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Role of the Health System in Combating Covid-19: Cross-Section Analysis and Artificial Neural Network Simulation for 124 Country Cases

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ABSTRACT

In the fight against Covid-19, developed countries and developing countries diverge in success. This drew attention to the discussion of how different health systems and different levels of health spending are effective in combating Covid-19. In this study, the role of the health system in the fight against Covid-19 is discussed. In this context, the number of hospital beds, the number of doctors, life expectancy at 60, universal health service and the share of health expenditures in GDP were used as health indicators. In the study, firstly 2020 data was estimated by using the Artificial Neural Networks simulation method and this year was used in the analysis. The model, with the data of 124 countries, was estimated using the cross-sectional OLS regression method. The estimation results show that the number of hospital beds, number of doctors and life expectancy at the age of 60 have statistically significant and positive effects on the ratio of Covid-19 recovered/cases. Universal health service and share of health expenditures in GDP are not significant statistically on the cases and recovered. Hospital bed capacity is the most effective variable on the recovered/case ratio.

KEYWORDS

Novel Coronavirus; Covid-19; healthcare system; global health

Introduction

Covid-19 started in Wuhan, China in December 2019 and spread rapidly all over the world. Covid-19 was named 2019-nCoV by the World Health Organization (WHO) on January 12, 2020, and was declared a pandemic on March 11, 2020. According to the WHO (2020) report, the pandemic, which spread to more than 200 countries and affected 9 million people as of 30 July 2020, caused 500 thousand deaths all over the world.

The number of cases that tend to decrease in some countries is at the beginning stage in other countries and is increasing rapidly. For this reason, the ranking of the countries most affected by the pandemic is changing very often. At this stage, it is difficult to make clear predictions about the course of the pandemic and its ending process. According to Fernandes (2020), some of the worst scenarios for the current pandemic are based on the global flu that killed 40 million people worldwide in 1919. Today, due to the larger and highly interactive world population and shorter travel times, the pandemic may kill over 80 million, a scenario based on 1919 global flu.

While large-scale measures are being taken by countries to control the pandemic, on the other hand, leading universities are concentrating on treatment, since no vaccine has yet been found for the pandemic. According to La et al. (2020), the world of science makes similar efforts. Prestigious journals such as the Journal of American Medical Association, British Medical Journal, Lancet, and

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New England Medical Journal, and publishers such as Springer Nature, Elsevier, Taylor and Francis have made all relevant resources available to open access and have declared their eagerness for any possible collaboration.

In addition to the extraordinary measures taken by governments in controlling the outbreak, the health system of the countries is also very important. Therefore, exceeding health capacity may lead to more spread of the pandemic. For example, in Wuhan, the starting point of COVID-19, quarantine at home was emphasized to alleviate the demand for health resources in the early stages of the pandemic. However, with the exponential increase in the number of patients who could not be admitted to the hospital due to limited capacity, the pandemic reached alarming figures. Exceeding the health capacity and insufficient stock for several medical devices brought an increase in the mortality/case ratio (Liu, Xiao, & Tchounwou, 2020).

According to the OECD, ensuring that all individuals have access to diagnosis and treatment; strengthening and optimizing health system capacity to overcome the rapidly increasing number of cases; ensuring maximum benefit from digitalization; and measures such as how to improve R&D for diagnosis, treatment and accelerated development of vaccines should be the primary objectives of the health system (OECD, 2020a). Because the experience in China has revealed that there is a relationship between the capacity and availability of healthcare resources of countries in the COVID-19 outbreak and the mortality rate in the epidemic (Ji, Ma, Peppelenbosch, & Pan, 2020). Therefore, the coordinated implementation of restrictive public and health policies plays a vital role in combating COVID-19.

Many indicators are used in evaluating the performance of the health system, such as the number of hospital beds, the number of doctors, health expenditures, life expectancy, newborn infant mortality and vaccination. Table 1 includes health system variables and the universal health coverage (UHC) index. These are assumed to be effective in the fight against COVID-19. The countries with the highest number of cases in the world are chosen.

Table 1. Health system responses to COVID-19.

Country	Accelerate R&D for vaccines and treatment	Encourage telemedicine, smarter use of data for surveillance and tracking	Improve affordability of diagnostics and treatment for all	Increase access to mental health services	Increase supplies of diagnostic tests, protective equipment, ventilators, essential medicines	Mobilize and protect health workers	Optimize hospital beds and spaces for diagnostics and treatments	Protection for the elderly	Additional funding/financing for the health system
Argentina	1	1	1		1	1	1	1	
Australia	5	2	4	2	11	3	4	2	1
Austria	1	4		1		2		1	
Belgium		8	3	1	5	5	3	5	2
Brazil (national level)	1	1	1	1	1	1	1		
Canada	2	1	1			2	1		
Chile		1	1	1	1	1	1	1	1
China (national level)		1							
Colombia		1	1		1	1	1	1	1
Costa Rica		1	1	1	1	1	1	1	
Czech Republic		2	1		3	1	2	2	2
Denmark	2	2			2	1	3	3	
Estonia		2	1		2	1	2		1
European Union	1								
Finland		2	1		3	2	2	1	
France	4	7	3	2	7	12	5	14	4
Germany	3	2	2		3	1	2	1	3
Greece		2	1	1	2	3	2	2	1
Hungary					4	4	1	3	
Iceland					1	1		1	
India (national level)	1	1			4		3		
Ireland	2	1	2	1	2	1	1	2	1
Israel	2	3		2	2	1			

(*Continued*)

Table 1. (Continued).

Country	Accelerate R&D for vaccines and treatment	Encourage telemedicine, smarter use of data for surveillance and tracking	Improve affordability of diagnostics and treatment for all	Increase access to mental health services	Increase supplies of diagnostic tests, protective equipment, ventilators, essential medicines	Mobilize and protect health workers	Optimize hospital beds and spaces for diagnostics and treatments	Protection for the elderly	Additional funding/ financing for the health system
Italy					2	3	3		
Japan	2	10	2	3	17	7	7	3	5
Korea	1	1	1	1	1	1	1		
Latvia				1	3	1	1		
Lithuania			1		2	2			
Luxembourg	4	1	1	2	1	2		1	
Mexico		1	1	1	1	1	1	1	1
Netherlands		1			3		2	1	
New Zealand		2	1	3	2	6	1	3	1
Norway	1		1	1		3			
Other International	1								
Peru		1	1	1	1	1	1	1	
Poland		2				1		1	2
Portugal	1	1	2	1	2	1	1	1	2
Slovak Republic		1			2				
Slovenia	1				1	1	2		
Spain	2	1	1		1	2	1	1	
Sweden					1				1
Switzerland	1	4			1	1	1	1	
Turkey	3	5	3	1	5	2	2	2	1
United Kingdom	1	2	1	2	5	5	2	2	2
United States (federal level)	4	2	1	2	2		1		1

OECD 2020d.Beyond containment: Health systems responses to COVID-19 in the OECD. http://www.oecd.org/health/COVID19-OECD-Health-System-Response-Tracker.xlsxth/COVID19-OECD-Health-System-Response-Tracker.xlsx https://www.oecd.org/coronavirus/policy-responses/beyond-containment-health-systems-responses-to-covid-19-in-the-oecd-6ab740c0/

It is seen that the country with the highest number of COVID-19 cases in the world is the USA with 2,297,360 (June 19, 2020). The USA is followed by Brazil, Russia, Spain, the United Kingdom, Italy and France, respectively. However, given the case/death rate, the ranking differs. When the countries with the highest COVID-19 cases ratio are considered, the highest death/case rates belong to France, Italy and the United Kingdom, respectively. On the other hand, the lowest death/case ratios belong to Russia, Turkey and India, respectively. While, the countries with the highest ratio of COVID-19 recovered/cases are China, Germany and Turkey, the countries with the lowest ratio countries are the UK, USA and France, respectively. Turkey is the most successful country in terms of the recovered and death rates. The lowest performances in these two indicators belong to France and the UK, respectively.

France has the highest ratio of death/cases and a lower number of recovered/cases among the most vulnerable countries. The pandemic occurred during a troubled period because the country's health system was struggling with strikes. Various industries' workers have been on strike for a long time. Many hospital workers, including emergency specialists and nurses, launched a strike last November/December, requesting additional resources for public hospitals. Also, quarantining the country, the insufficient stocks of the protective mask, disinfection, and diagnostic kits in the first days of the pandemic made the country difficult in the pandemic. Although France is in a better position in the number of hospital beds than many European countries, late measures and troubles caused the country to fail in the fight against COVID-19. As part of measures taken in the field of the health system, tents have been set up outside to diagnose and screen COVID-19 cases by many hospitals. To prevent crowds in hospitals, mobile emergency services have been increased; many retired healthcare professionals have been called in and 70% of practitioners have begun to offer online health counseling (Gandre & Or, 2020). Besides, patients' transfers were provided by

using trains, helicopters, private aircraft and even warships to reduce the patient burden in busy hospitals (Winkelmann, 2020).

The UK has the lowest recovered/case rate and relatively high death/case rate. The negative effects of the decentralization of the management in the health system, inadequate healthcare workers and inadequate of physical capacities such as health infrastructure and protective equipment are the main criticisms of the health system in England (Hunter, 2020). In fact, the National Health Service in England was an important healthcare system in the country that offers free and comprehensive health care services to everyone. However, poorly financed by the government's austerity policies following the 2008 financial crisis, this COVID-19 outbreak puts the NHS under enormous pressure (Luonga, 2020). Following the chronic insufficient funding and austerity period, general acute hospital bed capacity in the UK has shown a downward trend in the past 20 years. As a result of all these, the UK has the lowest number of hospital beds among developed economies and the lowest number of doctors after the USA. Before COVID-19 outbreak, hospitals had 92% occupancy rates in general and more than 95% occupancy rates, especially in winter. Especially in London and some big cities, the densities in hospitals were serious. For this reason, in the early stages of the pandemic, the disease was planned to be treated in certain hospitals, but with the rapid increase of cases, all hospitals were actively used and also, intensive care units were turned into critical care units (Rajan, 2020). To minimize the effect of the pandemic on the economy and forecasting that the health system may be inadequate for the pandemic, testing was made only for severe cases in the beginning. Also, it was aimed to gain herd immunity by spreading the epidemic to society. But all these policies led to a rapid increase in cases and deaths.

The rapidly increasing number of cases in Italy, where both the number of cases and the rate of deaths/cases were high, led to the locking of the health system. The insufficiency of healthcare workers before the epidemic has been an important and still ongoing public health problem for Italy and this deficit has become more prominent with COVID-19. As a result of the rapidly increasing cases in the country, both the healthcare professionals and the hospitals were insufficient to meet the needs due to the excessive density. Therefore, the country announced that retired doctors and nurses and medical students in the last academic year could be employed under the national health system for six months. And also, some patients started to receive treatment in the floor coverings and then the exhibition areas and large industrial areas in Milan were converted into hospitals, and hospitals in regions with higher infection rates are designated as COVID-19 hospitals. Similar problems have been experienced in medicine and equipment. Stock problems have emerged in many medicines, ventilators, oxygen and personal protective equipment (De Belvis et al., 2020; OECD, 2020c). In addition to the healthcare system, patient profiles, hospital densities and concentration of cases in certain regions were also determinative in the country's failure to fight the Covid-19. For example, in China, 15–20% of cases required hospitalization, whereas, in Italy, 40% of patients were treated in hospitals and 7% in intensive care units (Wu and McGoogan, 2020; Lazzerini and Putoto, 2020; Davoodi et al 2020;) Therefore, this situation further increased the insufficiency of the health system and played an important role in increasing the ratio of deaths/cases.

In Spain, which is one of the countries most affected by the pandemic and where the harshest measures were taken after Italy, especially the big hospitals in Madrid faced excessive patient burden. Too many healthcare workers were infected with Covid-19 and this has aggravated the situation. The lack of personal protective equipment such as gloves and masks, and limited ventilator and intensive care beds due to the rapid increase of critical patients led to a more difficult struggle with the outbreak (Tanne et al., 2020). When the measures taken were examined, trained nurses, along with other specialties such as internal medicine, anesthesiology, pneumology and geriatrics, started to work with intensive care specialists to increase care capacity. Also, general practitioners (such as family physicians), primary care pediatricians and nurses were directed to hospitals with special duties. Those who are referred to these hospitals have received minimal training on preventive measures and patient management. In these hospitals, patients are taken to the emergency services or quarantined at home, screened, diagnosed, monitored and visited when necessary. In addition, general practitioners (such as

family physicians), primary care pediatricians and nurses were also directed to the hospitals with special duties. Those who are referred to these hospitals have received minimal training on preventive measures and patient management. In these hospitals, patients are taken to the emergency services or quarantined at home, screened, diagnosed, monitored and visited when necessary. These hospitals were categorized with telehealth units. Also, 16 field hospitals have been set up, especially in Madrid, to control and treat less severe cases. In some areas, hotels have been adapted and put into service to allow very busy hospitals to relax (Delgado, Ester, & Francisco, 2020).

While the death/case ratio is relatively high in the USA, which has the highest number of cases in the world, the recovery/patient rate is quite low. The US healthcare system has a mixed structure where different models are used together. In this mixed system, where there is no general health insurance concept, there are Medicare and Medicaid programs for people over 65, disabled and/or below a certain income level, insurance provided by the army for veterans and their relatives, and private insurance for employees and their families through their employers. However, this fragmented insurance system does not cover all segments of society (Smith & Medalia, 2015). Due to the fragile nature of the health system, it cannot be said that health indicators are sufficient. In particular, the number of hospital beds and doctor density in the country is quite low compared to developed economies. In the USA, which has one of the lowest ratios of hospital beds/population among OECD countries, imbalances among the number of hospital beds between states have also made it difficult to combat the pandemic. The number of hospital beds has been insufficient in the USA, especially in Washington, California, New York and Chicago. In the USA the population at risk in need of the number of hospital beds varies from state to state. On the other hand, insufficient protective equipment such as a ventilator, glove, apron and mask caused the current situation to become more severe especially in these regions. In this framework, facilities such as gyms, hotels, dormitories and congress centers have been converted into medical facilities, thereby increasing the hospital bed capacity. In the USA, where the number of physicians per person, as well as the number of hospital beds, is insufficient compared to other high-income countries, former physicians and nurses were asked to rejoin the workforce with the pandemic, and in some cities, health workers were offered the opportunity to stay in hotels to avoid exposure to the virus (Unruh, Alexander, & Koval, 2020)

Germany is one of the most successful countries in controlling the outbreak. Germany, which is in the best position after China in the world in terms of the number of recovering per case, has also performed successfully in the dead/case ratio. The country ranks first in the number of hospital beds and doctors per capita among European economies. Looking at the measures taken, the country has shown an example of rapid adaptation to the pandemic by doubling the number of staff in laboratories. Some stem cell donor registry laboratories and public chemical and veterinary research offices in some federal states have started laboratory tests for COVID-19. The German army also provided support in different ways. While medical units consisting of approximately 20,000 soldiers and five hospitals of the army were prepared for the public, a mobile doctor service was also provided. It is also aimed to double the bed capacity using temporary facilities such as rehabilitation centers and hotels. To increase the number of current healthcare professionals, part-time healthcare workers are working all day, students of medical, nursing and health departments are working in clinical practices, retired healthcare professionals are included in the workforce and recognition and equivalence procedures for foreign-educated healthcare professionals are simplified and accelerated (Winkelmann, 2020). However, in addition to the high performance in the health system, it is important for Germany to have a younger population compared to other European countries and to test many people in the country to be successful in fighting the epidemic (Bennhold, 2020).

Turkey is among the top three best-performing countries, in the fight against Covid-19 in terms of low/dead ratio and recovered/case rate. Even in times of economic problems, investments in the health system have not been disrupted and the health infrastructure in the country has been strengthened considerably. The fact that the profession of medicine is one of the most respected professions in society has led to the most successful and smart individuals to turn to this field, so the sector has become quite strong with both public policies and successful healthcare professionals. Measures such

as the rapid response of the Ministry of Health, the effective use of COVID-19 Scientific Committee, the quarantine of the citizens coming from abroad for 14 days in dormitories, constant information in written, visual and social media with a transparent understanding were very successful for combatting COVID-19. The concept of City Hospital[1] also played an important role in success. The public sector is dominant in the Turkish health sector and the private sector's share is relatively low. Health services are provided free of charge also to the poorest segments of the society. For this reason, individuals do not refrain from going to hospitals due to hospital expenses. The citizens who are exposed to the pandemic are treated in hospitals and there is a high success in the fight against the pandemic in the country since there are no equipment and doctor problems. In addition, thanks to the high number of tests, detection and control of individuals who were exposed to the pandemic are very effective. This process plays an important role in controlling the pandemic. Besides, the curfew imposed on all citizens, especially on the weekends, has minimized the risk of contagion on the busiest days. However, even in periods when the ban was relaxed, prohibitions on the population aged 65 and over have continued. This contributed to the reduction of mortality rates by protecting the elderly, who are considered as high-risk groups. Also, while hospital facilities are offered to all individuals in regions where the epidemic is at a low level, priority is given to those with chronic diseases and the elderly in regions where there is agglomeration. In treatment, immune plasma was prioritized, and this contributed to the country's success in treatment.

The very harsh measures implemented in China, which has the highest recovery/case ratio in the world. Chinese example has an important role in controlling the pandemic. In the country, positive cases were followed in the form of a chain, and everyone likely to become infected was tested. In the streets, the temperature of people was measured with thermal cameras. Hospitals special to COVID-19 patients were built, large areas such as stadiums and convention centers have been transformed into mobile cabin hospitals for medical observation and treatment of suspicious cases, patients with mild symptoms and individuals in close contact with patients. Also, medical supplies were provided to the outbreak zone Wuhan and more than 42,600 healthcare providers and medical rescue teams have been sent (Liu et al., 2020). Local authorities in Wuhan have taken a series of measures, including the isolation of suspicious cases, close monitoring of contacts, collection of epidemiological and clinical data from patients, development of diagnosis and treatment procedures for the diagnosis, and treatment and control of the outbreak (Zhu, Wei, & Niu, 2020).

Russia has the lowest dead/case ratio among the countries with the highest number of cases. Existing hospitals have been restructured to increase the capacity for COVID-19 patients in Russia. In addition to existing hospitals, temporary hospitals have been built for COVID-19 patients. In these hospitals, all costs regarding the test, maintenance and treatment for diagnosis and treatment of COVID-19 are provided free of charge. Although there is a shortage of healthcare professionals in some specialties, Russia has a large health workforce. However, 5^{th} and 6^{th}-grade medical students were also mobilized in the fight against the pandemic. In addition, to reduce the risk of coronavirus infection, all patients in hospitals are subjected to mandatory COVID-19 testing, even if they have different diseases. On the other hand, to minimize the contact of the public with health institutions, the validity period of the prescriptions was extended and the obligation of individuals with chronic diseases to go to the polyclinics for prescription was removed. The importance of these measures is more understood, especially given the role of health institutions in the spread of the disease. The treatment focuses on the application of blood plasma therapy taken from voluntary donors who have fully recovered to critical and severe patients (Schmitt & Vujnovic, 2020).

As of 29 May 2020, after the USA, Brazil is the second country where most cases seen in the world. Brazil has a mixed health system, everyone in the country has free access to the unified healthcare system (SUS), and about 80% of the population only benefits from SUS. Also, private healthcare services are provided by the private sector through private insurances (Castro et al., 2020). Brazil is one of the countries that has some advantages in the fight against COVID-19. The most important of these is that the population consists mainly of young people. Besides, Brazil is already one of the countries that suffer from public health emergency (PHEIC) with diseases such as polio, smallpox, cholera,

H1N1 (influenza A), bird flu, yellow fever, severe acute respiratory syndrome and Zika. Among the latest PHEIC, the H1N1 outbreak in 2009 and the Zika outbreak in 2015–2016 are remarkable. Both outbreaks provided the country with significant experience in how to deal with outbreaks. In addition, the country showed its success in the scientific field due to the relationship of Zika infection with microcephaly cases. However, the disadvantage is that more than half of the cases are concentrated in one region (in the South East region of São Paulo) and the prevalence of comorbidities and coinfections such as diabetes, hypertension, HIV, tuberculosis, obesity. Looking at the measures taken, 0.4% of GDP was allocated to the public health system with the outbreak. In this context, taxes and import duties on materials used by hospitals have been removed and import transactions have been simplified. Field hospitals have begun to be built and efforts are underway to provide respirators and increase the capacities of intensive care units. Doctors were allowed to examine online, and they were allowed to provide medical reports or prescriptions with electronic signature (Brady et al., 2019; Cimerman, Chebabo, Da-Cunha, & Rodríguez-Morales, 2020; Croda et al., 2020; OECD, 2020b).

In combating epidemics, it would be misleading to evaluate health system indicators only in terms of quantity. Efficiency and experience are also determinative in this combating. For example, according to the WHO, 2015a report, health sector expenditures are 17.1% of GDP in the USA, which is the country with the highest health expenditures, whereas in Singapore this rate is only 9.4% of GDP. However, Singapore is better (ranked second) than the US (ranked 44) in health indicators such as infant mortality rates. This shows the difference between the efficiency of health expenditure in the health care systems of both countries. We can give a similar sample for Bangladesh. With a population of around 165 million, Bangladesh has 7,000 fewer beds in isolation units and only about 1,622 healthcare professionals (595 are doctors) to treat COVID-19 patients. However, despite all these, the country has a highly developed public health system experienced in combating infectious diseases. Therefore, the history of the health system in combating similar epidemics also strengthens the hand of countries (Khan, Awan, Islam, & Muurlink, 2020; Ministry of Health and Family Welfare Bangladesh, 2020; Raeesi, Harati-Khalilabad, Rezapour, Azari, & Javan-Noughabi, 2018; WHO, 2015a, 2015b).

One of the points to be emphasized here is the changing roles of healthcare expenditures and healthcare capacity in combating COVID-19. Because the relative prices of goods and services differ in health expenditures, so costs can be determinant in expenditures. In this framework, there are many studies (Nolte and Mckec, 2004; Young, 2001; Zakir and Wunnava, 1999) that reveal that there is no significant relationship between health expenditures and health outcomes. Besides that, Khan et al. (2020), who focus on both health expenditures and health capacity in combating COVID-19, found that higher healthcare capacity is associated with lower case fatality rates in 86 countries. According to the study, each additional unit increase in health capacity leads to a 42% decrease in case of death. However, they argued that health expenditures were statistically insignificant.

Undoubtedly, it may be misleading to link the success criterion alone to existing health indicators in the fight against covid-19. In this context, the speed of the health system's response to the pandemic is also important. For example, when Germany was just at the beginning of the pandemic, it rapidly expanded the intensive care capacities of hospitals across the country. While there were 28,000 intensive care beds equipped with ventilators in January, this number was rapidly increased to 40,000 (Bennhold, 2020). Turkey also showed a similar attack, pandemic hospitals were built rapidly, especially in Istanbul where the epidemic was at the highest rate, and it was decided to open pandemic services in the existing hospitals. In fact, within the framework of the health policies that started before the pandemic, in recent years, the number of single-person patient rooms has been increased throughout the country with the aim of increasing qualified patient beds. This has facilitated the isolation and care of patients throughout the epidemic. Especially in large cities, city hospitals played a major role in combating the pandemic with qualified and single-person patient rooms, numerous intensive care beds, all units with state-of-the-art medical devices and materials during COVID-19. In this context, city hospitals, having a horizontal architecture with 1000 beds, one on the European side and one on the Anatolian side, that will make Istanbul ready for epidemics, earthquakes and all kinds

of disasters, were opened in 45 days (TÜSPE, 2020). Therefore, the speed of measures to strengthen the health system in the first phase of the epidemic has also been decisive in combating COVID-19.

Table 2 contains the Health System Responses of the countries regarding COVID-19. As can be seen from the table, in addition to the current health parameters, the speed of the response to COVID-19 is also important in success.

Table 2. Health system responses to COVID-19.

Country	Accelerate R&D for vaccines and treatment	Encourage telemedicine, smarter use of data for surveillance and tracking	Improve affordability of diagnostics and treatment for all	Increase access to mental health services	Increase supplies of diagnostic tests, protective equipment, ventilators, essential medicines	Mobilise and protect health workers	Optimise hospital beds and spaces f or diagnostics and treatments	Protection for the elderly	Additional funding/ financing for the health system
Argentina	X	X	X		X	X	X	X	
Australia	X	X	X	X	X	X	X	X	x
Austria	X	X		X		X		X	
Belgium		X	X	X	X	X	X	X	X
Brazil (national level)	X	X	X	X	X	X	X		
Canada	X	X	X			X	X		
Chile		X	X	X	X	X	X	X	X
China (national level)		X							
Colombia		X	X		X	X	X	X	X
Costa Rica		X	X	X	X	X	X	X	
Czech Republic		X	X		X	X	X	X	X
Denmark	X	X			X	X	X	X	
Estonia		X	X		X	X	X		X
European Union	X								
Finland		X	X		X	X	X	X	
France	X	X	X	X	X	X	X	X	X
Germany	X	X	X		X	X	X	X	X
Greece		X	X	X	X	X	X	X	X
Hungary					X	X	X	X	
Iceland					X	X		X	
India (national level)	X	X			X		X		
Ireland	X	X	X	X	X	X	X	X	X
Israel	X	X		X	X	X			
Italy					X	X	X		
Japan	X	X	X	X	X	X	X	X	X
Korea	X	X	X	X	X	X	X		
Latvia				X	X	X	X		
Lithuania			X		X	X			
Luxembourg	X	X	X	X	X	X		X	
Mexico		X	X	X	X	X	X	X	X
Netherlands		X			X		X	X	
New Zealand		X	X	X	X	X	X	X	X
Norway	X		X	X		X			
Other International	X								
Peru		X	X	X	X	X	X	X	
Poland		X				X		X	X
Portugal	X	X	X	X	X	X	X	X	X
Slovak Republic		X			X				
Slovenia	X				X	X	X		
Spain	X	X	X		X	X	X	X	
Sweden					X				X
Switzerland	X	X			X	X	X	X	
Turkey	X	X	X	X	X	X	X	X	X
United Kingdom	X	X	X	X	X	X	X	X	X
United States (federal level)	X	X	X	X	X		X		X

OECD 2020d. Beyond containment: Health systems responses to COVID-19 in the OECD. http://www.oecd.org/health/COVID19-OECD-Health-System-Response-Tracker.xlsx

The health system responses of the countries regarding COVID-19 are shown in Table 2. It is seen that Australia, France, Ireland, Japan, Portugal, Turkey and the United Kingdom fulfill certain criteria determined by OECD. It is seen that Germany, which is considered as one of the most successful countries in combating the epidemic, has taken all the measures included in the list, except for increasing access to mental health services. However, as we have seen in the UK example, if the health capacity is inadequate, providing conditions such as financing, R&D and technology support at the last moment can sometimes be inadequate in combating COVID-19.

To assess the epidemic process as a whole from the perspectives of the health professionals in Turkey and the United States, a few questions were directed. A nursing home worker who was consulted for the USA stated that even though the patients in the age group of 65 and over were provided services under normal conditions, even 43-year-old patients were served during the pandemic period. Patients with symptoms were kept in isolated rooms and the transmission of the epidemic was partially prevented, but since people who did not show symptoms could not be detected, transmission from the employee to the patient could not be prevented. According to health experts, the epidemic has significantly affected the perspective on the relative weight of the state and private sector in the health sector. Accordingly, the weight of the state in health should increase. With the increase in the number of cases, the health system started to clog, healthcare workers for both mental and physical health were insufficient, and therefore some temporary arrangements were made in the existing regulations. For example, in normal times in the USA, while clinical workers must know the laws of that state and pass the exam by taking courses to be able to care for patients in another state, this limitation has been temporarily removed during the pandemic period. A psychiatrist was able to see a patient living in a different state and prescribe medication, which is especially important for minority groups as it facilitates the opportunity to work with a specialist who speaks their language.

In Turkey, basic problems such as the inadequacy of test kits, the need for protective masks and equipment, and the public's inability to take the epidemic seriously enough were pointed out in the early stages of the epidemic. According to the Turkish doctors who were consulted, the following factors, in Turkey's success in the fighting pandemic, are the main factors stand out: Establishment of the pandemic scientific board by the Ministry of Health, shaping the policy recommendations in line with the decisions of the board, closely following the developments in the world, working together with the different scientific disciplines in the health field, accessing the medication easily, training all healthcare personnel on this issue, and establishing a treatment protocol quickly. The procedure followed in the diagnosis and treatment of the epidemic was applied differently depending on the stage of the disease: After the first examination and laboratory analysis of the patient, if the patient is in good general condition, does not have respiratory distress, and does not have a high fever, after the swab is taken for COVID-19, the patient is sent home, and it is recommended to be isolated in a separate room and to wear a mask at home while leaving his/her room. If the saturation of the patient evaluated in COVID-19 outpatient clinic is low, simultaneous tomography is also performed. According to PCR and tomography results, if there is pneumonia, appropriate treatment is started by hospitalization. Blood tests are performed intermittently on the patient, who is followed up daily, and patients with negative test results are required to be discharged and isolated at home for 14 days. During the treatment, patients who get worse and whose need for oxygen increase, are given oxygen support and ventilation with a CPAP mask first. If this is not enough, the patient is intubated and followed up in the intensive care unit. Those whose clinical and laboratory findings are arranged (within 5–14 days) are discharged.

In Figure 1 are presented COVID-19 adult treatment algorithm in Turkey. The table is important as it summarizes the diagnosis and treatment process of COVID-19.

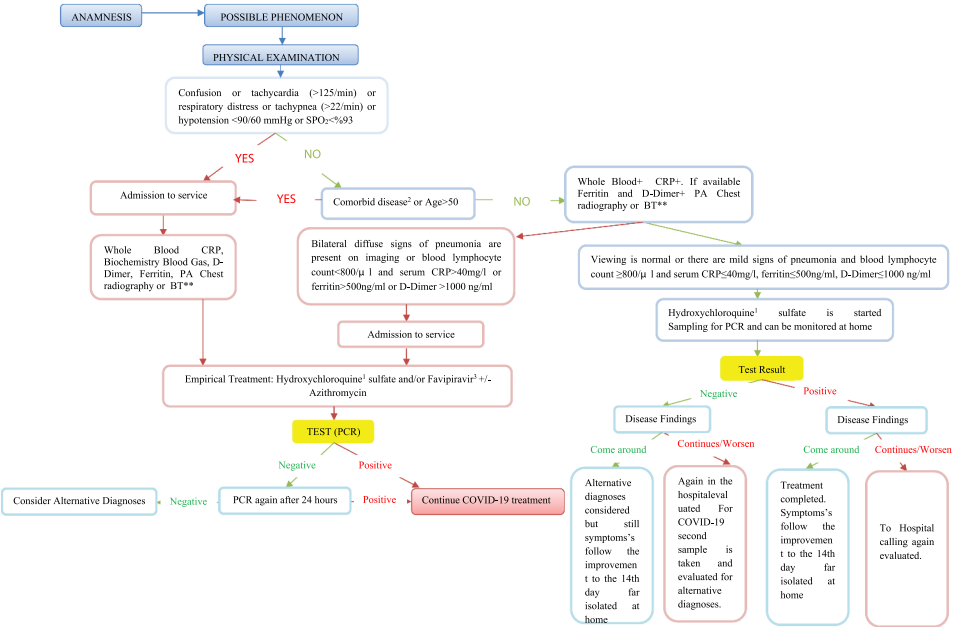

Figure 1. COVID-19 adult treatment algorithm. **Source**:T.C Ministry of Health, https://dosyahastane.saglik.gov.tr/Eklenti/165504,covid19-plkacilhastayonetimipdf.pdf?0

Simulation: artificial neural networks model

In 1958, The artificial neural network (ANN) introduced by Rosenblatt to model information processing of the brain, it is a mechanism that copies the human brain in order to achieve certain performance features (Rosenblatt, 1961). ANN is artificial intelligence application that are applied by engineering to implement specialized design tasks (Basheer & Hajmeer, 2000; Rafiq, Bugmann, & Easterbrook, 2001). ANN is a widely used method for estimating complex processes and pattern classification of multivariate datasets such as engineering, physics (Hakim et al., 2011; Işık, Toktamış, & Işık, 2020). The ANN model supposes that nodes (ie neurons) have their own values for processing data, and values are passed through connections through neurons. Then, each link has a weight that replicates the values transmitted in a neural network and applies an activation function to its input to determine the output value of each neuron (Cho, Sthiannopkao, Pachepsky, Kim, & Kim, 2011; Iliadis & Maris, 2007; Lee & Park, 2001; Tagluk & D Işık, 2019).

Last few years, it is commonly used in health and social science such as estimation of patient health management by using data of warnings, alerts, events and precautions (Ghavami & Kapur, 2012). In this study, it has been tried to develop methods to design better predictions and simulations for health systems. For some country, the values of 2020 were estimated using data from previous years of life expectancy at age 60 (years), current health expenditure (CHE) as a percentage of gross domestic product (GDP) (%), the density of medical doctors (per 10 000 population) and hospital beds (per 1,000 people).

The variation of density of medical doctors versus years is shown in Figure 2 for five different countries. The density of medical doctors increased with the increasing year for Turkey. There was a fluctuation for the others but generally increased. All the predicted data have similar characterizations with the real data of density of medical doctors. It can be observed that it is a quite successful prediction of the values of 2020 for the density of the doctor, and it was confirmed that the model in which the estimate was made was done with an accuracy of over 95%. Since countries and variables are

too many to be given in a single figure, only selected countries are included in the figure in terms of sampling, and 2020 values of other countries are also estimated.

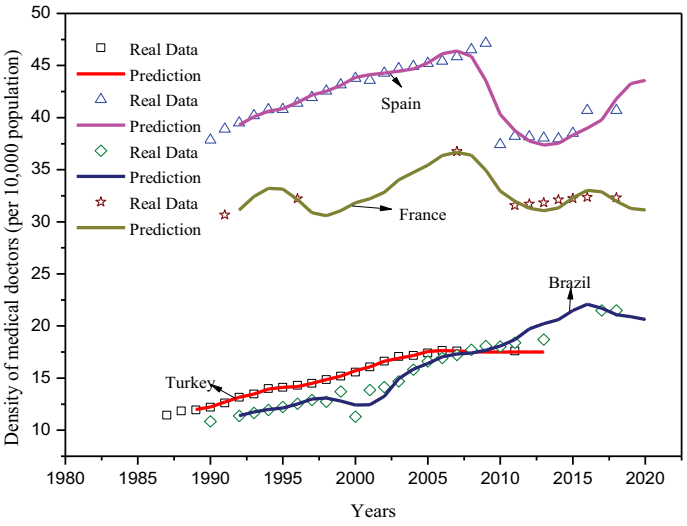

Figure 2. Predicted and real data of Density of medical doctors versus years for Turkey, Brazil, Spain and France.

In Figure 3, Density of hospital beds is plotted with respect to the year. There is a decrement in the density of hospital beds in all countries. There is a linear reduction in Germany until 2005, but it is observed that not a significant change in the density of hospital beds until 2020. The predicted 2020 values of all the variables are given in the table in section 3. In summary, the 2020 values of these variables were estimated with an accuracy rate of over 98% by using the ANN model, and at the same time, data belong the other years were simulated. These predicted values are used for OLS regression method.

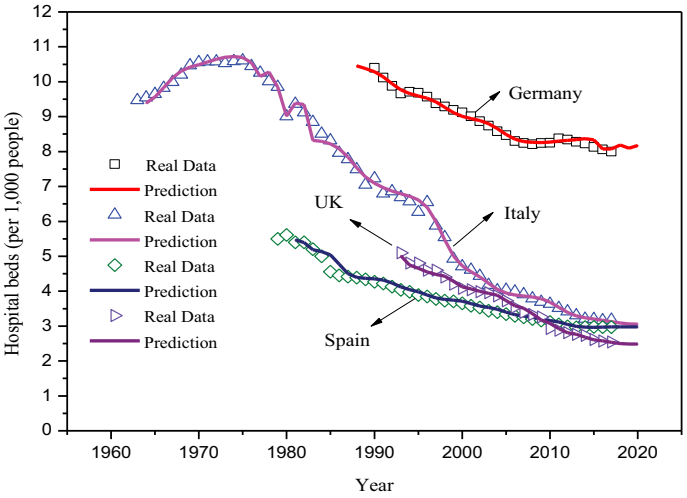

Figure 3. Density of hospital beds (per 1000 people) versus year of real and predicted data for Spain, Germany, UK and Italy.

Model and data set

In this study, the data of 2020 for 124 countries are analyzed with the cross-sectional regression method to determine the effect of the health system on Covid-19. The ratio of recovered patients to total cases is taken as the dependent variable. Independent variables are life expectancy at 60 years old, the number of hospital beds (per 1,000), number of doctors (per 10,000), and the share of health expenditure in GDP (%). Also, the dummy variable was used for Universal Health Coverage (UHC), which means that all individuals and communities can access the health services they need without financial difficulties. Accordingly, countries with the UHC system are denoted by 1 and non-UHC by 2. The Least Squares (OLS) cross-sectional equation is as in equation (1):

$$\text{Recovered} = \beta_0 + +\beta_1 HospBed + \beta_2 \text{Doctor} + \beta_3 \text{CHE} + \beta_4 LifeExp + \beta_5 UHC + u \quad (1)$$

The information about the variables in the model is shown in Table 3.

Table 3. Data Description.

Variables	Description	Data Source
Recovered	Rate of Recovered in Total Cases	Worldometer
Doctor	Density of medical doctors (per 10,000 population)	WHO
HospBed	Hospital beds (per 1,000 people)	OECD; Eurostat; World Bank
CHE	Current health expenditure (CHE) as a percentage of gross domestic product (GDP %)	WHO
LifeExp	Life expectancy at age 60 (years)	WHO
UHC	Countries that have passed legislation on Universal Health Coverage (UHC)	WHO

Note: All variables except Recovered and UHC are simulation estimates for 2020. For recovered, data of 29 May 2020 were used.

Empirical results

The estimation results obtained with the OLS method of the model, which deals with the relationship between health system components and Covid-19, are presented in Table 4.

Table 4. Result of OLS Regression.

Variables	Coefficient	Robust Std. Error	t-Statistic	Prob
HospBed	0.0206**	0.0095	2.16	0.033
Doctor	0.0026*	0.0014	1.85	0.067
CHE	−0.0107	0.0083	−1.29	0.200
LifeExp	0.0187**	0.0086	2.17	0.032
UHC	−0.019	0.0522	−0.37	0.715
Constant	0.1399	0.1626	0.86	0.391
Observation: 124				
R^2: 0.1748				
F (5,118): 5.03				

Notes: ***,** and * denote significance at the 0.01, 0.05, and 0.10 levels, respectively.

According to the analysis findings, there is a statistically significant and positive relationship between HospBed and the recovered/case ratio. Accordingly, while the other variables in the model are fixed, a 1 unit increase in HospBed increases the recovered/case ratio by 0.02 points. On the other hand, the most effective variable in the fight against Covid-19 is the number of hospital beds, which is one of the important indicators of the health infrastructure.

There is a statistically significant and positive relationship between the number of doctors and the recovered/case, one unit increase in the number of doctors increases the recovered/case ratio by 0.002 points. As the number of hospital beds, the number of doctors is an important criterion in the treatment of infected individuals. It is clear that the density of the doctor needed in carrying out the necessary medical interventions will have an effect on the recovered patient.

Another variable that affects the recovery/case ratio is the life expectancy at the age of 60, which is included in the model as an indicator of the health system. According to the estimation results, when there is a one-unit increase in LifeExp, the recovered ratio increases by 0.018 points. On the other hand, health spending has not statistically significant effect on the recovery/case ratio. When the health expenditures of the most successful/unsuccessful countries in the fight against Covid-19 in Table 4 are examined, it is seen that there is no correlation between the two variables, so the current insignificant relationship confirms the analysis results.

According to the study findings, where the countries that provide and do not provide universal health care are symbolized by the dummy variable, there is no statistically significant relationship between UHC and Covid-19. Relatively both the lower performance and higher performance countries offer UHC supports the analysis findings and the number of cases is high in both groups. This finding supports analysis results that there is no impact of UHC on the recovered.

Conclusion

The Covid-19 epidemic, which has been effective worldwide and led to the death of hundreds of thousands of people, brought about health system discussions. Especially in countries with high cases, the shortage of medical equipment and health personnel, especially the number of hospital beds, made it more difficult to control the pandemic.

In this study, the role of the health system in the fight against Covid-19 was analyzed using the cross-sectional regression method over 124 countries' data. According to the analysis findings, the number of hospital beds, life expectancy at 60 years old and the number of doctors increase the number of people recovering in total cases. The most effective variable on the recovered/case ratio among the independent variables is the number of hospital beds. During Covid-19, the most serious problems countries face are the number of medical supplies and hospital beds. In this context, the number of beds has an important place in the treatment of patients infected with Covid-19. Because, if the bed capacity is exceeded in hospitals, it is difficult to treat patients who are in critical condition. It is seen that countries that encounter these difficulties try to apply the treatment on different campuses. Estimation results also support the strong effect of the increase in the number of hospital beds on the recovered/case ratio.

In contrast, both the share of health expenditures in the GDP and the universal health coverage which indicates whether Universal Health Services legislation has been adopted are statistically insignificant on the recovered/case ratio. According to a recent OECD report, many factors such as health expenditure policies, elderly and needy population, and relative prices of medical equipment and medicines included in expenditures are determinant in the final impact of health expenditures. Accordingly, in 2016, three-fifths of health expenditures in the EU member states were provided for curative and rehabilitative care services, 20% for medical drugs, 13% for long-term care services and the remaining 7% spent on the management of the healthcare system and services. In this context, considering the share of medical equipment/tools and medical drug expenditures, it is seen that the current price differences among countries are an important factor in the level of expenditure. For example, the cost of medical products consumed in polyclinics, which is an important item of health expenditures, has an important share in total expenditures. Thus, the following factors affect expenditure regarding medical products consumed in polyclinics through the differences in distribution channels, the prevalence of generic drugs and the relative prices in different countries. These drug expenditures comprise a larger portion of health expenditures, especially in low-income countries. Similarly, the growing elderly population is putting more pressure on the health system. Another point to be emphasized is the necessity of effective and productive expenditure policies rather than the level

of expenditures in combating pandemic. In this context, what needs to be discussed is the level of supportiveness of these expenditures in combating pandemic (OECD, 2018). Many parameters such as relative price, cost, income per capita, pollution level, age structure of the population and dependent population rates are important determinants in health expenditures. Therefore, it is misleading to evaluate health expenditures alone in combating the pandemic. In addition to these, considering the negative effects of excessive drug use and unnecessary antibiotic use on the immune system, it is impossible to say that health expenditures alone are effective health policy and public health tool. Moreover, when looking at the health expenditures of the most successful/unsuccessful countries for the correlation between health spending and the fight against Covid-19, statistically meaningless relationship finding confirms the argument. Similar findings were obtained for UHC. The estimation results show that there is no difference between countries that have and do not have the universal health system in the fight against Covid-19, that is, the UHC variable is statistically insignificant. When the Covid-19 case and recovery ratios (Table 4) are analyzed, the UHC indexes of the countries that have both the best and the worst performances in the fight against the outbreak support the analysis findings.

Note

1. * City hospitals are large health complexes with high bed capacity and intensive care units built and operated in a public private partnership.

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