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Exploring inter-hospital emergency patient referral network

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ABSTRACT

Transferring patients between hospitals is a common and necessary element of emergency departments and patient care. Inter-hospital referrals establish a network, which is also an indicator of how well health institutions are performing. The interaction between hospitals and patient transfers can be similar to the person's relation in a social network. In the study, it is aimed to determine how the measurable differences in the service delivery of the hospitals in the Eastern Black Sea region of Türkiye affect the direction of patient referral flows between hospitals. The study encompasses inter-hospital patient transfers conducted by 112 ambulances and includes data from the years 2015, 2016, and 2017, involving 110,688 patient referrals among 42 provinces and 272 hospitals.The study was analyzed using the network analysis program NODEXL. As a result of the research, the roles and positions of the hospitals and the hospitals that were most efficient were identified. The hospitals in the region exhibit strong and heterogeneous connections with each other, indicating a high degree of coordination. Although geographic distances have an impact on patient referrals, it has also been revealed that there is a relationship between the characteristics and capacities of hospitals and their centrality. It was determined for which reasons the patients in the region were referred the most and from which disease group they were referred. It is thought that the study will contribute to the health sector on a country basis, since focusing on the analysis of all hospitals in a region is a representative of sub-component of the health system. This is the first thorough regional study in the national literature to indicate that social network analysis may be used to evaluate inter-hospital patient referrals.

Authors statement

Dilek GÖNÇER DEMİRAL: Investigation, Data Curation, Conceptualization, Formal Analysis, Methodology, Writing.

Üstün ÖZEN: Investigation, Methodology, Validation, Review & Editing.

1. Introduction

The inter-hospital referral process is a comprehensive and complex structure. It includes the Provincial Ambulance Service Directorate, the referring and accepting hospitals, doctors, healthcare personnel and requires high coordination, cooperation, and information flow. The primary goal in such a decision-making chain is to provide the best possible health service and increase the quality of patient care. This process is directly related to the resources of institutions, such as the presence of specialist physicians, intensive care units, incubators, medical equipment, etc. In this context, the establishment of inter-hospital relationships is important for revealing the strong and developable aspects of the healthcare system.

Referral occurs when the same patient is checked or treated by two different doctors at a certain time [1]. The process and organization of patient referral between hospitals may vary according to the health system of the countries. Inter-hospital patient transfers are organized by the Provincial Ambulance Service Directorate using 112 ambulances in Türkiye.

The inter-hospital transfer process in Türkiye occurs through ambulance services in three specific situations: 1- In emergency cases that demand immediate attention, the 112 emergency ambulance transfers the patient to the closest hospital. If the hospital lacks the necessary equipment or specialist physicians to provide adequate care, or if advanced diagnostic tests are required, the patient is referred to another hospital. 2- If a patient's condition worsens while they are hospitalized and there is a lack or insufficiency of resources or advanced testing is required, the patient is transferred to another hospital. 3- Once a hospitalized patient has completed the essential treatment process,

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there is a possibility that they might be transferred to a hospital at a lower level or located in the patient's district or province for further follow-up and monitoring.

Previous research on patient referrals has also backed up the "resource dependency theory". Referrals occur, according to this view, because hospital resources are not homogeneously distributed [2]. Patient referrals are related to many relational decisions such as hospital organizational structures, geographical distances, the existence of procedural processes, and the distribution of resources according to the structure and population of the provinces. This situation stated by Ref. [2] as follows; patient transfers can be interpreted as the results of "highly structured social context". For this reason, hospitals that are in a strong relationship with each other should be aware of all the changes to be made. This can only be achieved through cooperation and continuity of information flow.

Patient referrals provide learning for doctors. Referral of rarer diseases to full-fledged centers can increase the experience of health personnel working in these facilities and can be an important learning resource for physicians. While patient transfer occurs, it is also accompanied by diagnostic analyses, clinical documents and reports. This information transfer provides important learning opportunities related to documentation processes. [3] stated that with the common use of resources, hospitals can increase their financial income and reputation by increasing their knowledge and skills. In addition, since the proper management of inter-hospital patient referrals affects the healthcare expenditures of institutions and contributes to the country's economy, it is seen as an area that needs to be researched. Previous studies have shown that coordinated and harmonious inter-hospital patient transfers can increase institutional efficiency and positively impact the quality of patient care [4].

The hospital community in a region is similar to the people in the social network in many ways. Just as people are socially connected with each other, hospitals also create a network by connecting with each other through patient referral. Ensuring the readability of inter-hospital networks is of great importance in terms of affecting both the quality of patient care and the performance of health institutions. Revealing the connections between hospitals provides valuable information about the service areas and organizational structures of healthcare institutions.

Although network analysis has applications in many fields such as sociology, physics, biology, management and military operations, less studies have been done in patient transfers. There are numerous advantages to presenting patient flows as networks. The most essential benefit for health planners is that they may quickly obtain information on the hospital's roles and positions in the region and within hospitals. In addition, it helps hospitals make strategic decisions that can affect the delivery of health services such as bed capacity, medical equipment, clinical specialties, various care units (burns, intensive care, etc.). [5] emphasized that network analysis can provide new information about hospital quality and help policymakers to understand the network effects of stress factors such as infectious diseases and disasters.

This study aims to determine the position and role of hospitals in the Eastern Black Sea region through social network analysis (SNA) method. In addition to revealing the relationships, the study also highlights the most frequent reasons for patient referrals, thereby identifying areas that require improvement in hospitals. The study is anticipated to offer health managers valuable insights into improving patient care quality, optimizing resource utilization, and formulating strategies to achieve these objectives. Health managers of each province periodically calculate the statistical calculations of patient transfers between hospitals. Especially, interpreting the analyses conducted within a large dataset of regional patient transfers (between 5 provinces and districts) is both time-consuming and difficult. Since the SNA method can graphically represent patient transfers quickly, it is easier and faster to interpret.

Although there are economic, demographic, and social differences at the regional level, focusing on the analysis of all hospitals in a region will be a representative sub-component of Türkiye's healthcare system. Therefore, the study will serve as preliminary knowledge about the strengths and weaknesses of our country's healthcare system. Although there are SNA studies in the international literature in the field of health, there are very few studies on inter-hospital patient referrals. Especially, the wide temporal dimension of the study, the large number of data, and the method used will bring a different perspective to the literature.

2. The Concept of Social Network Analysis and Literature Review

A network consists of entities which can be a person, company, country or a hospital and the links between these entities. SNA is defined as a set of methods used for mapping, measuring and analyzing social relationships among people, groups, and organizations. It can be used in any research that belongs to a field of study where the connections of entities are important such as the discovery of organizational structures, the spread of a disease, determining the relationships between genes, or generally any study area where the connections between entities are important [6].

The most important feature that distinguishes SNA from other methods is to use the structural or relational information to examine and test the theories [6].

In the literature, the analysis methods of social network data are discussed within the framework of drawing graphs, visualizing the data, and performing various numerical analyses on the data. It has an important role in visualizing data with figures and graphs in many disciplines. A well-structured graphical representation is more effective in explaining the desired outcome than many words.

The majority of the studies in the literature have used SNA such as analyzing the distribution of infectious diseases and hospital infections, exploring the transfer of knowledge between individuals, studying the formation of new methods, investigating the influence of personal and social relationships on health behaviors, and examining the inter-organizational structures within the health system [7].

[8,9] have examined the spread of hospital infections through SNA. As a result of the creation of inter-hospital patient referral networks, they have demonstrated that infections are directly associated with patient transfers. [5] emphasized that the inter-hospital network analysis could provide new information about hospital quality and help policymakers understand the network effects of stress factors such as epidemic diseases and disasters. [10] analyzed the common disease groups among patients according to their nationalities using SNA and found that Indians mostly suffered from common cold, Americans suffered from measles, and Chinese people suffered from influenza. [11–13] concluded that network analytical techniques were utilized to enhance the efficiency of referral networks, resulting in the majority of patients being referred to larger and better-equipped hospital. [14,15] found that patient referrals were high between hospitals that are geographically close to each other, but many hospitals also referred patients to hospitals in distant areas. They also noted that hospitals in close relationships with each other could affect each other's spread of infectious diseases and hospital-acquired infections. [5] emphasized that small hospitals were found to refer more patients, while larger hospitals were effective in accepting referrals. [16] revealed the relationship between doctors through network analysis of patient referrals between hospitals. As a result of the study, they found that network properties varied according to geographic regions and that doctors referred patients to similar-level doctors. [4] found that hospitals with a high degree of centrality had lower patient acceptance probabilities. [17] used SNA method to reveal the doctor's network for patients referred with CVS diagnosis in India. [1] found that some doctors acted as hubs in inter-regional referrals, and that network analysis provided a new perspective on improving and enhancing the healthcare system. [18–23] examined the social structure within healthcare institutions using network analysis techniques. Healthcare professionals were surveyed in various studies conducted by Refs. [24–27]; and [28]. The

survey findings underscore the significance of social interactions in relationships and shed light on the crucial role of bonds between relationships in the dissemination of innovations. [8] showed that hospital-specific MRSA bacteria in patient transfers are associated with the spread of hospital infections.

3. Method

Network is a term that has both technical and common uses. In this study, since networks will be used to reveal the relationship between health facilities, they should be perceived differently from the concept of "socialization".

This study covers 110,688 patient referrals from Training and Research Hospital (TRH), State Hospitals (SH), University Hospitals (UH), and Private Hospital (PH) in the Eastern Black Sea region in Türkiye, in the years of 2015, 2016 and 2017 by 112 ambulances. The data used in this study was approved by the Recep Tayyip Erdogan University Non-Interventional Clinical Research Ethics Committee with the decision number 2018/42 dated 23.02.2018. The data were obtained from the Provincial Ambulance Service Head Physicians of the provinces of Artvin, Rize, Gümüşhane, Trabzon and Giresun. Patient referrals were made among totally 272 hospitals in total, including 42 provinces and 75 hospitals in the Eastern Black Sea region. There are 115 SH, 64 PH, 55 TRH and 38 UH in the referral network.

In the study, each hospital is a node, each edge (connection between two hospitals) represents the patient flow. In order to enhance the readability of networks, 'filtering' is applied to connection weights. "Filtering" on the edge weights is used to improve the readability of the networks and is necessary to improve the comprehensibility of networks that consist of a large number of nodes and connections. Filtering is done with threshold values. To increase the network's clarity and identify the core nodes in the region, threshold values have been determined for the number of referred patients. The threshold values were judged *"unlimited", "10" and "50"* as appropriate in this study. There is no known method for calculating these threshold values, and subjectively, the threshold values are used where the readability of the network is more understandable.

For the analysis of the data, the Excel-based NodeXL program was used. Degree, betweenness, and eigenvector centrality criteria were applied in this study. To make viewing the graphs easier, the NODEXL program utilized the same applications for the nodes and edges during the study. The arrangements are as follows:

Input Degree: The input degree of a node gives the number of hospitals that accept patients. The node with the highest input degree is shown as the *largest node* in the network.

Output Degree: A node's output degree refers to the number of hospitals that have referred patients. The node with the highest output degree is the *reddest node* in the network.

Edge Weight: Edge weight refers to the *number of patient referrals.* The NodeXL program shows the edge weight of each node pair in a separate column, and threshold values are made according to these edge weights.

Edge Color: As the number of edge weight increases between the node pairs, the color of the edge changes *from gray to orange*. The edge color of the node pair with the most patient shares is the most orange line in the network.

4. Results

Degree distribution is a statistical characterization of the graph given by the sequence of degrees or by the relative probability distribution of degrees [29]. The concept of degree distribution is critical for establishing the network type as well as the structure and resistance of the network. There are 272 nodes in total and 206 nodes are between 1 and 14°. According to Table 1, nodes with edges 1–14 range are 75.7% of the total nodes, and nodes with more than 14 edges make up 24.3% of all nodes. As the number of degrees increases, the number of nodes decreases. That is, few nodes have many edges, many nodes have few edges obeying the "scale-free network model" in accordance with Barabási's preferential attachment model.

Inter-hospital patient referral networks are seen in a power law structure, that is, as scale-free networks (Table 1). In many network around us (underground-overground transportation routes, pipes under cities, cables etc.) are usually similar to scale-free networks. However, scale-free networks have undeniable advantages in many cases in which they are "solid but fragile" [34]. That means, networks are resistant to random failure but vulnerable to targeted attacks [35].

4.1. Network statistics

The network statistics gives information about the whole network. Three different threshold values were used in the study. The network that took place without applying any filtering on the data was evaluated as "unlimited". The networks of hospitals with more than 10 and 50 patient referrals between two hospitals are shown as ">10", ">50". This is the feature of filtering to reduce complexity and access important nodes within the network.

Accordingly, patient referrals occurred among with respectively 189, 178 and 184 nodes, in an unlimited network (Table 2). According to the >50 threshold, patient referrals occurred between 59, 63, and 62 nodes, respectively. Thus, there is no big difference in the number of nodes according to the years in threshold values. It is seen that the number of edges decreases as the number of nodes decreases in every threshold values.

The distance between two nodes in a network is explained by the concept of "path." A path is a sequence of connections starting from one

Table 1
Degree Distribution.

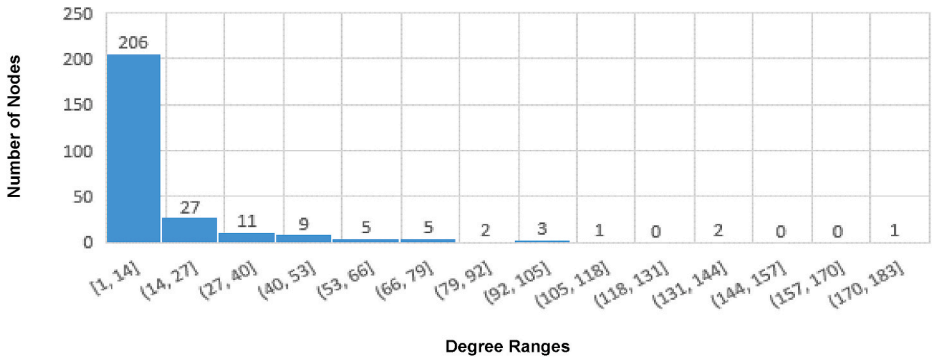


Table 2
Network Statistics.

	2015			2016			2017		
	Unlimited	>10	>50	Unlimited	>10	>50	Unlimited	>10	>50
Node Number	189	77	59	178	79	63	184	83	62
Edge Number	1206	316	148	1136	335	152	1153	335	154
Diameter	4	6	6	4	5	5	4	6	6
Density	0,034	0,054	0,043	0,036	0,054	0,039	0,034	0,049	0,041
Minimum Input Degree	0	0	0	0	0	0	0	0	0
Maximum Input Degree	52	36	20	54	33	18	52	33	19
Minimum Output Degree	0	0	0	0	0	0	0	0	0
Maximum Output Degree	95	23	8	82	22	8	79	18	7

node and ending at another node. Geodesic distance (shortest path) is the shortest path between two nodes, representing the minimum number of connections required to reach from one node to another [30]. [6] state that the maximum geodesic distance between any pair of nodes is equal to the graph's diameter. A larger diameter of a network indicates that nodes in the network are less connected to each other. It is observed that the diameter increases according to the threshold values. The increase in diameter may imply that some pre-existing connections have been broken in the network. In other words, patient referrals between previously connected nodes in the network did not occur.

This situation may explain that more than a certain number of patients are sent to certain hospitals, or that hospitals may behave according to the judgments formed over time instead of displaying rational behavior. In the studies conducted by Ref. [14] on inter-hospital patient referrals, it is also seen that the diameter length increases according to the threshold values.

The geographical spread of hospitals, structural and equipment differences of hospitals, distance from each other, and the existence of district hospitals affect the network density. As long as these variabilities exist, the network density will never be "1" and "whole network". For a network to be a "whole network", all hospitals must be connected to each other. As a result of these findings, it can be said that high density may be a rare situation in network studies related to patient referrals. In the study of [5] for intensive care patients, they found that the network density was low (0.1%), which is consistent with our study.

The fact that the minimal input and output numbers are both 0, this suggests that some hospitals merely refer or accept patients. It is noticed that the input degrees of the threshold values do not differ much over years. Accepted patients of hospitals have higher input levels than referral patients of hospitals.

Fig. 1 shows the emergency patient referral graphs between hospitals. Only the graphs belonging to the year 2017 are included, as they are similar to other graphs and due to space constraints. Nodes with dense connection are geodesically very close to each other. In unlimited threshold, a majority of the nodes are positioned at the edge of the network, representing hospitals located outside the Eastern Black Sea region. The dense connections are evident from the intensity of the patient referral flow. The provinces where the patient referral flow is intense are the places that are geographically close to each other as well. At threshold value > 50, each province has much referral flows within itself. In networks with a threshold value of 50, we can observe clustering. The patient flows in 5 different cities have formed 5 different clusters. This also indicates a dense patient flow within each city and its own districts. There seems to be very little change in the networks over the years. This demonstrates that there is no significant regional variation in patient flows, and the region maintains a stable approach in patient referral flows. There are also connections with hospitals in the provinces of outside of the Eastern Black Sea region (Erzincan, Erzurum, Ordu and Sivas). Due to their geographical proximity, these provinces also play a significant role in providing healthcare services to the region.

4.2. Degree centrality

In a directed network, degree centrality is analyzed by considering both the input and output degrees of a node. The sum of these degrees represents the "degree centrality" of the node. In network terminology, a node with a high input degree is referred to as an "authority," while a node with a higher output degree is known as a "hub.". Being an authority and hub in the network is a measure of centralization. "Authority" is to be in the position that accepts patients from the most hospitals in the network. The fact that a hospital is in a position of authority is related to its ability in service delivery and indicates that the hospital is preferable by other hospitals in terms of equipment and structure.

Table 3 shows the hospitals with the highest input and output degrees over the 3 years. According to the table, Giresun TRH acts as a hub in the region. The node in the authority position is Trabzon Farabi UH. Being an authority in the network affects all the nodes in the network both positively and negatively. For example, if any disruption occurs in Trabzon Farabi UH (closure of a part of the hospital, renovation-repair a service etc.), other hospitals will be affected by this situation. Regarding the study of [5] hospital characteristics and capacities have a strong relationship with hospital centrality.

4.3. Betweenness centrality

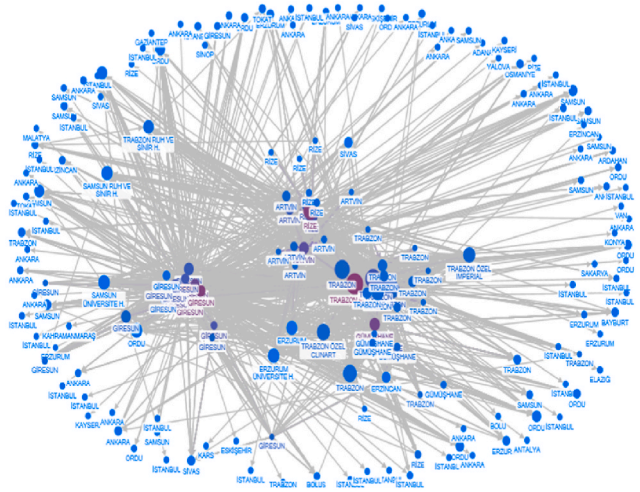
Betweenness centrality refers to the number of nodes in a network that connects two nodes that have no or few direct connections to each other. It serves as a link between nodes and is involved in the network's information flow. Giresun TRH became at first for the betweenness centrality (Table 4). High betweenness centrality acts as a bridge by providing coordination with different hospital groups during crisis periods. Although it has a potential impact on communication, it is also thought that it will be most affected by any change within the network. For example, the inability of more than one department of the hospital to provide service may mean that it will greatly affect the patient traffic as transferred out of the region. Due to space constraints, the first 5 in the ranking are stated.

4.4. Eigenvector centrality

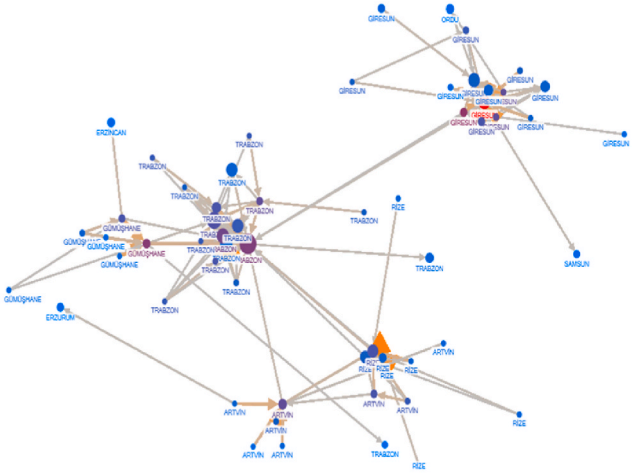
Eigenvector centrality considers not only the number of connections a node has, but also the centrality of the nodes it is connected to. In other words, it considers the centrality of the node's neighbors. Nodes with high eigenvector centrality are called "prestigeous" in the network.

High eigenvector centrality hospitals are very well correlated with other central hospitals. The most prestigious (with high reputation) hospital in the region is Trabzon Farabi UH (Table 5).

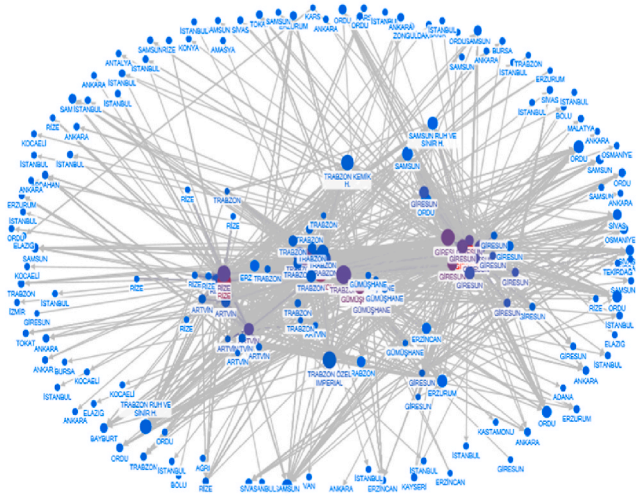
As mentioned by Ref. [31] the presence of well-equipped and specialized hospitals offers significant benefits, as it promotes collaboration and information exchange among healthcare facilities. Moreover, hospitals that maintain frequent connections with reputable hospitals can acquire valuable insights into their own capabilities and available resources. Additionally, hospitals that share a substantial patient base



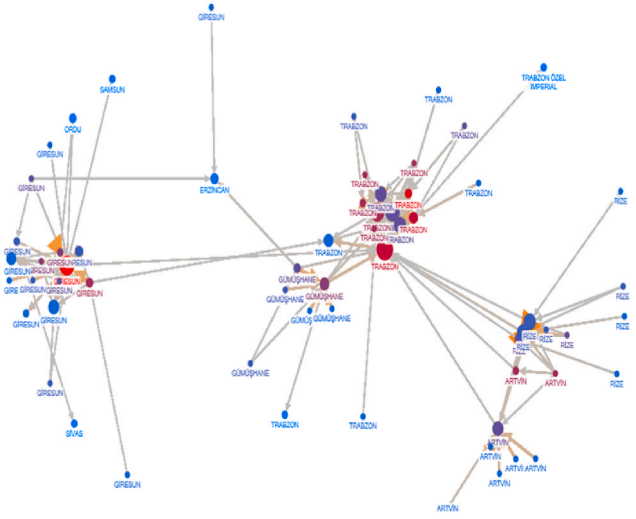
2015- Unlimited



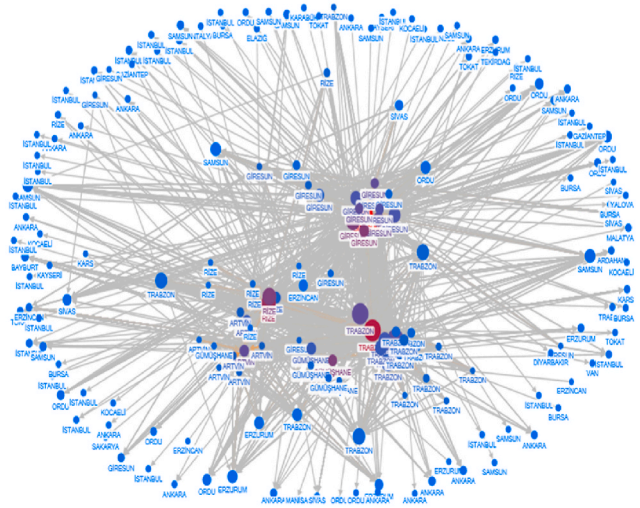
2015- >50



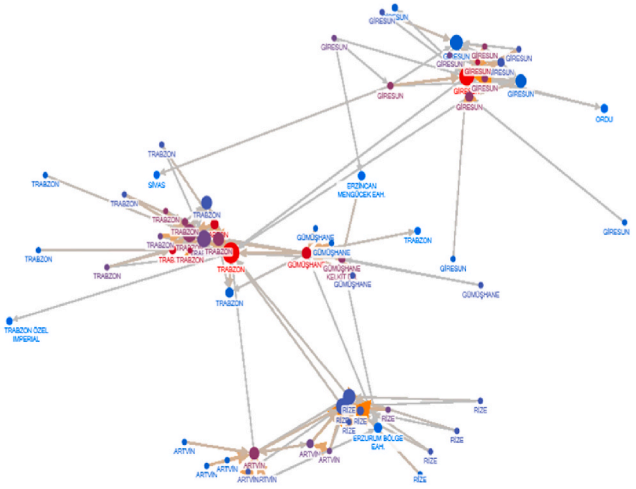
2016- Unlimited



2016- >50



2017- Unlimited



2017- >50

Fig. 1. Inter-hospital patient referral network.

Table 3
Input-output degree centrality.

	Rank	2015		2016		2017	
Input Degree	1.	Trabzon Farabi UH	52	Trabzon Farabi UH	54	Trabzon Farabi UH	52
Output Degree	1.	Giresun TRH	95	Giresun TRH	82	Giresun TRH	79

Table 4
Betweenness centrality.

RANK	Hospıtal	2015	2016	2017
1	Giresun TRH	12.7876	9.446	9.914
2	Rize TRH	5.150	5.942	6.104
3	Trabzon Farabi UH	3.751	5.087	4.052
4	Giresun Ada PH	4.132	–	3.426
5	Rize SH	2.549	2.728	2.953

Table 5
Eigenvector centrality values

RANK	HOSPITAL	2015	2016	2017
1	Trabzon Farabi UH	0,027	0,029	0,029
2	Giresun TRH	0,026	0,027	0,025
3	Trabzon Kanuni TRH	0,023	0,024	0,024
4	Trabzon Medicalpark PH	0,023	0,024	0,024
5	Giresun Ada PH	0,022	0,023	0,023

with Trabzon Farabi UH also stand a significant chance to improve and expand their own capacities.

4.5. *Inter-hospital patient sharing network*

In evaluating a hospital's network relationships, both the number of patients referred and accepted and the hospital's affiliations with other hospitals carry paramount significance.

The number of accepted or referred patients may not necessarily correlate with a hospital's high input and output degree; there might be cases where a hospital with high degrees has a relatively low number of accepted or referred patients, and vice versa. For this, the criteria of centrality and the number of patient referrals and admissions are also important.

Fig. 2 shows the number of patient referrals and acceptances in 2017. The classes of the hospitals were determined by the Ministry Health Services of Türkiye, and the hospitals were grouped accordingly in the network diagram.

Node colors, from blue to red, represent the increase in the number of referrals. An increase in node sizes indicates that the amount of patient acceptance increases. Node size numbers are also indicated next to the nodes. A1 group hospitals are the most equipped and have the highest capacity. Within this group, while Giresun TRH also refer and accept the patient, Rize TRH and Trabzon Kanuni Kaşüstü UH accept the most patients. According to the graph, most of the patient referral and admission is realized through A1 group hospitals. It can be seen from the size of the nodes that A1 group hospitals accept more patients instead of patient referrals. C group hospitals are the most sending patients in the region.

The network drawn according to hospital classes is shown in Fig. 3. Group C is the class of hospitals that refer the most. A1 group, is the class of hospitals that accept the most patients. D groups are referred to B hospitals, and C and B groups are referred to A1 group hospitals. Based on the network representation, hospitals of all classes refer patients to higher-class group hospitals. This observation provides evidence that the healthcare system adheres to the Emergency Health Service Regulation in Türkiye. The expectation that the number of referrals will be high due to the existing health infrastructure of the C group hospitals coincides with the network results. The study also reveals a tendency among hospitals to refer patients to higher-level facilities. This can be attributed to the fact that healthcare facilities in the region, including the number of clinics, beds, presence of specialized units, and medical

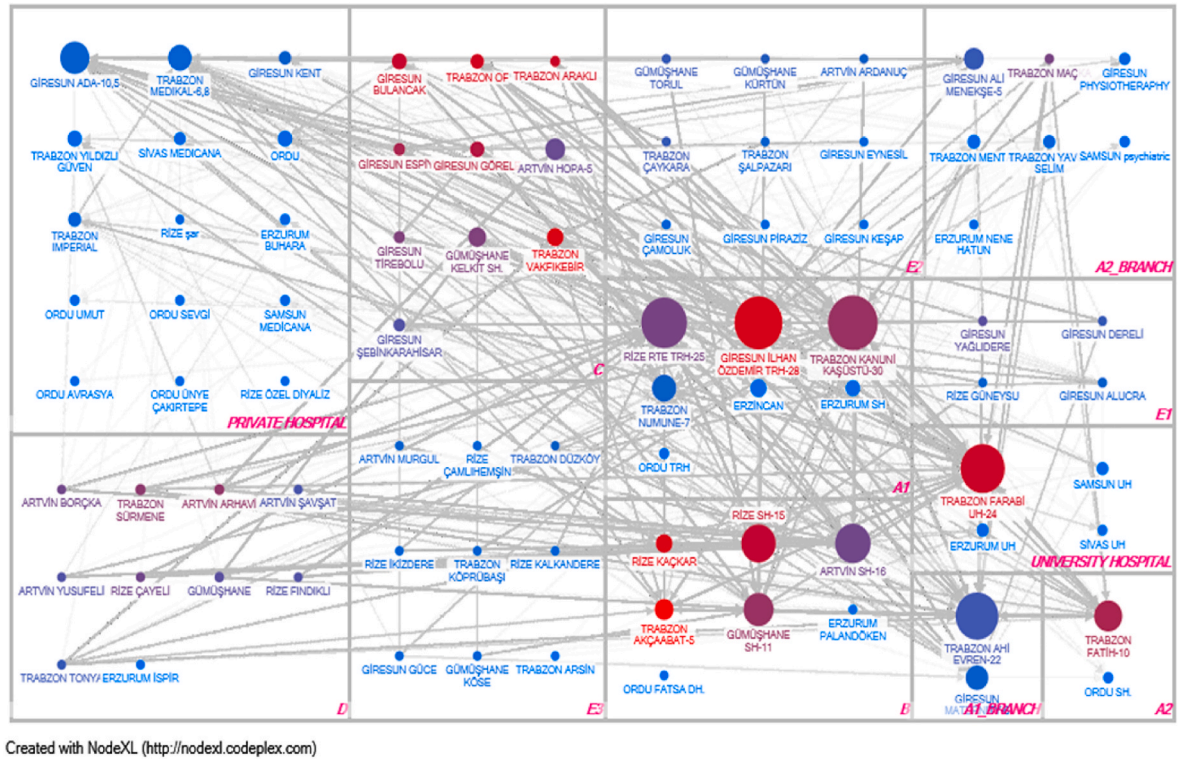


Fig. 2. Inter-hospital patient sharing network.

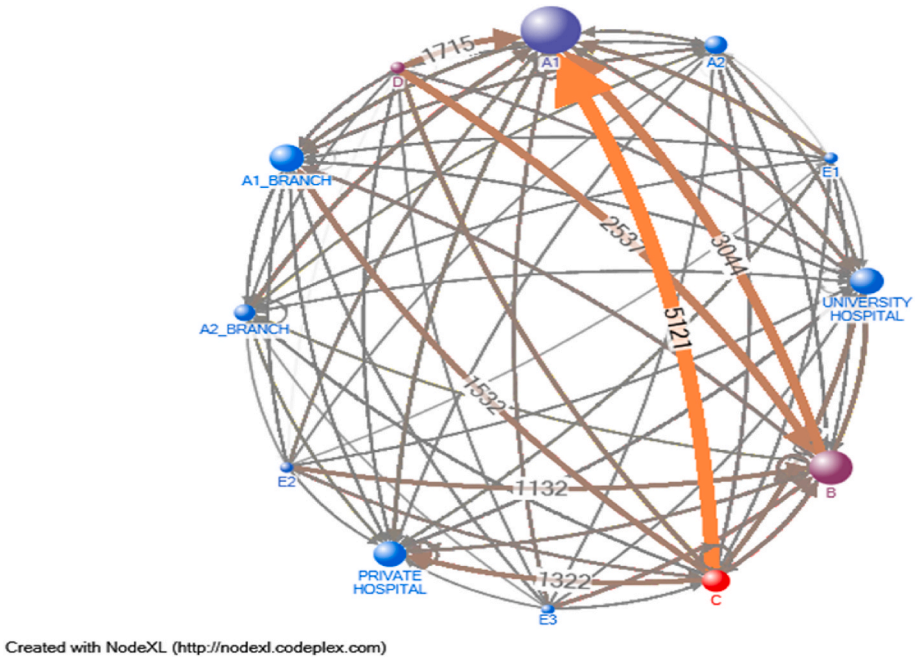


Fig. 3. Patient referral network according to hospital classes.

equipment, are planned according to the population.

4.6. Analysis of diagnostic groups and reasons for referral

Diagnostic data were grouped according to ICD (International Classification of Diseases). Diagnoses are a cluster, and referral reasons are a separate cluster. Such networks are called "bipartite networks".

Node sizes are correlated with the quantities of diagnosis and reasons of the referrals. According to Fig. 4, the highest number of referrals occurred due to CVS (Cardiovascular) diseases during the three years. This was followed by "Other" and "Respiratory System" diseases, respectively. The primary reason for referrals is the absence of specialist

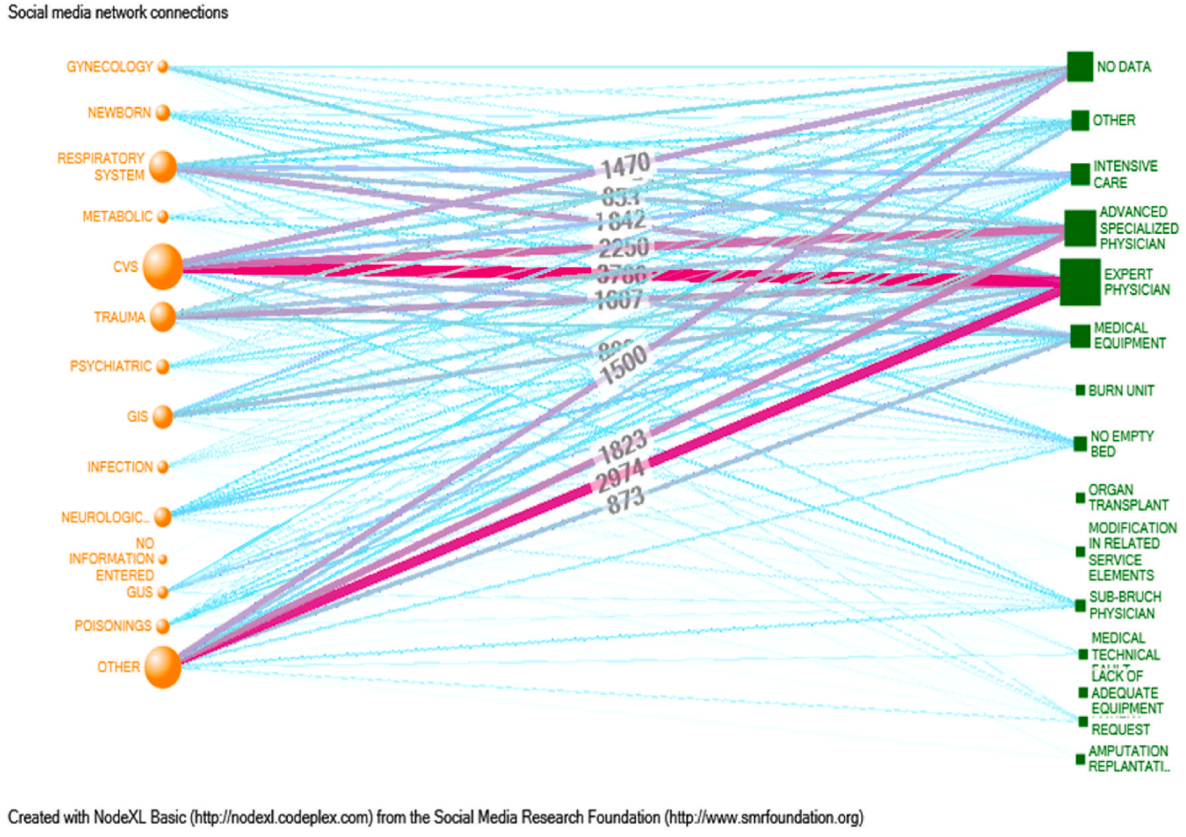


Fig. 4. Diagnostic group and reason for referral Bi-partite network.

physicians, closely followed by a shortage of highly specialized doctors who have received additional subspecialty training after their specialization, including fields like gastroenterology, nephrology, hematology, endocrinology, and more. “Other”, “lack of medical equipment” and the “need for intensive care” are among the most common reasons for referral. According to Ref. [11] the leading cause of referrals is the inadequacy of medical equipment.

Fig. 5 graph includes hospitals that refer and accept patients with CVS diagnosis. The numbers on the edges represent the number of patient referrals. Trabzon Ahi Evren accepts the highest number of accepts patients in the region.

5. Conclusion

SNA is a graph-based method that can be used not only for studies related to social networks, but also for all entities that contain a connection and is a very effective method for managers to make decisions in a short time. Utilizing network analysis techniques presents a promising opportunity to enhance the effectiveness of current referral networks, provide hospitals with valuable insights into patient distribution, and elevate the quality of service delivery. In this context, the study reveals that SNA is also a method that can be used in inter-hospital patient referrals.

In this study, the connections of the hospitals between each other, their roles and positions in the region have been evaluated over the years. Also, the reasons for referrals were analyzed according to the diagnosis of the disease.

In every province, there is at least one hospital located in its central area, boasting advanced equipment and well-developed infrastructure. The hospitals within each province maintain close connections, fostering a spirit of collaboration. The hospitals have strong heterogeneous ties with each other.

The most patient referrals were made to A1 group hospitals. A1 group hospitals are more equipped institutions that provide educational opportunities to students, offering a comprehensive range of main branches (internal medicine, pediatrics, obstetrics-gynecology, general surgery, neurosurgery, cardiovascular surgery, etc.) as well as some subspecialties. We can say that A1 group hospitals form the backbone of the region in patient acceptance. Our results shows parallelism with the findings of [12,13,32]. As stated by Ref. [11]; referral of patients to high quality hospitals is a key decision in patient care.

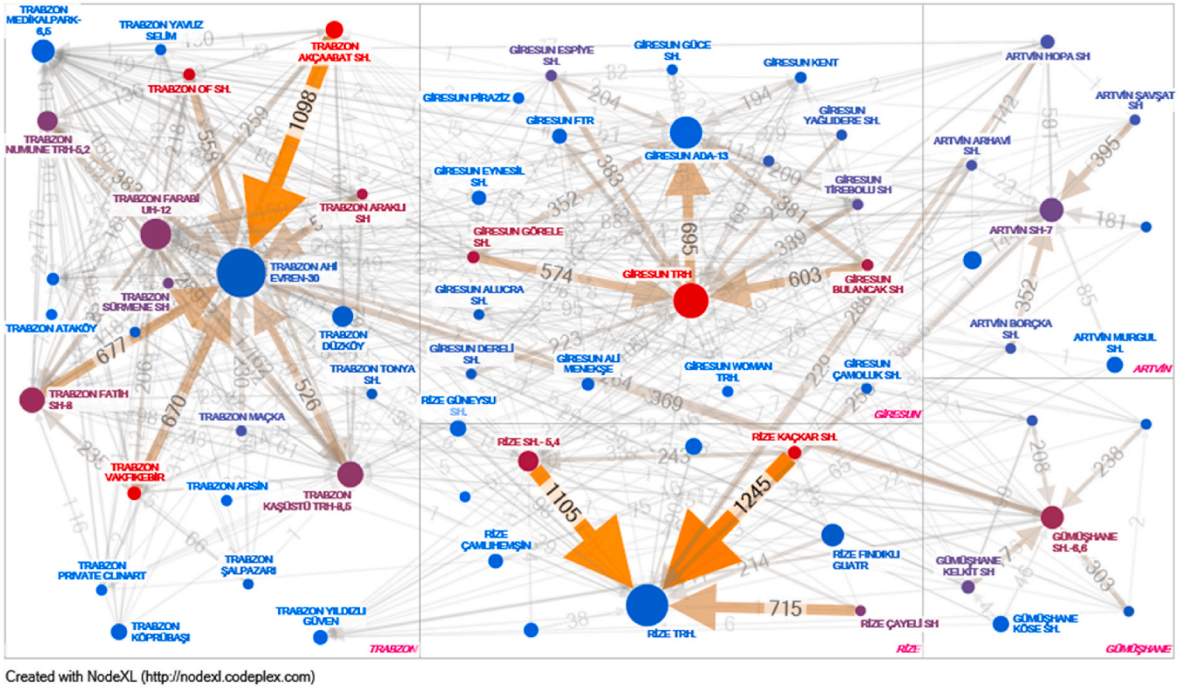
Although our study indicates a tendency for A1 group hospitals to accept a larger number of patients, and C group hospitals to refer them, this should not be interpreted as a general admission pattern. Notably, there are nodes within A1 group hospitals that exhibit high values in both patient referral and acceptance. This situation can be attributed to various factors, including the high patient volume in these hospitals, congestion that might prevent central hospitals from accepting or referring patients, hospitals specializing in particular disease groups, and families making choices based on preferences, such as seeking prestigious or nearby facilities. [5] found quite similar findings in their study, and it was concluded that tertiary care hospitals do not always tend to accept referrals, and that secondary and primary care hospitals do not always tend to refer.

The primary reasons for referrals have been identified as CVS and a lack of specialist physicians. It is imperative to conduct a thorough investigation into the underlying factors contributing to the high prevalence of CVS in this region. Additionally, health planners should carefully examine the causes behind the scarcity of specialist physicians and implement appropriate measures to address this issue effectively.

Patient referrals are also influenced by the distance between hospitals. For the study of referral between health facilities, it is consequently critical to understand the topography of the region. Geographic distances have an impact on patient referrals [12,14,33].

As a result of the study, hospitals in hub and authority positions have been identified. These hospitals, which are more central and have more specialized equipment and structures compared to other hospitals, are therefore more prominent. Thus, the relationship between the characteristics and capacities of hospitals and their centrality has been revealed, which is parallel to the study of [11].

Although the diagnosis names in the study were classified according to the ICD system, it was noticed that certain groups were used categorically. There are many different types of diseases, especially in the disease group called "Other". It is not possible to understand which diseases are under the “other” diagnosis group with the data we have. For this reason, it is important for the accuracy of the analysis to



Created with NodeXL (http://nodexl.codeplex.com)

Fig. 5. CVS diagnosis network graph.

introduce all ICD codes to the information health system.

The fact that health applications are based on information technology not only reduces business processes, but also increases the quality of patient care. For this, the information system used in 112 Emergency Health Services should be compatible and integrated with all other information systems used in the field of health. In the years covered by the study, incomplete and non-standardized data were encountered in the information systems used by the 112 Emergency Health Services. It took quite a long time to clean, combine and analyze this data. Therefore, data standardization should be ensured, and new studies should be developed for integration.

The study not only assessed each hospital's position within its province but also considered its standing within the broader region, enabling comparisons with other hospitals and revealing their strengths and weaknesses. Moreover, this approach assists health planners in making strategic decisions concerning referral processes and disease diagnoses. By seamlessly integrating a SNA software program into hospital information systems, valuable data on referrals can be swiftly obtained, facilitating timely and informed decision-making.

Since the development of hospitals and the sustainability of healthcare services are only possible with the existence of patients, collaborations between hospitals are crucial in patient referrals. Collaborative networks enhance hospitals' innovative abilities and improve their institutional performance. Comprehensive research evaluating healthcare service providers has also revealed important results indicating that patient referrals are a sign of collaboration between hospitals [32]. Therefore, inter-hospital referrals should be considered within the framework of "collaboration", and decision-makers can plan to develop new studies based on existing findings to address the problems in healthcare service delivery and restructure in areas where problems are encountered.

The study serves as a sub-component for such research that can be conducted at a country level. Therefore, despite regional and organizational disparities in patient transfers, diagnostic patterns, and referral reasons within hospitals in Türkiye, it provides a partial prediction about the country's healthcare system.

This is the first study in the national literature to indicate that inter-hospital patient referrals can be examined and analyzed using SNA, and it is expected to give the way for future research.

Constraints of the study

The characteristics of hospitals have a significant impact on referral flows. In this study, characteristic features of hospitals (such as number of employees, managerial problems, equipment of employees, financial adequacy or inadequacy of hospitals, number of specialist physicians and their areas of expertise, legal limitations, etc.) are not included. Such research would require a much more comprehensive study outside the scope of this study.

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.

Data availability

The authors do not have permission to sharedata.

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