INTERVENING IN A SOCIALLY NETWORKED PROBLEM: A SIMULATION-BASED APPROACH

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Abstract

We can refer to society as a group of individuals living together in a community with interactions between interconnected parts. It is complex in structure, behaviour and has problems like poverty, drug abuse, and illness, to name a few. Understanding and acting on such societal problems is getting difficult as current societies become complicated. Studies on such problems may focus on identifying the associated factors and their impact. While there is no doubt regarding the importance of such studies, it is also important to perceive these problems as an outcome of complex interactions between interconnected parts of society. We can model any society as a network, with its parts represented by nodes and interactions by links. A network-based approach can help us study a problem in society as a socially networked problem that is not easy to comprehend otherwise.

In this study, we selected the spread of infectious diseases as an example of a societal problem to demonstrate the application of a network-based approach in modelling and intervening in a socially networked problem. With the rapid spread of infections like COVID-19, the spread of infectious diseases is a problem faced by modern societies worldwide. Today researchers from multiple disciplines are working on different approaches for developing models to study epidemics. In this study, we examined the spread of infection as a network-based situation, where we represented individuals in the society as nodes and contacts between them as links. We proposed a framework using a novel network-based approach to intervening in the dynamically evolving situation. However, modelling the spread of infectious diseases or other societal problems using a network-based approach has challenges.

In recent years, data on online social networks have been readily available. However, the networks we are part of in society are not just online but also offline. We meet people in person through relationships like friendship, family, and daily contact in society. A network constructed from online data may seem inadequate to study a societal problem. A suitable method to collect data depends on the context of the problem we want to study. It is difficult to collect data to study the spread of infectious diseases between individuals in a society without intruding on the privacy of those we wish to study. Data collection can be expensive, unethical, and infeasible for a large society. In this context, using simulations to generate suitable network datasets and imitate the complex interactions in society through dynamic models would be a promising approach. To study the socially networked problem, we developed a computer program to

implement the proposed network-based approach and presented a novel framework in this dissertation.

Overall, this study makes several relevant contributions to the existing body of literature. Among the academic contributions, first, it introduces a novel framework to study a societal problem such as the spread of infection using a network-based approach. Earlier models, in general, lack flexibility in analysing different network-centric situations by changing the underlying network structure. We designed an algorithm in this study to model the situation in a new way. We then developed a computer program to allow the user to create any desired network structure and conduct analysis based on that. Second, while most existing research on modelling the spread of infection in a society focussed on modelling factors concerning population and infection, they may have neglected individual-level parameters. Such studies overlooked the differences between individuals in a population and treated society as a homogenous collection of individuals. We contributed by modelling heterogeneity between individuals in their ability to withstand an infection which may vary due to several underlying factors. Third, taking COVID-19 as a specific example, we simulated the spread of infection using the proposed network-based approach to model epidemics under different scenarios and compared their outcomes to empirical data corresponding to eight countries from different regions. Fourth, we introduced eight measures to compare the outcome of simulated scenarios and empirical data; some of these sophisticated measures have never been used in earlier epidemiological model studies. Although we have highlighted the contributions to modelling epidemics in this study, the novel framework using the network-based approach discussed here; can be customized to solve a broader range of network-centric problems.

Apart from the above academic contributions regarding building a novel framework and its application under different situations, the findings of this study have practical implications for policymakers. The proposed approach can be used to explore the outcome of different intervention strategies under hypothetical conditions. Policymakers can apply the simulation-based model to determine the impact of different pharmaceutical and non-pharmaceutical interventions and their combinations before implementing them on the ground. They will be able to understand better which intervention may have what impact under different situations. This ability can be beneficial to policymakers in decision-making under constraints. For example, applying a non-pharmaceutical intervention like lockdown for a long duration may not be practical, or a pharmaceutical intervention like vaccination may not be possible due to the lack of available vaccines. Policymakers can mix and match intervention strategies and study their effect under hypothetical conditions using the proposed framework before implementing them on the ground. Thus, we believe the study presented in this dissertation makes several valuable contributions that can be used by academicians and policymakers alike.