



Social network analysis of tourism data: A case study of quarantine decisions in COVID-19 pandemic

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ABSTRACT

Tourism is one of the most affected sector during the COVID-19 pandemic all over the world. Quarantine decisions are the leading measures taken in practice to reduce possible negative consequences of the COVID-19 pandemic. There is limited work in the literature on how to make the right quarantine decisions in a pandemic. Therefore, the aim of this study is to propose the use of social network analysis (SNA) based on tourism data to make the right quarantine decisions in the COVID-19 pandemic. A case study on quarantine decision is conducted based on data obtained from Turkish Statistical Institute to show how to perform SNA. Household domestic tourism survey is used as input data for SNA. The most critical region among 12 regions in Türkiye is Istanbul to decrease possible negative affect of COVID-19 pandemic on the tourism sector.

1. Introduction

The COVID-19 pandemic is an infectious disease that occurred in Wuhan, China, in December 2019 (Yum, 2020). The virus that causes the pandemic is transmitted quickly by breathing or close contact (Shah et al., 2021). The person suffering from the disease does not experience an individual illness or an individual situation. At least one family member is affected both psychologically and economically. In fact, the effect can be imagined by multiplying the number of people affected by the epidemic by at least two. This pandemic has caused a significant economic problem all over the world due to quarantine, travel restrictions and social distancing (Kumudumali, 2020). The tourism sector is one of the most important sectors that develop countries economically. “The word “tourism” was included in the Oxford English Dictionary in 1811” (Verma et al., 2022). It is the fourth largest economic activity (Knežević Cvelbar and Ogorevc, 2020) and the growth of this sector is very important for the world economy (Kar et al., 2021). Additionally, this sector has grown tremendously from the last decade (Mishra et al., 2020) and it is quite important for economic development (Mishra et al., 2021). On the other hand, the sector that has suffered the most due to the COVID-19 pandemic is the tourism sector (Han et al., 2020). It is the most life-altering event in most of our lifetimes (Machiraju et al., 2021). Knowing potential spreading relationships between regions helps decision makers to determine the effects of epidemics on tourism. Therefore, it is vital to use a strong method to decrease the spread of COVID-19 pandemic in practice. In this study, the number of people entering and

exiting among regions is used as an important indicator increasing disease transmission among regions. A case study on quarantine decisions is performed using social network analysis (SNA) based on the number of people entering and exiting among regions. Tourism is one of the vital sectors in the growing service economy (OECD, 2020). For this reason, quarantine decisions should be made based on scientific methods in order to provide sustainable tourism during the period of COVID pandemic.

Evaluating interregional travel restrictions with a scientific method is very significant to reduce the rate of spread of the COVID-19 pandemic due to region-to-region relationships. Quarantine decisions are used as a public health strategy to reduce disease transmission in all around World (Mediouni et al., 2020). Currently, countries make regional quarantine decisions based on only the number of cases. Wrong quarantine decisions negatively affect the tourism activities of the regions. The impact of quarantine decisions on reducing the diffusion of the COVID-19 pandemic have little or no effect due to disregard for inter-regional relations.

The following two research questions are researched in this study:

- RQ1: What is the strength of the relationship among regions in Türkiye with respect to the COVID pandemic?
- RQ2: Which region has the most impact on the spread of COVID-19 pandemic?

The subsequent sections of this study is organized as follows: Literature review is given in next Section 2. Then, data collection and data analysis are presented in Section 3. Section 4 provides findings.

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Table 1
Studies examining the effects of quarantine during Covid-19 pandemic.

Author (Year)	The effects of quarantine
Jiménez-Pavón et al. (2020)	The mental and physical
Besnier et al. (2020)	Cardiac rehabilitation
Mattioli et al. (2020)	Changes in diet and physical activity
Muscogiuri et al. (2020)	Diet

Discussions are presented in Section 5. Conclusions are given in Section 6.

2. Literature review

It is emphasized in the literature that tourism is among the sector highly affected by COVID-19 pandemic. Kumudumali (2020) and Rutynskyi and Kushniruk (2020) analyzed the effect of the COVID-19 pandemic on the tourism. Obembe et al. (2021) conducted a study to understand sense of the sentiments of the tourism public during the beginning of COVID-19 pandemic. The main reason why the COVID-19 pandemic affects the tourism is the quarantine decisions taken. Various aspects of the effects of quarantine have been discussed in the literature. Among them, Saurabh and Ranjan (2020) researched what kind of psychological effect it had on parents and children during the pandemic period. In another study, Kılınçel et al. (2020) examined what kind of anxiety the adolescents living in Türkiye experienced during their stay in quarantine at home. Studies examining the effects of quarantine decisions in various aspects during the COVID-19 pandemic period is given in Table 1.

Chen et al. (2007) highlighted that SNA is a good supplementary tool for contact tracing such as AIDS. Twitter data is also used for scientific research in the literature (e.g.; Neogi et al., 2021). The use of Twitter data for SNA is highly performed in the literature. Among these studies, Yum (2020) used Twitter data and utilized SNA to explore how public key players play an important role for the COVID-19 pandemic. In addition, Pascual-Ferrá et al. (2020) analyzed conversations on Twitter based on SNA to understand public discourse related to the COVID-19 pandemic. Hung et al. (2020) used Twitter data related to the COVID-19 pandemic to construct social networks of dominant topics in practice.

The use of SNA to analyze the COVID-19 pandemic with respect to several aims is performed except for decreasing the spread of COVID-19 pandemic based on quarantine decisions. Wang et al. (2020) used SNA to find the super-factors causing the COVID-19 infection in medical staff in China. Jo et al. (2020) performed network analysis to analyze the focus of people’s anxiety and worry in the questions based on data obtained from Korean web portal. In another study, So et al. (2020) visualized the degree of connectivity between different regions with SNA based on reported COVID-19 cases. In another study, Kim (2020) constructed social networks to understand how people express their opinions about the COVID-19 pandemic. Wanga et al. (2020) applied various statistical and network analysis methods to examine COVID-19 patient data. Additionally, Saraswathi et al. (2020) utilized SNA to monitor and control the COVID-19 pandemic in India based on 1147 cases of COVID-19. Azad and Devi (2020) investigated the spread of COVID-19 from international to the national level and find a few super spreaders using SNA. Additionally, Nagarajan et al. (2020) constructed a network to show epidemiological relations between patients having COVID-19 disease using SNA. Ramamoorthy et al. (2021) conducted a systematic review related to the use of SNA for cancer, COVID-19, and smoking related disease to assess the tools and techniques used to study social media disease networks. Recently published studies using SNA for COVID-19 pandemic are given in Table 2. Furthermore, several aspects of COVID-19 disease are analyzed in the literature such as prominent health issues and COVID-related public concerns using social media (Reveillhac & Blanchard, 2022), public opinion and emotions regarding the COVID-19 pan-

Table 2
SNA based COVID-19 studies.

Author (Year)	Method(s)
Obadimu et al. (2021)	Topic Modeling and SNA
Jo et al. (2021)	SNA
Bahri et al. (2020)	SNA
Yie et al. (2021)	SNA
Saraswathi et al. (2020)	SNA
Ahmed et al. (2020)	SNA
Wickramasinghe and Saman (2021)	SNA and Exponential Random Graph Models
Hasan and Kamal (2021)	SNA
Wijaya & Handoko (2021)	SNA

demic (Mahdikhani, 2022), understanding public sentiment related to COVID-19 outbreak in Singapore (Ridhwan & Hargreaves, 2021), the use of contact-tracing technology for COVID-19 disease (Ross, 2021), the impact of the COVID-19 pandemic on public sector job opening (Koch et al., 2021), and classification of COVID-19 cases (Chauhan et al., 2021). Additionally, Karami et al. (2021) used text mining to examine COVID-19 literature.

In the literature, there is no study focusing on the use of SNA to decrease the spread of COVID-19 pandemic in practice. The tourism sector are among the sectors most economically affected by this pandemic. Therefore, this study proposes important implications for quarantine decisions based on SNA to decrease the effect of COVID-19 pandemic on tourism.

3. Methodology

3.1. Data collection

In this part of the study, it is aimed to determine the priority regions for quarantine decisions between regions. For this purpose, household domestic tourism survey data are used for SNA. The data is obtained from Türkiye Statistical Institute (TSI) prepared in 2018, and carried out Nomenclature of Territorial Units for Statistics (NUTS) 1 classification in Türkiye. SNA is conducted using Gephi 0.9.1 software. Türkiye is divided into 12 regions, namely Istanbul (TR1), West Marmara (TR2), Aegean (TR3), East Marmara (TR4), and West Anatolia (TR5), Mediterranean (TR6), Central Anatolia (TR7), West Black Sea (TR8), East Black Sea (TR9), North East Anatolia (TR10), Central East Anatolia (TR11), and South East Anatolia (TR12). These regions are shown in Fig. 1.

3.2. Data analysis

“A network is a structure formed by connecting nodes with different weight values to each other with edge” (Altuntas & Gok, 2021). In SNA, each node represents a region in this study. The relationship between regions is indicated by edge. In the analysis, 12 nodes and 132 edges are used. Node size is determined according to the weighted degree value in order to detect the effective areas in the spread of COVID-19 disease. The colors of the node are colored according to modularity. The modularity value is 0.077. Edge thicknesses are shown according to “weight” value. Edge colors are colored according to the source. Whichever node has an exit, edge takes the color of that node. Different layouts such as fruchterman reingold, circle pack layout, circular layout, noverlap, dual circle, yifan hu are used for SNA. The connected component value is 1 in the analysis. This means that all nodes are linked to each other. A fully connected network structure has been formed in the social network. For this reason, the statistical value of betweenness centrality is zero for all nodes. There is no outside node (zone). As a result of SNA of the regions, the density value is 1. This means that all possible connections are occurred in practice.

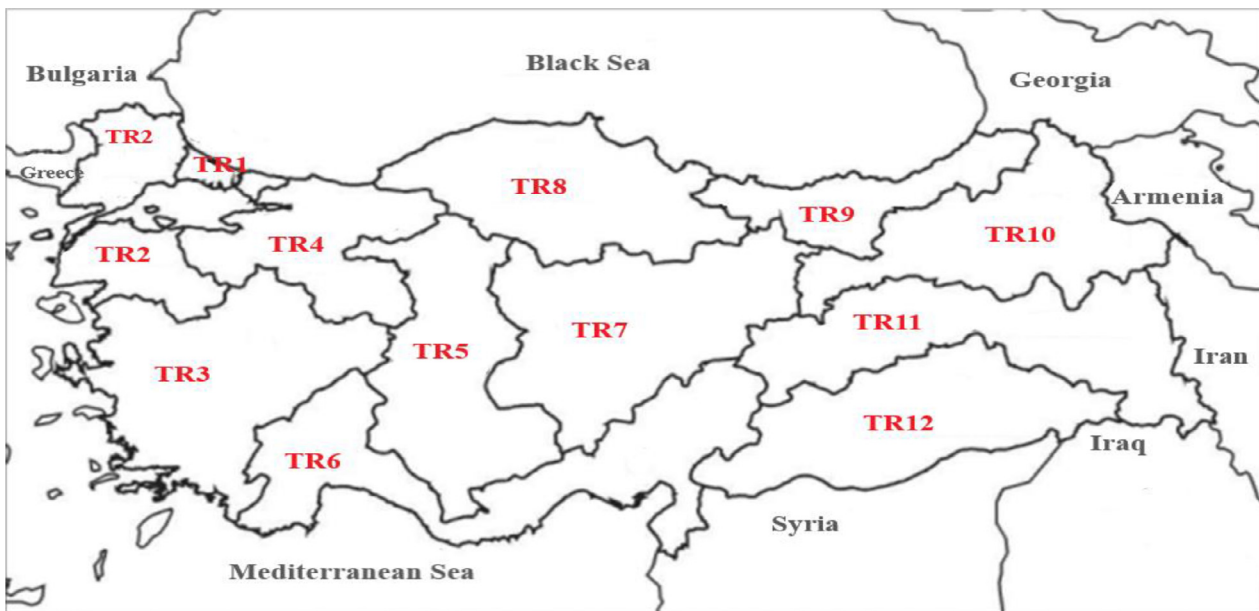


Fig. 1. Regions according to Nomenclature of Territorial Units for Statistics (NUTS) 1 classification in Türkiye.

4. Findings

In this study, the regions are first shown with the fructerman reingold layout in Fig. 2. According to this layout, the most important region among the regions is concentrated in the center. It can also evaluate the most important region according to the node size. When looking at the node size and the feature of gathering in the center, it is seen that the most important region is Istanbul. In order to reduce the impact of the COVID-19 epidemic according to this location, decisions should be taken by taking Istanbul into consideration when quarantine decisions are made. Istanbul is connected to all regions and edge thicknesses appear to have the strongest connection in these connections. The North East Anatolia and South East Anatolia regions are less important than Istanbul according to the Fructerman reingold layout. However, it is thought that quarantine decisions to be taken in these regions will give positive results faster. If the North East Anatolia and South East Anatolia regions are disconnected from Istanbul for a certain period of time or limited, it is thought that the epidemic will decrease considerably in these two regions.

According to the Fructerman reingold layout, the most tourism activity takes place from the East Marmara region is the Aegean region. As can be seen from Fig. 1, the border neighborhood of the East Marmara and Aegean regions is thought to be one of the reasons that increase tourism activities. It is estimated that if the East Marmara region is put under quarantine, it will be an important measure for the COVID-19 outbreak in the Aegean region.

Another layout used in this study is circular layout. Circular layout weighted in-degree values are shown in Fig. 3. Clockwise alignment is provided towards the less important node than the most important node. As it can be seen from Fig. 3, Istanbul, which represents the most important node in terms of node size, is a critical region according to the Circular layout. When the connections of Istanbul are examined according to Fig. 3, it is seen that the edge showing the most intense relationship is with West Marmara, East Marmara and Aegean regions. According to the circular layout given in Fig. 3, the region that should be considered first for quarantine decisions to be taken is Istanbul. Additionally, considering the domestic tourism movements, it is understood from the edge thickness that West Marmara, East Marmara and Aegean regions have more density in terms of visitor entrance and exit with Istanbul. Although there is a tourism density between West Marmara, East Marmara and Aegean regions and Istanbul region in the circular layout, East

Marmara and West Black Sea Regions come after Istanbul in the node ranking. This means that West Marmara, East Marmara and Aegean regions are critical for quarantine decisions after Istanbul.

Another feature of the circular layout in Fig. 3 is that it is sorted according to in degree values. According to the Circular layout, although the West Black Sea region is not in the foreground in terms of node size, it should be considered among the critical regions. The reason for this is that the West Black Sea region is located after the East Marmara region. At the same time, the West Anatolia region has relatively less contact with the Istanbul region (in terms of edge thickness). According to the Circular layout, if the Istanbul region is considered the center (zero point) in the node ranking, West Anatolia ranks third. It should be noted that the capital of Türkiye (Ankara) is located within the boundaries of Western Anatolia.

According to the circular layout shown in Fig. 3, more visitors come to the West Anatolia region from the Mediterranean region, which is among the regions in the green group. When a quarantine application is made in the West Anatolia region, the Mediterranean region can be taken under control. In the node group shown in green, the Mediterranean region and the South East Anatolia region are intense at the entrance and exit point of the visitors. According to Fig. 1, there is a border connection between the Mediterranean region and the South East Anatolia regions. One of the reasons for the density here is this border neighborhood. If the Mediterranean region is quarantined or restrictions are made on visitor entry and exit, there will be a decrease in COVID-19 cases in the Southeast Anatolia region.

Finally, according to the Circular layout shown in Fig. 3, since there are very few visitors entering and exiting between the North East Anatolia region and other regions, both the edge thickness is very thin and it is located in the last row in the circular layout (because Istanbul is considered the center). There have been very few visitors between the North East Anatolia region and other regions. Therefore, the edge thickness is very thin. From Türkiye map in Fig. 1, North East Anatolia region is geographically far away from Istanbul, West Marmara, and East Marmara regions. According to the Circular layout, the North East Anatolia region is considered as a low risk area in the COVID-19 outbreak. North East Anatolia region is less developed than Istanbul, West Marmara, East Marmara and Aegean regions (Ersungur et al., 2010). During the epidemic, it is thought that the economically less development of the North East Anatolia region can be improved by tourism efficiency.

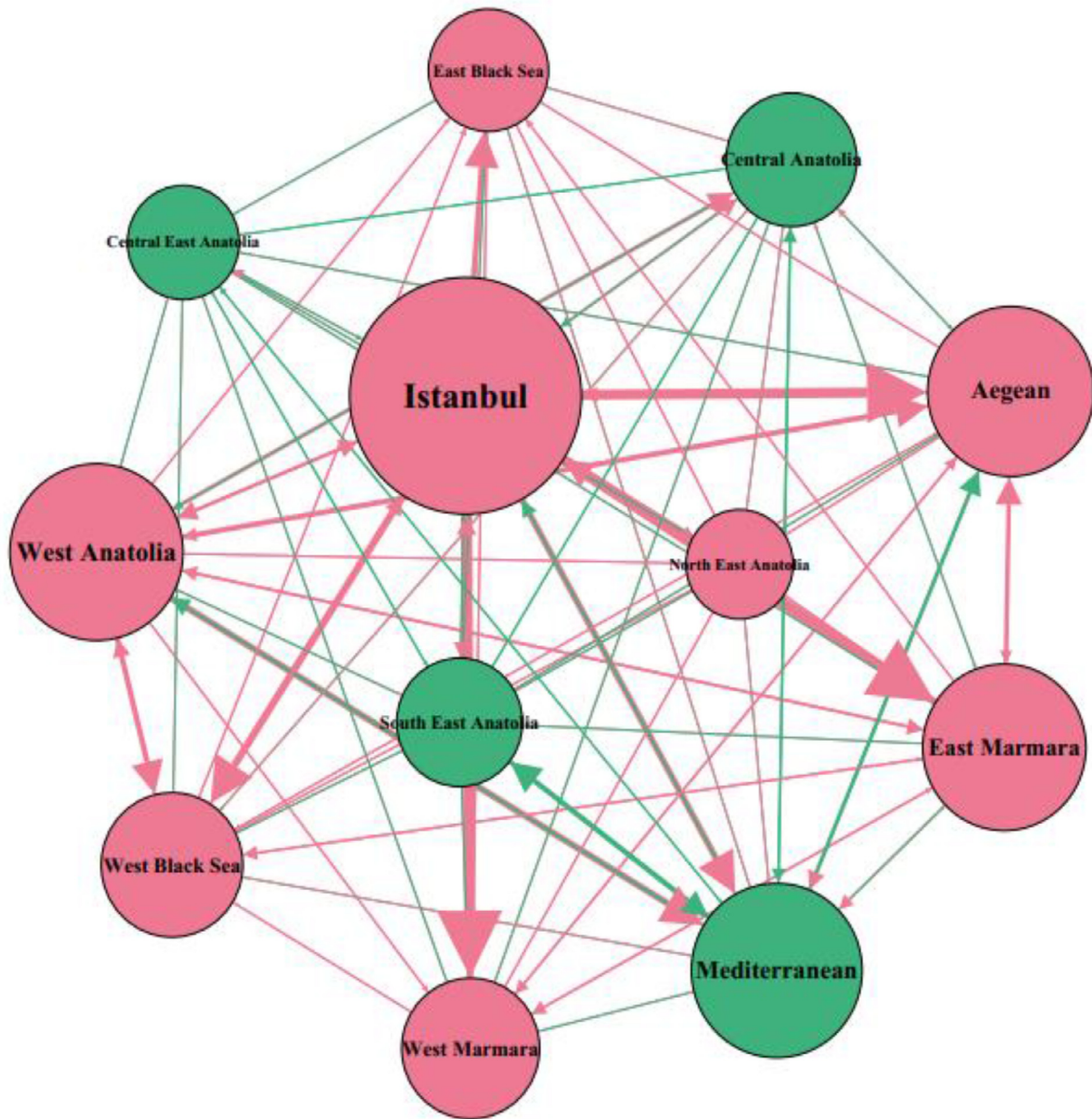


Fig. 2. The fruchterman reingold layout.

Another layout type is the circle pack layout given in Fig. 4. This layout is drawn according to two hierarchies. In the first hierarchy, the eigenvector centrality value is taken into account. The modularity class option is marked in the second hierarchy. Regions according to this layout are shown in two packages. The first packaged group includes eight regions: Istanbul, East Marmara, West Anatolia, West Marmara, Aegean, West Black Sea, East Black Sea and North East Anatolia. In the second group, there are four regions: Mediterranean, Central Anatolia, Central East Anatolia, and South East Anatolia.

According to circle pack layout is given in Fig. 4, government in Türkiye can evaluate the country as two groups while quarantine as Türkiye's strategic planning with respect to COVID-19 pandemic. The effect of COVID-19 pandemic on the tourism sector can be evaluated in two groups.

In Fig. 5, the dual circle layout is shown by ranking the first four regions in the clockwise direction according to their page rank values.

While making quarantine decisions according to this layout, more attentions should be paid to Istanbul, Mediterranean, Aegean, West Anatolia regions respectively. These four regions are the most intensely associated regions. It is thought that the epidemic will continue if the entry and exit of COVID-19 cases continue uncontrolled among the regions in Istanbul, Mediterranean, Aegean, West Anatolia regions. According to the dual cycle layout, although the East Marmara region has heavy visitor entrance and exit with Istanbul, it is not located in the center.

The latest layout used in this study is Yifan Hu which is given in Fig. 6. According to the Yifan Hu layout, the most important node (region) is Istanbul. According to the Yifan Hu layout, the most important regions are settled far away from the center. West Anatolia and Central Anatolia are located at the center of the network. The two closest locations to the Istanbul region in the Yifan Hu network are West Black Sea and West Marmara.

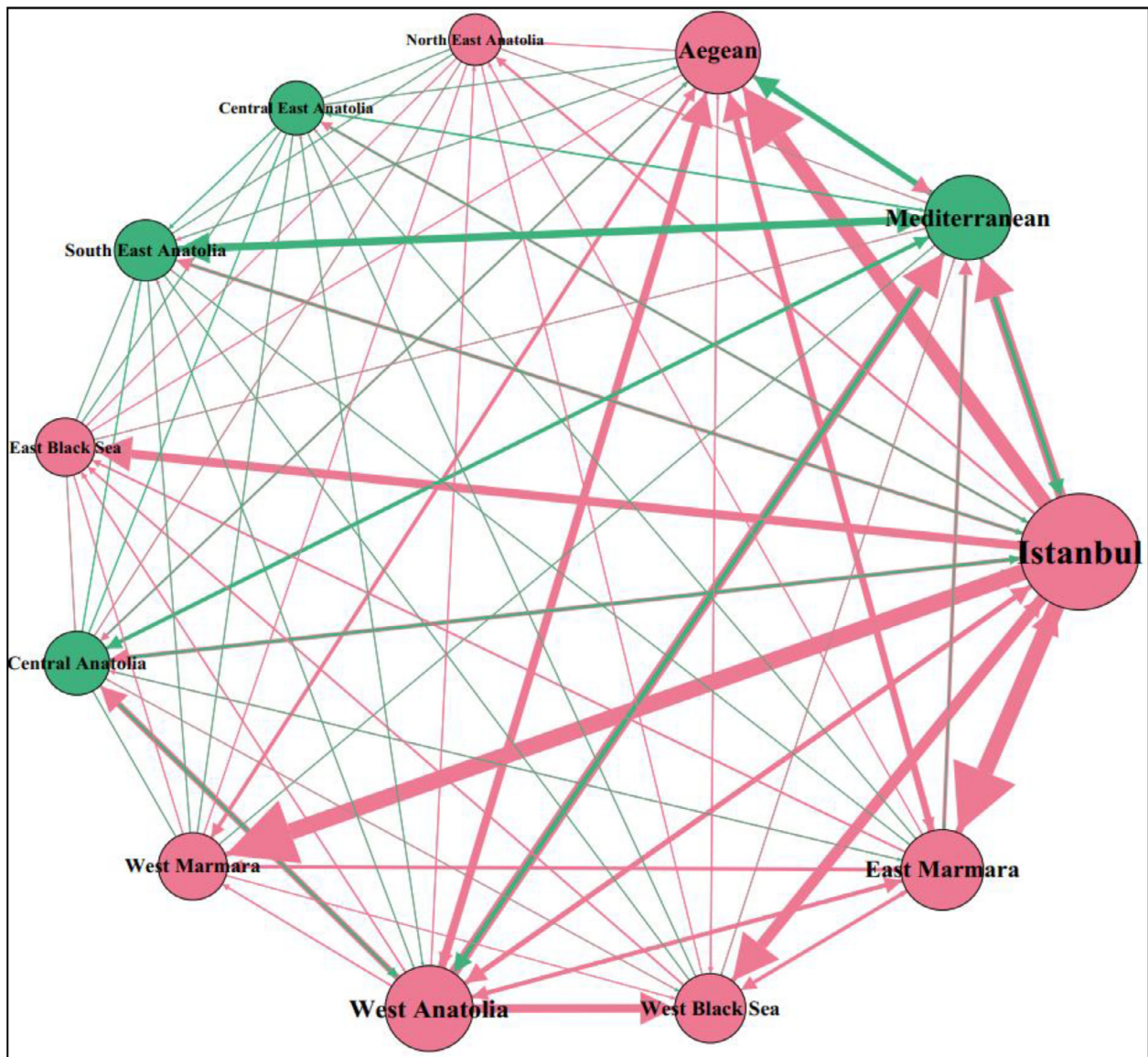


Fig. 3. The circular layout.

According to this layout, the West Black Sea and West Marmara regions, which are closest to the Istanbul region, are considered as the regions that have a key role in preventing the COVID-19 outbreak.

5. Discussion

5.1. Contributions to literature

A number of study has been done on the spread of COVID-19 disease (e.g. Coccia, 2020; Singer et al., 2021; Serra et al., 2021). It is a known fact that the spread of COVID-19 disease occurs through close contact. Making the right quarantine decisions ensures that contact is minimized. Failure to comply with the quarantine rules causes the disease to spread rapidly in the region in a short time. If careful precautions are not taken regarding the increasing spread of the disease, the risk of interregional transmission increases. In case of inter-regional contact in a country, it becomes difficult to control the disease. Therefore, cutting off contacts between regions is critical to stop the rapid spread of the disease. The critical issue is how to make interregional quarantine decisions. This study is about this subject, which has not been studied much in the literature.

The effect of the COVID-19 pandemic on the tourism (Kumudumali, 2020) and Rutynskyi & Kushniruk, 2020), and the effects of quarantine decisions in various aspects during the COVID-19 pandemic period (Jiménez-Pavón, et al., 2020; Besnier et al., 2020; Mattioli et al., 2020 and Muscogiuri et al. 2020) have been conducted in the literature. Additionally, SNA based COVID-19 studies are also utilized by researchers such as Obadimu et al. (2021), Jo et al. (2021), Bahri et al. (2020), Yie et al. (2021), Saraswathi et al. (2020), Ahmed et al. (2020), Wickramasinghe and Saman (2021), Hasan and Kamal (2021), and Wijaya & Handoko (2021). However, these studies are not focus on the use of SNA to decrease the spread of COVID-19 pandemic among regions. The current study applies social network analysis to tourism data to decrease the spread of COVID-19 pandemic among regions in Türkiye. The results of the current study are helpful to make right quarantine decisions during COVID-19 pandemic in practice.

Tourism is one of the sectors affected by the spread of the COVID-19 disease. For this reason, tourism data were used in this study. Interregional tourism mobility in Türkiye was used as data input for this study. Considering the level of relationship between regions, results have been obtained that will assist in making quarantine decisions. Thanks to the

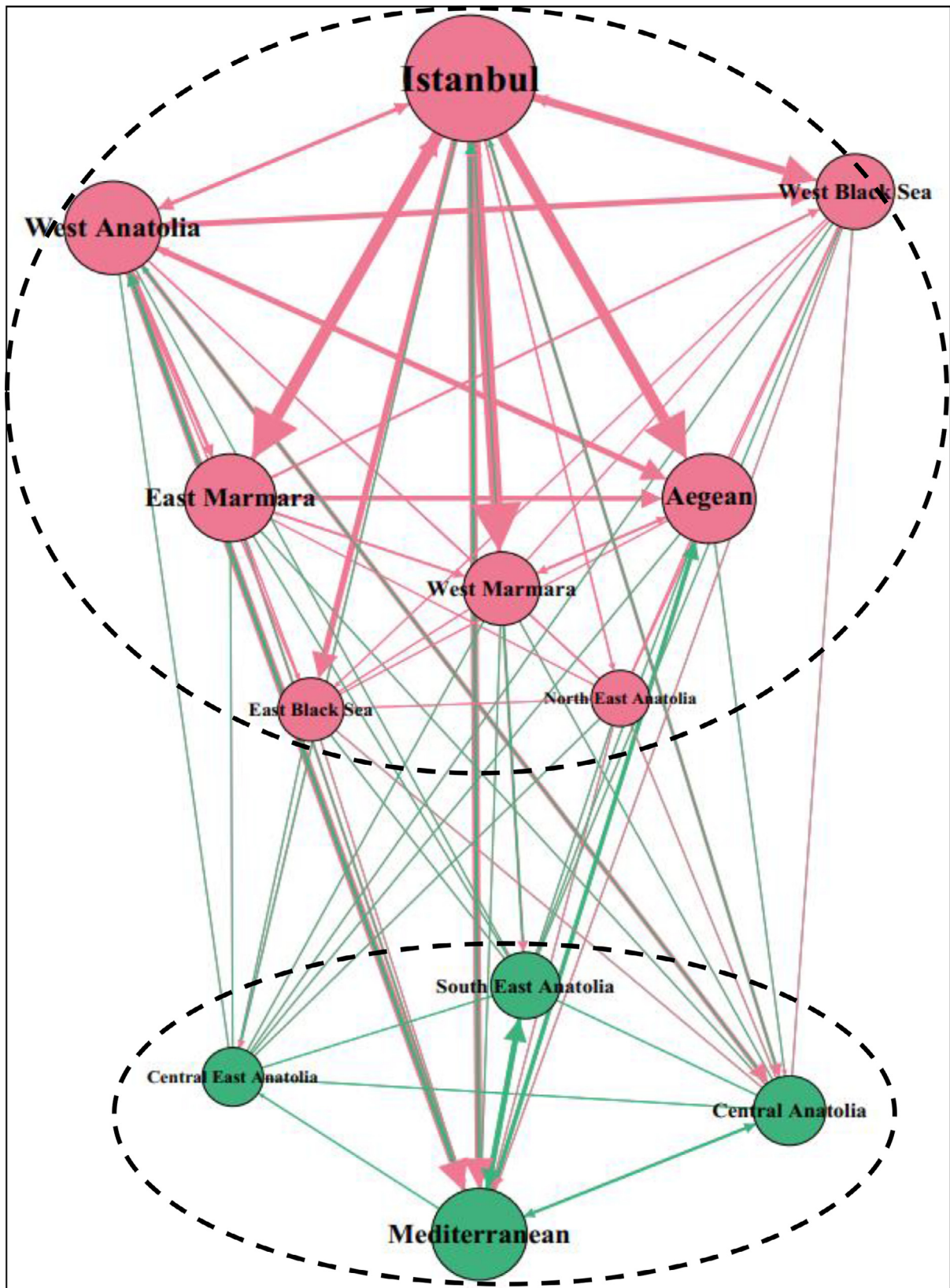


Fig. 4. The circle pack layout.

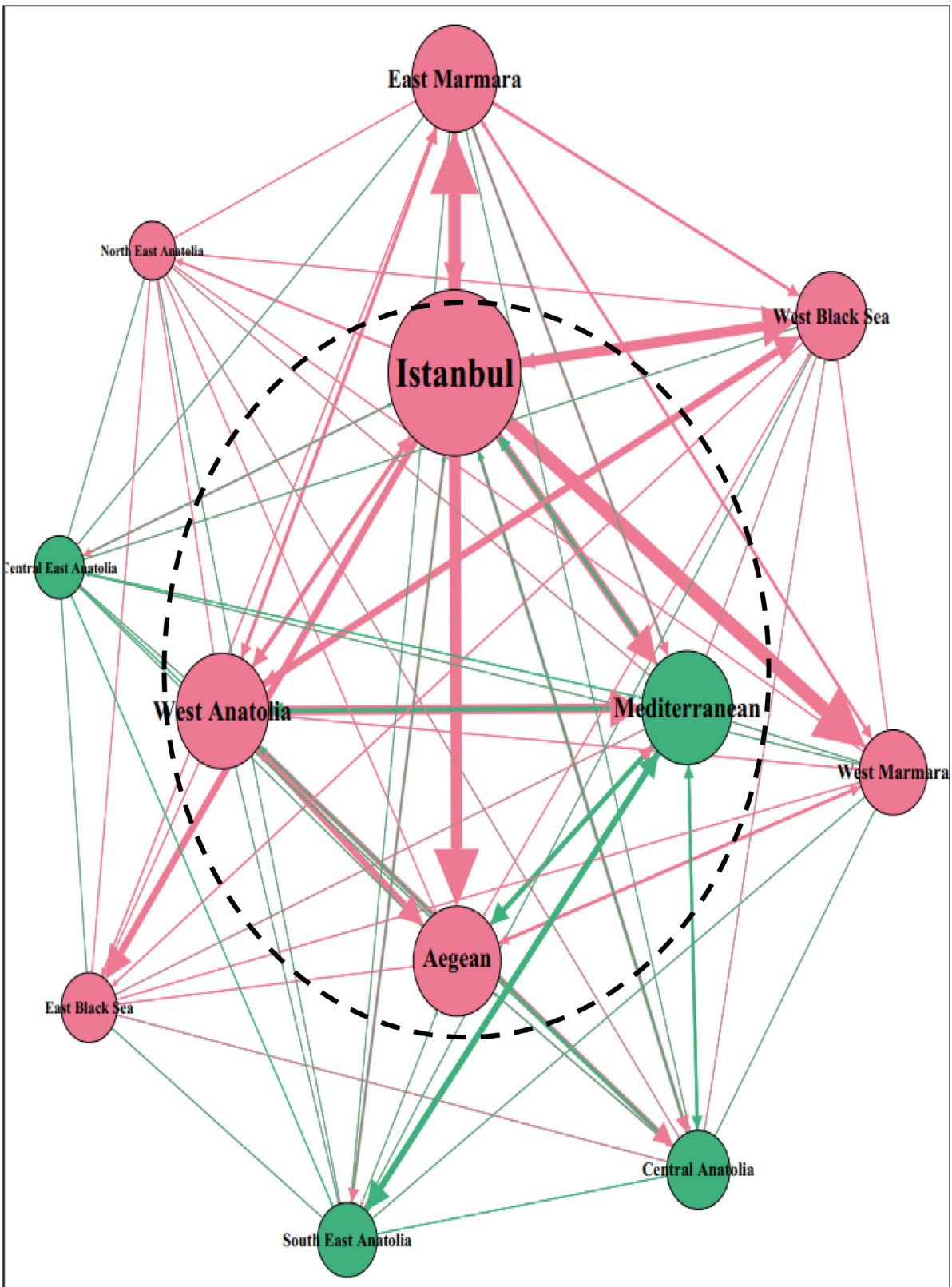


Fig. 5. The dual circle.

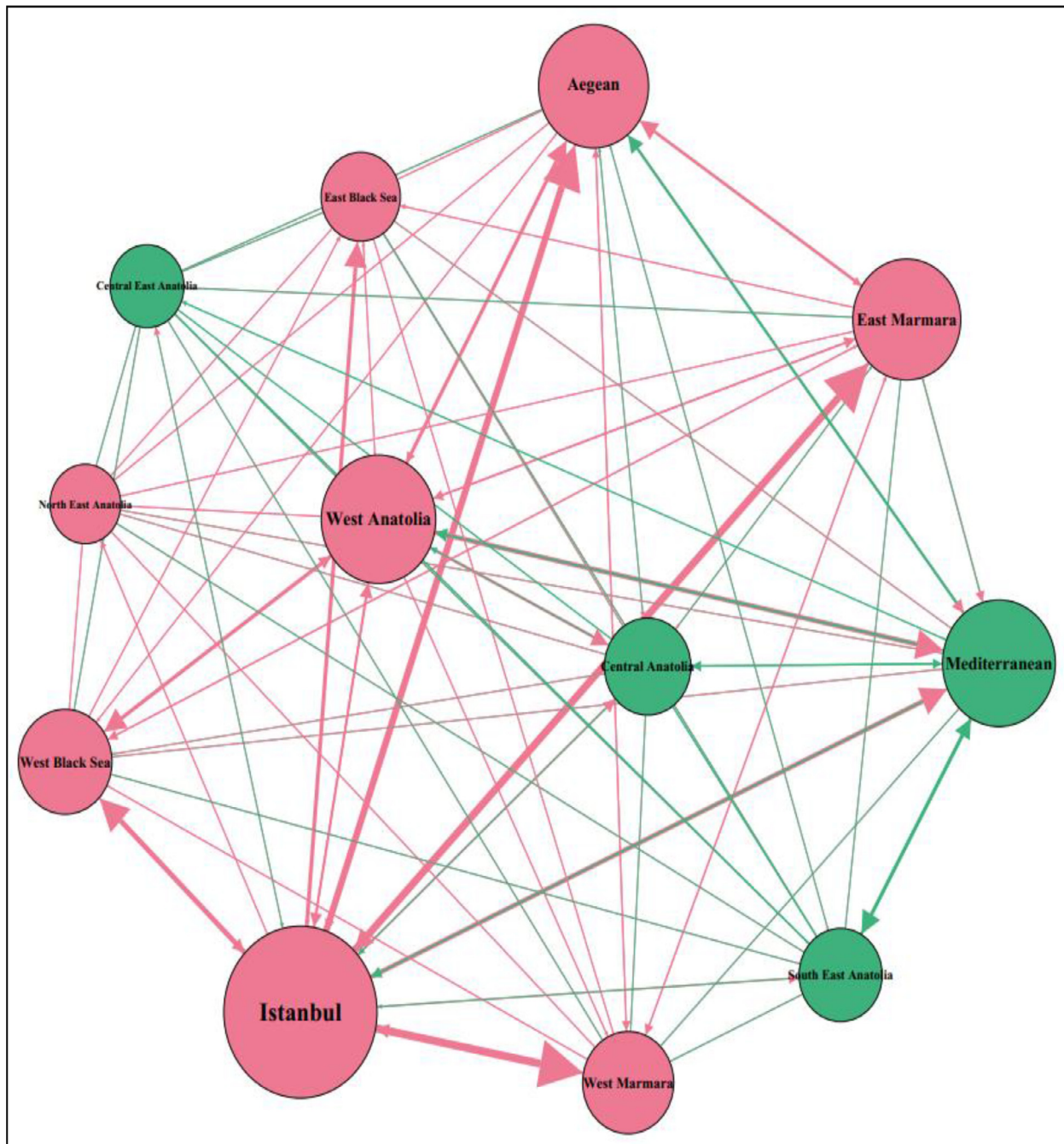


Fig. 6. The yifan hu.

use of social network analysis, various layout patterns have been obtained and the relations between the regions have been examined in detail. Additionally, the most effective regions in the spread of the COVID-19 pandemic within the regions in Türkiye were determined. The results obtained in this study and the case study conducted constitute the original aspect of the study.

Altuntas and Gok (2020) highlighted that considering relationships among regions can decrease the negative impact of the COVID-19 pandemic on the hospitality industry. In order to meet practical needs, priority regions that should be quarantined are determined based on inter-regional travel data in this study. Thanks to SNA, the region (s) with the most interaction, the region (s) with the most contact and the region (s) with the most impact are easily determined in this study. SNA is a powerful analysis to reveal association among regions in a network. The use

of SNA provides a pandemic network which showing the relationships among the regions based on the traveling information. There is limited work in the literature on how to make the right quarantine decisions in a pandemic. To fill this gap in the literature, the aim of this study is to propose the use of SNA based on tourism data to make the right quarantine decisions in the COVID-19 pandemic.

5.2. Implications for practice

Türkiye is located in a critical geography with borders with Europe. For this reason, the implementation of SNA was carried out for Türkiye. The COVID-19 disease, which spread rapidly between countries in a short time, caused countries to take inter-regional quarantine decisions. There are two main problems in making quarantine decisions. Which

areas will be quarantined first? Second, when will the quarantine be implemented? In cases where correct answers are not given for these two questions, the tourism sector is directly affected negatively. This study was conducted to answer the first of the critical questions. Root Cause Analyzes can be used to go into the details of the reasons affecting diffusion of the COVID-19 disease among regions in Türkiye. Policies can be developed to eliminate the causes of rapid spread of the pandemic.

A pandemic wave that will occur in the Istanbul region will affect all regions. For this reason, Istanbul should be considered as a critical region when making quarantine decisions. Crisis-readiness mechanism is of vital importance to meet all vital needs for the tourism sector. Such a system will also be an important investment against a possible future pandemic. It is found that the regions where tourism activities are intense are generally among the neighboring regions. The regions such as Istanbul, Mediterranean, Aegean, and West Anatolia are geographically closer to Europe, political diplomacy activities are more intense, commercial activities are more active, agricultural activities are more frequent due to climate. For these reasons, quarantine decisions should be made using the results of this study to prevent the spread of the COVID-19 pandemic in Istanbul, Mediterranean, Aegean and West Anatolia regions.

The intensity of vital activities in Istanbul, Mediterranean, Aegean and West Anatolia regions can be reduced if the government officials make use of the advantages of the North East Anatolia region and invest in education, trade and healthcare, where online transactions can also be made in this region. In addition, periodic quarantine decisions can be taken in Istanbul, Mediterranean, Aegean, West Anatolia regions.

5.3. Limitations

There are two limitations of this study. First, only domestic tourism data were used in this study. Second, this study is conducted based on the number of people entering and exiting among regions. This means that provinces of Türkiye are not considered.

6. Conclusion

This study focuses on quarantine decisions, one of the most critical measures that can be implemented to prevent the COVID-19 pandemic. The study was conducted using real life data from Turkish Statistical Institute. SNA was performed based on Household Domestic Tourism Survey in Türkiye. The regions that should be quarantined primarily were determined using results obtained from SNA.

According to the results obtained from the case study, the following important suggestions should be considered to take regional quarantine decisions in critical regions:

1. Türkiye's 12 regions are clustered in two groups according to the modularity of SNA.
2. The most critical region in the COVID-19 pandemic is Istanbul.
3. Quarantine decisions to be taken for the regions of Istanbul, Mediterranean, Aegean, West Anatolia are extremely important in preventing the spread of the COVID-19 pandemic.
4. Tourism activities are intense in Istanbul, Mediterranean, Aegean and West Anatolia regions. Therefore, dynamic planning related to quarantine decisions would be appropriate to prevent economic disruptions in the tourism sector.
5. The North East Anatolia region is the lowest risky region in terms of the spread of the COVID-19 pandemic.

Quarantine authorities in each country can utilize SNA to make the right quarantine decisions to reduce the impact of the pandemic on the tourism. In addition, SNA using the provincial tourism data of each country will provide more detailed information. There will be too many nodes in the SNA in case of the use of a large number of provinces. Therefore, it is recommended to use the overlap algorithm to eliminate overlapping nodes due to the large number of provinces.

In future research, SNA can be applied to other countries. Quarantine authorities in each country can utilize SNA to make the right quarantine decisions to reduce the impact of the pandemic on the tourism. In addition, SNA using the provincial tourism data of each country will provide more detailed information. There will be too many nodes in the SNA in case of the use of a large number of provinces. Therefore, it is recommended to use the overlap algorithm to eliminate overlapping nodes due to the large number of provinces. Additionally, only domestic tourism data were used in this study and therefore foreign tourism data may also be used in the future.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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