ONLY CONNECT **Nicholas A Christakis**

"You make me sick!"

Network science can offer new ways to think about public health strategies

"You make me sick" is a colloquialism, but it reflects a reality. Our health depends not just on our own biology, choices, and actions but also on the biology, choices, and actions of those around us.

This claim may strike some as anathema. Particularly in the United States, we are accustomed to seeing our destinies as largely in our own hands. We "pull ourselves up by our bootstraps." And we have a "do it yourself" culture that clearly extends to our own health. The radical individualist perspective is that by making changes in everything—from what we eat to how we exercise, how we brush our teeth, when we sleep, and whether we seek regular check-ups—we can improve our survival chances, mental stability, and reproductive prospects.

But the picture is much more complicated. Our unavoidable embeddedness in social networks means that events occurring to other people, whether we know them or not, can ripple through the network and affect us. A key factor determining our health is, in fact, the health of others. This is obvious when it comes to infectious diseases: if the people around you wash their hands or get vaccinated, it decreases your risk of infection. But it is also the case when it comes to other health phenomena. We are affected by the choices and actions of dozens or even hundreds or thousands of other people in our extended social network.

Hence network science can offer new ways to think about public health. For example, if we were trying to reduce the prevalence of smoking in a school or workplace, the conventional approach might be either to broadcast a message to everyone or to work with a small group of people who were believed to be especially at risk. In the second case, these individuals might be identified because they are the poorest, say, or because they are known to be smokers. But an alternative approach would be to identify the people at the hubs in the social network—namely, those people at the centre of the network or those with the most contacts—and target them with smoking cessation messages and incentives, even though these people might not be either poor or smokers. Early results with such network based approaches have had success in fostering better diets and safer sex.

Some recent work has also clarified the specific circumstances whereby influential individuals are most apt to have an impact. A key consideration is that networks with particular patterns of connection are more prone to the spread of desirable (and undesirable) behaviours. Understanding the structure of social networks is crucial to understanding such naturally occurring and artificially induced diffusion processes, in both infectious and behavioural domains.

Understanding networks can lead to still other innovative, non-obvious strategies—related to infectious and non-infectious disease. Randomly immunising people in a population to prevent the spread of a pathogen typically requires that 80-100% of the population be immunised. For example, to prevent measles epidemics, 95% of the population must be immunised.

A more efficient alternative is to target the hubs of social networks. However, it is often not possible to discern network ties in a population in advance, when trying to figure out how best to immunise it. A creative alternative is to immunise the acquaintances of randomly selected individuals. This strategy allows us to exploit a property of networks even if we lack the time, money, or ability to discern the whole network structure. The reason that this strategy works is that acquaintances have more links and are more central to the network than the initial, randomly chosen people who named them; people with many links are more likely to be nominated as acquaintances than people with few. In fact, the same level of protection can be achieved by immunising roughly 30% of a population identified by this method that would otherwise be obtained if we immunised 99%.

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Similar ideas can be exploited for the obverse problem: how best to conduct surveillance of a new behaviour (such as self-injurious "cutting," which is epidemic among US adolescents at the moment) or a new pathogen or even a bioterrorist attack. Do we monitor people randomly or choose them according to their network position? Analytic models by Jure Leskovec and colleagues indicate that a choice informed by network science could be 700 times more effective and efficient at detecting outbreaks.

Such approaches shift the focus of decades of admittedly valuable public health work. They target neither socioeconomic inequality nor socioeconomic or behavioural vulnerability but rather structural inequality and structural vulnerability. As James Fowler and I argue, people can be placed at risk for bad or good health by virtue of their network position, and it is to this position that certain public health interventions might beneficially be oriented. As well as focusing on whether people are poor or where they live or even what they do, we might focus on whom they know and what kinds of social networks they inhabit.

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