MEASURING HEALTH SYSTEMS RESILIENCE: A COMPARATIVE STUDY OF TURKEY'S HEALTH SYSTEM DURING COVID-19 PANDEMIC

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***Abstract*—The recent outbreak of the COVID-19 pandemic has drawn significant attention to the topic of health-system resilience. Many countries have taken certain measures to deal with the negative outcomes of the pandemic and to improve their health systems. Having a resilient health system during pandemics ensures the continuity and success of healthcare services. Resilience, as a concept, represents a proactive rather than a reactive approach to overcoming the negative outcomes of disasters. Understanding the characteristics of a resilient health system will help to strengthen the health systems for future pandemics or any other disasters. In this research project, characteristics of resilient health systems are investigated using a framework based on three main dimensions of systems resilience: (1) a system's capability to decrease its level of vulnerability to expected and unexpected disruptive events, (2) its ability to change itself and adapt to the changing environment; (3) its ability to recover in the least possible time in case of a disruptive event. Based on this framework, four attributes of resilience are identified, namely agility, adaptability, flexibility, and vulnerability. Further, these attributes of resilience are evaluated using country-specific COVID-19-related qualitative and quantitative data from Turkey and compared with several other countries. Suggestions and further recommendations are provided on how to measure and improve the resiliency of health systems for future pandemics.**

***Index Terms*—Resilience, Health Systems Resilience, COVID-19 Pandemic, Turkey's Health System, Resilience Assessment**

I. INTRODUCTION

The operations of health systems have come under pressure from disruptive events such as pandemics, natural disasters, economic crises, man-made disasters, and many other similar unexpected and inevitable events. Realization of these inevitable, unexpected and unforeseen events such as the COVID-19 pandemic has brought much attention to the concept of resilience in health systems. From a 'systems engineering' perspective; resilience, as a concept, represents a proactive approach to risk, accepts the reality of unforeseen and inevitable disruptive events; but rather focuses on designing, developing and maintaining systems to manage the negative consequences of such risks. The health systems were not ready to deal with such a pandemic of this magnitude. Some health systems have reacted better than others and some health systems have had serious negative effects. This article summarizes the preliminary results of an ongoing research project designed to investigate the characteristics of resilient health systems using a system engineering perspective. A model was developed to measure the resilience of health systems during pandemics. This model was used to measure the resilience of Turkey's health system using country-specific COVID-19 pandemic-related data from Turkey and was compared with several other countries.

II. LITERATURE REVIEW

The literature review has been conducted gradually; from understanding the concept of resilience, researching the relative concepts of resilience, obtaining systems resilience and health systems resilience definitions, and investigating resilience measurement models and how resilience measurement models can be applied for health systems. Finally, specific emphasis is given for the recent literature about health system's resilience during COVID-19 pandemic. Selected literature which has been provided as a conceptual baseline for our research is summarized in Fig. 1.

Fig. 1. Graphical Representation of the Examined Articles

The COVID-19 pandemic has brought much attention to the concept of resilience in health systems. Resiliency in health systems has been the focus of many researchers in this field. There has been an ongoing effort to propose and publish current advancements in the area of health systems resilience and responses towards COVID-19. Although resilience has been a highly discussed concept within systems engineering research, it has not been adapted for health systems until the early 2000s. As shown in Fig. 2, the concept of resilience in health systems is first discussed in a report published by the World Health Organization (WHO) in 2007 and starting in 2020 with the outbreak of COVID-19 health systems resilience has gained more attention. [1]–[7].

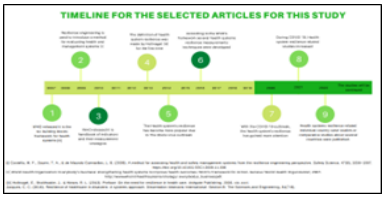

Fig. 2. Timeline for the Selected Articles

A study published in 2019 summarizes the contributions made by several countries Fig. 3 the United States, United Kingdom, Australia, and Canada were the countries where majority of resilient health systems related work have been published. On the other hand, we have observed that many other countries have lately contributed to the topic of health systems resilience.

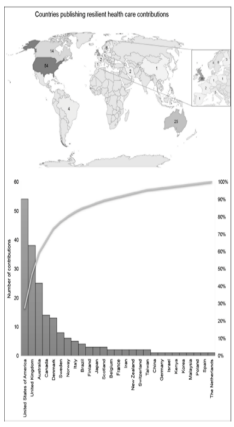

Fig. 3. The Countries Publishing Resilient Health Care Contributions

III. SELECTED CONCEPTS FROM LITERATURE REVIEW

Concept of Resilience

The concept of resilience has been frequently used and discussed in the literature in a range of disciplines including materials science, ecology, organizational theory, economics, risk management, sociology, psychology, and computer networks. The word resilience is defined as the ability to recover from or adjust easily to misfortune or change [9].

Systems Resilience

Resilience is identified as an inherent attribute of a system in most of the definitions found in the literature [15], [22]–[26]. Another key aspect of these definitions is that resilience is defined as a system-wide attribute which focuses on the behavior of the system as a whole [15]. Most of these definitions of resilience can be applied to any type of system—from natural to engineered. Additionally, many researchers have agreed that creating resilience requires holistic systems approach [16], [17], [27] and we should investigate ways to identify any patterns of resilience observed in ecological systems and adapt them to engineered systems [9], [28].

Health Systems Resilience

In health systems, the developments and improvements made by making predictions against risky situations the ability to adapt to these situations quickly and the capacity of the financial, equipment and health system according to the existing conditions and the concept of resilience in health systems are strongly defined. In this context, resilience can be evaluated as having a significant effect on health systems. Although the different types of resilience in health systems-related studies have been brought to the literature in the last twenty years, considering the epidemic diseases experienced in 2013 and afterwards, health services have continued to work on the issues of security, quality, and performance in the perspective of the system of resilience. However, the health system is a multi-scale, adapted, and interactive system that surrounds each other. Resilience in the health system is the focus of this literature review. First, resilience definition and explanation studies are investigated in the health system. After that, the literature on the definitions, measurement, simulation, and syntheses in the joint studies are examined. As a result of examining the studies in the last six years, the definitions of resilience in the health system are compiled. It is the capacity of health actors, institutions, and populations to be prepared and effectively respond to crises, to maintain basic functions while crises exist, and to inform with lessons learned during the crisis, and to reorganize them if circumstances require [29]. It is the ability of an emergency such as Ebola to absorb shock, and to continue to provide regular health services and to operate the other sectors of the country fully [30]. Despite an unstable climate, it is the ability to predict, respond, cope, and adapt to climate-related shocks and stress to ensure continuous improvement in population health [31]. Resilience is the capacity to absorb internal and external shocks while maintaining success and to maintain functional

health institutions [32]. Resilience in the context of health systems is the capacity of the health system to recover, which is often framed as the capacity to absorb shocks measured by health outcomes and to sustain gains [33]. Resilience is defined as maintaining positive harmony under harsh conditions so that the organization can strengthen from harsh conditions and emerge more resourcefully [34]. The resilience of healthcare facilities is defined as the ability of a hospital to resist an event, absorb disaster shock, and quickly return to its original state or adapt to a new condition while maintaining its medical capabilities [35]. Resilience in the health system is about (i) everyday resilience, not simply a response to sudden shocks, (ii) health system software, not only its hardware, and (iii) creative adaptation, and transformation, rather than simply bouncing back [36]. Its capacity to adapt, absorb and transform when exposed to a shock such as a pandemic, natural disaster, armed conflict or financial crisis and still retain the same control over its structure and functions [37]. Resilience is both a function of planning and preparing for future crises and adapting to chronic stresses and acute shocks. Beyond resilience to acute shocks, routine and chronic stress resilience of healthcare systems is the key [38]. It is able to adapt its function to absorb a shock and transform it if necessary, in order to get rid of the disaster [39]. Resilience means adaptability in the context of robustness. [40]. Resilience is defined as a capacity that allows the healthcare system to return to its ”normal and usual” function when faced with a shock/stress [41]. Resilience in healthcare is the capacity to adapt to challenges and changes at dissimilar system levels to maintain high-quality care [42]. A method for the evaluation of health and safety management systems is introduced with the Resilience engineering perspective [43]. It is aimed to understand the concept of resilience, the risk between cultures, comprehensive and meaningful measurement of resilience, and to make research subjects sustainable health practices. Existing insights about risk and resilience have been synthesized [44]. In the study, the delivery of healthcare, which is a complex system, is evaluated, and the value of adaptable capacity and margin as well as its vulnerability and dangers are discussed [45]. This study proposes several new methods. The first tool is a new resilience metric, the second tool is a detailed error tree analysis of healthcare services, the third tool is a standard survey and analysis methodology. These tools addressed the issue of examining the flexibility of health systems and facilities in the United States and New Zealand in several ways [46]. Between 2011 and 2013, the population growth caused by the influx of Syrian refugees constituted a shock for the health system and provided an opportunity to examine the resilience in the health system. Factors contributing to the resilience of the Lebanese health system have been investigated. The input-process-output-result approach is used to evaluate resilience in the health system [32], [35] developed a simplified model that can describe the ability of the Hospital Emergency Department to serve all patients after a natural disaster or other emergencies. In this article, patients' waiting time (WT) is determined as the main parameter to evaluate the resilience indicator of the Emergency Department. The methodology section describes the method for the development of an Emergency Department (ED) meta model. Different scenarios are considered for the construction of the meta model, considering the intensity of the seismic input and the number of functional emergency rooms. The proposed model can be used by any hospital to measure the performance of the Emergency Room and to estimate its disaster resilience without performing complex simulations [35]. Present a long-term, primarily qualitative research in three different district health system settings in Kenya and South Africa and adopts the principles of case study research methodology and meta-synthesis in its analytical approach. The analysis emphasized that for resilience, it is a combination of strategies that take advantage of broader organizational capacities and resources, embedded in relationships and managerial routines [34]. This article presents a new framework for the analysis of health systems resilience. This framework extends previously existing frameworks from ecological science to the study of health systems. resilience is defined here as the ability of a healthcare system to absorb, adapt, and transform when exposed to a shock, yet still, retain control over its structure and functions. Therefore, it is concluded that healthcare systems are resilient if they exhibit absorbent, adaptive, or transformational capacity in the face of different intensity shocks [37]. Three case studies, including several authors, in which major health shock contributed to the improvement of health system resilience are examined. The article discusses chronic system dysfunction worsening from a population influx in Lebanon, a sudden and serious infectious disease epidemic in Liberia, and repeated, expected disaster shocks in Indonesia. Various country experiences such as Lebanon, Liberia, and Indonesia have been shown how to create resilience after health crises [47]. The domestic response to the Ebola virus disease epidemic between 2014 and 2016 aimed at a control system that could improve health sector resilience to future infectious disease events and identify health-related planning and operations directly based on operations, and qualitatively analyzed. Health facility problems, psychosocial impact, unit staff, staff training, and appropriate personal protective equipment output are obtained. It is intended to strengthen the resilience of health systems [48]. This paper is to review the resilient health care literature via multiple analysis, to examine the growth and global longitudinal trends through bibliometric analysis and the influence of this body of work through citation and network analyses. The results are divided into four themes. As a method, simulation has been seen as a prominent research tool to understand endurance [49]. The health system resilience has been studied and shows that the capacity oriented resilience frameworks are generalize for healthcare systems facing difficulties. The proposed resilience framework has promised to guide strategies for providing ongoing care in these contexts [41]. It is aimed to develop a conceptual understanding of the resilience of health systems. The clarity and precision of the concept of health systems resilience are evaluated by using the term,

sense, and referent dimensions [50]. Five building blocks of the health system in Spain against the COVID-19 pandemic are examined [51]. This study has been made to determine the basic operational concepts of resilience for researching resilience in health services and to propose the definition of resilience work of health services that form the basis of international resilience in the health research program [42]. A scoping review is conducted to determine the definitions and properties of resilience in the health system [52].

IV. SUGGESTED FRAMEWORK TO MEASURE HEALTH SYSTEMS RESILIENCE

1. Defining Health Systems Resilience and Its Key Attributes

System's resilience is defined as the capacity to decrease vulnerability, the ability to change and adapt, and the ability to recover quickly from disruptions [9]. Based on this definition; below definition can be derived: Health systems resilience is defined as its capacity to decrease vulnerability, the ability to change and adapt, and the ability to recover from disruptions.

2. Measuring Health Systems Resilience

The literature review identifies four attributes to further define and measure resilience: decreased vulnerability, increased flexibility, adaptability, and agility. In other words, system resilience is a function of its level of vulnerability, flexibility, adaptability, and agility Fig. 4.

$$\text{Health System Resilience} = f\,(\textit{Minimized Vulnerability}, \textit{Maximized Flexibility}, \textit{Maximized Adaptability})$$

Fig. 4. The Definition of the Health System Resilience Formula

3. Creating Health Systems Resilience

Some key characteristics are needed to measure the resilience of the health system. It contains four main characteristics which are agility, adaptability, flexibility, and vulnerability. The definitions of these concepts are as follows:

Agility:In the event of a situation that may create a crisis in current health conditions, it is to take quick action and develop the system according to new conditions to prevent this crisis and update the health system according to the new situation. Health systems need to activate themselves to the process as quickly as possible, to always offer the closest optimal solutions and services.

Adaptability: Health systems can change according to developing technology and current health conditions. Accordingly, it is the ability to quickly adapt to changing conditions and the ability to adapt the requirements of the system according to the criteria of the existing conditions.

Vulnerability: The absence of any precautionary infrastructure against this situation in the health system in dangerous situations such as pandemic events that may arise in a health system, the lack of systemic deficiencies and the insufficient protective systems that can be taken against the situation.

Flexibility: It is the ability to use and manage the health systems efficiently by adapting the equipment and infrastructure in the system to the situations without any interruption or trouble according to the developments and improvements made in the health systems. According to this formula, Fig. 4 suggested model is created as shown in Fig. 5.

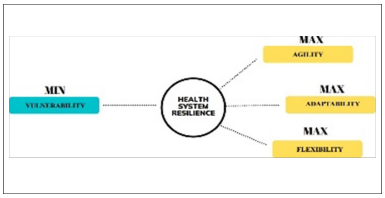

Fig. 5. Suggested Framework for Health Systems Resilience

V. METHODOLOGY

In this research project, the resilience of Turkey's health system was evaluated both qualitatively and quantitatively. A research study which evaluates the health systems resilience of 28 different countries [53] was selected as a reference work for the qualitative evaluation. Using this reference work, Turkey's response to COVID-19 is evaluated. On the other hand, another reference work was selected for the quantitative evaluation [54]. Two indices are created, inspired by the work by Coccia and Alberto [54]. For these two indices, five factors are chosen to evaluate the resiliency and preparedness of health systems. The calculation of this data by the study is shown in Fig. 6 and Fig. 7.

Factor1: Cumulative Deaths/ Cumulative Cases rate is obtained by proportioning the cumulative death and case numbers from 3^{rd} January 2020 to 1^{st} June 2022. This rate shows how many sick people died as a percentage. This factor is chosen because the quality of work of patient service can be observed in this evaluation [55].

Factor 2: Mortality rate is given by (the number of deaths divided by population of the country) inhabitants from 3rd January 2020 to 1^{st} June 2022 [56] argue that actual case numbers appear vague, whereas mortality number related to COVID-19 can be a precise indicator of the negative impact on society. Hence, the mortality rate is a main indicator to evaluate the effects of COVID-19 in society, reducing whenever possible under reporting and/or under detection of COVID-19 cases. [55]

Factor 3: People Fully Vaccinated is given the total number of people who received all doses prescribed by the initial vaccination protocol from 2^{nd} December 2020 to 1^{st} June 2022. [57]

Factor 4: Total Vaccinations are given by total number of COVID-19 vaccination doses administered from 2^{nd} December 2020 to 1st June 2022.

Factor 5: Health expenditure (percentage of GDP) in 2019 (last data available) is a proxy of the efficiency of health systems. Level of current health expenditure expressed as a percentage of GDP includes healthcare goods and services consumed during each year. This indicator does not include capital health expenditures, such as buildings, machinery, IT and stocks of vaccines for emergency or outbreaks. [58]

Additional factors. Population in selected countries in the 2020. The number of persons having their usual residence in a country on 1 January of the year 2020. When usually resident population is not available, countries may report legal or registered residents. [59]

A. INDEX R (AS RESILIENCE) OF COUNTRIES

Index r indicates the capacity of health system preparedness and in general of the governance of countries to minimize the mortality rate in the presence of rapidly changing scenarios given by pandemic threats in society.

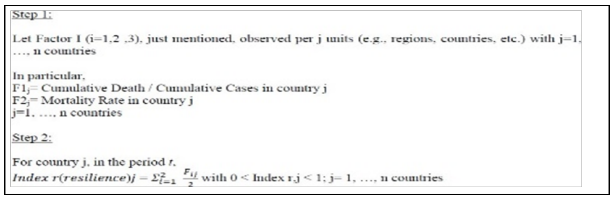

Fig. 6. Calculation of the Index r (resilience) (WHO Coronavirus (COVID-19) Dashboard — WHO Coronavirus (COVID-19) Dashboard with Vaccination Data, n.d.) (Population, Total — Data, n.d.)

The ranking of the Index r for j countries in increasing order indicates the performance of resilience of countries in terms of health system preparedness in the presence of an unforeseen pandemic threat;

- Index r, j = 0 indicates the best performer country j with a low negative effect of pandemic threat in terms of mortality rate in society
- Index r, j = 1 indicates the worst performer country j with a high negative effect of pandemic threat in terms of mortality in society

B. INDEX P (AS PREPAREDNESS) OF COUNTRIES

Index p indicates the capacity of the governance of countries to stop and/or reduce the impact of future pandemic threats by maximizing the vaccinations and supporting rapidly a normal operation of economic systems satisfying population needs.

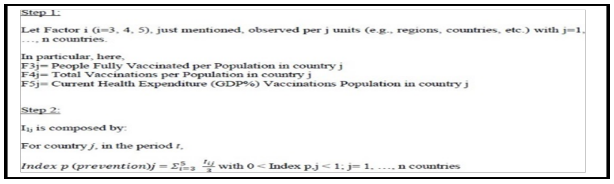

Fig. 7. Calculation of the Index p (prevention) (Coronavirus (COVID-19) Vaccinations - Our World in Data, n.d.) (Current Health Expenditure (GDP) — Data, n.d.) (Population, Total — Data, n.d.)

As the goal is the maximization of vaccination, the ranking of the Index p for j countries in decreasing order indicates the performance of the governance of countries to stop and/or reduce the impact of future pandemic threat supporting an optimization of vaccinations for leading rapidly to a normal operation of economic systems and satisfaction of population needs.

In this case,

- Index p, j = 1 indicates the best performer country j with a high proactive capacity to stop epidemics and support a recovery of economic system, satisfying population needs.
- Index p, j = 0 indicates the worst performer with a low capacity of reaction and adaptation to stop future negative effects of pandemic threats and consequential damages for socioeconomic systems

Properties of the indexes:

- Range of variation. Indexes have a range of variability in the set of real numbers given by [0, 1]
- *Transitive property*. If Fi, $j \leq$ Fi, j+1 $\rightarrow$ indexes $j \leq$ indexes $j+1$
- Symmetry property. If F i, $j = Fi$, $j+1$ j+1 $\rightarrow$ indexes j= indexes $j+1$ for $I = 1, \ldots, m$ factors, $j = 1, \ldots, n$ countries

The j^{th} units (countries) are classified from 1^{st} to nth rank according to the value of suggested indexes. Particularly, a rank close to the 1^{st} position indicates a best-performer country for the proposed index, and a rank close to n (last position) suggests a worst-performer country in terms of resilience and preparedness for pandemic threats. This novel method of measuring the performance of countries to cope with the pandemic threat with indexes that synthesize multivariate factors, representing them to rank countries is an important finding because this ranking presentation makes it easy for the human mind to grasp many of the essential aspects of the general performance of countries in the presence of a pandemic crisis.

VI. DATA COLLECTION

The data is collected about COVID-19 from three sources including research papers, industry reports, and statistics [57] until June 1, 2022.

The data set includes thirty-seven countries and five factors. These factors are used to create two indexes and graphics. These evaluations determine the level of Turkey among the countries. The primary purpose of this evaluation, in line with the project, is mortality rate and cumulative death/ cumulative case rates to determine the resilience levels of countries by directing the data during the pandemic period and health systems are evaluated by taking the average of people fully vaccinated, total vaccinations and current health expenditure values to measure preparedness. As output, the results of these data are displayed graphically, and the levels of the countries are determined more clearly. In this direction, countries are examined separately in each chart and their status is shown in terms of each parameter. The selected countries are selected from the countries that provide us with options that will give us results in all conditions. Also, data such as population and total vaccination are added to the evaluation. Mortality rate Deaths - cumulative total/population ratio is calculated. To determine health resilience with all necessary data, index calculations are made for each country.

VII. RESULTS

A. QUALITATIVE COMPARISON

In the reference article [53], many general issues are discussed in terms of pandemic process management such as countries' finances, government support, medical equipment, contact tracing policies, quarantine strategies, increasing the capacity of the health system, etc. Since one of the primary purposes of this project is to determine the way Turkey handles the pandemic process and in which areas superior action has been taken and studies are being carried out, the base information has been defined accordingly. In the same 28 Countries article, one-to one reviews for countries are collected and data for each criterion for Turkey are collected and tabulated in line with the research.

At the same time, in addition to the 28 countries taken as a basis in the article, which is one of the aims of the project, Turkey's evaluations are made as to the 29th country. And in this way, in case of a possible pandemic in the future, one of these decisive criteria, Governance approach, Coordination with scientific advice, Cost of COVID-19 treatment services, Cost of diagnostic testing, and Financial relief packages to individuals/ households/ businesses, Involvement in providing essential services, Risk communication strategies for the community, and Government providing a channel for feedback on national strategies, Construction of new treatment facilities, Converting public venues into treatment facilities, Re-configuring existing medical facilities, Postponement of elective medical procedures, Increased usage of digital health technologies for regular consultations, Primary-care providers as the first point of contact before triaging to onward care, Strategies to rapidly expand health workforce capacity, Reallocation of healthcare professionals, Pandemic related training for healthcare professionals, Mental health support for the health workforce, Financial support for the health workforce, Preexisting national stockpiles, Measures to increase domestic production volume, Measures to facilitate the import of medical products, Measures to restrict the export of medical products, Receiving donations of medical products, Securing grants or loans for procuring medical products, Guidance principles released for the rational use of medical products, Advance-purchase agreements with pharmaceutical companies, Participation in the COVAX facility, Platforms to monitor supply chains, Diagnostic testing strategies, Increasing laboratory capacity, Contact tracing policies, Contact tracing teams, Quarantine, Self isolation strategies (home-based), Self-isolation strategies (designated facilities, Social and economic support for the general public to aid adherence to public health interventions, Surveillance strategies, Contact tracing technologies, and Online or phone-based cases When examining forty-one aspects as management tools for the public, it is possible to have clear information about the criteria and points of Turkey. In this way, it is integrated to shed light on which areas can be improved in future studies and how to make the resilience of the health system sustainable. When Turkey's data, is updated over time, it will also be clarified at points that cannot be known.

When the data is examined, it is possible to access the points where Turkey has agility, adaptability, flexibility, and vulnerability. In light of the data, quarantine strategies for Turkey, taking teams and actions for contact tracing, strengthening health systems in line with the pandemic, being agile in the supply of medical products, adapting to the process from the first point of the pandemic, financial supports, funds and It can be clearly observed that agile actions have been taken in many areas such as making restructurings, providing strong health services at home, in the hospital and online by strengthening the technological infrastructure, making phone follow-ups, being able to work flexibly in the filiation teams and providing patient follow-up, configuring isolation strategies in a wide area, etc. This has been a part of a study that will help to have an idea about the future pandemics that may occur and to get an idea of what should be correct and fast.

The evaluations in terms of service delivery, medical products, health information, health workforce, leadership, and government and finance are included in this paper, in line with the evaluation of forty-one criteria created for Turkey. This suitability has been determined in terms of agility, adaptability, flexibility, and vulnerability. Whichever of the four characteristics matches the criterion evaluation to be added is integrated accordingly. As a result, situations such as speed, adaptability, flexibility, and lack of points in terms of actions taken by Turkey could be determined. Especially with the start of the pandemic process, it can be clearly observed. Turkey got involved in the process quickly and that they are able to adapt their systems and shares according to the COVID-19 pandemic process, both in terms of health and in different aspects. From an Agile perspective, Turkey's ability to take these actions in a short time provides information in terms of situations such as the government's immediate notification over social media, the initiation of PCR tests one week after the emergence of the virus, and the initiation of the construction of the Atatürk Airport and Sancaktepe Hospital in the same way.

In Adaptability, it is seen that Turkey has made technological and digital developments by adapting to the process immediately. These digital applications and technological developments have helped the public in processes such as providing information, patient follow-up, and controlling the process. In addition, many contributions have been made by Turkey, such as creating financial funds and increasing the capacity of the laboratory, to be resilient in the pandemic process management. In the Flexibility section, it has been examined from many points, such as dentists taking part in the filling teams, the sharing of financial support in terms of the health workforce, and the ability of the teams to follow up online, from home, and from the hospital in terms of health information. To summarize, there are serious studies in Turkey in terms of flexibility. Thanks to its adaptability and flexibility to the process, it is possible for us to achieve the idea of successful flexibility. Since no item suitable for vulnerability could be found among the items in the Turkey assessment based on forty-one criteria, different sources are searched

to make the vulnerability assessment. From a vulnerability, according to April 2020, it can be said that refugees have difficulties accessing medical products and are vulnerable in terms of information.

B. QUANTITATIVE COMPARISON

According to the Fig. 8 Argentina top on the list. It has a high number of vaccines. In terms of total vaccination per population, it is followed by New Zealand, Switzerland, Norway, Denmark, Israel and Australia. If we look at Turkey, it is in the 5^{th} place the last among the thirty-seven countries examined. Accordingly, it can be said that Turkey has good resilience in the process in terms of vaccination. Because it is in more than half of thirty-seven countries. This can be a good reference that it is not mismanaging the situation and the process. Pakistan is one of the countries with the lowest figures. This is followed by the United States, India, the Russian Federation, Turkey, and Thailand. Because high total vaccines per population is a good resilience trait, countries with a high rate do well, while countries with a low rate are positioned as a hard spot in terms of resilience.

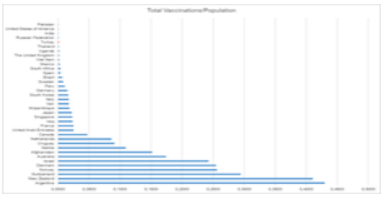

Fig. 8. The Comparison Graph of the Total Vaccinations per Population

When we look at the current health expenditure GDP in Fig 9, it can be observed that the country at the top of the ranking is the United States of America. The ranking is Afghanistan, Germany, Switzerland, France, Sweden, and Canada follows. Since these countries are data that will increase current health expenditure parameter resilience according to the graph, higher resilience results in better resilience. Therefore, the top five countries with the highest rates are in the best position in terms of resilience. Additionally, Turkey is in 31^{st} place here. It has really a not good location among thirty-seven countries for the current health expenditure parameter. Also, the countries that are at the lowest levels in line with this parameter, are India, Pakistan, Thailand, Uganda, Singapore United Arab Emirates, and Turkey. At the lowest level in India. According to the result of this analysis, according to the current health expenditure GDP parameter data, India is the country that is not in a good position among thirty-seven countries.

When we look at the People fully vaccinated/population, Fig. 10, it can be observed that the country at the top of the ranking is the United Arab Emirates. The ranking of Singapore, South Korea, Spain, Australia, and Peru follows. Since these countries are data that will increase people's fully vaccinated resilience according to the graph, higher resilience results in better resilience. Therefore, the top five countries

Fig. 9. The Comparison Graph of the Current Health Expenditure

with the highest rates are in the best position in terms of resilience. Additionally, Turkey is in its twenty-ninth place here. It has a not good location among thirty-seven countries for the people fully vaccinated/population parameter. Also, the countries that are at the lowest levels in line with this parameter, are Mexico, Pakistan, Russian Federation, Serbia, South Africa, Uganda, Iraq, and Afghanistan. At the lowest level in Afghanistan. According to the result of this analysis, according to the doses of vaccines administrated parameter data, Afghanistan is a country that is not in a good position among thirty-seven countries.

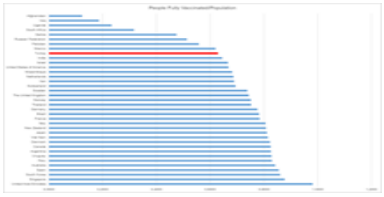

Fig. 10. The Comparison Graph of People Fully Vaccinated per Population

Looking at the mortality rate, Fig. 11 it can be observed that the country with the highest rate in the ranking is Peru. Countries that follow this ratio in a similar direction are Brazil, the United States of America, Argentina, Italy, The United Kingdom, the Russian Federation, Mexico, and Serbia. According to the mortality rate parameter, Turkey ranks twentieth out of thirty-seven countries. Turkey's being on the list on average can be a reference for neither very good nor very bad. The countries of Australia, Singapore, Japan, United Arab Emirates, New Zealand, Afghanistan, Pakistan, Uganda, and Mozambique are on the lowest list in the mortality rate ranking. The fact that this rate is low can be interpreted in terms of applying a more powerful and dynamic system in terms of resilience. While creating the Cumulative Deaths per Million chart, the cumulative death numbers of thirty-seven countries covered until June 1, 2022, are divided by one million. As in the cumulative cases per million charts, the USA has the highest value in this evaluation. New Zealand is at the top of the list with the lowest value. In this case, issues such as population, and death registration sensitivity in countries may be a factor. Turkey ranks 15^{th} among these thirty-seven countries and is in a better position on the cumulative death per million charts than the cumulative cases per million charts.

While creating the Cumulative Cases per million charts, the total number of cases of the countries covered until 1 June 2022 is shown as per million. According to the chart, the USA

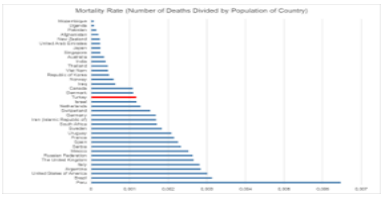

Fig. 11. The Comparison of the Mortality Rate of Countries

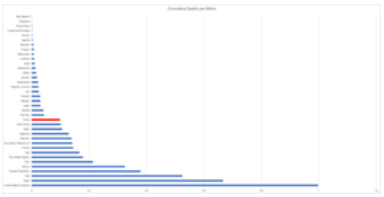

Fig. 12. The Comparison of the Cumulative Deaths per Million

has the highest value for the cumulative cases per million and the lowest country is Uganda. In this case, the ranking may have been like this because the populations of the countries are also factors. On the other hand, Turkey is tenth among these thirty-seven countries examined. Looking at the cumulative cases per million parameters for this situation, it cannot be said that Turkey is in a very good spot.

The Resilience Index is created by averaging the mortality rate and cumulative death/ cumulative cases values for each country separately Fig.6. Since these averaged factors have a negative effect on resilience, it is a negative situation that the resilience index obtained is large. In other words, the country with a large resilience index is in a worse condition than the country with a small resilience index. The thirty-seven countries considered for evaluation are ranked according to this index and colored according to their status. Looking at the ranking, Peru has the highest resilience index, and it can be interpreted as being in poor condition based on this index. Countries such as Mexico, Afghanistan, and South Africa are also among the countries with a high resilience index indicated in red. On the other hand, New Zealand has the lowest resilience index and is the best in this ranking. Countries like Singapore, Australia, and South Korea are next, and they do well in this order. Looking at Turkey, it is observed that it is in the middle of the resilience index. It is 16^{th} out of thirty-seven countries, and this shows that Turkey is neither too bad nor too good.

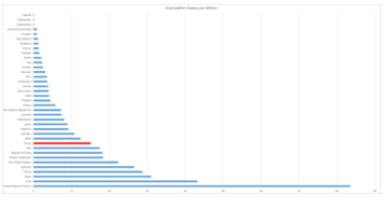

Fig. 13. The Comparison of the Cumulative Cases per Million

As stated in the Fig.6 the averages of people fully vaccinated, total vaccination, and health expenditure to GDP are taken. The fact that this value obtained as a percentage is large is a good situation for the country. In this context, the countries are ranked according to the preparedness index and the ranges are indicated with colors. According to this ranking, Iraq has the lowest index, showing that it is bad on a preparedness index basis. In addition, countries such as Uganda, Afghanistan, and South Africa are also at low levels in this ranking. Looking at Argentina, it is seen that it is at the top of this ranking.

This is an indication that the country is in the best condition among these thirty-seven countries based on the preparedness index. As can be seen later, countries such as New Zealand, Denmark, and Australia follow the ranking and these countries also have a high preparedness index, that is, they are in good shape when interpreted for this index. Considering Turkey, it ranks 30th in thirty-seven countries.

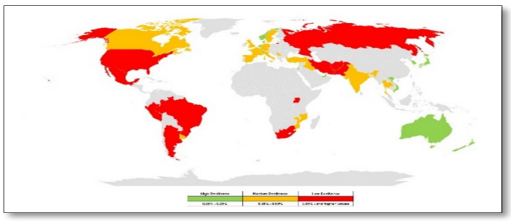

Fig. 14. The Colored World Map According to the Resilience Index

As a result of these analysis, resilience of Turkey's health systems will be examined and detailed. With the help of parameters and metrics, evaluations, comparisons and analyses will be made according to Turkey and resilience will be measured. The ranking formed by calculating both indexes is categorized according to colors and the list is shown in the world map in Fig. 14 and Fig.15.

VIII. DISCUSSION

The main purpose of this study is to evaluate the resilience of the health system in Turkey during the COVID-19 pandemic process, as well as to evaluate and measure the health system resilience in line with the data obtained from different countries, and to make a comparative study and to be a reference against the pandemics that may occur in the future.

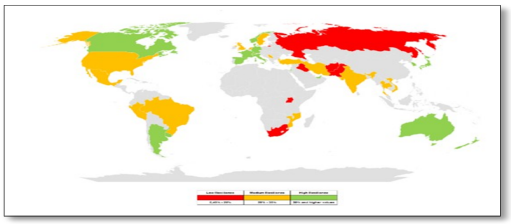

Fig. 15. The Colored World Map According to the Preparedness Index

In this study, firstly, the management of the health systems of different countries and the direction in which countries act, especially during the COVID-19 pandemic are investigated. As a result of these research, data that could guide the project are

collected and analyzed. Cumulative deaths/cumulative cases, mortality rate, total vaccinations, and people fully vaccinated data is used for analysis. In these data, total vaccinations, people fully vaccinated, and GDP data is used to create the preparedness index, while mortality rate and cumulative deaths/cumulative data are used to create the resilience index. Of these index values, it creates a good situation when the preparedness index is high, while the lower the resilience index, the more resilience it means. In addition, this analysis is made in terms of thirty-seven different countries and provides important data by observing the process evaluation of the situation in Turkey and other countries. In addition, it is normally planned to use ICU2 2020-2022 data in addition to these data in line with the project. However, ICU 2020-2022 data could not be used because it is not included in the data sets and the information in the sources with data is not up to date. One of the challenges of the project is not being able to find an up-to-date source for ICU data. However, if the GDP data used in the data is from a more recent period than 2019, it would be better to use upto- date data for the purpose. However, despite the difficulties experienced in these data calculations, the data is successfully integrated into the project and used, and the resilience and preparedness index are successfully obtained. This data analysis provides important information about the measurement and evaluation of resilience. In addition, since the project wanted to make an assessment specifically related to Turkey's health system resilience, a qualitative assessment is made in line with forty-one criteria. In this evaluation, a Turkey-based evaluation is made by investigating what is done in Turkey by considering many criteria such as financial, government support, medical equipment, quarantine strategies, isolation processes, and management. In this evaluation, critical points and critical dates are specified and evaluations are completed in terms of agility, flexibility, adaptability, and vulnerability related to the process. These four characteristic evaluations provide important information regarding the resilience of Turkey's health system during the COVID-19 period, as well as shed light on future studies. As a result, the study is concluded successfully, despite all the difficulties, thanks to analyses, evaluations, calculations, and reference studies. As a result of this study, in addition to obtaining results about Turkey's health system resilience in the period of COVID-19, a comparative study is also made, and a general analysis result is obtained in thirty-seven countries.

IX. CONCLUSION

The concept of resilience in health systems is a point that countries pay attention to in the current pandemic COVID-19 period to develop health systems and ensure the sustainability of health systems. With the emergence of the pandemics, the most important developments in global pandemic process management have been made on resilience and sustainability in health systems. The main reason for this is the resilience of health systems, which are most affected by the effects of the pandemic process and played the biggest role in the process. While countries act in various criteria to manage the process, the most important actions have been made for the health systems and epidemic situations, by making the most important actions on the developments in the health systems, managing and the pandemic

This study, besides examining the resilience status of health systems in Turkey's COVID-19 process, is presented as a comparative study by analyzing and evaluating together with thirty-seven different countries. There are qualitative and quantitative evaluations and analyses in this study. Qualitative analyses and assessments, determination of all actions and critical points taken by Turkey in the pandemic process in line with forty-one criteria, and evaluations of these determined actions in terms of agility, flexibility, adaptability, and vulnerability in the 6 building blocks of service delivery, finance, health information, health workforce, and medical products criteria. In line with Quantitative analysis and evaluations, resilience and preparedness index calculations are made and there are analyzes for thirty-seven countries.

As a result of this analysis, while grading the levels of resilience in the health systems of thirty-seven countries, the position of Turkey within these countries is also evaluated in detail. By combining the results of the quantitative and qualitative analyzes, Turkey's health system's resilience in the COVID-19 period and comparison with other countries are revealed. Thanks to this study, deficiencies, developments, and continuous improvement actions will be updated according to new conditions. At the same time, it will be possible to complete the deficiencies and make improvements before a new pandemic situation occurs. As a result, this study will have the feature of being a reference against future pandemics and shedding light on the information given.

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