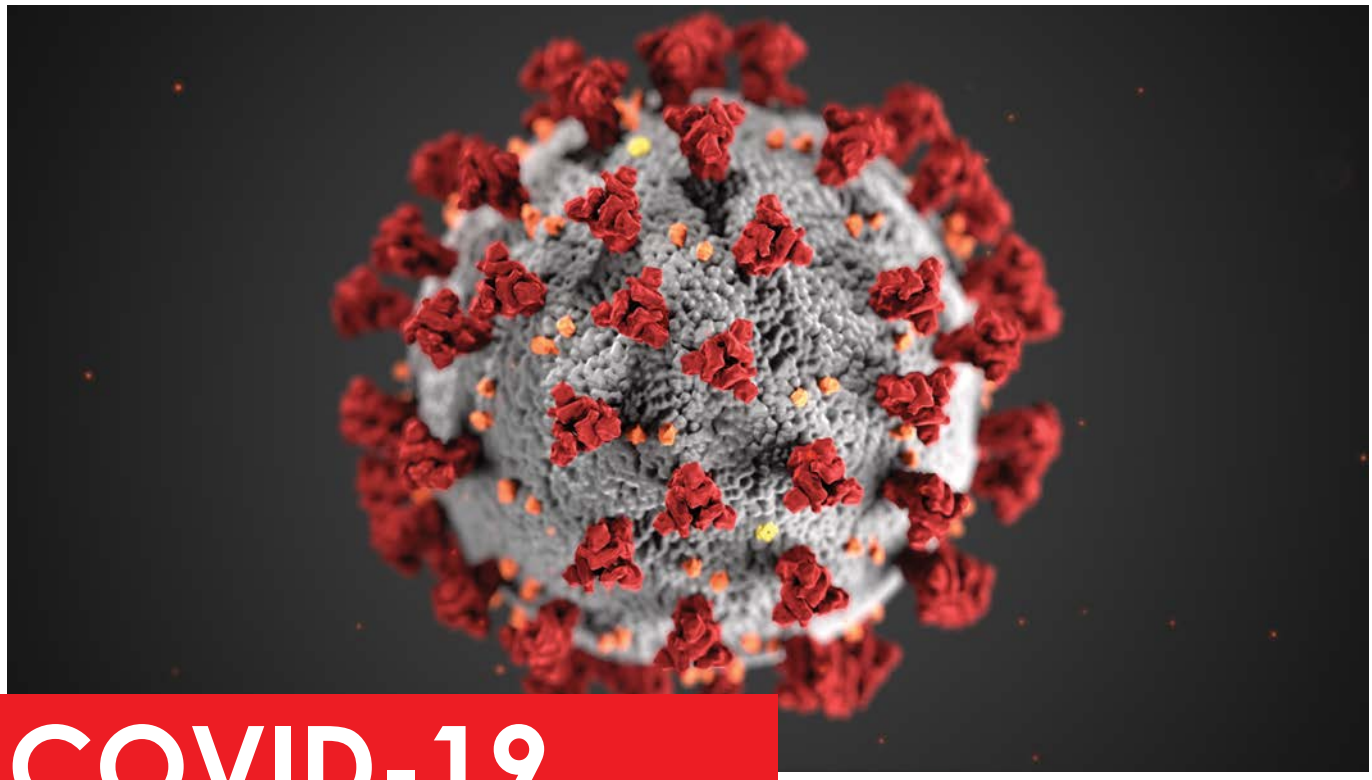


CDC

COVID-19

Early warning systems

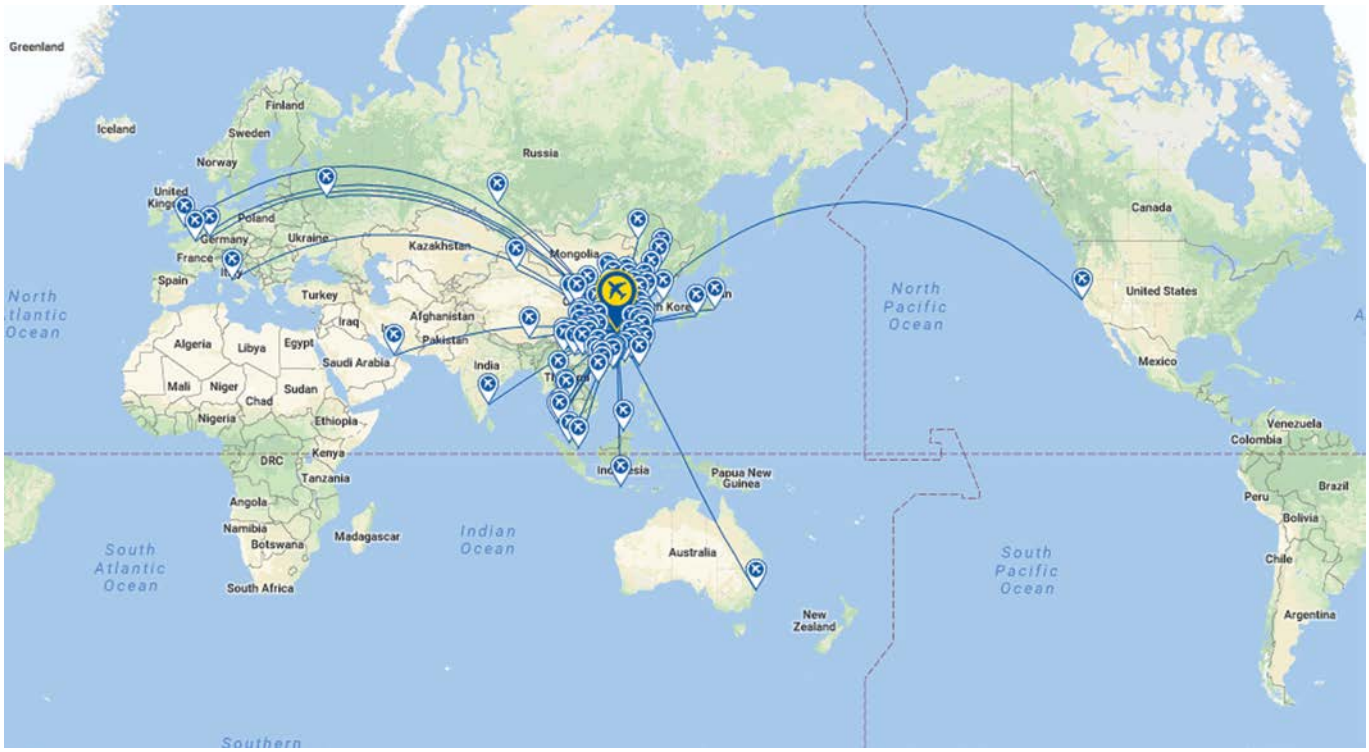
In the first week of January 2020, before the world had woken up to the havoc that COVID-19 was about to cause, a small team in Canada were already working on a paper about the potential international spread of the then-unnamed disease. They submitted their paper to the 'rapid communication' section of the *Journal of Travel Medicine* on 8 January, and it was published online within a week. In the paper they listed the top 20 cities they considered most at risk, based on travel data and an Infectious Disease Vulnerability Index (IDVI) that takes into account a country's demographics, health care and political stability. The travel data was from the period January to March 2018, and consisted of passenger volumes on commercial flights that had originated in Wuhan, China, where the first outbreak occurred.

Bangkok in Thailand was at the top of their list, and sure enough, Bangkok was the first place outside China to report a case of the disease, on 13 January. The remaining cities were from 11 countries or territories, eight of which were next to report cases, up to 25 January. At the end of that month, the six countries with the most confirmed cases outside China closely corresponded to those listed by the team. By that time they had already published a follow-up paper in the same journal, using flight data from the period February to April 2019 to indicate the threat to the 50 international cities receiving the highest passenger volumes from mainland China, as well as Hong Kong.

Most of the papers' authors are associated with BlueDot, which was founded by Dr Kamran Khan, an infectious disease physician and University of Toronto professor. Having experienced the impact of the 2003 SARS outbreak in Toronto, Dr Khan knew that countries need a headstart in preparing for the possible arrival of infectious diseases. In 2008 he launched a scientific research programme called BioDiaspora to study the role that commercial air travel plays in the worldwide spread of such diseases, and converted this to BlueDot in 2014 after having acquired venture capital funding. He assembled a diverse group of people with expertise in epidemiology, geographic information systems (GIS), data analysis, mathematical modelling, computer science, software engineering and design, and put them to work to develop a global early warning system for infectious disease that harnesses the power of big data, artificial intelligence and digital technologies.

Today, the BlueDot system can detect outbreaks of more than 150 pathogens, toxins and syndromes by continuously scanning over 100 000 official and mass media online sources in 65 languages every day. It also anticipates dispersion of any disease using flight itinerary data as well as anonymous location data from millions of mobile phones, and assesses the impact of the disease's arrival by analysing climatic conditions, health-system capacity and numbers of animal vectors, where applicable.

During its scanning on New Year's Eve, the BlueDot system had flagged a report about a cluster of pneumonia cases in Wuhan, and within two hours had sent an alert to its clients, which include a dozen public health agencies and some hospitals and airlines. That initial report was on ProMED-mail, which was also set up as an early warning system of sorts, way back in 1994. An abbreviation of Programme for Monitoring Emerging Diseases, ProMED-



Blue Swan Daily

mail relies more on a 'people approach' than state-of-the-art technology, because reports of disease outbreaks are screened by expert moderators before being made freely available. Currently there are about 80 000 subscribers to the email notification service, but anyone can access the searchable database from the ProMED-mail webpage, with information available in several languages. The initial Wuhan report, for example, was a machine translation from a Chinese business news site, discussing an urgent notice from the Wuhan Municipal Health Committee about the treatment of pneumonia of unknown cause at a number of local hospitals.

The ProMED-mail report was also picked up immediately by EIOS – the Epidemic Intelligence from Open Sources system being developed by the World Health Organisation (WHO) and the Joint Research Centre (JRC) of the European Commission. The report prompted WHO to send an official request to China, on New Year's Day, for more information under the International Health Regulations. On the same day it activated its Incident Management Support Team to coordinate the response across its headquarters and its regional and country offices.

EIOS is a web-based system that aims to improve early detection, verification and assessment of public health risks and threats using open-source information. It consolidates a number of existing systems including the Early Alerting and Reporting system (Global Health Security Initiative), the Hazard Detection and Risk Assessment System (WHO) and MEDISYS / Europe Media Monitor, all of which were developed by JRC. Each day the system collates hundreds of thousands of articles from a broad range of sources, and uses a series of text mining and analytical modules to sort them by category, country, language and source.

Kentaro Iemoto, CC BY-SA 2.0

BlueDot's early warning system used flight itineraries from Wuhan, China, to predict the spread of COVID-19 from the epicentre to other countries.

The EIOS governance structure involves multiple stakeholders, with the coordination group including organisations such as the Centres for Disease Control and Prevention (CDC) of the United States, the Food and Agriculture Organisation (FAO) of the United Nations, and the World Organisation for Animal Health (OIE). Collaborating organisations have their own space within the system, where they can securely share information. For example, FAO hosts the Global Early Warning System (GLEWS), set up in 2006 as part of the WHO/FAO/OIE tripartite alliance to address heath threats and emerging risks at the human–animal–ecosystems interface (*see page 24*), but it now uses EIOS for media monitoring, disease tracking and information dissemination.

A more recent early warning system being developed for COVID-19 relies on wastewater surveillance. Infected

people shed SARS-CoV-2, the coronavirus that causes the disease, in their bodily fluids, particularly their faeces. It is not yet known to what extent the virus survives in a viable and infective state in faecal matter, but its genetic material, in the form of RNA fragments, can be detected using reverse transcription polymerase chain reaction (RT-PCR) analysis. By taking regular samples from sewage arriving at wastewater treatment works (WWTW) and analysing these for SARS-CoV-2 genetic material, researchers could potentially get an indication of COVID-19 hotspots or new outbreaks, since WWTWs service a defined geographical area. Ongoing surveillance could also provide advance warning of a 'second wave' of the disease, or its re-emergence in the future. It is particularly useful given that many infected people are asymptomatic, and are thus unlikely to be tested for the virus.

The concept is not new, as many countries have been conducting such surveillance for polio since the 1980s. Wastewater-based epidemiology has also proved effective in assessing the use of pharmaceuticals and illicit drugs in an area – certain compounds or metabolites will even survive the WWTW process and still be detectable in rivers receiving the final effluent. Studies are now under way in a number of countries to apply the concept to COVID-19. In South Africa, the Water Research Commission (WRC) launched its 'National programme for monitoring COVID-19 spread in communities using a water and sanitation-based approach' on 20 May.

Jason Turgeon, CC BY 2.0

The potential for using wastewater surveillance to monitor COVID-19 is being investigated by researchers. Samples collected from the wastewater arriving at treatment works can be analysed for RNA fragments of SARS-CoV-2 to give an indication of the extent of COVID-19 infection in an area.

Written by Sue Matthews

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