Proceedings of the International Conference on Modern Medicine and Global Health (ICMMGH 2023)
DOI: 10.54254/2753-8818/6/20230252

How diseases spread through social networks

Justin Jia[1,2]

[1]Ulink College of Shanghai, Shanghai, 20000, China

[2]xiqing.jia@ulink.cn

Abstract. This paper uses the main concept of centrality accompanied by the theory of "the strength of weak ties" to explain how social networks facilitate the spread of major diseases. The major diseases that this paper would take a look at are the COVID virus, smallpox, and cholera. Before doing so, a brief introduction would be made and the paper would infer some research that utilizes social network models and helps the paper to further elaborate. Eventually, the paper would conclude with the reasons if applying social networks to the study of the spread of diseases could help with understanding the spread or not. As well as the fact to see what factors could interfere with the process.

Keywords: centrality, degree centrality, social network models.

1. Introduction

Social diseases have always been a major part of this world, whether it is the bubonic plague that took over the world completely, or recently the largest hit to our world, the COVID pandemic. Hence people would find ways to study and find solutions to such diseases, whether it is finding vaccines to eradicate said viruses, or using policies to prevent the spread. The latter has major relevance to the topic of the essay, This paper would be examining several diseases in the world and look at how social networks help facilitate the spread or on the other hand, prevent spreading.

Moreover, the paper would also introduce some simple concepts that would help us further analyze how certain diseases spread. Rather, it is fairly hard to examine diseases that would spread currently, since most popular diseases would happen and take place in rural areas or remote areas in the world, yet the way to track interactions between each person on a social network would be using their mobile phones, hence it is unlikely that this paper would present heavy data since this paper would take a look at diseases that happened at wider scales. Also, environmental factors would make the research difficult. For example, when examining models and concepts that help to understand the spread of disease, factors such as contact with contaminated medium; consumption that may lead to bacteria growth in one's body; etc are being neglected. This paper is only looking at the social network factions that help or don't help the spread of a virus.

2. Case studies

The concepts of networks and several other theories must be made clear and familiarized to fully understand this paper. A network is comprised of nodes and links. Nodes are what are essential to social networks. A node could be a person, a firm, or company, or on larger scales, countries. Links, also

DOI: 10.54254/2753-8818/6/20230252

known as edges, are what connect the nodes to form a network. This is where it gets rather complicated, but for this paper, the scope only includes some important parts.

This paper can now dissect a social network and look at some other concepts. The one to note is centrality [1]. Centrality can be separated by a few, but the ones this paper requires are degree centrality and betweenness centrality. Degree centrality is the measure of how many nodes are connected to one node in a social network. For example, if a person has five friends in a class, then the degree centrality of this person in the network of this class is five. Betweenness centrality is much more visual, betweenness centrality in short terms means relatively how close is one node to other nodes. Another concept to familiarize with is clustering, clustering is defined to be classifying nodes into the same network, this could be people in the same company, firms that make trades, or even countries that make strategic alliances.

Furthermore, there is a concept called the strength of weak ties [2], the theory is that the weak ties between people help the spread of information in a dense population. Therefore, it is also known as invisible ties. It is so minimal, and also hard to measure in a social network model.

With the concepts being explained, it is also important to see models being used in a social network. From [3], an SEIR model is being used to study the outbreak of COVID when a new strand of the COVID virus hit Lombardy Italy back in May 2020.

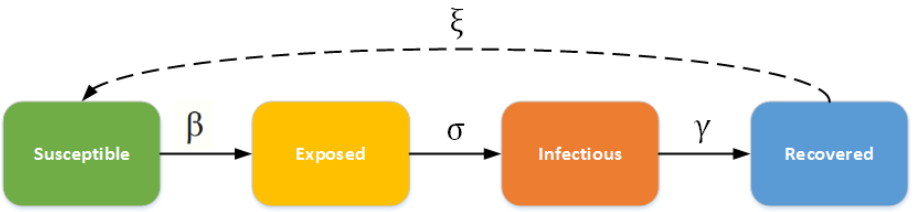

Figure 1. What comprises the SEIR disease model.

The acronym means to cluster nodes of people in a network into fractions that are susceptible to a virus, exposed to a virus, infected by the virus, and recovered from the virus. In [3], the virus would be the COVID virus. Eventually, [3] gets to the conclusion that a lockdown would be useful during a pandemic situation.

Another example could be [4], where the paper is talking about research in an Ecuadorian village. The paper states how more ties and higher degrees of nodes did facilitate the spread of diarrheal disease in the village. Rather another interesting point is shown, that if given communal gatherings on how to improve sanitation issues and constantly stressed the importance, a social norm of sanitation would be adopted. Eventually, in [4], the results are down to a village level, where each is labeled with percentages of numbers of households that include water treatments and sanitation measures, but the results show that even with high levels of sanitation, as long as the remoteness is relatively low, the cases of the disease is still relatively high.

The conclusion can be made that whilst studying for a disease, concepts of social networks must be applied, which can be seen from many papers that have dealt with this concept, such as [5], where the paper shows that social network models are key to studying the spread of diseases.

3. Case studies

The paper will start by looking at betweenness and degree centrality. The paper will look at the COVID virus. The COVID virus is a good example due to the easy gathering of statistics since the virus only broke out in 2020 hence cases are recorded on a more detailed level.

DOI: 10.54254/2753-8818/6/20230252

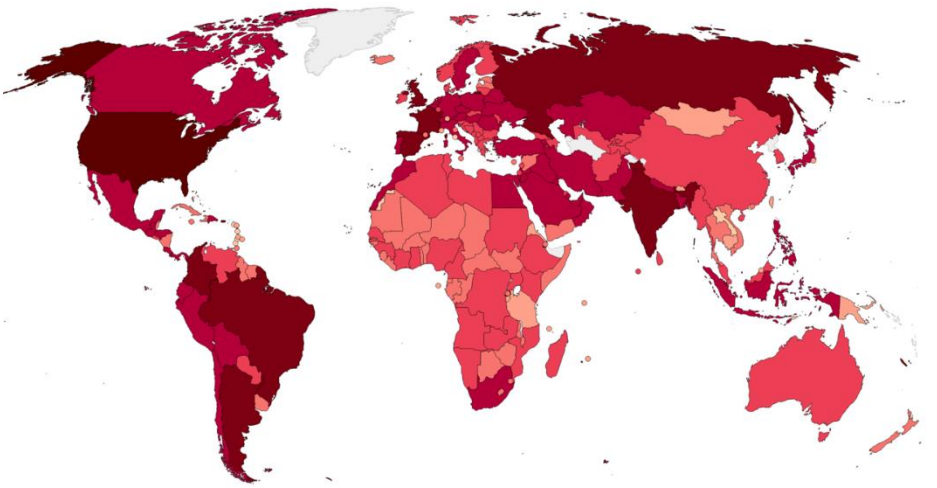

Figure 2. The case density of each country of the Covid virus as of 2023.

Look at figure 2, this exhibits the number of cases for the past 3 years of COVID. The redder a country is on figure 2, which shows more cases are present. However, an anomaly is easily spotted, which is Greenland and Denmark. Since Greenland is an autonomous country, this paper would look at it alone. The data gathered shows that as of February 9th, 2023, only 11971 cases are recorded and only 21 deaths. This is low regarding that Greenland is a high-income economy. To put those data in respective, Australia is also a high-income economy and shares similar features with Greenland, yet got a whooping 11 million cases as of 2023. This is when centrality comes forth. If the consideration of betweenness was put forward, Greenland only shares borders with three countries: Canada, Iceland, and Norway. Yet not the normal borders, only maritime borders. Also taking the population into consideration, which is 55653 citizens. Hence, the reasons for the low cases of COVID in Greenland could be explained, by the low population and low centrality. On the other hand, the point could also be easily disproved and many studies like [6] consider how many overlooked the importance of tiny factors that could cause the estimation of cases to be either under or overestimated, which directly, changes the how this theory of social networks facilitating the spread of diseases to not be validated. Another study from [7], indicates that social distancing is a good method in epidemic situations, in [7], it is stated that social distancing would delete the edges in social networks and stop the transmission of the virus, therefore proving the point of this case study. Concluding this particular study, the next case study should further solidify the points of this paper.

Another overlooked pandemic would be smallpox, the paper will quickly examine some facts from [8]. Smallpox was first recorded in the 6th century due to the increasing trading operations between China, Japan, and Korea. The main point to denote is the traveling of smallpox. It is only a major problem when Portugal settlers brought the disease to Western Africa. This is another example of centrality, where the link between Portugal and the African areas caused the disease to spread vigorously. However, that is not all to smallpox.

DOI: 10.54254/2753-8818/6/20230252

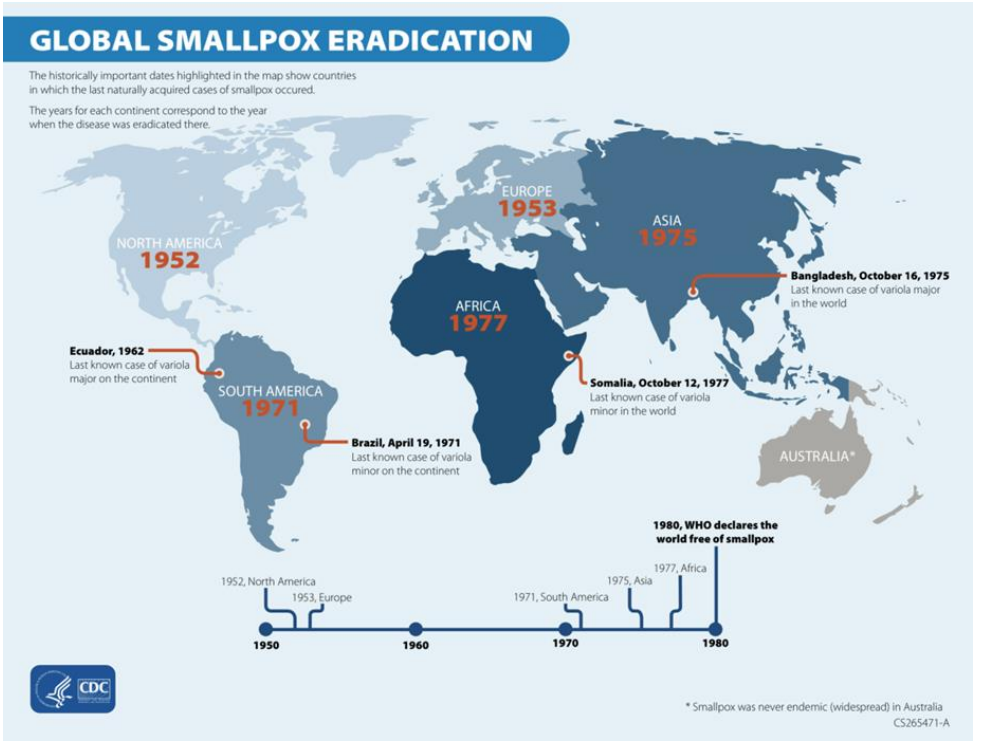

Figure 3. The number of cases of cholera on each continent and when the said case was eradicated.

Looking at figure 3, likewise, to figure 2, the tonality shows the amounts of cases of a virus, here it would be smallpox. The observation can be made that the entire region of Australia is gray, and labeled on figure 3, it is known that Australia never had any wide eradication of the smallpox virus. This is most likely since Australia is only discovered around the 17th century, which would be a century after the Portuguese had brought the virus to African areas. This is also the time when early forms of vaccination were created hence it could be concluded that since the links between Australia and the parts of the world with smallpox would be made during a time when good social norms and sanitation were created, smallpox wouldn't have been a problem. Moreover, Australia is relatively a country with a small population, ergo, the strength of weak ties would've not been facilitating the spread of disease since it requires a large population.

The final disease that this paper will go through is cholera. Closely examining [9], the research from [9] looks at how social networks affect the spread of cholera in a village in Bangladesh. Although cholera is only associated with the Industrial Revolution, it is still active around the world, being found in coastal areas and contaminated water. The disease spreads orally and through face-to-face contact.

The study from [9] eventually concludes with the results that social factors could be one of the reasons, yet it could be isolated and prove the spread with other reasons, hence it could be out of the consideration for this paper.

However, directly looking at the cholera outbreak as stated above from the Industrial Revolution could help. It also ties in with the theory of weak ties being stronger than stronger ties. This can be shown when, during the Industrial Revolution, more and more people went to urban areas to settle for jobs, rather due to the lack of research and lack of good social norms, the habit of drinking contaminated water had widespread. Since everyone wouldn't have had a lot of ties in urban areas, the strength of the weak ties kicked in, and the large spread of misinformation and the large population the urban areas held had been the key reason for the widespread of cholera. The citation of [10] could be made that, in [10], the paper directly proves the efficiency and higher levels of vaccine coverage highly depends on the density of a social network, by using social network models. That of which results in the networks with a higher coverage resulted in more protection and fewer cases of cholera found. Hence that would conclude the section on case studies with 3 analyses of widespread diseases.

DOI: 10.54254/2753-8818/6/20230252

4. Conclusion

In this essay, some basic concepts of social networks were brought up. Mainly the idea of centrality, clustering, and a theory called the strength of weak ties. The paper also introduced the concept of social network models, yet due to the scope of this essay, further elaboration is not required since it is out of the scope. Furthermore, the paper took a look at some real-life case studies. The results were quite clear, as the paper examined three major diseases that took over the world. They were: COVID, smallpox, and cholera. The paper examined some anomalies and came to several conclusions. Greenland survived major hits from COVID due to the lack of close ties and a large population, causing a low spread. Australia was safe from smallpox since it was only discovered by Europeans that carried the disease in the late periods of the smallpox virus when treatments are made. Cholera took over the urbanized areas of the United Kingdom back in the Industrial Revolution due to the dense population; lack of good social norms to promote sanitation and the betweenness due to the ongoing triangle trades. Hence the paper concludes that social networks play huge roles in facilitating the spread of diseases, yet it depends on the three concepts that were introduced at the very start. Also to denote, studying a spread of a disease in a social network would never be one hundred percent accurate since the environmental factors and invisible ties could not be measured precisely. Ergo, this paper could deduce that social networking factors do play a huge role in preventing or spreading a disease.

References

[1] Garcia David, “Centrality in social networks” 2021, https://dgarcia-eu.github.io/SocialDataScience/4_SNA/044_Centrality/Centrality.html

[2] Granovetter, Mark, “The Strength of Weak Ties” jstor.org, May 1973, https://www.jstor.org/stable/2776392

[3] Salathé Marcel, Kazandjieva Maria, Lee Jung Woo, Jones James, “A high-resolution human contact network for infectious disease transmission” PNAS, 13 Dec 2010, https://www.pnas.org/doi/10.1073/pnas.1009094108#fig03

[4] Zelner, Jonathan L et al. “Social connectedness and disease transmission: social organization, cohesion, village context, and infection risk in rural Ecuador.” American journal of public health, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3519324/

[5] Read, Jonathan M, et al. “Dynamic social networks and the implications for the spread of infectious disease.” National Library of Medicine, 4 Mar 2008. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2607433/

[6] Giorgi Rossi, Paolo et al. “Factors Influencing the Accuracy of Infectious Disease Reporting in Migrants: A Scoping Review.” International journal of environmental research and public health vol. 14,7 720. 5 Jul. 2017, doi:10.3390/ijerph14070720

[7] Maheshwari, Parul et al. “Network model and analysis of the spread of Covid 19 with social distancing.” Public Medicine, 1 Jan 2020 https://pubmed.ncbi.nlm.nih.gov/33392389/

[8] *History of Smallpox | Smallpox | CDC*. (2021, February 20). History of Smallpox | Smallpox | CDC. https://www.cdc.gov/smallpox/history/history.html

[9] Giebultowicz, Sophia et al. “The simultaneous effects of spatial and social networks on cholera transmission.” Interdisciplinary perspectives on infectious diseases. 7 Dec 2011. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3236480/

[10] Root Elisabeth, et al. “The role of vaccine coverage within social networks in cholera vaccine efficacy.” PLOS ONE, 29 July 2011. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0022971.