Prioritizing high-contact professions raises effectiveness of vaccination campaigns

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Abstract

Recent studies have proposed network interventions for reducing the propagation of COVID-19. By restricting close-range contact to occur only within predetermined interaction structures, the speed and reach of COVID-19 spread can theoretically be reduced. However, even severe social distancing policies such as full-scale lockdowns can only temporarily reduce infections and hospitalizations, leaving large-scale vaccination as the primary vehicle for sustainable control over the SARS-CoV-2 virus. Nonetheless, global vaccine roll-out has logistical and financial limits. The challenge is how to effectively control the virus with limited supplies.

A twenty-year-old idea from network science is that vaccination campaigns would be much more effective if high-contact individuals were preferentially targeted. Implementation is impeded by the ethical and practical problem of differentiating vaccine access on the basis of a personal characteristic that is informal and private. Here we develop an agent-based model on how to effectively vaccinate in times of a pandemic by prioritizing specific occupational groups. We draw on data from a survey conducted at the beginning of the COVID-19 pandemic in early 2020 that measures close-range contact for occupational groups. The data reveal substantial occupational differences, with teachers and cashiers being among the most connected and computer programmers among the least connected. To investigate whether this variability can produce significant gains when exploited in targeted vaccination programs, we first used a genetic algorithm to generate networks of 10,000 nodes that map the occupational contact data onto network degree. We then simulated epidemics and compared the effectivity of vaccination campaigns that target individuals either randomly or targeted by occupational group membership, prioritizing the highest reported average number of social contacts.

Our simulations suggest that random distribution of vaccines amounts to 35% of nodes getting infected on average, compared to 60% in the baseline/no-vaccination condition. Prioritizing high contact professions, however, results in a mean of 20% of nodes getting infected, while the vast majority of epidemics are prevented entirely (median number of infections close to 0%). Furthermore, we show that the positive effect of targeted vaccination is stronger if networks are more clustered and if there is lower occupational group homophily. A comparison between random vaccination of 40% and targeted vaccination of 20% of the population (everything else equal) shows that the latter achieves similar numbers of cumulative infections with significantly later and lower epidemic peaks.

Based on our findings, we propose that occupational groups can function as a reasonably effective proxy to increase effectiveness of vaccination campaigns.

Keywords

Pandemics, Diffusion, Vaccination, Network Intervention, Professional Networks, Agent-Based Modeling