Network models of vaccine hesitancy on COVID-19 vaccines

Keywords: misinformation, vaccine hesitancy, complex contagion, networks, simulations

Extended Abstract

The COVID-19 pandemic has highlighted the importance of human opinions and behaviours in the development and spread of disease. Specifically, individuals' decision-making processes related with vaccination have a significant impact on the control of infectious disease [1,2]. In fact, the prevention of disease contagion requires the vaccination coverage of a certain population to be above the level of herd immunity threshold [2]. Literature on vaccination decision making have been generally focused on several factors associated with the risks and benefits of vaccination. Among the main determinants related with the decisions on vaccination we can mention: the perceived risk of disease infection [3]; the perceived safety and/or efficacy of the vaccines regarding possible side-effects [4]; or even the economic costs associated with vaccines and disease infection [5]. However, although these factors are essential to explain how and why certain social dynamics of diseases transmission emerge and spread in current societies, there are also other structural determinants that should be taken into account such as the social dynamics of opinion contagion through social networks [6].

The present study, based on preliminary findings from the projects ACTION and DCODES, aims to analyse the process of diffusion of vaccine hesitancy through the computational analysis of different simulated scenarios. Using evidence from a pilot online survey and network data aimed at characterising vaccine hesitancy among university students, our study aims to answer two basic questions: (1) what are the main polarizing themes around the new COVID-19 vaccines; (2) how the structural positioning of initial hesitant nodes may affect the final composition of vaccine hesitancy in a network. The simulated diffusion network included the following parameters: a) 1000 nodes; b) 30 time periods; c) three scenarios based on the initial seed nodes (i.e., vaccine hesitant agents) were considered: random, marginal, and central according to their position in the graph; the vaccine hesitancy was distributed between [0.1, 0.5] depending on uncertainty and doubts regarding certain topics (i.e., concerned about adverse effects, perceived risks, necessity of vaccines, willingness to accept new doses of COVID-19 vaccines); and the network model selected was scale-free.

According to the survey data, we could observe that: a 45% of respondents were concerned about the adverse effects of COVID-19 vaccines; 22% of respondents did not consider vaccines necessary for diseases that were no longer common; 54% felt that the new COVID-19 (mRNA) vaccines carried more risk than the old vaccines; and 13% would not accept new doses of COVID-19 vaccines. These were the topics that produced higher polarisation among students. Figure 1 shows the three initialization scenarios of the simulation models used in this study: random seeds, central seeds and marginal seeds (A), on which susceptibility and infectivity (i.e. the level of exposure in relation to contagiousness) would be also analysed (B). From these three initial scenarios, the parameter that would define the level of vaccine hesitancy in relation to the four topics that generated the greatest division among informants would be incorporated, which would offer us 12 different scenarios (C). Preliminary findings indicate the relevance of agents' centrality in disseminating vaccine hesitancy. Furthermore, it is observed that regardless of the level of

vaccine hesitancy shown by the different (mis)information disseminating agents, the central positioning of the nodes in the network structure is critical in the propagation of ideas that could affect the decision to vaccinate and, therefore, be also harmful to the health of the population (D). In fact, the strong effect of the central seeds of vaccine hesitancy remains practically unchanged in the different scenarios, while the marginal seeds are the ones that, in global terms, have a weaker effect.

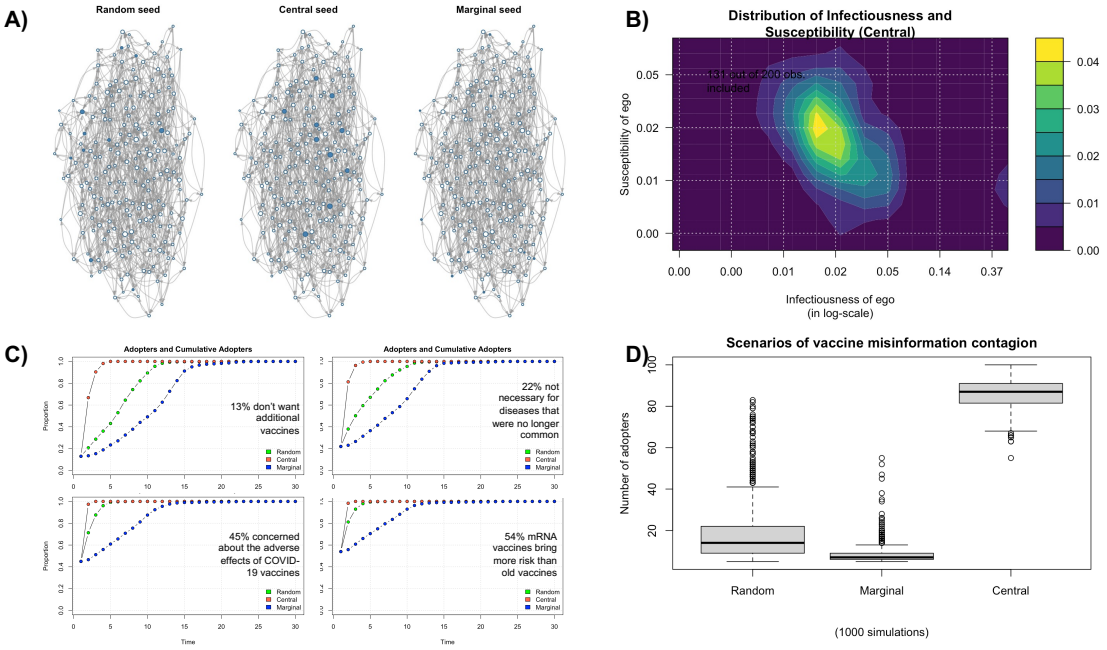

Figure 1. Diffusion of vaccine hesitancy under different scenarios (results after 1,000 simulations).

The present results highlight the relevance of the social structure and, particularly, of the connections and positioning of social agents in the diffusion of ideas that can be potentially detrimental to disease control and prevention in our societies. These preliminary findings are relevant because they highlight the relevance of social networks structures both in the propagation of vaccine hesitancy and in possible strategies aimed at combating health misinformation.

References

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