Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Predicting the next pandemic

Internet giants and infectious disease experts are trying to harness new technologies to predict when and where the next pandemic might strike. With proper surveillance systems in place, disease spread and numerous deaths could be prevented, say experts. Eliza Barclay reports.

Even as HIV/AIDS and avian influenza remain unresolved threats to human health, increasingly attention is shifting to the next pandemic, and how to predict and prevent the disastrous consequences of widespread transmission of a new disease.

That undiscovered viruses and pathogens are evolving with the potential to infect the human population is not under dispute. According to an analysis published in *Nature* in February, 2008, 335 emerging infectious disease events occurred between 1940 and 2004. Of those, 60·3% were zoonoses, and most originated in wildlife, including the virus that causes severe acute respiratory syndrome (SARS) and the Ebola virus. Vectorborne diseases made up 22·8% of the total. The analysis also found that the threat of emerging infectious diseases to global health has been increasing over time.

As international travel and trade have proliferated, disease-causing agents now have the ability to move around the globe at faster rates. Human beings and animals are also finding themselves in increasingly closer contact with each other from deforestation and higher demand for animal products in local and international markets.

Google.org—the philanthropic arm of the technology giant—has surfaced as one of the champions of intercepting emerging diseases before they become pandemics with its Predict and Prevent initiative. "Zoonoses have only come to our attention when people start dying in the USA", said Frank Rijsberman, Google.org's director of water and climate adaptation initiatives. "We want to move surveillance to the places of origin and the current hotspots to find out when people get sick." At the moment "there are few systematic ways to do that".

Predict and Prevent has a special interest in two regional hot spots: southeast Asia—where animals and human beings coexist more intimately than anywhere else in the world—and sub-Saharan Africa—which has the greatest burden of infectious diseases and worst public-health infrastructure in the world. Poverty makes both regions exceptionally vulnerable to new diseases.

> **"...with viral genetics, researchers can now follow the evolution of a virus at a molecular level and estimate its ability to infect large numbers of human beings.**

Until recently scientists' understanding of the process of disease emergence was poor. But with viral genetics, researchers can now follow the evolution of a virus at a molecular level and estimate its ability to infect large numbers of human beings.

Many infectious-disease experts believe widespread transmission of HIV/AIDS could have been prevented if the proper surveillance systems had been in place in the 1970s and 80s as the disease emerged. Nathan Wolfe, professor of epidemiology at the University of California, Los Angeles and the founder and director of the Global Viral Forecasting Initiative, says the failure of the "wait-and-respond" approach to HIV/AIDS and the lack of an early warning system cost millions of lives.

Wolfe's work on prediction of zoonosis emergence has shown that the global emergence of a zoonotic pathogen such as SARS or HIV/AIDS depends on three steps. First, the pathogen must be successfully transmitted between a wild reservoir and human beings or their domestic animals. Second, the pathogen must be directly transmitted between humans. Finally, the pathogen must move from a local epidemic into the global population.

"We work with bushmeat hunters and other people who [often come into contact with] wild animals because these people are highly exposed to viral agents that could be emerging diseases", said Wolfe. "We also look at animal die-offs as important indicators of an emerging disease."

According to Wolfe, samples from human beings in close contact with animals can reveal patterns of viral chatter, where viruses bubbling up in animal populations are constantly crossing into human populations. "These viruses are pinging humans, or chattering. In the same way we monitor cellphone conversations for key words, we are monitoring viral chatter, and looking for viruses that

The printed journal includes an image merely for illustration

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A web-based initiative helped to disseminate inital reports of SARS

are transmissible and cause disease", said Wolfe. "Not all of the chatter will be real; we'll have to understand patterns of chatter to improve our ability to predict a pandemic. "

As scientists like Wolfe gather samples from human beings on potentially threatening new viruses, other scientists interested in emerging infectious diseases are trying to cull data gathered by wildlife biologists and veterinarians on zoonoses.

The Wild Bird Global Avian Influenza Network for Surveillance (GAINS) is a mapping and data sharing initiative of the Wildlife Conservation Society with partners in 34 countries. The project was launched during the avian influenza scare in 2006 and currently has over 100 million birds with their Global Positioning System [GPS] locations logged into the system, along with other relevant data. "We can't begin to predict and prevent until we have information on what's going on and where", said William Karesh, vice president for global-health programmes at the Wildlife Conservation Society. "The information has to be readily available so that people can look in the right place."

Although data are currently available only for wild birds, GAINS has the technological capacity to make data for other animal species available in the future. GAINS also counts on an unusual relationship with scientists—that they will share their data before they are published in a journal in hopes that they will be useful to other researchers interested in or working on similar issues.

With systems like GAINS and other resources, the world took one step closer to anticipating the potential of avian flu to become a pandemic. "Avian influenza helped a lot of people get mobilised but so far it is a relatively isolated event", said Rijsberman. "We would like to use some of the tools developed for avian flu for other emerging infectious diseases."

What Rijsberman foresees is a broad, international community of people bringing data together to build early warning systems covering various diseases. Thus far, most of the scientific and surveillance effort has focused on developed countries from where the next emerging infectious disease is least likely to originate.

Several web-based tracking initiatives are attempting to broaden the scope of available information on outbreaks and emerging diseases by culling information from news reports around the world. The best developed of these initiatives are HealthMap, ProMED-mail, and the Public Health Agency of Canada's Global Public Health Intelligence Network (GPHIN). GPHIN helped establish the credibility and need for online tracking systems when it helped to capture and disseminate initial reports of SARS in China.

HealthMap is a free, web-based program that searches news and other non-traditional or informal web information sources to assist and publicise early outbreaks using Google Maps. John Brownstein, co-creator of HealthMap and an assistant professor of paediatrics at Harvard Medical School, says HealthMap is one of the few systems tracking outbreaks in real time with respect to when news gets posted, whereas official government sites usually confirm outbreaks before posting them online.

One of the challenges for HealthMap is filling in the gaps between what is happening on the ground in disease hot spots and what information is making it into the news. HealthMap says it is on the cusp of integrating text messages into its system as cellphone usage is increasing at a more dramatic pace than is internet use. "As we roll out the system eventually we want to build in ways to allow anyone to input information", said Brownstein.

Clark Freifeld, co-creator of HealthMap, says HealthMap is also looking at ways to build in data from scientists like Wolfe and those who are contributing to GAINS. "We are building up a database of infectious disease reports, which we will catalogue in a way to look at different pathogens" he said.

ProMED-mail is one key source of relevant news reports for HealthMap and another web-based surveillance system that is helping to monitor disease emergence. The service is daily report, monitored and edited by public health experts affiliated with the International Society for Infectious Diseases.

Although HealthMap and ProMED-mail are the free, multilingual programs accessible to anyone, GPHIN is available by subscription only and is limited to officials and institutions that are involved in public-health surveillance.

As existing systems for disease surveillance develop and integrate, Google.org is looking at creating new ways to share information globally using the internet. "We would love to see something like an eBay or a virtual marketplace for samples where demand, supply, and knowledge would come together, where people doing research on diseases in Africa collaborate with sites in Asia", said Rijsberman. "The current systems are very far behind the power of the internet, and Google has the ability to build new platforms for researchers. In a couple of years we could see real concrete outputs that allow us to predict and prevent in new ways."

Eliza Barclay