

# **New model accurately describes COVID-19 waves and plateaus**

December 14 2021, by Siv Schwink

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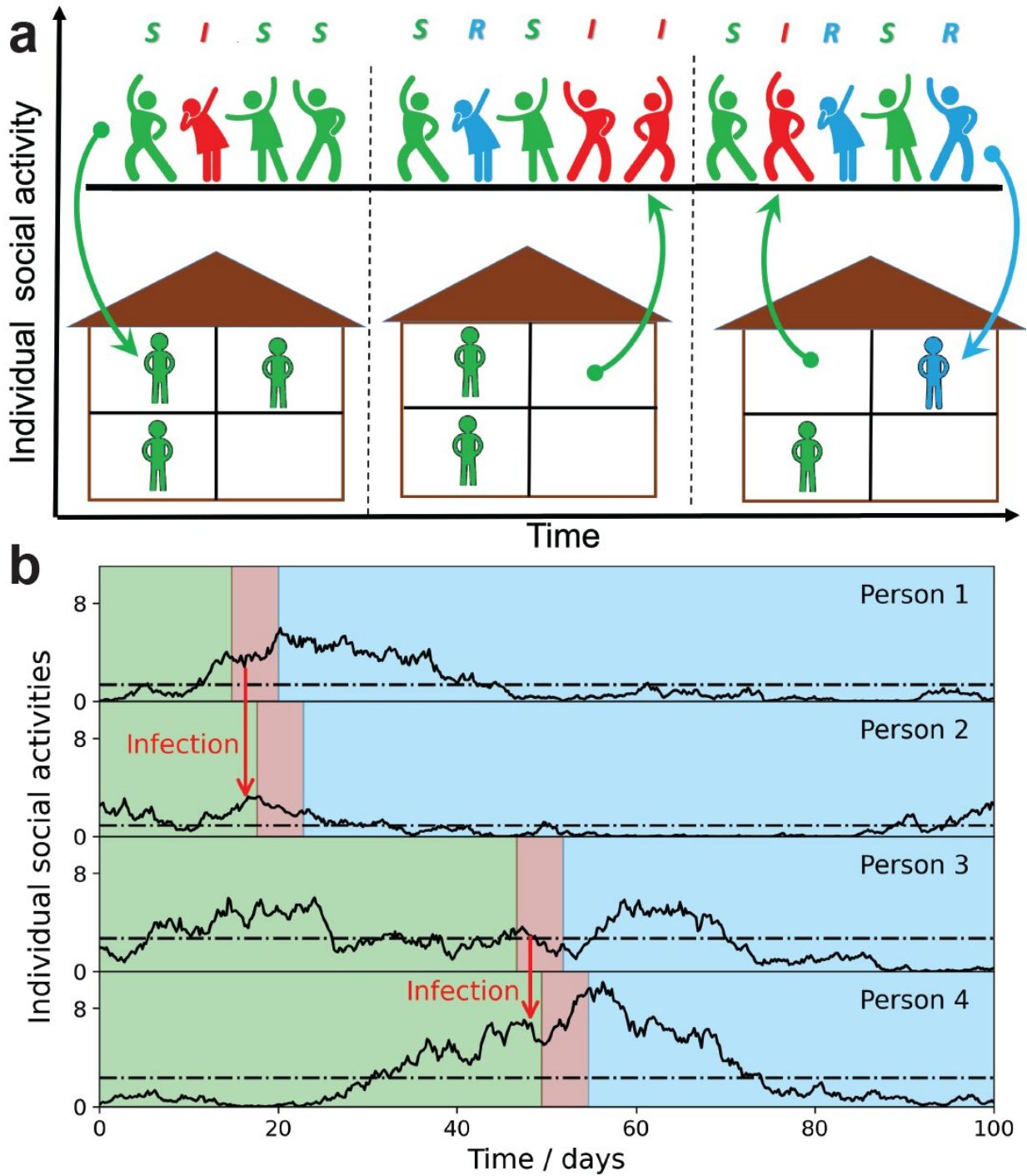


Figure 1 in the published paper depicts a schematic illustration of the Stochastic Social Activity model in which each individual changes their social activity over time. People with low social activity (depicted as socially isolated figures at home) occasionally increase their level of activity (depicted as at a party). The

average activity in the population remains the same over time, but individuals constantly change their activity levels from low to high (arrows pointing up) and back (arrows pointing down). Individuals are colored according to their state: susceptible = green, infected = red, and recovered/removed = blue. The epidemic is fueled by constant replenishment of the susceptible population when individuals move from the low-activity state to high-activity settings. Virus transmission occurs predominantly between individuals having high current activity levels. Credit: A. V. Tkachenko, et al., *eLife*, December 14, 2021

To better understand the factors governing the wave and plateau dynamics of the spread of COVID-19, a team of scientists at the U.S. Department of Energy's (DOE) Brookhaven National Laboratory, the University of California San Diego (UCSD), and the University of Illinois Urbana-Champaign (UIUC) has developed an epidemiological model inspired by real-world observations based on proximity data, like the fact that any given individual's social activity tends to happen in bursts over short time scales, with longer in-between periods reverting to average sustained social-activity levels.

The new [model](#)—dubbed the stochastic social activity (SSA) model—was paired with a traditional [epidemiological model](#) and validated against empirical data taken from four U.S. regions before introducing COVID-19 vaccines. Stochastic refers to individual social activity being random and unpredictable, a variable that can nevertheless be captured in mathematical equations through probability distributions that are averaged out over time.

The new model builds on the team's earlier work published in April of this year in the *Proceedings of the National Academy of Sciences* that showed the concept of "herd immunity" does not apply to the COVID-19 pandemic, because this type of collective immunity to the disease turns out to be short-lived. Instead, what emerges is a fragile and

temporary state of collective immunity, which they coined "transient collective immunity" (TCI). The prior study also considers individual differences in the size of social networks.

The team reports in the current work that this newly accounted-for random dynamic factor will always produce waves or plateaus of infections—like those seen throughout the pandemic—whether the model also accounts for individuals' changing their social behavior based on knowledge of current infection rates. The model further tells us that COVID-19 may be here to stay—it shows a clear path for it to become endemic in the [global population](#), much like the common cold or the flu.

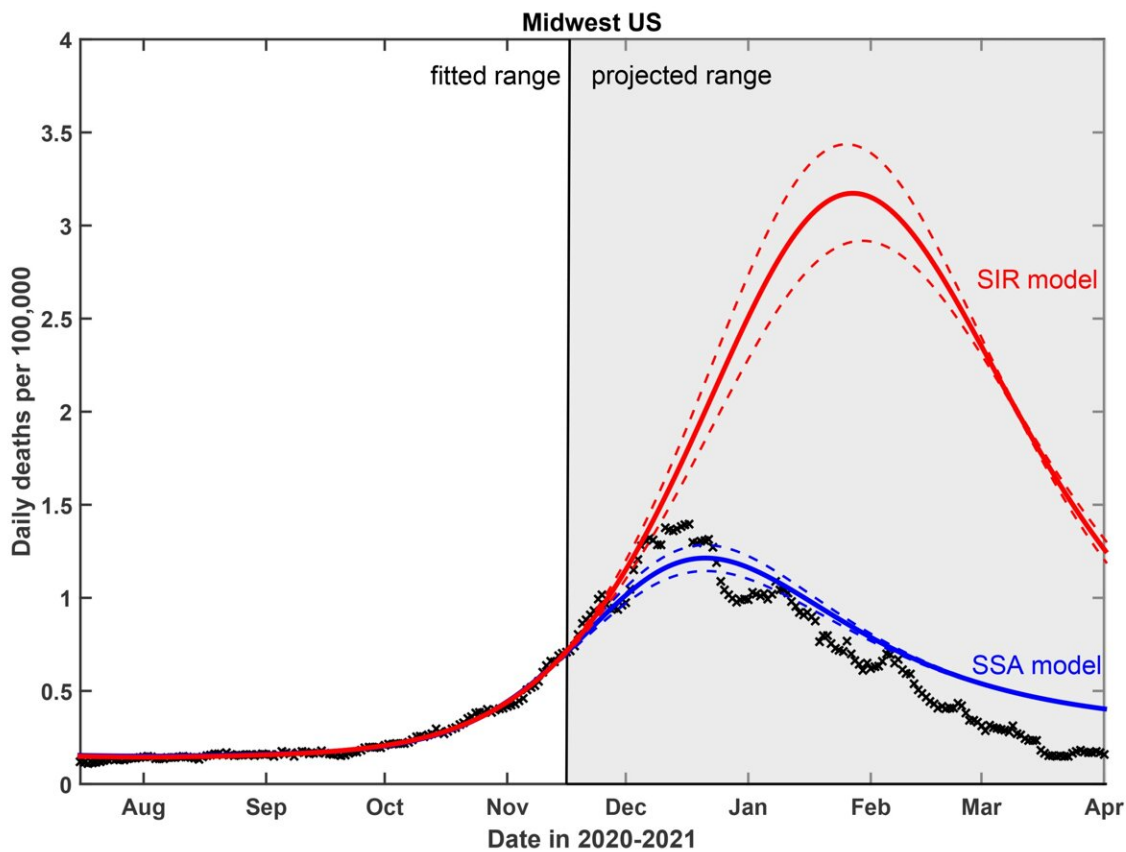


Figure 8 in the published paper depicts a test of the predictive power of the Stochastic Social Activity (SSA) model developed in this work. Daily deaths data in the Midwest region of the USA have been fitted up to Nov 17, 2020. The epidemic dynamic beyond that date has been projected by our model (blue). One observes a good agreement between this prediction and the reported data (crosses). In contrast, the classical SIR model (red) substantially overestimates the height of the peak, and projects it at a much later date than had been observed. Solid lines represent the best-fit behavior for each of the models, while dotted lines indicate the corresponding 95 percent confidence intervals. Credit: A. V. Tkachenko, et al., *eLife*, December 14, 2021

"Our new model describes three phenomena: why during a pandemic, a wave stops; how it can progress at a nearly constant rate, forming a plateau; and why new pathogens actually stay with us permanently, entering what's called an endemic state. Classical theory tells us when a new pathogen is introduced, it will eventually kill itself off by infecting enough people that herd immunity is developed, unless biological immunity is very short-lived. But even in the case where long-term biological immunity is developed, we explain the scenario of how a new pathogen stays endemic in a population," notes lead author and physicist in the Theory and Computation Group at the Center for Functional Nanomaterials (CFN), a DOE Office of Science User Facility at Brookhaven Lab, Alexei Tkachenko.

"What we are providing here is yet another factor that contributes to the dynamics of a pandemic that consists of multiple waves. In our case, our waves are caused exclusively by changes in the time-averaged level of social activity of individuals. The fluctuations in activity level led to a significant change in the propagation of the epidemic in waves and plateaus," adds Sergei Maslov, University of Illinois Urbana-Champaign professor of bioengineering and physics and Bliss Faculty Scholar.

These results are published online in the December 14, 2021 issue of the journal *eLife*.

**More information:** Alexei V Tkachenko et al, Stochastic social behavior coupled to COVID-19 dynamics leads to waves, plateaus, and an endemic state, *eLife* (2021). [DOI: 10.7554/eLife.68341](https://doi.org/10.7554/eLife.68341)

Alexei V. Tkachenko et al, Time-dependent heterogeneity leads to transient suppression of the COVID-19 epidemic, not herd immunity, *Proceedings of the National Academy of Sciences* (2021). [DOI: 10.1073/pnas.2015972118](https://doi.org/10.1073/pnas.2015972118)

Provided by University of Illinois at Urbana-Champaign

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