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Examination of Centrality in a Health Social Network

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Abstract. Growing importance of health information platforms are acknowledges in recent studies. Such platforms are subject to discussion about an extent to which social network characteristics are realized. The platform under examination indeed demonstrates social network peculiarities. In this work, we explore the nature of centrality in one of the leading health information networks in Europe. Among other findings, we identify two nodes (representing patient and physician) are as the most important people in the network in terms of structural analysis Egregiously, these nodes are connected with the other types only and exhibit worth noticing connection patterns. These connections have been discussed along with a medication advice seeking behavior.

Keywords. Social Network Analysis, Centrality Analysis, Health Information Platform, Patient Experience

Introduction

Social networks' growing importance in industries such as e-commerce and media, social networks play an increasingly prominent role in health care. While importance of social networks is increasing dramatically, people tend to use health social networks and more Hospitals increasingly are using social networks for promotional purposes and to gauge consumer experiences with their organizations. More than 700 of the U.S.' 5,000 hospitals have a social media and social networking presence to enhance their ability to market services and communicate to stakeholders [1].

In this paper, we aim to analyze an information network of people joining a health platform. We employ a network science perspective to find out an extent to which the platform demonstrates social network characteristics. Our particular research interest is to explore the centrality notion for a social health network. Structural analysis is conducted to identify the most important nodes and their particular connection pattern.

1. Method

1.1. Research Background

Network science has an emerging trans-disciplinary characteristic which provides methods, techniques and tools to understand things and their relations. Online social

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networks have made considerable progress since the launch of Six Degrees.com. After 1997, many other social network platforms were created such as BlackPlanet, LunarStorm, Cyworld, Friendster, LinkedIn and Facebook.

In the health context, one can expect that patients having the same diseases could communicate each other in a social network. Similarly, physicians who have the same area of specializations could consult themselves. In order to call an information network as a social network a well, some characteristics should be examined:

Diameter is the maximum eccentricity of all the vertices [2] meaning the distance between the farthest nodes. Small-world experiment conducted by Stanley Milgram created a model called "Six Degrees of Separation" [3]. If there is a giant component in a non-randomly generated network, that network is worth to examine if it is a social network or not [4].

Centrality in network perspective is the importance of an individual node in that graph, through several algorithms. In this study, we consider Degree, and Betweenness as useful measures to identify important nodes.

Betweenness centrality ranks the nodes according to the how many times a node lies between the path of two nodes [5].

Our case is one of the leading health information platforms in Europe. The platform demonstrates some of the features of Facebook, Twitter, LinkedIn and forums. Some of similar attributes of the platform examined include user connections (patient, physicians) like in Facebook, following other people (like in Twitter), sense of professionalism and having premium accounts (like in LinkedIn) and asking questions (like in Bulletin Boards, Forums).

Patients can receive professional responses from physicians about their sicknesses. Physicians can publish their articles, videos, research and make it commercial like sharing their clinic addresses and making appointments.

There are 3 basic functionalities in the platform that can be considered as an edge. Connection, Questions & Answers, and Messages. The dataset provided consists of connections (physicians as MP and patients as P). We focused on Connection as edge type for the analysis.

1.2. Network Analysis

The provided dataset was in a raw form and analyzed with Gephi, which is an open source social network analysis tool [6].

When the dataset is analyzed, four different connection types are captured in the network: Patient - Patient, Patient - Physician, Physician - Physician, Physician - Patient. In the platform, nodes are modeled as patients and physicians. Since there are no multiple requests from one person to another, the network is considered as un-weighted.

There are 818 nodes with 1768 edges in our network initially and all the edges are directed. There are 246 physicians and 572 patients in the platform. The dataset has a time interval of 3 months (Oct 1, 2012 – Dec 31, 2012).

2. Results

Diameter of the network is 9, meaning it takes 9 nodes at most, to reach from one node to another. Close to the small world effect rule, which is 6.

There is one giant component in our network, covering 646 nodes which correspond to 78.97% of all the nodes. It includes 1611 edges, covering the 91.2% of all the edges. In the giant component, there are 439 patients (68% of the nodes in the giant component), and 207 physicians (32% of the nodes in the giant component).

Table 1. Basics of the Network at a Large Scale

Network at a Large Scale	
# of Nodes	818
# of Edges	1768
Network Diameter	9
Average Degree	2.161
Average Path Length	3.629

As shown in Table 1, the average degree is 2,161 and it means that there are many nodes who have at least 2 degrees (can be in degree or out degree). Lowest degree is 2 and highest degree is 318 (total of in degrees and out degrees) with node numbered as 138.

Node# 138 and node# 230 are ranked much higher than the rest with 0,226 and 0,225 in terms of betweenness centrality shown in Table 2 (normalized between 0 and 1) respectively.

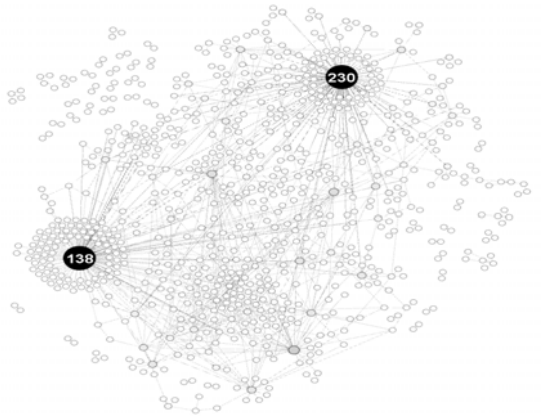

Figure 1. The nodes sized by betweenness centrality

Table 2. The following table shows the most critical nodes in the network in terms of centralities (ranked highest to lowest by betweenness) MP: Physician, P: Patient

Network at a Small Scale					
Node ID	**Roles**	**Betweenness Centrality**	**In-Degree**	**Out-Degree**	**Degree**
138	MP	0.226	147	171	318
230	P	0.225	115	120	235
364	P	0.041	32	42	74
242	P	0.027	15	22	37
267	P	0.026	20	29	49

Focusing on the two nodes with highest betweenness centrality values, their connection graphs are shown in Figure 2 and Figure 3.

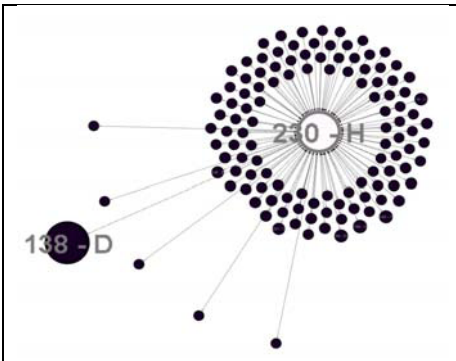

Figure 2. The connection graph of node# 230

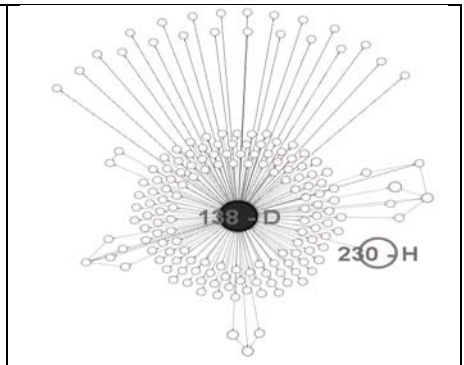

Figure 3. The connection graph of node# 138

3. Discussion

It is more reliable to examine the network for both a large-scale analysis and structural analysis for centrality, which is the importance of individual nodes with respect to network science.

From the point of large scale analysis, one may argue that the network has certain social network characteristics: Having a giant component, diameter value of 9, which is considerably close to Small World Effect and non-zero average clustering coefficient.

Focusing on the giant component; the percentage of patients decreases slightly while the percentage of physicians increase compared to the whole network. Some patients from the network seem to be not connected to the giant component. This could mean that there are more patients who are not actively using the network than physicians. These patients might idle users of the healthcare network.

The lack of validation in published healthcare social network analysis is a difficulty to interpret findings concerning health information platforms [7]. However, some interpretations can still be made about the results gained about the characteristics of the network.

The two nodes, (numbered as 230 and 138) which are a patient and physician respectively, seem to be the most important people in the network in terms of structural analysis. Egregiously, these nodes are connected with the other types only. Node# 230 only connects physicians. For the node# 138, a physician connecting with only his/her patients makes sense, but still this anomaly seems to be worth checking to find the reason behind this. The out-degrees of node# 138 are larger than his/her in-degrees. One can interpret that physicians use this health platform for different purposes such as promoting themselves and marketing. Further investigation, emphasizing on nodes numbered as 230 and 138 could be done.

4. Conclusion

The network meets some of the conditions required to be a social network. Diameter is small and close to what is expected for a social network and has a giant component covering most of the nodes.

From structural analysis, two nodes (Physician, Patient) are found to be the most important people. They have the highest betweenness centrality and degree centrality. The interesting thing is that they are only connected with nodes of the opposite group. One needs to use a larger data set to compare the findings along with time indication. Examining the network for the next 3-6 months period may justify the analysis. Also separation of the network by the groups (physicians and patients) and focusing on them separately can reveal other interesting results.

For the future work, community analysis of the network, node type analysis (brokerage) can be examined. Also with another tool, information exchange in the network (cliques) should be worked on. Dynamic analysis of the network for measuring the ongoing interactions between nodes with respect to the time stamp might be considered in the future works.

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