Stress testing the healthcare system

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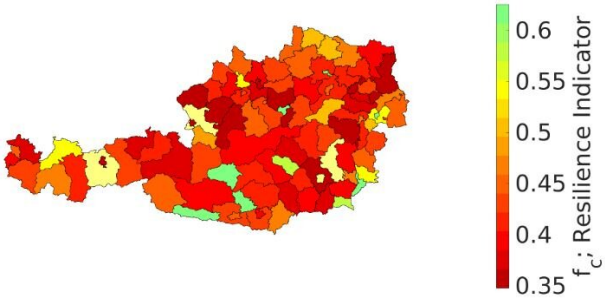

Resilience of the primary care system in Austrian districts in the years 2006 and 2007. Green-colored districts have a particularly high resilience, meaning that they will digest shocks such as doctors' retirements easily. The resilience in red-colored districts is low. Credit: © Lo Sardo et al., Complexity Science Hub Vienna

Scientists at the Complexity Science Hub Vienna (CSH) have developed a stress test to determine the resilience of regional health care in real time. They used a 1:1 computer model of the Austrian primary health care system in the form of patient flows in regional physician networks as a basis. The innovative model provides concrete answers to questions: How important is a certain doctor for the functioning of primary care in my region? How many and which doctors' retirements can the system absorb? At what point can primary health care no longer be guaranteed for everyone in a region?

The paper appears in the latest issue of the journal *PNAS*.

How safe is the primary health care system?

Usually, the number of physicians in relation to the population—the so-called physician density—is used as an indicator for the quality of health care. Yet, this indicator assumes that all physicians are equally accessible and equally important for all patients. "We show that this is not the case," says Peter Klimek from CSH and MedUni Vienna. "Physicians and their patients form networks. With the same physician density, these networks can either be resilient or prone to collapse, or something in between," Klimek says.

The complexity researchers used a research data set including all Austrian physicians and patient streams from 2006 to 2007 to create the network. Resident physicians are the nodes, connected to each other by their patients. "We were surprised at how closely connected and regionally focused the networks of patient flows are," says Klimek. The researchers called this "patient sharing."

This point becomes relevant as soon as a doctor's office closes. The data show that more than 80 percent of all patients choose physicians with whom they have previously had contact for further medical care. Knowing that, the researchers are able to calculate with high accuracy where patients of a particular doctor will turn after the doctor's retirement.

Simulation makes patient flows visible

An interactive simulation programmed by Johannes Sorger (CSH) illustrates the network dynamics. In the simulation, natural persons were replaced 1:1 by anonymous avatars. "We can click away single doctor avatars and observe where their patients are moving on to," explains Peter Klimek (see link below).

A resilient health care system will recover quickly and fully from such shocks. However, the loss of too many doctors at a time or of particularly important doctors can overstrain the system. "The simulation shows the critical point at which the system's ability to absorb additional patients or compensate for lost doctors collapses," says first author Donald Ruggiero Lo Sardo (CSH, MedUni Vienna). "Thanks to our model, we know how many and which doctors can be removed from the system

without problems," he adds. "We can say how resilient the health care system is in a certain region. And we can determine how relevant each avatar is to the stability of the regional network."

For example, doctors with particularly large numbers of patients and good accessibility within the doctors' network lend stability to the system. Poorly networked doctors, on the other hand, will more likely weaken the system.

A model for many areas

The model provides stakeholders in the health care sector with a tool that allows (personnel) decisions and their effects to be tested in advance.

The researchers emphasize that the new method can be extended to diverse scenarios, such as the outbreak of an epidemic or a natural disaster with many casualties. "With up-to-date data, we can make valid assertions about the resilience of different sub-systems in health care," maintains Klimek. This knowledge facilitates planning and improves medical care. "As soon as people in charge know the systemically relevant doctors in a region, they can make the health care system more resilient by either trying to retain those doctors or to adequately refill their positions after their leave," Klimek concludes.

More information: Donald Ruggiero Lo Sardo el al., "Quantification of the resilience of primary care networks by stress testing the health care system," *PNAS* (2019). www.pnas.org/cgi/doi/10.1073/pnas.1904826116

Follow the link for a detailed description: csh.ac.at/vis/med_public/pcn-resilience

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