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Efficiency Analysis of Middle-Income Countries in Terms of Health Indicators for the Covid Process

Elif ACAR[1], Durmuş GÖKKAYA[2] & Osman ŞENOL[3]

Abstract

Systems transform their current inputs into outputs to achieve their goals and objectives. Efficiency analysis is used to describe the degree to which a system achieves its goals using its resources. Pandemics similar to the Covid process may recur, and countries must use their existing resources more effectively in these struggles. The scope of this study was to evaluate the struggle of middle-income countries with Covid-19 within the scope of certain health indicators according to the World Bank's income classification by using the DEA, one of the methods used to measure the effectiveness of health systems. The ratio of GDP devoted to health services, the number of patient beds, the number of doctors per thousand population, the number of nurses and midwives per thousand population, and finally, the amount of health expenditure per capita were selected as the input variables in the study. The number of people recovering from Covid-19 disease per 100.000 people, total cases per 1 million people, total deaths per 1 million people, and total number of tests per million people were selected as the output variables in the study. The VZA input-oriented CCR model was used in the study. The reasons for the inefficiency of inefficient countries have been identified. In order for these countries to be located on the effective border, the targeted values have been revealed. Based on the efficient countries, potential improvements are made in the input values of the inefficient countries and the input values that can increase their efficiency are calculated. As a result of the study, 18 countries out of 47 countries were located in the effective border. Finally, the reasons for the inefficiency of the countries below the efficient frontier were calculated using the multiple linear regression analysis method, and the suggestions for necessary corrections were presented.

Key Words: Health Indicators, Data Envelopment Analysis, COVID-19, Middle Income Countries, Efficiency

Orta Gelirli Ülkelerin Covid Süreci Sağlık Göstergeleri Açısından Etkinlik Analizi

Öz

Sistemler, amaç ve hedeflerine ulaşmak için mevcut girdilerini çıktılara dönüştürür. Etkinlik analizi, bir sistemin kaynaklarını kullanarak amaçlarına ulaşma derecesini tanımlamak için kullanılır. Yaşanan Covid sürecine benzer pandemiler tekrar edebilir ve bu mücadelerde ülkeler, mevcut kaynaklarını daha etkin kullanmak zorundadır. Bu çalışmanın kapsamı, sağlık sistemlerin etkinliğini ölçmek için kullanılan yöntemlerden biri olan VZA ile Dünya Bankası gelir sınıflandırmasına göre orta gelir grubunda yer alan ülkelerin Covid-19 ile mücadelesini belirli sağlık göstergeleri kapsamında değerlendirmektir. Araştırmada sağlık hizmetlerine ayrılan GSYİH oranı, hasta yatak sayısı, bin nüfusa düşen doktor sayısı, bin nüfusa düşen hemşire ve ebe sayısı ve son olarak kişi başına düşen sağlık harcaması miktarı girdi değişkenleri olarak kullanılmıştır. Araştırmada çıktı değişkeni olarak 100.000 kişi başına Covid-19 hastalığından iyileşen kişi sayısı, 1 milyon kişi başına toplam vaka, 1 milyon kişi başına toplam ölüm ve bir milyon kişi başına toplam test sayısı seçilmiştir. Çalışmada VZA girdi odaklı CCR modeli kullanılmıştır. Etkin olmayan ülkelerin verimsizlik nedenleri tespit edilmiştir. Söz konusu bu ülkelerin etkin sınırda yer alabilmesi için hedeflenen değerleri ortaya konmuştur. Etkin ülkeler referans alınarak, etkin olmayan ülkelerin girdi değerlerinde potansiyel iyileştirmeler yapılmakta ve etkinliklerini artırabilecek girdi değerleri hesaplanmaktadır. Çalışmanın sonucunda 47 ülkeden 18 ülke etkin sınırda yer almıştır. Son olarak da çoklu lineer regresyon analizi yöntemi ile etkin limitin altındaki ülkelerin etkinsizliğinin nedenleri hesaplanmış ve gerekli düzeltmeler için öneriler sunulmuştur.

Anahtar Kelimeler: Sağlık Göstegeleri, Veri Zarflama Analizi, COVID-19, Orta Gelirli Ülkeler, Etkinlik

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[1] Dr. Öğr. Üyesi, Yozgat Bozok Üniversitesi, İktisadi ve İdari Bilimler Fakültesi, İşletme Bölümü, elif.acar@bozok.edu.tr,
ORCID: 0000-0001-6974-4866

[2] Dr. Öğr. Üyesi, Yozgat Bozok Üniversitesi, İktisadi ve İdari Bilimler Fakültesi, Sağlık Yönetimi Bölümü, durmus.gokkaya@bozok.edu.tr,
ORCID: 0000-0002-6713-1748

[3] Dr. Öğr. Üyesi, Karadeniz Teknik Üniversitesi, Sağlık Bilimleri Fakültesi, Sağlık Yönetimi Bölümü, osmansenol@ktu.edu.tr,
ORCID: 0000-0001-5626-2921

Introduction

Since the last months of 2020, countries have entered into an important process of struggle along with the spread of the Covid-19 pandemic around the world. Countries have taken stringent measures since the beginning of the pandemic in order to reduce the impact of the pandemic and prevent individuals from contracting the disease. In this regard, countries have closed their borders to each other, especially in the early days of the pandemic. Within the borders of the countries, curfews were imposed, masks and distance rules were imposed in public places and organizations, and schools and some business lines were suspended. Social and cultural restrictions were imposed on various activities to prevent the spread of the pandemic. As of 26.01.2022, there were more than 350 million cases worldwide (www.covid19.who.int) and nearly 6 million deaths due to these cases. On the other hand, vaccine studies were initiated as the most important means of combating the Covid-19 pandemic, and various vaccines have been developed and individuals have been immunized against the disease. According to the data of the World Health Organization (WHO), approximately 10 billion vaccines have been made so far (www.covid19.who.int). Nearly 5 billion of these vaccines were administered at least as a single dose, while the other half were administered as a double dose. It can be said that while mortality rates are relatively reduced with vaccines, there is an increase in the rate of pandemic and the incidence of Covid-19 cases with the changing variants in the virus. In the event of similar pandemics in the future, countries need to be better prepared to combat them at various levels and in multiple fields.

In addition to countries taking social, cultural, and economic measures against the pandemic, governments continued to struggle with their health systems, which are the main center of the pandemic. The central health system and organization together with the hospitals, where the cases are treated clinically, and their sub-components constitute the main pillar of this struggle. The importance of the health system with all its components (technology, human resources, facilities, informatics infrastructure, pharmaceutical stocks, medical devices, etc.) has come to the forefront even more with the pandemic. However, Why do some countries' health systems perform better, while others do less? Why do some countries have higher case rates and lower death rates? In other words, why might death rates be high when case rates are low? How are these situations related to health systems and indicators? With these questions and perspective, this study has based on examining the productivity and efficiency of combating the Covid-19 pandemic through the health systems indicators of middle-income countries. In its most general sense, efficiency refers to the relationship between the various factors (inputs) included in the system and the outputs obtained at the end of this process (Yükçü, & Atağan, 2009, p. 4). Therefore, in a technical sense, efficiency is defined as "the ratio between the quantity of goods and services produced and the inputs used to produce that quantity of goods and services", and this measure is often formulated as output/input (Prokopenko, 2005, p. 19). Efficiency analysis is used to describe the degree to which a system can achieve its goals by using its resources. One of the frequently used methods in which productivity and efficiency analysis are evaluated together is the Data Envelopment Analysis (DEA). DEA evaluates the performance of similar systems, called the Decision Making Unit (DMU), using the relationships between input and output, and sets targets for similar systems and measures the effectiveness of a particular system. (Cooper et al., 2011, p.1-2).

If it is expressed with different definitions, DEA is a technique used when there are many input and output variables where it is difficult to measure the efficiency of decision-making units (Şenol, & Gençtürk, 2017, p. 265). DEA is a method used to measure the relative efficiency of decision units that produce homogeneous goods or services by using input and output variables expressed in a wide variety of different measurement units (Bağrıaçık, 2021, p. 221). DEA is a mathematically formulated method based on fractional programming developed by Charnes, Cooper and Rhodes (1978, p. 429).

On the other hand, DEA is based on two main approach frameworks in performance measurement and efficiency analysis methods. These are constant returns to scale (CCR) and variable returns to scale (BCC). The increase in outputs as a result of increases in inputs is examined in the CCR model. More or less increase in outputs as a result of the increase in inputs is examined in the BCC model (Sel, 2021, p. 186). The increases and decreases in the amount of input and output required for efficiency are determined by dual models, thus dual models are called envelopment models. Input-oriented dual model shows how much inputs can be reduced for a given amount of output, and output-oriented dual model shows how much output can be increased for a given number of inputs (Tütek et al., 2016; Dinç, &

Haynes, 1999). If it is desired to produce the most output with the least input, then additive or non-oriented models are used (Özden, 2008).

Within the scope of this study, an efficiency analysis is conducted between the health services indicators used as inputs in the process of combating Covid and the outputs, which are Covid indicators. By identifying countries that use input resources efficiently and inefficiently during the pandemic process, the amounts that inefficient countries should reduce their inputs are calculated through the input-oriented CCR Model. Moreover, the efficiency rankings of countries are determined with the help of the super-efficiency model. Finally, the reasons for the inefficiency of countries below the efficient frontier are calculated using multiple linear regression analysis, and recommendations for necessary corrections are presented. With regard to the contribution of the study to the literature, Covid 19 is a vital and international problem and studies with Covid 19 data should be increased quantitatively. The study was segmented in terms of middle-income countries. No similar studies in the literature measure the efficiency of middle-income countries using DEA in terms of health indicators during the pandemic period. The importance of the study is to ensure that middle-income countries can use their existing resources efficiently and that countries are more cautious and ready when faced with such pandemics in the future.

In the literature section of the study, studies using DEA in the field of health were investigated and the input and output variables to be used in this study were determined. Then, the aim, data and sample of the study are presented. In the method section, mathematical calculation details about the input-oriented CCR method, the input-oriented CCR-Dual model and the improvement rate are presented within the scope of DEA. According to the input and output variables used within the scope of the study, the efficiency analysis of the countries in the Covid process is presented in the findings section and the efficient countries were determined. Furthermore, multiple linear regression analysis was performed between the input improvement rates and the efficiency value, and the explanatory input variables were determined in determining the efficiency value. In the conclusion part of the study, suggestions and ideas for future studies are presented by summarizing the reasons why the effective countries in the Covid struggle process are effective and the general research findings.

Literature Review

Due to the unique characteristics and complex structure of health services, the number of inputs and outputs is quite large and diverse. These input and output factors also do not have the same unit of measure. It is appropriate to use DEA, which is a parameterless method, to analyze all these variables together, to make comparisons, to determine the most efficient countries and to determine the things to do in order for the countries below the efficient frontier to be efficient (Şenol, & Gençtürk, 2017, p. 267). In fact, DEA is a very widely used method to measure the efficiency of the health system or to measure the efficiency of the relative health systems of countries. Past Covid-19 pandemic is the biggest problem that countries are struggling with all aspects of their health systems. Effective and efficient use of existing opportunities in the fight against the pandemic is an inevitable element for success. The increasing population, the increase in the elderly population and the diversification of diseases require this struggle (Bağrıaçık, 2021, p. 217). In this context, the study was conducted within the scope of measuring the relative efficiency of middle-income countries in the fight against Covid-19. In this context, the literature on studies attempting to measure the efficiency of the health systems of countries using DEA is included.

In a study conducted by Shirouyehzad et. al. in (2020), the countries affected by the Covid-19 pandemic were examined by considering their population density and health system infrastructures. The efficiency level of the countries in the fight against the Covid-19 pandemic was investigated by the DEA method. The study was conducted using two models: medical treatment and the control of transmission risk. In the first model, efficiency values were calculated by considering the performance of countries in disease transmission control. In the second model, efficacy values were calculated by considering the number of confirmed cases to evaluate medical treatment as inputs and the number of deaths and recoveries as outputs. According to these efficiency evaluations or analysis results, the countries were divided into four classes according to their performance in the control of transmission and medical treatment, and recommendations were made for each group. As a result of the analysis, it was revealed that Singapore, Vietnam and Belgium were the countries with the highest efficiency in both models. In particular, Singapore had the highest efficiency among the countries and was far ahead of the others. The country with the highest efficiency in Europe was Belgium, while Italy had the least efficiency. In the

Middle East, Iran was the most efficient country in the control of transmission. Egypt was the most efficient country in medical treatment despite being the least efficient in the control of transmission.

Breitenbach et. al. (2021) conducted a study using the DEA method to analyze how efficient the use of resources in the top 36 countries representing 90% of global infections and deaths from 220 countries. The data collected from Worldometers and the World Bank and dated 11 November 2020 were used in the study. In this study, the relative efficiency of the health systems of 36 countries in the management of the Covid-19 pandemic was examined, the number of tests, the number of doctors, the number of nurses and health expenditure as a percentage of GDP were used as input variables, the recovery rate was used as the desired output variable, and the mortality rate and the case rate were used as the undesired output variables. Furthermore, the technical efficiency of the countries in managing the Covid-19 pandemic was examined with a new DEA approach by modeling the mortality rate and infection rates as undesired outputs using the approach developed by You and Yan (2011). As a result, the average efficiency of global health systems in managing the Covid-19 pandemic was found to be very low. Under the assumption of variable returns to scale, it was concluded that only 6 out of 36 countries had efficiency or efficient systems.

In a study conducted by Mariano et. al. (2021), situation of the Brazilian States regarding the Covid-19 pandemic was evaluated comparatively by the Network DEA method. The data of the study were collected by obtaining the virus cases recorded in all states until April 27, 2020, from the Ministry of Health website.

In this study which was conducted to evaluate the regional inconsistencies in the country, the number of doctors, the number of ventilators and the number of clinical beds were selected as the input variables. The number of deaths was selected as the output variable and the number of reported cases was selected as the intervening variable. According to the results of the study, it was revealed that the federative unit with the worst performance was Amazonas and the worst capital was Manaus.

In the study of Mohanta et al. (2021) performance of the 32 states and union territories of India against the Covid-19 pandemic was measured using the efficiency score calculated by DEA, and the efficiency of the health system was evaluated. In the model of the study, the public health expenditure per capita, number of hospitals, number of hospital beds, percentage of health workers, population density and number of infected people were considered as the input parameters. The output parameters are grouped as good output and bad output. While the number of people who recovered from the Covid-19 disease was considered as the good output, the number of people who died from the Covid-19 disease was considered as the bad output. According to the results of the study, 16 (50%) of 32 Indian states and union territories were found to be efficient. Among the efficient states, Chandigarh was the most efficient, while Meghalaya was the most inefficient. Rajasthan was most referenced state for inefficient states.

Selamzade and Özdemir (2020) conducted a study in which the efficiency of OECD countries in the fight against Covid-19 was evaluated by DEA. In the model of the study, the number of doctors, nurses and hospital beds per ten thousand people and the ratio of health expenditures in Gross Domestic Product (GDP) were used as the input variables. The Covid-19 pandemic data of OECD countries on April 24, 2020, the number of tests per million people, the number of cases and the number of deaths were considered as the output variables. As a result of the analysis made with the output-oriented Charnes, Cooper and Rhodes (CCR) model of the study, 11 countries were found to be efficient as a result of the analysis made with 8 Banker, Charnes and Cooper (BCC) models. These efficient countries efficiently fought against the Covid-19 pandemic. According to the study, it was determined that Slovakia and Iceland had the highest efficiency scores. The USA, France, Northern Ireland, Italy, the United Kingdom and Spain were the countries that could not efficiently fight against the Covid-19 pandemic and had the lowest scores.

In the study conducted by Sel (2021), the Covid-19 performance of the G-20 countries, which constitute two-thirds of the world's population, was examined. The data used in the study were created by taking the averages of the health indicators of the countries in the years 2000-2018 from the database of the World Bank. In the model, current health expenditures (% of GDP), people using at least primary health services (% of population), and the number of nurses and midwives, beds and physicians per 1000 people were used as the input variables. The mortality rates per million people, number of people recovered per million people, and test rates per million people were used as the output variables. Upon examining the results of the study, it was observed that China, Turkey, USA, England, Brazil and France were efficient according to the output-oriented CCR model. Furthermore, India and Indonesia were found to be efficient or productive according to the output-oriented BCC model.

In a study conducted by Bayram and Yurtsever (2021), the efficiency evaluation of 27 European countries in terms of Covid-19 was examined. In the study, the performance of these countries on the spread and deaths caused by the Covid-19 epidemic was examined and comparisons were made by using the input-oriented DEA method. The efficiency of the disease transmission control was analyzed in the first stage of the study. In the second stage, the efficiency of medical treatment was examined. By creating an area chart, the transmission control and medical treatment activities and performances of the countries were interpreted over four regions. According to the results of the study, Malta, Montenegro, Cyprus, Denmark, Estonia, Finland, Greece and the Netherlands showed high performance in both transmission control and medical treatment in the fight against the Covid-19 pandemic. It was concluded that Luxembourg, North Macedonia, Switzerland and Turkey were in critical condition.

Finally, according to another study (Wang et. al., 2021), the efficiency performance of 50 countries in America, Europe, Asia and Africa against Covid-19 was examined by DEA method with an undesired output model. Five input variables were used in the study. These variables were the total number of tests, the total number of beds, the total population, life expectancy, and the ratio of each country's population aged 70 and over to the total population. Three parameters, namely Covid-19 total cases, total deaths, and total recoveries, were used as the output variables. As a result of the study, 50 countries were divided into three levels according to their efficiency in the fight against the Covid-19 pandemic. In general, Colombia, Mexico, Czechia, Cameroon, Ghana, Bolivia, Saudi Arabia, Chile, Bangladesh, Peru, India, Argentina, Brazil, Costa Rica, Venezuela, Turkey, the United States and Israel were found to be the first-class efficient countries in the fight. While 17 countries were efficient at the second level, the last 15 countries were efficient in the fight against the pandemic at the third level. France was the country at the third level and the least efficient in the fight against the Covid-19 pandemic.

Method

Aim of the Study

The aim of this study was to evaluate the struggle of the countries in the middle-income group determined by the World Bank income classification with Covid-19 within the scope of certain health indicators by the Data Envelopment Analysis Method. Within the scope of this study, an efficiency analysis will be conducted between the health services indicators used as inputs in the process of combating Covid in middle-income countries and outputs, which are Covid indicators. At the same time, the quantities that can be reduced in input variables will be determined through the CCR model. One of the important assumptions in Data Envelopment Analysis is the existence of homogeneous decision units. All decision units in the analysis should be homogeneous and/or as similar as possible. The homogeneity assumption is based on the fact that the units to be compared perform similar activities since they produce the same outputs with the same inputs (Çınar, 2010, p. 107). The common approach adopted to ensure homogeneity in studies comparing efficiency and productivity between countries with DEA method is to group countries according to their similarities (Çınar, 2010, p. 107). It can be said that the homogeneity assumption is met since middle-income countries are in the same category in terms of income level, they are similar in terms of economic and health indicators, and they produce the same type of outputs by using similar inputs in terms of health systems.

At the same time, DEA measures its relative effectiveness using input and output variables expressed in a wide variety of different units of measurement (Bağrıçak, 2021: p. 221). In this context, it is aimed to measure the relative efficiency of countries in this study. The secondary aim of the research is to investigate the reasons for the inefficiency of the countries below the efficient frontier by using multiple linear regression analysis based on the DEA findings. Using the results obtained from DEA in multiple regression analysis, it is researched that countries can increase their efficiency by changing which inputs they can change, and more detailed information is presented for countries.

Data and Sample

While determining the variables to be used within the scope of the study, similar studies in the literature were examined and the most appropriate input and output variables are selected for the aim of the study. The input variables are, ratio of GDP devoted to health services, number of patient beds, number of doctors per thousand people, number of nurses per thousand people, number of midwives per thousand people, and finally the amount of health expenditure per capita. The output variables are the number of people recovering from Covid-19 disease per 100.000 people, total cases per 1 million people, total deaths per 1 million people, and total number of tests per 1 million people.

By considering the World Bank income classification, the struggle of the countries in the middle-income group with Covid-19 within the scope of certain health indicators was evaluated. Although there are 55 countries in the middle income group, 47 countries whose data could be accessed were included in the analysis and selected as decision-making units (DMU). While the data on health indicators were obtained from the World Bank site, the data on Covid-19 were obtained from the "Our World in Data" site. Since data on health indicators were available until 2018-2019, the average of the data for the 2000-2019 periods was taken make a better evaluation. The total values of the data related to Covid-19 for the years 01.04.2020-15.01.2022 were taken. Vaccine indicators could not be included in the study because they were not suitable in terms of the time dimension and data type compared to other variables.

The input variables used in the study are essentially the data of the entire health system. Output variables are data used only in the fight against the pandemic. In this context, the input-oriented CCR Model was used to calculate how effectively the available resources were used during the pandemic process. Appropriate input variables were selected due to the fact that during the pandemic period, a large part of the available resources was devoted to combating the pandemic; for example, there were no beds in hospitals, and there were insufficient doctors.

The efficiency perspective in this research is that with fewer doctors, fewer nurses, fewer beds, and less expenditure, more cases can be dealt with, more tests can be performed, and more improvements can be made. The fact that there are more deaths is again thought to be due to the high number of cases. In this direction, the aim is to identify which countries have been able to combat a great struggle with their scarce resources.

Since the output variables in the analysis are pandemic-specific variables, there is no control over outputs. Therefore, output-oriented models cannot be used. The input-oriented CCR model is presented in the following section.

Model and Method of the Study

Input-oriented CCR modeling, one of the Data Envelopment Analysis (DEA) models, was used to measure the efficiency of the countries included in the analysis. The input-oriented CCR model (Cooper et al., 2000, p. 41) aims to minimize inputs to meet a minimum level of output.

CCR model for maximum efficiency (Charnes, Cooper, & Rhodes, 1978):

$$\max h_k = \frac{\sum_{r=1}^{s} u_{rk} y_{rk}}{\sum_{i=1}^{m} v_{ik} x_{ik}} \quad 1)$$

Constraints;

$$\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1 \quad 2)$$

$$u_r, v_i \geq 0 \quad 3)$$

In the objective function in the models, *"h_k"* gives the efficiency value. *"k"* index indicates the countries, k=1, 2, …,47 is represented by the index j=1, 2,..n. It is calculated separately for each country. The number of inputs is represented by "m" and it is 5, indexed with the index i i=1, 2, ..5. The number of outputs is represented by "s" and it is 4, indexed with "*r*" index r= 1, 2, ..4. "y_{rk}" is the value of the r th output for the k th country and "x_{ik}", is the i th input value for the k th country. The unknowns of the model are "v_i" is the weight of the i th input and "u_r" is the weight of the r th output. The objective function is provided in the constraint that it can take a maximum of 1 value. Cooper et al., (2001) indicates that the number of units should be $n \geq max\{mxs,\ 3(m+s)\}$, the number of units in the study was determined as 47 >27.

Input-oriented CCR –Dual Model;

$$Min\ z_k - \varepsilon\left[\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+\right] \tag{4}$$

Constraints;

$$-\sum_{j=1}^{n} x_{ij}\,\lambda_j + z_k x_{ik} - s_i^- = 0 \tag{5}$$

$$\sum_{j=1}^{n} y_{rj}\,\lambda_j - y_{rk} - s_r^+ = 0 \tag{6}$$

$$\lambda_j, s_i^-, s_r^+ \geq 0 \tag{7}$$

where; Equations (1) and (2) were first converted to linear model, then dual model was established. s_i^-, represents the reducible amount of the i th input quantity s_r^+, represents the extra amount of the r th output. The objective function h_k, in other words, when the country efficiency takes the value 1, shadow-dual prices, in other words s_i^-, s_r^+ variables take the value 0. λ_j is the dual variable for the j th country. Efficient countries' own λ value is 1 and the dual variables of other countries are 0. Inefficient countries' own λ value is 1 and λ value of at least one different country is positive. For inefficient countries, countries have positive λ countries constitute the reference group. l are the units in the reference group. For the j th country, the target value for the i th input is calculated by Equation (8), and the improvement rates are calculated by Equation (9);

$$t_{ij} = \sum_{l=1}^{p}(x_{il} * \lambda_l) \qquad l = 1,2,..,p \tag{8}$$

$$IR_i = \frac{x_{ij} - t_{ij}}{x_{ij}} \tag{9}$$

The improvement rate in Equation (9) shows how much inputs can be reduced for a given amount of output. Using these equations, the potential improvements (PI) for the inputs and outputs of relatively inefficient DMUs can be calculated with a clearer notation as a percentage with the following formula;

$$*\ PI = \frac{Actual - Target}{Actual}100 \tag{10}$$

In order for a relatively inefficient DMU to become efficient, the value of the variable with a positive PI percentage should be decreased by PI, and the variable with a negative percentage should be increased by PI. If the PI value is zero, there is no need to make any improvements.

In the research, first of all, correlation analyzes were made between input and output variables. Since there was no negative correlation between any of the variables, DEA analysis was applied without any conversion. Within the scope of the study, the data of the variables were analyzed using the DEAP package program. 47 countries that could be reached in the middle-developed country group according to the World Bank were included in the analysis. Using the outputs obtained from the DEAP package program, the potential improvement rates of the countries were calculated in the Excel program. In the final stage of the study, the improvement rates were selected as the independent variables and efficiency score "h_k" was selected as the dependent variable, and the fact that through which inputs efficient countries were countries was investigated by the multiple linear regression analysis model. The multiple linear regression analysis is applied in the SPSS program.

Results

The descriptive statistical data of the variables of input and output health indicators of middle-income countries included in the study are presented in Table 1.

Table 1. *Descriptive Statistics of Input and Output Variables Used in the Analysis*

	Input and Output Variables	Max Value	Min. Value	Avg
Input Variables	Ratio of GDP devoted to health services	9.89	2.07	6.01
	Number of Patient Beds Per 1,000 Persons	11.38	0.57	3.48
	Number of Physicians Per 1,000 Persons	6.89	0.30	1.96
	Number of Nurses and Midwives Per 1,000 Persons	10.32	0.44	3.71
	Health Expenditure Per Capita	881.39	119.19	344.96
Output Variables	Number of people recovering from Covid-19 disease in 100.000 people	47163	6.63	8590
	Total cases per 1 million people	295463	72	83826
	Total deaths per 1 million people	4582	2.16	1560
	Total number of tests per 1 million people	3310464	242	566360

When the ranges of input variables in the 47 countries included in the study were examined, the Cuba had the highest ratio of GDP devoted to health services, which was 9.89%, and Equatorial Guinea had the lowest ratio. Although these two countries are in the same income group, it is seen that there was a difference of more than four times in terms of the ratio devoted to health services. Considering the number of patient beds per thousand people, the country with the highest value was Belarus by 11.38, and the country with the lowest value was Guatemala by 0.57. This health indicator is one of the most important indicators that affect the quantity and quality of health services in a country. Considering the number of doctors per thousand people, who are the main executives of health services, it was observed that there were significant differences. While Cuba was the country with the highest value in the number of doctors per thousand people by 6.89, Equatorial Guinea had the lowest ratio by 0.30. It was observed that there was about 22 times difference between the two countries in terms of the number of doctors per thousand people. Such a difference between countries in terms of the number of doctors per causes significant differences in other health indicators and struggle with health problems. Another important health indicator is the number of nurses and midwives who play an important role in the execution of health services. While Belarus was the country with the highest number of nurses and midwives per thousand people by 10.32, Equatorial Guinea had the lowest ratio by 0.44. As can be seen from the health indicators, one of the most critical problems of Equatorial Guinea is the lack of human resources in the health sector. Inadequate personnel may cause disruption of the services to be provided, incomplete delivery and inefficient use of resources. Another important health indicator is the amount of health expenditure per capita. It was seen that there were significant differences between countries in the amount of health expenditure per capita. Among the countries included in the analysis, while Argentina was the country with the highest health expenditure per capita by 881.39 dollars, Azerbaijan was the country with the lowest value by 119.19 dollars.

When the range of output variables was examined, the country with the highest number of Covid-19 cases per million people was Montenegro and the lowest country was China. It was remarkable that the number of Covid-19 cases per million was found to be low in China despite its large population. An important difference between countries was the number of people who died from Covid-19. Bulgaria was the country with the highest number of Covid-19 deaths per million people, while Russia had the lowest number of deaths. Another important indicator to be considered between countries within the scope of the fight against Covid-19 is the total test value per one million people. While the country with the highest number of tests per million people was Georgia, and the country with the lowest number of tests per million people was Jamaica. It was seen that there were significant differences between countries in the number of people recovering per hundred thousand people. While Saint Vincent and the Grenadines was the country with the highest number of people recovering per hundred thousand people by 47163, China had the lowest number of people recovering per hundred thousand people by 7. These output variables were evaluated by considering the country populations to evaluate the countries more accurately within the scope of efficiency analysis.

47 countries in the middle income group were selected as DMUs by considering the income classification of the countries of the World Bank in Table 2. Within the scope of the specified indicators, countries were subjected to efficiency analysis and efficient and inefficient countries were determined.

According to the results of the CCR input-oriented analysis, it was seen that 18 countries out of 47 middle-middle-income countries were in the efficient frontier. It can be said that these 18 countries used their existing health resources more efficiently in the fight against Covid-19 compared to other countries.

Table 2. *CCR Input-Oriented Efficiency Results of the Countries Included in the Analysis*

No	Countries	CCR Value	CCR Ref. Set No	No	Countries	CCR Value	CCR Ref. Set No
1	Albania	0.73	44 19 6 34	25	Jordan	0.84	12 19 44 34
2	Argentina	0.69	98 11 34	26	Kazakhstan	0.48	19 44 34
3	Armenia	0.81	44 19 36 6	27	Lebanon	0.79	11 22 34
4	Azerbaijan	0.68	44 19 34	28	Libya	0.48	34 9 19 44
5	Belarus	0.51	19	29	Malaysia	0.76	19 44 34
6	Bosnia and Herzegovina	1	6	30	Maldives	0.93	12 34 44
7	Botswana	1	7	31	Mauritius	0.28	19 34 39 9
8	Brazil	0.86	34 6 44 38	32	Mexico	1	32
9	Bulgaria	1	9	33	Moldova	1	33
10	China	0.09	7 19 47	34	Montenegro	1	34
11	Colombia	1	11	35	Namibia	1	35
12	Costa Rica	1	12	36	North Macedonia	1	36
13	Cuba	0.28	44 34 19	37	Panama	0.89	44 34 22 47 7
14	Dominican Republic	0.39	11 44 19 34	38	Paraguay	1	38
15	Ecuador	0.64	9 38	39	Romania	1	39
16	Equatorial Guinea	0.65	7 47	40	Russian Federation	0.8	19
17	Fiji	0.99	34 44 19 7	41	Serbia	0.68	19 44 34
18	Gabon	1	18	42	South Africa	0.81	6 7 45 35 38
19	Georgia	1	19	43	St. Lucia	0.83	34 38 7 6
20	Grenada	0.88	34 6 7	44	St. Vincent and the Grenadines	1	44
21	Guatemala	0.97	19 34 11 44 38	45	Suriname	1	45
22	Guyana	1	22	46	Thailand	0.56	34 44 19 7
23	Iraq	0.73	34 44 19 7	47	Turkey	1	47
24	Jamaica	0.7	35 45 7 38 6				

The countries with an efficiency score of 1 above the efficient frontier, in other words, efficient countries are shown in bold in Table 2. As a result of the efficiency analysis, when the reference status to other countries among the efficient countries was examined, it was seen that Montenegro was the country with the highest reference with 21 references. Higher frequency of a country's reference to other countries means that the relevant country is more efficient. Montenegro combated intensely with its scarce resources during the Covid pandemic. On the other hand, although Cuba was quite good in terms of health indicators compared to other countries, the biggest reason why it was not in the efficient frontier was due to the high amount of health care inputs. The main reason why some small-scale countries were found to be efficient was that their input amounts were low compared to the countries included in the analysis and that they achieved output above the average with these low input amounts.

According to the results of the dual model, in Table 3, an efficiency analysis was performed to evaluate the Covid-19 struggle with the health care input sources of the countries in the middle-income group according to the World Bank. In the results of the input-oriented analysis, the amounts required to improve the input variables of the countries that were not in the efficient frontier were calculated. On the other hand, the target input amounts were not calculated because they were the same as their current situation, since the countries on the efficient frontier were found to be efficient as a result of the analysis.

Table 3. *Quantities Required by Inefficient Countries to Bring Their Inputs According to the CCR Input Oriented Technique Target Values*

	Countries	Efficiency Score	GDP devoted to health services	Number of Patient Beds	Number of Physicians	Number of Nurses and Midwives	Health Expend. Per Capita
1	Albania	0.73	2.518	1.136	0.962	1.461	136.837
2	Argentina	0.69	6.118	1.899	1.738	1.801	384.324
3	Armenia	0.81	5.667	2.830	2.292	2.895	192.302
4	Azerbaijan	0.68	1.973	0.885	0.931	1.088	82.115
5	Belarus	0.51	2.919	1.258	1.612	1.472	76.721
6	Bosnia and Herzegovina	1	-	-	-	-	-
7	Botswana	1	-	-	-	-	-
8	Brazil	0.86	6.480	2.070	1.459	2.393	321.645
9	Bulgaria	1	-	-	-	-	-
10	China	0.09	0.338	0.16	0.137	0.163	19.650
11	Colombia	1	-	-	-	-	-
12	Costa Rica	1	-	-	-	-	-
13	Cuba	0.28	2.851	1.271	1.406	1.550	106.435
14	Dominican Republic	0.39	1.736	0.563	0.576	0.548	106.312
15	Ecuador	0.64	4.249	0.991	1.022	0.573	173.665
16	Equatorial Guinea	0.65	0.616	0.326	0.201	0.287	52.906
17	Fiji	0.99	2.290	0.967	0.592	1.245	140.781
18	Gabon	1	-	-	-	-	-
19	Georgia	1	-	-	-	-	-
20	Grenada	0.88	4.655	1.748	0.728	2.602	233.645
21	Guatemala	0.97	2.010	0.556	0.498	0.477	100.058
22	Guyana	1	-	-	-	-	-
23	Iraq	0.73	1.561	0.737	0.529	0.963	103.209
24	Jamaica	0.7	3.641	1.190	0.333	1.021	164.893
25	Jordan	0.84	4.367	1.445	1.878	2.014	216.466
26	Kazakhstan	0.48	1.582	0.749	0.537	0.977	106.659
27	Lebanon	0.79	6.487	1.974	1.832	1.207	344.895
28	Libya	0.48	1.768	0.929	0.581	1.126	127.502
29	Malaysia	0.76	2.464	1.210	0.621	1.635	207.628
30	Maldives	0.93	5.721	2.462	1.439	3.484	482.751
31	Mauritius	0.28	1.192	0.843	0.457	0.872	81.398
32	Mexico	1	-	-	-	-	-
33	Moldova	1	-	-	-	-	-
34	Montenegro	1	-	-	-	-	-
35	Namibia	1	-	-	-	-	-
36	North Macedonia	1	-	-	-	-	-
37	Panama	0.89	4.760	2.070	1.286	2.215	256.265
38	Paraguay	1	-	-	-	-	-
39	Romania	1	-	-	-	-	-
40	Russian Federation	0.8	4.108	1.771	2.268	2.072	107.981
41	Serbia	0.68	4.709	2.207	1.678	2.843	302.959
42	South Africa	0.81	5.974	2.147	0.601	2.059	283.732
43	St. Lucia	0.83	4.495	1.697	0.811	2.149	289.670
44	St. Vincent and the Grenadines	1	-	-	-	-	-
45	Suriname	1	-	-	-	-	-
46	Thailand	0.56	1.306	0.543	0.237	0.723	87.519
47	Turkey	1	-	-	-	-	-

From the perspective of this research, an efficiency score of 1 and a breakeven output/input ratio implies that the country in question is combating a great struggle with its scarce resources during the Covid pandemic. It can be said that Bosnia and Herzegovina, Botswana, Bulgaria, Colombia, Costa Rica, Gabon, Georgia, Mexico, Moldova, Montenegro, Namibia, North Macedonia, Paraguay, Romania, and Turkey are the countries most affected by the Covid process.

When the efficiency values of the countries are analyzed, first of all, the main reason why China's efficiency ratio is relatively low is due to the fact that the amount of input resources is relatively high compared to other countries. On the other hand, China took strict measures during the pandemic and attached great importance to the isolation process. When the output variables of China compared to other countries are analyzed, it is seen that the number of cases per 1 million people is 72. Due to the fact that it is a very dense country in terms of population, the number of cases per population has been quite low. When examined in terms of the number of deaths, the number of people who died per 1 million population in China was determined as 3.

One of the most important reasons why China stays away from the effective border is the number of Covid-19 recoveries per 100.000 people. The fact that this value, which is an important output variable, is very low, has been the most important reason for China to stay away from the effective border. Compared to other countries, the low output indicators relative to the population, especially the number of recovered patients, have pushed China away from the effective border.

Another remarkable country was Cuba. It was seen that Cuba was not in the efficient frontier despite having similar rates with developed countries in terms of basic health indicators. When the biggest reason for this situation was compared to the population, it can be said that Cuba had the highest health input sources compared to other countries. As a result of the analysis, it was seen that Turkey was in the efficient frontier and was one of the efficient countries. Turkey was the one of the countries that struggled with its scarce resources during the past pandemic. On the other hand, it was seen that the countries in the middle-income group, which are below the average in terms of economic scale, were generally efficient. It was largely due to the fact that the input resources in terms of basic health indicators were very limited and few in number. The perspective of this research is to identify countries that achieve the same level of output with scarce resources. Although Fiji and Guatemala are not in the efficient frontier, the fact that they are the two closest countries to the efficient frontier is one of the best examples to explain this situation. On the other hand, taking the average of the last twenty years of the basic health indicators of the countries is another factor that affects the efficiency results.

After determining the reference groups for the inefficient countries using the dual results in the CCR input-oriented model, the target values and improvement rates that enable inefficient countries to reach the efficient frontier were calculated and presented in Table 4. Potential improvement rates of middle-income countries, that were included in the analysis as DMU but were not in the efficient frontier, are presented in Table 4. Potential improvement rates were not calculated since the countries in the efficient frontier were efficient.

Table 4. *Potential Improvement Rates of Inefficient Decision-Making Units*

	Countries	Efficiency Score	GDP devoted to health services	Number of Patient Beds	Number of Physicians	Number of Nurses and Midwives	Health Expend. Per Capita
1	Albania	0.73	56%	63%	26%	64%	26%
2	Argentina	0.69	24%	57%	-55032%	24%	51%
3	Armenia	0.81	28%	37%	-80858%	43%	19%
4	Azerbaijan	0.68	29%	87%	72%	87%	29%
5	Belarus	0.51	48%	86%	-46177%	84%	66%
6	Bosnia and Herzegovina	1	-	-	-	-	-
7	Botswana	1	-	-	-	-	-
8	Brazil	0.86	76%	87%	36%	36%	48%
9	Bulgaria	1	-	-	-	-	-
10	China	0.09	93%	94%	90%	91%	90%
11	Colombia	1	-	-	-	-	-
12	Costa Rica	1	-	-	-	-	-
13	Cuba	0.28	71%	75%	80%	81%	78%
14	Dominican Republic	0.39	67%	66%	61%	61%	61%
15	Ecuador	0.64	36%	36%	-61896%	70%	42%
16	Equatorial Guinea	0.65	71%	82%	35%	35%	79%
17	Fiji	0.99	30%	53%	1%	53%	1%
18	Gabon	1	-	-	-	-	-
19	Georgia	1	-	-	-	-	-
20	Grenada	0.88	11%	57%	11%	26%	39%
21	Guatemala	0.97	67%	2%	1%	45%	40%
22	Guyana	1	-	-	-	-	-
23	Iraq	0.73	37%	38%	7%	25%	7%
24	Jamaica	0.7	30%	29%	29%	29%	29%
25	Jordan	0.84	47%	16%	16%	45%	16%
26	Kazakhstan	0.48	47%	89%	83%	86%	47%
27	Lebanon	0.79	18%	38%	20%	21%	34%

… Table 4. *Potential Improvement Rates of Inefficient Decision-Making Units*

	Countries	**Efficiency Score**	**GDP devoted to health services**	**Number of Patient Beds**	**Number of Physicians**	**Number of Nurses and Midwives**	**Health Expend. Per Capita**
28	Libya	0.48	51%	75%	68%	81%	51%
29	Malaysia	0.76	10%	20%	20%	54%	12%
30	Maldives	0.93	36%	10%	10%	39%	15%
31	Mauritius	0.28	72%	74%	72%	72%	76%
32	Mexico	1	-	-	-	-	-
33	Moldova	1	-	-	-	-	-
34	Montenegro	1	-	-	-	-	-
35	Namibia	1	-	-	-	-	-
36	North Macedonia	1	-	-	-	-	-
37	Panama	0.89	29%	11%	11%	10%	55%
38	Paraguay	1	-	-	-	-	-
39	Romania	1	-	-	-	-	-
40	Russian Federation	0.8	80%	17%	37%	30%	23%
41	Serbia	0.68	43%	60%	29%	58%	29%
42	South Africa	0.81	10%	19%	10%	10%	18%
43	St. Lucia	0.83	17%	22%	17%	17%	28%
44	St. Vincent and the Grenadines	1	-	-	-	-	-
45	Suriname	1	-	-	-	-	-
46	Thailand	0.56	53%	70%	19%	52%	19%
47	Turkey	1	-	-	-	-	-

Before examining Table 4, it is worth emphasizing that the input-oriented CCR Dual model presents the number of inputs that need to be reduced for the same output level. The improvement rate in equation (9) shows how much inputs can be reduced for a given amount of output. Percentage of potential improvement (PI) in Equation (10); if the actual input amount is higher than the target input amount, it is positive. Each positive percentage value gives the ratio of the inputs to be reduced. It would be a more accurate approach to interpret the results of the analysis by comparing the countries that are effective, that is, the countries that struggle with scarce resources during the pandemic, with those that are not effective.

When the improvement rates in Table 4 are examined, for example, the reference countries for Belarus with low efficiency are Botswana, Georgia and Russia. Compared to Belarus, these three reference countries saved 48% in share of GDP allocated to health. This shows that Belarus is using the input variable of the share allocated to health inefficiently. On the other hand, compared to the reference countries included in the analysis, it is seen that Belarus uses the number of patient beds in a significant amount an inert and can reach the same output amount with less number of patient beds. Finally, it is seen that Belarus should make an increase of approximately 46177% in terms of the number of doctors compared to other countries. Overall, it appears that Belarus can produce the same amount of services with significant savings in input resources compared to other countries. The most important factor pushing Belarus away from the efficient frontier is the high average level of input resources compared to other countries.

These results from the efficiency analysis are evaluated in the context of the reference countries included in the analysis. It should be noted that the efficient countries are efficient compared to the inefficient countries included in the sample. For this reason, it should not be inferred that efficient countries are perfect. It should be ensured that these inefficient countries increase their efforts to use their available input resources more efficiently. When the potential improvement ratios of the countries are analyzed, it is seen that China is the country that needs to make the highest correction on average across all variables. China's reference countries are Bostwana, Georgia, and Russia. It is shown that it is possible for China to reach these output rates by using approximately 90% less input resources than reference countries. On the other hand, it is seen that South Africa is the country that needs to make the lowest correction on average in all input indicators. It is also seen that the indicator that needs the most correction among the input sources of South Africa is the number of patient beds.

When countries' improvement rates were evaluated in terms of Coefficient of Variation [(CV, Standard Deviation/Mean) × 100], the inputs with the highest variability were the number of physicians (-

261 CV) and the number of health expenditures per capita (60 CV). The inputs of the number of doctors and health expenditures per capita are quite different from country to country.

In the next stage, multivariate linear regression analysis was applied to answer the question of which input improvement rates were explanatory in determining the efficiency value obtained from the DEA model. Efficiency scores were selected as the dependent variable, while improvement rates of the share of GDP allocated to health, the number of beds, doctors, midwives, nurses, and health expenditure per capita were selected as independent variables.

Improvement rates calculated according to DEA outputs differ from country to country. Countries with high efficiency have low improvement rates, and countries with low efficiency values have high improvement rates. The reason for including the improvement rates in the regression analysis is to investigate whether there is similarity in terms of improvement rates across all countries and to determine which input variables have critical importance on the efficiency value. As the improvement rates differ from country to country, it is expected that none of the input improvement rates will have a significant effect as a result of the regression analysis, but if there is a critical input, it will be revealed.

According to the regression analysis results, the improvement rates of the inputs which are the number of nurses-midwives and the health expenditures per capita are the variables that are efficient in determining the efficiency value. It was observed that the improvement rates for other inputs did not have a statistical effect on the determination of the efficiency score. According to the p significance values in Table 5, other variables were not found significant. It should be noted that since the values of the improvement rates are used in the analysis, not the value of the input variables, it should not be interpreted that the input variables have no effect on the efficiency value. The number of nurses and midwives and the rate of improvement in health expenditures per capita explained approximately 70% of the change in the efficiency score with the adjusted R^2 value of 0.681. In social science research, an explanation rate of approximately 70% is considered significant.

The number of nurses and midwives and per capita health expenditure are of critical importance across all countries. Countries can increase their efficient score especially by changing the improvement rates of these two inputs, the number of nurses and midwives and health expenditure per capita. The health expenditure per capita input variable was also found to be quite different from country to country in terms of CV.

Table 5. *Regression Results*

Dependent Variable: Efficiency Score	Method: Multiple Linear Regression					
			Sample:30			
Independent Variable:	Std. Beta	Std. Error	t	Sig.	Tolerance	VIF
Constant		,056	19,145	<,001		
GDP devoted to health services	,006	,140	,040	,968	,493	2,030
Number of Patient Beds	-,111	,125	-,669	,510	,404	2,478
Number of Physicians	-,052	,000	-,468	,644	,902	1,108
Number of Nurses and Midwives	-,421	,134	-2,708	,012	,455	2,197
Health Expenditure Per Capita	-,485	,143	-3,154	,004	,465	2,150

Statistics					
R	R^2	Adjusted R^2	S.E.Estimate	Durbin-Watson	
,858a	,736	,681	,12663	1,714	
Sum of Squares	df	Mean Square	F	Sig.	
1,071	5	,214	13,363	<,001b	

Spearman's rho	Standardized Residual		
		Number of Nurses and Midwives	Health Expenditure Per Capita
Standardized Residual	Correlation Coefficient	,049	,077
	Sig.	,795	,688

a. Predictors: (Constant), GDP devoted to health services, Number of Patient Beds, Number of Physicians, Number of Nurses and Midwives, Health Expenditure Per Capita. b. Dependent Variable: Efficiency Score

The assumptions were tested in the multiple linear regression analysis. Since the model was found to be significant for only two variables, the model was analyzed again using the significant variables, and Durbin-Watson was calculated was 1.799. There was no autocorrelation since the number of independent variables for K=2 and n=30 was du=1.489 dL= 1.352 with table values du≤d<4-du. For multicollinearity, tolerance values were greater than 0.2. There was no multicollinearity, Spearman's correlation was calculated for heteroscedasticity, there was no relationship between error terms and independent variables, and p values were greater than 0.05.

Priority inputs for increased efficiency are the number of nurses and midwives and health expenditures per capita. Standardized beta coefficients for the improvement rates of these variables were calculated as -0.421 and -0.485, respectively. The decrease in the rate of improvement in health expenditure per unit of person causes an increase of 0.485 in the increase of the efficiency value. It is useful to remind that the lower the improvement rates found according to the DEA results, the more positive a result for efficiency. The negative beta value indicates that the efficiency score will increase if the improvement rate decreases. It can be said that there is an inefficient use of the number of nurses and health expenditures for all inefficient countries. These input variables are of common importance for all countries participating in the analysis.

Discussion and Conclusion

The struggles of the countries in the middle-income group according to the World Bank income classification with the Covid-19 pandemic were evaluated by Data Envelopment Analysis. In the study, the effectiveness of health indicators, which were determined as input variables by using the input-oriented CCR model, on pandemic-specific output variables was investigated. In the pandemic process, countries that use input resources effectively and inefficiently were determined, and the amounts that countries should reduce their inputs were calculated. 47 countries were included in the study and the overall efficiency average of the countries was found to be 80%. Of the 47 countries, 18 countries in the efficient frontier were efficient. The countries that were found to be efficient as a result of the analysis were Bosnia and Herzegovina, Botswana, Bulgaria, Colombia, Costa Rica, Gabon, Georgia, Guyana, Mexico, Moldova, Montenegro, Namibia, North Macedonia, Saint Vincent and the Grenadines, Suriname and Turkey.

These efficient countries are calculated by comparing them with the countries included in the analysis. For this reason, it should not be inferred that inefficient countries are wasting their resources. This shows that the efficient countries in the sample use their available input resources relatively more efficiently. Another reason for these countries to be effective is that they have a limited number of input sources compared to other countries. The fact that they had to contend with fewer input resources, both in terms of quantity and in proportion to the population, led to a higher overall level of efficiency. The fact that other countries used above-average input resources in the fight against Covid-19 made countries using below-average input resources efficient. In conclusion, it was seen that although countries were in the same income group, they adopted different practices in the fight against the pandemic. It was seen that some countries reached test numbers below the average. On the other hand, although the total number of cases was above the average in some countries, it was seen that the number of deaths was low. The biggest contribution to this situation was that the health services input resources were sufficient in terms of quantity and quality.

For a more detailed analysis, it is important to identify the main differences in the use of resources of these countries, which are similar in terms of economic and health indicators. The reasons for the inefficiency of countries below the efficient frontier were calculated by multiple regression analysis. As independent variables, the improvement rates showing the number of inputs that need to be reduced, and the efficiency score as the dependent variable were taken. Since the improvement rates of all countries are determined according to each country's own potential, the input improvement rates of each country are determined uniquely to the country. The improvement rates that change the effectiveness score according to the regression findings are the number of midwives/nurses and the per capita health expenditure variables. It was concluded that the improvement rates for the share of GDP allocated to health, the number of doctors, and the number of beds are not the improvement rates that are effective in determining the efficiency score across all countries.

Since the improvement rates in the number of nurses and midwives and health expenditures per capita explained about 70% of the variation in the efficiency value, inefficient countries can become efficient countries by improving these inputs. The common characteristics of countries such as Colombia, Namibia, Paraguay, Bosnia and Herzegovina, which were identified as efficient countries in the study, are that they allocate fewer resources in terms of the number of midwives/nurses and per capita health expenditure inputs compared to other countries and reach the same level of output compared to their reference countries. Improvements should be made in the number of midwives and nurses, who are the main operators of health services, and in health expenditures per capita to achieve better health indicators. In this way, inefficient use of inputs due to excessive input use can be prevented. When such pandemics occur in the future, they can be fought more effectively, and the country's resources can be used in different areas.

When the literature is examined, health indicators of countries have been examined in many different studies within the scope of various indicators with Data Envelopment Analysis. However, it is seen that the health performances of countries against the Covid-19 pandemic have not been adequately compared due to the recent Covid-19 pandemic, and its impact on country health indicators cannot be fully measured. One of the studies using input and output variables similar to this research is Selamzade and Özdemir (2020). In this context, Selamzade and Özdemir (2020) examined OECD countries' struggles with Covid-19 in their research. As input variables, they used the number of doctors, nurses, and hospital beds per ten thousand people and the ratio of GDP allocated to health services. As output variables, they used the number of tests per million population, number of cases per million population, and number of deaths per million population. As a result of the research, 11 OECD countries were found efficient. In this study, unlike Salemzade and Özdemir (2020), per capita, health expenditure data is used as an input variable. As a different output variable, the number of people who recovered from Covid-19 disease per 100.000 people was used. Mexico and Turkey are both countries participating in this study and our study, and they were found to be effective in both studies.

In another study, Mohanta et al. (2021) performed performance measurements against Covid-19 disease in 32 different states of India. The number of hospitals, number of hospital beds, percentage of health workers, and population density was taken as input variables. As the output variable, the number of infected patients and the number of patients who died were considered. They identified 16 states out of a total of 32 Indian states as productive. Similar input and output variables were used in this study as in our study.

Finally, Mourad et al. (2021) performed performance measurements for the Covid-19 pandemic in countries with a population of more than fifty million. The variables covered in the research are the number of cases per million, the number of beds per million, the number of recoveries per million, the number of deaths per million, and finally, the ratio of GDP allocated to health services. It found 15 of the countries included in the analysis below the effective limit, in other words, inefficient. In terms of countries included in the analysis, China, Turkey, Colombia and Brazil are partner countries in both studies. While Turkey and Colombia were effective in both studies, Brazil was not effective in both studies.

It was found effective in the study of China Mourad et al. (2021). In this study, China was the country furthest from effectiveness. The reason for this is that the reference countries included in the analysis are struggling with scarce resources. According to the perspective developed in this research, China has allocated more resources for the same output level than the countries it takes as a reference. Effective countries have performed superiorly in the Covid process with their very limited resources compared to inactive countries.

The output variables used in the study are only data specific to the pandemic struggle. Although the input variables are not pandemic-specific data used for the entire health system, the input-oriented CCR Model was used to calculate how effectively the available resources were used during the pandemic process. Although a large part of the resources was devoted to the fight against the pandemic during the pandemic period, resources were also used to fight against different diseases and health services. However, this rate is much lower, but it can still be expressed as a limitation of the research.

When the results are evaluated in general, it is seen that the effective countries perform more tests than the others. On the other hand, having less health service resources and higher output than the average in the Covid-19 process also contributed to the countries being on the effective border. Another important point is that the amount of health services provided and the way of delivery have changed considerably during the Covid-19 process.

Finally, the results obtained in the study are limited to the input and output data set used. The use of different input and output data sets can change the results. In addition, according to the scale, using another analysis technique instead of input-oriented VZA based on a fixed return basis may differentiate the results.

As a suggestion from the scope of the research, similar indicators can be examined with different country groups, and the results obtained can be compared. The analysis can be differentiated by using input data from the pandemic process. Differences between income groups of countries can be identified. Finally, re-estimation can be made by taking different time dimensions as reference.

Ethical Statement

"*Efficiency Analysis of Middle-Income Countries in Terms of Health Indicators for the Covid Process*" During the writing process of the study titled, scientific rules, ethical and citation rules were followed; No falsification has been made on the collected data and this study has not been sent to any other academic media for evaluation.

Statement of Contribution Rate of Researchers

The contribution rates of the authors in the study are equal.

Declaration of Conflict

There is no potential conflict of interest in the study.

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GENİŞ TÜRKÇE ÖZET

2020 yılının son aylarından itibaren Covid-19 salgınının dünya geneline yayılmasıyla birlikte ülkeler önemli bir mücadele sürecine girmiştir. Pandeminin etkisini azaltmak ve bireylerin hastalığa yakalanmasını önlemek için ülkeler salgının başlangıcından itibaren çok sıkı tedbirler almıştır. Ülkelerin pandemiye karşı sosyal, kültürel ve ekonomik tedbirler almasının yanı sıra, ülkeler pandeminin ana merkezi olan sağlık sistemleri ile birlikte mücadeleyi sürdürmüştür. Vakaların klinik olarak tedavi edildiği hastaneler ve onların alt bileşenleri ile birlikte merkezi sağlık sistemi ve örgütlenmesi bu mücadelenin temel direğini oluşturmaktadır. Bütün bileşenleri (teknoloji insan kaynakları, tesisler, bilişim alt yapısı, ilaç stokları, medikal cihazlar vb.) ile sağlık sisteminin önemi pandemi ile birlikte daha da ön plana çıkmıştır. Ancak bazı ülkeler sağlık sistemleri olarak daha başarılı bir performans ortaya koyarken, neden bazı ülkeler daha az başarılı ya da başarısız olmaktadır? Neden bazı ülkelerde vaka oranları daha yüksekken ölüm oranları daha az olmaktadır? Diğer ifadeyle, vaka oranları düşükken ölüm oranları neden yüksek olabilir? Bu durumlar sağlık sistemleri ve göstergeleri ile nasıl ilişkilidir? Bu sorular ve bakış açısıyla bu araştırma, orta gelirli ülkelerin sağlık sistemleri göstergeleri üzerinden Covid-19 salgınıyla mücadelenin etkinlik ve verimlilik açısından incelenmesine dayanmaktadır. Sağlık hizmetlerinin kendine has özellikleri ve karmaşık yapısı nedeniyle girdi ve çıktı sayısı oldukça fazla ve çeşitlidir. Bu girdi ve çıktı faktörleri de aynı ölçü birimine sahip değildir. Tüm bu değişkenleri bir arada analiz etmek, karşılaştırmalar yapmak, en etkin ülkeleri belirlemek ve etkin sınırın altında kalan ülkelerin etkili olabilmesi için yapılması gerekenleri belirlemek için parametresiz bir yöntem olan VZA'nın kullanılması uygundur (Şenol ve Gençtürk, 2017:267). Aslında VZA, sağlık sisteminin etkinliğini ölçmek veya ülkelerin göreceli sağlık sistemlerinin etkinliğini ölçmek için çok yaygın olarak kullanılan bir yöntemdir. Geçmiş Covid-19 pandemisi, ülkelerin sağlık sistemlerinin tüm unsurları ile birlikte mücadele ettiği en büyük problemdir. Salgınla mücadele sürecinde mevcut imkânların etkin ve verimli kullanımı başarı için kaçınılmaz bir unsurdur. Artan nüfus popülasyonu, yaşlı nüfusun çoğalması ve hastalıkların çeşitlenmesi bu mücadeleyi zorunlu kılmaktadır (Bağrıaçık 2021:217). Bu bağlamda araştırma, orta gelirli ülkelerin Covid-19 mücadelesindeki göreli etkinliğinin ölçümü kapsamında yürütülmektedir. Bu çerçevede VZA kullanarak ülkelerin sağlık sistemlerinin etkinliğini ölçmeye çalışan araştırmalara ilişkin literatüre yer verilmektedir. Bu araştırmanın amacı, Dünya Bankası gelir sınıflandırması dikkate alınarak belirlenen orta gelir grubunda yer alan ülkelerin belirli sağlık göstergeleri kapsamında Covid-19 ile mücadelesini veri zarflama analiz yöntemi vasıtasıyla değerlendirmektir. Araştırmanın kapsamı, seçilen mevcut sağlık kaynakları girdileri ile Covid -19 mücadelesinde gösterge olabilecek çıktıları üretmede hangi ülkelerin etkin olduğunu araştırmak ve önemli sağlık girdilerini belirlemektir. Bu değerlendirme sürecinde amaç, ülkelerin etkinliğini belirlemek, etkin sınırın altında kalan ülkelerin etkin olmama nedenlerini tespit ederek gerekli düzeltmeler için öneriler geliştirmektir. Böylelikle, benzer pandemilerin tekrar ortaya çıkması durumunda ülkelerin hazır olmalarına bu araştırmanın katkı yapması beklenmektedir. Araştırma kapsamında kullanılacak değişkenler belirlenirken literatürde benzer çalışmalar incelenerek araştırmanın amacına en uygun girdi ve çıktı değişkenleri seçilmiştir. Araştırmada girdi değişkenleri; GSYİH'dan sağlık hizmetlerine ayrılan oran, hasta yatağı sayısı, bin kişi balına düşen hekim sayısı, bin kişi başına düşen hemşire sayısı, bin kişi başına düşen ebe sayısı ve son olarak kişi başı sağlık harcama miktarıdır. Çıktı değişkenleri; her 100.000 kişiye düşen Covid-19 hastalığından iyileşen kişi sayısı, 1 milyon kişi başına düşen toplam vaka, 1 milyon kişi başına düşen toplam ölüm ve bir milyon kişi başına düşen toplam test sayılarıdır. Dünya Bankası gelir sınıflandırması dikkate alınarak orta gelir grubunda yer alan ülkelerin belirli sağlık göstergeleri kapsamında Covid-19 ile mücadelesi değerlendirilmiştir. Orta gelir grubunda 55 ülke bulunmasına rağmen verilerine ulaşılabilen 47 ülke analize dâhil edilerek karar verme birimi (KVB) olarak seçilmiştir. Sağlık göstergeleri ile ilgili veriler Dünya Bankası sitesinden elde edilirken, Covid-19 ile ilgili veriler "Our World in Data" sitesinden elde edilmiştir. Sağlık göstergeleri ile ilgili verilerin 2018-2019 yıllarına kadar bulunmasından dolayı daha iyi değerlendirme yapabilmek adına 2000-2019 dönemlerine ait verilerin ortalaması alınmıştır. Covid-19 ile ilgili verilerin ise 01.04.2020-15.01.2022 yıllarına ait verilerin toplam değerleri alınmıştır. Analize dâhil edilen ülkelerin etkinliğini ölçmek amacıyla Veri Zarflama Analizi (VZA) modellemelerinden girdiye yönelik CCR modellemesi kullanılmıştır. Sonuç olarak bu araştırmada, Dünya Bankası gelir sınıflandırmasına göre orta gelir grubunda yer alan ülkelerin Covid-19 salgını ile mücadeleleri veri zarflama analizi ile değerlendirilmiştir. Araştırmaya 47 ülke dâhil edilmiş olup ülkelerin genel etkinlik ortalaması %80 olarak bulunmuştur. 47 ülke içerisinden etkin sınır üzerinde yer alan 18 ülke etkindir. Analiz sonucunda etkin çıkan ülkeler ise; Bosna Hersek, Botsvana, Bulgaristan, Kolombiya, Kosta Rika, Gabon, Gürcistan, Guyana, Meksika, Moldova, Karadağ, Namibya, Kuzey Makedonya, Saint Vincent ve Grenadinler, Surinam ve Türkiye'dir. Etkin olan bu ülkeler, analize dâhil edilen ülkeler ile kıyaslanarak hesaplanmaktadır. Bu nedenden dolayı etkin olmayan ülkelerin kaynaklarını boşa sarf ettikleri anlamı çıkmamalıdır. Bu örneklemde yer alan etkin ülkelerin mevcut girdi kaynaklarını görece daha etkin kullandıklarını göstermektedir. Bu ülkelerin etkin çıkmasının bir diğer nedeni ise, diğer ülkeler ile kıyaslandığında sınırlı sayıda girdi kaynağına sahip olmalarıdır. Hem miktar olarak hem de nüfusa oranla daha az girdi kaynağı ile mücadele etmek durumunda kalmaları genel ekinlik düzeyinin yüksek çıkmasını sağlamıştır. Daha detaylı bir analiz için ekonomik ve sağlık göstergeleri açısından birbirine benzeyen bu ülkelerin kaynaklarının kullanımındaki temel farklılıkların tespit edilmesi önemlidir. Etkin sınırın altındaki ülkelerin verimsizliğinin nedenleri çoklu regresyon analizi ile hesaplanmıştır. Bağımsız değişkenler olarak girdilerin azaltılması gereken miktarı gösteren iyileştirme oranları ve bağımlı değişken olarak etkinlik skoru alınmıştır. Tüm ülkelerin iyiletirme oranları her ülkenin kendi potansiyellerine göre belirlendiği için her ülkenin girdi iyileştirme oranları değerleri ülkenin kendisine has olarak belirlenmektedir. Regresyon bulgularına göre etkinlik skorunu, ülkeler açısından ortak olarak değiştiren-etkileyen, iyileştirme oranları; Ebe/Hemşire sayısı ve kişi başına düşen sağlık harcaması değişkenleridir. GSYİH'dan sağlığa ayrılan pay, doktor sayısı, yatak sayısı iyileştirme oranları ise tüm ülkeler genelinde etkinlik puanının belirlenmesinde etkili olan iyileştirme oranları olmadığı sonucuna ulaşılmıştır. Hemşire ve ebe sayısı ile kişi başına düşen sağlık harcamalarındaki iyileşme oranları, etkinlik değerindeki değişimin yaklaşık %70'ini açıklamaktadır. Özellikle bu iki iyileştirme oranı değişkenleri tüm ülkeler genelinde ortaktır ve etkin olmayan ülkeler bu girdileri geliştirerek etkin ülke olabilirler. Ek olarak, ülkeler aynı gelir grubunda yer almasına rağmen salgın ile mücadelede konusunda farklı uygulamalar benimsemişlerdir. Bazı ülkelerin ortalamanın altında test sayılarına ulaştığı görülmektedir. Diğer taraftan bazı ülkelerde toplam vaka sayıları ortalamanın üstünde olmasına rağmen ölüm sayılarının az olduğu görülmektedir. Bu duruma en büyük katkının ise sağlık hizmetleri girdi kaynaklarının miktar ve nitelik olarak yeterli olmasıdır. Sonuçlar genel olarak değerlendirildiğinde etkin ülkelerin diğerlerine göre daha fazla test yaptığı görülmektedir. Öte yandan Covid-19 sürecinde sağlık hizmeti kaynaklarının daha az olması ve ortalamanın üzerinde çıktıya sahip olması da ülkelerin etkin sınırda yer almasına katkı sağlamaktadır.