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## Australia's biosecurity: future challenges for animal industries

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**Abstract.** Australia's very good animal health status faces a wide range of biosecurity challenges that will arise during the next decade from changes in disease risk, ecosystems, technology and the policy environment in which animal producers operate. An understanding of these challenges should help enable producers to adopt management strategies to make their enterprises more resilient, as well as help policy-makers make better-informed choices to maintain and improve the health of Australia's animals and animal industries.

**Keywords:** animal health, biosecurity, climate change, ecosystem change, emerging diseases, environmental change, policy, risk, risk analysis, technology.

### Introduction

Australia enjoys a very good animal health status and remains free of many major animal diseases such as foot-and-mouth disease (FMD), highly pathogenic avian influenza ('bird flu'), classical swine fever, and rabies. This enviable status faces a wide range of biosecurity challenges during the next decade. These range from changes in disease risk, ecosystems, technology and the policy environment in which animal producers operate.

### Australia's animal health status

Australia's animal health status can change if there are incursions of diseases that do not occur here (i.e., exotic diseases), re-emergence of diseases that are already in Australia (i.e., endemic diseases), or the emergence of previously unknown diseases (i.e., 'new' diseases) here.

Incursions of exotic diseases can occur naturally or with human assistance. New strains of bluetongue virus enter when tropical weather events dump infected insect vectors in northern Australia. Various strains of avian influenza are brought into Australia by migratory birds and some mutate and become virulent leading to disease outbreaks in poultry, as occurred here in five years (during the period from 1976 to 1997), and led to successful eradication responses on each occasion. Incursions also occur inadvertently through human assistance through people, goods, or vessels or aircraft coming from areas where exotic diseases occur (e.g., the incursion of equine influenza here in August 2007, resulting in infection on more than 10,000 properties and a successful eradication response in which the last case was recorded in December 2007). Human assistance may also be deliberate, such as smuggling (e.g., of birds' eggs, the most likely means of entry of pigeon paramyxovirus in 2011) or malicious activity such as from acts of bioterrorism (deliberately introducing a pathogen into a population to cause disruption). In addition to

microbial disease agents such as viruses and bacteria, animal and human diseases can also result from incursions of pests and parasites, while some incursions of exotic pests cause mainly environmental damage (e.g., marine pests such as black-striped mussel, which entered Australia in 1998, but was eradicated).

Re-emergence of endemic disease can occur with changes in the distribution, virulence, prevalence or host range. This has occurred in Australia, for example, with Newcastle disease in poultry after a mild strain of the virus, first recognised here in 1966, slowly mutated over time and became highly virulent to poultry. The resulting outbreaks and control responses caused the death or destruction of more than 2 million birds between 1998 and 2000, and led to ongoing preventive vaccination of poultry here since then.

Another example of re-emergence of an endemic disease is anthrax, which was inadvertently introduced into Australia in 1847 and now occurs only occasionally, typically in small numbers of sheep or cattle on single properties in the 'anthrax belt' from the centre of New South Wales to northern Victoria and Gippsland. However, on rare occasions outbreaks may involve large numbers of animals (e.g., an outbreak on more than 80 properties in the Tatura district of Victoria in 1997) or occur outside the 'anthrax belt' (e.g., in the Hunter Valley in New South Wales in 2007).

'New' diseases, previously unrecognised or unknown to science, have been identified on several occasions in Australia during recent years. Some of these 'new' emerging diseases cross from wildlife into domestic animals and, sometimes, people (e.g., Hendra virus, involving bats, pigs and humans, first described in 1997; Menangle virus, involving bats and pigs, first described in 1994; and Bungowannah virus, the cause of porcine myocarditis, first described in 1996). Some of them also arise and, at least to date, stay in free-living ('wild') animals

(e.g., pilchard herpesvirus, first described in 1995; Tasmanian devil facial tumour disease, first described in 1996).

The cost and other adverse effects of diseases in Australia can be very high. For example, a single case of bovine spongiform encephalopathy (BSE or 'mad cow disease') would result in lost trade worth several billion dollars a year and the cost of an outbreak of FMD in Australia was estimated in 2001 to be about \$13 billion (Productivity Commission 2002), without including social costs (e.g., suicide or long-term health impacts on producers), the negative effect on land values, and the effect on the viability of regional towns and communities. The outbreaks of virulent Newcastle disease in 2001 cost \$50 million in direct losses such as compensation, but the total costs were far greater. The full economic effects of the incursion of equine influenza in 2007 have not been calculated but are substantial (Hoare 2011; Smyth et al. 2011).

### Changing disease risks

Globally, animal diseases are having increasingly adverse effects on human health, animal production and trade, rural development and the natural environment. Factors contributing to the increase of disease include demographic changes, intensive animal production, globalisation and trade, urbanisation and other environmental changes — including climate change — that influence the ecology of disease agents (Cohen 2000). These effects will continue unless strong and well-coordinated measures are taken to prevent and manage major animal diseases at source.

Worldwide, production-diminishing infectious diseases, such as FMD and classical swine fever, resulted in severe hardship for many farmers, hinder livestock development, and restrict or close access to markets (Thiermann 2004). The highly infectious nature of such diseases has resulted in transboundary spread, particularly from countries that have suboptimal veterinary services and animal health systems, creating risks to countries (like Australia) that are free of such diseases.

Many emerging diseases are 'transboundary diseases' that often spread between countries and continents. In addition, up to 75% of newly recognised infectious diseases of humans are zoonotic, this is transmitted from animals (domestic animals and wildlife) to humans (Woolhouse 2002; Morse 2004; Slingenberg et al. 2004; Woolhouse and Gowtage-Sequeri 2005). Wildlife diseases can also have significant effects on the wildlife hosts themselves, in some cases threatening biodiversity (Daszak et al. 2000; Thomas et

al. 2004), and the livestock–wildlife interface is a source of introduction of diseases to domestic animals and humans (Osofsky et al. 2005).

Climate change is part of the larger set of environmental and ecosystem changes that are promoting the emergence and re-emergence of animal diseases. There is considerably more information on the likely effects of climate change on human health than there is on its likely effects on animal health and production (Baylis and Githenکو 2006). To help rectify this situation, the World Organisation for Animal Health (OIE) reviewed the effect of climate change on the epidemiology and control of animal diseases (de la Rocque et al. 2008) and surveyed member countries to gain chief veterinary officers' views on the effect of climate and other environmental changes on animal health. Responses to OIE's questionnaire revealed that most countries' chief veterinary officers are concerned by the effect of climate and other environmental change on emerging and re-emerging animal disease, and are not confident that veterinary institutions are effectively preparing professionals who are capable of understanding the effect of such changes on animal health and production (Black and Nunn 2009).

Emerging and re-emerging food safety issues such as contamination and zoonotic food-borne diseases pose problems throughout the world. Episodes of food-borne illness in recent years include BSE, *Escherichia coli* O:157, *Campylobacter jejuni* and salmonellosis. As well there are problems associated with antimicrobial resistance and a range of chemical residues and toxins (Schlundt et al. 2004; Dagg et al. 2006).

Forecasts suggest that the world's population will increase from about seven billion people now to more than nine billion by 2050, with most of this growth occurring in Africa, Asia, and Central and South America. Some authorities estimate that demand for animals and animal products will increase between 2% and 3% per annum for at least the next 10 years, and argue that much of this demand can be met from developing countries if animal diseases there are better managed (FAO 2009). However, given the rapid rate of growth in human population there is increasing concern about global food security (FAO 2011).

### Changing ecosystems

Animal production has significant effects on ecosystems worldwide, particularly through negative impacts on land, water, biodiversity and climate (Steinfeld et al. 2006), and development agencies are increasingly including livestock as a focus of attention

(World Bank 2009). For example, responses to climate change will include alterations in livestock production systems, and some of these will have animal health implications. Climate change thus contributes to changing animal health risks both directly (e.g., via the effects of increasing temperature) and indirectly (e.g., via changes in production systems designed to mitigate or adapt to climate change).

Many animal diseases are affected by weather, which can affect the distribution of disease, the time when outbreaks occur, or the severity or intensity of outbreaks (Baylis and Githenکو 2006). Climate change is likely to increase the vulnerability of the primary industry sector to both biophysical and economic stresses. In particular, it is likely to have a significant effect on the supply of water as a result of increased temperatures, increased evaporation, and reduced rainfall in some areas of Australia. Increased climate variability and increased frequency and severity of extreme weather events such as drought are also likely to lead to additional stresses (Pittock 2003).

Within Australia, climate change will affect future patterns of livestock density, distribution, production and trade that could also affect the risk of disease. For example, there may be a shift in agriculture, including livestock production, from temperate areas of southern Australia to the northern tropics as a result of the expected effect of climate change on each of these regions. Some breeds (e.g., meat sheep for prime lamb production, European British breeds of dairy cattle) are likely to be disadvantaged by a more sub-tropical climate and by their greater susceptibility, in comparison with more tropical breeds, to a range of vector-borne diseases to which they will be more exposed.

Australia has complex and highly variable weather (Pearman 1995), even without any increased variability as a result of climate change, and such variability makes climate modelling difficult. However, as data going into models and the models themselves improve, there will be a reduction in associated uncertainties and an increase in the validity of model outputs and of consequent projections and inferences related to animal production and animal health. For example, a study of the projected effect of climate change on wheat, beef, sheep meat and wool (Heyhoe et al. 2007) examined likely impacts of a high-rainfall and a low-rainfall scenario by 2030 on the Western Australian wheat belt and the central western slopes and plains of New South Wales. Under the low-rainfall scenario, productivity was projected to fall by 1.8% to

4.2% in the New South Wales study area and by 0% to 7.3% in the Western Australian study area. With the adoption of a number of adaptive responses, the projected fall in productivity was halved.

If changes in climate allow the vectors of tick-borne diseases to expand periodically into new areas, severe outbreaks of diseases such as babesiosis and anaplasmosis can be expected in susceptible animals of all ages. Higher temperatures increase the rate of development of some pathogens or parasites that have part of their life cycle outside an animal host. This may shorten generation times and lead to increases in the population of some pathogens and parasites. For example, the range of the cattle tick (*Boophilus microplus*) is likely to extend southwards and lead to significant losses (from a decline in total live-weight gain and from tick-borne diseases) that, without new control measures, will reduce the productivity of the beef cattle industry (White et al. 2003).

In areas where climate change results in more humid conditions and higher summer rainfall, the prevalence of blowfly strike on sheep can be expected to increase, with consequent higher costs of prevention and treatment as well as reduced wool production and quality (Harle et al. 2007). The prevalence of some pests and parasites might also become more variable in response to increased variation between seasons (e.g., they may appear earlier in a season and go through more generations each year). In sheep, these effects might be exacerbated by the reduced nutrition resulting from increases in poorer quality forage species and decreases in the nutritional value of existing species as a result of climate change (Harle et al. 2007).

Climate change will not increase the risk from all diseases and many livestock diseases will be little affected, or even unaffected, by climate change. Such diseases include those that are transmitted primarily by close contact between hosts (e.g., mastitis) or that are food-borne (e.g., salmonellosis). In some cases, the risk from disease may decline. For example, the snail intermediate hosts of the liver fluke *Fasciola hepatica* depend on moisture to survive and multiply. The decreased rainfall and soil moisture (particularly in summer) that is projected as a result of climate change in areas of south-eastern Australia where fascioliasis occurs is likely to reduce the current prevalence and distribution of the disease.

As both livestock producers and wildlife adapt to climate change (e.g., via changes to where livestock are farmed and changes in the

distribution of wildlife populations in response to climate-induced changes to water and vegetation), opportunities will undoubtedly arise for further diseases of wildlife to infect domestic animals and humans. In areas where one of the adaptations to climate change is increased intensification of animal production, there will also be further opportunities for the emergence of previously unknown diseases and the re-emergence of known endemic diseases (Otte et al. 2007).

### **Changing technology**

Science and technology are changing and are likely to continue to advance rapidly. Advances in areas such as molecular biology (e.g., genomics, proteomics) offer new ways to diagnose diseases better — faster, on-site ('penside' or 'point-of-care'), cheaper and more accurately. They also offer potential new ways to prevent (e.g., by vaccination), control and treat diseases.

Rapid advances in information technology have led to tools such as geographic information systems (GIS), remote sensing and disease modelling that can all be applied to improve disease prevention, preparedness and response. Recent advances in information and communications technology have caused an explosion of the information available on the internet and the widespread use of 'new media' (e.g., Facebook, Twitter). Monitoring such open-source information and using techniques such as emerging issues analysis and other strategic foresight tools to analyse enables semi-automated rapid detection of disease events worldwide and provides insight and intelligence to inform disease prevention and control and reduce the risk of incursions. Advances in disciplines such as epidemiology and disease ecology are enhancing our understanding of factors that drive the emergence or re-emergence of disease. Such advances will increasingly enable us to target surveillance to areas where such risk factors are highest and to develop and apply preventive actions to reduce risk factors that drive disease.

Enhanced disease surveillance systems are a key component of maintaining and improving biosecurity. Local and global surveillance systems can be improved in a number of ways, such as approaches that combine data from a range of different sources and scales, including sourcing data on some of the drivers for disease emergence. The development of new technology for disease diagnosis will also influence disease detection and control. For example, the availability of robust and reliable point-of-care tests will enable earlier detection of disease and earlier response to contain outbreaks. Such developments, combined with new

technology in vaccines (Breeze 2006) that enable the differentiation of vaccinated from infected animals, will offer cheap and effective improvements in disease surveillance and control. However, such new technology will achieve little unless accompanied by a well-trained and well-prepared animal health systems and animal producers.

There is a clear need for veterinarians, medical specialists, and wildlife and environmental experts to adopt an interdisciplinary framework such as ecosystem health ('ecohealth') or 'one health' (Waltner-Toews 2004, Parkes et al. 2005, Whittington 2006, McMichael et al. 2007). One of the many challenges with the use of new technology is to ensure that it is used in an interdisciplinary environment where its application is enhanced by the insights provided through the subject knowledge of specialists in different disciplines working together. Embracing this approach can require a fundamental shift in thinking as specialists in the medical and veterinary scientific and technical disciplines traditionally involved in disease prevention and control work more with other specialists to address emerging disease risks. Other disciplines that need to be involved include social sciences (e.g., anthropology, communications), economics, environmental sciences (e.g., ecology), ethics, and policy and politics). Similarly, there is a need for changes in the education and training of animal producers to promote better stewardship of the land they manage and to encourage them to apply new technology in adaptive strategies that enhance biosecurity and minimise the negative effects of climate and other environmental change on animal production and health.

### **Changing policy context**

The broad policy context around biosecurity is one of continuing growth of globalisation and trade, and with it the potential for what many call 'pathogen pollution' — the spread of pathogens and pests with that trade. Australia has long had a strong quarantine presence at the border, with close inspection of incoming passengers, goods and mail to help prevent the entry of disease agents. Greater emphasis is now being given to pre-border biosecurity such as capacity-building in animal disease control in neighbouring countries. These activities help both to control known disease risk in these countries, thus reducing the risk of spread to Australia, and also provide early warning and intelligence of changing risk such as from newly recognised emerging diseases. Greater emphasis is also being given to offshore audit and verification in countries that are major

trading partners. These activities help manage biosecurity risks offshore and aim to ensure that what is exported to Australia is safe.

### Changing expectations

Society, particularly in developed countries, is increasingly demanding assurances about safety, including safety from infection from animal diseases. Twenty years ago when a disease outbreak occurred, animal health authorities faced questions such as 'What effect will it have on production or productivity?', 'Will it affect trade?', 'How much will it cost to control it or eradicate it?', and, occasionally, 'Could it infect people?'. Now, the very first question animal health authorities are asked is 'Can you guarantee it *won't* affect people?' That is a very different question, and a much harder one to answer, particularly when the outbreak is of a newly identified or previously unknown disease. Animal health authorities and animal producers will continue to be challenged to respond to this question as 'new' diseases emerge.

Within Australia, as in many other developed countries, intensification of animal production is likely to continue, not only in pigs and poultry but also increasingly in beef cattle feedlots, dairy production and aquaculture. However, intensive facilities, with large numbers and high densities of animals, increase the risk of disease emergence and need high standards of biosecurity to maintain the health of stock. In developed countries, public concern about intensive animal production focuses on issues related to animal welfare, effluent disposal, and the use of chemicals (e.g., hormones, probiotics, therapeutics). Such concerns are likely to continue to grow as more consumers' expectations expand to include greater assurances about the origin and safety of food and the welfare of the animals that produce the food, fibre and other products they use. There will also be, particularly in developed countries, increased public demand to demonstrate more rigorously the safety of new technology (e.g., gene technology, cloning, nanotechnology) and its products. Society will continue to demand increased assurance about environmental effects of animal production, the welfare of farmed animals, and the safety of animal products and the technology used in animal production.

These changing expectations will lead to greater demands to reduce the destruction of large numbers of animals as a primary tool to contain and eradicate outbreaks of infectious animal diseases. Internationally, 'slaughter-out' responses are increasingly unacceptable

to society, especially if other control options (for example, vaccination) are available. The influence of public opinion on outbreak responses is illustrated by the response to FMD in the United Kingdom in 2001–02 in which the public response to media coverage of the imminent destruction of a single photogenic white calf ('Phoenix') almost stopped the eradication program. Consideration of the ethics of the destruction of millions of poultry in response to ongoing outbreaks of avian influenza in many countries — particularly in developing countries, where animal protein is in scarce supply and poultry production is a significant source of income for millions of smallholder farmers, — is also likely to lead to changes to the way authorities manage animal disease outbreaks in the future.

### The changing science–policy interface

The use of formal science-based risk analysis frameworks will become more important in identifying, characterising, assessing and managing risks, both real and perceived. Risk analysis is a demanding, complex and resource-intensive process. In the natural resource area generally (including quarantine and biosecurity), it involves consideration of scientific and economic factors, often requiring the use of multidisciplinary teams. In complex analyses of animal diseases, risk assessment teams may need to include specialists with skills in disciplines such as communications, mathematics, statistics, computer simulation and disease modelling, ecology and environmental science in addition to those in risk analysis, animal or plant health, and economics (Nunn 1997; 2001). Sound risk management approaches will need to be applied at all levels of the supply chain. Given that problems will occur in even the best-managed systems, more effective and more refined approaches to contingency planning will be necessary to protect animal production and health, safeguard human health, and support consumer confidence.

Perceptions of risk by stakeholders or the general public often align poorly with those of 'experts', and a rapidly growing body of work on risk perception and communication has defined a number of key factors that determine individual and group perceptions of risk. For example, factor analysis has shown that hazards that are perceived as unfamiliar or provoke dread are assigned a higher risk than can be demonstrated statistically (Slovic 2000). Unfamiliar or unknown hazards, even with a low probability, that are regarded as having potentially catastrophic effects are perceived as high risk and provoke strong public demands for government to regulate and

protect against them (e.g., hazards such as the introduction of an unfamiliar disease that might be a zoonosis, or the introduction of a known disease that might decimate one or more native species). Risk analysts need to be mindful of such reactions to risk and take account of them in their communication with stakeholders (Powell and Leiss 1997). Similarly, they should also appreciate the effects of trust, fear and outrage on how stakeholders feel and behave. Improved approaches to risk communication will be necessary to enhance the sharing of information between governments, industry and the public – both nationally and internationally.

Science provides a framework for analysis and synthesis that can inform policy. However, science is still largely based on classical, reductionist approaches that may not always be appropriate in situations of high complexity and uncertainty. When both uncertainty and the consequences of a decision are high (as often occurs with emerging diseases), a more appropriate strategy may be that of 'issues-based post-normal science' (Funtowicz and Ravetz 1994). This strategy aims to engage an 'extended peer community' including all stakeholders to evaluate the quality of scientific information provided as input to the policy process. Proponents of 'trans-science' (e.g., Weinberg 1985) distinguish between science (or 'research science') and trans-science (or 'policy science') and argue that there are some questions that can be asked of science, but cannot be answered by science. Under this approach, increased complexity and uncertainty of questions should result in greater democratisation of how to 'do' science when scientific ways of knowing break down, especially if there is a high 'dread' factor (e.g., environmental risk), and that this compels scientists to look beyond the (known) facts to make judgments or determinations. Others (e.g., Carolan 2006) argue that increased complexity and uncertainty require a focus on 'expertise' rather than science, and recognise public expertise that allows the explicit incorporation of values and changes the focus from questions of 'what is' to questions of 'what should be done'.

### Conclusion

Australia's animal industries face a wide range of biosecurity challenges. These challenges arise from changes in disease risk, ecosystems, technology and the policy environment in which animal producers operate. Australia's enviable animal health status will continue to be threatened by incursions of exotic diseases, re-emergence of endemic diseases, and the emergence of

previously unknown diseases here. However, Australia has a strong legislative and governance basis for animal disease prevention, preparedness, response and recovery – including strong partnerships between animal health services and the animal industries they serve. This sound foundation, combined with a range of strategic approaches to identify and minimise biosecurity risks, should ensure that Australia is well-placed to maintain and improve its animal health status, despite the range of future biosecurity challenges it faces.

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