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Why Couldn't the COVID-19 Epidemics be Managed? In the Context of Complexity Science, a Solution Framework Global Cooperation, Regional Policies, and Local Intervention

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Abstract

Background and aim: The COVID-19 epidemics, is considered to be the most recent and already one of the most destructive epidemics in human history. As part of this study, primarily the biological, economic, and social effects of past epidemics and the COVID-19 epidemics on societies were examined. The aim of the study was to examine the similarities between countries' current state in the context of the COVID-19 epidemics and to develop an approach to epidemic management from a complexity perspective.

Material and methods: The analysis used data from 27 European Union member countries, the United Kingdom and the United States, and primarily examined the current state of the countries in the context of the epidemic using the Multidimensional Scaling Analysis method. In addition, SARS-CoV-2-induced cases, deaths and tests were examined via the correlation analysis method with nine variables that were identified in the context of the COVID-19.

Results: As a result of the analysis, it was determined that the current state of the countries, based on the impact and sources of the epidemic was quite similar, and that the variables mentioned were minimally related to the number of cases, deaths, and tests.

Conclusion: These findings have been interpreted notes only showing that traditional approaches to today's epidemic management, and public health approaches have aspects that need improvement, but also that the epidemic is a multidimensional dynamic system and can be explained from the complexity perspective. As a result, the epidemic management framework was developed from the complexity perspective, which includes global cooperation, regional policies, and a local intervention approach. Therefore, the lifestyles of societies determine the size of the epidemic, while the management style determines whether or not the epidemic turns into a crisis for societies.

Keywords: SARS-CoV-2; Epidemic management; Complexity

Introduction

Nature is a complex structure made up of living and inanimate beings. Life is established, continues and ends with the interaction of living structures in nature with each other and especially with their environment. Viruses that occur in structures such as polyhedral, rod like, filamentous, and are usually 20-200 mm in size is also a part of this interaction [1]. However, it is known that some types of viruses pose a significant danger, especially to humans, and said danger can intensify with mutations that they go through over time [2].

For humans, this condition is experienced in the form of human-to-human or animal-to-human transmission, and can be observed in many different examples such as influenza, HIV, and viruses belonging to the coronavirus family. If the virus has a biologically negative effect on a group of people, the situation is called an epidemic; if it affects almost all people or other living things in that group, it is called an epidemic [3].

Epidemics that can be explained in this way have from time to time in human history caused bio psychosocial destruction in social and individual terms, especially on health and management systems. The first example that comes to mind on this issue is the Black Plague. Seen in Asia, Europe and Africa in the 14th century, and thought to be caused by the virus named Yersinis Pestis today, the plague has caused the deaths of millions of people all over the world; so much so that today it is estimated that the disease resulted in the death of at least 30% of the European population [4]. On the basis of it being widespread, plague has led to various social transformations. Here, in particular, it has been noted that a serious decrease in the labor supply increased labor costs, and feudal structures began to lose their power in the process of centralization [5]. In addition, this unusual decrease in labor supply led to technological developments and their spread through labor mobility [6]. Another large-scale epidemic in history is the Spanish Flu, which occurred between 1918 and 1919. It is estimated that 500 million people were infected with the Spanish Flu and that close to 50 million people, which is 1-3% of the world's population, died [7,8]. The greatest impact of the Spanish Flu, which spread rapidly with the impact of World War I, was impoverishment. According to Barro, et al. there was a 6% decrease in national income per capita, and 8% decrease in consumption expenditures due to the Spanish Flu [5]. In addition to its general economic effects, Spanish Flu has also had an impact on economic inequality in society. In Italy,

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for example, Spanish Flu led to a 2% increase in income inequality [9]. In Sweden, it is estimated that every death caused by Spanish Flu led to impoverishment of four people [10]. In addition to the plague and Spanish Flu, it is known that a type of plague experienced between 541-543, and epidemics caused by viruses such as SARS, MERS, H1N1 experienced at the beginning of the 21st century have also had negative socioeconomic and sociocultural effects [11].

Without a doubt, it is possible to add the ongoing epidemic to these experiences. Having first occurred in December 2019 in Wuhan, China, and announced by the World Health Organization on March 11, 2020, as an epidemic, the SARS-CoV-2 virus has already affected humanity extraordinarily in different ways [12]. It is estimated that this virus is approximately 80-120 mm in diameter and has thirty thousand RNA helices, and is transmitted from bats or pangolins to humans [13].

SARS-CoV-2, which is believed to be transmitted directly from animals through an intermediate host animal, or through cold chain products, is a virus belonging to the coronavirus family and has a genome similar to other coronaviruses by 79% and to MERS by 50% [12]. But despite this genetic similarity, as can be seen in Figure 1, the SARS-CoV-2 virus ranks only the second to last among viruses in the last 50 years in terms of fatality.

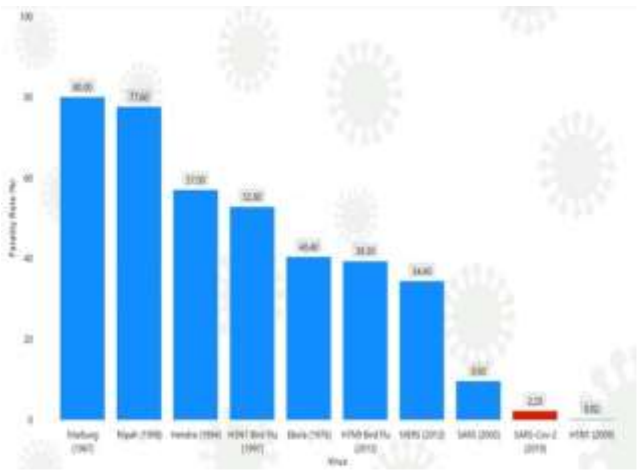

Figure 1: Fatality rate of various viruses.

It is known that up to 50% of SARS-CoV-2 infections, also known publicly as COVID-19, can be asymptomatic and have different consequences on people who are infected, from mild symptoms to death [11,14]. The most common symptoms of SARS-CoV-2, which can be listed as fever, dry cough, shortness of breath, fatigue, headache, and weakness, have very harmful effects, especially on the respiratory system and immune system [13]. It is known that the SARS-CoV-2 epidemic is especially dangerous for individuals over 65 years of age and people with chronic illnesses; the epidemic is also affected by the internal and external mobility of countries, as well as the prevalence of testing and detection studies [15].

Unlike the SARS-CoV virus that emerged in 2003, the symptoms of SARS-Cov-2 surface within a few days of the onset of inter-human viral transmission, which was one of the biggest factors in the transformation of SARS-Cov-2 into an epidemic [11]. In addition, the fact that the first symptoms of SARS-CoV-2 are quite similar to cold and influenza also affects this situation [14]. Naturally, the growth of globalization and the resulting mobility of human and commercial animals can also be considered as another important factor in the transformation of the virus into an epidemic. Another study conducted using data from 360 different cities showed a positive relationship between the national income per capita and geographical latitude, and the number of COVID-19 cases; meanwhile the number of cases has a negative relationship with temperature. This also shows that a global epidemic is actually shaped by various local factors [16].

The biological structure and developmental process of the COVID-19 epidemics caused by the SARS-CoV-2 virus can be explained in this way. According to World Health Organization data, a total of 200,840,180 cases were reported worldwide as of 07.08.2021, of which 4,265,903 resulted in deaths. When the distribution of cases and deaths per hundred thousand people is examined, especially the United States, Russia, Canada, South American countries, and European countries rank the highest [12].

Data from the World Health Organization proves that the COVID-19 epidemics have reached a fairly significant magnitude. But a epidemic, due to its factual nature, is not just a condition that causes biological damage. As in previous epidemics, the COVID-19 has involved various socioeconomic damages. A study conducted by Figueiredo, et al. showed that social isolation in childhood increases the risk of infection, obesity, depression and loneliness in later years, noting that quarantine processes especially in developing countries negatively affect income inequality and domestic relationships [17]. Robb et al. (2020) have found a positive relationship between quarantine and anxiety [18]. Gonçalves, et al. (2020) concluded in their study that mental well-being is negatively associated with social isolation and loneliness [19]. According to UN Women, the psychosocial and socioeconomic conditions caused by the epidemic increased gender inequality and, in particular, increased domestic violence [20]. Another effect caused by the epidemic is the change in criminal activity. A study conducted by Stickle and Felson examined the relationship of the epidemic with criminal activities and revealed that this relationship depends on the variables of type, place, and time of crime [21]. These findings show that the epidemic-crime relationship is changeable but can pose social hazards according to the local characteristic of the epidemic (Stickle and Felson, 2020). Pietrabissa and Simpson (2020) claimed that the next epidemic will be the 'depression epidemic', referring to many studies that examined the negative effects of social isolation and loneliness [22]. In addition to the psychosocial effects of the epidemic, some studies state that there is a negative relationship between the inactive lifestyle caused by quarantine restrictions, and biological health (the heart above all else) and a regulated life (sleep, nutrition, etc.) brought by social isolation [23,24].

In addition to the social and biological effects, the epidemic has important economic effects. Shang, et al. (2021) revealed that COVID-19 has been the most destructive epidemic of the 21st century in the sense of unemployment rates, inflation and investments, and supply chains [25]. In addition, according to the International Monetary Fund (IMF),[26] the world economy experienced a 3.5% contraction in 2020 in terms of real gross domestic product values [27]. According to the International Labor Organization (ILO), industrial production in the G-20 countries has decreased by up to 60% as of February 2020 compared to the previous period. According to the same report, there has been 14% reduction in total paid working hours in the aforementioned countries. In addition, due to the epidemic, unemployment rates in these countries have increased by more than 10% [28]. As can be seen from these statistics, the destruction caused by the epidemic has reached such a serious extent that an assessment shared by the World Health Organization in October 2020 predicts that the number of malnourished people will increase from 690 million to 822 million in 2020 alone due to the recession occurring in the economy [29].

Several measures have been developed against the ongoing destructive effects of the COVID-19. Some methods developed to treat infected people can be listed as natural cell therapy, immunotherapy, and various drug supplements used to treat diseases such as malaria [13]. Furthermore, vaccine developments efforts have been continuing from the beginning, and as of 07.08.2021, 3,984,596,440 doses of vaccine have been administered worldwide [30]. Moreover, 96 vaccine studies are in clinical development, while 184 vaccine studies are in pre-clinical development, according to World Health Organization data from August 2021 [30].

In addition to measures for the treatment and prevention of disease, full or partial quarantine measures such as the closure of the facilities outdoors that are not vital, the closure of schools, limiting hours of work and transition to flexible working hours, cancellation of events that are not urgent, emphasizing personal hygiene and social distancing have also been developed [31]. In addition, according to the IMF, as of October 2020, the worldwide epidemic support offered includes $9,930 billion for additional payments or waived revenues, and $6,104 billion for liquidity support [27]. The dynamics of the epidemic that interrupt the natural flow of social life suggest that epidemic management should also be evaluated in a multidimensional and interactive framework.

Methodology

Analysis

In order to understand complex and dynamic systems such as an epidemic, how the factor that causes an epidemic interacts with different parameters in certain situations in time. Accordingly, primarily, the relationship between various variables, which are considered important factors in observing the course of traditional epidemic management, and the number of cases, deaths, and tests were studied in terms of the current state of countries in epidemic management. In addition, the relationship between these variables was studied by correlation analysis method.

Methodological theory

Multidimensional Scaling Analysis (MSA) is a multivariate statistical method used to study countries' current situations in epidemic management in terms of their similarities. In MSA, the goal is to make interpretations based on similarities and differences between observations. In the analysis, a coordinate value for each observation is determined based on the differences between observations, and usually these coordinate values are presented by the Shepard diagram in two-dimensional space. This diagram is the output of the MDS analysis, while the success of the analysis is measured by the GOF value. The GOF value is a value that shows how much of the reality in the dataset can be explained within the scope of the analysis performed, and varies within the 0-e1 range. The strength of the explanation provided by the analysis increases along with the GOF value [32].

Correlation analysis as a statistical analysis method is the study of the relationship between two variables according to the joint changes in observations. Correlation analysis, which can be performed by various methods such as Pearson and Spermans allows the relationship between variables to be measured at a value between (-1) and (+1). As the correlation coefficient (r) approaches zero, the relationship weakens. According to this, if the correlation coefficient is above 0.7, it is called a strong relationship. If it is between 0.4-0.7, it is called a medium relationship, while it is called a weak relationship if the correlation coefficient is below 0.4. Also, in correlation analysis, the direction of the relationship can be negative or positive [33].

Results

As part of the study, observations on the countries included in the data set are primarily studied in terms of the similarities of countries via the Multidimensional Scaling Analysis method. The output of the relevant analysis is as presented in Figure 2. As can be seen in Figure 2, when data from 27 European Union countries, the United Kingdom, and the United States are examined, it seems that these countries are quite similar in terms of epidemic management and available resources. As a matter of fact, 26 of the 29 countries are located close to each other in the origin. Here, Ireland and Luxembourg [19,34] are partially separated from other countries, but are still not significantly separated from the origin. But the United States appears to differ significantly from other countries [6]. This can be attributed to both the total population of the country and the comprehensiveness of its health system. However, these findings can be interpreted as countries failing to develop practices and different perspectives on the correct parameters in epidemic management.

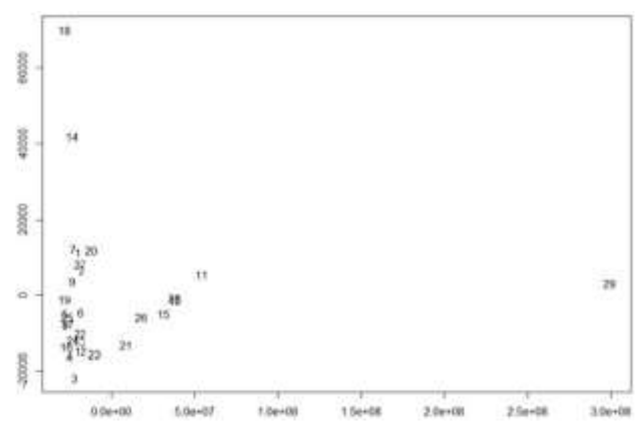

Figure 2: Similarities of countries in terms of epidemic management and resources.

Common methods used to combat the epidemic in the field of Public Health include various methods such as diagnostic and treatment studies, reducing interaction, providing and universalizing personal hygiene, isolation, and quarantine [14]. All these measures are carried out within the surveillance system based on the principles of epidemiology [34]. It can be said that most of the measures taken by governments during the COVID-19 epidemics are in line with the public health approach. Although it has been shown that these measures can be useful in epidemic management, various studies have emphasized the importance of various factors such as effective communication between the state and the individual [35], the existence of effective decision-making mechanisms and effective detection and use of social capital in epidemic management [34-36]. Furthermore, the sharing of information in a transparent and accessible way to all segments of society contributes significantly to the management of the process. In this framework, the level of complexity of the current epidemic caused by SARS-CoV-2 is highest in history.

The emphasis on effective identification and use of social capital is not accidental. As a matter of fact, interventions appropriate to the characteristics of the epidemic are possible only with the efficient use of available resources. In Figure 3, which was developed within the scope of this study, the relationship of the number of cases and deaths per hundred thousand people with various variables across countries supports this view.

Figure 3: The relationship of the number of cases and deaths with various factors.

Variable	Date	Definition	Source
Cases	07.08.2021	Covid-19 Cases (cumulative total per 100000 population)	World HealthOrganization
Deaths	07.08.2021	Covid-19 Deaths (cumulative total per 100000 population)	World HealthOrganization
Tests	04.08.2021	Covid-19 Tests (per 1.000 people) (avaragebetween 19.05.2020/19.05.2021	Our World in Data
Age	2015	Avarage Age of Countries	United Nations
Pop	2019	Total Population	World Bank
Urban	2018	Percentage of Urban Population	United Nations
Density	2018	Populationdensity (peoplepersq. km of landarea)	World Bank
Lexp	2019	Life Expectancy	United Nations Development Programme
Gdp_pp	2019	GDP Per Capita	United Nations Development Programme
Sch	2019	MeanYears of Schooling	United Nations Development Programme
Ineq	2017	Coefficient of Human Inequality	United Nations Development Programme
Beds	2019	HospitalBeds (per 1.000 people)	World Bank

Table 1: Descriptions of variables in the data set.

Figure 3 shows correlations between the total number of cases and deaths per hundred thousand people as of 07.08.2021 and the variables described in detail in Table 1. As can be seen from Figure 3, the correlations between these variables are at (-0.48) the most. This finding shows that the relationship between the variables involved is decidedly weak.

What determines the course and state of the epidemic is not the countries' sociodemographic characteristics or the resources they have (age, income, population, human resources, hospital capacity, etc.), but their lifestyles and how that manage them. As a matter of fact, the COVID-19, compared to past epidemics such as the Black Plague and the Spanish Flu, emerged at a time when technological advances were exponential, and gene technology and genetic engineering were extremely advanced and widespread. In this case, first, it is necessary to understand why the Covid-19 epidemics cannot be managed. In fact, this is due to the fact that the epidemic is not a phenomenon that can only be considered from a biological point of view. This process is a result of significant managerial and organizational deficiencies with today's lifestyle. The fact that, despite the various measures taken in almost two years, the epidemic is far from predictable due to new mutations and waves, and that the attempt to manage the process has been with masks and various restrictions, as was the case with the Spanish Flu a hundred years ago, is indicative of this situation [8]. Naturally, there are almost no similarities between the conditions of the world where the ongoing epidemic caused by SARS-CoV-2 occurred and the world where the Spanish Flu occurred about a hundred years ago (1918-1919). Despite this, the approaches to epidemic management and the methods as measures have not changed.

Discussion

This study has examined the biological characteristics of the SARS-CoV-2 virus, and the biological, social, and economic repercussions caused by the epidemic regarding the COVID-19. In addition, the relationship of various variables with COVID-19 cases, deaths, and numbers of tests was examined, and it was found that the variables studied did not have a singular strong relationship with the management of the epidemic process. As a result of all these observations, it has been shown that the COVID-19 epidemics are already one of the most devastating epidemics in history, and the parameters for managing the epidemic have not yet been correctly identified. This situation is associated with the dynamic and complex structure of the epidemic.

According to the algorithm approach of the science of engineering, everything that can be described can be programmed. However, for issues that are difficult to describe, such as living and consciousness, the situation is not easy. Understanding dynamic and complex systems such as epidemics is also important at this point. The main thought that lies in the foundations of complex system science is the "the whole is greater than the sum of the parts" principle. It means that the property that is not found in the parts can appear in the whole. For example, when an ant is alone, it shows no intelligent skills. However, an ant colony shows sign of intelligence that could find the shortest way to a solution of a problem. Complex systems are also organic systems that can self-organize and adapt to changing conditions. A complex system occurs as a result of the intense interaction of a large number of components, which follow relatively simple rules, with each other. Siegenfeld and Bar-yam (2020) describe complexity as “the complexity of a behavior as equal to the length of its description [37]. The length of a description of a particular system’s behavior depends on the number of possible behaviors that system could exhibit. According to them, for example, a light bulb that has two possible states-either on or off-can is described by a single bit: 0 or 1. Two bits can describe four different behaviors (00, 01, 10, or 11), three bits can describe eight behaviors, and so on” [37]. As can be seen, complex systems are nonlinear, not linear. Therefore, studies of the relationship between factors in the linear plane, which are commonly encountered today, decisively fail to help to understand complex systems. Instead of holistic approaches to the obscure and complex way the epidemic functions, simple and reductive approaches that are completely independent and unrelated are preferred most of the time. Focusing too much on achieving results as soon as possible makes it difficult to achieve epidemic management at the global level with the right parameters and approaches. Understanding why the epidemic process cannot be managed provides important clues as to how it should be managed.

Complexity science is a new understanding of science that tries to understand complex systems that can exist biologically, physically, and socially on the basis of all their components. In Complexity science studies, facts are understood through their frameworks. This framework is basically explained through random, coherent and correlate systems. Random systems are systems with the highest complexity at the smallest scales. But as the scale grows, the complexity of random systems decreases and the complexity is resolved over average values. Coherent systems have the same degree of complexity, but offer large-scale evaluation, which allows understanding the general behavioral structure of the system and the components that make up the system in general. Correlate systems, on the other hand, make clear the general characteristics of complex systems formed by different components. The development of these frameworks allows complex systems to be understood and managed as a whole that is formed by different components, as an alternative to separate and linear evaluation of components outside their context [37]. Especially given the mobility level and dynamics of today's lifestyles, the variety of economic activities, fundamental rights and freedoms, and expectations from life, the dynamic situations that can arise in such an environment of epidemic can only be understood from the perspective of complexity.

At this point, a framework is needed for a global epidemic to be manageable. For this reason, the epidemic management framework presented in Figure 4 was developed using the complexity perspective within the scope of the study.

As presented in Figure 4, epidemic is a dynamic system that occurs in random systems, but spreads through coherence-level relationships and turns into a epidemic in correlate systems, which cannot be separated by precise boundaries regarding biological, economic, social, and physical components but has its effect through different main patterns and sub-patterns.

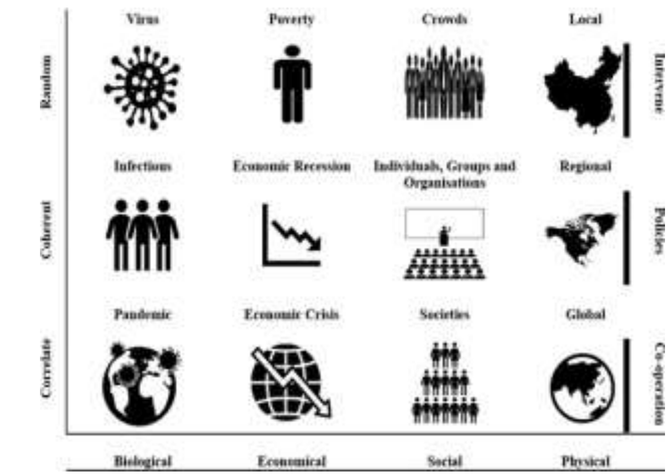

Figure 4: Epidemic management framework in the context of complexity.

The virus, which exists in nature at the random level, achieves the chance to cause infections among human communities. This can usually happen in host-to-human, then in human-to-human form. Where on earth it will occur, and how it will spread to which crowds and persons take place within a set of possibilities. Reactions of crowds to this new situation with existing local resources, which represents the smallest scale,(biological symptoms, fear-panic in people, efforts to understand this new situation in organizations and search for methods, etc.) occurs when the level of complexity is highest. The lifestyle of the local determines how the epidemic will occur. In this sense, it is thought that the general dynamics of life in random systems in which the virus can be transmitted determined that viruses such as SARS (2002, Hong Kong) and MERS (2012, Middle East) did not turn into global epidemics and remained as epidemics. At this point, the transformation of SARS-CoV-2 into a global epidemic is a result of the current local lifestyle in which the virus is transmitted. Dynamics that determine lifestyles can be described as geographical features and mobility level, as well as the social life dynamics specific to every society. The effects of the biological nature of the virus on masses as well as persons happen at a random level. In particular, the prevalence of vulnerable groups in the local population and the bio psychosocial characteristic of the local lead to the nature of the developmental process at the random level. Dynamical systems that will occur at then random level lead to the occurrence of many different complexities. Naturally, the progress of the epidemic varies for each society. In the statistical term, degree of freedom it is at (n-1) level. Because of this, the intervention to the epidemic occurs at the local level, where the complexity is highest. The reason for this is that, as the level of complexity decreases, that is, as the geographical area expands and the number of people who are naturally infected increases, it will lead to the formation of completely different subsystems in relation to time, and eventually it will be difficult to understand each new situation and develop methods of intervention for them. In addition, this makes it difficult to predict the change of the epidemic, which is also a dynamic system, in relation to time, as well as to control, understand, interpret, and generalize epidemic management.

An increase in the number of people infected at the coherent level allows the complexity to reach regional level from local level by resolving it. At this level, the virus has now spread to a wider geographical area. As the scale expands, the virus's domains begin to change. The effects of the virus become evident in each component that forms coherent systems, which leads to the possibility of observation and evaluation. As a result of the expansion of the scale, while virus-induced effects are initially only a health problem, they lead to a change of the complexity of the problem over time. For example, a two-hour power outage in a local area is just an energy problem and requires technical intervention. However, if a power outage lasts a week, a month, or a year, each scale expansion creates a new complexity, and they are no longer just power outage problem. The initial state, which can be solved with just a technical intervention, has now changed too much to be solved the same way. But regardless of the situation on each scale, the components that make up the complexity in coherent systems are related to each other. At this level, relationships must be understood and policies must be determined. If lifestyles are dramatically interrupted due to different practices and under the name of measure, the effects of these also start to be seen in other components associated with each other. For example, in coherent systems in the social component, if age-specific quarantine or lockdown practices are applied, the course of the existing complexity changes, leading to the creation of a new complexity. In a similar way, the virus also responds to this new situation with a new variant. Although it seems a decrease in the number of cases and deaths were observed thanks to quarantine or other precautionary practices at first, the virus recedes to respond to each new situation with a new pattern. However, with changes in the biological characteristics of the virus in each process, its target audience in crowds begins to differentiate in coherent systems. For example, at the beginning of the epidemic, the virus posed a risk to elderly and chronic patients more; however, it has changed its target audience with each variant. The delta variant, which affects middle-aged and young people nowadays, seems to point to the inevitability of later variants that will also affect children [38].

Correlate systems are closely related to the components that make up the complexity. A global epidemic affects all other components. Therefore, cooperation at the global level appears to be the basic condition principle in epidemic management. This approach allows the identification of different policies at the regional level, and then the response at the local level, leading to the epidemic occurring in a manageable framework. It also brings with it an understanding of the nature of the epidemic. A epidemic management where there is no global cooperation is unlikely. It is also technically impossible for each country to overcome the epidemic with different measures and practices that are not compatible with each other. On the contrary, different practices of each country lead to a constant renewal of complexity. The results presented in Figure 3 also prove this situation, because in random systems, there is no statistical relationship between the biological characteristics of the virus and the general characteristic features of the local. But there is a very close relationship between the components that make up the complexity in correlate systems, as revealed in this study. Therefore, epidemic management for SARS-CoV-2 can be summarized as cooperation at the global level, policies at the regional level and intervention at the local level. The criteria according to which the 'local' and 'regional' can be determined is in relation to what scale the level of complexity begins to differ.

In this context, the framework presented in Figure 4 does not manifest itself at the local or regional level in the same time period. Because of this, the first thing to do at the local level is to adapt the framework presented in Figure to local characteristics. In addition, epidemic that is predictable, interpretable, and manageable can be provided with the help of correct resource management at the level where the level of complexity is highest. As presented in Figure 5, complexity profiles for random, coherent, and correlated systems (Figure 4). Any given system may have aspects of each at various scales Another important aspect of an effective epidemic management is to prevent the spread of the infections well as combatting with negative contingencies that arise with the increase in the complexity of the epidemic. The virus is transmitted by contact. Mobility and interaction are the main factors giving rise to this contact. Therefore, prevention of transmission is possible by keeping mobility and interaction under control. The limits of this control are again related to the complexity of the epidemic. The dramatic termination/reduction of social mobility and the level of interaction make the complexity level of the epidemic far from predictable and controllable, within the dynamic structure of life as illustrated in Figure 4. At this point, the main thing is to manage the contact that causes the transmission in a controlled manner.

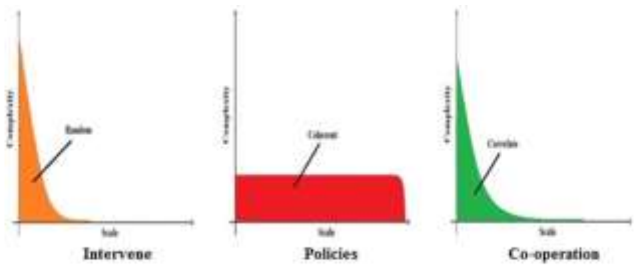

Figure 5: Complexity and scale level of complex systems components.

For this, the level of mobility and interaction that creates the contact must be defined at the local level in the first place. In general, mobility is the displacement of the geographic position of a person in a certain time period, and interaction is the contact of the person with another person or people at the same time depending on the mobility. These two basic components are effective in the spread of virally transmitted viruses such as SARS-Cov-2. However, other components can also be defined according to the characteristics of the locality. Mobility can appear as active or inactive. While there is no interaction in inactive mobility, active mobility creates interaction. Naturally, not every mobility and interaction causes contamination, but the increase in the level of mobility and interaction is directly proportional to the risk of transmission. In epidemiology this risk generally differs from the coefficient R0, which is defined as the expected number of cases directly generated by a case. Because the aforementioned risk is not an average value, but is related to the instantaneous mobility, the interaction it creates, and the density of the location, which is the appropriate environment for the interaction that will cause this contagion. As can be understood, it should be taken into account, in the calculation of the risk of transmission, the density of people at the location where the interaction takes place in addition to the mobility and the interaction. This factor can be defined as volume. As a matter of fact, although it is a very important approach to isolate infected people in the current situation, one of the biggest factors in the transformation of SARS-Cov-2 into an epidemic is that infected people may not show any symptoms for up to 2 days. Therefore, it is expected to determine the risk of infection of people who have not yet been infected and to manage the risk at the individual level, rather than the isolation of people who have been diagnosed as infected. Mobility value (M) and interaction value (I) responds to the coefficient person's risk of being infected or a source of transmission (Ri) in the same time period. In mathematical expression, this risk is as formulated as;

$Ri=x(t).\ M+y(t)\ I+\ldots.$

Scaling the Ri value between 0-100 will ensure that the risk of being infected and a source of transmission on an individual basis can be revealed within a certain scale [39-42]. These calculations present that regarding the current and ordinary effects of the epidemic, an effective way of epidemic management based on person and risk factors is possible by giving a dynamic response to the dynamic nature of the epidemic without interrupting the ordinary flow of life with dramatically changes, The epidemic risk management framework at the local level from the perspective of complexity science is as in Figure 6.

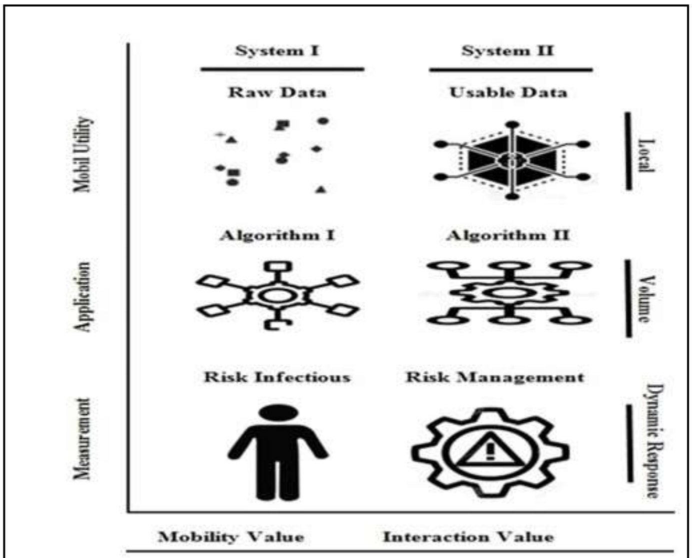

Figure 6: Epidemic risk management framework at local.

The epidemic is not only a public health problem, but also a major risk management problem. Supporting this view, current public health literature also argue that, in addition to the studies in fields such as healthcare, biology and genetics, an effective public health policy can be achieved by observing various sociocultural and socioeconomic factors such as culture, gender, income and social status, social support networks, and working conditions. This has also been addressed by international organizations. According to the European Commission, in addition to successful epidemic management diagnostic and treatment techniques, it is recommended to have early warning and prevention systems, to have effective social security mechanisms, and to form trust in the individual-state relationship (European Commission, 2020). As shown in a study, the positive relationship between the rule of law and the manageability of the epidemic makes the emphasis on this healthy relationship meaningful. Furthermore, according to the World Health Organization, the management of the 21st century epidemics and epidemics is challenging even in countries with good public health mechanisms. For this reason, risk management is one of the most important topics in epidemic management (World Health Organization, 2018). In this sense, it may be insufficient to manage the multicomponent complexity created by the epidemic with traditional public health and medical devices in today's epidemic.

The reason for this is that COVID-19 is a global-scale epidemic developing in a world where mobility and urbanization are higher than ever before. From the beginning of the process, it is understood that the traditional approaches used by various organizations ranging from local to organizations are insufficient given the current situation. In fact, as noted in the work of Roberts and Tehrani, the approaches and methods of intervention developed by the field of public health regarding epidemics have almost never changed in the 101 years from the 1918 Spanish Flu to the present day. In addition, as can be seen from the experiences to date, in a world where mobility is the highest, it is not possible for countries to overcome the epidemic on their own. As a matter of fact, the findings cited in Figure 1 shows that the prevalence and severity of the epidemic are not related to the demographic characteristics of countries and the resources they have.

These findings are interpreted as determining epidemic severity not by general characteristics of societies, but by lifestyles and epidemic management methods. Therefore, the lifestyles of societies determine the size of the epidemic, while the management style determines whether or not the epidemic turns into a crisis for societies. In this context, managing the difficulties experienced in epidemic management caused by the lifestyles of societies also determines the development of the virus through natural and unnatural interventions, and allows the formation of new complex processes. In other words, the fact those countries have largely carried out their struggle with the epidemic in a way that is far from cooperative increases the complexity of the epidemic on a global scale and prevents the solution from being provided.

Due to the nature of the epidemic occurring in today's world, it can be managed by an approach developed from the perspective of complexity. In this context, the epidemic management framework developed in the study presents the dynamics of the epidemic and the characteristics of the relationship between systems. But it is important to determine how to adapt to the epidemic on a local scale, considering it manifests differently in different societies. Intervention at the local level first needs to decipher the causality relationship between the frameworks presented in Figure 4 and the local characteristics of the epidemic. This also allows for the highest level of epidemic complexity to be intervened and the optimal use of resources, because the dynamics of each local differ from each other [43-50].

Conclusion

The basic principle of local-scale epidemic intervention is to avoid interrupting the usual flow of social life, which allows for the formation of new complexes, and to prevent the disintegration of the complexity. On the other hand, this means that the dynamics of the epidemic at the local and regional level can be observed, measured, and naturally controlled using the correct parameters.

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Author Contributions

Both of authors have worked on introduction and literature sections together. Also the epidemic management framework in the context of complexity and epidemic risk management framework at local have been developed with authors' mutual work. MD collected and statistically analyzed the data which show the relations between some epidemic management components. TY interpreted analyzed results and write discussion and conclusion parts of study. All authors read and approved the final manuscript.

Availability of Data and Materials

All data analyzed during this study are included in this published article in and in its supplementary information files.

Competing Interests

The authors confirm that there are no known conflicts of interest associated with this publication.

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