PHYS.ORG

Can social interactions affect spread of disease?

December 11 2018

Most real-world systems, such as biological, social, and economic schemes evolve constantly. The dynamics of such systems are characterized by significantly enhanced activity levels over short periods of time (or "bursts") followed by long periods of inactivity.

This is true of social communities, in which the pattern of connections between individuals progresses over time, and the tendency to form connections occurs intermittently, or in bursts, rather than in a steady stream. Such bursts are often interspersed with latent periods without social activity. These social dynamics in turn affect other phenomena, such as disease spread.

"Most of the existing literature assumes that epidemics spread either much faster or much slower than individuals build social connections," Maurizio Porfiri, professor at New York University's Department of Mechanical and Aerospace Engineering and Department of Biomedical Engineering, says. "However, this is seldom true, as people can travel any distance in a few hours, effectively spreading many pathogens."

In a paper publishing next week in the *SIAM Journal on Applied Dynamical Systems*, Porfiri—along with collaborators Lorenzo Zino and Alessandro Rizzo, both of Politecnico di Torino, Italy, and with visiting appointments at NYU—draws connections between people's social activity and the spread of epidemics through a mathematical model.

The temporal evolution of a social community is dependent on the evolution of single individuals' characteristics within the community; the reverse is also true. The more active an individual is in generating links, the more he or she further increases his or her activities in such tasks.

"Our model of time-varying networks factors in the innate variability of people's connections with others over time and accounts for the fact that some are more active in creating contacts than others," explains Porfiri. This tendency to form connections is considered self-excitement. Such self-exciting processes are able to generate bursts of correlated events followed by periods of inactivity, contributing to "burstiness" and temporal event clustering.

"The model incorporates self-excitement and burstiness to better explain the intricate relationship between an individual's social activity and emergent collective phenomena," as Zino describes. "Human social behavior is often prone to self-excitement: the more active we are, the more we receive attention and gratification, which, in turn, bolsters our activity in a positive feedback loop. Hence, self-excitement plays an important role in the emergence of bursty behaviors that shape the evolution of social systems."

Activity driven networks (ADN) have recently been used to model the temporal evolution of networks of interactions, such as epidemic spread, opinion dynamics, and dissemination of innovation. However, so far, researchers have not sufficiently accounted for the temporal evolution of individual characteristics within the ADN framework.

The interactions between individuals—which tend to cluster in time, with short high-activity surges alternating with longer moderate-activity periods—cannot be overlooked in the case of realistic processes. "This phenomenon [of individual interaction] shapes the evolution of social systems and cannot be neglected when modeling real-world problems," notes Rizzo. "We believe that the formalization and analysis of such a feature is key to a mathematically-grounded study of real-world problems, both from qualitative and quantitative points of view."

The authors developed a time-varying network model, which generalizes the ADN paradigm by including these individual dynamics. They use Hawkes processes—which rely on just two parameters—to model the activation of nodes; Hawkes processes reflect temporal characteristics of realistic systems better than the time-homogenous processes used in previous studies. Despite the model's simplicity, it is capable of reproducing phenomena observed in empirical data, such as burstiness and clustering.

The NYU-Politecnico team first analyzes the manner in which self-excitement mechanisms dynamically influence individuals' predisposition to establish connections, and then examines the effects of these individual kinetics on epidemic transmission. By analytically computing the epidemic threshold in the thermodynamic limit—which occurs when the number of people tends to infinity—the authors demonstrate that self-excitement dynamics tend to lower the epidemic threshold, thus increasing disease communicability.

"We prove that neglecting individual interactions in the study of epidemic spreading may cause dramatic underestimation of the severity of an infection," Zino points out. "Understanding the crucial role of self-excitement at the inception of an epidemic outbreak is key to formulating accurate predictions on the evolution of epidemics and supports effective vaccination and containment techniques."

With the help of these results combined with numerical simulations, the authors illustrate that self-excitement mainly yields increased variability in the individual's social activity, which in turn, decreases the epidemic threshold of the system, thus increasing susceptibility to disease outbreaks.

"This piece of research is a compelling step in the direction of developing mathematical models that are able to describe and predict social dynamics," remarks Rizzo. "In our current and future work, we aim to include further real-world features of human systems. Within the study of epidemic outbreaks, we plan to explore the co-existence of contrasting behaviors, like self-excitement due to social activity, and adoption of preventive measures, such as quarantine."

Their method is also adaptable to other kinetics within such systems. As Porfiri explains, "We are interested in investigating other dynamics that take place in social systems, such as the evolution of opinions in social communities, cognitive biases or dissonances, and the competing spread of information and misinformation. Lastly, we must validate our mathematical framework and theoretical findings through critical comparison with real-world data. With this in mind, we are currently analyzing publicly available datasets and developing a mobile application to carry out our own experiments."

More information: Zino, L., Rizzo, A., & Porfiri, M. (2018). Modeling Memory Effects in Activity-Driven Networks. *SIAM Journal on Applied Dynamical Systems*, 2018. dx.doi.org/10.1137/18M1171485

Provided by Society for Industrial and Applied Mathematics

Citation: Can social interactions affect spread of disease? (2018, December 11) retrieved 25 April 2024 from https://phys.org/news/2018-12-social-interactions-affect-disease.html