Zoonosis

Quest reports on pathogens that jump the species barrier

The scientific consensus is that SARS-CoV-2, the coronavirus responsible for the COVID-19 pandemic, probably originated in bats. Less clear at present is how it 'jumped' to humans. It's likely that an intermediate host was involved, the initial suspects being snakes or pangolins, both of which are traded in the 'wet markets' of Wuhan, China, where COVID-19 was first detected.

When the earlier Severe Acute Respiratory Syndrome (SARS) outbreak occurred in China in late 2002, the disease was linked to palm civets. These animals, from the same family as genets, are also sold in markets and eaten as a delicacy in China. A few years later, it was realised that civets were an intermediate host, but horseshoe bats probably serve as the reservoir of the virus. Likewise, Middle East Respiratory Syndrome (MERS) – first identified in Saudi Arabia in 2012 but with ongoing sporadic outbreaks – is known to be passed to humans from camels, but genetic analysis has indicated that the virus originated in bats and was transmitted to camels sometime in the distant past.

All of these viruses are coronaviruses, but bats are also known to harbour other kinds of viruses that cause diseases in humans and the animals they keep. As a result, bats have become the subject of intense research effort by virologists around the world, as well as in South Africa. Stellenbosch University, for example, has awarded two PhDs on the subject, with Ndapewa Ithete having investigated viruses in bats, rodents and shrews for her thesis, completed in 2013, while Nadine Cronjé focused in on coronaviruses in southern African bat populations for her study, which she finished in 2017.

But it is the University of Pretoria that has been producing much of the research output in recent years, under the leadership of Prof. Wendy Markotter. She not only occupies the DST-NRF South African Research Chair in 'Infectious Diseases of Animals (Zoonoses)', but is the Director of the university's Centre for Viral Zoonoses, established in 2016 to strengthen collaboration between researchers in the

A zoonosis (plural: zoonoses) is any disease or infection that can be transmitted from vertebrate animals to humans. A zoonotic agent may be a bacterium, virus, fungus or parasite. Sometimes an invertebrate vector may be involved, as when a tick carries *Rickettsia africae* bacteria from cattle or wildlife to people, potentially causing African tick bite fever. Nearly 75% of all new human diseases are zoonoses, and the threat is growing due to drivers such as human encroachment into natural areas, habitat destruction, agricultural intensification, the wildlife trade, climate change and globalisation.

Oleksander Zakletskiy, CC BY 4.0

Bats perform vital ecosystem services such as pollination, seed dispersal and pest control, but they are also natural reservoirs for a variety of viruses.

three faculties of Health Sciences, Natural and Agricultural Sciences, and Veterinary Science. Prof. Markotter also heads the centre's Biosurveillance and Ecology of Emerging Zoonoses (BEEZ) research group. Apart from collecting data on pathogen presence in bats and other small mammals in various African countries, the BEEZ group studies host ecology and environmental factors so that the conditions leading to 'spillover' from these animals to people can be determined.

Many zoonotic diseases are endemic in certain regions, where they represent an ongoing threat to people. These include rabies, Rift Valley Fever, tick bite fever, sleeping sickness, leptospirosis, brucellosis and bovine tuberculosis, among many others. New zoonotic diseases – such as COVID-19, avian influenzas and the Zika virus – are referred to as 'emerging'. The World Health Organisation (WHO), the United Nations Food and Agriculture Organisation (FAO) and the World Organisation for Animal Health (OIE) agreed in 2004 on the following definition: "An emerging zoonosis is a zoonosis that is newly recognised or newly evolved, or that has occurred previously but shows an increase in incidence or expansion in geographical, host or vector range".

In 2009, during the H1N1 influenza ('swine flu') pandemic that started in the United States and spread around the world, the United States Agency for International Development (USAID) launched its Emerging Pandemic Threats (EPT) programme to pre-empt or combat other diseases that could cause future pandemics. In the initial phase, the programme sought to build capacity in 20 countries around the world, with technical assistance from the US Centres for Disease Control and Prevention (CDC). It consisted of four projects:

- PREDICT focused on the detection and discovery of zoonotic diseases at the wildlife–human interface,
- PREVENT focused on characterising risks associated with disease transmission between animals and people, and developing risk-mitigation strategies,
- IDENTIFY focused on strengthening laboratory capacity to safely diagnose and report common animal and human pathogens, and was implemented by the WHO/FAO/OIE alliance,
- RESPOND focused on pre-service workforce training, and strengthening outbreak response capacity.

In 2014 the EPT programme was renewed for a second five-year phase, and the PREDICT project along with it. It was due to cease in March 2020, but following press coverage and political lobbying after COVID-19 had been declared a pandemic, the project was given a six-month extension to provide emergency support to other countries for outbreak response, including technical support for early detection of SARS-CoV-2. During its 10-year lifespan, PREDICT-associated researchers had detected almost 1 000 novel viruses (i.e. 'new' viruses that had not previously been identified), including over 100 coronaviruses and an ebolavirus. They had also sampled some 130 000 animals, mostly bats, and strengthened laboratory systems in more than 60 labs around the world.

The PREDICT project was led by the One Health Institute of the University of California, Davis, School of Veterinary Medicine, which USAID has now awarded a five-year project called One Health Workforce – Next Generation. It will expand upon the One Health Workforce project led by the University of Minnesota during the second phase of the EPT programme, providing training in selected countries to build capacity relating to disease threats using a One Health approach.

The USAID's Emerging Pandemics Threat programme provided training in laboratory techniques for virus detection in a number of countries in Africa.

So what exactly is One Health? The CDC describes it as a collaborative, multisectoral and transdisciplinary approach – working at the local, regional, national and global levels – with the goal of achieving optimal health outcomes, recognising the interconnection between people, animals, plants and their shared environment.

South Africa was not one of the African countries selected for intervention as part of the EPT programme, because it was already benefiting from such training and capacity-building initiatives through the CDC, which had established an office here in 1995 to assist with HIV and TB programmes. A decade later, the need to help strengthen surveillance, laboratory and workforce capacity for influenza and other epidemics was recognised, so a number of additional initiatives were rolled out over time.

For example, the South African Field Epidemiology Training Programme (SAFETP) was introduced from 2007 and continues to this day, with an average of 10 candidates per year being accepted for the two-year, full-time residency. It began as a collaboration between the CDC and the National Department of Health, the National Institute of Communicable Diseases (NICD) and the University of Pretoria, but Wits University is now involved too.

In July 2010, South Africa was selected by the CDC to be one of the 10 countries in which it would establish a Global Disease Detection Regional Centre. The South Africa Regional Global Disease Detection Centre (SARGDDC) was set up in partnership with the NICD, which is a division of the National Health Laboratory Service (NHLS). Funding and technical assistance to strengthen laboratory and surveillance systems was provided through the CDC's International Emerging Infections Programme.

In 2014 a One Health programme was initiated at SARGDDC, with a major focus on the expansion of zoonotic disease surveillance. The programme's director was Prof. Marietjie Venter, who had worked on zoonotic viruses at the NICD before joining the University of Pretoria in 2005. In 2016 she returned to the university to head the Zoonotic Arbo- and Respiratory Virus (ZARV) research group in the newly established Centre for Viral Zoonoses.

Meanwhile, by 2012 the NICD had established the Centre for Emerging Zoonotic and Parasitic Diseases (CEZPD) by amalgamating six former sections. Headed by Prof. Janusz Paweska, the CEZPD has a strong track record in the diagnosis, surveillance and research of pathogens of public health importance. Members of the team have been involved in much of the aforementioned research on viruses in bats, and have participated in Ebola, Marburg and Rift Valley Fever outbreak responses elsewhere in Africa. They are now heavily engaged in SARS-CoV-2 work that will facilitate development of diagnostics, vaccines, molecular epidemiology and clinico-pathological studies.

- Watch this explainer video for more information: https://ed.ted.com/lessons/how-do-viruses-jump-from-animals-to-humans-ben-longdon

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