variables provide good prediction accuracy.

In the second part of the study, the effects of the Box-Cox transformation were examined on the performances of forecasting methods to predict the health expenditures of OECD countries. Holt's method, Autoregressive Integrated Moving Average (ARIMA), and Neural Network Autoregression (NNAR) models were employed on health expenditure data for 37 OECD countries using both original and transformed data. The results based on the comparison of performances of forecasting methods by Mean Absolute Percentage Error showed that ARIMA outperforms other methods whether or not original or transformed data are used; the performance of NNAR improved with power transformation, whereas that of Holt’s method with logarithmic transformation.

CLAIM OF ORIGINALITY

In this thesis study, the influential factors affecting health expenditures for OECD countries were analyzed with the CHAID decision tree method. CHAID is the first study of the decision tree model implemented to health expenditures. As a result of the first part of the study, although GDP per capita and life expectancy at birth were found to be significant similar to other researches, unlike other studies, out-of-pocket expenditure, fertility rate, and death rate were calculated as significant. These indicators are significant findings for OECD nations, and when governments and policy makers plan health spending, the study's outcome serves as a crucial signal. Each country can develop its own forecasting model and plan health care budget based on these influential variables. A regression model was constructed for each OECD country using the identified significant variables as a result of the decision tree method. In the regression model applied for each country, MAPE values were calculated below 10%, proving that the prediction model and its variables were applied correctly. The applied regression model provides policy makers and budget planners with information for health expenditure modeling.

In the second part of the study, Holt's method, ARIMA, and NNAR forecasting methods are applied to the current health expenditure data (% of the GDP) with Box-Cox transformation for each OECD country. Analysis of health expenditures is considered as popular research issue and this is the first study in which the Box-Cox transformation is applied to health expenditures. As a result of the study, it was concluded that the predictions of ARIMA with Box-Cox transformed data gave the best results with a low MAPE values and performs well by providing forecasting accuracy.

SYMBOLS

α : Smoothing parameter

β : Smoothing parameter

λ : Parameter of Box-Cox transformations

F_{t+h} : h-period ahead forecast

L_t : Level at time t

R : Correlation coefficient (r)

R-sq(adj) : The adjusted coefficient of determination

T_t : Trend at time t

X_k : Influential variables of health expenditure

Y : Current health expenditure (% of GDP)

S : Standard error of estimate (S)

ABBREVIATIONS

ANN : Artificial Neural Network
ARIMA : Autoregressive Moving Average
BRICS : Brazil, Russia, India, China, and South Africa
CHAID : Chi-square Automatic Interaction Detection
CART : Classification and Regression Tree
ECO : Economic Cooperation Organization
FNN : Feedforward Neural Network
LSTM : Long-Short Term Memory
MAPE : Mean Absolute Percentage Error
NNAR : Neural Network Auto Regression
OECD : Organisation for Economic Co-operation and Development
OOEC : Organization for European Economic Cooperation
OLS : Ordinary Least Squares
RMSE : Root Mean Square Error
RNN : Recurrent Neural Network
VAR : Vector Autoregressive Regression
WHO : World Health Organization

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

Health is one of the most important indicators in the development of a country and in determining the level of development. The health policies and health systems of the countries are constantly examined with health indicators, and studies are carried out to improve these criteria. Health indicators are one of the leading criteria that show the quality of life and development level of a country. Countries are in a constant search in the historical process to bring these indicators to higher levels. In this respect, investments and expenditures made to increase the level of health have always been included in public budgets with large amounts.

Considering the definition of health, the definition made by WHO in 1948 emerges: *"Health is not only the absence of disease and disability but also the state of complete physical, mental and social well-being"* (WHO/1948). In the Constitution of the Republic of Türkiye, health is emphasized as an inalienable right, and everyone has the right to live in a healthy and balanced environment (Güler, 2012).

Modern human rights include some basic features; Being human is enough to have these rights, they are not acquired later, they are found naturally, they apply to all people in the world, no one is distinguished, and these rights mainly involve and regulate the relationship between people and their states. Health services are considered an extension of basic human rights, especially since public health services, which are a basis of the social state understanding, are carried out directly or indirectly by the state. Government officials protect and promote health while also protecting and promoting human rights (Mann et al., 1994; Mann, 1997)

The World Health Organization (WHO) emphasizes that health is the fundamental right of all individuals, regardless of race, politics, economic and social position, in achieving the highest standard level of health. WHO ensures full cooperation between countries to raise the standards of services in health. The World Bank filled the policy gap that developed due to the decline in the effectiveness of the WHO in the late 1980s and early 1990s (Kutbay, 2002). Health policy can be defined as regulating and structuring the health sector in a country in line with the philosophy adopted. The tools for structuring the health sector are; funding, organization, and manpower. When all of the countries are examined, it can be seen that the health sector is structured very differently and each of them has different characteristics, and none of them is similar to the other (Dinler, 2013).

A healthy society is very important for the economic development of countries. For individuals and societies to have a healthy life and to maintain it, it is necessary to provide health services properly. Access to health services is an indicator of the development level of countries and represents directly proportional to the share allocated to health expenditures.

Health expenditures, which are an important factor in ensuring economic growth, are considered an important indicator for all countries in the world, although they generally differ between countries. Health expenditure refers to the utilization of resources with the primary aim of enhancing, recovering, and sustaining health. National or total health expenditure refers to the financial value of all resources utilized within the healthcare system within a specific year (World Bank, 2023). Developed countries allocate a higher share of health expenditures than developing and underdeveloped countries. The existence of a healthy person and a healthy society is seen as the main objective of all countries in the world. Because it is accepted that the most basic component of economic stability, prosperity, security, happiness, and peace is health. The fact that a healthy society and health expenditures are seen as the level of development of countries has increased the importance of studies on health expenditures. Influential variables affecting expenditures are investigated using various methodologies for each country and many country groups. Nowadays, the health expenditures of countries are increasing day by day, requiring the prediction of health expenditures in the coming years in terms of financial sustainability and planning of the health budget and investments. In this thesis study, it is aimed to identify influential variables affecting the health expenditures of OECD countries and to predict health expenditures accurately using forecasting methods.

2. LITERATURE REVIEW

2.1 Introduction to Health Expenditures

Health expenditure is identified as an important factor that explains the differences in economic development, attributed to better health outcomes. It is thought that adequate and efficient health expenditures are inevitable in improving health status. Increases in the cost of healthcare services are one of the major issues facing countries and the health sector. The resources allocated for health services and the health spendings made in the provision of services have an important place in the general expenditures of the countries. Resources allocated to health and expenditures are considered as the most influential factors affecting the development indicators of countries (Aboubacar, 2017).

The main aim of all countries globally is to achieve a society of healthy individuals. Because the most important factor of prosperity, power, security, stability, and happiness is to have mental and physical health. The health status in a country is related to the economic growth of the country. When the number of healthy individuals in the general population increases, the country can produce more output through the combination of physical capital, skills, and technological knowledge. The system formed by all institutions and organizations that produce health-related services to protect, develop, and ensure the continuity of health is called the health sector, and all expenditures made for this sector are called health expenditures (Wang, 2011)

In health economics, discussion and research continue about which expenditures will be accepted as health expenditures and which will not. In addition, there is a need for standard definitions to compare international health expenditures. The most important of these are health expenditures per capita the share of health expenditures in GDP and total health expenditures. Thus, health changes and trends between countries can be observed in a certain period. It is seen that almost all major initiatives related to public health around the world are financed by the public. The public generally funds or supports public health services, treatment services, and public insurance programs (Dieleman & Hanlon, 2014: 129) (Tokalaş, 2006: 25).

Total healthcare expenditures worldwide reached $10.89 trillion in 2020, which is equal to 10.89 % of global GDP as shown in Figure 2.1. In every year of the forecast period through 2028, health spending is anticipated to increase faster than the overall economy on average, as it has done for the previous few decades, accounting for an ever-increasing portion of GDP. One of the main reasons driving the rise in national health expenditures is anticipated increases in the price of medical goods and services. This is due, in part, to the prediction that the percentage of the population with insurance coverage will somewhat fall, meaning that the usage and intensity of services will expand more slowly than in recent years (Hartman et al., 2019).

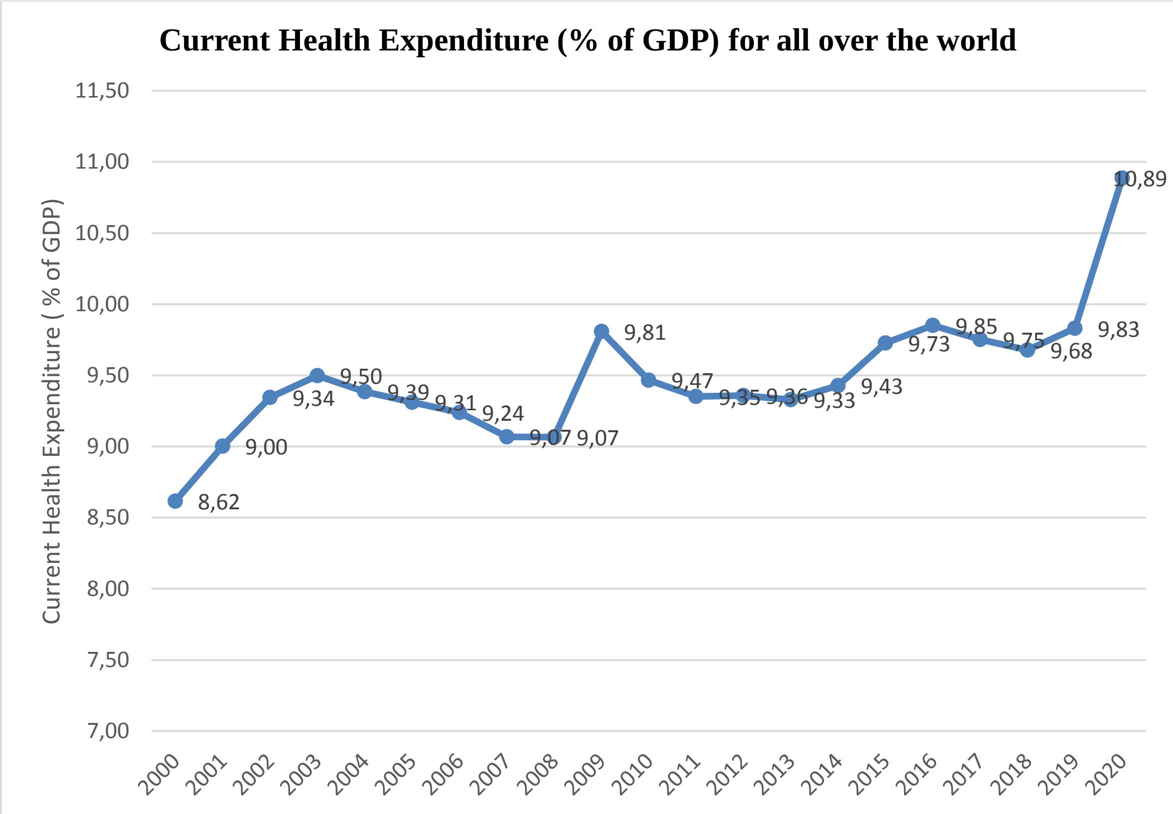

Figure 2.1. Current Health Expenditure (% of the GDP) for the World

According to the World Health Organization (2017), total health expenditures per capita are still low in many developing countries according to health financing statistics. Most developing countries allocate between 5% and 8% of GDP. Public health expenditure per capita increased by about 40% in real terms between 2000 and 2013 for all regions. This can simply show economic growth, but it is also known that in a few countries, there is an increase in the prioritization of health in state budget collections. People tend to value their quality of life more when their economy grows, which increases demand for medical services, particularly in industrialized nations with high national incomes. Prior research on the relationship between economic development and health spending has clarified why health spending differs substantially among nations with comparable economic development levels. Research has demonstrated that this disparity is much more pronounced in nations with varying degrees of economic development, even within OECD nations with comparable economic development features (Wang, 2011).

2.2. OECD Formation and Historical Development

OECD is an international economic organization called the Organization for Economic Co-operation and Development. OECD was established in 1961 as a progression of the Organization for European Economic Cooperation (OEEC), which was founded in 1948 with a decision to change the existing structure within the Marshall Plan based on the Paris Agreement signed on December 14, 1960, after the Second World War.

Within the scope of the Paris Convention, the preamble of the "Convention on the Organization for Economic Co-operation and Development" agreement begins with "With the belief that achieving the objectives of the United Nations (UN), which is to increase the general level of welfare by protecting individual freedoms, is to increase the level of economic power and welfare"

The main objectives of OECD countries are as shown in Figure 2.2; to improve the quality of life in member countries while maintaining financial stability in developing countries, to support policies that ensure sustained and equitable economic growth and eliminate unemployment, to promote economic expansion and coordinated socio-economic development, to promote the advancement of world trade in line with international regulations, to promote democracy, and human rights.

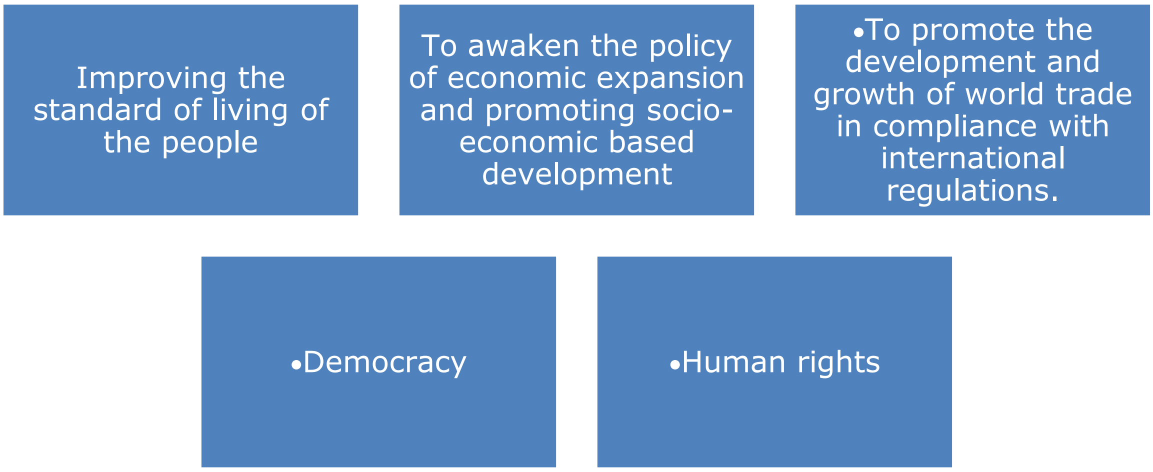

Figure 2.2. Objectives of OECD

While the OECD contributes to the strengthening of member countries, it also aims to achieve these goals by promoting its principles in countries that are not members of the organization.

For the reform of the OEEC, the Convention on the Organization for Economic Cooperation and Development was prepared and signed in 1960 after the 1957 Rome treaties to start the European Economic Community. After the signing of this convention, the OECD officially substituted the OEEC in 1961. The founder members of the OECD consist of the United States and Canada, in addition to the founding European members of the OEEC (OECD, 2018).

2.3. Health System Models of OECD Countries

2.3.1. Beveridge Model

In the organization and development of an inclusive health system, the effort to create a health system that will cover the entire population of the country with public financing and the restructuring wishes of the countries after World War II have been effective. The first attempts were made by Hungary in 1920 and New Zealand in 1938 to organize a health system that aimed to cover all citizens of the country.

The UK's "Beveridge Report" in 1948 is the first exemplary application in European countries to finance health services through taxes and to organize an inclusive health system. The state plays a decisive role in the provision of health services and financing to produce health services, to deliver them equally to all individuals in society, and to eliminate social injustice by including all people in society (Mossialos et al., 2002).

One of the problems that may be encountered in the financing method with taxes is the decrease in tax rates because the country has economic problems and enters a recession period or production decreases. For this reason, it is very important to direct the limited resources available to the needy people in the country. Limited numbers of groups, such as illegal immigrants, are excluded from the scope of the Beveridge model.

The scope of health services is determined based on citizenship or residence. While the countries that are based on residence in the provision of health services are the UK, Australia, New Zealand, Scandinavian countries, and Northern European countries, the countries that determine the scope of health services depending on citizenship are Italy, Spain, Portugal, and some Southern European countries. Over time, information and services are provided to protect individuals in the community from infectious diseases, with limited limits for immigrants who are not citizens but have come to the country legally, and for infants and pregnant women who have come to the country illegally.

In this model, the main principles of the social security system are grouped under the following headings.

1. The Principle of Generality and Uniqueness in Insurance Benefits: Not only workers but all British people, regardless of their professional activities, should be covered by social security as members of society.
2. The Principle of Unity in Management: With this principle in the report, it is a principle that aims to unite all social insurance institutions that are scattered.
3. The Principle of Uniqueness in Premiums and Contribution by Taxes: As a rule, the report adopted the principle of personal responsibility. In other words, in addition to the state, individuals must also contribute to the financing of social security.
4. Supporting the Social Security System with “Full Employment” and “National Health” Policies:

According to the report, the public service to be created about the distribution of insurance benefits is only a specific part of a more general system. For this to be effective, it will inevitably be supported by other policies. In the economic plan, there should be a general health policy that can be embodied in the form of a full employment policy, a national health service, and policies that complement the demand for social security. The national health service should be financed through taxes so that all people can benefit from medical benefits free of charge.

2.3.2. Bismarck Model

The Bismarck model, also known as the is a type of healthcare where people contribute to a fund that then pays for healthcare costs which is based on "Social Health Insurance Model". Institutions owned by the government, the private sector, or the state may offer these services. Otto von Bismarck established the first Bismarck model in 1883 with the primary objective of supporting laborers and their families. After the first Beveridge

Model was presented in 1946, with the goal of providing healthcare as a basic right for every person using tax dollars, nearly all Bismarck systems adopted a universal strategy. As a result, the government started providing financial aid or insurance to those who couldn't pay it (German Healthcare, 2008).

Another name for the Bismarck model is Social Health Insurance and membership in this model is mandatory. In this system, where membership is mandatory, it can be explained as health services that meet the health needs of their members through payroll deductions of employers and workers, and are approved by the state within the scope of a social welfare project (Birn et al., 2009). In the Bismarck model, health services are a duty of the public to ensure that people can benefit from therapeutic health services with personal payments, apart from being able to benefit from health services free of charge. Individuals are compulsorily included in the scope of health care by not making individual payments directly (Sargutan, 2005b).

2.3.3. Mixed Model

The Workers' Insurance Model, the first modern social security system established by Bismarck, and the People's Insurance Model established by Beveridge have been adopted in many countries. Some countries, on the other hand, have started to implement both systems together. In the social security system, known as the Mixed Model, which emerged as a result of the application of the Workers' Insurance Model and the People's Insurance Model together, financing is provided by employers over a certain percentage of workers' wages. Among the characteristics of this model implemented in the Netherlands are universal regulations emphasizing social risk over occupational risk and high benefit levels, an organization that includes social security administration and socio-economic policymakers, a focus on income compensation, and low levels of women's participation in the labor force (Health Care Systems).

2.4. Recent Developments in OECD Health Expenditure

The health expenditures/GDP acceleration of OECD countries has generally been upward. Although there was a slight decrease after 2009 due to the impact of the crisis, it seems to have recovered afterward. As of 2019, the USA is the country with the highest total health expenditures in GDP among OECD countries, with a rate of 16.8%. The USA is followed by Germany with 11.7% and Switzerland with 11.3%. An important common feature of these countries is that they do not lose their current superiority over the years. In other words, in 2000, they were the countries with the highest ratio of total health expenditures to GDP (USA 12.5%, Germany and Switzerland 9.8%).

In terms of health expenditures per capita, as of 2019, the USA is the leading country among OECD countries with $ 10,948. The USA is followed by Switzerland with $7,138 and Norway with $6,744. It is seen that the USA ranked first among OECD countries not only in 2019 but also in 2000. Similarly, Switzerland ranks second. However, what is different here is that Norway does not rank 3rd in per capita health expenditures as in 2019. Norway has shown significant progress over the years and ranked third in per capita health expenditures in 2019.

When all of the OECD nations are evaluated, Switzerland has the highest out-of-pocket expenditure per person, at $1,805. After Switzerland, the USA ranks second with $1,238, and Korea ranks third with $1,030. Among the countries in question, the change in Korea is striking. So much so that while per capita out-of-pocket expenditure was $316 in 2000, it has shown a significant development over the years and more than tripled in 2019. It is also worth noting that in 2000 the US rate was $685 and in Switzerland $1,032 (Zorkun & Bülbül, 2022).

2.5. Definition and Importance of Health Expenditures

Recently, the issue of health expenditures has become one of the most fundamental issues of health economics and has not started to be among the frequently discussed areas. It is also an important parameter in terms of making comparisons between countries and knowing the resources that countries have allocated to the health sector. For this reason, the concept of health expenditures is defined as all expenditures made for health promotion, protection, care, and nutrition (Taşkın, 2011; Boz & Sur, 2015).

One of the most fundamental problems that arise in health-related research is which expenditures will be considered as health expenditures. In addition to treatment and preventive health services, the evaluation of medical care, cosmetic expenditures, and food-beverage-accommodation expenditures within health expenditures has been a matter of debate and how much of such expenditures will be within the scope of health expenditures has started to be discussed. Health expenditures are a parameter shaped by the effect of the health policies implemented by the countries. In general, health expenditures for the treatment of diseases, protection of health status, and sustainability of existing health are important in determining and increasing the level of public health. In addition, the health indicators that emerge as a result of health expenditures are also considered important for countries (Çulha, 2019).

The main definitions of health expenditure and its leading indicators are expressed as follows in Figure 2.3.

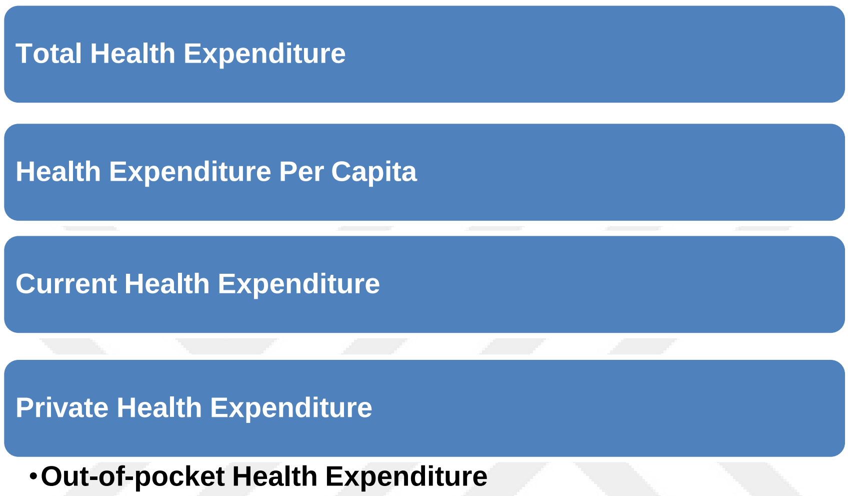

Figure 2.3. Health Expenditure Indicators

2.5.1 Total Health Expenditure

The total sum of the expenditures made to protect and improve the health of the individual and society and to prevent epidemics is defined as total health expenditure. Health expenditures are generally evaluated in two parts current health and health investment. For this reason, total health expenditures are included in health investments (Ünal, 2017).

According to another definition, total health expenditure is expressed as the total value of all public and private health expenditures in a country. Total health expenditure is calculated based on “Health Calculation Systems” created by WHO and OECD.

2.5.2. Health Expenditure Per Capita

Health expenditure per capita is defined as the ratio of total health expenditures of the public and private sectors to the total population. Emergency aid, preventive, therapeutic health services, nutrition, and family planning activities payments constitute the scope of expenditures; however, water sanitation services are not considered within the scope of these expenditures (World Bank, 2018).

In terms of health expenditures, health expenditures per capita are considered an important parameter. In addition, this indicator is a variable that allows comparisons between countries. Health expenditure per capita is seen as the main determinant of changes in real health expenditures in OECD countries and changes in health status indicators of countries. GDP per capita, education rate, and indicators are generally considered to be the second or third variable that determines health. Therefore, per capita health expenditures are determined as influential variables for the development of health indicators in any country (Ünal, 2017; Sungur, 2018).

To compare health expenditure levels per capita in terms of countries, country expenditure levels are converted into a common currency and adjusted to evaluate the different purchasing power of countries' national currencies. To calculate the most reliable conversion rates, purchasing power parity is generally not taken into account when calculating health expenditures per capita (OECD, 2018).

It is seen that the health indicators of countries that spend more on health services and allocate more resources to the economy are better (First National, 2007). Thanks to the developments in the regulations made by the countries for health services, improvements are also made in the economic outlook of the country. From this point of view, the fact that countries are in a good economic position affects health, and a good state of health affects the economy of the country positively. Another factor affecting the economy and health of countries is income distribution. In general, the healthiest societies are seen as societies with a more equitable distribution of income. Therefore, it is possible to see a significant relationship between the level of economic, and socio-cultural development and the amount spent on health services by the country (Karabulut, 2010).

2.5.3. Current Health Expenditure

These expenditures are health expenditures for goods and services, many of which are permanent, whose effects are not permanent, and which are used and consumed only at once. They consist of personnel expenses, service procurement expenses, drug expenses, medical equipment expenses, and all treatment, rehabilitation, protection, and public health. Investment Expenditures, on the other hand, are expenditure items that include payments for buildings, equipment, and motor vehicles and are evaluated in health-related functions. It is stated that building-facility expenses, machinery-equipment expenses, repair expenses, and ambulance expenses consist of expenditure items under this expense class (Büyüktanır, 2021).

2.5.4. Private Health Expenditure

It covers the part of the total health expenditure provided through the private sector. Private sector health expenditures include out-of-pocket health expenditures (including direct payments and user contributions), private health insurance programs, and charities (OECD, 2018).

The share of private health expenditures in general health expenditures and private sector health expenditures per capita are among the important criteria used in economic analysis and comparisons between countries. Out-of-pocket health expenditures, which are an important criterion among private health expenditures, are considered as a direct type of expenditure. Direct payment, user contribution, and informal payments are included in this group. In addition, it is emphasized that the payments given to doctors and drug providers in return for disease treatment and disease prevention are also considered within this group (Ünal: 2017; World Bank, 2018).

Out-of-pocket health expenditures rank second after public health expenditures in terms of percentage of total expenditures. Out-of-pocket expenditures for health purposes are a tool used to create additional resources in the financing of health services, to enable individuals to consider the costs and benefits of various services and thus to avoid unnecessary health care use, and especially to reduce and control public health expenditures. Kraipornsak's research (2017) indicates that out-of-pocket expenditures are key factors in both OECD and Asian countries' health expenditures.

2.6. Factors Affecting Health Expenditures

Recently, health expenditures have been on an upward trend worldwide. Health spending is increasing at a faster rate in developed than in underdeveloped or developing nations, particularly in wealthy nations. Therefore, there is the fact that health expenditures are increasing rapidly around the world. From this point of view, it is of great importance to determine the underlying causes of health expenditures. In the light of previous studies, the reasons for the increment in health spending in developed and developing countries were investigated. Influential factors affecting expenditures are summarized as economic, demographic, and health-related.

2.6.1. Economic Factors

The economy has affected many structures in society, as well as health in many ways. There is an important relationship between health status and main economic variables such as GDP per capita, income, income distribution, Research & Development (R&D) expenditures, inflation, and unemployment.

2.6.1.1. GDP Per Capita

Increments in GDP and increases in per capita income are generally described as economic growth. However, to talk about economic growth in the real sense, many social parameters other than these parameters need to be considered and evaluated together. These are parameters related to human rights, such as nutrition, education, and health status. Today, while economic development is taking place, the dimensions of the relationship between individual elements and economic elements are becoming important. Studies on the determination of these dimensions are increasing day by day. Among the human development indicators, health indicators are one step ahead of other indicators because they are in a closer relationship with economic development, and the studies on this subject are more than others. Different variables are used in most studies investigating the relationship between health and the economy.

The relationship between GDP and health indicators has been discussed at all stages of economic development. In the previous research, it was stated that there was a strong positive correlation between life expectancy at birth, and GDP, and a negative correlation with death rate indicators. (Aytürk, 2010).

It is stated that the higher the average income per capita of a country, the longer and healthier the life of the people in that society will be. Briefly, the increase in income level positively affects health indicators. (Çelik, 2019).

2.6.1.2. Change in Per Capita Income

The main factor affecting the total amount and rate of increment in health expenditures is seen as the rise in GDP per capita. It is known that with the increase in income, people will demand goods and services for a better quality of life. For them to lead a better life, the individual must be healthy and educated. Furthermore, when comparing health spending in different countries, per capita income is considered to be a critical indicator in understanding the variations in healthcare costs, so when personal income increases, it is expected that the demand for health services for a more comfortable life will increase (Boz & Sur, 2015; Ke, et al., 2011).

2.6.1.3. Income Distribution

Showing how the income generated in an economy in a certain period is shared is expressed as income distribution.

This sharing is considered functional when it is made between the factors of production; individual income distribution if it is made in the form of the share of the household in the total income; sectoral income distribution if it is made between sectors; and regional income distribution if it is made between geographical regions.

The issue of income distribution as well as health expenditures is seen as an important factor in health status indicators. It is stated that with the increase in income level, the obstacle to accessing financial resources that can meet the basic needs of people may have been removed (Saunders, 1996). It is estimated that those living in countries with high per capita income levels have a higher level of well-being and therefore have a longer life expectancy (Judge, 1995).

When the effect of income distribution on health indicators is evaluated, it is stated that this effect is more common in both underdeveloped and developing countries. On the other hand, the effect of income distribution is more common in developed countries (Wilkinson, 1996). However, on the contrary, some opinions suggest that income distribution is linked to poverty and that the impact of income disparity on health is significant, regardless of the country's level of development (Deaton, 2003).

2.6.1.4. Research and Development (R&D) Expenditure

The research and development term consists of basic, applied, and experimental research. R&D expenditures are defined as expenditures allocated to basic research, applied research, and experimental research in public institutions, higher education institutions, commercial enterprises, and non-profit private organizations (World Bank, 2021). R&D expenditure is the basis of technological progress which is an important indicator for the healthcare system (Okunade et al., 2002; Murthy & Okunade, 2016). In Okunade's research (2002), its effect has been researched and R&D expenditure is calculated as statistically significant for health expenditure.

2.6.1.5. Unemployment and Inflation

Other economic factors of health status are shown as unemployment and inflation. Health can be expressed as a state of complete physical and mental well-being. From this point of view, inflation and unemployment rates, which do not improve in the economy, affect both the health and psychological health of the society. Studies have concluded that unemployment and inflation rates harm health indicators (Şahin, 2018).

From the point of view of unemployment, it is stated that an individual who is unemployed for a long time will be deprived of the right to a healthy diet as his purchasing power will weaken. For people to maintain their current health status and to eat adequately and healthily, their financial means should be at a sufficient level. The good productivity of the labor element used in the production process proceeds in parallel with the high health status. The fact that the individual is unemployed and this process continues for months leads to the emergence of psychological problems (Şimşek & Kesbiç, 2020).

2.6.2. Demographic Factors

Demographic factors of health expenditure are summarized as population, education level, urbanization, crude birth rate, overall fertility rate, crude death rate, death rate by age-sex-cause, and age dependency ratio (% of working-age population).

2.6.2.1. Population

The main demographic factors affecting health expenditure are considered as the population. The first of the factors that directly affect the quality and quantity of the population living in the country is fertility. It is stated that there is a direct and indirect relationship between extreme fertility and health. In light of previous studies in this field, it is emphasized that excessive fertility rate has negative effects on maternal and infant health, so it causes multiple problems by affecting the general health status, economic status, and cultural and social development of the society.

In addition, it is stated that mother-infant health problems due to excessive fertility are in the first place among the health problems of countries, and this increases the risk of mother-infant mortality (Fişek, 1982).

It is stated that the quality of a country's population is important as well as its quantity. Because one of the most important elements in the development of a country is to have spiritually, physically, and socially healthy generations. (Şirin, 2000; Fişek, 1982).

The other component that shows the effect of population change on health status is mortality. It is important to know the mortality rates in terms of evaluating the changes in the population of a region or country and performing health services (Korkmaz, 2019).

2.6.2.2. Education Level

The increase in people's awareness of education and health increases the demand for health expenditures on an individual and community basis. As people's education level increases, their intellectual level also increases, and accordingly, individuals can become more aware of the developments in the health sector. This awareness also raises the demand for health expenditures (İzgi, 2019). The relationship between education level and spending can be highlighted using two approaches. Primarily, the presence of high levels of education in various countries significantly contributes to the economic advancement of these countries, hence enabling the allocation of greater resources towards healthcare. Furthermore, individuals who possess advanced levels of education exhibit a greater inclination towards prioritizing their health as well as the well-being of their family members, hence benefiting from healthcare services (Yetim, et al., 2018).

It is stated that in cases where the level of education is lower, people may be more reluctant to benefit from preventive health services and may be unconsciously afraid to receive health services. This result will raise the problem of treating diseases at a higher cost instead of preventing them at a low cost due to their progression (İzgi, 2019).

2.6.2.3. Urbanization

Another important result of industrialization, which has increased with the economic progress in the world, is the phenomenon of urbanization. Economic development leads to an increase in urbanization. The phenomenon of urbanization plays a more important role in accessing health services than in rural areas. Economic growth brings with it the necessity for people to live together for production. The increase in the number of people living together reveals that an increase in health services is a necessary result. In areas where the level of urbanization is increasing, health institutions must be at a sufficient level, and the necessary qualified workforce, the drugs, and the technology to be used must be in sufficient quantity. It is said that infectious diseases that may occur in these regions can affect a large number of people and cause serious losses (Taşkın, 2011). The living conditions of rural societies that make their living with agriculture and the living conditions of urbanized societies differ from each other. In addition to better health care, education, employment, social and cultural activities are considered to be better located in urbanized areas than in rural areas (Moore et al., 2003: 269). At the same time, in places where there is urbanization, the number of health institutions and specialist health personnel is higher. It is much easier to find enough specialist personnel, medicines, and equipment in these regions than in rural areas. In rural areas, health conditions are extremely poor. Access to health services in these regions is not sufficient. Sometimes even the provision of clean drinking water is a problem in rural areas. According to a study conducted in Asian countries, the health system indicators of OECD countries and non-OECD countries were evaluated. Although population density and urbanization are positively associated with healthy life expectancy in non-OECD Asian countries, it has been stated that drinking unsafe water increases the infant mortality rate in non-OECD countries (Jakovlevic et al., 2020). In the study conducted among the countries of the Economic Cooperation Organization (ECO), it was determined that urbanization is a significant variable in health expenditure (Samadi & Homaie, 2013).

2.6.2.4. Crude Birth Rate

Another indicator of health status, which is used to reveal information about the general health status of individuals living in any region, is expressed as crude birth rate. This rate is seen as being influenced by the age structure of the population and the general fertility level: this rate is generally higher in undeveloped countries.

If the crude birth rate is defined, it can be expressed as the value found by dividing the number of live births occurring in a year by the number of the mid-year population and multiplying it by 1000 (Sungur, 2018).

2.6.2.5. Overall Fertility Rate

The total fertility rate is the average number of children a woman gives birth to in her lifetime per population. The total fertility rate is obtained by summing the odd-year age-specific rates at a given time. The fertility rate is defined as the rate at which an appropriate number of women live births over some time, usually annually (for example, or 15-50 years of age). The total fertility rate is the sum of the overall fertility rates by age over a period (Tezcan, 2017).

The fertility rate is a statistical index that measures the natural tendency of a population to increase or decrease. It makes it possible to calculate the natural variation of the population of a society, that is, without taking into account migratory flows, subtracting the mortality rate. The general fertility rate may vary according to religion, culture, and social values. In addition, this rate may vary depending on family or population planning, female literacy rate, and female labor force participation rate in the region or country in question. The industrialization, urbanization, and modernization of countries allow education, which is the main driver of fertility, to improve child health and to increase the acceptance of contraceptives. Educational status not only increases women’s knowledge but also affects women’s decision-making processes about having children (Sungur, 2018).

2.6.2.6. Crude Death Rate

Generally, the ratio of those who died in a certain region in a year to the quantity of surviving individuals in the same region is defined as the crude death rate. It identifies a general picture of the health status of the population or geographic region. Since it is a rough indicator, it does not provide detailed information in terms of demographics. It is not an appropriate indicator to measure mortality in different age groups or to compare the specific effect of age. Although the crude mortality rate gives a general idea of the death that occurs in a society, this death rate is not preferred for comparison because it does not fully reflect the risk of mortality of gender or age groups. The crude death rate is calculated by proportioning the total number of deaths in a year in the society by the mid-year population of the same society and multiplying it by 1000. With this death rate, it is tried to determine the health problems of the societies and their health-related priorities with the statistical data calculated by considering the deaths that occur in the country or region quantitatively and qualitatively (Napsis, 2009). Rahman et al. (2018) claim that private healthcare expenditure has a significant impact on lowering the crude death rate in South Asian countries which have lower income than OECD countries.

The advantages of the crude death rate are that it is easy to calculate, it can measure an average mortality risk of the society, the comparison of the death rate of two different societies with similar sex and age, and it allows comparison in similar periods (Çelik, 2019).

2.6.2.7. Death Rate by Age-Sex-Cause

Death Rate by Age is a health indicator used to show the level of mortality in certain age groups. This indicator is used for groups such as the 5-10 year age range and the 15-49 age range. It is calculated by dividing the number of people who died at the age of X in a certain period in a society by the number of people aged X in the same period in the same society and multiplying by 1000. Death rate by sex is an indicator of health status that is used only in calculating the mortality rates of men or women in society. This indicator is measured by multiplying the number of men/women living in a society who died in a certain period by the number of men/women in the same society in the same period and multiplying it by 1000. Finally, the death rate by the cause is an indicator of health status used to reveal the causes and dimensions of their deaths. It is expressed as an indicator that needs to be calculated when it is desired to determine the most common causes of death in society. The cause-specific death rate is obtained by proportioning the number of deaths due to cause X in a certain period in the society by the number in the same society over the same period and multiplying it by 1000. Health status indicators are important for comparing health levels between countries and regions of countries and determining welfare levels (Kumbasar, 2016).

2.6.2.8. Age Dependency Ratio

The ratios highlight the possible impacts of shifts in population age distributions on social and economic progress, revealing general patterns in social assistance requirements.

The dependency ratio changes by comparing the economically dependent group (net consumers) to the economically active group (net producers), indicating potential social support needs due to shifts in population age distributions. The ratio illustrates the increasing burden on workers due to dependency and the changing demographics as societies transition from high mortality and fertility rates to low rates. A high dependence ratio signifies that the working-age population and the economy as a whole bear a heavier responsibility to sustain and offer the necessary social services for children and elderly individuals who are often financially reliant. A high young dependency ratio necessitates increased spending on education and childcare. As fertility lowers, the dependence ratio initially reduces due to a lower number of children and a higher proportion of working-age adults (UN Report 2005; 2006). Since it reflects the population-age population structure of the society; It is used to determine demographic variables of health expenditures (Akca et al., 2017).

2.6.3. Health Variables

The health status is determined through the measurement of perceived health level. In the measurement method of health status, which can be measured based on people's perceptions, factors such as the ability to perform various functions and well-being of individuals are emphasized. (McDowell, 2006; Tezcan, 2017).

The main function of health status indicators is to establish a standard criterion to be used to benchmark international health levels. Therefore, there are some important factors to be considered in determining health indicators. These elements are defined as follows:

- Health status indicators should be defined, and the definition of any health status indicator should be at an international level.
- It should be valid, reliable, and interpretable.
- Technologically, health indicators must be appropriate.
- It should play a useful and informative role.
- Health indicators should be up-to-date and comparable.
- In response to the possibility of changes in political practices in the field of health, health status indicators should be flexible to adapt to all conditions.
- Indicator preference should be taken into account the previous studies of WHO, OECD and Eurostat for definitions, and should be compatible with and supportive of these databases (Kramers, 2003).

Health indicators guide institutions and organizations providing health services on issues such as the functionality of the health care system, whether the health expenditures are sufficient, and the prevention of diseases that are common in societies. In addition, these indicators ensure more efficient and effective use of healthcare resources. Thanks to health indicators, services that are suitable for the health needs of the society can be determined and how the resources allocated for health expenditures should be distributed can be ensured.

Health related indicators can be described as measurable values that are announced through national and international organizations that express the health of societies. Health status indicators are the most preferred tools of states when determining health policy. In addition, it is aimed to reveal the differences between the situations of certain subgroups in the society, such as privileged groups and the poor, and those living in rural-urban areas, and since it is difficult to directly determine the health needs of the society, various health status indicators are used. Among the most commonly used health related variables are life expectancy at birth, infant mortality rate, morbidity, hygenic conditions, number of physians, number of hospital beds, and technological change.

2.6.3.1. Life Expectancy at Birth

The most commonly used variable among health status indicators is life expectancy at birth (Anwar et al., 2023). Life expectancy at birth is defined as the average time a person survives (Bilas et al., 2014). The life expectancy variable is considered one of the economic and social indicators of the country or region, because the level of economic development contributes to the development of social conditions and increases the life expectancy of countries at birth.

Life expectancy at birth is often used to refer to trends in death. This indicator is also seen as an excellent data source to predict how the country's population will age and to determine the planning and delivery of health services (Sungur, 2018).

High-income levels and consequently higher levels of health expenditures, good nutritional conditions, advances in medical technology, and positive developments in health supply contribute to the prolongation of life expectancy at birth. This indicator is presented by total and gender and is measured in years (Daştan & Çetinkaya, 2015).

Talking about the development levels of the countries, the first thing that comes to mind is the income level of the country. However, in today's conditions, the Human Development Index revealed by the United Nations Development Program is taken into account when characterizing development. This index is calculated based on three variables that are thought to represent economic development or development. The first of these is GDP per capita according to the HSP as an indicator of welfare, adult literacy rate and schooling rate as an education criterion, and life expectancy at birth, which also represents a health status indicator as a health criterion (Şimşek and Kesbiç, 2020).

Although it is not possible to estimate the average number of years of an individual's life, statistical data reveal that the life of an individual is approximately 80-85 years in today's conditions. It is seen that there is a decrease in the rate of increase as the income level of the individual approaches this limit in countries with high-income levels, and in countries with low-income levels, the rate of increase increases until it approaches this limit. As the income level and development level of these countries increase, it is seen that the life expectancy at birth increases. Differences in life expectancy at birth between countries and regions are due to many factors, including socio-economic and demographic factors. Increases in life expectancy at birth also accelerate economic growth and development by providing significant benefits to human capital. In this respect, one of the main goals of countries with low-income or high-income levels is to increase life expectancy at birth (Kızıl & Ceylan, 2018).

The prolongation of the average life expectancy is another important factor that increases health expenditures. While examining countries all over the world, the increase in per capita income and technological developments cause an increase in the quality of life of individuals and bring an increase in life expectancy. There is a reciprocal interaction between life expectancy at birth and health expenditures. While expenditures for health in any country increase life expectancy at birth, the increase in life expectancy at birth in the country also leads to an increase in health expenditures. The main reason for this situation is that aging increases the demand for health services in direct proportion.

It has been concluded that the increase in average life expectancy and the increase in the elderly population are associated with an increase in life expectancy at birth and a decrease in the birth rate. With the increase in various health problems as we age, the demands of the elderly for health services increase, and health expenditures tend to increase (Akın, 2007: 34). In many research, it is indicated that life expectancy at birth is considered as significant indicator as a result of regression and decision tree studies (Anwar et al., 2023; Awais et al., 2021; Akca et al. 2017; Linden & Ray, 2017).

2.6.3.2. Infant Mortality Rate

The infant mortality rate is known as one of the most basic health indicators used to determine the health levels of societies. Infant mortality rate is expressed as deaths that occur within 1 year after birth and birth. This ratio is an indicator of health status that shows the level of socio-economic development of countries. Because it is known that where infant mortality rates are high, the health standard of the entire population is also low. Various criteria are used to calculate the infant mortality rate. Each of these criteria is crucial. Due to the different risks and problems of infant mortality, the infant mortality rate is examined indicator of health expenditure (Mohapatra, 2018). According to the study conducted among 177 countries, it is revealed that increasing healthcare expenditure had a more significant effect on lowering infant and maternal mortality in developing countries compared to high-income countries (Owusu et al., 2021). Rahman et al. (2018) studied the relationship between total health expenditure and health status outcomes in the South East Asian Nations. panel data analysis results indicate that total health expenditures have a significant impact on lowering the number of infant mortalities per 1000 live births in the area. Another research compared health spending indicators of OECD and non-OECD nations in Asia. Japan is the first-ranked country with a low infant mortality rate. Korea is in the second rank (Jakovljevic et al., 2020).

2.6.3.3. Morbidity

Morbidity criteria are indicators that reveal the incidence of diseases in the community and the probability of people getting the disease. It is indicated that morbidity is a situation that affects healthcare expenses. Its effect especially on the elderly population is being investigated (Harris & Sharma, 2018).

2.6.3.4. Hygienic Conditions

Drinking safe water and having advanced sanitation facilities are indicators of a country's health status and level of development. Improved sanitation facilities have been seen as the most important factor in healthy life expectancy (Karacan et al., 2020), and have been stated to be effective in reducing the infant mortality rate and crude death rate (Rahman et al.; 2018). When comparing OECD countries and non-OECD countries in Asia, it was found that unsafe water consumption increased the infant mortality rate for non-OECD countries (Jakovljevic et al., 2020).

2.6.3.5. Number of Physicians

The physician must determine the time, scope, and extent of treatment in healthcare on behalf of the patient. In health services, it is not the recipient of the service who decides how much the service will be and how it will be used, but the party that provides the service (Pala, 2007). The number of physicians is one of the most important indicators of the development of a country's health system. Indicators of the health system directly affect health expenditures. Studies have stated that the number of physicians is one of the variables affecting health expenditures (Samadi & Homaie, 2013; Chaabouni & Abednnadher, 2014). According to Jackknife resampling plan estimates study (Okunade et al.,2004) Growth in physician density is measured as statistically significant for periods 1983–1987 and 1988–1992 of OECD countries' health expenditure growth.

2.6.3.6. Number of Hospital Beds

One of the most important indicators of the development of a country's health system is the number of hospital beds. It is expressed as all of the specialized patient beds available in general, private, public, and rehabilitation centers, including chronic and acute care beds (World Bank, 2021). Since the distribution of beds in public and private hospitals will vary depending on the country, this variable is also taken into account in the models when calculating health expenditures (Akca et al.,2017).

2.6.3.7. Technological Change

As a result of advanced technology, many diseases that could not be diagnosed before and therefore could not be treated have become treatable. Advanced technology has allowed physicians to diagnose and treat patients (Khanolkar et al., 2016). Technological innovations such as the use of robotic systems in surgeries, coronary bypass surgeries, pacemaker use, early diagnosis of cancer diseases, x-ray devices, tomography, and MRI are highly preferred. The fact that technological innovations have become so intensively used in the healthcare market also causes the costs of health services to increase (Bodenheimer and Fernandez, 2005).

For these reasons, the technological developments preferred in the field of health make health services easier, reduce mortality rates worldwide, and extend the average human life (Okunade et al., 2002). Therefore, the cost of these technological developments brings with it an increase in the costs of hospitals and health institutions. In short, all kinds of technological developments in the field of health and the use of these technologies cause an increase in health expenditures (Khanolkar et al., 2016). According to Cutler & McClellan (2001a; 2001b), technological progress affects health spending increment both by treatment substitution effect and the treatment expansion effect. In Nghiem & Connelly's (2017) study on OECD countries, the main reason for the increase in health expenditures is technological progress, which corresponds to four percent per year and increases every decade.

2.7. Literature Review on Influential Variables of Health Expenditures' OECD Countries and Other Country Groups

Health expenditure is one of the most important expenses for both governments and individuals. It is summarized as all spending made for prevention, development, care, treatment, nutrition, and emergency programs to improve and protect health (Boyacıoğlu, 2012). The rising cost of health care in the world forces countries to plan their health system, budgets, and expenditures. Prediction of health expenditures and determining their factors accurately allows countries to support their healthcare services and plan their budgets with long-term financial sustainability. In this part, researches on health expenditure determinants of OECD countries are summarized.

Influential variables of health expenditures have been researched for many years. The rapidly rising trend in health expenditures is now recognized as a primary obstacle to maintaining the long-term sustainability of public budgets on a global scale. The continuous increase in Health expenditures and the apprehensions regarding its long-term budgetary viability emphasize the need for policymakers to develop efficient measures to control costs. To control the increment in health expenditures, it is crucial to first understand the elements that determine their growth and the extent of their impact (Amiri et al., 2017). This study aimed to identify the elements that are regarded as determinants of health expenditure of OECD countries. In this part, a literature review of health expenditure determinants of OECD countries has been summarized.

It is determined that GDP per capita is considered the most significant variable in health expenditure of OECD countries (Akca et al. 2017; Hosoya, 2014; Mosca; 2007; Barros, 1998; Hitiris & Posnett, 1992). Akca et al. (2017) used the Classification and Regression Tree (CART) to identify determinants of health expenditure, age dependency ratio, life expectancy at birth, GDP per capita, percentage of the population with bad perceived health status, and the number of hospitals indicated as significant variables as a result of the study.

Kraipornsak's (2017) research includes variables of health expenditures of both OECD and Asian countries. The most effective factor for both groups was found to be the income factor. Out-of-pocket expenses were also found to be significant variables for both groups, but out-of-pocket expenses were three times more significant for OECD countries than for Asian countries.

In Beylik et al.'s research (2022), The Driscoll-Kraay standard error approach is utilized to determine economic indicators of OECD countries' health expenditures. It was determined that the share of current health expenditures in GDP, public health expenditures, out-of-pocket health expenditures, and per capita health expenditures were significantly positively related to GDP.

The optimization model of Atalan and Dönmez (2021) showed that an improvement of 29.13% was achieved by minimizing the health expenditures of OECD countries. GDP, % unemployment in the labor force, % female labor from the female population aged 15 – 64, number of people per sq. km are determined as main factors as a result of panel data analysis of OECD countries (Hosoya, 2014).

Nghiem & Connelly (2017) studied determinants of health expenditures of OECD countries for the period 1975-2004 by using panel data economic methods. Technological progress has been identified as the influential factors for the increment in health expenditures. Yetim et al. (2021) investigated socioeconomic factors of OECD countries which affect health expenditure by panel data analysis. It results that education level, income, and inflation are statistically significant. Dreger & Reimers (2005) also indicate that income level affects health expenditure of OECD countries according to panel data analysis, in addition to income level medical progress is determined as an influential factor.

According to Dogan et al. (2014), public spending and age dependency ratio: young are the main drivers of health expenditures of OECD countries result of the panel ARDL approach.

The study found that the unemployment rate and exchange rate had a positive impact on health outcomes and the health expenditure analysis of OECD Asian and Pacific countries between 1995 and 2013 (Blanquez-Fernandez et al., 2017).

In the study among OECD countries, Barros (1998) investigated the most important variables affecting health expenditures and, in common with other studies, calculated GDP per capita as the most important variable. Public reimbursement is calculated as the second most important variable for health care expenditure. Healthcare is considered a necessity, not a luxury, for OECD countries. According to studies, when the ratio of public expenditures to health care expenditure increases, the income elasticity of HCE also proportionally increases (Wu et al., 2013).

Ordinary least squares (OLS) regression methods are used to determine the determinants of health expenditures of OECD countries. Determinants of countries and country groups are defined by using this method. Health expenditure inertia, life expectancy at birth, the population percentage of 65 ages older, the Baumol variable, growth of urbanization, and growth of female labor force participation are indicated as influential factors among OECD countries (Tian et al., 2018).

The influence of the aging population on health spendings in OECD countries is being investigated by many researches. The results of the semiparametric estimation study confirm that population aging leads to an increase in the share of per capita income allocated to both public and private healthcare expenditure with age among 18 OECD countries (Herwartz & Theilen, 2009). Okunade et al. (2004) investigated drivers of health spending among OECD countries by using Jackknife Resampling Plan Estimates. The percentage of the population above 65 is determined as significant for the period 1967-1997. The percentage of the population below 15 found as insignificant.

Jakovljevic et al. (2020) compared indicators of OECD and non-OECD countries in Asia. According to the results of the research, Japan ran a percentage among the groups in life expectancy and low infant mortality. Korea followed with second place.

Table 2.1. Literature review chart of OECD countries' health expenditures

Author(s)	**Year**	**Method**	**Significant Variables**	**Country Group**
Akca et al.	2017	CART Decision Tree	GDP per capita, % of the population with a bad perceived health status, age dependency ratio, life expectancy at birth, and number of hospitals	OECD Countries
Kraipornsak	2017	Panel Estimation Method	Income effect, urban population, out-of-pocket expenditure	OECD Countries
Kraipornsak	2017	Panel Estimation Method	Income effect, out-of-pocket expenditure	15 Asian Countries
Beylik et al.	2022	The Driscoll-Kraay standard error approach	% of current health expenditures in GDP, public health expenditure, out-of-pocket expenditure on healthcare, health expenditure per capita	OECD Countries
Hosoya	2014	Standard panel regression approach	GDP, % unemployment in the labor force, % female labor from the female population aged 15 – 64, number of people per sq. km	OECD Countries
Nghiem & Connelly	2017	Panel Data Analysis	Technological progress	OECD Countries
Yetim et al.	2021	Panel Data Analysis	Education level, income, inflation	OECD Countries
Dreger & Reimers	2005	Panel Data Analysis	Income, medical progress	OECD Countries
Dogan et al.	2014	Panel ARDL Approach	Public spending, age dependency ratio: young.	OECD Countries
Blanquez-Fernandez et al.	2017	Panel and time-series data techniques	Income, unemployment rate, exchange rate	OECD Asia/Pacific area countries
Barros	1998	Panel Data Analysis	GDP per capita, public reimbursement	OECD Countries
Tian et al.	2018	Ordinary least squares (OLS) regressions	Health expenditure inertia, life expectancy at birth, population percentage of 65 ages older, Baumol variable, growth of urbanization, growth of female labor force participation,	OECD Countries
Anwar et al.	2023	Generalized method of	Life expectancy at birth	OECD Countries

		moments (GMM)		
Hitiris & Posnett	1992	Pooled time series and cross-section	GDP	OECD Countries
Mosca	2007	Panel Data Analysis	GDP per capita, population structure, unemployment rate	OECD Countries
Herwartz & Theilen	2009	Semiparametric estimation method	Aging population	18 OECD countries 1975–2006
Hartwig	2008	Baumol's model of 'unbalanced	Wage increases that exceed productivity growth	19 OECD countries
Wu et al.	2014	Panel smooth transition regression model	GDP per capita, percentage of public expenditure of health expenditure, population percentage of 65 ages older, time trend	16 OECD countries
Okunade et al.	2004	Jackknife Resampling Plan Estimates	The relative price of health care, the percentege of the population above 65 years	OECD countries

Anwar et al. (2023) examined the effect of health spending on health indicators in OECD nations through the implementation of the Generalized Method of Moments (GMM). The findings indicated the negative effect of health spending on infant mortality and the positive effect on life expectancy in the analyzed nations. It is stated that a negative impact of air pollution, income, the number of doctors, and on infant mortality.

Samadi, A., & Homaie (2013) found GDP per capita, number of physicians, the proportion of population below 15 and above 65 years old, and urbanization as significant variables by using panel data analysis among Economic Cooperation Organization (ECO) countries (Afghanistan, Azerbaijan, Kazakhstan, Kyrgyz Republic, Pakistan Tajikistan, Turkmenistan, Türkiye, and Uzbekistan).

Younsi et al. (2016) modeled health expenditure determinants with a fixed effect and dynamic panel model. GDP per capita, out-of-pocket expenditure, general government health expenditure (% of GDP), percentage of the population age 65 and over, and time trend are calculated as significant variables as a result of the model.

As a result of hierarchical multiple regression analysis (Han et al., 2016), the main health expenditure determinants of Korea are identified as GDP, the percentage of elderly people in the population as shown in Table 2.2.

Table 2.2. Literature review chart of health expenditures for country groups

Author(s)	Year	Method	Significant Variables	Country Group
Samadi, A., & Homaie	2013	Panel Data Analysis	GDP per capita, number of physicians per 1000, % of population below 15 and above 65 years old (negative relationship), % of the people living in urban areas	ECO Countries
Younsi et al.	2016	Fixed-effect and dynamic panel model	GDP per capita, GGE (% of the GDP), OOP (% THE per capita), % of the population 65 aged and over, time trend	167 countries
Han K et al	2013	Hierarchical multiple regression	The proportion of elderly people in the population, gross domestic product (GDP) per capita, Medicare Economic Index, and other determinants.	Korea
Murthy & Okunade	2016	Autoregressive distributed lag (ARDL)	Per capita real income, % of population over 65 years, the level of R&D expenditure in health care	US
Khan et al.	2016	Time Series Analysis/Auto-RegressiveDistributed Lag Model (ARDL), Ordinary least square (OLS)	GDP per capita, technological changes, life expectancy	Malaysia

Khan et al (2016) and Murthy & Okunade (2016) used autoregressive distributed lag (ARDL) to determine influential variables of health expenditure. Health determinants of the US are examined as per capita real income, percentage of the population above 65 years, and percentage of research & development expenditure in health care (Murthy & Okunade, 2016).

2.8. Literature Review on Forecasting of Health Expenditures

Prediction of health expenditure has been continued research by using both traditional forecasting methods and machine learning methods. Methods used in previous research are summarized as linear regression (Quercioli et al., 2018), and multiple regression (Han et al., 2013), Autoregressive Integrated Moving Average (ARIMA) (Zheng et al., 2020; Piontkowski, 2020; Ramezaneian et al., 2019; Dritsakis & Klazoglou 2019; Kaushik et al., 2017), stochastic time series (Lee & Miller, 2002), Holt's linear model (Piontkowski, 2020), artificial neural networks (Chaabouni & Abednnadher, 2013), recurrent neural networks (Yang et al., 2018), decision trees (Akca et al., 2017), clustering algorithms, data mining methods (Bertsimas et al., 2008) and hybrid heuristic methods (Aladag & Aladag, 2011).

Traditional forecasting methods have great importance in health expenditure forecasting. Most common methods can be expressed as ARIMA (Zheng et al., 2020; Dritsakis & Klazoglou, 2019; Lee & Miller, 2002), linear regression, multiple regression (Han et al., 2016), logistic regression, least square regression, and exponential smoothing (Sahoo et al., 2023).

Health expenditure depends on several factors and the ARIMA model is considered one of the most appropriate models due to its simplicity and stability properties (Zheng et al., 2020). ARIMA (3, 3, 0), ARIMA (1, 3, 1), ARIMA (2, 4, 0), and ARIMA (2, 2, 2) models are implemented to forecast China's total health expenditure, government health expenditure, social health expenditure, and out-of-pocket health expenditure for the period 2013-2017 respectively. Forecast accuracy is calculated by the mean relative errors which are calculated for total health expenditure, government health expenditure, social health expenditure, and out-of-pocket health expenditure as 2.76%, 1.36%, 2.33%, and 2.01%, respectively.

Forecast accuracy is calculated by the mean relative errors which are calculated for social health expenditure, government health expenditure, out-of-pocket health expenditure, and total health expenditure, as 2.33%, 1.36%, 2.01%, and 2.76%, respectively.

According to the study, which is based on the US health system and its expenditures, stochastic time series models are accepted as one of the most appropriate methods to forecast health expenditure in the US and to determine the correlation between the aging population with annual health spending as a GDP percentage from 2002 to 2075 in the US. The increment in health expenditure is related to per capita health spending and the aging population. It is predicted that healthcare expenditures will continue to increase by 8% of GDP by 2075 by using stochastic time series models (Lee & Miller, 2002).

Dritsakis and Klazoglou (2019) used an ARIMA (2,1,0) model following the Box-Jenkins methodology to predict total health spending in the US. It is estimated by integrating the non-linear maximum likelihood optimization method utilizing the Broyden-Fletcher-Goldfarb-Shanno algorithm (BFGS), which is an optimal way for solving nonlinear least squares problems. According to the results, it is stated that actual values are very close to the predicted health expenditure values.

Ramazenian et al. (2019) used ARIMA (1, 1, 4) model to predict total and private health expenditure of Iran and the ARIMA (1,1,1) model for out-of-pocket expenditure. In the forecast study, it was calculated that out-of-pocket expenses will be 40 percent of total health expenditures by 2020.

Kraipornsak (2017) used the regression panel estimation method to predict health expenditure per person for OECD countries and 15 Asian countries. As a result of the study, it was predicted that the per capita health expenditure value would increase for both groups. According to the prediction results, only a one percent rise in annual income can enhance health expenditure per person by $484.3 for the Asian country group and $387.5 for the OECD countries.

The exponential smoothing method has been used in many fields, as well as in the prediction of health expenditures, due to its ease of implementation and good performance in various prediction studies (Hyndman et al., 2008). Total, government, pre-paid, and out-of-pocket health expenditures of Brazil, Russia, India, China, and South Africa (BRICS) countries have been estimated with an exponential smoothing method for the period 2020-2035 (Sahoo et al., 2023).

The effect of aging and the growing number of elderly people in the population on health care spendings is examined . Harris & Sharma (2018) utilized a simple demographic projection model to predict total health expenditure, health expenditure per elderly person, and total health expenditure on the elderly in Australia. A predictive model of spending growth indicates that health expenditure per old person is projected to rise from $7,439 in 2015 to $9,594 in 2035. Additionally, total expenditure is expected to climb from $166 billion If individuals have increased longevity without any additional health issues, then the overall expenditure on healthcare will only increase at an average annual rate of 0.48%. If only a portion of those additional years are spent in good health, then the average year-on-year gain is 1.87%.

Forecasting terms are examined as short-term, medium-term, and long-term. ARIMA model is implemented in all terms to forecast health expenditures when appropriate variables of the models are considered. It is explored that employment and inflation are statistically significant for the short term, income per capita and health system structure are significant for the long-term, and insurance contact and income per capita are significant for medium-term study (Getzen, 2000).

Machine learning methods are widely used to forecast health expenditure. Recurrent neural network (RNN) is one of the main prediction methods. It is indicated that recurrent neural networks give better prediction accuracy, when it is compared with gradient boosting machine, regularized regression, and ordinary least squares linear regression (Yang et al., 2018). Long Short-Term Memory (LSTM) model which is a variant of RNN, is implemented the prediction of monthly medicine expenditures of patients. It is stated that stacked LSTM outperformed than ARIMA and single layer LSTM model (Kaushik et al., 2017).

Kazemian et al. (2022) used vector autoregressive regression (VAR), and ordinary least squares (OLS) regression models to predict the growth of real per capita health expenditures of Iran. The results of the research showed that real health expenditure per capita will increase by 43 percent by 2025.

Utilizing demographic and socioeconomic factors, Chaabouni and Abednnadher (2013) researched to predict health expenditure in Tunisia. In this study, neural networks and autoregressive distributed lag models were used, and more accurate predictions were obtained with neural networks with lower RMSE and MAPE values.

Another frequently used technique in neural networks is the feed-forward neural network (FFNN). According to Jodicke et al. (2019), when compared to logistic regression, it provides more accurate results. Feed-forward neural networks can be integrated with the tabu search algorithm. It is asserted that hybrid heuristic methods effectively predict total health expenditures (Aladag & Aladag, 2011). Feedforward neural networks are widely considered to be the most efficient approach for predicting health expenditures. When comparing boosted decision trees, neural networks, and logistic regression models. The boosted decision tree model attained a total accuracy of 67.6% and an area under the curve-score of 0.74. In comparison, the neural network and logistic regression models exhibited a decrease in performance by 0.4% and 1.9%, respectively (Jodicke et al., 2019). In addition to machine learning methods, Variable –based generative adversarial networks (V-GAN) are developed to measure predicting the medicine expenditure of patients (Kaushik et al., 2020). Medicines are also considered an important part of healthcare expenditures. Multimorbidity grouping is an also essential measure in medicine expenditure with using clinical risk groups. Durable medical equipment, hospital care, and prescription drugs are indicators for prediction of health expenditures (Wang, 2009).

Total, government, pre-paid, and out-of-pocket health expenditures of BRICS countries have been estimated with an exponential smoothing method for the period 2020-2035 (Sahoo et al., 2023).

Table 2.3. Literature review chart of studies on forecasting health expenditures

Reference	**Forecasting Method**	**Forecast Variable with units (yearly/monthly)**
Zheng et al. (2020)	ARIMA Model	Social health expenditure (year), out-of-pocket health expenditure (year), government health expenditure (year), total health expenditure (year),
Wang (2010)	AR(1) and AR(2))	Growth of personal health care expenditure (year)
Piontkowski (2020)	Holt's linear model, ARIMA (0,2,2)	The probability distribution of the total health spendings
Lopreite & Mauro (2017)	A Bayesian VAR analysis	Health expenditure per capita (year), life expectancy, aging index.
Lee & Miller (2002)	Stochastic time series models	Health expenditure (year)
Kraipornsak (2017)	Regression panel of estimation method	Health expenditure per person (year)
Kaushik et al. (2017)	ARIMA Model, Standard Long Short Term Memory (LSTM) Model, Stacked LSTM Model	Patient's Expenditure on Medications (monthly)
Jia et al. (2021)	New Structure of Multivariate Gray Prediction Model, Traditional grey model, BP neural network	Total Health Expenditure (year)

Harris & Sharma (2018)	Simple demographic projection model	Total healthcare expenditure on aged population, total health expenditure, health expenditure per elderly person;
Getzen (2000)	Regression models	% growth in health expenditures (this year) (short term), % growth in real per capita health expenditures (medium term), the percentage of GDP (long term)
Dritsakis & Klazoglou (2019)	ARIMA Model	Total health expenditure (year)
Caballer-Tarazona et al. (2019)	Two-part models (Logit models, log-linear OLS regression)	Pharmaceutical expenditure and hospital expenditure (year), pharmaceutical prescription expenditure, total healthcare expenditure,
Bertsimas et al. (2008)	Clustering algorithms, classification trees	Health care cost (monthly)
Ramezanian et al. (2019)	ARIMA Model	Total health expenditure (year)
Quercioli et al. (2018)	Multivariate linear regression	Total health expenditure by patient (one year 2012)
Chaabouni & Abednnadher (2013)	The autoregressive distributed lag (ARDL) model, artificial neural network (ANN)	Total health expenditure (year)
Aladag & Aladag (2011)	Hybrid heuristic method (Feedforward neural networks)	Total health expenditure (monthly)
Kazemian et al. (2022)	Vector autoregressive regression (VAR), ordinary least squares (OLS) regression models	The growth of real per capita health spending
Jödicke et al. (2019).	Boosted decision trees, neural network, and logistic regression	Patient’s health care cost (year)
Sahoo et al. (2023)	Exponential smoothing	Total Health Expenditure (% of GDP) and per capita ($PPP), pre-paid private health expenditure Per Capita ($PPP) and (% of CHE), out-of-pocket health expenditure Per Capita ($PPP), and (% of CHE), government health expenditure Per Capita ($PPP) and (% of CHE),
Deb & Norton (2018)	Ordinary least squares (OLS) and two- part models, (Generalized linear model and linear model).	Total healthcare expenditures (US$)

Two-part models provide more accurate predictions than other econometric models used in modeling health expenditures (Caballer-Tarazona et al., 2019). Ordinary least squares (OLS) and two-part models have been used in forecasting health care expenditure (Caballer-Tarazona et al., 2019; Deb & Norton, 2018; Khan et al., 2016).

3. METHODOLOGY

3.1. Decision Trees

The decision trees are used in research methods as models that contribute to determining the strategy that has the highest probability of achieving a goal. In addition, it is also a popular tool in machine learning and data mining.

A decision tree is a hierarchical decision support model that uses a decision tree to represent choices and their potential outcomes. It makes an algorithm with conditional control statements viewable.In research methodologies, decision trees are employed as models that help identify the plan with the highest chance of success. Furthermore, it is a well-liked machine learning toolIt operates like a flowchart, where each leaf node represents the outcome, each branch represents a "test" on an attribute, and each internal node represents a test. The pathways from the root to the leaf are the classification rules, and the class label is the choice made once all the characteristics have been computed. A visual and analytical decision assistance tool in decision analysis is a decision tree and its closely related influence diagram, where the expected values or expected usefulness of competing alternatives are estimated. When an individual adheres to all the rules necessary to achieve a particular leaf, there is a rather strong likelihood that they will be allocated to that leaf and hence to a specific class. The classification model is comprised of a collection of rules that govern the characteristics and attributes of all the leaves. Decision trees can also be used as a descriptive tool for conditional probability calculations. In business, health economics, health research, decision trees, impact diagrams, utility functions, and other decision analytic tools and techniques are frequently employed. The main decision tree algorithms are CHAID, Classification and Regression Tree (CART), and C5.0 (Tuffery, 2011).

3.1.1. CHAID Decision Tree

The principle of the CHAID decision tree is explained as the χ^2 test is employed to determine the most statistically significant variable for each node, thereby limiting its applicability to discrete or qualitative independent variables exclusively. χ^2 criterion is utilized in this tree for splitting criterion. The majority of software applications that employ CHAID have been specifically developed to handle continuous independent variables by automatically converting them into discrete categories. This process often involves dividing the variables into 10 classes, however, in certain cases, the user has the flexibility to decide the number of classes. In contrast to CART, this method does not employ strategies such as equal splitting or equal reduction to replace missing values. Instead, it treats all missing data as a distinct class and may combine it with another class if deemed suitable.

The χ^2 test is used in the sequential stages of node division, with steps 1-4 involving the merging of independent variable categories and step 5 including the splitting of nodes. The aforementioned procedures are executed iteratively, specifically on each leaf node that comes after the root node, up until a predefined stop condition is achieved. It is imperative that the frequency of the node to be divided matches or exceeds the value specified when the tree's parameters are defined. If it is not possible to split this node, the following iterations do not carried out.

1- Classifying of the categories of an independent variable X, which must have a minimum of three categories, the χ^2 statistic is used. This involves cross-tabulating the categories of X with the k categories of the response variable, which serves as the dependent variable. The initial step involves the identification of the permissible pair of X categories, where the sub-table (2 x k) is linked to the lowest χ^2 value, representing the highest associated likelihood. The two categories exhibit minimal disparity in their respective responses. If the χ^2 value does not meet the significance level, as indicated by a probability higher than the specified threshold the two categories are combined, resulting in a new composite category. It should be noted that a pair is considered admissible if it is nearby when X is ordinal or quantitative, or if it is any pair when X is nominal.

2- Step 1 is iterated until all categories defined as simple or composite, exhibit a substantial χ^2 value, indicating a significant difference in their responses. Alternatively, the iteration process ends if no more than two categories are remaining. If a category's frequency falls below the predetermined minimum defined during the configuration of the tree parameters, said category will be included with the category that exhibits the closest proximity with respect to χ^2, regardless of whether this χ^2 value was previously deemed important. In each instance, if a novel merged category is formed by combining a minimum of three initial categories that possess an adequate frequency, it becomes feasible to ascertain the binary division. This division is determined among the initial categories that exhibit maximum χ^2 value, and if it is statistically significant, the split is executed.

3- After step 2, if the variable consisted of six categories $\{n_1, n_2, n_3, n_4, n_5, n_6\}$, these categories would be classified into either three classes $\{n_1, n_4\}$, $\{n_2, n_3\}$, and $\{n_5, n_6\}$, or two classes $\{n_1, n_2, n_3, n_4\}$ and $\{n_5, n_6\}$. In the case where the independent variable is nominal and contains missing values, these values are regarded as a distinct category that is treated equivalently to the other categories.

However, in the case of an ordinal or quantitative variable, the category representing missing values is not included in the previous merging procedures. The merging of a category in CHAID occurs only after the completion of preceding procedures. Specifically, CHAID aims to merge a category with another category that exhibits the closest proximity in terms of χ^2. The analysis involves comparing the probabilities of the χ^2 statistic for two tables: one that incorporates the merged category of missing data and another that does not. The decision is made in favor of the table with the lowest likelihood.

4- Upon completion of step 3, the probability linked to the χ^2, of the optimal table acquired is determined. The coefficient mentioned refers to the count of potential arrangements for dividing the m categories of an independent variable into g groups, where g ranges from 1 to m. Its multiplication with the probability linked serves the purpose of avoiding an excessive assessment of the significance of variables with numerous categories.

5- CHAID determines which independent variable has the most significant χ^2—that is, the one for which the probability is lowest, after classifying all categories as optimally as possible for each variable and the probability of the corresponding χ^2, has been computed, adjusted for significance. It is possible to partition the node into many leaf nodes, with each leaf node linked to one of the categories of the variable after classified. If the value of χ^2 does not meet the predetermined threshold, the node will not split (Tuffery, 2011).

3.2. Regression Analysis

Influential variables affecting the health expenditures of OECD countries were determined using the CHAID decision tree technique. In the regression analysis section, regression models are created using influential variables to evaluate the success of the technique, and health expenditures of OECD countries are forecasted.

The regression equation used to find models for OECD countries is given in Eq.1. The best subset regression is applied using influential variables as explanatory variables to select the best regression model for each OECD country. Y is identified as current health expenditure (% of GDP). X_k are influential variables of health expenditure according to CHAID analysis.

$$Y = \beta_0 + \beta_1 X_1 + \cdots + \beta_k X_k + \varepsilon \qquad (1)$$

The forecasting accuracy is calculated using Mean Absolute Percentage Error (MAPE) (Eq. 2).

$$MAPE = \frac{1}{n}\sum_{t=1}^{n}\left|\left(\frac{Y_t - F_t}{Y_t}\right)\times 100\right| \qquad (2)$$

3.3. Time Series Forecasting

In this study, OECD countries' current health expenditure (% of the GDP) data for the years 2000-2019 were extracted using the World Bank database (World Bank, 2023). 2000-2015 were used for the training set and 2016-2019 were used for the test set in forecasting methods. The OECD countries included in this study are shown by the country codes as in Table 4.2.

The health expenditure of each OECD country has a trend pattern. In this study, the methods used, which allow forecasting with trend patterns, are Holt's exponential smoothing method, ARIMA, and Neural Network Autoregression (NNAR).

3.3.1. Holt's exponential smoothing method

The forecast (Eq. 5) for Holt's method is calculated using two components, level (Eq. 3) and trend (Eq. 4).

$$L_t = \alpha Y_t + (1-\alpha)(L_{t-1} + T_{t-1}) \quad (3)$$

$$T_t = \beta(L_t - L_{t-1}) + (1-\beta)T_{t-1} \quad (4)$$

$$F_{t+h} = L_t + hT_t \quad (5)$$

where the components L_t and T_t are the estimates of level and trend at time t, respectively, α, β are smoothing parameters, and F_{t+h} is the h-period ahead forecast.

3.3.2. ARIMA

The health expenditure of each OECD country over time has a trend pattern, therefore, each series is not stationary in its mean. To obtain stationary data, the first difference is taken and an ARIMA model (Eq. 6) is fitted to the data as ARIMA (p, d, q) for each country where the order of differencing d is equal to 1. Akaike's Information Criterion (AIC) is used in determining the order of the ARIMA model.

$$Y'_t = c + \emptyset_1 Y'_{t-1} + \emptyset_2 Y'_{t-2} + \cdots + \emptyset_p Y'_{t-p} + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2} + \cdots + \theta_q \varepsilon_{t-q} + \varepsilon_t \quad (6)$$

where Y'_t is the differenced series, p is the order of the autoregressive part, q is the order of the moving average part, and ε_t is the error term. ARIMA is the most widely used method for the prediction of health expenditures.

3.3.3. Neural Network Autoregression (NNAR)

The neural network autoregression (NNAR) model is a feed-forward network with one hidden layer denoted by NNAR(p,k) (Hyndman & Athanasopoulos, 2018). This network uses *p-lagged* values ($Y_{t-1}, Y_{t-2}, \ldots, Y_{t-p}$) as inputs, k nodes in the hidden layer, and Y_t as the output. The inputs to each hidden layer node are combined using a weighted linear combination. The weights are randomly assigned to begin the network and then they are updated using the inputs. The nonlinear activation function sigmoid is used in the hidden layer.

3.4. Transformations

The parametric power transformation technique is first proposed by Box & Cox (1964), to minimize heteroskedasticity, nonadditivity, and nonnormality properties of data. It is indicated that this power transformation technique increases the prediction accuracy by normalizing the data and reducing the variance (Sakia, 1992). Although the power transformation technique is widely used in many fields, it has not been used in research on health expenditure prediction.

The family of Box-Cox transformations, which includes both power transformation and logarithmic transformation, is defined as given in Eq.7 (Hyndman & Athanasopoulos, 2018). λ is the main parameter of Box-Cox transformations. If $\lambda = 0$, the Box-Cox transformation is a logarithmic transformation based on natural logarithm. If $\lambda \neq 0$, the Box-Cox transformation is power transformation with parameter λ. In this study, Box-Cox transformations are applied to the data using Holt's, ARIMA, and NNAR methods to find the best prediction model for each OECD country.

$$\omega_t = \begin{cases} \log(Y_t), & if\ \lambda = 0 \\ (Y_t^{\lambda} - 1)/\lambda & otherwise \end{cases} \tag{7}$$

In this study, the effect of transformations on forecasting methods Holt's, ARIMA, and NNAR is researched.

4. APPLICATIONS AND RESULTS

4.1. Definition of Data

The World Bank database was utilized to extract the current health spending (% of GDP) for the OECD nations from 2000 to 2019 for this study (World Bank, 2023). The training set encompassed the years 2000 to 2015, whereas the test set consisted of the years 2016 to 2019, as employed in the application of forecasting methodologies. Current health expenditure refers to the aggregate monetary value spent on healthcare services and products within a given year, excluding expenditures on machinery, information technology, buildings, and vaccination supplies, denominated in the currency of a country or region (Worldbank, 2021; Zheng et al., 2018). The independent variables in the decision tree model were grouped as economic, health, and demographic variables. Health variables are hospital beds (per 1,000 people), life expectancy at birth, total (years), people using safely managed sanitation services (% of population), and physicians (per 1,000 people). Economic variables are out-of-pocket expenditure (% of current health expenditure), GDP growth (annual %), GDP per capita (current US$), inflation, GDP deflator (annual %), and Research and development expenditure (% of GDP). Demographic variables are age dependency ratio (% of working-age population), birth rate, crude (per 1,000 people), fertility rate, total (births per woman), death rate, crude (per 1,000 people), population, total, population growth (annual %) as shown and labeled in Table 4.1. Chi-square automatic interaction detection (CHAID) decision tree model is selected to analyze determinants of current health expenditure.

Table 4.1. Variables used in CHAID analysis

Category	**Variable**	**Label**
Dependent Variable	Current health expenditure (% of GDP)	CHEP
Health Variables	Hospital beds (per 1,000 people)	HB
	Life expectancy at birth, total (years)	LIFEX
	Physicians (per 1000 people)	
	People using safely managed sanitation services (% of population)	SS
Economic Variables	Out-of-pocket expenditure (% of current health expenditure)	OOPEP
	GDP growth (annual %)	GDPGP
	GDP per capita (current US$)	GDPCD

	Inflation, GDP deflator (annual %)	INFD
	Research and development expenditure (% of GDP)	RDEGDP
Demographic Variables	Birth rate, crude (per 1,000 people)	BR
	Fertility rate, total (births per woman)	FR
	Death rate, crude (per 1,000 people)	DR
	Population, total	PT
	Population growth (annual %)	PG
	Age dependency ratio (% of working-age population)	ADR

The World Bank database was used to extract data for the years 2000–2018 of the OECD countries' current health expenditure (% of GDP) as well as health, economic, and demographic, characteristics that were thought to affect the health expenditure and to include in the analysis (World Bank 2021). The CHAID decision tree is generated by using 2015-year data.

All OECD countries in the study are listed in Table 4.2. The dependent variable is current health expenditure (% of GDP). The variables in the model are selected in the light of previous studies and categorized as health, economic, and demographic variables as given in Table 4.1.

Table 4.2. OECD Countries in the model

Code	**Country**		**Code**	**Country**
AUS	Australia		KOR	Korea Republic
AUT	Austria		LVA	Latvia
BEL	Belgium		LTU	Lithuania
CAN	Canada		LUX	Luxembourg
CHL	Chile		MEX	Mexico
COL	Colombia		NLD	Netherlands
CZE	Czech Republic		NZL	New Zealand
DNK	Denmark		NOR	Norway
EST	Estonia		POL	Poland
FIN	Finland		PRT	Portugal
FRA	France		SVK	Slovak Republic
DEU	Germany		SVN	Slovenia
GRC	Greece		ESP	Spain
HUN	Hungary		SWE	Sweden
ISL	Iceland		CHE	Switzerland
IRL	Ireland		TUR	Türkiye
ISR	Israel		GBR	United Kingdom
ITA	Italy		USA	United States
JPN	Japan			

Definitions of variables are as follows.

4.1.1. Economic Variables

Definitions of economic variables in the decision tree model are given as follows.

GDP per capita: GDPCD is determined by dividing the gross domestic product by mid-year population.

Out-of-pocket expenditure (% of current health expenditure): OOPEP is defined as payments on health directly by individuals for each country. The variable is calculated by dividing out-of-pocket expenditure by current health expenditure.

GDP Growth: GDPGP is calculated by the yearly percentage of growth rate of GDPCD.

Inflation, GDP deflator (annual %): INFD is calculated by the the rate of price change in the economy. It is yearly increment rate of GDP deflatör.

Research and development expenditure (% of GDP): RDEGDP is defined as gross domestic expenditures on research and development percentage of GDP. The research and development involve experimental development and basic and applied research. Its expenditure is related to four main fields; business enterprise, government, higher education, and private non-profit (World Bank, 2021).

4.1.2. Health Variables

Health-related variables used in the CHAID analysis were defined as hospital beds (per 1,000 people), life expectancy at birth, total (years), people using safely managed sanitation services (% of the population), and physicians (per 1,000 people).

Hospital beds (per 1,000 people): They comprise inpatient beds available in general, private, and public, rehabilitation centers, and specialized by involving chronic and acute care beds.

Life expectancy at birth, total (years): LIFEX is defined as the number of years a newborn would live if current mortality rates at the time of birth remained the same throughout its life.

People using safely managed sanitation services (% of the population): SS refers to the percentage of people who use improved sanitation facilities—which are isolated from other residences and provide safe on-site or off-site disposal of waste

Physicians (per 1,000 people): The generalists and specialists in medicine are involved in this indicator (World Bank, 2021).

4.1.3. Demographic Variables

The third group is the variables that affect the health expenditures of each country according to the demographic structure, and the variables in the analysis are demographic variables, summarized as age dependency ratio (percentage of the population of working age), birth rate, crude (per 1,000 people), fertility rate, total (per birth). female), and death rate crude (per 1000 people).

Age dependency ratio (% of working-age population): ADR is the ratio of dependents, or those under the age of 15, to the working-age population, or people aged 15 to 64, is known as the age dependency ratio (ADR) (% of working-age population).

Birth rate, crude (per 1,000 people): It demonstrates the number of live births occurring during the year per 1000 population, predicted at mid-year.

Fertility rate, total (births per woman): Based on each age group's fertility rate in a given year, FR shows the average number of children a woman would have if she survived to be a reproductive age and gave birth.

Death rate, crude (per 1,000 people): It is the number of deaths that occur throughout a year per 1,000 individuals in the population calculated at midyear.

Population, total: The total population of any country is determined which includes all residents regardless of their legal status or citizenship.

Population growth (annual %): The exponential rate of increase of the midyear population from the prior year (t-1) to the present year (t) is the yearly population growth rate for a given year (t), expressed as a percentage (World Bank, 2021).

4.2. CHAID Analysis and Regression

The CHAID decision tree has the root node at the top, which has only leaf nodes. The root node is split into branch nodes, which have a root node and several leaf nodes, by the best splitting variable identified based on the Chi-square test and corresponding *p*-value. The Chi-square test is applied to define the most significant variable of each node for the dependent variable and the procedure continues iteratively until there are no splits to make or no variables left or a pre-specified number of branch levels is achieved hence, leaf nodes are formed through identified variables and their cut-off points. Leaf nodes have only a root node. The path between the root node and each leaf node gives the decision rule for the classification.

Based on the CHAID decision tree in Figure 4.1., among fifteen variables analyzed, five variables are identified as influential on current health expenditure which are GDP per capita (GDPCD), life expectancy at birth (LIFEX), death rate (DR), out-of-pocket expenditure (OOPEP), and fertility rate (FR). These findings are consistent with the findings of the studies on health expenditure in the literature as summarized in the Literature Review section.

The best first split GDP per capita divides the OECD countries into two groups (Node 1 and Node 2 in Figure 4.1.) regarding current health expenditure as of 2015. Node 1 is a leaf node including the countries Chile (CHL), Colombia (COL), Czech Republic (CZE), Estonia (EST), Hungary (HUN), Latvia (LVA), Lithuania (LTU), Mexico (MEX), Poland (POL), Slovak Republic (SVK), and Turkiye (TUR) with the decision rule GDPCD is equal to or less than US$ 17829.698. Three middle-income countries Colombia, Mexico, and Turkiye are within this group. Other thirty-four OECD countries included in the analysis are high-income countries. Current health expenditures of countries grouped in Node 1 are given in Fig. 2 from the year 2000 to 2018, and their GDP per capita in Fig. 3. At the last branch level of the CHAID tree, among eight leaf nodes five of them contain a single country. Node 13 contains Italy (ITA) with the decision rule GDPCD is greater than US$ 17829.698, LIFEX is greater than 78.69 years, DR is greater than 7 per 1,000 people, GDPCD is greater than US$ 25732.018, and FR is equal to or less than 1.4 births per woman. Figure 4.1 presents the current health expenditure of OECD countries, in total CHAID decision tree classified thirty-seven OECD countries into eleven groups. Among these eleven leaf nodes, six of them (Node 3 and Nodes 9-13) contain a single country.

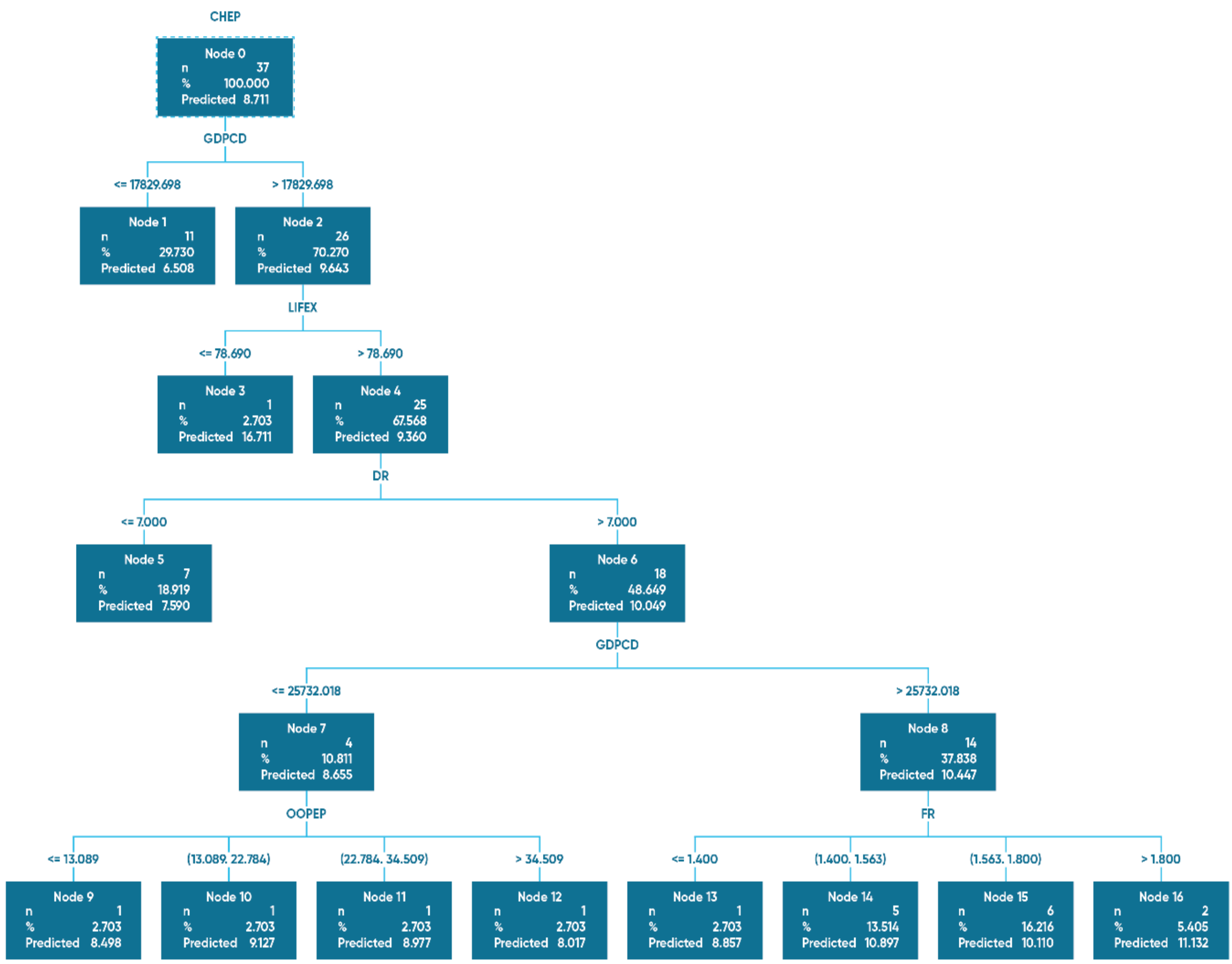

Figure 4.1. CHAID decision tree for current health expenditure (% GDP)

Country distribution by nodes and the actual and predicted CHEP values of each country are summarized in Table 4.3. Node 1 includes Chile, Colombia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Mexico, Poland, Slovak Republic, and Turkiye. Node 2 represents 26 OECD countries. While Node 3 identifies The United States. Node 4 represents 25 OECD countries. Node 5 includes Australia, Iceland, Ireland, Israel, Korea Republic, Luxembourg, and New Zealand and Node 6 represents 18 countries. Node 7 identifies Slovenia, Spain, Portugal, and Greece and Node 8 represents 14 OECD countries.

Nodes 9, 10, 11, 12, and 13 include Slovenia, Spain, Portugal, Greece, and Italy. respectively. Node 14 represents Austria, Canada, Germany, Japan, and Switzerland. While Node 15 determines the countries Belgium, Denmark, Finland, Netherlands, Norway, and the United Kingdom. Last Node 16 includes France and Sweden. R-value is calculated as 0.93.

Table 4.3. Country distribution by nodes

Country	Node	Predicted Health Expenditure (% of GDP)	Health Expenditure (% of GDP)	R
Australia	5	7.59	9.323	0.93
Austria	14	10.897	10.367	
Belgium	15	10.11	10.427	
Canada	14	10.897	10.683	
Chile	1	6.508	8.303	
Colombia	1	6.508	7.523	
Czech Republic	1	6.508	7.243	
Denmark	15	10.11	10.227	
Estonia	1	6.508	6.346	
Finland	15	10.11	9.645	
France	16	11.132	11.466	
Germany	14	10.897	11.178	
Greece	12	8.017	8.017	
Hungary	1	6.508	6.889	
Iceland	5	7.59	8.131	
Ireland	5	7.59	7.317	
Israel	5	7.59	7.106	
Italy	13	8.857	8.857	
Japan	14	10.897	10.885	
Korea, Rep.	5	7.59	6.653	
Latvia	1	6.508	5.686	
Lithuania	1	6.508	6.495	
Luxembourg	5	7.59	5.284	
Mexico	1	6.508	5.797	
Netherlands	15	10.11	10.324	
New Zealand	5	7.59	9.315	
Norway	15	10.11	10.131	
Poland	1	6.508	6.398	
Portugal	11	8.977	8.976	
Slovak Republic	1	6.508	6.793	
Slovenia	9	8.498	8.49824	
Spain	10	9.127	9.127	
Sweden	16	11.132	10.797	
Switzerland	14	10,897	11.369	
Turkiye	1	6.508	4.117	
United Kingdom	15	10.11	9.904	
United States	3	16.711	16.710	

The correlation coefficient (r) between predicted values and actual values of health expenditure of countries is 0.93, indicating a strong positive relationship and excellent predictive ability. Furthermore, to assess the effectiveness of the CHAID decision tree in finding important factors that impact health spending, the best subset regression is utilized, incorporating these factors as explanatory variables. The best regression model for each country is determined by evaluating three criteria: the highest adjusted coefficient of determination (R-sq(adj)), a Mallows Cp value that is less than the number of explanatory variables in the model plus one, and the lowest standard error of estimate (S).

The chosen regression model for each country is applied to the training data and used to generate forecasts. The calculation of forecasting errors is applied using the test set, and the accuracy of the forecast is measured using the Mean Absolute Percentage Error (MAPE). The results are presented in Table 4.4. Except for two countries, the MAPE values are below 10%, while all MAPE values are below 12%, which indicates a high level of accuracy in the regression models' forecasts. Thus, it can be inferred that the CHAID decision tree technique effectively identified the relevant variables affecting current health expenditure.

The regression models, selection criteria, and forecast accuracy are provided in Table 4.4.

Australia has the lowest MAPE value and Korea has the maximum R-sq(adj) % value among OECD countries as a result of regression analysis.

Table 4.4. Regression models, selection criteria, and forecast accuracy

Country Code	Regression model (CHEP =)	R-sq(adj) %	Mallows Cp	S	MAPE (%)
AUS	-39.22 + 0.5876 LIFEX + 0.565 DR - 2.087 FR	91.94	2.5	0.13774	0.89
AUT	-20.85 + 1.95 FR + 0.462 DR + 0.2956 LIFEX	85.50	3.2	0.15516	2.11
BEL	-51.5 + 0.000043 GDPCD + 1.022 DR + 0.621 LIFEX	88.04	2.4	0.30588	4.94
CAN	-109.74 - 0.000085 GDPCD + 4.477 FR - 2.432 DR + 1.651 LIFEX	98.19	4.1	0.10872	6.22
CHL	-76.6 - 3.84 FR + 1.978 DR + 0.935 LIFEX	61.26	2.9	0.33078	5.95
COL	149.1 - 0.000242 GDPCD - 11.91 FR + 8.04 DR - 2.107 LIFEX	92.99	4.3	0.16604	4.61
CZE	-43.8 + 0.000015 GDPCD + 1.207 DR + 0.491 LIFEX	74.67	2.9	0.31646	7.64

DNK	-14.0 - 0.590 OOPEP + 2.69 FR + 0.346 LIFEX	84.78	2.0	0.30334	6.09
EST	-19.06 - 0.1673 OOPEP - 0.000088 GDPCD + 2.471 FR + 0.3456 LIFEX	87.36	5.0	0.22372	7.83
FIN	-46.5 - 0.290 OOPEP - 0.000044 GDPCD + 2.56 FR + 0.728 LIFEX	94.87	4.7	0.20426	0.72
FRA	-39.27 + 0.68 FR + 0.607 DR + 0.5360 LIFEX	91.25	2.2	0.20229	3.68
DEU	-15.32 - 3.59 FR + 0.758 DR + 0.288 LIFEX	70.61	2.4	0.25801	3.62
GRC	6.60 - 0.0793 OOPEP + 3.38 FR	70.53	1.6	0.31665	5.23
HUN	-1.75 - 0.1891 OOPEP - 4.66 FR + 0.586 DR + 0.1733 LIFEX	49.94	4.1	0.28868	4.12
ISL	52.7 - 0.370 OOPEP - 0.000030 GDPCD - 1.328 FR - 0.836 DR - 0.343 LIFEX	64.36	6.0	0.31989	1.21
IRL	-29.5 + 0.352 OOPEP - 0.000100 GDPCD + 7.76 FR - 2.00 DR + 0.460 LIFEX	91.42	6.0	0.50424	8.37
ISR	-6.62 + 0.0595 OOPEP + 0.814 FR + 0.1201 LIFEX	7.97	2.9	0.10723	3.52
ITA	-18.90 - 0.1221 OOPEP - 0.000036 GDPCD + 2.88 FR + 0.183 DR + 0.3130 LIFEX	92.91	6.0	0.12513	1.00
JPN	8.45 - 0.484 OOPEP + 0.843 DR	96.30	0.6	0.28245	4.53
KOR	-35.96 - 0.0630 OOPEP - 0.000052 GDPCD + 1.480 FR + 0.5413 LIFEX	98.98	4.6	0.09086	8.48
LVA	2.26 - 0.0540 OOPEP - 0.000082 GDPCD + 0.0898 LIFEX	23.08	2.4	0.23756	11.82
LTU	6.078 - 0.1109 OOPEP + 2.360 FR	65.54	0.7	0.26670	2.39
LUX	122.8 + 0.000022 GDPCD - 1.950 DR - 1.292 LIFEX	49.79	2.8	0.49446	1.98
MEX	-131.8 - 0.0758 OOPEP - 0.000184 GDPCD + 1.903 LIFEX	91.35	2.4	0.13392	9.30
NLD	-67.5 + 4.50 FR + 0.838 DR + 0.7766 LIFEX	88.57	2.1	0.30514	5.70
NZL	-87.0 - 0.000048 GDPCD + 1.394 FR + 1.176 LIFEX	90.49	2.1	0.25216	4.78
NOR	24.85 - 0.884 OOPEP - 0.000029 GDPCD	75.01	0.8	0.32249	3.54
POL	17.09 - 0.1595 OOPEP - 0.0904 LIFEX	84.02	0.6	0.13790	4.03
PRT	-4.55 - 0.1509 OOPEP + 0.000095 GDPCD + 1.67 FR + 0.170 LIFEX	73.34	4.0	0.22888	2.51
SVK	-0.05 + 0.0745 OOPEP + 0.000053 GDPCD + 3.46 FR	91.14	2.5	0.26339	9.83

SVN	3.93 - 0.301 OOPEP - 0.000033 GDPCD + 2.814 FR + 0.513 DR	73.84	4.2	0.19795	8.41
ESP	-33.79 - 0.3064 OOPEP - 0.000049 GDPCD + 0.6169 LIFEX	95.67	2.2	0.19426	5.83
SWE	-369.1 - 0.171 OOPEP - 6.22 FR + 4.49 DR + 4.290 LIFEX	92.13	4.0	0.36426	10.36
CHE	-76.6 - 3.84 FR + 1.978 DR + 0.935 LIFEX	61.26	2.9	0.33078	4.52
TUR	0.095 - 0.0424 OOPEP - 10.07 FR + 4.795 DR	87.89	3.9	0.13333	4.27
GBR	-46.90 - 0.0902 OOPEP - 0.000024 GDPCD + 1.50 FR + 0.6972 LIFEX	96.22	4.6	0.18564	1.86
USA	44.27 - 1.282 OOPEP - 0.000073 GDPCD - 1.077 DR	97.99	2.6	0.17761	2.73

4.3. Time Series Forecasting

Time series forecasting analysis are implemented by using Holt’s method, ARIMA, and NNAR methods 37-OECD country. Holt’s method, ARIMA, and NNAR methods are applied to original and transformed data using Box-Cox Transformation and logarithmic transformation.

4.3.1. Holt’s Exponential Smoothing Method

The results of MAPE values of Holt’s method are shown in Table 4.5. When MAPE values of Holt’s method with original data and transformed data are compared. According to Table 4.5., when the results of Holt’s method implementations with original data, Box-Cox transformed data, and logarithmically transformed data for 37 OECD countries were compared, lower MAPE values were obtained in 16 countries from 37 countries (43.84% of the OECD countries) in the Box-Cox power transformation implementation. As a result of the logarithmic transformation application, lower MAPE values were obtained in only 5 countries (13.8% of the OECD countries). In 16 countries (43.84% of the OECD countries), Holt's method applied to the original data gave better results than transformed data. Among OECD countries, all the MAPE values with original and transformed data are compared, the lowest MAPE value is 0.48 which belongs to Germany with implementation of logarithmic transformation. In Figure 4.2., CHEP values of Australia are represented with original and transformed data. It is shown that the nonnormalities of the data are reduced by using the Box-Cox transformation before using Holt’s method.

In Figure 4.3. autocorrelation function of Holt's method is shown for CHEP values of Australia.

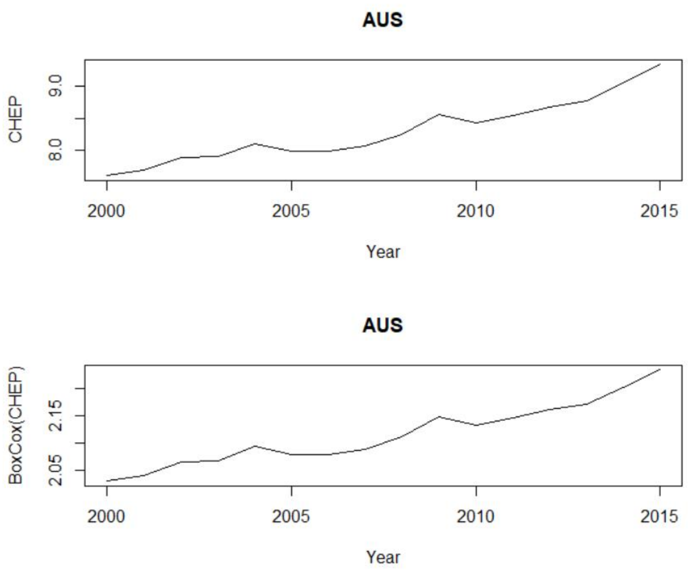

Figure 4.2. CHEP value of Australia with original data and Box-Cox transformed data

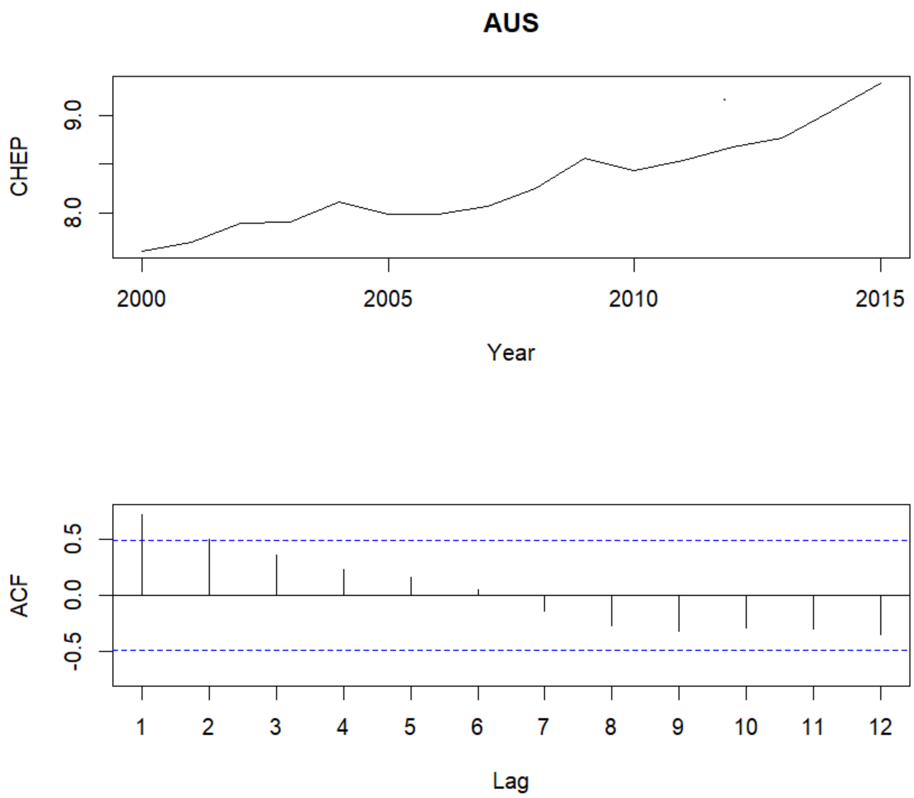

Figure 4.3. Autocorrelation function and forecast of Holt's method for Australia

Table 4.5. MAPE values of Holt's method of original data and transformed data

	MAPE		
	Original	**Box-Cox Transformation ʎ≠0**	**Box-Cox Transformation ʎ=0**
AUS	2.979	1.923	2.582
AUT	2.478	3.200	2.972
BEL	1.880	1.600	3.357
CAN	2.837	5.184	3.439
CHL	1.639	1.478	5.294
COL	2.718	4.016	4.016
CZE	4.466	7.637	5.627
DNK	5.475	6.657	5.932
EST	0.453	1.919	0.461
FIN	13.31	18.452	15.744
FRA	7.121	8.122	7.417
DEU	0.509	0.696	0.482
GRC	2.401	2.777	2.777
HUN	5.021	3.406	2.619
ISL	6.867	6.800	6.093
IRL	52.006	24.073	2.460
ISR	3.715	3.605	3.826
ITA	4.921	1.702	5.200
JPN	6.261	10.477	7.995
KOR	4.195	5.725	2.474
LVA	10.897	11.100	10.297
LTU	2.353	2.351	2.309
LUX	2.501	12.227	6.445
MEX	10.177	7.86	6.549
NLD	6.528	7.542	3.631
NZL	3.536	10.048	4.455
NOR	4.249	4.544	3.595
POL	2.242	2.274	3.846
PRT	0.553	5.276	2.547
SVK	13.498	10.455	11.753
SVN	3.063	3.128	3.184
ESP	5.640	5.044	6.424
SWE	6.363	9.504	7.005
CHE	1.994	1.34	1.864
TUR	10.526	9.827	7.928
GBR	3.321	1.113	1.483
USA	1.481	1.469	2.910

4.2.2. ARIMA

The results of MAPE values of the ARIMA method are shown in Table 4.6. When the results of ARIMA method implementations with original data, Box-Cox transformed data, and logarithmically transformed data for 37 OECD countries were compared, lower MAPE values were obtained in 21 countries from 37 countries (56.76% of the OECD countries) in the Box-Cox power transformation implementation. As a result of the logarithmic transformation application, lower MAPE values were obtained in only 5 countries (13.51% of the OECD countries). In 11 countries (29.72% of the OECD countries). ARIMA applied to the original data gave better results than transformed data. All MAPE values of the ARIMA method with original and transformed data are evaluated, 36 OECD countries have <10% MAPE value, except Ireland. The lowest MAPE values confirm the success of the method and forecast accuracy.

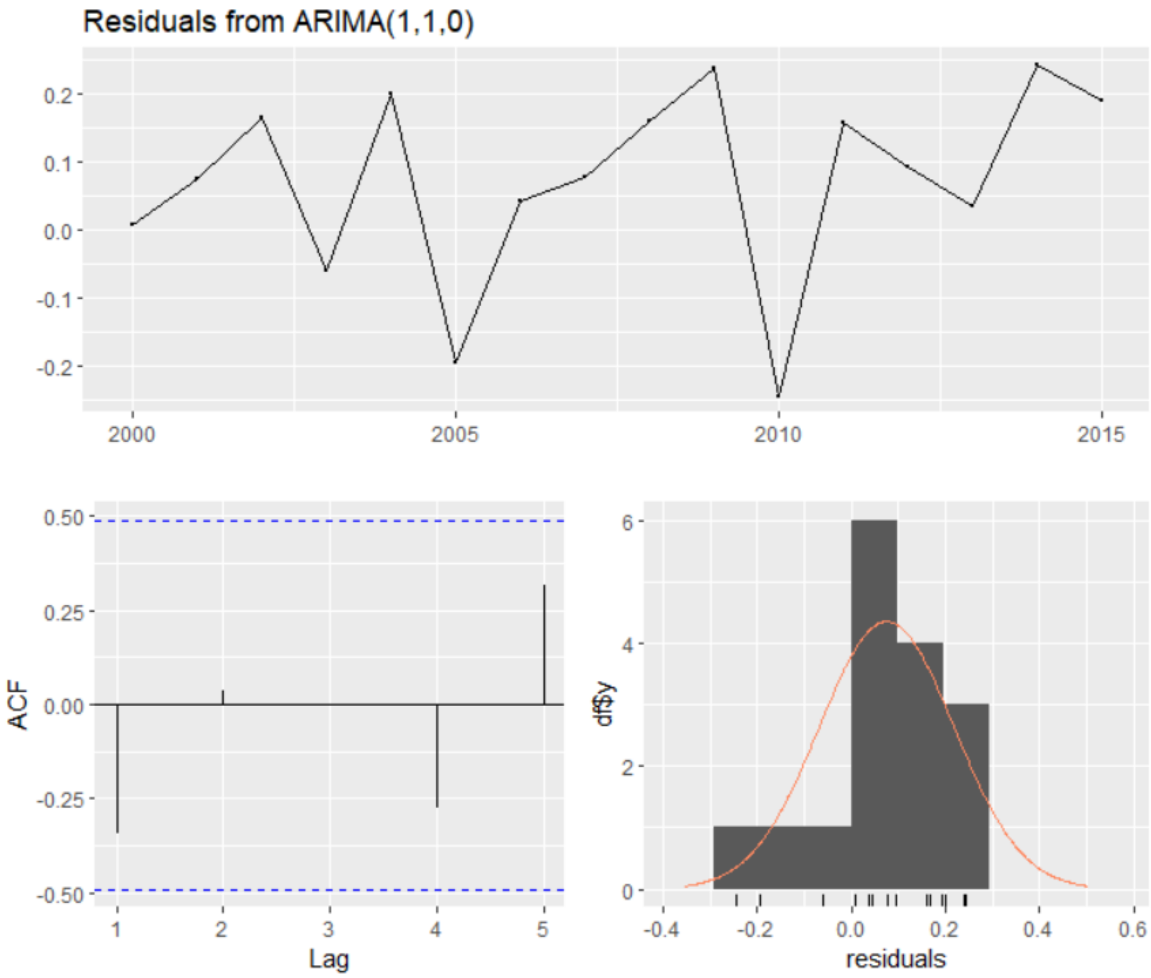

Figure 4.4. Graphs of ARIMA forecasts for Australia

Graphs of the Autocorrelation function and residuals for ARIMA (1,1,0) are shown in Figure 4.4.

Table 4.6. MAPE values of ARIMA method of original data and transformed data

	MAPE		
	Original	**Box-Cox Transformation ʎ≠0**	**Box-Cox Transformation ʎ=0**
AUS	3.022	2.943	2.980
AUT	0.359	0.359	0.359
BEL	3.540	3.508	3.569
CAN	0.663	0.703	0.555
CHL	4.459	4.688	4.584
COL	0.800	0.673	0.744
CZE	3.634	3.630	3.630
DNK	1.764	1.838	1.796
EST	2.047	1.816	1.913
FIN	4.434	4.291	4.370
FRA	1.671	1.648	1.660
DEU	2.084	2.066	2.075
GRC	2.185	2.203	2.17
HUN	3.960	3.823	3.894
ISL	3.891	3.833	3.862
IRL	34.013	20.611	25.707
ISR	3.367	3.365	3.369
ITA	1.942	1.943	1.942
JPN	0.514	0.532	0.521
KOR	9.198	9.181	9.831
LVA	9.412	9.385	9.399
LTU	2.536	2.489	2.504
LUX	9.412	2.015	1.929
MEX	5.327	5.128	5.583
NLD	0.68	0.829	0.862
NZL	2.180	2.192	2.186
NOR	2.002	1.995	1.997
POL	1.603	1.605	1.600
PRT	1.153	1.170	1.161
SVK	2.119	2.118	2.119
SVN	1.791	1.791	1.791
ESP	1.507	1.518	1.492
SWE	0.593	0.573	0.581
CHE	0.897	0.905	0.873
TUR	4.748	5.160	5.142
GBR	0.997	1.077	1.023
USA	0.811	0.805	1.088

4.2.3. NNAR

The results of MAPE values of NNAR are shown in Table 4.7. NNAR method implementations with original data, Box-Cox transformed data, and logarithmically transformed data for 37 OECD countries were compared, and lower MAPE values were obtained in 20 countries from 37 countries (54.05% of the OECD countries) in the Box-Cox power transformation implementation.

As a result of the logarithmic transformation application, lower MAPE values were obtained in only 3 countries (8.11% of the OECD countries). In 14 countries (37.84% of the OECD countries). ARIMA applied to the original data gave better results than transformed data. MAPE values of all OECD countries are examined, lowest MAPE value belongs to Japan with original data, 2nd lowest MAPE value is Austria with Box-Cox transformed data. 34 OECD countries have smaller than <10% MAPE value. The forecast for Australia using the NNAR (1,1) method is shown in Figure 4.5. The CHEP value of Australia has a trend and the forecast proves it for the years 2016-2019.

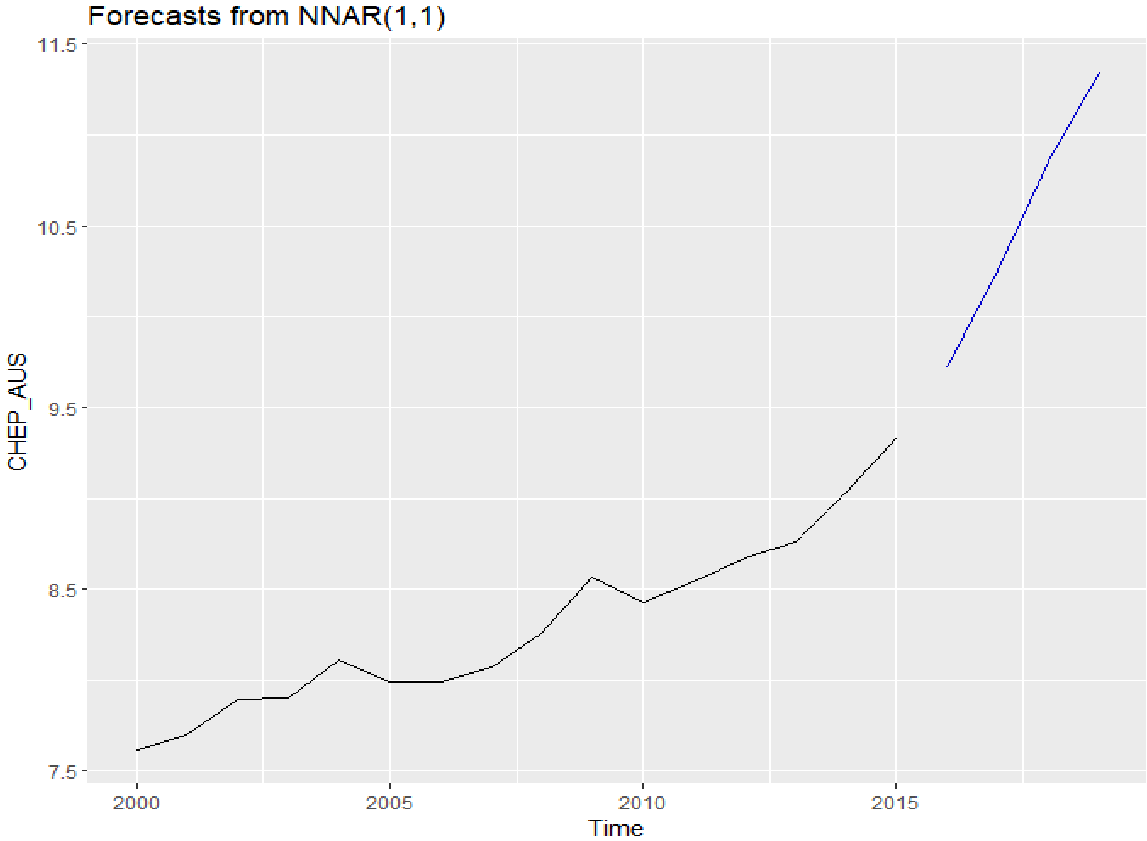

Figure 4.5. Graph of forecasts of Australia with NNAR

Table 4.7. MAPE values of NNAR method of original data and transformed data

	MAPE		
	Original	**Box-Cox Transformation ʎ≠0**	**Box-Cox Transformation ʎ=0**
AUS	3.300	3.256	3.133
AUT	0.789	0.742	0.769
BEL	2.511	2.477	2.579
CAN	3.159	3.185	3.181
CHL	1.945	1.357	1.784
COL	6.283	6.477	6.402
CZE	3.587	3.692	3.630
DNK	2.131	2.120	2.122
EST	8.831	8.859	8.999
FIN	5.880	5.959	5.934
FRA	1.399	1.405	1.402
DEU	3.651	3.671	3.662
GRC	3.760	3.758	3.705
HUN	8.687	11.451	8.486
ISL	2.694	2.736	2.710
IRL	15.322	14.395	14.904
ISR	4.330	4.327	4.342
ITA	1.581	1.539	1.564
JPN	0.426	0.438	0.431
KOR	10.920	8.479	12.080
LVA	7.345	7.554	7.465
LTU	2.687	4.043	2.694
LUX	1.857	1.425	1.622
MEX	5.570	5.611	5.531
NLD	3.028	2.949	2.917
NZL	2.899	2.831	2.863
NOR	1.884	1.876	1.952
POL	1.759	1.716	1.802
PRT	3.180	1.117	1.585
SVK	5.151	4.868	5.005
SVN	2.692	2.685	2.679
ESP	1.436	1.408	6.424
SWE	0.581	0.921	0.731
CHE	15.814	14.95	21.986
TUR	2.415	2.465	2.437
GBR	1.064	1.115	1.087
USA	2.566	2.578	1.924

Forecasting results of Holt’s method, ARIMA, and NNAR with original data are represented in Table 4.7. ARIMA has the lowest MAPE values for 16 countries (43.24% of OECD countries), NNAR is best for 13 countries (35.13% of OECD countries), and Holt’s method for 8 countries (21.62% of OECD countries).

Table 4.8. MAPE values of three forecasting methods with original data

	MAPE		
	Original		
	Holt's	ARIMA	NNAR
AUS	2.979	3.022	3.300
AUT	2.478	0.359	0.789
BEL	1.880	3.540	2.511
CAN	2.837	0.663	3.159
CHL	1.639	4.459	1.945
COL	2.718	0.800	6.283
CZE	4.466	3.634	3.587
DNK	5.475	1.764	2.131
EST	0.453	2.047	8.831
FIN	13.310	4.434	5.880
FRA	7.121	1.671	1.399
DEU	0.509	2.084	3.651
GRC	2.401	2.185	3.760
HUN	5.021	3.960	8.687
ISL	6.867	3.891	2.694
IRL	52.006	34.013	15.322
ISR	3.715	3.367	4.330
ITA	4.921	1.942	1.581
JPN	6.261	0.514	0.426
KOR	4.195	9.198	10.920
LVA	10.897	9.412	7.345
LTU	2.353	2.536	2.687
LUX	2.501	9.412	1.857
MEX	10.177	5.327	5.570
NLD	6.528	0.680	3.028
NZL	3.536	2.180	2.899
NOR	4.249	2.002	1.884
POL	2.242	1.603	1.759
PRT	0.553	1.153	3.180
SVK	13.498	2.119	5.151
SVN	3.063	1.791	2.692
ESP	5.640	1.507	1.436
SWE	6.363	0.593	0.581
CHE	1.994	0.897	15.814

TUR	10.526	4.748	2.415
GBR	3.321	0.997	1.064
USA	1.481	0.811	2.566

Forecasting results of Holt’s method, ARIMA, and NNAR with power-transformed data are represented in Table 4.9. ARIMA has the lowest MAPE values for 19 countries (55.35% of OECD countries), NNAR is best for 12 countries (32.43% of OECD countries), and Holt’s method for 6 countries (16.21% of OECD countries).

Table 4.9. MAPE values of Box-Cox Transformation for three methods

	MAPE		
	Box-Cox Transformation $\lambda \neq 0$		
	Holt's	**ARIMA**	**NNAR**
AUS	1.923	2.943	3.256
AUT	3.020	0.359	0.742
BEL	1.600	3.508	2.477
CAN	5.184	0.703	3.185
CHL	1.478	4.688	1.357
COL	4.016	0.673	6.477
CZE	7.637	3.630	3.692
DNK	6.657	1.838	2.120
EST	1.919	1.816	8.859
FIN	18.452	4.291	5.959
FRA	8.122	1.648	1.405
DEU	0.696	2.066	3.671
GRC	2.777	2.203	3.758
HUN	3.406	3.823	11.451
ISL	6.080	3.833	2.736
IRL	24.073	20.611	14.395
ISR	3.605	3.365	4.327
ITA	1.702	1.943	1.539
JPN	10.477	0.532	0.438
KOR	5.725	9.181	8.479
LVA	11.100	9.385	7.554
LTU	2.351	2.489	4.043
LUX	12.227	2.015	1.425
MEX	7.860	5.128	5.611
NLD	7.542	0.829	2.949
NZL	10.048	2.192	2.831
NOR	4.544	1.995	1.876
POL	2.274	1.605	1.716
PRT	5.276	1.170	1.117
SVK	10.455	2.118	4.868
SVN	3.128	1.791	2.685
ESP	5.044	1.518	1.408

SWE	9.504	0.573	0.921
CHE	1.340	0.905	14.950
TUR	9.827	5.160	2.465
GBR	1.113	1.077	1.115
USA	1.469	0.805	2.578

Forecasting results of Holt's method, ARIMA, and NNAR with logarithmic transformed data are represented in Table 4.10. ARIMA has the lowest MAPE values for 19 countries (55.35% of OECD countries), NNAR is best for 11 countries (29.73% of OECD countries), and Holt's method for 6 countries (16.21% of OECD countries). Only one country has equal MAPLE values for ARIMA and NNAR.

Table 4.10. MAPE values of three methods with logarithmic transformed data

	MAPE		
	Box-Cox Transformation ʎ=0		
	Holt's	**ARIMA**	**NNAR**
AUS	2.582	2.980	3.133
AUT	2.972	0.359	0.769
BEL	3.357	3.569	2.579
CAN	3.439	0.555	3.181
CHL	5.294	4.584	1.784
COL	4.016	0.744	6.402
CZE	5.627	3.630	3.630
DNK	5.932	1.796	2.122
EST	0.461	1.913	8.999
FIN	15.744	4.370	5.934
FRA	7.417	1.660	1.402
DEU	0.482	2.075	3.662
GRC	2.777	2.170	3.705
HUN	2.619	3.894	8.486
ISL	6.093	3.862	2.710
IRL	2.460	25.707	14.904
ISR	3.826	3.369	4.342
ITA	5.200	1.942	1.564
JPN	7.995	0.521	0.431
KOR	2.474	9.831	12.800
LVA	10.297	9.399	7.465
LTU	2.309	2.504	2.694
LUX	6.445	1.929	1.622
MEX	6.549	5.583	5.531
NLD	3.631	0.862	2.917
NZL	4.455	2.186	2.863
NOR	3.595	1.997	1.952
POL	3.846	1.600	1.802
PRT	2.547	1.161	1.585

SVK	11.753	2.119	5.005
SVN	3.184	1.791	2.679
ESP	6.424	1.492	6.424
SWE	7.005	0.581	0.731
CHE	1.864	0.873	21.986
TUR	7.928	5.142	2.437
GBR	1.483	1.023	1.087
USA	2.910	1.088	1.924

Table 4.11 summarizes the Mean absolute percentage error (MAPE) values calculated as a result of the implementation of Holt's, ARIMA, and NNAR methods using the original data (current health expenditure (% of the GDP)) and transformed data for 37 OECD countries. MAPE values are examined for original and transformed data, ARIMA has minimum MAPE values for all countries. ARIMA method with original and transformed data has a <10% MAPE value. Low MAPE values also prove the accuracy of the forecasting study. When Table 4.11. is examined, it is concluded that the transformation applied to the data also minimizes the MAPE value and increases the forecasting accuracy.

Table 4.11. Mean absolute percentage error forecast accuracy for all methods

	MAPE								
	Original			**Box-Cox Transformation $\lambda \neq 0$**			**Box-Cox Transformation $\lambda = 0$**		
	Holt's	**ARIMA**	**NNAR**	**Holt's**	**ARIMA**	**NNAR**	**Holt's**	**ARIMA**	**NNAR**
AUS	2.979	3.022	3.300	1.923	2.943	3.256	2.582	2.980	3.133
AUT	2.478	0.359	0.789	3.020	0.359	0.742	2.972	0.359	0.769
BEL	1.880	3.540	2.511	1.600	3.508	2.477	3.357	3.569	2.579
CAN	2.837	0.663	3.159	5.184	0.703	3.185	3.439	0.555	3.181
CHL	1.639	4.459	1.945	1.478	4.688	1.357	5.294	4.584	1.784
COL	2.718	0.800	6.283	4.016	0.673	6.477	4.016	0.744	6.402
CZE	4.466	3.634	3.587	7.637	3.630	3.692	5.627	3.630	3.630
DNK	5.475	1.764	2.131	6.657	1.838	2.120	5.932	1.796	2.122
EST	0.453	2.047	8.831	1.919	1.816	8.859	0.461	1.913	8.999
FIN	13.310	4.434	5.880	18.452	4.291	5.959	15.744	4.370	5.934
FRA	7.121	1.671	1.399	8.122	1.648	1.405	7.417	1.660	1.402
DEU	0.509	2.084	3.651	0.696	2.066	3.671	0.482	2.075	3.662
GRC	2.401	2.185	3.760	2.777	2.203	3.758	2.777	2.170	3.705
HUN	5.021	3.960	8.687	3.406	3.823	11.451	2.619	3.894	8.486
ISL	6.867	3.891	2.694	6.080	3.833	2.736	6.093	3.862	2.710
IRL	52.006	34.013	15.322	24.073	20.611	14.395	2.460	25.707	14.904
ISR	3.715	3.367	4.330	3.605	3.365	4.327	3.826	3.369	4.342
ITA	4.921	1.942	1.581	1.702	1.943	1.539	5.200	1.942	1.564
JPN	6.261	0.514	0.426	10.477	0.532	0.438	7.995	0.521	0.431

KOR	4.195	9.198	10.920	5.725	9.181	8.479	2.474	9.831	12.800
LVA	10.897	9.412	7.345	11.100	9.385	7.554	10.297	9.399	7.465
LTU	2.353	2.536	2.687	2.351	2.489	4.043	2.309	2.504	2.694
LUX	2.501	9.412	1.857	12.227	2.015	1.425	6.445	1.929	1.622
MEX	10.177	5.327	5.570	7.860	5.128	5.611	6.549	5.583	5.531
NLD	6.528	0.680	3.028	7.542	0.829	2.949	3.631	0.862	2.917
NZL	3.536	2.180	2.899	10.048	2.192	2.831	4.455	2.186	2.863
NOR	4.249	2.002	1.884	4.544	1.995	1.876	3.595	1.997	1.952
POL	2.242	1.603	1.759	2.274	1.605	1.716	3.846	1.600	1.802
PRT	0.553	1.153	3.180	5.276	1.170	1.117	2.547	1.161	1.585
SVK	13.498	2.119	5.151	10.455	2.118	4.868	11.753	2.119	5.005
SVN	3.063	1.791	2.692	3.128	1.791	2.685	3.184	1.791	2.679
ESP	5.640	1.507	1.436	5.044	1.518	1.408	6.424	1.492	6.424
SWE	6.363	0.593	0.581	9.504	0.573	0.921	7.005	0.581	0.731
CHE	1.994	0.897	15.814	1.340	0.905	14.950	1.864	0.873	21.986
TUR	10.526	4.748	2.415	9.827	5.160	2.465	7.928	5.142	2.437
GBR	3.321	0.997	1.064	1.113	1.077	1.115	1.483	1.023	1.087
USA	1.481	0.811	2.566	1.469	0.805	2.578	2.910	1.088	1.924

Selected forecasting models for ARIMA and NNAR methods are summarized for each OECD country in Table 4.12. The ARIMA (1,1,0) model gives the best results for 36 countries, while the ARIMA (4,1,3) model is chosen as the best model for Ireland. The NNAR (1,1) is selected for 31 countries as the best network, the NNAR (2,2) network gives better results for 5 countries and the NNAR (2,1) is selected as the best network for Turkiye.

Table 4.12. Forecasting models selected as best

	ARIMA(p,d,q)	NNAR(p,k)		ARIMA(p,d,q)	NNAR(p,k)
AUS	(1, 1, 0)	(2, 2)	KOR	(1, 1, 0)	(1, 1)
AUT	(1, 1, 0)	(1, 1)	LVA	(1, 1, 0)	(1, 1)
BEL	(1, 1, 0)	(1, 1)	LTU	(1, 1, 0)	(1, 1)
CAN	(1, 1, 0)	(1, 1)	LUX	(1, 1, 0)	(1, 1)
CHL	(1, 1, 0)	(2, 2)	MEX	(1, 1, 0)	(1, 1)
COL	(1, 1, 0)	(1, 1)	NLD	(1, 1, 0)	(1, 1)
CZE	(1, 1, 0)	(1, 1)	NZL	(1, 1, 0)	(1, 1)
DNK	(1, 1, 0)	(1, 1)	NOR	(1, 1, 0)	(2, 2)
EST	(1, 1, 0)	(1, 1)	POL	(1, 1, 0)	(1, 1)
FIN	(1, 1, 0)	(1, 1)	PRT	(1, 1, 0)	(1, 1)
FRA	(1, 1, 0)	(1, 1)	SVK	(1, 1, 0)	(1, 1)
DEU	(1, 1, 0)	(1, 1)	SVN	(1, 1, 0)	(1, 1)
GRC	(1, 1, 0)	(1, 1)	ESP	(1, 1, 0)	(1, 1)
HUN	(1, 1, 0)	(1, 1)	SWE	(1, 1, 0)	(1, 1)
ISL	(1, 1, 0)	(1, 1)	CHE	(1, 1, 0)	(2, 2)
IRL	(4, 1, 3)	(2, 2)	TUR	(1, 1, 0)	(2, 1)

ISR	(1, 1, 0)	(1, 1)	GBR	(1, 1, 0)	(1, 1)
ITA	(1, 1, 0)	(1, 1)	USA	(1, 1, 0)	(1, 1)
JPN	(1, 1, 0)	(1, 1)			

When countries were classified according to the methods with the lowest MAPE values as Table 4.13., Holt's method with original data gave the best results for Estonia and Portugal. ARIMA method with original data is best for Austria, Denmark, Netherlands, New Zealand, Slovenia, and, the United Kingdom. The NNAR method with original data gave the best results for the Czech Republic, France, Iceland, Japan, Latvia, and Türkiye. Holt’s method with Box-Cox power transformed data is best for Australia and Belgium. ARIMA with Box-Cox power transformed data gave the best results for Colombia, Finland, Israel, Mexico, Slovakia, Sweden, and the United States. NNAR with Box-Cox power transformed data. Holt’s method with logarithmic transformation gave the best results for Germany, Hungary, Ireland, Korea, and Lithuania. While the logarithmically transformed ARIMA method, gave the best results for Canada, Greece, Poland, and Switzerland, NNAR with logarithmically transformed data did not perform well in any country.

Table 4.13. The number of countries with the lowest MAPE values

The number of countries with the lowest MAPE values								
Original			**Box-Cox Transformation $\lambda \neq 0$**			**Box-Cox Transformation $\lambda = 0$**		
Holt’s	**ARIMA**	**NNAR**	**Holt's**	**ARIMA**	**NNAR**	**Holt's**	**ARIMA**	**NNAR**
2	6	6	2	7	5	5	4	0
EST	AUT	CZE	AUS	COL	CHL	DEU	CAN	
PRT	DNK	FRA	BEL	FIN	ITA	HUN	GRC	
	NLD	ISL		ISR	LUX	IRL	POL	
	NZL	JPN		MEX	NOR	KOR	CHE	
	SVN	LVA		SVK	ESP	LTU		
	GBR	TUR		SWE				
				USA				

It is observed in Table 4.14. that when MAPE values are averaged over all countries, ARIMA with Box-Cox transformed data is ranked first. According to the average MAPE values, ARIMA with logarithmic transformed data and ARIMA with original data are calculated as the second and third successful methods, respectively. The next successful method is NNAR and its performance is not good when the logarithmic transformation has been used, while Holt’s method performance is better for logarithmic transformation.

It is determined that forecastings made with transformed data provide better forecasting accuracy with lower MAPE values than the original data for all countries.

Table 4.14. Average MAPE values and ranks

	Original			Box-Cox Transformation $\lambda \neq 0$			Box-Cox Transformation $\lambda = 0$		
	Holt's	**ARIMA**	**NNAR**	**Holt's**	**ARIMA**	**NNAR**	**Holt's**	**ARIMA**	**NNAR**
Average MAPE	5.951	3.657	4.138	6.045	3.092	4.066	4.784	3.267	4.412
Rank	8	3	5	9	1	4	7	2	6

The best method for each country is summarized according to the lowest MAPE values in Table 4.15. ARIMA with Box-Cox transformed data is the best method for seven country groups and ranked first as a result of average MAPE values as stated in Table 4.14.

Table 4.15. Method with Lowest MAPE Value for each country

	Method with Lowest MAPE Value
AUS	Holt's Method with Box-Cox transformed data
AUT	ARIMA with original data
BEL	Holt's Method with Box-Cox transformed data
CAN	ARIMA with logarithmic transformed ddata
CHL	NNAR with Box-Cox transformed data
COL	ARIMA with Box-Cox transformed data
CZE	NNAR with original data
DNK	ARIMA with original data
EST	Holt's Method with original data
FIN	ARIMA with Box-Cox transformed data
FRA	NNAR with original data
DEU	Holt's Method with logarithmic transformed data
GRC	ARIMA with logarithmic transformed data

	Method with Lowest MAPE Value
KOR	Holt's Method with logarithmic transformed data
LVA	NNAR with original data
LTU	Holt's Method with logarithmic transformed data
LUX	NNAR with Box-Cox transformed data
MEX	ARIMA with Box-Cox transformed data
NLD	ARIMA with original data
NZL	ARIMA with original data
NOR	NNAR with Box-Cox transformed data
POL	ARIMA with Logarithmic transformed data
PRT	Holt's Method with original data
SVK	ARIMA with Box-Cox transformed data
SVN	ARIMA with original data
ESP	NNAR with Box-Cox transformed data

HUN	Holt's Method with logarithmic transformed data	SWE	ARIMA with Box-Cox transformed data
ISL	NNAR with original data	CHE	ARIMA with logarithmic transformed data
IRL	Holt's Method with logarithmic transformed data	TUR	NNAR with original data
ISR	ARIMA with Box-Cox transformed data	GBR	ARIMA with original data
ITA	NNAR with Box-Cox transformed data	USA	ARIMA with Box-Cox transformed data
JPN	NNAR with original data		

5. DISCUSSION

The study on "Forecasting of Health Expenditures and Determining its Indicators" has been conducted in two separate phases. The initial phase of the study involves identifying the variables that influence health expenditures using the CHAID decision tree. The subsequent phase aims to assess whether the results can be better explained by applying data transformations. The initial phase of the study utilized the CHAID decision tree to identify five variables out of the fifteen evaluated that significantly influenced current health expenses. The variables included in the analysis are GDP per capita (GDPCD), life expectancy at birth (LIFEX), death rate (DR), out-of-pocket expenditure (% of current health expenditure) (OOPEP), and fertility rate (FR). The discussion section presents the chronology of research conducted on five variables.

Health expenditure in OECD member countries increases annually. The study identified the key factors that determine current health expenditure (% of GDP) in OECD member nations. These factors were used to categorize the member countries using the CHAID decision tree approach.

When the influential variables of health expenditures of all countries are examined, it is observed that economic, demographic, and health variables are different for all countries, country groups, and each country. The income level of the countries, the development, and the strong structure of the health system are the most important factors.

Influential variables affecting health expenditures are examined for OECD countries in the world, and it has been emphasized in many studies that GDP per capita is the most important economic variable (Akca et al., 2017; Hosoya, 2014; Wu et al., 2014; Mosca, 2007; Barros, 1998; Hiritis & Posnett, 1992). The views and results obtained from research on how per capita GDP income affects health expenditures can be summarized as follows. In the study investigating the health expenditures of 167 countries, Younsi et al (2016) found that GDP per capita is an influential variable not only for OECD countries but also for all countries, using the fixed-effect and dynamic panel model. Samadi & Homaie (2013) indicate that GDP per capita is a significant variable for ECO countries as a result of panel data analysis variables affecting health expenditures discussed in many studies. According to most studies, GDP per capita is the most important 'factor' explaining health expenditures. Gerdtham et al. (1998) The OECD conducted an analysis on the determinants of health expenditure in countries over 20 years and found that GDP is highly significant for health care expenditure (HCE). Canada's GDP and the elasticity of HCE were analyzed by Bilgel and Tran (2011), and HCE was found to be less than one, and it was explained that GDP growth had minimum effect on HCE. When Bilgel and Tran's findings and Ke et al.'s results (2011) are compared, the both of the results found as similar. Health expenditures are not growing faster than GDP. The relationship between GDP and HCE in OECD countries shows that in many cases income elasticity is above the OECD average (Schieber, 1999; Getzen, 2000). The results of this thesis study reveal that GDP per capita has a positive effect on health expenditures in the countries included in the study. These results can be explained by the fact that countries can increase public health expenditure by making per capita income higher.

The relationship between the income level of countries and health expenditures also has special importance. Governments in developing countries have significant hurdles due to a lack of financial and administrative capabilities as well as significant service needs. Countries with similar income levels may have different health expenditures in terms of quantity and quality. The reasons for the differences in the health expenditures of the countries are open to various interpretations. In general, it is known that in countries with high per capita income, per capita health expenditure is also high. There is a positive relationship between the two variables. In the study of Schieber and Maeda (1999), a positive relationship was found between per capita income and health expenditures across countries. The study results revealed that a 10-point change in GDP per capita means an 11.3-point change in per capita health expenditures.

The correlation between health expenditures and economic growth is a significant topic of discussion. Health expenditures in a format that enhances the health system contribute positively to establishing the institutional infrastructure for health and improving individuals' health situations. The impact of a healthier society on economic growth is significant, as it affects both human capital and physical capital. Specifically, the restricted availability of healthcare services for the impoverished workforce can impose a burden on the economy through the overall workforce channel, as there exists a mutually beneficial connection between health and human capital. Hence, the optimal utilization of healthcare spending might have a favorable impact on economic growth by enhancing labor productivity. Nevertheless, if health expenditures are utilized inefficiently or fail to enhance health outcomes, it might result in a squandering of resources. An alternative perspective is that higher healthcare spending can enhance the longevity of older persons, but it can also impose a financial strain on the economy. This metric is subject to debate, particularly in countries with a significant senior population. Another contentious matter is the impact of health costs on exclusion. Hence, a rise in healthcare spending can displace more advantageous investments (Ozyılmaz et al., 2022)

As a result, as income increases, the amount of health services consumed also increases at a similar rate. Healthcare services need to be specific. In other words, if the individual experiences any problems in terms of his physical or mental health due to the income increase people have earned, can apply to health institutions and receive treatment. This has a positive effect on the person's health, which is his/her most important need. After a certain time, with the development of production techniques in countries, the increases in their production and indirectly in their incomes lead to an increase in the demand for services that will enable people residing in the country to live a more spacious life.

Securing the lowest level needs through the government or other institutions increases individuals' demands for goods and services other than their basic needs. An increase in the national income of countries will also have a positive impact on per capita income. As a result, the need for health services provided by the public as well as the private sector is increasing. It is an undeniable fact that individuals and society improve themselves in the fields of health and education every day. Due to people's rising awareness and need for the wealthy and a good life, there is a greater need for health services, which influences health-related costs.

As a second outcome of the decision tree study, life expectancy was calculated as one of the significant variables. Researches investigating the relationship between life expectancy at birth and health expenditures are summarized. Life expectancy is among the goals of health policymakers and planners to provide more effective ways to handle the world's rising health spending. Efficient and equitable distribution of scarce resources to the community necessitates careful and systematic implementation. Hence, policymakers require data that is grounded in empirical evidence to inform their decision-making process. Contrary to Colombier's (2017) panel data analysis research, the research conducted among OECD countries, they have been concluded that LIFEX is considered as among the most influential variables impacting health expenditures (Akca et al., 2017; Tian et al., 2018; Anwar et al., 2023). LIFEX is a crucial factor for evaluating the overall welfare of a country on a global scale. Prior research focusing on individual nations or certain groupings of countries has already identified the correlation between healthcare spending, social or economic behavior, and life expectancy. The study conducted by Roffia et al. (1999–2018) examines a dataset that includes 36 OECD nations. The study presents a model that evaluates the relationship between life expectancy and many factors in OECD countries. Factors related to life expectancy in the model; health expenditures, financing policies, medical treatment, health behaviors, public health, social indicators and expenditures. In this study, a significant relationship was found between health expenditures and LIFEX. The findings are similar to the results of previous research.

LIFEX is defined as the mean duration of life that an individual can anticipate to have starting at birth, under the assumption that mortality rates at different ages remain consistent (Laranjeira & Szrek, 2016). Health expenditures serve as a crucial data source for policymakers when formulating health policies. Several studies in the literature analyze the correlation between LIFEX and health costs by utilizing data from various sample nations or country groups. Multiple studies have demonstrated The study presents a model that evaluates the relationship between life expectancy and many factors in OECD countries. Factors related to life expectancy in the model; health expenditures, financing policies, medical treatment, health behaviors, public health, social determinants and expenditures. In this study, a significant correlation was calculated between health expenditures and LIFEX. The findings are similar to the results of previous research, healthcare quality, and the average lifespan. Uncovering the correlation between life expectancy and health expenses is of utmost significance. Examining the impact of healthcare spending on life expectancy and the impact of life expectancy on healthcare spending is crucial for implementing effective health policy. Jaba et al. (2014) examined the correlation between LIFEX and per capita health expenditures to assess the country's degree of development. Based on the findings of the study, which analyzed data from 175 nations between 1995 and 2010, there is a positive correlation between per capita health expenditure and LIFEX in industrialized countries. Rana et al. (2018) examined the variations in the connection between health expenditures and health outcomes, including the disparities in income levels between nations. Life expectancy at birth is one of the four variables used to measure health outcomes. Empirical evidence has demonstrated that there is a comparatively greater correlation between health expenditures and health outcomes in low-income nations.

Linden et al. (2017) found that the association between health expenditures and LIFEX driven by public health expenditures (% of the GDP). Empirical data has demonstrated that both public and private healthcare spending have beneficial impacts on life expectancy in nations where the public sector plays a significant role. Aisa et al. (2014) examined how health expenditures impact life expectancy in 29 OECD nations. They emphasized the significance of public health spending on life expectancy. Nevertheless, it was also discovered that public health expenditures have a positive impact on increasing life expectancy, but only up to a specific threshold. According to Shahbaz et al. (2016), there is a favorable correlation between public health spending and life expectancy. The causality analysis results indicate a reciprocal relationship between public health spending and life expectancy.

Crémieux et al.'s (1999) analysis was conducted on a 15-year dataset from eleven Canadian provinces, revealing a correlation between reduced healthcare expenditure and decreased life expectancy. Consequently, it may be asserted that insufficient investment in healthcare affects negatively life expectancy.

In a study conducted by Nixon et al. (2006), data from 15 European Union nations between 1980 and 1995 was examined to determine the impact of health expenditures on life expectancy. The findings revealed that health expenditures had only a minimal effect on improving life expectancy.

Life expectancy serves as a means to comprehend and assess the impacts of governmental policies, human conduct, and cultural trends within a nation. It has the potential to impact various social and economic factors, including life expectancy, fertility rate, consumer buying habits, investment in human capital, pension expenses, state budgets, and economic growth (Shaw et al., 2005). The majority of studies examining economic growth and health expenditures have discovered a positive association between population health, as assessed by economy and life expectancy at birth (Bhargava et al., 2001; Sunde & Vischer, 2015).

Life expectancy at birth is influenced by two primary factors. The first factor that influences survival chances in the early years is the sort of behavior and outside support network that they have to access (Adler & Newman, 2002; Braveman & Gottlieb, 2014). Furthermore, healthcare expenditure (HCE) and the quality of the healthcare system are significant elements that impact both variables, as stated by Nixon and Ulmann in 2006. Based on economic principles, public spending should be focused on achieving the highest level of efficiency, taking into account the expected outcomes of the health system, including preventative, therapeutic, and rehabilitative medical services. Life expectancy can be influenced by healthcare outcomes that are connected with behavioral, social, and other factors (Braveman & Gottlieb, 2014; Dahlgren & Whitehead, 1991). The variables investigated in studies on health expenditures and life expectancy mostly encompass factors about health services, as well as social and behavioral aspects. Furthermore, it is crucial to consider the significance of health system outcomes as well as other social, behavioral, or structural elements. The third component arises within the framework of enhancing healthcare systems (health workforce and service provision) and social care systems, both of which are linked to life expectancy at birth and, consequently, to public health overall (Roffia et al., 2023).

Studies on life expectancy at birth have found that certain factors, such as medical supplies, labor, and machinery, in the healthcare system (HCS) are influenced by the number of visits, surgeries, therapies, and other factors. These inputs play a significant role in transforming the HCS into outputs, as observed in studies by Cochrane et al. (1978) and Papanicolas et al. (2019).

The study of prediction methods has mostly focused on variables about the health system and its inputs, as well as the manner of life and overall population's health. The predominant dependent variable utilized was LIFEX, which is determined by the efficacy of the Health Care System (HCS) and the impact of other variables (Ho & Hendi, 2018; Nolte et al., 2002). External variables encompass several aspects such as hygienic conditions, environment, economy, social considerations, and innovation. Sanitation has been identified as a crucial determinant of public health and longevity (Ranabhat et al., 2018). Karacan et al. (2020) also indicate that sanitation facility is a significant variable for healthy life expectancy. In the model of this study, people using safely managed sanitation services (% of the population) (SS) data was included, to investigate the relationship between health expenditure and sanitation facilities. Although sanitation facility are significant for life expectancy at birth, they are not found to be significant in the decision tree model and are not calculated as an important variable for health expenditure.

Recent studies highlight the favorable influence of the resources utilized in the healthcare system on the lifespan of the population (Jaba et al., 2014; Nixon & Ulmann, 2006). The researches examined health expenditures using both absolute measures (such as per capita expenditure) and relative measures (such as the share of GDP spent on health care). Research conducted by Mackenbach et al. (2011) has revealed a positive correlation between the rise in healthcare spending, particularly concerning the provision of healthcare services for the elderly, and an increase in life expectancy. When considering only government spending, there is a positive correlation between greater levels of spending and longer life expectancy (Aisa et al., 2014; Linden & Ray, 2017). On the other hand, disparities in government spending are accountable for variations in health system results (Jaba et al., 2014). OECD states that an increase of 10% in health spending per person has been the primary factor contributing to the recent improvements in life expectancy. This rise is linked to a 3.5-month increment in life expectancy. (Papanicolas et al., 2019). There is a direct correlation between the amount of money spent on healthcare and the average lifespan of a population. Out-of-pocket payments, which assess individual contributions to health funding, are correlated with life expectancy. Health policy significantly influences life expectancy by enhancing the standard of healthcare and advocating for a wellness-oriented way of living. The Sustainable Development Goals are based on the principles of optimizing population health outcomes and minimizing health inequities (Ranabhat et al., 2018).

In this thesis study, one of the five significant variables found in the decision tree as a result of the model is out-of-pocket health expenditures (% of current health expenditure). Researches investigating the relationship between out-of-pocket expenditures, and health expenditures are summarized as follows. Out-of-pocket health expenditure includes payments made directly by patients or households for health services. In many countries, out-of-pocket health expenses rank second in terms of total expenditures, after public health expenses. Out-of-pocket expenditures in the form of contributions, direct payments, and informal payments have a share between 1/3 and 2/3 in the total health expenditures of many low and middle-income countries without social security systems. Out-of-pocket expenditures for health purposes are a tool used to create additional resources in the financing of health services, to enable individuals to consider the costs and benefits of various services and thus to avoid unnecessary health care use, and especially to reduce and control public health expenditures (Van de Ven, 1983).

In studies on the analysis of health expenditures of OECD countries, it was concluded that out-of-pocket health expenditures were a significant variable by using the Driscoll-Kraay standard error approach method (Beylik et al., 2022). Out-of-pocket health expenditure was found to be a significant variable in the study using the fixed effect and dynamic panel model, conducted not only among OECD countries but also among 167 countries (Younsi et al., 2016). Research highlights that out-of-pocket expenditures are related to increasing a country's general government revenues and social insurance policies (Amiri et al., 2021). Akca et al.'s (2017) research, as a result of the CART decision tree analysis, the relationship between out-of-pocket health expenditures and health expenditures was not found to be significant. It is assumed that this difference is because 2015 data was used in this study and that it was implemented among 37 countries instead of 35 countries.

One finding that unites all studies is that a rise in out-of-pocket expense causes a fall in demand for a particular medical service. There are numerous signs that this money price effect is bigger the lower the time price, lower income, less urgent medical care, and greater patient power over the decision to receive medical care (Van de Ven, 1983).

Out-of-pocket expenditures, which started to be used as a health financing tool in the 1980s, have been widely used to ensure the quality and sustainability of health services in developing countries since the 1990s. For this reason, the extent of out-of-pocket expenditures is much higher in developing countries, where adequate financing for health through taxes and social insurance premiums cannot be created, especially due to poverty and the prevalence of the informal sector (Piontkowski, 2020; Rana et al., 2020). These general benefits of the share of out-of-pocket expenditures in total expenditures in developed countries in terms of the average OOP expenditures in terms of financing the health system can also be examined in terms of out-of-pocket expenditure types. The most common reasons for informal payments include increasing or accelerating the access and use of health services, which have decreased due to a lack of resources, by providing additional resources to the health system (Sabra, 2022; Schieber & Akiko, 1999; Schofield & Rothman, 2007; Shahriari et al., 2001) In regression analysis of this thesis study, it is seen that the OOPEP variable takes place in 24 countries out of 37 countries.

Contributions (and co-insurance) as another type of out-of-pocket expenditure also have two important positive effects on the health system in general. First, it creates additional resources for health system financing when tax or social insurance contributions are insufficient. Second, raising awareness of the quality and cost of health services limits the demand for low-quality and unnecessary health services, thus reducing costs and increasing productivity (Shahriari et al., 2001; Smith, 2005; Walley & Wright, 2001).

Due to this reason, it is necessary to comprehend and evaluate the factors affecting out-of-pocket health expenditures, in which people have to spend a significant part of their current income to benefit from health services and deepen health inequality in low-income groups.

In this thesis study, one of the significant variables that entered the model in the decision tree is the fertility rate (FR). The fertility rate is correlated with the degree of economic growth. Developed nations exhibit markedly lower birth rates, which are commonly linked to higher levels of affluence, education, urbanization, and other related characteristics. In contrast, fertility rates are generally greater in the least developed countries. The lack of access to healthcare and the limited availability of birth control methods contribute to greater fertility rates. Additionally, low levels of education among women and low rates of female employment also contribute to this trend. As long as rising fertility rates result in rising infant mortality, which in turn causes a decline in birth weight, they are inversely correlated with life expectancy.

Government health spending boosts the fertility rate while private and external health spending decreases it. This suggests that some health initiatives support large families, and it may also point to more effective birth-control education initiatives in the private health sector, whereas ineffective or lacking such initiatives exist in the public sector.

Additionally, the inverse relationship between life expectancy and growth highlights the cost of caring for the young and elderly under conditions of significant unemployment, particularly among young people (about 30%). This encourages the recommendation of increased spending on education in addition to health to improve human development, which increases productivity, and employment participation, and lowers fertility rate. In contrast to the prevalent thinking in underdeveloped nations, educated family members prioritize investing in their health and education over raising large families. (Walley & Wright, 2001).

Compared to other decision tree studies, GDP per capita and life expectancy at birth were found to be significant variables in studies, and it was determined that CHAID analysis of this study was similar to previous studies. In this CHAID analysis study, out-of-pocket expenditure (% of current health expenditure), fertility rate, and death rate were found to be significant, while in the other study using the CART decision tree, number of hospitals, age dependency ratio, and share of the population with a bad perceived health status was found to be significant (Akca et al., 2017). It is assumed that these differences are due to the different years of the data set and the fact that the CHAID analysis includes all OECD countries.

In this thesis study, one of the five significant variables included in the model in the decision tree is the death rate (DR). The overall health status and death rate at different life phases varies across developed, developing, and least developed countries due to multiple causes. The variation in death rates between countries can be attributed to factors such as government spending, health insurance coverage, and funding from private sources such as out-of-pocket payments, NGOs, and private enterprises. There are variations in death rates and health spending among different states within countries. In light of this, the study aims to investigate the overall impact of healthcare spending on mortality rates, specifically focusing on maternal and infant mortality. Maternal and newborn mortality are significant concerns due to their vulnerability in society. Over the years, researchers have examined the correlation between health outcomes, specifically mortality rates, and health expenditure. Over the years, researchers have examined the correlation between health outcomes, specifically mortality rates, and health expenditure. These studies have focused on both individual cases, using time series data, as well as groups of nations, such as the OECD and sub-Saharan Africa (OECD, 2019). According to studies conducted among OECD countries, the mortality rate was found to be significant only in the study investigating the Baumol cost disease variable for health expenditure (Columbier, 2017).

In their study, Novignon et al. (2012) examined the correlation between public and private health expenditures and health status in 44 countries from 1995 to 2010 using panel data analysis. The study incorporates health indicators such as life expectancy at birth, child mortality rate, and overall mortality rate. The study findings indicate that higher levels of public and private health expenditures are associated with increased life expectancy but also with a decrease in the death rate. Consequently, when there is a rise in both public and private health spending, death rates often decline. The study indicated that the general public plays a significant role in health expenses. Health expenditures are covered by both the public and private sectors in many countries. The effects of public or private sector health expenditures on the health of the individual and society is a separate discussion topic apart from this study. In some countries, such as the USA, the private sector is heavily predominant, while in many of the rest of the world, the public sector is dominant. The effects of health expenditures on health indicators have been discussed for a long time. It is known that health expenditures and investments in health generally provide health improvement and therefore reduce death rates (Maynard & Dixon, 2002).

When assessing the health status of any country, maternal and infant mortality rate indicators, as well as the death rate, which are indicators of preventable or treatable conditions, are important. These variables play a vital role in assessing population health, health services, socioeconomic status, and health expenditures. Research has demonstrated a correlation between health expenditures and both life expectancy and death rates. It can aid public officials and politicians in making decisions about investing in the health system.

In the regression analysis part of the study, when the regression model developed from significant variables is evaluated, the variables obtained from the CHAID decision tree are included in the regression model in different combinations for each country to analyze country-based health expenditure. The explanation of the country-based regression model according to the influential variables is given below. The GDPCD variable was included in the model in 21 out of 37 countries (56.75%), the LIFEX and FR variables were included in the model in 28 countries out of 37 (75.67%), the DR variable was included in the model in 19 countries (51.35%), and the OOPEP variable was included in the model in 24 countries. GDPCD, LIFEX, DR, FR, and OOPEP variables exist simultaneously in 3 countries: ISL, IRL, and ITA; GDPCD, LIFEX, DR, and FR variables are included in

BEL, and COL at the same time; GDPCD, LIFEX, FR, and OOPEP variables are present simultaneously in 4 countries: FIN, KOR, PRT, and GBR; LIFEX, DR, FR variables simultaneously; It is included in the model in 6 countries: AUS, AUT, CAN, CHL, FRA, DEU; LIFEX, FR OOPEP variables are located simultaneously in DNK and ISR countries; GDPCD, LIFEX, and DR variables are present in CZE, and LUX at the same time. GDPCD, LIFEX, and FR variables are simultaneously present in NLD and NZL; GDPCD, LIFEX, and OOPEP variables are only available in LVA and ESP; GDPCD, FR, and OOPEP variables were affected only in EST; FR and OOPEP variables are included in GRC and LTU; LIFEX, DR, FR OOPEP variables are included in HUN; DR, FR, and OOPEP variants are found in Türkiye; GDPCD, DR, FR, and OOPEP variables are included in SVN; GDPCD, OOPEP, and DR variables are only available in the USA; OOPEP and DR variables are included in JPN. It has been observed that LIFEX and OOPEP are only useful in POL.

It is useful to evaluate the relationship between the variables obtained from the CHAID decision tree and the health systems of the countries where they are located. It can be said that variables exist in different combinations in countries that provide health services in different health systems.

In the second phase of the study, the effects of the Box-Cox Transformation on health expenditures of OECD countries were examined by implementing three time series forecasting methods: Holt, ARIMA, and NNAR, where annual data contain trend models for all of the OECD countries. The successful forecasting performance of ARIMA in past studies for health expenditure forecasting has been confirmed by the lowest MAPE values in this study (Zheng et al., 2020; Piontkowski, 2020; Dritsakis & Klazoglou, 2019; Ramazenian et al., 2019; Kaushik et al., 2017). When the results of the ARIMA method with the original data and the transformed data were examined, MAPE values were calculated below 10% in 36 (97.3% of the OECD countries in the model) of 37 countries. As stated in Table 4.14 in the previous section, when the average MAPE values of the original data and transformed data of the ARIMA method are compared for all countries, the ARIMA method with Box-Cox transformed data is ranked first and becomes the most successful method of the study. ARIMA with logarithmically transformed data (Box-Cox transformation λ=0) is ranked second, confirming that the transformation improves the prediction performance and forecasting accuracy. When the results of the method with original and transformed data are evaluated, it is seen that the MAPE value of the NNAR method is below 10% in 34 of 37 countries. Evaluating the comparison of the original and transformed data method confirms that NNAR with Box-Cox transformed data ranks fourth, and the implementation of data transformation improves the prediction performance of forecasting analysis. Regarding Holt's method, it was calculated that MAPE values were below 10% in 33 countries when the original data was used, in 30 countries when Box-Cox transformation was applied to the data, and in 34 countries where logarithmic transformed data (Box-Cox transformation λ=0) was used. According to the comparison of average MAPE values, it was calculated that Holt's method with logarithmically transformed data has lower values than the MAPE values calculated using the original data and Box-Cox transformed data and that using logarithmically transformed data for Holt's method gives better prediction performance.

It has been demonstrated that the three applied methods have different effects on the transformation. In general, while the prediction performance is enhanced with transformation in all methods, power transformation is recommended for NNAR, and logarithmic transformation is recommended for the Holt method. Although ARIMA's prediction performance increases with Box-Cox transformation, it is the most successful method for all types of data among the methods studied.

6. CONCLUSION

Health expenditures are both an indicator of a country's development level and a performance indicator of its health system. The governments must constantly assist the healthcare industry and the health system as a whole by ensuring that appropriate and timely legislation is passed and that health expenditure is used efficiently to improve health outcomes. Enhancing the health system's core components and fortifying its weaknesses is essential. Nevertheless, the recent increment in healthcare spending among OECD countries has prompted significant apprehension regarding long-term economic sustainability. It is vital to improve key aspects of the health system and strengthen deficiencies. Developing and analyzing health expenditure models, identifying influential variables for OECD countries is of great importance and benefits for countries and country groups. The rising health spending forces the countries to strengthen their health systems and plan health spending budgets to adapt to that trend for financial sustainability. The CHAID decision tree technique is suggested as an effective tool in determining variables affecting health expenditure which in turn can be an important aid in health spending projections and planning.

The CHAID decision tree method was chosen to determine the influential variables of 37 OECD countries. The CHAID decision tree uses frequencies, not actual values, so it does not require special probability distributions for variables and is insensitive to outliers in data sets. It provides a visual tool for decision rules and classification. Influential variables that make up the decision rules can be used as input in other analyses. As a result of decision tree study, GDP per capita, life expectancy at birth, out-of-pocket expenditure (% of current health expenditure, fertility rate and death rate determined as significant variables.

Country-based regression models were modeled using significant variables obtained from the decision tree. The regression model developed from significant variables provides an accurate prediction of the health expenditure value of each country, and this prediction study provides information for country and country-group-based to policymakers, goverments, and budget planners for health expenditure modeling.

Second phase of this study examines the effects of Box-Cox transformation with an application on health expenditure data of OECD countries using three-time series forecasting methods: Holt's exponential smoothing, Autoregressive Integrated Moving Average, and Neural Network Autoregression, which are appropriate to use for data with trend patterns.

It is concluded that the prediction performance of the methods applied improved with transformation but the type of transformation to be made is important according to the method used. The prediction performance of NNAR improves with power transformation, whereas the prediction performance of Holt's method improves with logarithmic transformation. As a result of this study, both of the average ranking of MAPE values and all MAPE values are examined, ARIMA method with Box-Cox power transformed data outperforms the other methods and is selected as the most successful method for current health expenditure forecasting of OECD countries. ARIMA outperforms other methods whether original or transformed data are used.

In conclusion, the findings of this study can contribute to policymakers on sustainable financial planning, investment planning, and decision-making for health spending with accurate country groups, and country-based projections. In further studies, the impact of the COVID-19 pandemic effect on health expenditure can also be investigated by using data on health expenditure for 2020 and the following years and by employing suggested methods and transformations.

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RESUME

Name Surname: TUĞÇE İŞSEVER

EDUCATION

2017- (continue): Marmara University Industrial Engineering (Ph.D)

- Thesis: Forecasting of Health Expenditures and Determining Its Indicators

2013- 2016: Marmara University Industrial Engineering (Master of Science)

- Thesis: Sales Forecasting in Textile Industry

2008 - 2012: Istanbul Technical University Textile Engineering (BSc)

WORK EXPERIENCE

- 2018-(continue): Health Institutes of Türkiye- Business Analyst & Project Management Specialist
- 2015-2018- SBS Textile- Product Development Merchandiser
- 2013-2013- Nikea Textile- Assistant Merchandiser
- 2012-2013- Kaya Group- Production Planning Assistant

PUBLICATIONS

Issever, T., Sennaroglu, B., Dönmez, CC., Corum, A., (2024). Identifiying Variables on Health Expenditure of OECD Countries. Iranian Journal of Public Health.

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