Preventing the next pandemic: the power of a global viral surveillance network

Dennis Carroll and colleagues call for a global early warning system to detect viruses with pandemic potential

The covid-19 pandemic has exposed failures to respond effectively to the emergence of a highly contagious and lethal microbial threat. Covid-19, however, is not the first pandemic this century due to an emergent pathogen and is unlikely to be the last. Over the past 20 years a number of high impact pathogens have emerged or re-emerged, such as three new coronaviruses—namely, severe acute respiratory syndrome (SARS) in 2003; Middle East respiratory syndrome (MERS) in 2012; and the current covid-19 pandemic (SARS-CoV-2). We have also seen several highly pathogenic influenza A viruses (eg, H5N1 in 2003; H7N9 in 2013; and the H1N1 pandemic in 2009), the Zika virus in 2016, and the continuing rise and spread of Ebola in West and Central Africa since 2013. All these pathogens have jumped from transmission among non-human animals to transmission among humans. During this century, the frequency of epidemics and pandemics might continue to increase, driven mainly by demographic trends, such as urbanisation, environmental degradation, climate change, persistent social and economic inequalities, and globalised trade and travel.1-3

Current systems are not equipped to deal with pandemics

Past epidemics with pandemic potential were mainly identified through an unusual cluster of severe cases or deaths in humans. This means of identification is weak, and is often missed by classic surveillance systems. Estimates suggest that 1.7 million viruses exist across 25 high consequence viral families, of which 500 000-700 000 are likely to be zoonotic. Few viruses are likely to have the ability to infect humans and even fewer the ability to spread.4 Even if the likelihood of spreading is low, the impact, as illustrated by the covid-19 pandemic, might be disastrous and justifies investment in systems that can prevent such events.

Attempts to strengthen global health security over the past decade have been welcomed, but existing capacities, processes, and institutional arrangements, such as the International Health Regulations5 and the Global Health Security Agenda,6 have been insufficient to prevent events such as those caused by SARS-CoV-2. The experience of the covid-19 pandemic underlines the need to create global strategies, policies, and regulatory frameworks that deal directly with the multisectoral aspects of disease emergence and improve our collective ability to prevent, rapidly detect, and respond to threats.

In addition to strengthening existing health systems, key to these efforts is building a surveillance system that spans wildlife, livestock, and human populations.7,8 Such a system would use known geographical “hot spots”9 10 for early detection of any viral transfer into human and livestock populations, and pre-emptively disrupt further transmission of the virus locally.11 Pre-emptive action would contribute to an enhanced ability to forecast future threats and enable early intervention.

Examples of global syndromic and viral surveillance systems

Much can be learnt from ongoing surveillance systems.11 For example, the global early warning and response system is a formalised monitoring and reporting platform for outbreaks of disease, established in 2006 by the World Health Organization, the Food and Agriculture Organization (FAO), and the World Organization for Animal Health (OIE).12 This early warning system aims to combine the strengths of three organisations to enhance a public and animal health early warning system intended to reduce the incidence and effects of emerging infectious diseases in animals and humans. Partners from all over the world working in the animal and public health sectors share real time information on disease outbreaks; conduct rapid cross-sectoral risk assessments; and support the forecasting, prevention, and control of emerging diseases. In addition, for over 50 years, WHO’s global influenza surveillance and response system has been monitoring the evolution of influenza viruses to inform the development of the annual influenza vaccine, and to serve as a global alert mechanism for the emergence of influenza viruses with pandemic potential.13 This system with its national, regional, and global partners identifies and analyses influenza strains isolated from clinical specimens and conducts detailed characterisation of unusual virus isolates. This information and the web based data reporting and mapping system FluNet14 provide information on circulating seasonal influenza viruses. FluNet is further supported by WHO FluID, a global platform for data sharing that integrates regional influenza epidemiological data into a global database.15 The 2009 H1N1 pandemic showed that real time monitoring for viruses without information on the severity and impact of
the disease was inadequate for mitigating the effects on health of an epidemic. Therefore, from 2009, most influenza surveillance systems around the world started to include standardised case definitions for influenza-like illnesses and severe acute respiratory influenza, and real time modelling. Similarly, OFFLU, the name of the OIE/FAO network of expertise on animal influenza, was established in 2005 to collaborate with the existing WHO influenza network.18 OFFLU promotes the collection, exchange, and characterisation of animal influenza viruses within the network and the sharing of such information more widely.

These collaborations are important examples of current surveillance operations, but nearly all are event based, syndromic in nature, or focused on a single pathogen. For example, the scope of the global early warning and response system concentrates on early detection of disease outbreaks and does not monitor the detection of emerging pathogens in animals and humans. The global influenza surveillance and response system and OFFLU are excellent examples of robust, multisectoral global viral surveillance systems, but they focus mainly on influenzas. In these systems, pathogens are predominantly detected and isolated from outbreaks. Apart from the West Nile virus and other arbovirus surveillance activities,19 no formal system is in place in any country that routinely conducts active viral surveillance in humans and domestic animals combined with rapid clinical assessment for a list of priority emerging and re-emerging viral diseases.20

The time for building a sustained, multisectoral global viral surveillance network is now

The magnitude of the health and socioeconomic effects of the covid-19 crisis reinforces the need to establish a formal global surveillance network specifically to prevent pandemics. Such a network would conduct viral surveillance for the early detection of spillover from wildlife to livestock and humans well before development into localised outbreaks, and thus pre-empt high consequence epidemics and pandemics. Although such a formal network has never been set up, it would not necessarily constitute an entirely new undertaking. Rather, it would build on existing multisectoral surveillance operations, leveraging the systems and capacities that are already operational. These operations would be aligned through the adoption of standardised protocols and a commitment to data sharing to inform a global database.

The network’s focus on strategic sampling in wild animals, humans, and their livestock in predefined hotspot regions10 11 would preclude the need to conduct viral surveillance worldwide. In practice, the latest diagnostic technologies would be required to detect early spillover in real time and to test samples for many viruses from priority pandemic viral families, and other new viruses originating from wild animals. In parallel, a globally agreed protocol and decision support tool would be needed to ensure the elimination of new viruses from infected humans and animals as soon as they were discovered. Technically, such an approach is feasible with rapidly evolving multiplex diagnostic methods and affordable next generation DNA sequencing technologies that enable a generic approach to virus identification, without a priori knowledge of the targeted pathogens, delivering a species/strain-specific result.21

A global viral surveillance network would become more efficient in detecting early viral spreading into humans as new genetic data of zoonotic viruses in wild animals from viral discovery projects, such as the Global Virome Project,4 and associated metadata, are deposited in global databases. These data could also contribute to improved diagnostic reagents and their use through new, and more widely available, cost effective pathogen detection and sequencing devices. The targeting of proposed viral surveillance would also be enhanced with the refinement of current hotspots. These analytics, combined with bioinformatic tools, artificial intelligence, and big data, would help to prevent pandemics by progressively strengthening the capacity of a global surveillance system to improve infection and transmission dynamic models and forecast.

Establishing such a network for longitudinal surveillance has considerable challenges, particularly in under-resourced, hotspot regions, where basic health and laboratory capacities are weak. Technical and logistical challenges exist in designing sampling frames for viral surveillance, establishing mechanisms for information sharing about rare spillover events, training a skilled workforce, and ensuring infrastructural support across public and animal health sectors for the collection of biological samples, transportation, and laboratory testing. A regulatory and legislative framework would be necessary to deal with the challenges of handling, standardisation, analysis, and sharing of large volumes of multidimensional data.

A formal surveillance network would also require its own governance mechanism and membership of public and private sector organisations, similar to the Global Alliance for Vaccines and Immunisation. It should also be fully aligned with existing United Nations structures, such as the FAO/OIE/WHO.22 To ensure long term sustainability of the network, innovative financing strategies, such as a combination of endowment, grants, and contributions from financing institutions, member countries, and the private sector, will be needed. These investments should also be linked to incentives, especially for the global south, including technology transfer, capacity development, and the equitable sharing of information about new viruses detected through the global surveillance programme.23 24

The approach we describe is fundamentally different in scope and scale from syndromic, passive, or single pathogen surveillance from disease outbreaks, requiring the collaboration of multiple sectors and a strong political commitment from most countries in the global north and south. Although an integrated surveillance system is critical, ultimately, a multipronged, multisectoral approach will be necessary to prevent zoonotic transmission. Efforts must focus on dealing with the root causes of spread, reducing risky practices, improving livestock production systems, and enhancing biosecurity along the animal food chain.25 26 At the same time the development of innovative diagnostics, vaccines25 26 and therapeutic agents must continue.

The world is now well aware of the devastating health and socioeconomic impacts of the covid-19 pandemic. We have an opportunity to leverage political and financial support to establish and implement a global early warning surveillance network to deal with emerging threats in a sustainable way.23 24 Coordination among international agencies, relevant national and regional partners across sectors, and financing institutions will be essential for the progress of such an important global initiative.

Contributors and sources: DC developed the original concept, designed the outline of the paper, and generated the first draft. SM, SB, CKJ, DM, KS, OT, and SW reviewed the draft manuscript, made critical intellectual inputs, and suggested changes to the concept and design of the paper. DC and SM

DOI: 10.1136/bmj.m485 | BMJ 2021;372:m485 | the bmj
COVID-19: THE ROAD TO EQUITY AND SOLIDARITY

This is an Open Access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: http://creativecommons.org/licenses/by-nc/4.0/.

OPEN ACCESS

1 Woolhouse MEJ, Gowtage-Sequeria S. Host range and emerging and reemerging pathogens. Emerg Infect Dis 2005;11:1842-7. doi: 10.3201/eid1112.050997
2 Patz JA, Epstein PR, Burke TA, Balbus JM. Global climate change and emerging infectious diseases. JAMA 1996;275:317-23. doi: 10.1001/jama.1996.0353070057032
3 Semenza JC, Suk JE. Vector-borne diseases and climate change: a European perspective. FEMS Microbiol Lett 2018;365. doi: 10.1093/femsle/fnx244.
4 Carroll D, Daszak P, Wolfe ND, et al. The global virome project. Science 2018;359:872-4. doi: 10.1126/science.aap7463
5 World Health Organization. Strengthening health security by implementing the International Health Regulations. 2005. https://www.who.int/ith/about/en/
6 Wolicki SB, Nuzzo JB, Blazes DL, Pitts DL, Iskander JK, Tappero JW. Public health surveillance: at the core of the Global Health Security Agenda. Health Secur 2016;14:185-8. doi: 10.1089/hs.2016.0002.
7 People P, Planet O. The economics of One Health. World Bank, 2012.
8 Zinsstag J, Crump L, Schelling E, et al. Climate change and emerging micropathogens. FEMS Microbiol Lett 2018;365:fny085. doi: 10.1093/femsle/fny085
9 Zinsstag J, Utzinger J, Probst-Hensch N, Shan L, Zhou XN. Towards integrated surveillance-response systems for the prevention of future pandemics. Infect Dis Poverty 2020;9:140. doi: 10.1186/s40249-020-00757-5
10 Jones KE, Patel NG, Levy MA, et al. Global trends in emerging infectious diseases. Nature 2008;451:806-11. doi: 10.1038/nature06636
11 Allen T, Murray KA, Zambrana-Torrelo C, et al. Global hotspots and correlates of emerging zoonotic diseases. Nat Commun 2017;8:1124. doi: 10.1038/s41467-017-00923-8
12 Kreuder Johnson C, Kitchens PL, Smiley Evans T, et al. Spillover and pandemic properties of zoonotic viruses with high host plasticity. Sci Rep 2015;5:14830. doi: 10.1038/srep14830
13 Morse SS. Global infectious disease surveillance and health intelligence. Health Aff (Millwood) 2007;26:1069-77. doi: 10.1377/hlthaff.26.4.1069
14 FAO-OIE-WHO Global early warning and response system for major animal diseases, including zoonoses. 2006. https://www.who.int/zoonoses/outbreaks/glwes/en/
15 Ziegler T, Manahil A, Cox NJ. 65 years of influenza surveillance by a World Health Organization–coordinated global network. Influenza Other Respir Viruses 2018;12:558-65. doi: 10.1111/irv.12570
16 FluNet. https://www.who.int/influenza/surveillance_monitoring/flu/en/
17 WHO. Fluid—a global influenza epidemiological data sharing platform. https://www.who.int/influenza/surveillance_monitoring/flu/en/
18 Edwards S. OFLU network on avian influenza. Emerg Infect Dis 2006;12:1287-8. doi: 10.3201/eid1208.060380
19 Patenoster G, Babo Martins S, Mattivi A, et al. Economics of One Health: costs and benefits of integrated West Nile virus surveillance in Emilia-Romagna. PLoS One 2017;12:e0188156. doi:10.1371/journal.pone.0188156
20 WHO. 2018 annual review of diseases prioritized under the research and development blueprint. 2018. https://www.who.int/docs/default-source/blue-print/2018-annual-review-of-diseases-prioritized-under-the-research-and-development-blueprint.pdf?sfvrsn=4c22e36_-2
21 Gardy JL, Loman NJ. Towards a genomics-informed, real-time, global pathogen surveillance system. Nat Rev Genet 2018;19:9-20. doi: 10.1038/nrg.2017.88
22 FAO-OIE-WHO Collaboration. Sharing responsibilities and coordinating global activities to address health risks at the animal-human-ecosystems interfaces. A trilateral concept note. 2017. http://www.who.int/foodsafety/zoonoses/final_concept_note_Hanoi.pdf?ua=1
23 Cameron D. We need a new international body to sound the alarm earlier. Times, 2020 Jun 24. https://www.thetimes.co.uk/article/david-cameron-we-need-a-new-international-body-to-sound-the-alarm-earlier-2wwkxc3ml
24 Krofah E, Schneeerman K. Lessons learned from covid-19: are there silver linings for biomedical innovation? 2021. https://milkeninstitute.org/sites/default/files/reports-pdf/MilSivNetInn_GuidingPrinciples_2021-12-01.pdf
25 Zinsstag J, Schelling E, Wyss K, Mahamat MB. Potential of cooperation between human and animal health to strengthen health systems. Lancet 2005;366:2142-3. doi: 10.1016/S0140-6736(05)67731-8
26 Douglass D, Christodoulou M, Plotkin SA, Hatchett R. CEPI: Driving progress toward epidemic preparedness and response. Epidemiol Rev 2019;41:28-33. doi: 10.1093/epirev/mxz012

Cite this as: BMJ 2021;372:n485
http://dx.doi.org/10.1136/bmj.n485