COVID-19
AI & Simulation Project

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BIG DATA DRIVES JAPAN'S PANDEMIC RESPONSE STRATEGIES

Lessons taken from data and scientific models could IMPROVE FUTURE POLICY.

Although the global crisis of the COVID-19 pandemic has passed, governments and researchers around the world continue to collect and sift through data, and refine their research models to learn how to best respond to the next pandemic.

Japan is accustomed to large-scale earthquakes and flood damage, and is experienced at responding to uncontrollable crises. Nevertheless, the pandemic caught Japan off-guard in 2020, when it was forced to rapidly devise policies with little practical evidence of the efficacy or adverse impacts of the control measures it was implementing.

▲ **Commuters at the Shibuya crossing in Tokyo, Japan — one of the busiest pedestrian scramble crossings in the world.**

To address this, the government sought input from a team of researchers and scientists from various disciplines, whose real-time data analyses, combined with a healthy respect for data among policy makers, helped mediate policy decisions over the course of the pandemic.

"The Japanese government tried to take a science-based approach in responding to the pandemic, but early on in the crisis, the evidence and data were lacking," says Yukio Ohsawa, an expert in artificial intelligence at the University of Tokyo.

As part of the Japanese government's COVID-19 AI and Simulation Project, Ohsawa and other researchers from the University of Tokyo and the Tokyo Foundation for Policy Research have been using an approach involving both big and small data, and refining models for simulating the spread of infection and its influence on the society, to help make pandemic policies, such as movement restrictions, more effective, targeted and efficient.

"We're trying to frame countermeasures for future pandemics and other disasters based on science, but also an understanding of the subsequent economic impacts," says Ohsawa.

CRISIS NAVIGATION

Taisuke Nakata, an economist also based at the University of Tokyo, leads a research group that became a key point of reference for the Japanese government throughout the pandemic. Having previously worked with economic models in the central banking system of the United States, Nakata quickly adapted those models to simulate the interaction between infection and the broader economy in Japan, taking into account the specific policy settings and societal underpinnings of Japan.

"We started in 2020 with the aim of jointly modelling infection and the economy," Nakata says. "The standard economic

models are very abstract and theoretical. So, we came up with a relatively simple framework that could be easily calibrated using real data and policy settings for Japan[1]."

At that time, however, there were no other groups providing frequent updates of infection projections. Because the model from Nakata's team could be frequently updated, they ended up publicly releasing weekly updates of projections considering the latest infection data, and they had to put their economic analyses on the backburner.

"We also simulated different virus variants and vaccination and policy scenarios, as well as simulating the impact of the 2021 postponed Tokyo Olympics on infections, which we provided to the government to help guide it," says Nakata.

Now the team has time to analyse the socioeconomic consequences of those policy decisions. Nakata is working closely with Asako Chiba, a fellow economist from the Tokyo Foundation for Policy Research, on understanding the longer-term impacts of the pandemic to help ensure that such consequences can be properly considered in future responses.

BEYOND PUBLIC HEALTH

Chiba adapted an open-source, agent-based model to construct an 'artificial community' using census data and local policies to test and retest different policy scenarios. The agent-based approach involves using census data to create a set of typical individuals characterized by age and gender, family composition, job type and industry, eating habits, health status, and other factors. This data is combined with virus transmission factors and social contact modes reflective of each individual's characteristics. A community of approximately 75,000 agents — representative of the population of Tokyo — was then used to simulate different assumptions and policy settings to help guide policy decisions.

"In the model we differentiate between 'fixed' daily contacts like family and work colleagues, and 'flexible' contacts such as individuals encountered at restaurants — and we can further differentiate between high and low risk flexible contacts under a probabilistic transmission model," says Chiba. "This modelling shows that restrictions on long-distance travel at the beginning of the outbreak are very effective in containing virus spread, whereas broad-based working from home arrangements are much less effective, because of the way the virus is transmitted among different fixed and flexible contacts.[2]"

Chiba is now working to improve the model to include economic impacts.

"AS CASES WENT UP, RISKY BEHAVIOURS SUCH AS PARTIES AND BAR VISITS WENT DOWN."

"One of the biggest challenges we faced during the pandemic was the communication of risk to the public at a time of high uncertainty," says Nakata. "Surveys suggest that the public substantially overestimated their risk of infection. This shows to us that we need to do better at communicating risks in such situations."

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▲ Researchers can now analyse the socioeconomic impacts of policy decisions made during the pandemic.

TWITTER CHATTER

In addition to comprehensive health and testing data, publicly available data from Twitter provided an unparalleled insight into the responses and behaviours of the Japanese public over the course of the pandemic. Masashi Toyoda, a computer scientist also based at the University of Tokyo, saw the untapped value of this unique dataset during the early waves of the pandemic, and set out to apply linguistic analysis approaches to extract actionable meaning from the data.

"Twitter is widely used in Japan. Japanese is actually the second most used language on Twitter after English," explains Toyoda. "We were able to access the entire Twitter stream which was provided by NTT Data in real time, so we set up a cluster PC system to host and start analysing the data. The challenge was then how to extract behavioural information from tweets, which defied the usual natural language processing approaches used in AI because of the shortened, unnatural language."

Toyoda derived a library of linguistic patterns that could be used to analyse population behaviours, symptoms, and long-term effects in real time. Those analyses showed that the population had high compliance with public health directives over the first five waves of the pandemic, but that the compliance level started to wane over the sixth to eighth waves[3].

"We also found that as cases went up, risky behaviours such as parties and bar visits went down, showing that the Japanese population voluntarily restricted their own behaviour. I think this means that people can be trusted to act responsibly if given enough information," says Toyoda.

▲ Yukio Ohsawa leading a workshop in Shimoda, Japan, based on the 'stay with your community' principles created during the pandemic.

"But at the same time, those risky behaviours also preceded the next transmission wave, to the extent that the real-time risky behaviour metric turned out to be one of the key factors predicting an increase in cases. This could be a highly valuable tool for government during similar crises in the future," he adds.

SOCIAL CLUSTERS

Ohsawa developed an original concept — intentional and unintentional social contacts based on a collaboration on data-federative innovation with citizens and workers in Yokohama and Tokyo. From this he developed a 'constrained scale free network" and extended it to 'network slicing' models to simulate how unintentional contacts in the network of communities affect transmission rates.

"We started this modelling during the pandemic and found that when a social cluster gets infected, mitigation measures have very little effect on transmission within the cluster," he says. "The biggest impact on transmission was when an infected person joined another cluster, starting an entirely new transmission chain."

Using anonymous mobile phone location data, Ohsawa could model the typical size and topology of each cluster, and also the transmission risk associated with commuter travel. Even the direction of travel and transfers revealed different transmission characteristics, with large terminal stations on rail lines presenting the highest risk of unintentional infection.

These analyses revealed that a 'stay with your community' (SWYC) approach[4], where people are advised to prioritize their habitual routines over unusual and new contacts, could reduce transmission, and prevent many of the adverse social and economic consequences of movement restrictions.

The modelling suggests that keeping the number of unintentional contacts, such as nearby restaurant diners, shoppers or interacting passengers, equal to the number of intentional contacts in a network was the critical tipping point.

"We actually trialled this approach in the city of Shimoda, west of Tokyo, with the support of the city mayor, by distributing simple cards summarizing the SWYC principles," says Ohsawa, "and workshops in several other cities that also created lifestyles based on SWYC." Although these were limited trials, with the data and modelling they have conducted since, and with more complex models to simulate travel impacts more accurately, the researchers suggest that SWYC be a key principle for future pandemic responses.

Through these big data approaches and the use of novel data sources, the COVID-19 AI and Simulation project is revealing the real behaviours of people in a crisis, and providing new data-driven insights into the effectiveness of different mitigation policies.

"COVID-19 was just one of many disasters suffered by Japan," Ohsawa says. "With this new knowledge and data tools we are more ready than ever to respond to such emergencies in the future." ■

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