Zoonoses

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The selection of papers included in this issue of *Microbiology Australia* present a broad brush of zoonotic diseases, from those known or described in ancient times such as rabies, first described in the Eshnunna cuneiform law tablets from ancient Mesopotamia dating back to the 18th–19th centuries BC[1], and glanders, thought to be first described in donkeys by Aristotle in Ancient Greece in 420–450 BC[2] and subsequently by the Romans[3], to some discovered or recognised as zoonotic within the past 30 years, such as the recently described zoonotic bat-borne pathogens in Australia, and *Clostridium difficile*, only recently recognised as a zoonotic pathogen. The selection of papers also demonstrates the wide range of zoonotic origins, including arthropod-borne viruses and potentially seafood-borne parasites.

More than 60% of human infectious diseases are caused by pathogens shared with wild or domestic animals[4], and over 75% of emerging diseases are zoonotic in origin. Over the past few decades, an increasing number of infectious diseases have jumped the species barrier from animals to humans to cause disease, and in many instances have subsequently spread regionally and/or globally. Most of these have been viruses jumping from wildlife to humans, as exemplified by HIV/AIDS in the 1980s originating from the great apes possibly as early as the 1920s[5]; Sin Nombre virus, recognised as a cause of hantavirus pulmonary syndrome in 1993, originating from the deer mouse (*Peromyscus maniculatus*)[6]; Nipah virus in 1998–99 originating from bats via pigs[7]; severe acute respiratory syndrome coronavirus (SARS-CoV) in 2002–03 originating from bats via civets[8,9]; Middle East respiratory syndrome coronavirus (MERS-CoV) in 2012 from dromedary camels, but probably originating from bats more than 30 years previously[10]; and currently, the novel coronavirus, SARS-CoV-2, almost certainly originating from bats and probably via an as yet unknown intermediary host, such as pangolins. Other important emerging diseases have jumped from domesticated species, such as pandemic influenza H1N1 originating from pigs in 2009.

What precipitates the cross-species jump, and what can be done to prevent or mitigate it? Much of the recent increase in the emergence and spread of zoonoses can be linked to environmental and societal changes that have brought people and wild and/or domesticated animals closer together, increasing the potential for cross-species transmission. Environmental factors and climate change are altering the habitats of animals or arthropod vectors of zoonoses, changing how and where they live. Anthropogenic factors have changed the interactions between humans and their domestic animals through intensive agriculture and altered land use; and with the need to seek meat for human consumption, there has been increased hunting of wild animals for bushmeat. As cities have expanded and new population centres emerged, there has been increasing encroachment into wildlife habitats. In addition, increased city living and expanding metropolitan areas are providing new homes for a variety of wildlife, from rats and mice to foxes, birds, fruit bats, wallabies, bandicoots, possums, and other small marsupials in Australia, which can live off the plentiful food supply we discard or which are available in parks and gardens, and in additional green areas[4,11]. In other countries, many local wildlife species are commonly making their homes in cities, including monkeys, squirrels, mongooses and raccoons. Underscoring this is that 'synanthropic' mammal species, those wildlife species that adapt well in human-modified environments, are 15 times more likely to be the source of emerging infectious diseases[12]. As pathogens evolve and emerge, transmission of zoonotic infections and outbreaks have occurred because of the everyday practices of people. This often involves the chain of activities in livestock production, such as intensive growing, breeding, transport, slaughter and sale of animals. In many countries, live ('wet') animal markets where several species of domestic or wild animals may be caged in close proximity have been the origins of zoonoses. The interactions of people with wildlife areas for recreational purposes such as hunting, hiking and camping, also lead to zoonotic transmission of pathogens.

Lessons should have been learnt from some of the emergent zoonoses over the past few decades, but despite major outbreaks

of disease, the memories and messages seem to fail to resonate. The outbreak of SARS in 2002–03 was clearly associated with transmission from live wild animals in the wet markets of Guangdong. Despite strong recommendations that these markets be stopped because of the risks they pose of potential human transmission, they continue to flourish selling poultry and wild and often exotic animals, often illegally (a temporary ban on the trade in wild animals was introduced from 26 January 2020 by the Chinese Government). The same problem exists in the trade and export of bushmeat in Africa. While it is unlikely that the bushmeat trade will be halted in Africa as it provides a much-needed source of dietary protein, export of bushmeat to Europe, US and elsewhere provides an ongoing risk of disease including Ebola, Marburg and other exotic diseases[13–15]. The amount of bushmeat exported is in surprisingly large amounts, measured in tonnes/airport/year rather than kilograms.

Another recommendation that has not been sufficiently heeded is the need to incorporate surveillance of wildlife disease outbreaks into national and global disease surveillance programs. In Australia, a surveillance system has been implemented to detect outbreaks in free-living wildlife, and the information fed into coordination mechanisms that exist between animal health and public health[16], and similar systems are in place in the United States and the UK. Wildlife disease surveillance is not well resourced or well reported in many countries, and a concerted and cooperative push is urgently needed to develop improved wild animal disease surveillance mechanisms, especially in resource-poor countries.

Understanding the drivers of human behaviours that lead to the emergence or re-emergence of zoonoses, not just the behaviours themselves, will be equally important to enable comprehensive disease control and mitigation strategies to be put in place. Fundamental to this will be the commitment and support of relevant government departments and industry groups within an affected country to resource zoonotic disease control and prevention through the combined efforts of the human health, livestock and wildlife sectors. Continued efforts to identify potential zoonoses through initiatives such as the USAID Expanded Pandemic Threats program will also be another key element to zoonotic disease preparedness. Closer to home, in Australia, zoonotic disease risks are well recognised, and it will be important for those involved in zoonotic disease diagnosis, research, surveillance and response to remain vigilant and vocal about the ongoing threat they pose. Continued and expanded support for the disease control capabilities of our neighbours in the Pacific and Southeast Asia will also pay dividends for pre-border disease mitigation with the dual benefit of addressing zoonotic disease threats in-country and potentially reducing the importation or spread of pathogens into Australia via people or animals/animal products.

It has been estimated that zoonoses cause about a billion cases of illness in people and millions of deaths every year, and emerging zoonoses are a rising threat to global health, having caused hundreds of billions of US dollars of economic damage over the past 30 years[4]. With the current emergence of the novel coronavirus in China now threatening to develop into a global pandemic, this should surely raise enough concern for a concerted effort to reduce potential opportunities for future zoonosis emergence, using One Health approaches.

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Biographies

Professor John Mackenzie is an Emeritus Professor of Curtin University, and Honorary Professor in the School of Chemistry and Molecular Biosciences at The University of Queensland. He is a past President of ASM (1992–94), and was awarded Life Membership of the Society in 2019. His recent work has been concerned with global aspects of infectious disease surveillance and response, particularly with respect to emerging zoonotic and vector-borne diseases. He has worked on a number of committees in the World Health Organization, including the Global Outbreak Alert and Response Network, the Asia Pacific Strategy for Emerging Diseases, and was Chair of the first IHR Emergency Committee on Pandemic influenza 2009. He currently serves on the Emergency Committees on the Spread of Poliovirus, and on the Novel Coronavirus Disease, COVID-19. He currently serves on the National Arbovirus and Malaria Advisory Committee. He is also a co-founder of a new foundation to support the concept of One Health, the One Health Platform, based in Belgium. He is also working for one session a week at PathWest in Perth.

Dr David Williams is the leader of the Emergency Disease Laboratory Diagnosis group at the CSIRO Australian Animal Health Laboratory, Geelong, Victoria. This group comprises multidisciplinary capability in virus diagnostics, contributing to national and regional emergency animal and zoonotic disease diagnostics and surveillance. Dr Williams' research interests have included the detection, diagnosis, and epidemiology of emerging and exotic viruses that affect humans and animals in Australia and overseas. This work has focused on arthropod-borne viruses and has more recently extended to the laboratory diagnosis and pathogenesis of livestock diseases such as African swine fever, Bluetongue and influenza. He is a member of the National Arbovirus and Malaria Advisory Committee and has worked in advisory roles for the United Nations Food and Agriculture Organization and the World Animal Health Organisation (OIE).