Analysis Of the Impact of Social Networks on The Spread of Covid-19

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Abstract. A worldwide pandemic was brought on by the infectious disease COVID-19, which was caused by the SARS-Cov-2 virus. In this essay I will shortly introduce the background and existing impact of COVID-19 and the former epidemiology understanding of the contagion of COVID-19, I will use the Sir model, basic reproduction number, and other epidemiology and network science measurement to analysis about will the social network effect or not in the contagion of COVID-19 and if it play a role will the government intervention influence the extent of its effect.It was discovered that social networks, which Sir Model ignores, are crucial to the spread of COVID-19. And some network science knowledge can help people to understand and prevent the contagion. Government institution can reduce network externality,the outcome depends on how strong their policy is ,Thus, this paper concluded that social networks give us a fresh perspective on the COVID-19 contagion, which is quite useful.

Keywords: COVID-19; social network; government institution.

1. Introduction

The COVID-19 pandemic, as an unprecedented global crisis, has being affecting millions of people and placing immense strain on healthcare systems, economies, and societal structures. In order to control the virus's spread, it has become increasingly important to understand the underlying factors that contribute to its dissemination. One underexamined factor is the role of social networks in shaping the trajectory of the pandemic. The book and essay inspire me about these factors is called the human network written by MATTHEW O. JACKSON [1] and Experience of the COVID-19 pandemic in Wuhan leads to a lasting increase in social distancing written by Darija barak and Edoardo gallo [2]. While traditional epidemiological models focus on direct physical contacts and demographic variables, an increasing number of research emphases the importance of social networks in the virus's spread. This extends not just to who we interact with, but also how our social structures, both online and offline, contribute to the spread of the virus across regions and countries.Governments worldwide have implemented a range of interventions, from social distancing and mask mandates to partial and full lockdowns, in an attempt to control the pandemic. But how effective are these measures in disrupting the social networks that help the spread of the virus? Moreover, can the effectiveness of these policies be improved with a better understanding of social network structures? This essay aims to solve these questions by exploring two key aspects. The first section focuses on the part that social networks played in the spread of COVID-19 and draws on current research that employs social network analysis to look at the dynamics of the epidemic. The second section evaluates the effectiveness of various government interventions, examining how these measures have impacted social networks and, consequently, the spread of the virus. Through this multidisciplinary measure, this essay seeks to offer insights into how a social network-centric approach could complement our strategies for tackling the COVID-19 pandemic.

2. Role of Social Networks on the Spread of COVID-19

2.1. Traditional Understanding of Epidemiological Spread

The susceptible-infected-recovered (SIR) model developed by Kermack and McKendrick is one of the most fundamental and classical models when estimating disease transimition [3]. The graph of

the SIR model is shown below. In this model, the percentages of people who are susceptible, infected or recovered add up to one. When the reproduction rate is higher than the recovery rate, the total number of infections is increasing, represented by the upward trend in the green curve; conversely, when the recovery rate is higher than the reproduction rate, the size of outbreak is shrinking, represented by the downward trend in the green curve. Though the SIR model is very useful in predicting how the disease spreads in a population, it does have some limitations - for instance, SIR model assumes that each susceptible individual has an equal chance to get in contact with an infectious individual. This assumption does not take social network effect into account, which is quite unrealistic. As shown in figure 1.

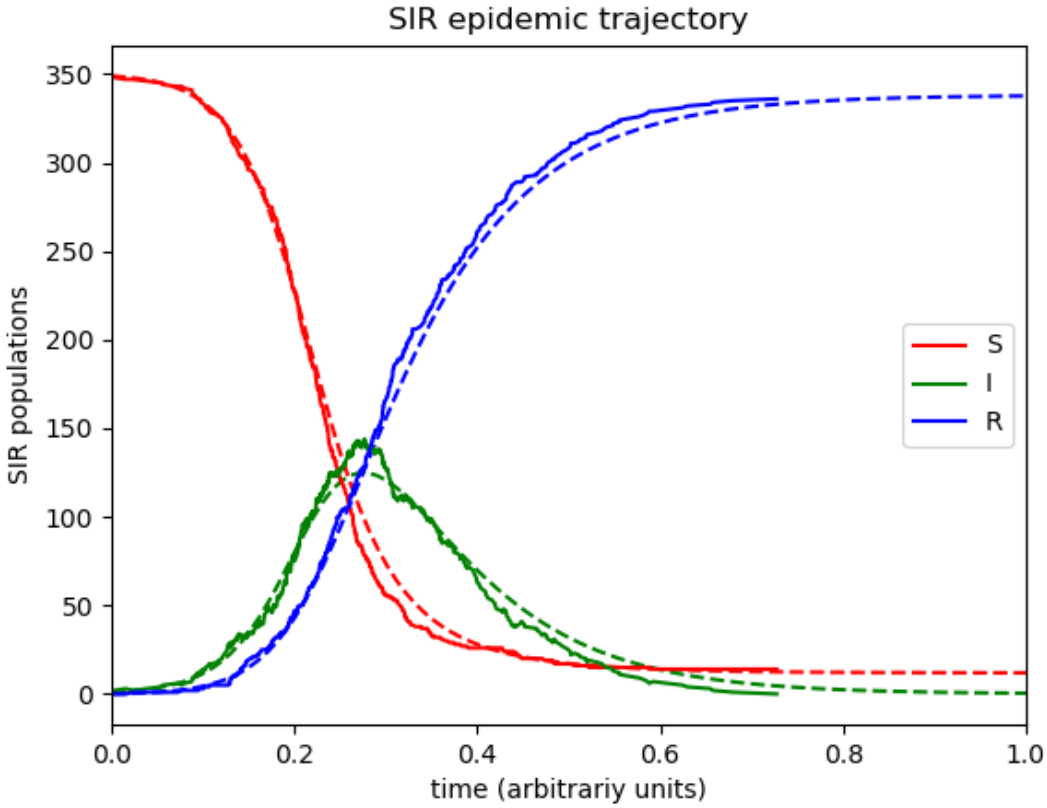


Fig. 1 Sir epidemic trajectory

2.2. New insights from social network analysis

The term "social network" usually refers to a set of relationships or interactions among individuals, groups, or institutions. In this framework, each agent, commonly referred to as a "node," is connected to various other nodes through "edges" that represent the relationships or interactions between them. These relationships can take many forms, such as friendships, and familial ties. To make a better prediction of the epidemic transmission, there are already a few papers applying the social network analysis into their analysis.

Yie et al. investigate how countries and regions are connected to each other and how COVID-19 spreads through these connections over time [4]. Additionally, they find that some places, called 'hubs,' are very important in how the virus spreads around the world [4]. In general, one big contribution of Yie is that it domenstrates the virus transmission dynamically and visually through a dashboard. However, the online data that they employ may suffer from a lack of accuracy because of underreport and missing tracks of cases.

Also, according to Gürsakal et al., they are introducing a novel method to visualise the COVID-19 transmission through network science [5]. The graph theory techniques are used to create "transmission graphs," which illustrate how the virus travels among people and communities. Further,

by using these graphs, Gürsaka shows that even a single person's behaviour can have a big impact on a broader network - they estimated that “20% of cases were responsible for 80% of local transmission" [5]. Their findings are quite usuful for the authorities to make public health policies. Nevertheless, their research might be biased considering the inaccuracy of their data [5].

The study by Theresa K, Dominic R, and Johannes S, using data from Facebook as a proxy for real-world social networks, reveals that there is a significant correlation between network density and the rate of disease transmission [6]. In areas where people interact more closely, the spread of the virus is faster. Thus, they suggest that targeting public health measures to disrupt these stronger social ties could be a more effective way to control the outbreak [6]. There are, however, still some limitations of their research. It could be the case that a certain age groups are more likely to use Facebook such as the teenagers and the middle-aged. Also, there are many other population social medias that people can use. Thus, relying on data solely from Facebook cannot depict a full picture of the virus spreading.

3. Effectiveness of Government Interventions

As the COVID-19 pandemic has rapidly spread across the globe, governments from various nations have been compelled to take swift action to prevent the virus's transmission. A diverse range of policies have been rolled out, including but not limited to mandatory facemask wearing, social distancing measures, large-scale lockdowns, and mass vaccination campaigns. These strategies represent the collective global effort to not just limit the spread of the virus, but also to mitigate its far-reaching impacts on healthcare systems, economies, and everyday life. Given the scale and complexity of the situation, there has been a surge in academic research aimed at examining the efficacy of these government-led interventions. Many papers have been published with the intent to evaluate existing policies critically and to propose more optimal solutions that could potentially minimise the social and economic costs associated with the pandemic.

In their 2021 study, Jo, Wonkwang, and their team look at the impact of governmental interventions on the dynamics of COVID-19 infection networks [7]. Specifically, they found notable changes during the period of social distancing measures [7]. Key network metrics like the mean distance and diameter within the infection network were significantly reduced, illustrating the effectiveness of these interventions. Building on this foundational analysis, the authors proceed to offer a series of practical policy recommendations aimed at further reducing the spread of the virus. These include targeted testing strategies as well as more localised lockdown policies, both designed to minimise not just viral transmission but also the disruption to daily life. While Jo offers a considerable contribution to our understanding of virus transmission dynamics and public policy implications, particularly within the context of South Korea, it's important to note that the applicability of these recommendations may vary when extended to other countries. Factors such as cultural and social norms, the structure of healthcare systems, and other region-specific variables may require adjustments to these suggested interventions. Therefore, while the paper provides invaluable insights, caution should be exercised when considering the adoption of these policies in different international settings.

The research conducted by Block, P., et al. provides an in-depth examination into how different strategic interventions can significantly mitigate the spread of a virus within diverse social networks [8]. Using mathematical simulations as their primary methodology, the researchers identified that the tactic of 'strategic reduction of interaction with repeated contacts' outperformed the other strategies they evaluated—namely, 'strengthening community' and 'seeking similarity.' According to their models, this strategy excels in both delaying the peak of infection rates and reducing the total number of infected individuals. Furthermore, Block focuses on the practical aspects of applying these strategies in real-world settings, recognizing that individuals usually interact within multiple social circles such as their workplace, extended family, and community [8]. Block conducted tests to see how a combination of these methods would fare and found that mixed-strategy approaches were

nearly as effective as employing a single strategy, providing an adaptable framework for public health interventions [8]. What's particularly noteworthy is the paper's additional insight into the varying effectiveness of these strategies depending on the nature of the social network. Their research reveals that in networks with limited connection opportunities, all of the examined strategies significantly outperformed their effectiveness in more densely connected networks. This suggests that these interventions can be particularly effective in environments where social interactions are naturally more constrained.

Similarly, Peak et al. (2020), in their paper, addresses a critical question during the COVID-19 pandemic: Which is more effective in mitigating the spread of the virus, individual quarantine or active monitoring of contacts [9]. Peak et al. suggests that individual quarantine of symptomatic cases is essential but insufficient on its own to control the epidemic [9]. Even in scenarios with optimal quarantine, the outbreak is only partially mitigated. On the other hand, active monitoring of contacts is a good supplementary strategy, especially when testing capacity is limited. Monitoring not only allows for the early detection of cases but also enables the healthcare system to be better prepared for incoming waves of patients. In general, their work is a valuable addition to the growing number of literatures focused on optimising public health responses to infectious disease outbreaks.

Another contribution that draws particular attention is the paper authored by Julliard Christian and his colleagues, published in 2023 [10]. Julliard centers on the pivotal role that networks, specifically London's commuting networks, play in the spread of the COVID-19 virus [10]. Utilising an approach that combined the traditional Susceptible-Infected-Recovered (SIR) model with network theory, it arrives at some useful conclusions [10]. It reveals that implementing lockdown measures that are strategically targeted based on both high numbers of COVID-19 cases and critical roles within the network can yield significantly more effective outcomes [10]. Such targeted strategies also prove to be more economically efficient compared to blanket, full-scale lockdowns [10]. Furthermore, Julliard emphasises the necessity of taking into account various types of interconnected networks when crafting lockdown policies [10]. These networks are not limited to just commuting pathways but also extend to include train networks, flight corridors, and even migration routes. The study argues that each of these networks can serve as a conduit for the virus, thus requiring their inclusion in comprehensive public health strategies. It emphasises a network-centric approach in managing the complex dynamics of the pandemic.

Government interventions have varied in their effectiveness, partly due to a lack of attention to these network effects. Social distancing and lockdown measures, although impactful, will be better through using social network to target high-impact nodes or 'hubs' within these networks, as evidenced by the studies examined. For example, the work of Jo, Wonkwang et al. and Block, P. et al. demonstrates the practical policy implications of social network theory, offering targeted testing and strategic reduction of repeated contacts as a way to effectively "break the chain" of transmission. Furthermore, the study by Peak et al. and Julliard Christian et al. suggests that a more network-focused approach to interventions like quarantining and lockdowns could result in not only better health outcomes but also lower economic costs.

4. Conclusion

The COVID-19 pandemic, a crisis of large scale and complexity, has urged us to rethink traditional approaches to epidemiology and public health. The essay has examined is the role of social networks in the spread of the virus, which has largely been underemphasised in standard epidemiological models like the SIR model. Research increasingly shows that an understanding of social network structures can provide insights into how the virus spreads, thereby informing more effective interventions. As demonstrated, social network analysis allows us to understand not only the dynamics of the virus's spread within local communities but also on a global scale.

Overall, while conventional epidemiological models offer a foundational understanding of disease spread, incorporating social network analysis can provide a more multifaceted view, giving

policymakers additional tools to combat the pandemic. As multiple studies suggest, targeted, network-informed interventions could offer a more effective and economically sustainable path forward. Future research could build on this interdisciplinary approach, potentially leveraging real-time data and machine learning algorithms to dynamically adapt policies in response to the ever-evolving landscape of the COVID-19 pandemic. With a more network-centric perspective, there will be a better chance of mitigating the far-reaching impacts of this global crisis.

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