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HOW PEOPLE'S BELIEFS DETERMINE SOCIETY'S DISEASE RESISTENCE

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ABSTRACT

Protecting public health from infectious diseases often relies on people's beliefs, especially when self-care interventions are the only viable tools for disease mitigation. In this study, we focus on how public opinion and its surrounding factors affect disease spread. We propose an agent-based simulation framework that incorporates opinion dynamics with an epidemic model. Our framework is built on the assumption that mass media channels are primary drivers of opinion dynamics. We demonstrate that the model can replicate the patterns of opinion and disease dynamics observed in 15 countries during the COVID-19 pandemic. Based on the fitted models, we examine how various opinion-related factors influence the consequences of the epidemic. Factors such as the public's average initial opinions on preventive interventions, media usage, news channel preferences, network homophily, and media channel reaction time are tested. For our explanatory model, we employ the random forest algorithm and assess the permutation importance of these factors. Partial dependence plots are also investigated to observe the direction of the factors' impacts. Our results reveal that the initial level of public opinion on preventive interventions has a dominant impact on the total count of new infections.

1 MODEL AND METHOD

We employ agent-based simulation to model both opinion dynamics and disease spread on the same timeline, assuming that an agent's opinion influences its behavior. As depicted in the upper-left corner of Figure 1 (a), our simulation model is based on the assumption that every agent in the system receives messages from two distinct mass media channels: each channel broadcasts pro-intervention messages and anti-intervention messages, respectively. The agents' opinion updating behavior follows the relative agreement model developed by Deffuant et al. (2002). The disease dynamics among the agents adhere to the network-based SEIR schematics described in Figure 1 (b).

To generate pivot parameter tuples for each country's dataset, we fit 10 opinion-related parameters and 7 disease-related parameters to replicate the observed trends in opinion and disease dynamics during the COVID-19 pandemic in 15 countries, respectively. We utilize basin-hopping with multiple starting points (Latin hypercube sampling) as a global search optimizer, and sequential quadratic programming as a local search optimizer. The objective of the fitting process is to minimize the root mean square error (RMSE) between the observed sequence and the simulated sequence. Figure 2 illustrates the model fitting results for the three selected countries.

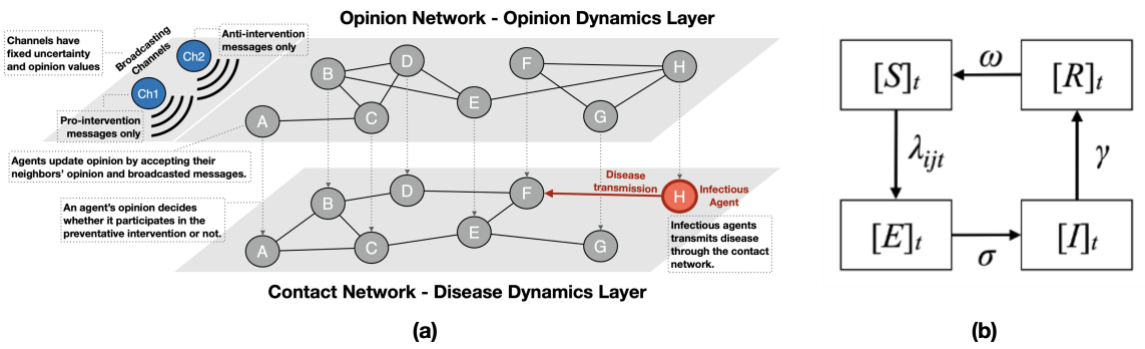

Figure 1: (a) The overall schematic of the simulation model and (b) schematic of the modified SEIRS disease transmission model.

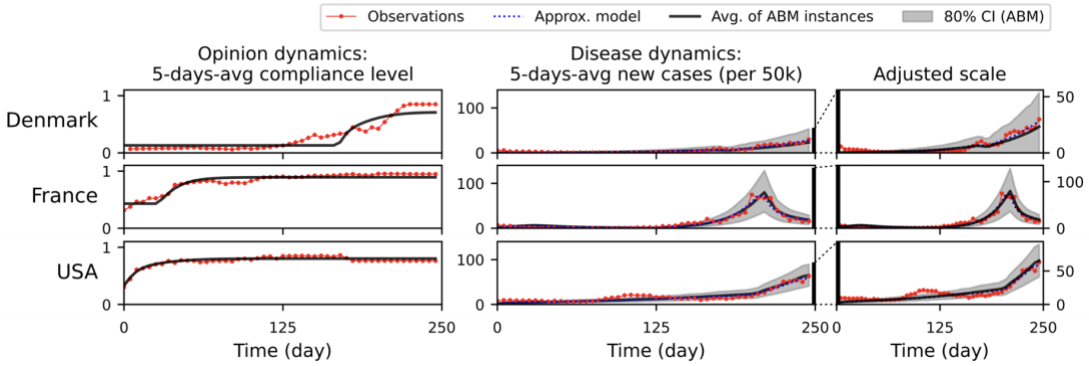

Figure 1: Observed 5-day average opinion (average compliance level to intervention, 1st column) and disease (average new cases, 2nd and 3rd columns) sequences and their corresponding simulated sequences of an agent-based model for 3 selected countries: Denmark, France, and USA.

Next, we vary and test six opinion-related factors: (1) the mean and (2) variance of the initial opinion distribution, (3) the mean and (4) variance of the usage distribution for the pro-intervention news channel, (5) the level of homophily in the opinion network, and (6) the response time of media channels to disease spread. We then monitor the total number of new infections during the simulation period. We keep the remaining opinion-related parameters of the RA model at their calibrated values. To explore the experimental parameter space, we generate 5,000 distinct parameter tuples within certain ranges using Latin hypercube sampling.

2 SELECTED RESULTS

Through our analysis on experiments, we discovered that the mean of people's initial opinion about preventive intervention dominates all other factors. This result aligns with the significance of early action and preparedness for disease spread, which has been underscored by multiple existing research articles. Furthermore, other factors also exhibit a significant influence on disease dynamics under specific conditions. For example, one country group (France, Germany, Italy, USA, and Viet Nam) tends to be more sensitive to the variance of the channel usage distribution given a high mean initial opinion on intervention. The other group (Japan, Singapore, and Spain) tends to be more sensitive to the variance of the initial opinion distribution.

REFERENCES

Deffuant, G., F. Amblard, G. Weisbuch, and T. Faure. 2002. “How Can Extremism Prevail? A Study Based on the Relative Agreement Interaction Model”. *Journal of Artificial Societies and Social Simulation*, 5(4).