

## The future of biosecurity in Australia

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I was assigned the task of talking about biosecurity, and biosecurity, it turns out, is an extremely broad term that can be used in a wide variety of ways so I'm just going to use it in the context of, as Brian notes, infectious diseases, particularly on what Australia may need to do to prevent and respond to future epidemics.

### SARS and other 'flu-like respiratory viruses

If you wind the clock back just a few years, you all remember the SARS outbreak of 2003. The numbers of people infected were not actually that great: overall globally about 8,000 people were infected. To put SARS in context, 'flu may infect millions every year, so 8,000 infected and about 800 died is not large, but even so it cost about \$40 billion globally. Nonetheless, the consensus is that we dodged a bullet with SARS. SARS is extremely dangerous and if the world hadn't pulled together as well as it did, it could have been a very, very scary epidemic because the mortality rate is 10 per cent, which is high.

Australia in fact got very lucky. What happened in 2003 is that a businessman from Guangdong got ill. He went to Hong Kong, where he basically vomited all over his hotel floor. People on that floor went to the airport, they went to Singapore and from Singapore they flew to Canada and to Germany. No-one got on a flight to Sydney or Melbourne, but that could have happened.

If it had come here, who knows what would have happened. SARS was a major warning shock.

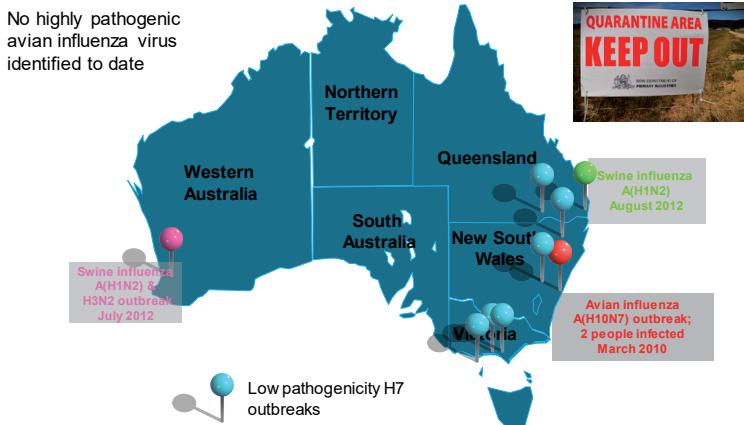
At the same time as these human outbreaks, our cultural systems face a very major threat too. Exactly at the same time as SARS, in the Netherlands there was an outbreak (which I'm sure you haven't heard about) of H7N7 influenza, a very nasty, highly virulent H7 strain of avian 'flu. This was completely concurrent with the SARS outbreak. The Dutch authorities were so scared about this that they basically went through a mass culling operation of chickens in Holland to eliminate the virus. They killed 30 million chickens: a third of the Dutch poultry industry was just wiped out in one go. They basically took these chicken barns, taped them up and gassed them, they were so worried about this virus. 89 people were infected by that virus, basically people involved in the control, and one person died.

These respiratory viruses circle the world and they will hit Australia. We will get them, we are at risk from 'flu — I'll keep coming back to 'flu. I sleep pretty well at night but if there's one thing that I do get worried about slightly it is still influenza. because it's a silent carrier. You don't know you're infected. By the time you've got off the train the bus, or the plane, you've infected somebody else. It is kind of a nerve-racking thing. So Australia is often exposed to 'flu. Every year or so our country experiences an exotic 'flu strain that

comes in that infects our poultry industry or our pig industry and of course the more centralised those industries are, the easier it is for a pathogen to spread quickly and cause a big outbreak. The figure shows some

of the strains of 'flu that have hit Australia in the last decade or so. Luckily these are all low pathogenic strains, which means they're quite mild, there's no real mass culling.

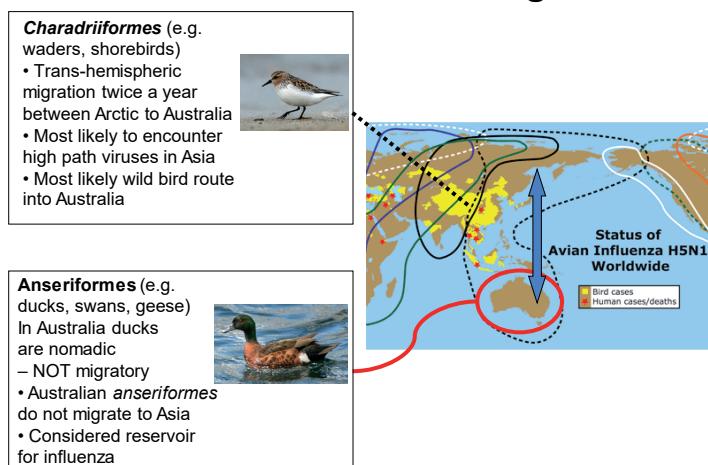
### Exotic Influenza Virus Outbreaks in Australia



To date, no very, very virulent strain of 'flu has hit Australia. We have been very lucky, and the H7N7 strain hasn't got here yet, but it could happen. We have very good biosecurity, we have very strong quarantine laws, but they may not stop the incursion. One reason for this, of course, is that the 'flu virus is basically a bird virus, and Australia is remarkably

ecologically diverse: about 10 per cent of the world's bird populations live in Australia. We are on a flight path that birds take every year and birds will fly north and south. The arrow in the figure is a flyway, the Australian east-Asian flyway, and birds will fly up and down that as they migrate every year.

### Avian Influenza and Bird Migration



Globally, two sets of birds carry 'flu viruses. One is Anseriformes (kind of duck-like things). They're not migratory, they're reservoirs for the virus. If you go and sample a duck in the wild, about 10 per cent of them carry 'flu naturally, so they're reservoirs. The other is Charadriiformes (waterbirds, shorebirds, waders) that take these long migrations from Asia into Australia, actually from Antarctica to Asia, and they can bring a virus with them. So we are continually exposed to these strains and they could cause an outbreak. So that's 'flu.

### Mosquito-borne diseases

But it's not just 'flu — you're getting scared now — that's a worry. We've also had an increase in the number of mosquito-borne diseases and, as climate change continues, as places get hotter and warmer, there will be more mosquitoes and there will be more mosquito-borne disease. It will happen. It's inevitable. For example, in Australia we have two or three native mosquito viruses that cause human illness: Ross River and Barmah Forest, and there are a few thousand cases every year. Occasionally people get a very serious thing called Murray Valley encephalitis, that can be fatal. Northern Queensland has had historic outbreaks of dengue, which again occasionally can be fixed. Not so much, it's controlled there now but it can happen.

There are also outbreaks of mosquito-borne diseases in cattle and livestock that are important to farmers and on our doorstep, in the region, we have viruses like Chikungunya and Zika, which are just off the coast of northern Australia, which could easily cause incursions. That's a threat to us.

### Plant pathogens

It's not just animals and humans, plants and our agricultural systems are also under threat from exotic pathogens. The figure from Robert Park shows work on stem rust, which are fungi. Robert Park is the global expert on this but these fungi come in every so often and they can cause very nasty outbreaks on cereal crops. Every few years there's an exotic incursion of these stem rusts into Australia that can cause really profound economic damage to our agriculture industries. There's also myrtle rust, you may have heard of, that's come in and that's now spreading on eucalyptus plants and other Myrtaceous plants across the eastern seaboard too — another fungal pathogen.

### Australia's biodiversity crisis

These pathogens are going to arrive, it is inevitable. So that's going to impact on many aspects of the way we live in Australia, including the biodiversity in this country. Australia has an absolutely miserable record in dealing with biodiversity. Australia's classified as a megadiverse country: we have more species of plants and animals than any other developed country. Most of what we have here is also endemic. Some numbers you see in the figure: 87 per cent of the mammals in Australia are endemic and 90 per cent of the reptiles are endemic. As I mentioned earlier, 10 per cent of bird species globally are found in Australia, yet our extinction rate for those animals is terrible. It's actually the highest of any country. So, 30 native mammals have gone extinct since Europeans arrived. That's one in three extinctions of mammals globally have occurred in this country in the last 400 years. That's partly human activity and it's also in part because pathogens come in and we bring them in on exotic systems.

## Australia's Biodiversity Crisis

- Australia is “megadiverse” and home to more species than any other developed country.
- Most of Australia’s wildlife is found nowhere else: 87% of mammal species and 93% of reptiles are found only in Australia.
- Australia has the **worst mammal extinction rate in the world**: 30 native mammals have become extinct since European settlement: 1 out of 3 mammal extinctions in the last 400 years have occurred in Australia.
- More than 1,700 species of animals and plants are at risk of extinction.
- Feral cats kill an estimated 75 million native animals every night across Australia.

### Detection and Circulation of a Novel Rabbit Hemorrhagic Disease Virus in Australia

Jackie E. Maher, Andrew J. Read, Xingjian Gu, Nadya Urakovska, Roslyn Meurant, Melissa Piper, Stephanie Haboury, Edward C. Holmes, Tanja Strive, Robyn N. Hall

### European Rabbits



- *Continent-wide spread began in 1859 by the introduction of 18-24 wild rabbits for hunting near Geelong.*
- *Probably >1 billion rabbits by 1950.*
- *Enormous economic and ecological consequences.*

The Australian government estimates that something like 700 species of plants and animals are at risk of extinction and it’s one staggering statistic of what has happened that feral cats kill an estimated 75 million native animals every single day. The number sounds unbelievable but I can tell you where it comes from. There are 4 million feral cats in Australia and every day they kill between five and 30 native animals. So 75 million is a kind of ballpark estimate. It’s a staggering thing. Although Australia may have been lucky for some of the humans living here, for the animals it’s definitely not been that lucky at all.

I’ll just give you one little example of this miserable state of biodiversity and it’s one that I’ve worked on myself for many years now: European rabbits. This is an extraordinary story. Rabbits were first brought into Australia successfully in 1859, when 24 were imported in Bowen Park near Geelong. By 1950 there were probably more than a billion. They literally bred like rabbits and it’s the

single biggest vertebrate population expansion in history. Just extraordinary. Virgin soil, no predators, explosion. You can imagine the kind of enormous economic and ecological consequences it’s had. So these kinds of feral invasions are terrible and they’re going on. Sadly, science has one view and governments have different views: now there’s very, very strong evidence that we should cull the brumbies to a certain level because they are destroying the natural environment<sup>1</sup> but policy won’t have it and it’s nonsense.

### Global problem, local threat

You reply that we have great quarantine and we’re safe, but actually it’s not true. New things are coming in all the time. I work on viruses and just in the last couple of years a novel rabbit virus has entered Australia, which means either a rabbit has got in somehow or someone’s been to a rabbitry, somewhere else in the world, and brought that in, which is quite extraordinary, and that’s now

<sup>1</sup> Including Canberra’s water catchment — Ed.

spreading through Australia. That's not a bad thing because it's actually killing rabbits, but there it is anyway.

The way I like to think about this is that we have a global problem and the global problem is that we have lots of these emerging diseases, but there's a local threat to Australia in that we're not very good at managing them. I'll try and put some meat on that statement. Emerging diseases like 'flu, like SARS, are everywhere. You can go on the web, you can find lots of pictures just showing you lists of these, maps of the world showing what's emerging. In our area we have Hendra, we have Nipah, we have Ebola, Zika, all these sorts of things are there and they mainly come — this is a very important point — from a pathogen that's jumped from an animal to humans. Animals are the reservoir and they jump to us and cause disease and it could also go the other way. Humans also give their diseases to animals too, it's a two-way kind of traffic.

Of course that process is exemplified in the modern world by the extreme rapidity and intensity of human travel. Global flight paths show the amazing kind of carbon footprint on the world and how we move so quickly. Australia is very well connected now, so we know it's one stop from many, many countries. Of course, that's going to bring people and it's going to bring pathogens too. The global problem is we don't really understand exactly how these pathogens jump boundaries in emerging new species, that's a kind of global research question that I work on as my day job. How do these epidemics actually start?

## An Australian Centre for Disease Control

For the rest of my talk I'm going to focus on the local: Australia has no national organisation that's designed to combat emerging diseases. We have state levels, but there's no Federal system and we really need a national entity, a national body, that's going to help, like other countries do, that's going to try and prevent the threat of emerging disease. Also we can't just separate humans and animals, veterinary and medics, because they're one, unified — it's called One Health, the one unified framework because diseases pass in a very fluid manner.

A good example of how I think we can proceed can be found in China. China, in the last 15 years or so, has formed what's called a Centre for Disease Control, a CDC. It was set up directly after SARS because China got a kind of global hammering after SARS. They were accused of being slow in their response and not sharing data and, again, I think we dodged a bullet. So they set up this national disease framework across the whole country to respond to future outbreaks. I'll give you an example of how it works. In 2013 I was working in Xinjiang province in south-east China. I was out in the country and I was collecting samples from bats and other animals in this population. It's a very rural area and there were lots of chickens around; chickens and pigs are part of daily life in rural China.

While I was there, a very nasty virus called H7N9 emerged: it's in chickens and it spread to humans and it killed birds and it killed humans. The mortality rate in humans (when they're affected) is almost 50 per cent. It's a very, very nasty thing and it emerged in this province in China. Each town, each province, each city has a local CDC centre.

As the virus emerged in that village where I was, the local CDC officer wrote on the board in the village square, “We’re closing the live bird markets. They may have virus. Avoid chickens.” That response of the local CDC and others in China really dramatically damped down that outbreak and it didn’t get going. It really didn’t become a national or a global threat. The CDC did a great job.

We haven’t got that structure in Australia but we need it. It’s not just me who thinks there’s a pressing need for an Australian CDC, a national centre or focus that’s going to allow us to respond to control infectious diseases. The House of Representatives in 2013 published a document called Diseases Have No Borders, and they realised that there is this threat of emerging disease. I’ll just give you a few quotes now but they said in this report from 2013, “This committee is concerned that the lack of uniformity in infectious disease control and inadequate coordination between portfolio agencies and across all layers of government could potentially compromise Australia’s preparedness to respond to a nation-wide outbreak of infectious disease in the future,” and that kind of sums it up. We’re not quite prepared. We have State level, we don’t have a Federal system.

Another important body, the Australian Medical Association, in 2017 published a paper and their point number one was: “We call for an immediate establishment an Australian National Centre for Disease Control (CDC),” and they quote, “A CDC is urgently needed to provide national leadership and to coordinate rapid and effective public health responses to manage communicable disease and outbreaks. The current approach to disease threats and control of infectious diseases relies on disjointed State

and [Commonwealth] informal structures, informal networks, collaborations and the goodwill of public health and infectious disease physicians.” Quite correct. It’s informal, it’s ad hoc and I wouldn’t say it’s a shambles but it’s an accident waiting to happen. We have to get better. Despite these kinds of calls, the inertia against it appears to be people in Sydney don’t want it to be there; people in Melbourne want it to be in Sydney. No-one wants it in Canberra and no-one talks about the rest of the country and it appears to be a very weird realism, which I think we have to stop.

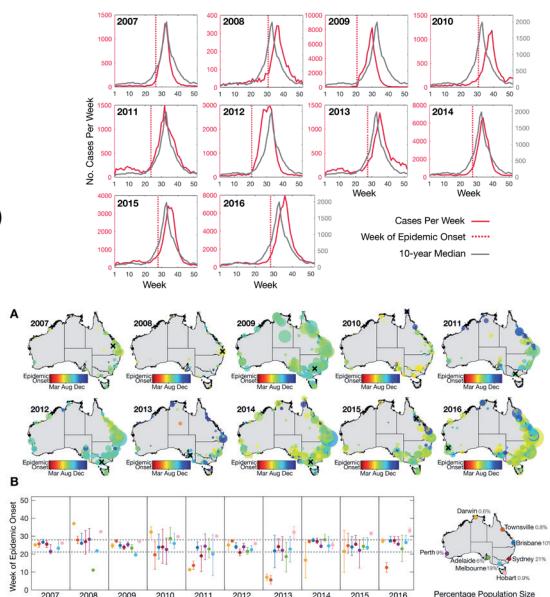
I just want to give you an example, going back to ’flu, which I work a lot on, why I think it’s really important. These are some data we got from looking at the instances of ’flu in Australia over a 10-year period. All these little graphs in the figure are when ’flu peaks every year in Australia. You see the peak is about week 32, that’s the second week of August, right, that’s when ’flu maximises its intensity in Australia. Now, the data we got to do that were lab-confirmed cases of ’flu. So people have been to a doctor, the doctor’s taken a sample and he’s tested it and it’s shown it’s ’flu and there’s almost half a million of those, but it took us almost a year to get those data. Each State and Territory has to sign off to give us that. We had to have an ethics approval for every single one. It’s an absolute madness. In the US you can download those data online.

I’ll just give you an idea of why we need this. The thing that came out from these data is that ’flu is extremely synchronised in Australia. Here we took samples of ’flu from these data from around the country, from Darwin, Townsville, Perth, Hobart, Sydney, and I’ve got that little plot in the bottom there, that’s when you see the onset

## Epidemiology of Influenza in Australia

- Lab-confirmed incidence data of >450,000 influenza cases from 2007-2016 (from the Australian National Notifiable Disease Surveillance System)  
 – very slow to access these data
- Seasonal influenza in Australia is **highly synchronized**

*Epidemic onset = timing of the break-point in influenza incidence*



of 'flu happening in each of those places. You can see how similar they are in time. If you look at 2009, that's swine 'flu, it's basically simultaneous. When you get a case of 'flu in Sydney, you've got one in Perth at the same time, more or less. So there's no lag time. It's not that a doctor in Sydney rings up Perth and says, "Oh, I've got a 'flu case. Be careful." It's already in Perth. It's already there. This kind of wait and watch approach dependent on the goodwill of people contacting each other is not going to work for something like 'flu that's so fluid. Instead we need to be very, very quick.

The good news is that although we haven't got a national focus, the tools we have now to respond and analyse these are remarkably good and remarkably powerful. Almost in real time we can sample species, that could be humans, we can sequence the disease, the pathogens, and do lots of clever evolutionary analysis to show where the things have come from, how they're spread and we can model it in real time, in a matter of days. So that

can be done. If we had a national focus we really could put this into action.

Just two quick examples of the technology now. It's so good you can now pretty much determine the cause of any new infection within 24 hours or so. A new novel disease, don't know what it is, the technology is so good with genome sequencing that the diagnosis we can do extremely rapidly. For example, there's lots of debate about whether tick-borne Lyme disease exists in Australia, particularly here in New South Wales. We can take people's tick bites and we can sample their tick bite and we can sequence and find out what bacteria or fungi Eukaryotes or viruses they have. We've done that across animals and people in New South Wales very, very quickly and it turns out there is no Lyme disease. You can go back and tell your friends it does not exist in Australia. These people are ill but they haven't got Lyme disease. We're now doing the same approach, we're going to work with Border Force and the Federal Police and the depart-

ments of agriculture to look at quarantined animals coming into Australia.

One other quick example: we've been looking at tularemia in Australia: this is a very nasty bacterial disease, and it's in animals. Again, it's an example of where you have animals and humans together, this is glandular tularemia, it's caused by something being bitten by a cat. We had a mass die off of possums in northern Sydney. We did lots of molecular work and it turns out the possums had tularemia too. In Australia, in suburban backyards the possums carry this very nasty bacterium that could spread to humans. That's kind of bad. The good news is the technology is there and we can detect that very quickly.

### Conclusion

Animals carry an enormous number of pathogens. The pathogens will jump boundaries. We will get new outbreaks, it's inevitable, particularly because of the way we live today. We have change in land use, we have deforestation. We live in megacities, such as Shanghai. International travel obviously and wars as well, wars and refugees. I worked in West Africa a few years ago, and the Ebola outbreak was fuelled by the war in Guinea, Sierra Leone and Liberia, that really made lots of displaced people who got ill. What we need to do to get better, we need that One Health framework, we need to think about humans and animal health in one context and, most of all, we need to build that national centre, that national CDC-like centre that's going to allow us to respond to human and animal disease very efficiently in the near future.

### References

- Australian Medical Association. Australian National Centre for Disease Control (CDC) – 2017. <https://ama.com.au/position-statement/australian-national-centre-disease-control-cdc-2017>
- Jiapeng Chen, Narayana M. Upadhyaya, Diana Ortiz, Jana Sperschneider, Feng Li, Clement Bouton, Susan Breen, Chongmei Dong, Bo Xu, Xiaoxiao Zhang, Rohit Mago, Kim Newell, Xiaodi Xia, Maud Bernoux, Jennifer M. Taylor, Brian Steffenson, Yue Jin, Peng Zhang, Kostya Kanyuka, Melania Figueroa, Jeffrey G. Ellis, Robert F. Park, Peter N. Dodds (2017). "Loss of *AvrSr50* by somatic exchange in stem rust leads to virulence for *Sr50* resistance in wheat," *Science* 22 Dec: Vol. 358, Issue 6370, pp. 1607–1610. DOI: 10.1126/science.aao4810
- Justin Jackson, Alistair McGregor, Louise Cooley, Jimmy Ng, Mitchell Brown, Chong Wei Ong, Catharine Darcy, and Vitali Sintchenko (2012), *Francisella tularensis* Subspecies *holarktica*, Tasmania, Australia, 2011 *Emerg. Infect. Dis.* Sep. 18(9): 1484–1486. doi: 10.3201/eid1809.111856
- Mahar JE, Read AJ, Gu X, Urakova N, Mourant R, Piper M, Haboury S, Holmes EC, Strive T, Hall RN. (2018) Detection and circulation of a novel rabbit hemorrhagic disease virus in Australia. *Emerg. Infect. Dis.* Jan; 24(1): 22–31. doi: 10.3201/eid2401.170412.
- The Standing Committee on Health and Ageing of the Australian House of Representatives (2013), *Diseases have no borders: Report on the inquiry into health issues across international borders*, Canberra, March. [https://www.aph.gov.au/Parliamentary\\_Business/Committees/House\\_of\\_Representatives\\_Committees?url=haa/internationalhealthissues/report.htm](https://www.aph.gov.au/Parliamentary_Business/Committees/House_of_Representatives_Committees?url=haa/internationalhealthissues/report.htm)

