Hacettepe Sağlık İdaresi Dergisi, 2024; 27(3), 411-428
https://doi.org/10.61859/hacettepesid.1406500

RESEARCH ARTICLE

THE EFFECT OF HEALTHCARE TECHNOLOGY ON HEALTH EXPENDITURES [§]

Gülay EKİNCİ [*]
Sevda Nur MEMUR [**]

ABSTRACT

This study aimed to determine the effect of Magnetic Resonance Imaging and Computed Tomography imaging services, which are within the scope of health technologies, on Health Expenditures. Panel analyses was used for the analyses. In the study, health expenditures were determined as the dependent variable, and the number of MR imaging and CT imaging within the scope of health technology as the independent variable, and 16 countries with regular data for the years 2007-2018 were included in the analysis. These countries were Australia, Belgium, Canada, Chile, The Czech Republic, Denmark, France, Germany, Iceland, Israel, Korea, Latvia, Lithuania, Luxembourg, Slovak Republic, and Slovenia. As a result of the analyses, it was determined that a one-unit increase in the number of Computed Tomography imaging increased health expenditures by 3.23 units, and a one-unit increase in the number of Magnetic Resonance imaging increased health expenditures by 21.9 units. The results of the study revealed that there was a positive and long-term relationship between health expenditures and the number of Computed Tomography and Magnetic Resonance Imaging, and there was a causal relationship in different directions between the variables. In addition, it has been determined that the number of Magnetic Resonance Imaging has increased more than the number of Computed Tomography imaging over the years, and that the number of Magnetic Resonance Imaging has a higher impact on health expenditures than Computed Tomography. When these two results were evaluated together, it is predicted that evaluating Magnetic Resonance Imaging and developing remedial activities will reduce health expenditures.

Keywords: *Health Technology, Health Expenditures, Magnetic Resonance, Computed Tomography*

ARTICLE INFO

[§] *This study was prepared based on the master thesis titled "Effect of health services use on health expenditures" conducted under the consultancy of Gülay Ekinci and defended by Sevda Nur Memur in 2022.*

[*] *Asst. Prof, Istanbul Sabahattin Zaim University, Faculty of Health Sciences, Department of Health Management, ekinciguláy@gmail.com*

https://orcid.org/0000-0003-4773-4821

[**] *Master's degree, Istanbul Sabahattin Zaim University, Faculty of Health Sciences, Department of Health Management, memursevdanur@gmail.com*

https://orcid.org/0000-0002-8124-3164

Recieved: 18.12.2023
Accepted: 23.07.2024

Cite This Paper:

Ekinci, G., & Memur S., N. (2024). The effect of healthcare technology on health expenditures. Hacettepe Health Administration Journal, 27(3), 411-428. https://doi.org/10.61859/hacettepesid.1406500

ARAŞTIRMA MAKALESİ

SAĞLIK TEKNOLOJİSİNİN SAĞLIK HARCAMALARINA ETKİSİ ††

Gülay EKİNCİ *
Sevda Nur MEMUR **

ÖZ

Bu çalışma sağlık teknolojileri kapsamında yer alan Manyetik Rezonans Görüntüleme ve Bilgisayarlı Tomografi görüntüleme hizmetlerinin Sağlık Harcamaları üzerindeki etkisini belirleme amacıyla yapılmıştır. Analizler panel veri analizi yöntemi kullaılarak yapılmıştır. Araştırmada bağımlı değişken olarak sağlık harcamaları, bağımsız değişken olarak sağlık teknolojisi kapsamında Manyetik Rezonans görüntüleme ve Bilgisayarlı Tomografi görüntüleme sayıları belirlenmiş olup, 2007-2018 yıllarına ait düzenli verisi olan 16 ülke analize dahil edilmiştir. Bu ülkeler Avustralya, Belçika, Kanada, Şili, Çek Cumhuriyeti, Danimarka, Fransa, Almanya, İzlanda, İsrail, Kore, Letonya, Litvanya, Lüksemburg, Slovak Cumhuriyeti ve Slovenya idi. Analiz sonuçlarına göre Bilgisayarlı Tomografi görüntüleme sayılarında meydana gelen bir birimlik artışın sağlık harcamalarını 3.23 birim, Manyetik Rezonans görüntüleme sayılarında meydana gelen bir birimlik artışın sağlık harcamalarını 21.9 birim arttırdığı tespit edilmiştir. Çalışmanın sonuçları sağlık harcamaları ile Bilgisayarlı Tomografi ve Manyetik Rezonans Görüntüleme sayıları arasında pozitif yönde ve uzun dönemli ilişki olduğu, değişkenler arasında farklı yönlerde nedensellik ilişkisi tespit edilmiştir. Ayrıca yıllar itibariyle Manyetik Rezonans Görüntüleme sayısının Bilgisayarlı Tomografi görüntüleme sayısından daha fazla arttığı, Manyetik Rezonans Görüntüleme sayılarının Bilgisayarlı Tomografiye göre sağlık harcamalarını daha yüksek düzeyde etkilediği tespit edilmiştir. Bu iki sonuç birlikte değerlendirildiğinde öncelikle Manyetik Rezonans Görüntüleme hizmetlerine yönelik değerlendirmelerin yapılarak iyileştirici faaliyetlerin geliştirilmesinin sağlık harcamalarını azaltabileceği öngörülmüştür.

Anahtar Kelimeler: *Sağlık Teknolojisi, Sağlık Harcamaları, Manyetik Rezonans, Bilgisayarlı Tomografi.*

MAKALE HAKKINDA

†† *Bu çalışma, Gülay Ekinci danışmanlığında yürütülen ve Sevda Nur Memur'un 2022 yılında savunduğu "Sağlık Hizmetleri Kullanımının Sağlık Harcamalarına Etkisi" başlıklı yüksek lisans tezine dayanılarak hazırlanmıştır.*

* *Dr. Öğr. Üyesi, İstanbul Sabahattin Zaim Üniversitesi, Sağlık Bilimleri Fakültesi, Sağlık Yönetimi Bölümü, ekincigulay@gmail.com*

https://orcid.org/0000-0003-4773-4821

** *Yüksek Lisans Mezunu, İstanbul Sabahattin Zaim Üniversitesi, Sağlık Bilimleri Fakültesi, Sağlık Yönetimi Bölümü, memursevdanur@gmail.com*

https://orcid.org/0000-0002-8124-3164

Gönderim Tarihi: 18.12.2023
Kabul Tarihi: 23.07.2024

Cite This Paper:

Ekinci, G., Memur S., N. (2024). Sağlık teknolojisinin sağlık harcamalarına etkisi. Hacettepe Sağlık İdaresi Dergisi, 27(3), 411-428. https://doi.org/10.61859/hacettepesid.1406500

I. INTRODUCTION

Human capital is an economic concept that expresses the transformation of qualified manpower into production, which is developed within the framework of the abilities of individuals in a society, such as their education level, culture, moral values, health status, etc. In terms of human capital, health is one of the most important components of investments such as education and nutrition for the development of qualified productive manpower. At the point of development and economic sustainability of national economies, states make expenditures and investments for health services to protect, develop, and improve the health of individuals. These expenditures and investments directly create positive effects on the health of individuals, and this effect is indirectly reflected on the social level and is among the determining factors of economic development and growth (Karataş and Çankaya, 2010; Tüylüoğlu and Karalı, 2006; Temiz, 2013; Akar, 2014).

As a matter of fact, according to the results of the research in which the growth rate of income per capita, the ratio of public and total health expenditures to national income, and life expectancy at birth were used as variables; health has a statistically significant and positive effect on growth; as well the results revealed that 22% and 30% of the per capita income growth rate in Sub-Saharan Africa and OECD countries, respectively, can be attributed to health (Brempong and Wilson, 2004).

In this context, states allocate a share of the public budget for health services to maintain and develop the level of health and, if necessary, improve it. This share is allocated to health services; It includes all expenditures made for infrastructure and processes used in health service delivery as health investments within the scope of health expenditures. These expenditures and investments, realized within the health services supply structure, facilitate the access of the demand for health services to these services and ensure that the need for health services is met.

The need for health services is health services with preventive, therapeutic, and rehabilitative features; in the literature on access and use of these services, Andersen defined the "behavioral model of health services use" and the factors affecting the use of health services are discussed under 3 main headings as predisposing factors, facilitating factors and need factors (Anderson, 2008).

Predisposing factors are demographic characteristics of individuals such as age, gender, race, marital status, household, population, income, and occupation. Facilitating factors are divided into two factors arising from the individual and the environment and society in which the individual lives. Factors arising from the individual; factors such as the total income of the family, insurance status, regular care, time to apply to health services, time to access health services, duration of implementation of health services, and the possibility of private examination. The factors arising from the environment and society in which the individual lives are; settlement, the service utilization rate of the population, population per bed, continuity of service, accessibility of service, and economic system. Need factors include duration of illness, symptoms occurring, perceived level of health, health concerns, and severity of illness (Yıldız and Eren, 2020).

Immunization services, consultation, screening and diagnostic procedures, hospital stay, diagnostic examinations, surgical procedures, and waiting times are considered within the scope of the use of health services. Diagnostic examinations included in this scope include various imaging methods that are used as supportive factors in the diagnosis and treatment of diseases as facilitating factors. Diagnostic examinations are techniques that create visuals of the internal parts of the body or reveal physiological findings during the medical evaluation and intervention phase of individuals and are evaluated within the concept of health technologies.

Health technology is defined as all kinds of infrastructure, processes, and systems used to provide accurate diagnosis and treatment to individuals. The United States Office of Technology Evaluation (OTA) has evaluated "medical technologies" in its health program as diagnostics, implantable devices, vaccines, surgery, drugs, and interventional procedures; and defined medical technology as "the techniques, drugs, equipment, and procedures used by health professionals in the delivery of medical care to individuals, and the systems by which such care was delivered" (OTA, 1976). WHO defines health technology as “the application of organized knowledge and skills in the form of devices, medicines, vaccines, procedures and systems developed to solve a health problem and improve quality of life” (WHO, 2022). Health technology is also defined as equipment (tools, sets, devices, machinery, apparatus, and other objects) and drugs that are the product of various techniques and technology during the production and supply of health services (Sargutan, 2005).

As it can be understood from the definition of health technologies, they can be considered on a product basis in concrete and intangible dimensions. As an intangible, procedural innovations developed for the design of health service delivery processes, which are products of health technology, can be given as an example; production of innovative vaccines and drugs such as mRNA, development of laparoscopic surgery methods, Angio catheterization, ECMO applications, development of dialysis applications and developments in medical imaging methods can be counted among the examples in terms of concrete products. We can say that tangible and intangible product processes are in close relationship with each other since tangible products developed in the field of health technology create procedural changes in service delivery.

Basic imaging systems within the scope of tangible products in health technologies are radiography, mammography, ultrasound, PET imaging, Magnetic resonance imaging and Computed Tomography. Medical imaging was born with the discovery of X-rays by Roentgen in Germany in 1895, used from 1896 to allow for X-ray pictures of the gastrointestinal tract, and by 1900, x-rays had begun to be used to diagnose fractures, gall and kidney stones, foreign bodies in the body, and lung diseases (Reiser, 1978). With the discovery of X-rays, changes have occurred in the organization of health care in the world, the Radiology specialty was officially established in the 1930s and the medical uses of X-rays began to spread (U.S. Congress, 1995).

By the 1970s, Computed Tomography (CT) was involved in the diagnostic imaging field, where skull anomalies began to be scanned (U.S. Congress, 1978). A CT scanner is a diagnostic device that combines X-ray equipment with a computer and a cathode ray tube (a television-like device) that gives images of cross-sections of the human body. While the first CTs were "head scanners" designed to produce images of abnormalities within the skull (for example, brain tumors), later "body scanners" were developed that could scan the entire body (U.S. Congress, 1995). Despite their high cost, CTs have been in high demand in the medical field. Magnetic resonance imaging (MR) was developed in the field of medical imaging based on nuclear magnetic resonance (NMR) and the first NMR image was published in 1973 (Lauterbur, 1973). Prototype MR units were established in the United States, England, and the Netherlands in the late 1970s (U.S. Congress, 1984). By the 1980s, small-scale breast cancer screening services were established in Australia and spread around the world as their benefits became apparent (U.S. Congress, 1995).

With the advancements in science and technology in the development of health technologies, the increase in the world population, the aging of the population due to the prolongation of life expectancy, the spread and diversification of diseases, the increase in the demand for better quality health services that develop in parallel with the increase in per capita income, the spread of the concept of patient rights, and the current diagnosis in the field of health law, and consideration of treatment protocols is among the main reasons. Accordingly, the benefits of health technologies can be listed as follows;

- More effective surgical treatments can be applied with modern medical imaging methods and methods are diversified.
- It ensures the efficiency of hospital services (shorter length of stay, operations with smaller incisions, and day surgery)
- It can shorten the processes in surgical interventions (such as closed-method surgical applications)
- Facilitating the treatment of patients who are expected to develop complications but need intervention (closed surgical methods can be preferred in elderly and multiple chronic diseases)

- It facilitates the diagnosis of suspicious physiological symptoms (swelling) (with these devices, it can distinguish between benign and malignant nodules)
- Providing evidence-based decision-making in healthcare
- Early diagnosis and treatment of diseases are provided with screening programs.

The benefits of technological developments in imaging services on the diagnosis and treatment processes of diseases have led to the widespread use of high-level imaging methods such as CT, MR imaging, PET in the health sector. Although this situation lead to an increase in investments in imaging devices in the field of medical technology in the health sector and the expansion of this field; it also caused an increase in health expenditures and investments.

Baker et al. (2003) examining the relationship between access to technology and health expenditures in the USA, found that as access to technology increases, health expenditures increase.

Shekelle et al. (2005) emphasized that increasing costs in health care may mostly be related to the use of technology.

Oh et al. (2005) found that there was a significant relationship between health expenditures per capita in the diffusion of health technology and the number of devices per capita.

Dybczak and Przywara (2010) examined the relationship between health expenditures and technology in EU countries using panel data analysis and it was shown that technology has a positive effect on health expenditures.

Qaseem et al. (2012) stated that many factors such as laboratory and radiology tests, drugs, diagnosis and treatment procedures, infection rates, complications, and recurrent hospitalizations play a role in the increase in health expenditures.

Öner and Ağırbaş (2014) made an economic evaluation of CT and MR devices within the scope of health technology in their research, and the results showed that the Cost-Benefit Ratio of the CT device was higher than the MR device.

Mauri et al. (2014) compared the use of contrast ultrasound with the standard treatment method, concluded that the use of contrast ultrasound reduced the number of repetitions of the treatment and the associated costs per patient, therefore it was a more efficient method than the standard treatment method.

Yiğit (2016) found in her research that there are differences in the diffusion and use of Magnetic Resonance health technology among OECD countries.

Arabloo et al. (2016) showed that radiotherapy with imaging techniques could reduce the amount of radiation emitted to the healthy tissue in the area where the tumor is located and the associated toxicity.

Tekin et al. (2019) examined the effect of innovation and health expenditures on innovation and health expenditures in developing countries between 2007-2015, it was shown that technological innovation increased health expenditures.

Nak and Sağbaş (2020) evaluated the regional distribution of medical imaging devices within the scope of health expenditures and found that there were inequalities in the regional distribution of medical imaging devices.

Akyol and Gurlaş (2021) examined the relationship between technological innovation (patent number), financial deepening, and health expenditures in their research and found that technological innovation encouraged health expenditures.

Due to the benefits of imaging services, the high consumption of supply and demand, as well as the effect of the rapid change in technology in health services, the desire to use more advanced technological devices, the high cost of installation of these devices or the presence of unnecessary imaging examinations increase the costs in health services. In addition, reasons such as legal concerns, defensive medicine understanding, an increase in evidence-based medicine practices, the desire of physicians to ensure themselves in the diagnosis and treatment processes, communication problems among health professionals, and rapid diagnosis of diseases caused the excessive use of health services, especially on the laboratory and radiology tests (Bentley et al., 2008; Smith-Bindman et al., 2008; Geitung, 2016; Sungur, 2018).

Unnecessary use of imaging services increases health expenditures. When the literature related to health expenditures and imaging services was examined, many publications have been published focusing on cost evaluations, regional distributions, or superiority assessments of techniques involving health technology (comparison of surgical techniques, drug efficacy evaluations, etc.). Again, although studies in which imaging services were associated with health expenditures was included in the literature, the number of studies in which imaging services and health expenditures were associated econometrically was limited. For this reason, this study aimed to determine the effect of imaging services on health expenditures within the scope of technology use in health services. In this context, 1 (one) main and 3 (three) sub-questions were determined.

Q1: Is there a relationship between the use of technology in health services and health expenditures?
Q1a: What is the current status of technology use and health expenditures in health services?
Q1b: What is the level of impact of technology use in health services on health expenditures?
Q1c: How does the use of technology in health care affect health expenditures?

II. METHOD

The analysis method in the study was determined as Panel data analysis. Panel data analysis allows the evaluation of cross-section data and time series data in a common area. Since the study was considered within the scope of countries with data in a certain year range, this analysis method was considered suitable for the study. In the study, health expenditures were determined as the dependent variable, and the number of MR imaging and CT imaging within the scope of health technology as the independent variable, and 16 countries with regular data for the years 2007-2018 were included in the analysis. These countries were Australia, Belgium, Canada, Chile, The Czech Republic, Denmark, France, Germany, Iceland, Israel, Korea, Latvia, Lithuania, Luxembourg, Slovak Republic, and Slovenia. In the study, firstly, descriptive information about the variables was included, the significance test of the econometric model established within the scope of the analysis was carried out with the Least Squares (LS) Method, unit root tests were applied to the variables, and the causality relations between them were investigated with the Granger causality test. In the last stage; Pedroni and Kao cointegration tests were used to determine the existence of a long-term relationship between the series and the cointegration relationship between the series was examined.

2.1. Variables used in the analysis of models

In this part of the study, the variables used in the analysis, the abbreviations used, and the source information from which the data were obtained are given, and explanations about the variables are made under the sub-headings.

Table 1. Defining variables

Variables	Definition	Unit	Source	Abbreviation
Health Expenditures	t period total Health Expenditure	US$ Per Person	OECD	HEXP
Magnetic Resonance Imaging	t period total Magnetic Resonance	Total views per 1.000 people	OECD	MR
Computed Tomography	t period total Computed Tomography	Total views per 1.000 people	OECD	CT

2.2. Limitations of the study

In the OECD database, where the data were obtained in the research, there are data on MR, CT, and PET imaging services under the diagnostic examination subheading. However, when the data of these 3 (three) variables were evaluated together, they were not included in the analysis due to the deficiencies in the data of PET imaging. Therefore, the study was limited to MR and CT Imaging data. The time dimension of the study was determined as 2007-2018, with regular data in MR and CT imaging. For this reason, the year range of the study was another important limitation of ours. Again, when we evaluate the variables and the year range together, 16 (sixteen) countries with common data were accepted as one of the other limitations.

2.3. Statistical analysis

Statistical analysis was performed using the Eviews 10 Statistics program.

2.4. Ethical approval

Ethical approval was not required due to the use of secondary data in the study.

III. EMPIRICAL RESULTS

According to the descriptive information of the variables subject to the analysis; the number of CT Imaging per 1000 people mean was 130.44±47.15 (min: 35.2, max: 228.3). The number of MR Imaging per 1000 people mean was 52.30± 30.89 (min: 5.0, max: 145.1). The mean of per capita health expenditures in the countries in our study was 3181.98± 1355.94 (min: 1008.64, max: 6291.04) US$.

Figure 1. Health Expenditures, The Relationship Between CT and MR Imaging, 16 Countries, 2007-2018

Source: Prepared by Authors

3.1. Econometric model

At this stage of the study, the mathematical function of the model to be used in econometric analysis was given.

$$\text{HEXP} = f(\text{MR}, \text{CT})$$

The econometric model to be estimated from this equation was established as follows:

$$\text{HEXP}_{it} = \beta_0 + \beta_1 \text{MR}_{it} + \beta_2 \text{CT}_{it} + u_{it}$$

In the model in the equation; "β_0" coefficient constant expresses the expenditures that occur independently of the explanatory variables. While "β_1" for MR and "β_2" represent the parameters to be estimated for CT, "u" represents the error term; "i" denotes the cross-sectional dimension of the panel data, and "t" denotes the time dimension. "HEXP" showed health expenditures as the dependent variable.

3.2. Least squares test

The least squares test, which is a standard regression model, is used to measure the significance of the model. To analyze our variables subject to analysis with the lowest margin of error, our model was estimated under random effects according to the Hausman test result (p>0.05). According to the test results, it was determined that the power of the independent variables to explain the dependent variables was good (R 68%, adjusted R^2 67%) and the relations between the variables were significant at the 1% level (p<0.000). In the model, it was determined that a one-unit increase in the number of CT scans per 1000 people increased health expenditures by 3.23 units, and a one-unit increase in the number of MR images per 1000 people increased health expenditures by 21.9 units. Besides these results, the coefficient constant expresses the expenditures (such as aging, vaccination, medication, etc.) that occur independently of the explanatory variables. Inter-unit correlation or spatial correlation is investigated with cross-section dependence tests. Ignoring cross-sectional dependence in panel data analysis may cause uncertainties in the estimators' effectiveness and the results' reliability (Phillips and Sul, 2003). For this reason, the existence of inter-unit correlation in our analyses was carried out using the Pesaran CD test, which is valid in both cases ($T > N$ or $T < N$) in terms of time and cross-section size and gives results with zero means (Pesaran, 2004; Kose and Yılmaz, 2023). According to this test results, it was determined that there was no cross-sectional dependence between units at the 5% level. Therefore, the LS model established in the study was accepted as significant. Besides these results, according to Variance Inflation Factors (VIF) the independent variables don't move together.

Table 2. Results of Least Squares Test

The dependent variable	**The independent variable**	**Coefficient**	**Prob.**	**R^2**	**Adjusted R^2**	**F-Statistic**	**Prob(F-statistic)**
HEXP	MR	21.91040	0.0000	0.68	0.67	194.8162	0.0000
	CT	3.233378	0.0257				
	C	1614.333	0.0000				
Diagnostic Test: Hausman Tests 0.2692; Peseran Test:0.0064*; JB Normality Test: 0.112045; VIF:1.2783-3.8532 *Denotes at %5 level.							

Source: Prepared by the authors.

3.3. Granger causality analysis

Granger causality analysis is a technique used to explain the causal relationship between two variables. In this relationship, it is evaluated whether the lagged values of the other variable (for example Xt variable) contribute to explaining the current value of one of the variables (sample Yt variable) (Granger (1969). The most important assumption of Granger causality analysis; is that the series of variables is stationary. For this reason, Unit Root Tests were applied to the series to determine the stationarity tests of the series. In the analyses, individual and common unit root tests were used together. The unit root test results and significance values of the variables were given in Table 3.

Table 3. Unit Root Test Results

Variables	Level		Levin, Lin ve Chu	Breitung t-stat	IM, Pesaran and Shin W-stat	ADF	PP
HEXP	Level	İnvidual Effects	1.0000	-	1.0000	0.9997	0.9878
		İnvidual Effects and Trends	0.0635***	0.9999	0.9801	0.9605	0.4704
		None	1.0000	-	-	1.0000	1.0000
	1. diff.	İnvidual Effects	0.0001*	-	0.0228**	0.0160**	0.0000*
		İnvidual Effects and Trends	0.0000*	0.0109**	0.0460**	0.0027**	0.0000*
		None	0.1148	-	-	0.3379	0.0163
	2.diff	İnvidual Effects	0.0000*	-	0.0000*	0.0000*	0.0000*
		İnvidual Effects and Trends	0.0000*	0.0000*	0.0002*	0.0000*	0.0000*
		None	0.0000*	-	-	0.0000*	0.0000*
MR	Level	İnvidual Effects	0.0183**	-	0.9973	0.3458	0.0554**
		İnvidual Effects and Trends	0.0000*	0.9595	0.5597	0.3238	0.4008
		None	1.0000	-	-	1.0000	1.0000
	1.diff.	İnvidual Effects	0.0010*	-	0.0189*	0.0226**	0.0000*
		İnvidual Effects and Trends	0.0813	0.7020	0.1517	0.0662***	0.0001*
		None	0.0000*	-	-	0.0169**	0.0107**
	2.diff	İnvidual Effects	0.0115**	-	0.0000*	0.0000*	0.0000*
		İnvidual Effects and Trends	0.1199	0.9329	0.2386	0.0382**	0.0000*
		None	0.0000*	-	-	0.0000*	0.0000*
CT	Level	İnvidual Effects	0.4958	-	0.9993	0.9943	0.6705
		İnvidual Effects and Trends	0.2565	0.9984	0.9234	0.5590	0.2507
		None	1.0000	-	-	1.0000	1.0000
	1.diff.	İnvidual Effects	0.0034**	-	0.0499**	0.0093**	0.0000*
		İnvidual Effects and Trends	0.0007*	0.8352	0.4865	0.1767	0.0000*
		None	0.0034**	-	-	0.0164**	0.0000*
	2.diff	İnvidual Effects	0.0000	-	0.0001*	0.0000*	0.0000*
		İnvidual Effects and Trends	0.0000	0.1204	0.1921	0.0201**	0.0000*
		None	0.0000	-	-	0.0000*	0.0000*

Source: Prepared by the authors.

According to the unit root test results, all of the variables are in common; it has been determined that the level value I(0) is not stationary. When the first differences of all the variables are taken, it has been determined that they are stationary at different levels of significance. For this reason, in the Causality and Co-Integration analyses conducted in the study, the variables were handled at the I(1) level, where the first difference was taken. The second step after this step was to determine the lag length. According to Table 4, the lag lengths of the variables FPE, AIC, SC, HQ tests were at "0" lag; It was detected in the second delay according to the LR test. In the study, the 1st and 2nd lag lengths allowed by the Eviews program were defined in the VAR model, and the Granger causality test results are given in Table 4.

Table 4. VAR Granger Causality/Block Exogeneity Wald Tests VAR Lag Order Selection Criteria

A. Delay Length Test Results						
Lag	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	-1158.678	NA	6504448.*	24.20163*	24.28176*	24.23402*
1	1152.573	11.70107	6909818.	24.26194	24.58248	24.39151
2	1142.753	18.20880*	6797012.	24.24485	24.80580	24.47159
3	1136.701	10.84242	7238442.	24.30627	25.10763	24.63019
4	1133.324	5.839122	8160468.	24.42342	25.46519	24.84452
5	1123.728	15.99302	8095300.	24.41101	25.69318	24.92928

B. Granger Causality Test Results	**Hypotheses**	**Significance Value**	**Conclusion**
Health Expenditures were not the cause of MR	HEXP ≠|> MR	0.0026	Rejection**
MR was not the cause of Health Expenditures	MR ≠|> HEXP	0.1719	Accepted
Health Expenditures were not the cause of CT	HEXP ≠|> CT	0.0616	Rejection ***
CT was not the cause of Health Expenditures	CT ≠|>HEXP	0.0855	Rejection ***
CT was not the cause of MR	CT ≠|> MR	0.0041	Rejection **
MR was not the cause of CT	MR ≠|> CT	0.3234	Accepted
Unit Root Test: 0.1775-0.7517; Serial Korelasyon LM Test: 0.4486; VAR Residual Portmanteau Tests for Autocorrelations: 0.0052*; *, **, *** shows significance at the 1%, 5%, and 10% levels, respectively.			

Source: Prepared by the authors.

According to the Granger-type causality analysis results in Table 4, a unidirectional relationship from health expenditures to MR imaging at the significance level of 5%; a bidirectional relationship between healthcare expenditures and CT imaging at the significance level of 10%; a unidirectional relationship from CT to MR imaging at the significance level of 5%; the existence of a Granger-type causality relationship has been determined among the variables. However, a causal relationship from MR imaging to health expenditures and from MR imaging to CT imaging has not been determined.

3.4. Cointegration analysis

Pedroni Residual Cointegration Test and Kao (Engle-Granger Based) Cointegration Test were used in the analysis of the variables in the model. According to Table 5, there are two test results, panel A and panel B.

According to the Pedroni Co-Integration test result, according to the Within Dimension Test result, 4 units are significant at the 1% level in the Deterministic Intercept and Trend model; In the No Deterministic Intercept or Trend model, cointegration relationships at 5 different levels of significance were determined. According to the Between Dimension Test Statistics test results, 2 units of 1% level in the Deterministic Intercept and Trend model; In the No Deterministic Intercept or Trend model, two co-integration relationships were detected at the 1% significance level. As an alternative, a second cointegration equation was established in the analysis. According to the ADF results in the Kao Residual Cointegration Test, our null hypothesis was rejected at 10% significance level and H_1 was accepted. According to this test result, it has been determined that there is a long-term cointegration relationship between the series.

Table 5. Cointegration Analysis Results

Panel A. Pedroni Panel Cointegration Test					
Intercept: Deterministic Intercept and Trend			**Intercept: No Deterministic Intercept or Trend**		
Within Dimension Test Statistics	**Statistic**	**Weighted Statistic**	**Within Dimension Test Statistics**	**Statistic**	Weighted **Statistic**
Panel v-statistics	-3.318557 (0.9995)	-4.585756 (1.000)	Panel v- statistics	-0.374743 (0.6461)	-1.940227 (0.9738)
Panel rho-statistics	2.003689 (0.9774)	1.720282 (0.9573)	Panel rho-statistics	-0.890143 (0.1867)	-1.478802 (0.0696)***
Panel PP-statistics	-5.853746 (0.0000)*	9.942537 (0.0000)*	Panel PP-statistics	-2.717808 (0.0033)**	4.041246 (0.0000)*
Panel ADF-statistics	-5.831822 (0.0000)*	-7.252829 (0.0000)*	Panel ADF-statistics	-3.453203 (0.0003)*	-4.187956 (0.0000)*
Between Dimension Test Statistics					
Group rho-statistics	3.095023 (0.9990)		Group rho-statistics	-0.118522 (0.4528)	
Group PP-statistics	-1.256786 (0.0000)*		Group PP-statistics	-5.578622 (0.0000)*	
Group ADF-statistic	-9.189332 (0.0000)*		Group ADF-statistics	-5.995977 (0.0000)*	
Panel B. Kao Residual Cointegration Test					
t-statistics :1.306733 (0.0957)***					
*, **, *** shows significance at the 1%, 5%, and 10% levels, respectively					

Source: Prepared by the authors.

IV. CONCLUSION, DISCUSSIONS AND RECOMMENDATIONS

Many factors that affect the number and use of medical devices. Among these factors; the health systems are affected by many factors such as per capita income, disease burden, per capita health expenditure, applied health policy, extended life expectancy at birth, applied reimbursement systems, elderly population ratio, and share of public expenditures in total health expenditures (Bozer and Ağırbaş, 2016). At the same time, it is seen that the increase in the quality of health services with the rapid development of health technologies depends on the use of these devices in health institutions. (Mollahaliloğlu et al., 2009). In addition, the fact that the patient has the right to receive health services with the most up-to-date practices developed in terms of international and national health law is another reason why health institutions internalize the latest technology in health services. For example; the detailed evaluation of a chest X-ray taken using X-ray film will be different from the lung image taken with a digital X-ray device and transferred to the computer environment. Therefore, since a chest X-ray that is examined in detail on the screen without deteriorating the image quality, can be examined in more detail than a chest X-ray printed on the X-ray film; it will cause fewer errors in the diagnosis process and in case of a legal dispute, the fault of the health institution in diagnosis will be evaluated in favor of the institution in terms of whether the technology is up-to-date or not. The expansion of the health sector at the level of institutions (increase in the number of hospitals, etc.) leads to the result that these devices are procured for use in institutions, and therefore, the demand for imaging increases with the increase in access to health services.

This study aimed to find answers to the questions determined to investigate the relationship between imaging services and health expenditures within the scope of health technology. Prepared in this context, "Is there a relationship between the use of technology in health services and health expenditures?" The main question and the evaluations for the sub-questions was discussed in this section in light of the findings obtained in the study.

“What is the current situation of health expenditures and technology use in health services at the country level?”

According to the results of this study, in which health expenditures and the use of health services were examined in terms of the number of MR and CT imaging, it was determined that the number of health expenditures, MR and CT Imaging increased over the years in the countries subject to the study. This increase has been calculated between 3-116% in terms of health expenditures, 20-206% in CT Imaging, and 28-593% in MR Imaging for 12 years. There were many reasons behind this increase. The most decisive reason was that the countries subject to the study were in the upper-income group according to their income groups. The most important factor that determined the increase and decrease in health expenditures is related to the expenditures and investments made by the countries in this field. The high level of income, the increase in health expenditures, and the number of CT and MR imaging indicate an increase in investments in this field.

On the other hand, when we evaluate the increase in health expenditures in terms of countries, health expenditures have increased at an average of 3% in 12 years in Luxembourg; when evaluated together with the other countries subject to the study, it was understood that it was the country with the highest per capita health expenditure with 5083.68 SGP$ in 2007, thus it showed that the increase in these expenditure rates (5220.87 SGP$ in 2018) was also a reason why it has remained at a lower level compared to other countries over the years.

Likewise, in Korea, where the highest increase was detected, the per capita health expenditure was 1434.15 SGP$ in 2007, and this amount increased by 112% to 3091.83 SGP$ in 2018; it can be said that it still lags behind Luxemburg, where the lowest increase was experienced. As a result, when we evaluate it independently of the current amount of health expenditures, health expenditures in the countries subject to the study have increased over the years (between 3-116%).

The number of CT scans has generally increased in the study countries over the years (between 20-206%). However, an issue that should be considered in the ranking of increases based on countries was that the most important factor determining the increases and decreases is related to the number of imaging services provided by countries over the years. For example, the number of CT scans has not changed much in Belgium over the years; in 2007, 167.9 examinations were performed per 1000 people; by 2018, this number was 201.9, which was the reason why the increased remained at a lower level compared to other countries. On the other hand, while the number of CT scans in Korea was 74.7 per 1000 people in 2007; by 2018, this figure has increased to 228.3, which was close to Belgium, and has become a country with a high increase in this area over the years.

The number of MRI scans has generally increased over the years in the study countries (between 28-593%). However, there was a situation similar to the increase in the number of CT scans in the order of increase based oncountries. Namely; MR imaging numbers have not changed much in Canada over the years; while 40 examinations were carried out per 1000 people in 2007; by 2018, this number was 51, which caused the increases to remain at a lower level compared to other countries. On the other hand, while the number of MR scans in Lithuania was calculated as 8.3 per 1000 people in 2007; by 2018, this figure had increased to 57.3. As a result, it has been determined that there has been a general increase in the number of MR and CT scans over the years in the relationship between the values of the countries in the initial years and the values of the last year.

There are many determinant reasons for these increases. According to studies, health professionals want to feel safe in terms of malpractice, defensive imaging procedures use innovative technologies to include innovative technologies in the diagnosis and treatment processes, patients also want to consult their imaging results with another physician, the density of health institutions, the number of older patients, and the type of injuries are included in the literature as important reasons that increase the number of imaging (Sungur, 2018; Tung et al., 2018; Ferguson et al., 2018). In the report prepared to reduce the excessive use of medical imaging services in the USA, the number of patients demanding imaging services is increasing, the per-service payment system encourages healthcare providers to provide more medical imaging services, and the physicians' defensive medicine approaches against malpractice accusations increased by between 5% -25 of the medical imaging costs was stated in this report (Mayor, 2010; Sungur, 2018). In another study, the increase in the use of CT and MRI was higher than in life-threatening situations (Korley et al., 2010).

“What is the level of impact of technology use in health services on health expenditures?”

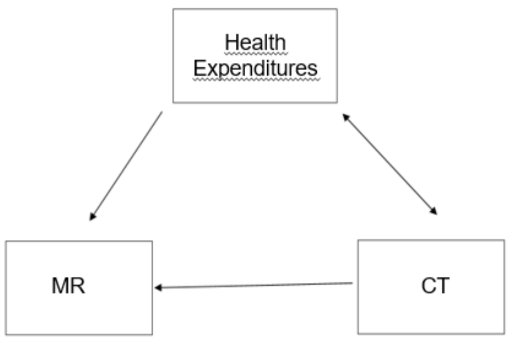
In our study, it was determined that a one-unit increase in the number of CT scans per 1000 people increased health expenditures by 3.23 units, and a one-unit increase in the number of MR images per 1000 people increased health expenditures by 21.9 units. In addition, the cointegration test results of the study reveal that the number of MR and CT scans was associated with long-term health expenditures. In a study on health expenditures and medical technology, it was determined that medical technology and health expenditures follow a long-term relationship, and this result was evaluated by the result obtained in our study (Llorian and Mann, 2022). Some studies showed that test expenditures increase faster than total health expenditures (Sivananthan et al., 2012), and it was thought that the medical consequences of false results of unnecessary tests caused overtreatment and unnecessary health expenditures (Wiener et al., 2011; Lyu et al., 2017).

MR and CT imaging services were devices that require the use of high technology and involve high costs in terms of investments. In this context, health expenditures and investments also include the costs of the supply processes of these devices. Both the investments made for these devices and the costs incurred as a result of the consumption of the services provided by these devices could be considered factors that increase health expenditures at a high level.

“How does the use of technology in health services affect health expenditures?”

According to the causality results of the research; a unidirectional causality relationship is detected from health expenditures to MR imaging; This relationship appears to be bidirectional between health expenditures and CT imaging. This result reveals that health expenditures and investments support the number of MR and CT imaging. While it was determined that there was a unidirectional relationship from the CT imaging numbers to the MR imaging numbers; no causal relationship was found from the number of MR imaging to the number of CT imaging. The model obtained according to the results of the causality analysis of the study was as follows:

Figure 3. Causality Relationship Between Number of MR-CT Imaging and Health Expenditures



Source: Prepared by the authors.

As a result of the causality test, it was determined that there is a flow from CT to MR. In addition, another important result of our study showed that the number of MR imaging (28-593%) increased at a higher level than the number of CT imaging (20-206%). In practice, this situation has been considered compatible since health professionals want to support CT imaging results with MR findings in the diagnosis and treatment processes of diseases. However, there were studies in the literature that support CT imaging results with MR imaging was not an effective approach to diagnosis. For example; Hammoud et al., (2016) wanted to support the CT scan-negative patient group presenting with atypical stroke symptoms with MRI imaging, but the results were found to be present in only 11.5% of these patients with MR imaging. In the patient group with positive MR imaging, hyperlipidemia, hypertension, diabetes, and use of anticoagulants were found to be determinants; it was also understood that the patients with positive MR imaging findings were older (74.1 years and 57.5 years) compared to those with negative imaging findings.

In the study in which patient files were examined with a group of experts on the necessity of medical imaging services in Iran; it was agreed that 58% of the MRI scans taken were necessary, 28% of them could not be clearly stated about their necessity, and 3% were not necessary (Keshtkaran et al., 2012). There were other studies in the literature showing that the results of the imaging tests requested for diagnostic purposes were negative and that these requests indicated excessive and unnecessary use (Goyal et al., 2006; Geitung, 2016; Swartzberg and Goldstein, 2018; Ozturk et al., 2018).

It has been stated that the number of medical devices per one million people in OECD countries was above the OECD average, these countries attached importance to preventive health care and early diagnosis and treatment of diseases also greatly affected the distribution of resources in health expenditures (Mertler et al., 2015). Again, there was a significant correlation between total health expenditure per capita and MR spread in OECD countries; it was stated that 18.13% of the total examination expenditures in Turkey is spent on MR health technology, and the reimbursement price of the MRI examination is over $1.000 in the USA, while it is around $26 in Turkey (Yiğit, 2016). In the EU countries, it was stated in the literature that 7.5% of the total health expenditures were made for medical technology, and the medical device expenditures, which constitute a large part of this rate, have a total share of 6.7% (Arık et al., 2016). Therefore, it was thought that careful evaluation of the inefficiencies in the use of services such as MR and CT, which were considered a long-term human capital investment, would have positive effects on total health expenditures (reduction in health expenditures) by reducing health costs in the long term.

The results of the study have determined that there was a positive and long-term relationship between health expenditures and the number of CT and MR imaging within the scope of health technologies, and there was a causal relationship in different directions between the variables. In addition, it has been determined that the number of Magnetic Resonance Imaging has increased more than the number of Computed Tomography imaging over the years, and that the number of Magnetic Resonance Imaging has a higher impact on health expenditures than Computed Tomography. When these two results were evaluated together, focusing primarily on MR imaging services would have a positive effect on health policies.

4.1. Recommendations

Imaging device technologies reduced inpatient costs by providing outpatient treatment of patients and were considered an important factor that increases hospital productivity (Bozer ve Ağırbaş, 2016). The article could suggest ways in which healthcare providers or policymakers could use these findings to improve the allocation of resources and reduce healthcare costs. In light of the results obtained from the study;

- Establishment of evaluation criteria/guidelines/application guidelines for medical imaging request
- Providing access to patients' imaging examinations and results at all stakeholder levels
- Informing healthcare professionals about the direct and indirect costs of imaging services

• It is recommended to analyze the examination requests in the number of MR imaging and take measures to prevent unnecessary requests.

Ethical Approval: This study was an empirical analysis and the data of the study were taken from OECD database; therefore, Ethics Committee Approval was not required in the study.

REFERENCES

Akar, S. (2014). Türkiye'de sağlık harcamaları, sağlık harcamalarının nisbi fiyatı ve ekonomik büyüme arasındaki ilişkinin incelenmesi. *Yönetim ve Ekonomi,* 21(1),311-322.

Akyol, H., & Gurlaş, F.(2021). Teknolojik patent, finansal derinleşme ve sağlık harcamaları arasındaki ilişkinin saptanması. *ETÜ Sosyal Bilimler Enstitüsü Dergisi,* 12,18-38.

Andersen, R.M. (2008). National health surveys and the behavioral model of health services use. *Med Care,*46(7):647-53. doi: 10.1097/MLR.0b013e31817a835d. PMID: 18580382.

Arabloo, J., Hamouzadeh, P., Mousavinezhad, S.M., Mobinizadeh, M., Olyeemanesh, A., & Pooyandjoo, M. (2016). Health technology assessment of ımage-guided radiotherapy: a systematic review of current evidence. *Medical Journal of the Islamic Republic of Iran,* 30,318. PMID: 27390688; PMCID: PMC4898870.

Arık, Ö., Ileri, Y.Y., & Kaya, B. (2016). Sağlık hizmetlerinde tıbbi cihaz sektörü. *Hacettepe Sağlık İdaresi Dergisi*, 19(2): 187-202.

Baker, L., Birnbaum, H., Geppert, J., Mishol, D., & Moyneur, E. (2003). The relationship between technology availability and health care spending. *Health Affairs,*3,537-551.Doi: 10.1377/hlthaff.W3.537.

Bentley, T.G.K., Effros, R.M., Palar, K., & Keeler, E.B. (2008). Waste in the U.S. health care system: a conceptual framework. *The Milbank Quarterly,* 86(4), 629– 659.

Bozer, A., & Ağırbaş, I.(2016). Tıbbi görüntüleme cihazlarının sayısal durumu ve kullanımlarının değerlendirilmesi. Ankara Üniversitesi Tıp Fakültesi Mecmuası: 69(3), 193-201.

Brempong, K. G., & Wilson, M. (2004). Health human capital and economic growth in sub-saharan African and OECD countries. *The Quarterly Review of Economics and Finance,* 44(2), 296-320.

Dybczak, K. & Przywara, B. (2010). The role of technology in health care expenditure in the EU. Economic ve Financial Affairs, European Comission, *Economic Papers*, 400, 1-26. doi: 10.2765/6765

Ferguson, B., Geralds, J., Petrey , J., & Huecker, M. (2018). Malpractice in emergency medicine-a review of risk and mitigation practices for the emergency medicine Provider. *Journal of Emergency Medical,* 55(5),659-665.

Goyal, N., Donnino, M.W., Vachhani, R., Bajwa, R., Ahmad, T., & Otero, R. (2006). The utility of head computed tomography ın the emergency department evaluation of syncope. *Intern Emerg Med.,*1(2),148-50. doi: 10.1007/BF02936543. PMID: 17111790.

Granger, C. W. (1969). Investigating causal relations by econometric models and crossspectral methods. *Econometrica,* 37(3),424-438.

Geitung, J. T. (2016). Modern radiology and the use of resources. too much technology (?) – not at all. *Acta Radiologica,* 57(1), 3–5.

Hammoud , K., Lanfranchi , M., Li , S., & Mehan, W. (2016). What is the diagnostic value of head mrı after negativee head CT in ed patients presenting with symptoms atypical of stroke? *Emergency Radiology*, 23(4),339-44. doi: 10.1007/s10140-016-1408-z. PMID: 27220652.

Karataş, M., & Çankaya, E. (2010). İktisadi kalkınma sürecinde beşeri sermayeye ilişkin bir inceleme. *Mehmet Akif Ersoy Sosyal Bilimler Dergisi,* 3, 29-55.

Keshtkaran, A., Bagheri, M., Ostovar, R., Salari , H., Farrokhi, M., Esfandiari, A.,& Yousefimanesh, H. (2012). Developing criteria for lumbar spine magnetic resonance ımaging (MRG) Using RAND appropriateness method (RAM). *Iranian Journal of Radiology,* 9(3), 130-138.

Korley, F.K., Pham, J.C., & Kirsch, T.D. (2010). Use of advanced radiology during visits to US emergency departments for ınjury-related conditions, 1998-2007. *JAMA,* 6,304(13),1465-71. doi: 10.1001/jama.2010.1408. Erratum in: JAMA. 2010 Nov 3;304(17):1901. PMID: 20924012.

Kose, Y., & Yılmaz, E. (2023). Şirket performans parametreleri aralarındaki ilişkilerin belirlenmesi: BİST-30 şirketleri üzerinde analitik inceleme, *Verimlilik Dergisi,* 57(1),199-210.

Lauterbur, P. (1973). Image formation by ınduced local ınteractions: examples employing nuclear magnetic resonance. *Nature,* 242,190-191.

Llorian, E.R., & Mann, J. (2022). Exploring the technology–healthcare expenditure nexus: a panel error correction approach. *Empirical Economics,* 62,3061–3086 https://doi.org/10.1007/s00181-021-02125-0

Lyu, H., Xu, T., Brotman, D., Mayer-Blackwell, B., Cooper, M., Daniel, M., & et al. (2017). Overtreatment in the United States. *PLoS ONE,* 12(9), e0181970.

Mauri, G., Porazzi, Cova, l., Restelli, u., Tondolo, T., Bonfanti, M., Cerri, A., Ierace, T., Croce, D., & Solbiati, L. (2014). Intraprocedural contrast-enhanced ultrasound (CEUS) ın liver percutaneous radiofrequency ablation: clinical ımpact and health technology assessment. *Insights Imaging,* 5(2), 209-216.

Mayor, S. (2010). US report calls for national strategy to reduce overuse of medical imaging. *British Medical Journal,* 341, 46-58.

Mertler, A.A., Karadoğan, N., & Tatarhan, G. (2015). Türkiye'de tıbbi cihazların sayısal durumu ve oecd ülkeleri ile karşılaştırmaları. *Uluslararası Sağlık Yönetimi ve Stratejileri Araştırma Dergisi,* 1(1), 52-70.

Mollahaliloğlu, S., Arı, H.O., Öncül, H.G., & Gürsöz, H. (2009). Türk sağlık sektöründe tıbbi cihazların sayısal durumu, bölgesel dağılımı ve oecd ülkeleri ile karşılaştırmalar. *Hacettepe Sağlık İdaresi Dergisi,*12(1), 69-86.

Nak, H., & Sagbas, I. (2020). Sağlık Harcamaları kapsamında tıbbi görüntüleme cihazlarının bölgesel dağılımının analizi. *Maliye Çalışmaları Dergisi*,63,77-92. https://doi.org/10.26650/mcd2020-822594

Oh, E., Imanaka, Y., & Evans, E. (2005). Determinants of the diffusion of computed tomography and magnetic resonance ımaging. International *Journal of Technology Assessment in Health Care,* 21(1), 73–80.

OTA, 1976. *Development of Medical Technology: Opportunities for Assessment.* Washington, D.C. Government Printing Office United States Congress, DC, USA.

Ozturk, K., Soylu, E., Bilgin, C., Hakyemez, B., & Parlak, M. (2018). Predictor variables of abnormal ımaging findings of syncope ın the emergency department. *Int J Emerg Med.*,12,11(1),16. doi: 10.1186/s12245-018-0180-0. PMID: 29532345; PMCID: PMC5847632.

Öner N., & Ağırbaş, I. (2014). Bilgisayar tomografisi ve manyetik rezonans görüntülemenin sağlıkta teknoloji değerlendirme ve maliyet-fayda analizi ile değerlendirilmesi, *Sağ. Perf. Kal. Derg.,* 8,147-163.

Qaseem, A., Alguire, P., Dallas, P., Feinberg, L. E., Fitzgerald, F. T., Horwitch, C. & et al. (2012). Annals of ınternal medicine ıdeas and opinions appropriate use of screening and diagnostic tests to foster high-value, cost-conscious care. *Annals of Internal Medicine,* 156(2),147-9.

Pesaran, H. (2004). General diagnostic tests for cross section dependence in panels, *Cambridge Working Papers in Economics,* 60,13-50.

Phillips, P., & Sul., D. (2003). Dynamic panel estimation and homogeneity testing under cross Section dependence, *The Econometrics Journal*, 6(1), 217-259.

Reiser, S.J. (1978). *Medicine and the Reign of Technology*. London: Cambridge University Press.

Sargutan, E.A. (2005). Sağlık teknolojisi yönetimi. *Hacettepe Sağlık İdaresi Dergisi,* 8(1),113-144.

Shekelle, P.G., Ortiz, E., Newberry, S.J., Rich, M.W., Rhodes, S.L., Brook, R.H., & Goldman, D.P. (2005). Identifying potential health care ınnovations for the future elderly: prospects for advances ın medical research and technology ın the first part of the twenty-first century. *Health Affairs,* 24 (Suppl2), W5-R67

Sivananthan, S.N., Peterson, S., Lavergne, R., Barer, M.L., & McGrail, K.M.(2012). Designation, diligence and drift: understanding laboratory expenditure ıncreases in british columbia, 1996/97 to 2005/06. *BMC Health Services Research,* 12(472),1-8.

Smith-Bindman, R., Miglioretti, D.L. & Larson, E.B. (2008). Rising use of diagnostic medical ımaging in a large ıntegrated health system. *Health Affairs,* 27(6),1491-502.

Sungur, C. (2018). Tıbbi görüntüleme hizmetlerinin gereksiz kullanımı ve buna karşı çözüm önerileri. *Kahramanmaraş Sütçü İmam Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi,*8(1),67-86 Retrieved from http://iibfdergisi.ksu.edu.tr/en/pub/issue/37890/437864.

Swartzberg, K., & Goldstein, L.N. (2018). High positive computed tomography yields ın the emergency department might not be a positive finding. *S Afr Med J.,* 27,108(3),230-234. doi: 10.7196/SAMJ.2018.v108i3.12635. PMID: 30004368.

Tekin, Z., Gurlaş, F., Karakuş, K., & Akyol, H. (2019). Teknolojik inovasyon ve girişimciliğin sağlık finansmanı ile olan ilişkisi nedir?", 4. Uluslararası Sağlık Bilimleri ve Yönetim Kongresi, 20-23 Haziran 2019, Üsküdar Üniversitesi, İstanbul.

Temiz, M. (2013). Ekonomik Kalkınma ve Yoksulluk İlişkisi. *Yayınlanmamış Yüksek Lisans Tezi.* İnönü Üniversitesi Sosyal Bilimler Enstitüsü, Malatya

Tung, M., Sharma, R., Hinson, J.S., Nothelle, S., Pannikottu, J., & Segal, J.B. (2018). Factors associated with imaging overuse in the emergency department: a systematic review. *Am J Emerg Med*.,36(2),301-309.

Tüylüoğlu Ş., & Karalı, B. (2006). İnsani kalkınma endeksi ve Türkiye için değerlendirilmesi. SÜ *İİBF Sosyal ve Ekonomik Araştırmalar Dergisi,* 12, 53-88

U.S. Congress, (1978).*Office of technology assessment, policy ımplications of the computed tomography (ct) scanner*.Washington, DC:U.S. Government Printing Office.

U.S. Congress, (1984). O*ffice of technology assessment, nuclear magnetic resonance ımaging technology, a clinical, ındustrial, and policy anazysis*. Washington, DC: U.S. Government Printing Office.

U.S. Congress, (1995). *Office of technology assessment, health care technology and its assessment in eight countries, OTA-BP-H-140.* Washington, DC: U.S. Government Printing Office.

WHO, 2022, www.who.int/ Accessed Time: 23.03.2022

Wiener, R., Schwartz , L., & Woloshin , S. (2011). Time trends in pulmonary embolism in the United States: evidence of overdiagnosis. Arch Intern Med., 171(9),831-7. doi: 10.1001/archinternmed.2011.178.

Yiğit, V. (2016). Manyetik rezonans görüntüleme sağlık teknolojisinin yayılımı. *Türkiye Klinikleri Sağlık Bilimleri Dergisi,* 1(1), 38–46. doi:10.5336/healthsci.2015-45601

Yıldız, Ş., & Eren, M. (2020). *Sağlık ekonomisi*. Ed. Başar S. Eskişehir: Anadolu Üniversitesi Yayın No: 4076,pp.30 .