Epidemics In A Changing World

REPORT OF THE
EXPERT WORKING GROUP
ON EPIDEMICS
IN A CHANGING WORLD

Contents

Chair's Comments

As the first cases of a new H1N1 influenza have appeared in Australia, and as north Queenslanders are experiencing the largest epidemic of dengue fever in years, it is timely to report to the Prime Minister's Science, Engineering and Innovation Council on *"Epidemics in a changing world"*.

We appreciate the strong continuing interest in this area of the Prime Minister, the Honorable Kevin Rudd MP, since his 2005 policy statement while Shadow Minister for Foreign Affairs.

Australia now faces new challenges from epidemics triggered by global climate change and other changing factors such as demographics, land use, mobility and trade.

In 2005, there was *"Plague in Parliament"* – a hypothetical on viral epidemics as part of the annual *Science meets Parliament* event. The Deputy Prime Minister, the Honorable Julia Gillard MP, was a participant in her former role as Shadow Minister for Health. The hypothetical panel was unanimous in deciding that the probability of a new flu pandemic was a *"when, not if"* scenario.

However, we must also be prepared for events we cannot foresee. The last few decades have demonstrated how difficult it is to predict epidemics of emerging infectious diseases such as SARS, avian influenza, Hendra, Ebola-Reston, and chikungunya. The last is caused by a moderately innocuous virus which was known initially from African forests, and appeared almost 50 years later as a major epidemic, involving over 2 million people in the Indian Ocean and India.

As outlined in this report, we live in a changing world and we must expect the unexpected. The best defence against the unknown is to ensure that we are building sufficient national and regional capacity in a broad range of epidemic-relevant disciplines to deliver quality risk assessments and responses.

We hope the deliberations of the Expert Working Group will lead to better preparedness for emerging epidemics in the face of global change.

I commend this report to the Prime Minister, Cabinet and PMSEIC and, in doing so, thank the Expert Working Group for its sterling efforts.

Brian Kay AM, PhD, FACTM, FAA
Chair, PMSEIC Expert Working Group on *Epidemics in a changing world*

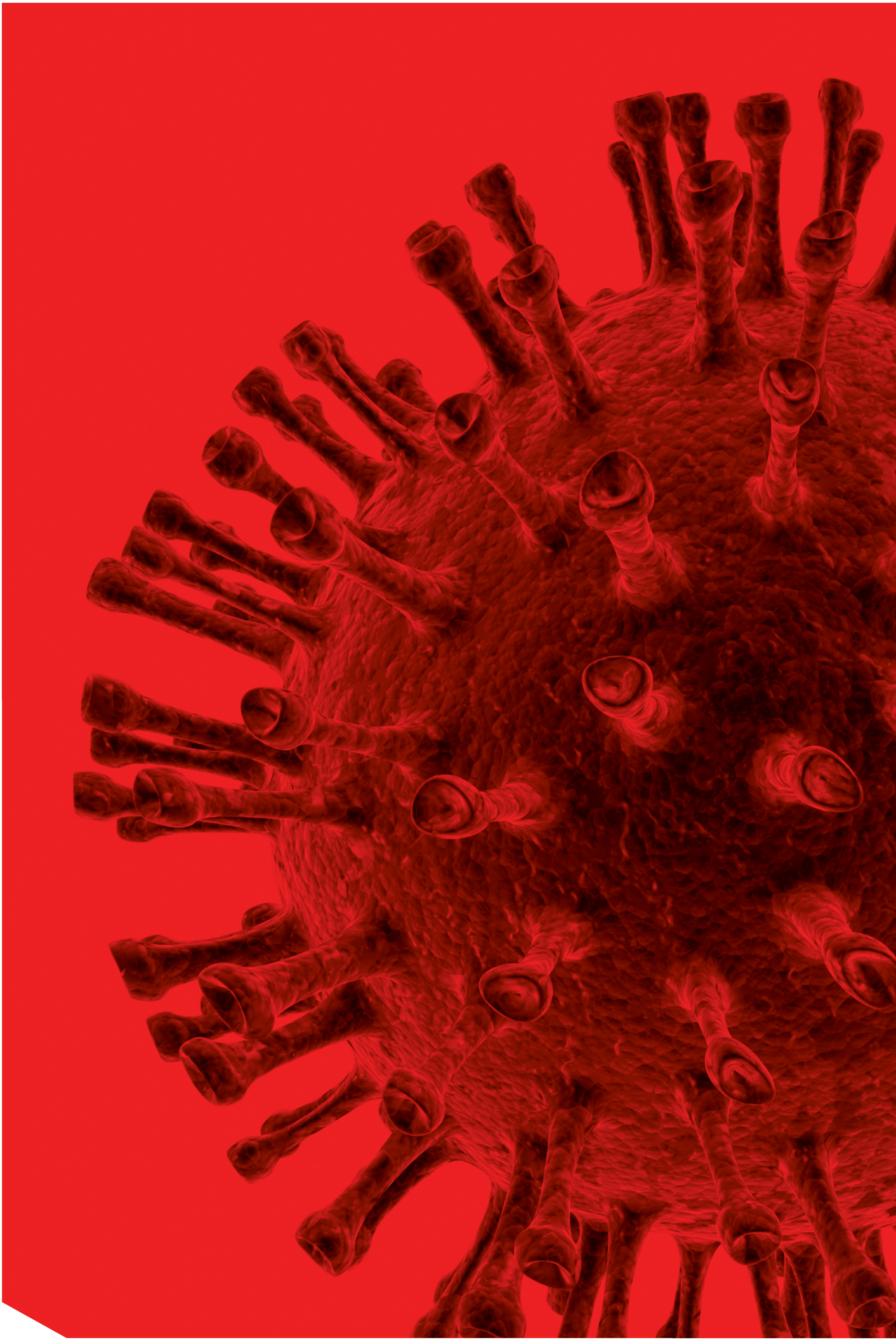
The members of the Expert Working Group are detailed in Appendix 1.

Terms of Reference[1]

The PMSEIC Expert Working Group on the thematic issue of epidemics will address the issue both from a national and international perspective. It will prepare a written report (a full technical report including a summary for policy makers) and a presentation for the PMSEIC 5 June 2009 meeting that presents a strategic viewpoint by:

1. Identifying key emerging risks and threats for spontaneous pathogen-mediated epidemics in Australia in the context of climate change over the next few decades.
2. Identifying and summarising information on current measures, strategies, and related technologies that could assist in anticipating and mitigating the risk and impact of epidemics.
3. Identifying the key factors likely to improve uptake of pre-emptive measures, strategies, and technologies.
4. Determining any gaps in and constraints to research and development in these areas, including those related to human capacity and to any intellectual property ramifications across jurisdictions.
5. Outlining current research, on a continuum from basic to applied, to prevent challenges posed by epidemics and mitigate their impact.
6. Identifying developments in forecasting, containment and prevention of epidemics (e.g. likelihood of zoonosis and of the emergence of new and highly virulent and drug-resistant pathogens through mixing of existing strains, and prevention through the potential use of vaccines).
7. The Expert Working Group will report its findings to PMSEIC and make recommendations on ways forward for Australia to address challenges posed by epidemics.

1 A more detailed version of the Terms of Reference is at Appendix 2.



EXECUTIVE SUMMARY

Human beings have co-existed for millennia with a continually evolving mix of diseases that have periodically erupted, collapsed and re-emerged in new forms.

During the last few hundred years for which reliable records exist we have experienced major epidemics with catastrophic consequences two or three times per century. Table 1 notes the death tolls from three influenza epidemics last century. The 1918–19 influenza pandemic alone caused more deaths than World War 1–40 million compared with 8 million.

It is a matter of when, not if, a lethally catastrophic epidemic will happen.

Table 1: Mortality associated with global influenza outbreaks[2]

DISEASE	YEAR	DEATHS
Spanish influenza	1918–19	40 million
Asian influenza	1957–58	2 million
Hong Kong influenza	1968–69	1 million

This report addresses the factors that prompt the emergence of infectious diseases, and that alter the frequency, location and spread of disease in a changing global environment. We are the key contributor to this change, through population growth, climate change and associated environmental impacts.

We now live in a world where the environment is changing more rapidly than in the past, which enhances the prospect for new encounters with infectious agents, with less predictable effects. In the past few decades a spate of epidemics raised fears of global disasters that, while they did not eventuate, nevertheless caused severe economic impacts.

The one thing that we know for certain is that the infectious agents that cause such diseases constantly evolve and migrate from one species to another, altering their characteristics as they go. This makes the prediction of future threats very difficult — so we must expect to be surprised.

We must therefore be ready to cope with the "unknown unknowns". This will require preparedness and agility, which in turn depend primarily on investments in human capital, both in Australia and overseas.

For tens of thousands of years Australia existed in relative isolation, but then experienced rapid migrational change while still retaining a relatively protected environment. We now need to move beyond the absolutism of a quarantine-based approach to one of pro-active engagement with our region based on disease surveillance and containment. We also need to continue to be a key player at the highest level in order to leverage the rest of the world's knowledge, especially in disease prevention and vaccine production.

2 WHO. 2005. Avian influenza: assessing the pandemic threat. Available at (http://www.who.int/csr/disease/influenza/H5N1-9reduit.pdf)

Recommendations

Following consideration of the matters noted above and detailed in this report, the Expert Working Group makes the following recommendations.

Recommendation 1

In order to underpin our preparedness to deal with emerging epidemic diseases we recommend that:

Australia possesses the human capacity to combat potential epidemics

The nation must be prepared and sufficiently agile to deal with unexpected epidemics. This requires that we develop, maintain and retain skilled people through:

- conducting ongoing national workforce planning for expertise in human and animal epidemic diseases; and
- boosting higher education and research training in areas of need.

Recommendation 2

In order to provide early warning of the emergence of epidemic diseases we recommend that:

Australia possesses a long term biosecurity information collection, analysis and interpretation capability

Capability must be developed and maintained to collect, analyse and interpret disease surveillance information. This must be secured by:

- creating an ongoing, effective national human and animal disease information system; and
- integrating this system with similar systems operating overseas.

Recommendation 3

In order to enhance our wider ability to deal with emerging epidemic diseases we recommend that:

Australia develops forward regional engagement to mitigate potential epidemics

Australia needs to commit human and other resources to engage our region on disease surveillance, preparedness and mitigation, through capacity building and collaboration. This requires that we develop political, scientific and technical relationships with our neighbours, at multiple levels, to reduce human and animal disease risk to Australia and the region by:

- establishing an active ongoing cross portfolio mechanism involving PM&C, DFAT, DoHA, DAFF, DIISR, DEEWR and other relevant agencies dedicated to managing and supporting effective regional engagement; and
- assisting regional countries to meet their obligations under the WHO International Health Regulations and the World Organisation for Animal Health requirements through:
  - supporting development of collaborative regional surveillance and early warning systems; and
  - developing regional expertise through professional training and higher education in Australia and in the region.

Recommendation 4

In order to secure the front-line defences needed to deal with emerging epidemic diseases we recommend that:

Australia has a self-sufficient vaccine development and production capacity

Australia needs to retain and enhance its onshore development and production capacity for vaccines. This is essential for domestic preparedness and, as importantly, to enable access to the latest overseas expertise and technology in this field. The focus should be on the onshore development and production capacity for:

- contemporary influenza vaccines; and
- niche vaccines, particularly in the context of future Australian needs.

Recommendation 5

In order to better coordinate our ability to deal with emerging epidemic diseases we recommend that:

The Government establishes the cross-portfolio arrangements essential for effective implementation of Recommendations 1, 2 and 3 as a matter of immediate priority.

Science and innovation will provide the key to safeguarding Australia's future. This report focuses on ensuring that the nation is well placed to deal with the effect of global changes on the occurrence and spread of human and animal epidemic diseases.

We take as a starting point that our current operational response to disease control is effective — and has been in recent times for disease events which have not resulted in major global epidemics. The recommendations presented here will provide Australia with the preparedness and agility to cope with the unknown challenges of a future world that we can expect will provide a substantively different environment for epidemic disease.

Introduction

Epidemics can place unexpected and intense demands on a nation's healthcare system, through widespread illness and mortality, and can cause enormous social and economic disruption. Similarly, emerging infectious diseases in animals can result in huge direct economic losses from outbreaks, from implementing interventions, and from consequential trade disruptions.

The rise and spread of epidemics that pose a risk to human and animal populations are caused by a range of factors. These factors include alterations in agricultural practices and land use, changes in society and human demographics, poor population health, deficient hospitals and medical procedures, contamination of water supplies and food sources, international travel and trade, reduced levels of biodiversity, inadequate urban planning and changing climatic conditions. The occasional emergence and spread of new variants is also part of the natural history of some infectious agents.

Climate change may contribute to the migration and mutation of infectious agents, elevated risk of zoonoses (animal infectious diseases that can be transmitted to humans), increased availability of vectors for transmission of infectious agents and increased proximity to reservoirs of such agents.

Given the potential origins and geographic range of future epidemics, international cooperation, particularly within the Asia Pacific region, is required for rapid and effective operation of global surveillance, alert and response mechanisms. New or altered infectious agents have also arisen and will continue to arise in our own human and animal populations, requiring strong local surveillance and responsiveness.

The world is currently experiencing an outbreak of a new H1N1 influenza. Some details on this emerging disease are presented in Text Box 1.

To mount an effective response to future epidemics in Australia, the nation requires a clearer and better understanding of emerging threats, particularly those that are likely to be accelerated by climate change. Furthermore, a risk-based approach needs to be developed to strengthen the formulation of national policy.

The EWG addressed all matters detailed in the Terms of Reference. However, given the changes currently underway as a consequence of the recent review of Australia's biosecurity and quarantine arrangements, the EWG did not explore the key factors likely to improve uptake of pre-emptive measures in depth. This may be a suitable topic for future consideration.

In addressing the Terms of Reference, the Expert Working Group (EWG) did not consider diseases of plants and the marine sector, as these diseases are generally not considered to have epidemic potential. However, it should be noted that some of these diseases can have considerable economic impact.

Further, the EWG did not explicitly consider the influence of an increased Australian population on the emergence and spread of infectious diseases, nor were invasive pests or food safety considered. The term 'epidemic' was limited to consideration of disease outbreaks caused by infectious agents.

In particular it should be noted that the Terms of Reference for the EWG were limited to consideration of spontaneous epidemics and thus precluded examination of bioterrorism-initiated biological epidemics.

Text Box 1: The new H1N1 influenza, April 2009

The emergence of "swine-lineage" A(H1N1) influenza virus infections in humans and their transfer to swine occurred during the compilation of this report. New strains of seasonal human influenza viruses arise almost annually, requiring the regular updating of seasonal influenza vaccines. However, the emergence and spread of a distinctly new influenza virus, like the 2009 H1N1 virus, has occurred only a few times in the last century. Neither the timing nor the location of such events can be predicted. Such is the nature of most emerging infectious diseases.

The new H1N1 virus is believed to have developed when one human or animal was co-infected with two different influenza viruses previously identified in swine in North America and Eurasia.[1] Because the genetic material of influenza viruses is divided into eight separate segments, co-infection allows "reassortment" to create new combinations of the eight segments. Occasionally reassorted viruses are infectious and spread successfully. Whereas the 1918 pandemic influenza virus appeared to arise by mutation of an avian influenza virus, the 1957 and 1968 pandemics were both caused by reassorted viruses with new combinations of human and avian influenza genes.[2]

(Anne Kelso, pers.comm.)

Figure 1: Quarantine camp, South Australia, in the 1918–19 influenza pandemic

Source: State Library of South Australia. Reproduced with permission of the copyright owner.

Chapter 1: Characteristics of emerging epidemic diseases

A list of selected significant infectious agents which can cause disease, including some which have recently emerged, is in Appendix 3. An emerging disease is one that has appeared in a population for the first time, or that may have existed previously but is rapidly increasing in incidence, virulence or geographic range.

A recent study of infectious diseases which emerged between 1940 and 2004 showed that most (60%) were derived from animals (zoonoses) and the majority of those (72%) emerged from wildlife.[3] Vector-borne infections were also evident, as shown in Figure 2 (adapted from the source). Changing patterns of contact with animals have allowed infections to cross to humans. Furthermore, many of these diseases emerged in equatorial regions while most surveillance and scientific expertise is concentrated in developed countries at higher latitudes.

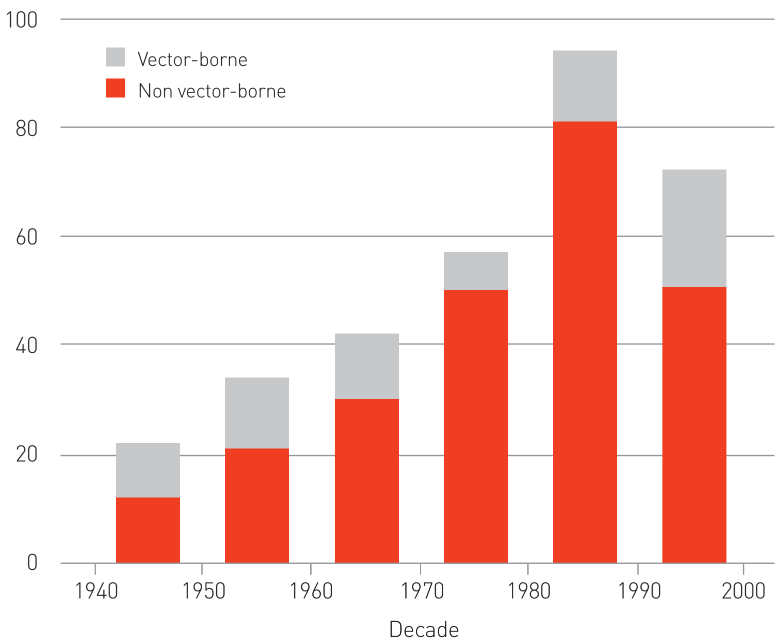


Figure 2: Number of emerging infectious disease events per decade[4]

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Since the early 1980s, the frequency of emergence of new infectious diseases has increased and some infectious agents that were previously thought to be under control have re-emerged.[5] Newly identified infectious agents, which are predominantly viruses, include certain subtypes of influenza A virus, West Nile virus, Hendra virus, Australian bat lyssavirus, Ebola virus[6], HIV/AIDS and Nipah virus[7,8].

Bungowannah and Menangle represent new viruses that have caused disease in Australian swine herds.[9,10]

Many of these are completely new infectious agents and their appearance was unexpected. Figure 3 depicts viruses that have been recently discovered. An example of a recently emergent virus is provided in Text Box 2.

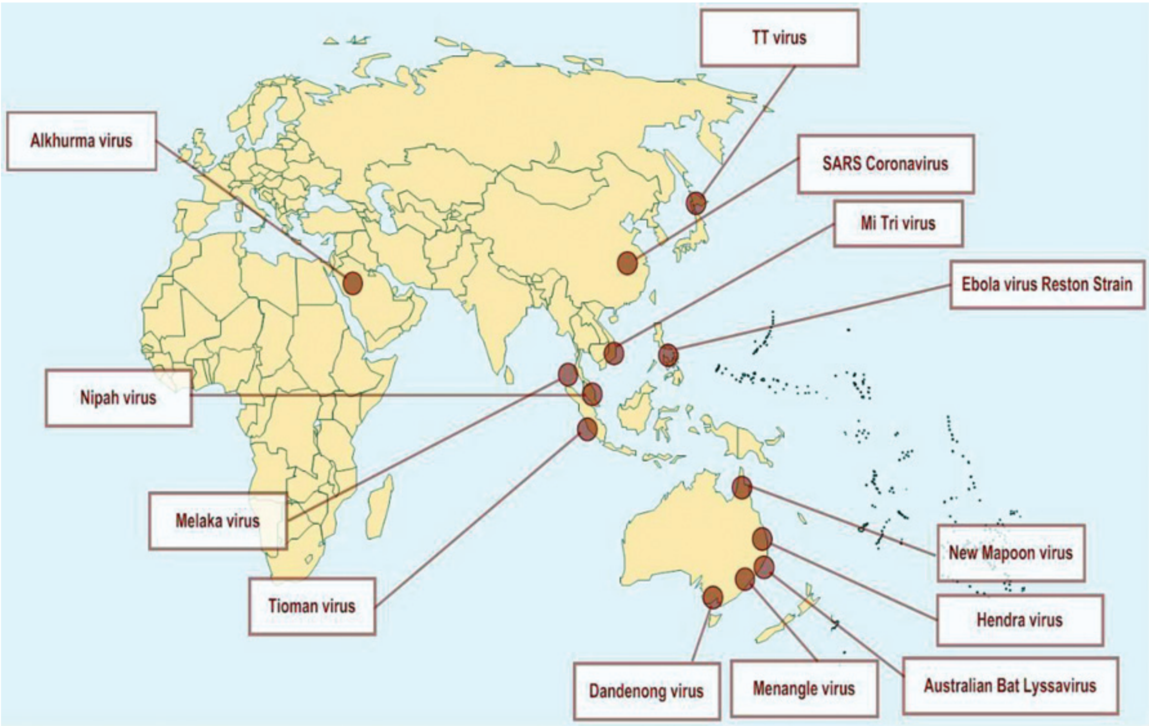

Figure 3: Emergent viruses identified since 1994

Source: John Mackenzie (pers.comm.)

Text Box 2: SARS – unexpected and unknown

SARS was the first severe and readily transmissible new human disease to emerge in the 21st century. Initially recognised as a global pandemic threat in mid March, 2003, SARS was successfully contained in less than four months, largely because of an unprecedented level of international collaboration and cooperation. However, those four months were characterised by economic and health system chaos in a number of affected countries, particularly in the Asian region. Of 8000 cases, 774 deaths were reported from 39 countries.

The cause of the disease was initially unknown; tests for all known infectious agents were negative. The World Health Organization (WHO) established a series of virtual networks of specialists to discuss epidemiological, clinical, laboratory, and other aspects of the outbreak. Through this system, a previously unrecognised coronavirus was discovered as the cause, and transmission was found to occur only after several days of illness, through inhalation of large droplets. It then proved relatively simple to contain the outbreak through good infection control practices.

(John Mackenzie, pers.comm.)

Vectors can also emerge in new areas and bring with them new infectious agents. Biting midges that carry some animal infections in Australia, such as bovine ephemeral fever and bluetongue, are expected to expand their geographical range under the influence of climate change.[11,12] Control of these vectors is not possible and their distribution is climate-dependent, with temperature, humidity and wind being important factors. Monitoring of their distribution and of the viruses they carry is vital for trade protection.

Why are these diseases important?

These emerging infectious diseases are important for a number of reasons. A serious disease outbreak has the potential to cause loss of life and considerable illness. The mortality associated with selected epidemics is shown in Table 1.

Table 1: Mortality associated with global influenza outbreaks[13]

DISEASE	YEAR	DEATHS
Spanish influenza	1918–19	40 million
Asian influenza	1957–58	2 million
Hong Kong influenza	1968–69	1 million

Epidemics also impose considerable stress on health care systems and may have significant social impacts (for example, on travel, workplaces and the supply of goods and services).

In addition, there may be major economic impacts associated with outbreaks of disease in humans and animals. These impacts may derive from factors including mortality, illness, the costs of control and other interventions, the costs of treatments and/or the loss of markets. Some recent data are summarised in Table 2.

Table 2: The impact associated with selected disease events

DISEASE (YEAR/S)	REGION	ECONOMIC IMPACT OR COST
Avian influenza (2003–2008)	Global	US$ 20 billion[14]
Nipah (1998-9)	Malaysia	US$ 276 million[15]
Bluetongue (2007)	France	US$ 1.4 billion[16]
Foot and mouth disease (2001)	UK	£ 3.1 billion[17]
Bovine spongiform encephalopathy (BSE) (1995)	UK	US$ 5.75 billion[18]
Plague (1994)	India	US$ 2 billion[19]
Equine influenza (2007)	Australia	AUD$ 1 billion[20]

It has been estimated that a 12 month outbreak of foot and mouth disease in Australia would cost between AUD$ 8 and 13 billion.[21]

Some details of Australia's capacity to anticipate and mitigate the risk and impact of epidemics are summarised in Appendix 4.

How do they spread?

Infectious agents are spread directly by contact or by droplets ejected when coughing or sneezing. Such close contact is a feature of the spread of respiratory viruses, for example, and hence the stress on hand washing and wearing of masks to reduce the transmission of influenza virus.

Indirect transmission can occur when the infectious agent contaminates an inanimate object (e.g. droplets sneezed onto a door handle can be transferred to the next person to open that door). Similarly, contaminated food, water or blood products can be vehicles for infectious agents.

Mosquitoes and midges are examples of insects that act as carriers, or vectors, of infectious agents. Their role in disease emergence was seen in Fiji in 1979 when local mosquitoes acquired Ross River virus from infected Australian tourists and transmitted it to the local population. This resulted in the largest such outbreak ever recorded, with some 500,000 infections and 50,000 symptomatic cases. The epidemic ran for a year before subsiding. A further example is provided by the current situation in north Queensland; dengue-infected travellers from Indonesia, Papua New Guinea and/or Vanuatu were bitten by local mosquitoes, triggering outbreaks.

Long-range airborne dispersal is another indirect means of transmission. Aerosols containing the infectious agent are dispersed in very fine sprays that remain airborne over long distances and can then infect via inhalation. This mechanism was responsible for many of the outbreaks of Q fever that have occurred in Australia.

Sources of emerging infectious disease risk for Australia

The principal risks of epidemic disease to Australia derive from three sources. The first is the potential entry of disease through our northern borders. Fruit bats and birds regularly cross from Indonesia and Papua New Guinea to Australia, especially across the Torres Strait and the Timor Sea, potentially introducing new viruses into Australia. Fruit bats, for example, can carry henipaviruses (Hendra and Nipah).

The second risk area is entry through our sea ports and airports. For example, new influenza viruses will almost certainly be carried to Australia by a passenger on a plane, and dengue virus is brought into Australia annually by infected travellers coming through airports. (The mosquito *Aedes aegypti* that carries dengue is widespread in Queensland and facilitates human to human transmission.) Since November 2008, north Queensland has experienced a prolonged outbreak of dengue (the worst for 50 years), with over 1000 cases to date. The 2007 outbreak of equine influenza occurred as a result of the entry of an infected horse into Australia and the subsequent escape of the virus from a quarantine station.

The third area of risk is diseases that emerge in Australia, especially from livestock and wildlife. Some 60% of recent (1940–2004) new and emerging diseases have their origins in animals. It is these diseases in particular that will continue to surprise and challenge us. For example, it took several years to investigate and determine that the cause of Tasmanian devil facial tumour disease was a transmissable tumour. We do not have good processes in place to investigate and prioritise diseases of wildlife.

Hendra virus first caused an outbreak of disease in humans and horses in Brisbane in 1994 and regular outbreaks have occurred since then, the most recent being in 2008 (Text Box 3). Menangle and Bungowannah are two diseases that have emerged from pig herds in Australia, the former being able to infect humans. Australian bat lyssavirus, a virus closely related to rabies, caused two deaths in bat carers in 1996 and 1998. The Hendra and Menangle viruses, and Australian bat lyssavirus, are carried by fruit bats.

Text Box 3: Hendra virus outbreaks in Queensland 2008

The most recent Hendra outbreaks of concern occurred in July 2008, when infected horses were identified at a veterinary clinic in Brisbane and in a separate outbreak in northern Queensland. At the Brisbane clinic, two staff members were also infected, one of whom died. In the Brisbane outbreak, three horses died and others were destroyed. All four species of flying fox (fruit bats) in Australia have been shown to carry the virus but do not show symptoms of disease. Evidence of infection has been found in bat colonies from Darwin across to the east coast and south to Melbourne. Infection in horses appears to be associated with transfer of virus from infected bats, and the infection appears to be passed from infected horses to humans through close contact. The Hendra virus outbreaks highlight the need to involve the human health, animal health and wildlife disease sectors in order to mount an effective response.

A closely related virus spread by bats, Nipah virus, severely impacted the Malaysian pig industry[22,23] in 1999 following transmission to humans, with a fatality rate of 38%. Since 2001, Nipah virus outbreaks in Bangladesh and West Bengal, India[24,25] have caused 152 deaths (at a fatality rate of 73%). For the first time, there is strong evidence human-to-human transmission of the Nipah virus through aerosol and ingestion.

Conclusion

The recent analysis provided in Figure 2 reveals a steady increase in epidemic prone disease events over the last 60 years or so. It seems likely that this trend will continue. Some of these events are caused by new or previously unknown infectious agents and some by the re-emergence of known diseases previously thought to be controlled. We therefore need to be prepared for unexpected disease outbreaks. Such outbreaks may have major consequences through mortality and illness, and significant economic impacts.

Australia is not immune from these diseases. The risks lie in three main areas. Diseases may enter Australia through our northern borders, or through sea ports and airports, or they may emerge from our own livestock or wildlife. In order to be better prepared to prevent and respond to disease outbreaks, it is important that the risk factors are identified and that, where possible, the risks are minimised.

Chapter 2: A changing world: Factors in emergence of infectious diseases

Introduction

This section presents the key factors likely to influence the occurrence of disease epidemics in Australia. These factors may interact and may affect:

- the disease causing organism, its vector and/or its host:
  - population growth and spread
  - movement and settlement
- host susceptibility to disease
- the risk of host exposure to unfamiliar viruses or bacteria.

These factors include the direct and indirect effects of climate change, in addition to other factors such as increased mobility and changing land use patterns. These are discussed briefly below.

Climate change

Climate change is likely to have significant impacts globally[26] and in Australia, and may result directly and indirectly in changes to human and animal disease patterns. These changes may affect disease incidence through impacts on the disease causing organism, on the vector, or on the host distribution. The extent and nature of these changes are not always predictable[27], but the impacts of climate change on global disease patterns will be profound[28].

An integrated and multidisciplinary approach will be necessary to manage these potentially complex changed patterns, in the context of potential water and food insecurity, vulnerable human settlements, extreme climatic events and population migration; these factors may change disease patterns in complex and interdependent ways which are not fully predictable.[29]

Already weather-sensitive disease events have led to health impacts from climate change. For example, short-term temperature increases in highland areas of Kenya are considered to have caused increased malaria transmission in populations without previous exposure; additional factors are also likely to include deforestation and the creation of breeding sites alongside roads and railways.[30]

The impacts of climate change on disease risk may be either direct (e.g. through the effects of increased temperature on a vector) or indirect (e.g. through changed production systems to address climate change).31 The recent spread of bluetongue into northern Europe provides a good example of the potentially significant direct impacts of increased temperature on disease patterns (Text Box 4).

Text Box 4: Movement of bluetongue virus and climate change

Bluetongue is spread by biting midges which have recently colonized the northern Mediterranean coast. Since 1998, rising temperatures appear to be linked to outbreaks of bluetongue across most of Europe, which have killed over 2 million animals, mainly sheep. It is the largest outbreak on record. Warmer weather increases the rate of infection and of virus replication in midges, and increases their activity in more northern areas. The outbreak in 2006 started in the Netherlands, where temperatures were 6°C higher than previously recorded. Mild winters may also allow infected midges to survive in sufficient numbers to maintain a reservoir of the disease.

It appears that there has been a fundamental shift in the spread of bluetongue that is linked to climate change. Northern Europe is now at significant risk from further incursions of bluetongue virus as well as other insect transmitted viruses, some of which can also infect humans.

Australia is also at risk from bluetongue. Midges carrying bluetongue virus come into northern Australia every summer, most likely carried by the monsoon. Two new bluetongue serotypes have been found in Australia since 2007.

(Stephen Prowse, pers.comm.)

Australia's vulnerability to epidemics will be heightened in a changed climate through the effects of changes in temperature patterns, rainfall, water storage and extreme weather events. These changes may increase our vulnerability and may decrease our adaptive capacity unless significant preventative measures are put in place.

Recognition of these many influences on the risks posed by emerging infectious diseases should prompt us to adopt proactive threat identification and mitigation strategies. A "One Health" or "One Biosecurity" approach is needed to address future challenges. This would encompass human and animal health, and environmental health, using cross-disciplinary analysis and multifaceted coordination.

Temperature

For mosquito-borne diseases, higher temperatures could lead to more rapid development of mosquito larvae, shorter times between blood meals, and shorter incubation periods for infections within mosquitoes.

It is expected that mosquito population size will increase faster, and mosquitoes may live longer.[32,33] Furthermore, higher minimum temperatures might assist larval survival in winter and extend the distributions south. Higher temperatures may also change human behaviour, including increasing outdoor activities and thus exposure, but also may keep people indoors.

Rainfall

Rainfall plays an important role in the transmission of vector-borne diseases, since insect vectors require water to support their development. Strong association of increased disease risk with increased rainfall is shown in studies of Ross River virus infections in Australia.[34] In some areas of Australia, climate change is forecast to lead to decreased rainfall which can potentially reduce the range of insect vectors of disease.

Some human respiratory virus infections, particularly influenza, are highly seasonal. While the reasons are complex and not fully understood, evidence that low absolute humidity favours the survival and transmission of influenza viruses suggests that climate change may alter the regional distribution and frequency of influenza epidemics.[35]

Water storage

The increasing population in urban and semi-urban areas in Queensland, coupled with the recent drought and water shortages, has contributed to the widespread use of water tanks and other water storage containers. These provide suitable living and breeding environments for *Aedes aegypti*, the main vector for the dengue virus.[36,37] This is discussed in Text Box 5.

Changes in land use, population distribution and rainfall, and the increased use of recycled water and ground water in areas of drought, all have the potential to lead to epidemics caused by water-borne microorganisms.[38,39]

Text Box 5: "Back to the future" – water harvesting and dengue

The major mosquito vector of the dengue virus, *Aedes aegypti*, is widespread in Queensland (but not in Brisbane). The provision of reticulated water (eliminating the need for rainwater tanks) has been cited as one factor in the disappearance of *Aedes aegypti* from southern regions of Australia. Today, drought and water restrictions have led to significant changes in household behaviour. There has been a steady increase in domestic collection and storage of water, which is of concern, as it provides a habitat for *Aedes aegypti* in urban areas.[40]

Surveys in Brisbane from 1995–1997 found no mosquitoes in domestic water storages. However, in 2008, 45–57% of households had one or more rainwater tanks, and 25–32% of households stored water in other containers. These informal storages accounted for up to a third of the larval mosquito population sampled in some suburbs (T. Hurst, QIMR unpublished data). Furthermore, while most tanks are in good condition now, ongoing tank maintenance is essential to ensure continued mosquito exclusion.

We could be creating a *"Back to the Future"* scenario. Western Australia, Northern Territory, New South Wales and Queensland had previously sustained both *Aedes aegypti* and dengue virus outbreaks. For example, in Brisbane in 1904–05, 50–75% of the 125,672 population was infected with dengue, causing 94 deaths.[41]

Extreme weather events

Extreme weather events such as cyclones and storms increase the possibility of flooding, and of high winds with associated dust movements. These events can facilitate infectious agent movement and insect incursion.[42] In addition, such events increase the risk of enteric infections following contamination of drinking water and destruction of infrastructure. More extreme weather events have been predicted and these have already been associated with incursions of infected insects by a process called vector 'dumping', whereby clouds of midges may be picked up and carried hundreds of kilometres by high altitude winds, which later sweep them back to ground level. For example, the occasional entry of bluetongue virus into northern Australia is attributed to the insect vector coming into Australia from south east Asia via the southern extension of the tropical monsoon.

Mobility of humans, animals and food

Increased mobility of humans, animals and agricultural produce carries with it the risk of exotic disease importation into Australia, and rapid worldwide spread of infection. Even with border controls and quarantine requirements in place, infectious agents can still enter Australia, for example in asymptomatic human or animal carriers.

There are numerous examples of how increased mobility has led to the spread of infection, or to the introduction of exotic diseases into Australia. One is the rapid spread of human influenza viruses along travel routes, as seen in the current 2009 A(H1N1) epidemic. Another is equine influenza: prior to 2007, Australia was one of only three countries worldwide considered free of this disease[43] (Text Box 6).

Text Box 6: Equine influenza 2007

An example of the effect of globalised trade on animal epidemics

Globalisation with the resulting increase in the trade of animals and animal products has increased the risk of spread of infectious diseases. For example, equine influenza was introduced through the importation of thoroughbred stallions. This epidemic led to the infection of nearly 80,000 horses across New South Wales and Queensland before the disease was contained and eradicated.[44] This is the first time that any country has been able to eradicate this disease. CSIRO, NSW DPI, QDPI&F, DAFF, AHA and the AB CRC all played critical roles in the eradication program. Direct costs to the Australian Government were approximately AU$ 350 million. However, indirect costs to both industry sectors and government were also high. For example, the thoroughbred industry estimated indirect costs to their industry of AU$ 1 billion.[45] Significant social costs were also borne by all sectors of the horse industry.[46]

A subsequent inquiry (the Callinan Inquiry)[47] found that the failure of existing processes led to the introduction of the virus.

Dengue fever is another example of population movement being associated with disease transmission. Increased potential for dengue transmission is associated both with increased mobility due to more affordable jet travel, and with increasing rural to urban migration (especially in Asia).

Since its re-emergence in 2003, the highly pathogenic avian influenza A(H5N1) ("bird flu") virus has caused devastating disease in domestic poultry, leading to the death from disease or culling of hundreds of millions of ducks and chickens. The virus is known to have infected more than 420 humans with about 60% mortality. Today highly pathogenic H5N1 is endemic in poultry in some countries, notably Indonesia, and continues to cause serious human infections, including at least 23 in Egypt in 2009 to date. Although migratory birds are thought to have contributed, the most important factors in the spread of this virus throughout south east and central Asia into Europe and Africa have been the mingling of birds in live bird markets and the transport of infected poultry or poultry products. The dependence of many people in developing countries on poultry for income and food, and the difficulties in controlling cross-border trade, mean that there is currently little prospect of controlling the spread of this virus in large areas of the world and it remains a significant pandemic threat.

Other factors

Prosperity and poverty

Changes in prosperity – either positive or negative – may alter disease patterns.

Increasing prosperity may result in increased demand for animal protein. This drives more intensive livestock production systems in developing countries, which may lack the infrastructure necessary to support such systems. For example, the establishment of large piggeries in combination with the rapid growth of the horticultural industry in Malaysia close to tropical rainforests and orchards resulted in an outbreak of the Nipah virus. The virus spread from fruit bats to pigs, which subsequently infected pig farmers. Similarly, the shift from traditional mixed homestead farming in south east Asia to intensive single-species farming (Figure 4) provides an environment in which large-scale epidemics can develop[48] and spread rapidly. Furthermore, increased prosperity has resulted in increased global trade, which in turn has the potential to contribute to the rapid spread or emergence of infectious diseases. Thus the farming practices of the region may have an impact on epidemic risk in Australia.

Figure 4: The changing pattern of farming in south east Asia

Top: traditional mixed homestead; Bottom: intensive single species industry.[49]
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Decreasing prosperity results in pockets of regional poverty, particularly in urban slums, which also contribute to the spread of infectious diseases. Poor public health infrastructure in these areas means that disease outbreaks are difficult to control, which then poses a risk to neighbouring countries.

Furthermore, the importation of products from countries with poor sanitary practices has the potential to spread diseases. The importation of buffalo meat from India to Indonesia and Malaysia, for instance, may lead to the spread of foot and mouth disease in the region.

Changing land use

Due to rapidly increasing human population densities and the demands placed on food production systems, there have been substantial changes in land use in Australia and in our region as a whole. The spread of many infectious diseases has been linked to changing land use, including the building of dams.[50] Further, deforestation and the spreading of farms into areas close to wildlife habitats have resulted in greater potential for contact between wild animals, domestic animals, and humans.[51]

For example, fruit bats may feed in cultivated areas and thus may indirectly contaminate animal and human food and water sources, leading to infection with Hendra and Nipah viruses.[52]

Changing livestock production technologies

Furthermore, the practice of feeding livestock with protein derived from livestock caused the spread of BSE.

Demographic changes

Human and animal populations inevitably change in composition and location, and these changes can alter disease emergence, host distribution, exposure risk and spread, and associated illness and mortality rates. Significant demographic changes can be expected as a consequence of climate change.[53]

Drug resistance

When infectious agents are exposed to therapeutics (such as antibiotics or antiviral agents) or to host antibodies induced by vaccines, evolutionary pressure will select for strains able to survive. Of particular concern is sub-optimal use of human or animal therapeutic drugs, increasing the potential for development of resistant strains. For example, feeding low levels of antimicrobial drugs to livestock leads to the development of drug-resistant bacteria capable of infecting large numbers of animals and therefore to widespread disease outbreaks. The potential exists also to have antibiotic resistant organisms transferred to humans via food.

Drug resistance has proven to be a particularly significant issue with infections such as tuberculosis that require long courses of drugs. This and some further examples of drug resistance are discussed briefly below.

Tuberculosis resistance

Similarly, the slow progression of tuberculosis and the need for long and complicated drug treatments mean that the risk of developing antibiotic resistant strains of tuberculosis is real. Many factors contribute to these failures including addition of a single drug to a failing regimen, failure to recognise resistance, inadequate initial regimen, and failure to address patient non-compliance.[54] Multi-drug resistant strains have become a problem in many countries in our region.

Methicillin resistant Staphylococcus aureus

Methicillin resistant *Staphylococcus aureus* (MRSA) has become established as a major cause of protracted stays, injury and death in our hospitals. We are also experiencing an epidemic of community-acquired MRSA (CA-MRSA) infections[55] which have no connection with health care institutions. One highly pathogenic strain has recently arisen in southern Queensland. The Australian Council for Safety and Quality in Health Care is addressing the problem of MRSA in health care establishments.

Influenza resistance

Antiviral drug resistance in influenza virus is a current concern, with Tamiflu®- resistant strains of human influenza and avian H5N1 viruses being reported. Because these viruses evolve so rapidly, intense research is required to develop a range of antiviral agents that act on different targets as the virus enters, replicates and exits from the host's cells.[56] Further information is in Text Box 7.

Text Box 7: Antiviral drug resistance in influenza viruses

The antiviral drugs oseltamivir (Tamiflu®) and zanamivir (Relenza®) were developed specifically to inhibit influenza viruses. Until early 2008, resistance had been seen only occasionally in seasonal and highly pathogenic avian A(H5N1) ("bird flu") influenza viruses isolated from Tamiflu-treated patients. In early 2008, however, it was recognised that a significant number of seasonal A(H1N1) viruses circulating in the northern hemisphere were resistant to Tamiflu and that these viruses were spreading in the absence of Tamiflu use.[57] A single mutation in the viruses was responsible for this resistance. During the 2008 winter in the southern hemisphere, 94% of A(H1N1) viruses isolated from Australian patients were resistant[58], again despite very little use of the drug in this country, and, in the most recent northern hemisphere winter, 98% of A(H1N1) viruses analysed in USA and Europe were Tamiflu-resistant. These viruses are sensitive to Relenza.

Influenza viruses of the A(H1N1) subtype represent only one of the three groups of influenza viruses that have circulated in humans over the past 30 years (until the new swine-lineage A(H1N1) viruses emerged in 2009). The emergence of resistance in this group has nevertheless caused global concern, first because it removes one line of defence against influenza and, second, because it raises the possibility that Tamiflu resistance might also emerge in A(H5N1) and the new 2009 A(H1N1) viruses. Many governments are now reconsidering the balance of Tamiflu and Relenza in their pandemic stockpiles.

(Anne Kelso, pers.comm.)

Vaccinations

Incomplete vaccination coverage can lead to the re-emergence of infectious diseases. In some developing nations, inadequate health care resources, lack of access to isolated populations and community distrust have meant that epidemics of common infectious diseases, such as measles and polio, continue to occur despite the availability of effective vaccines. As a result, the WHO's goal of polio eradication by 2000 has not yet been achieved although the polio virus has been eliminated from most countries of the world.

Incomplete vaccination coverage can also be an issue in countries such as Australia, when the choice of individuals not to be vaccinated for personal reasons or because of concern about adverse events, leads to a reduction in population immunity.

The emergence of mutations that allow an infectious agent to escape vaccine-induced immunity can reduce vaccine effectiveness. For example, because of continuing mutation of human influenza viruses, seasonal influenza vaccines must be updated with new strains almost every year, yet are still unable protect the population against a new pandemic influenza virus.

Conclusion

Many of the drivers of the emergence of infectious diseases noted in this chapter are inter-connected. Climate change, increased mobility of humans and animals, and other factors such as changing land use and livestock production technologies, can have significant influences on the emergence of infectious diseases. These changes may interact in complex and unpredictable ways.

Chapter 3: Gaps, Needs and Recommendations

Human capacity

The key weapon in the fight against emerging epidemic diseases are preparedness and agility founded on human capacity. It is essential that Australia has a well-trained national workforce which can research, monitor and respond to epidemic disease threats.

The current influenza outbreak may provide an opportunity to review national human epidemic response capacity and associated arrangements, as was the 2007 equine influenza outbreak a stimulus to review our quarantine system. The resultant Beale report provided recommendations for significant changes to the current quarantine and biosecurity arrangements.[59]

Research into infectious diseases of humans and animals underpins much of our national capacity to investigate and respond to disease outbreaks such as those detailed in Text Boxes 1, 2 and 3. Some key institutions working in these fields are noted in Text Box 8. It is noted that these and other institutions are undertaking a wide range of research in fields relevant to addressing the challenges posed by potential epidemics.

Text Box 8: Key Australian institutions working on disease emergence

Commonwealth, State and Territory Government agencies responsible for human and animal health, and environmental matters

CSIRO – Australian Animal Health Laboratory (AAHL) and other CSIRO groups

Universities – almost all universities have some capacity in this area

Research Institutes and Cooperative Research Centres, including the following

Queensland Institute of Medical Research

The Walter and Eliza Hall Institute of Medical Research

Burnet Institute

The Nossal Institute for Global Health

Peter Doherty Institute for Infection and Immunity

Menzies School of Health Research

Australian Biosecurity Cooperative Research Centre for Emerging Infectious Disease

Australian Centre of Excellence in Risk Analysis

Australian Biosecurity Intelligence Network

The best defence against future epidemics is to ensure that we develop, foster and maintain broad capacity over a wide range of skills such as virology, entomology, pathology, epidemiology, taxonomy, biostatistics, and public health.

A recent economic analysis of key investments in research by the AB CRC showed returns on investment ranging from 11% to 92%[60].

While we do have systems for coordination, surveillance, surge response, and intervention, we have been fortunate that:

- we have not had more epidemic emerging infectious diseases to deal with
- we have not had to deal with a highly transmissible and lethal emerging infectious disease yet
- we have not had to deal with a sustained outbreak of such an emerging infectious diseases (i.e. one lasting months to years).

While it is recognised that as a small nation we are unable to cover the full range of expertise in all fields, we need to have sufficient capacity to provide flexibility in our preparedness for dealing with epidemic diseases.

Furthermore, we need to possess expertise at the highest international level in many areas in order to provide a tradeable knowledge base that will allow access to overseas expertise. An example is the earlier strong research profile in virology that allowed Australia to become a major international contributor in the times of Burnet, Ada, and Fenner. However, while there are isolated current pockets of strength, we are losing our expertise in this critical discipline.

Critically, we need active ongoing monitoring of the demand and supply of essential epidemic-relevant expertise, in order to respond to the changing global environment. Currently, independent *ad hoc* decisions by authorities, government agencies and educational institutions may cause unintentional shortfalls in the breadth, depth and availability of essential expertise in Australia. National workforce planning is required for this critical field, encompassing the many disciplines required.

A recent report[61] outlined gaps in the ageing cohort of Australian taxonomists. Of particular relevance to this work is the potential shortage of entomological taxonomists; these specialists are at the front line in the identification of potential disease vectors. One example of our vulnerability in the area of entomology is our reliance on overseas expertise on midges – the vector for bluetongue viruses. One of two Australian midge experts died during the course of compiling this Expert Working Group Report, and the other is retired (aged 81). Australia has limited domestic capacity to fill the gap when this expertise is no longer available.

Another example is the recognised Australian shortage of animal health specialists. Diagnosis and management of animal disease requires a wide range of expertise, including pathology, virology, and bacteriology; anticipated Australian shortages in the relevant disciplines have been clearly identified.[62]

Recommendation 1

In order to underpin our preparedness to deal with emerging epidemic diseases we recommend that:

Australia possesses the human capacity to combat potential epidemics

The nation must be prepared and sufficiently agile to deal with unexpected epidemics. This requires that we develop, maintain and retain skilled people through:

- conducting ongoing national workforce planning for expertise in human and animal epidemic diseases; and
- boosting higher education and research training in areas of need.

Information

The detection of emerging and introduced diseases in Australia is as important as the awareness of external threats. It is essential that we have the internal capacity to monitor both human and animal health at a local level, and to transmit, collate, analyse and interpret that information as part of our epidemic preparedness.

Currently this capacity is being developed in part by the Australian Biosecurity Intelligence Network (ABIN), which builds Australia's biosecurity capability through the provision of internet based IT infrastructure, analytical tools, and expertise to facilitate virtual collaboration, networking and sharing of information. However, the capacity to analyse and interpret this information is not yet completely established. The ABIN program is funded until 2010, and currently there is no projected replacement.

Furthermore, the ability to process domestic information on epidemic diseases is part of our broader commitment to provide this information multilaterally overseas. Indeed, Australia has a particular responsibility through its WHO International Health Regulations (IHR) role to assist with the development of capacity in the region.[63]

Recommendation 2

In order to provide early warning of the emergence of epidemic diseases we recommend that:

Australia possesses a long term biosecurity information collection, analysis and interpretation capability

Capability must be developed and maintained to collect, analyse and interpret disease surveillance information. This must be secured by:

- creating an ongoing, effective national human and animal disease information system; and
- integrating this system with similar systems operating overseas.

Forward regional engagement

The possession of up-to-date information on disease occurrence is an essential part of our preparedness strategy for disease prevention. A key element in this strategy is collaborative forward engagement with regional nations to share this information.

Currently Australian institutions and scientists have relatively effective individual relationships with regional disease researchers and other professionals, but these are usually *ad hoc* and rely on personal contacts. Often they are formed during the education of overseas experts in Australia, which then provides an ongoing network of key individuals. There are also some Australian Government capacity building and collaborative research programs (e.g. through AusAID) which assist this process.

Information flow is also needed at a higher level to enable government agencies to exchange information and expertise, but as experience with outbreaks such as SARS indicates, this is often incomplete. It is therefore important that political engagement at an even higher government-to-government level exists to drive such imperatives through diplomatic channels.

To enhance this strategic forward engagement, the higher education and human/animal health sectors in Australia should participate in the development of regional capacity. This enhanced engagement will further augment the regional network of personal contacts already mentioned as important at the individual health researcher/practitioner level.

Recommendation 3

In order to enhance our wider ability to deal with emerging epidemic diseases we recommend that:

Australia develops forward regional engagement to mitigate potential epidemics

Australia needs to commit human and other resources to engage our region on disease surveillance, preparedness and mitigation, through capacity building and collaboration. This requires that we develop political, scientific and technical relationships with our neighbours, at multiple levels, to reduce human and animal disease risk to Australia and the region by:

- establishing an active ongoing cross portfolio mechanism involving PM&C, DFAT, DoHA, DAFF, DIISR, DEEWR and other relevant agencies dedicated to managing and supporting effective regional engagement; and
- assisting regional countries to meet their obligations under the WHO International Health Regulations and the World Organisation for Animal Health requirements through:
  - supporting development of collaborative regional surveillance and early warning systems; and
  - developing regional expertise through professional training and higher education in Australia and in the region.

Vaccine production

Although the entry and spread of new infectious agents can be restrained to some extent through border controls, quarantine, personal protective equipment and the strategic use of antiviral drugs or other medicines, vaccination remains the most effective long-term means of minimising illness and deaths due to infection. However, the production of vaccines requires highly specialised facilities and skills. Global demand may therefore limit Australia's ability to obtain vaccine supplies from offshore (e.g., in an emerging influenza pandemic).

Vaccine production *capacity* is therefore an irreducible component of our epidemic preparedness. Australian capacity resides with CSL Limited, formerly the Commonwealth Serum Laboratories and now a public company subject to commercial imperatives.

Such commercial imperatives do not always coincide with national interest. A case in point is the former CSL production line for Q fever vaccine for the livestock industry. A commercial decision was made to remove the plant, which was subsequently rebuilt with Commonwealth funding because of continuing need for this vaccine.

A mechanism must therefore be available for securing the production not only of vaccines which are important commercially, but also of vaccines which are of national importance.

In recent years, much progress has been made in vaccine design and development. One example is the creation of artificial non-infectious pathogens, such as the virus-like particles used in the human papillomavirus (cervical cancer) vaccine developed by Professor Ian Frazer and Dr Jian Zhou and then by CSL Limited. Another is the development of new adjuvants – materials that improve the induction of immunity by vaccines and/or reduce the amount of vaccine needed to achieve protection. The retention of Australian capability in the development and application of new vaccine technologies is critical to national preparedness. Together with local production capacity, such capability also provides Australia with internationally tradeable know-how.

A range of mechanisms is potentially available, from outright government investment in CSL Limited to the provision of retainers for vaccine production capacity in particular areas. The latter arrangement is currently being employed by Animal Health Australia to provide vaccine production capacity for foot and mouth disease.

Recommendation 4

In order to secure the front-line defences needed to deal with emerging epidemic diseases we recommend that:

Australia has a self-sufficient vaccine development and production capacity

Australia needs to retain and enhance its onshore development and production capacity for vaccines. This is essential for domestic preparedness and, as importantly, to enable access to the latest overseas expertise and technology in this field. The focus should be on the onshore development and production capacity for:

- contemporary influenza vaccines; and
- niche vaccines, particularly in the context of future Australian needs.

Coordination

A changing world means that there are unexpected challenges which require continuous refinement of our preparedness for epidemic diseases. The recommendations above highlight the need for ongoing cross-portfolio coordination of:

- human capacity building, maintenance and retention
- information collection, analysis and interpretation; and
- regional engagement and collaborative capacity development.

Furthermore, it should be noted that a series of related but separate Government programs which support epidemic preparedness are funded only until 2010. These include ABIN, the AB CRC, and the Public Health Education and Research Program (PHERP). These are the result of separate decision-making processes, and provide an example of changes in capacity which should be monitored and, if necessary, addressed through a whole-of-government approach.

Indeed, there is a need for "One Health" or "One Biosecurity" approaches to epidemic prevention which recognise the integration of humans and animals with their surrounding environments. In this context, it is important to remember that some 60% of emerging and re-emerging human diseases in the period 1940–2004 years were linked to animals.[64]

This Report notes the cross-portfolio approach to disease *response* which is present in, for example, the Australian Health Management Plan for Pandemic Influenza. The same philosophy pervades the recent Beale review of Australia's quarantine and biosecurity arrangements.[65] We also note the commitment of the Australian Government to implementation of many key recommendations detailed in the Beale review.[66] The 2009 Federal Budget Statements address many of the individual elements in this Report, including establishment of a national Biosecurity Advisory Council and significant organisational changes in relevant Australian Government agencies.

What we would like to emphasise here is the application of a whole-of-government approach to the key epidemic disease preparedness measures outlined in this Report.

Recommendation 5

In order to better coordinate our ability to deal with emerging epidemic diseases we recommend that:

The Government establishes the cross-portfolio arrangements essential for effective implementation of Recommendations 1, 2 and 3 as a matter of immediate priority.

Conclusion

Science and innovation will provide the key to safeguarding Australia's future. This report focuses on ensuring that the nation is well placed to deal with the effect of global changes on the occurrence and spread of epidemic diseases.

We take as a starting point that our current operational response to disease control is effective — and has been in recent times for disease events which have not resulted in major global epidemics. The recommendations presented here will provide Australia with the preparedness and agility to cope with the unknown challenges of a future world that we can expect will provide a substantively different environment for epidemic disease.

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Appendices

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The Expert Working Group benefitted greatly from the input of Dr Andy Carroll, the Chief Veterinary Officer, who served as an Expert Advisor.

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Appendix 2: Detailed Terms of Reference

The PMSEIC Expert Working Group on the thematic issue of epidemics will address the issue both from a national and international perspective. It will prepare a written report (a full technical report including a summary for policy makers) and a presentation for the PMSEIC 5 June 2009 meeting that presents a strategic viewpoint by:

1. Identifying key emerging risks and threats for spontaneous pathogen-mediated epidemics in Australia in the context of climate change over the next few decades.[1]
2. Identifying and summarising information on current measures, strategies, and related technologies that could assist in anticipating and mitigating the risk and impact of epidemics.[2]
3. Identifying the key factors likely to improve uptake of pre-emptive measures, strategies, and technologies.
4. Determining any gaps in and constraints to research and development in these areas, including those related to human capacity and to any intellectual property ramifications across jurisdictions.
5. Outlining current research, on a continuum from basic to applied, to prevent challenges posed by epidemics and mitigate their impact.
6. Identifying developments in forecasting, containment and prevention of epidemics (e.g. likelihood of zoonosis and of the emergence of new and highly virulent and drug-resistant pathogens through mixing of existing strains, and prevention through the potential use of vaccines).
7. The Expert Working Group will report its findings to PMSEIC and make recommendations on ways forward for Australia to address challenges posed by epidemics.

1 Disease focus will include, but need not be restricted to, human influenza, avian influenza, equine influenza and Hendra virus infection, multi-drug resistant tuberculosis and vector-borne diseases such as viral encephalitis, dengue fever and malaria, other relevant diseases, such as measles and polio, which may be endemic in areas that are sources of migrants to Australia.

2 Consideration should be given to existing policy and regulatory regimes, surveillance and monitoring infrastructure, coordination mechanisms across national and international boundaries, Australian investment in capacity building in the Asia-Pacific region to assist in controlling outbreaks and reducing risk of exposure to Australia, the link between food production practices and the risk of epidemics, quarantine and border security, immunisation status and vaccination of target populations both in Australia and within the Asia-Pacific region, and potential cost, availability and registration status of vaccines and medications especially in the context of an international crisis, and centralising of manufacture, stockpiling and distribution of relevant treatments and medications.

Appendix 3: Selected Infectious Agents

Brief notes on some infectious agents and diseases are below.

Vector-borne Infections

Dengue viruses (Dengue haemorrhagic fever)

- Four different viruses transmitted by container breeding mosquitoes. Regular large scale epidemics in Australia from 1886 until 1954–55, then in 1981 reappeared in Queensland after an absence of 26 years. Epidemics from 1990s onwards in most years, including more than 1000 cases in north Queensland in 2009.
- Downgrading of mosquito surveillance and control, public awareness good but lack of motivation to address a problem associated with the household; increasing in-bound travel from Asia, Papua New Guinea where dengue is endemic; poor water supply and other infrastructure.
- High levels of infection with mortality possible, driven in part water storage in households due to drought re-creating old scenario; potential for dengue to spread to south of Queensland.

Chikungunya virus

- Was a moderately innocuous mosquito transmitted virus from Africa which caused 261,000 cases in Indian Ocean islands and approximately 2 million cases in India from 2005–2007.
- Inadvertent transport of *Aedes albopictus* eggs via cargo especially car tyres and lucky bamboo (*Dracaena*); virus mutation; inadequate border inspection; no sustainable broad scale control program.
- Vulnerability high but full risk assessment is needed.

West Nile virus

- A mosquito transmitted virus involving mainly birds as hosts.
- Infections can cause severe neurological illness and death in humans and horses. The virus was declared endemic to the USA in 2002, having caused 4156 human infections and 284 deaths across the US with many thousands of horses infected and euthanased.
- Virus has spread into Canada, Mexico, Caribbean and South America; presence of virus in India, Malaysia and Sarawak could suggest pathway into Australia via an infected traveller as does a confirmed horse infection into Sydney.

Japanese encephalitis virus

- A mosquito transmitted virus associated with pigs and birds originally not in Australian geographic region; 30,000-50,000 cases annually throughout Asia.
- Considerable economic implications for trade and tourism as well as health care cost; small number of human infections in Torres Strait and north Queensland.
- The virus is best transmitted to those strains of mosquito whose distribution is geographically confined to the Torres Strait and the northern area of Cape York but potential for spread in Australia generally.

Malaria

- Parasites carried by Anopheles mosquitoes, causing over 500 million cases and 1 million deaths per year; malaria is endemic in 10 Asia-Pacific countries.
- Breakdown of residual house-spraying programs and larval control has seen a resurgence; programs now largely replaced with insecticide-treated bed nets; development of parasite and mosquito resistance; no vaccine yet despite decades of effort.
- Thousands of infected travellers and refugees enter Australia every year; in 1981 WHO declared Australia to be malaria free.
- Although risk of importation is high, good surveillance and diagnostics ensure risk of establishment is low.

Bovine Ephemeral Fever

- A disease of cattle transmitted by midges (buffalo can also become infected but do not show clinical signs).
- Seasonal epidemics in northern Australia cause significant loss to the cattle industry and the disease sporadically moves as far south as Victoria with prevailing winds during warm wet weather.
- There is an ongoing risk that the spread of this disease into the south could become more frequent with prolonged warm wet seasons.

Bluetongue virus

- A virus of ruminants carried by biting midges which mainly causes disease in sheep (cattle carry the virus but do not usually show clinical disease).
- Multiple strains have been isolated in Australia.
- The virus is found predominantly in moister northern regions of Australia.
- There is concern that more virulent strains will enter Australia from the north; recent experience in Europe has shown that this disease can have rapid geographical spread (some link this to global warming) and can start causing clinical disease in cattle.

Bat-Related Viruses

Australian bat lyssavirus

- A virus carried by bats that is very closely related to classical rabies and causes a rabies like disease in humans.
- Contact between an infected bat and a person can result in disease.
- Not considered an epidemic threat but pressure on bat ecosystems may cause greater exposure of humans to bats.

Hendra and Nipah viruses

- These are two related viruses (Hendra virus is found in Australia) that are carried by bats with occasional spillover to other animals and humans.

- Hendra virus in Australia occasionally infects horses exposed to bats and infected horses have sporadically subsequently infected humans.
- The most recent outbreak of Hendra virus was in 2008. All Hendra virus outbreaks in Australia have been controlled. Nipah virus has spread from human to human in Bangladesh. Further outbreaks of Hendra are expected to occur; increasing pressure on bat ecosystems may cause greater exposure of horses and humans to bats.

Ebola-Reston virus

- An outbreak of Ebola-Reston virus occurred in pigs and humans this year in the Philippines.
- This was entirely unexpected as Ebola-Reston had never been seen in pigs.
- If human-to-human transmission becomes efficient, an outbreak beyond the Philippines becomes likely.

Infectious agents with epidemic potential

Foot and mouth disease

- Foot and mouth disease is the most important epidemic prone disease of livestock.
- Infection causes production losses as well as major disruption to trade.
- Australia must remain vigilant so that prompt and efficient control measures can be implemented if necessary.

Influenza viruses

- Influenza is a respiratory virus that causes serious seasonal infections world wide.
- Influenza viruses affect various mammalian and avian species and are usually relatively host-specific. Humans, pigs and poultry can occasionally share influenza viruses facilitating genetic re-assortment and the production of more virulent strains.
- Vaccination is effective but vaccines must be regularly updated to include new circulating virus strains.
- Three times in the 20th century, new influenza viruses emerged that caused illness and death in unusually large numbers of people around the world. Depending on the severity of disease, such pandemics may cause significant social disruption and economic loss.

Highly pathogenic avian influenza A(H5N1) virus

- Causes severe disease in domestic poultry. The virus has spread to many countries in Asia and elsewhere, carried by infected poultry or poultry products or by migratory wild birds, and is endemic in some countries.
- The virus has occasionally been transmitted to humans in close contact with infected birds but only limited human-to-human transmission has been observed. This could change as the virus changes.
- A risk remains that this disease could enter Australia via an infected person or through wild birds.

Equine influenza virus

- Caused by a strain of influenza that infects horses. It entered Australia for the first time in 2007, most likely through a breakdown in quarantine. It is highly contagious.
- Infection results in a mild illness that results in reduced performance.
- Australia is one of the few countries to have eradicated this disease and is one of only three countries with a free status.

Appendix 4: Capacity and capability to respond to emerging infectious diseases

Operational response

Understanding the factors that may lead to the emergence of an infectious disease is vital to planning responses. Australian planning is based upon the "Preparation, Prevention, Response, Recovery" principles that underpin disaster management. The principles can be clearly seen in the management of emerging infectious diseases, with great care being taken to prepare plans and to maintain surveillance and intelligence gathering, including from overseas sources. Early warning of threats or unusual events is acted upon. Responses are well rehearsed and this allows for a satisfactory recovery process to begin. A recent review of Australia's current arrangements has resulted in recommendations for significant changes to Australia's quarantine and biosecurity arrangements, as noted in the body of this report.

Threats to livestock, marine animals and plants

The Office of the Chief Veterinary Officer (CVO) coordinates national approaches to issues of animal health, residues and food safety that affect Australian agriculture, fisheries and forestry. The Office of the Chief Plant Protection Officer (OCPPO) has a similar role concerned with plant health in Australia. The Australian CVO is Australia's principal representative on these matters nationally and internationally, being our representative on the World Organisation for Animal Health (OIE). Australia has obligations to OIE for maintaining health-related standards of exports and for reporting and managing animal emergencies.

Australia's ability to respond to animal and plant disease emergencies is a function primarily of cross jurisdictional cooperation combined with active industry participation and a well defined funding structure. Responses are planned, practised and resourced, and have appropriate legislative backing.

Livestock disease

The responsibility for the management of an Emergency Animal Disease (EAD) response, planning and action is shared between all jurisdictions, livestock industries, CSIRO, private veterinarians, laboratories and animal health workers[77]. Animal Health Australia engages the Australian Government, state and territory governments, the peak national councils of Australia's livestock industries and key research, veterinary and educational organisations, in response and preparedness.

Essentially, EAD responses are coordinated by the Emergency Animal Disease Response Agreement (EADRA) and are guided by the Australian Veterinary Emergency Plan (AUSVETPLAN) and directed by the Consultative Committee on Emergency Animal Disease (CCEAD) and the National Management Group (NMG) (see Figure 5).

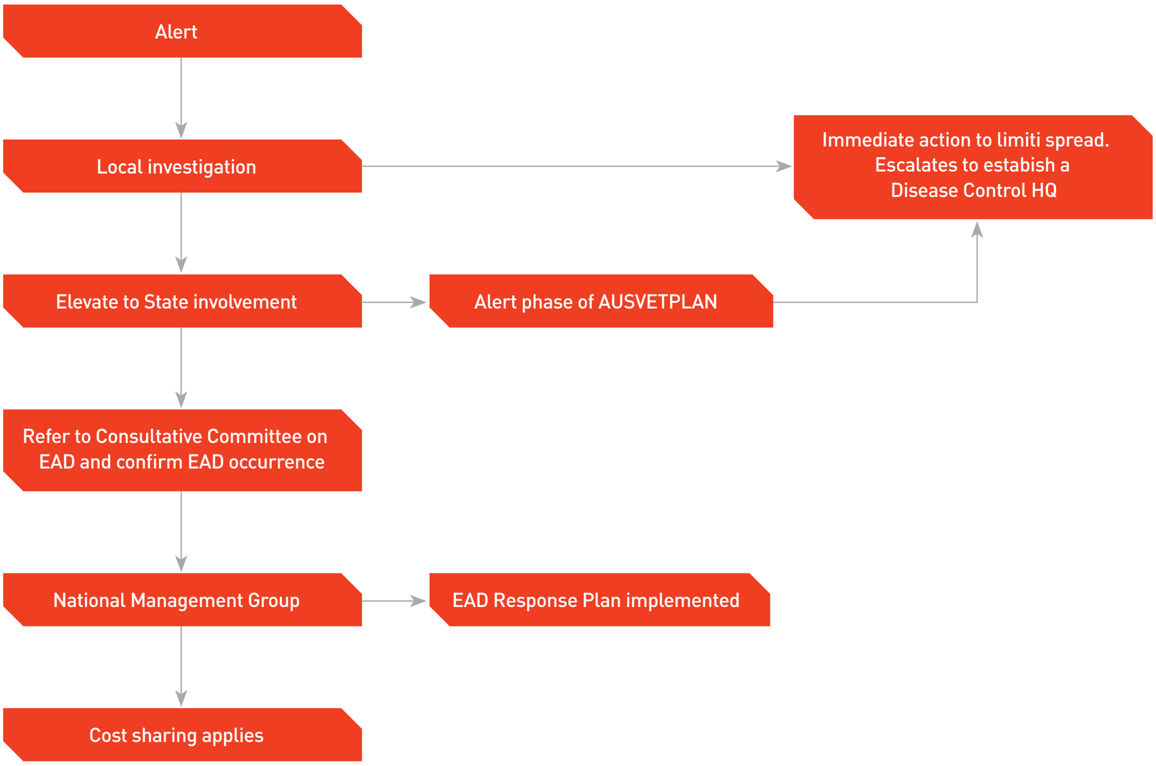

Figure 5: Conduct of an emergency animal disease response[3]

Marine animals and plants

The Aquatic Animal Health Plan details the national management of aquatic health and coordinates the national response to aquatic animal disease emergencies based on AQUAVETPLAN. Marine pests are similarly catered for. The national Office of the Chief Plant Protection Officer manages responses under PLANTPLAN. We recognise the importance of epidemics of plants and marine organisms but because of their limited capacity to cross over into humans, the EWG decided that this large and important area was outside of our brief.

Human disease

International relations

The International Health Regulations (IHR) establish a framework for effective international cooperation in monitoring, reporting, and responding to public health emergencies of international concern. This is a function of the Commonwealth Government mediated through a National Incident Room in the Department of Health and Ageing. One of Australia's key measures to implement the IHR was the passage, in September 2007, of the *National Health Security Act 2007*.

The Act's purpose is to enhance existing arrangements for sharing information about communicable disease and the occurrence of other public health events of national and international significance. The Act also implements recommendations of the COAG Hazardous Biological Materials Review.

3 Animal Health Australia. *Animal Health in Australia 2007.* Canberra. (2008)

To give effect to the *National Health Security Act 2007*, Australian jurisdictions have developed a National Health Security Agreement. The aims are to:

- formalise and enhance existing informal arrangements for the exchange of surveillance information;
- set out the operational arrangements for notifying and responding to public health events of national or international concern; and
- establish improved consultation and decision-making mechanisms to support a response to public health events of national or international concern.

The Agreement was signed by Ministers on 18 April 2008.

The Department's National Incident Room (NIR) (which is staffed 24 hours, 7 days a week) has been designated as the Australian IHR Focal Point, and has responsibility for communication with the WHO and coordination of the implementation of the IHRs.

The Department has developed emergency management coordination arrangements with Food Standards Australia New Zealand (FSANZ) and the Department of Agriculture, Fisheries and Forestry (DAFF). The protocol outlines the cooperative arrangements between the agencies that will facilitate the exchange, reporting and assessment of information, the initiation of joint response teams, the management of a response to incidents with human health impacts, and obligations under the IHRs.

Additional formal international links exist such as the Asia Pacific Strategy for Emerging Diseases (APSED)[4]. This strategy is an initiative of WHO in collaboration with Member States of the Asia Pacific Region, other UN agencies particularly the UN Food and Agriculture Organization (FAO) and the World Organisation for Animal Health (OIE), and key donors. APSED seeks to strengthen core capacities required for effective preparedness, prevention, detection and response to emerging infectious diseases that threaten national, regional and global health. Developed countries in the region such as Australia are regarded as key to the successful and sustainable implementation of the Strategy. Australia is both a donor and a key technical partner for knowledge, skills and technology transfer. Political associations and trading blocs active in the region such as ASEAN and APEC also realise the strategic importance of, and threats from, emerging infections particularly those related to travel, trade and food safety. They have a predominantly economic agenda.

Australia plays a prominent role in the WHO Global Influenza Surveillance Network, hosting one of the four WHO Collaborating Centres for Reference and Research on Influenza (the only one in the southern hemisphere) and three of the 126 WHO National Influenza Centres that monitor circulating seasonal and potential pandemic influenza viruses. The Australian WHO Collaborating Centre and the Therapeutic Goods Administration also participate in the development of the WHO's biannual recommendations on the selection of influenza viruses for inclusion in seasonal influenza vaccines for the northern and southern hemispheres and, in collaboration with CSL Limited, provide vaccine viruses and reagents to influenza vaccine manufacturers worldwide.

Australians are also involved in the Global Outbreak Alert and Response Network (GOARN) which pools human and technical resources for the rapid identification, confirmation and response to outbreaks of international importance. For instance, Australian epidemiologists and virologists played an important part in the global response to SARS.

4 WHO. Workplan for the Implementation of the Asia Pacific Strategy for Emerging Diseases 2006 – 2010. (2006)

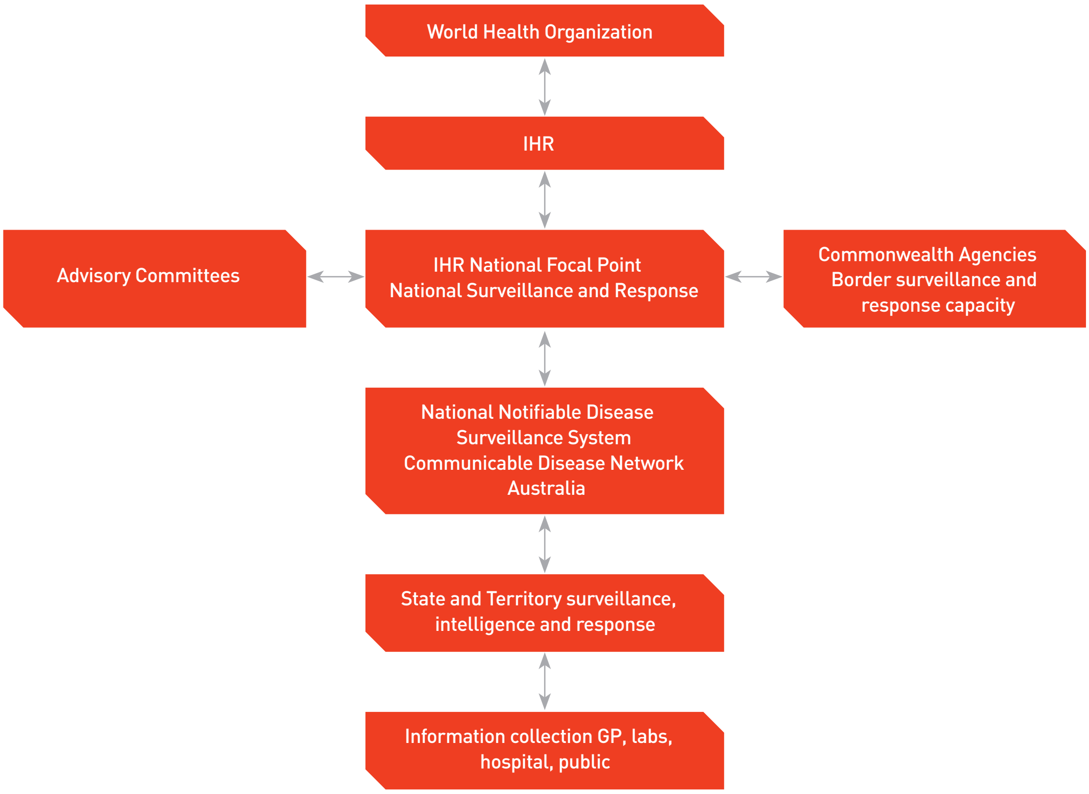

Figure 6: Flow of communicable disease information

Source: Australian Government Department of Health and Ageing

Responses to infectious disease threats to humans in Australia

The Commonwealth Quarantine Act 1908 as amended and state and territory public health law regulate the routine management of responses to infectious disease threats. It is the states and territories that conduct all surveillance of notifiable diseases and launch investigations into unusual events. Coordination of these activities is mediated through the Communicable Disease Network Australia (CDNA), supported by a range of other advisory bodies such as the Public Health Laboratory Network. The Department of Health and Ageing collates all notifiable disease data. Special collections of enteric disease data are made through OzFoodNet which has an important role in coordinating cross jurisdictional outbreak investigations.

Responses to emerging human infectious diseases differ from than those for animals; most powers to collect information and to perform public health action residing in the states and territories. Each has its own legislation and individual health systems but national approaches to surveillance and information sharing have become easier with the implementation of the National Health Security Agreement. The CDNA, comprised of the jurisdictional communicable disease epidemiologists, Commonwealth representatives and other expert members, coordinates data collections and responses and devises standard approaches to disease management. With the Public Health Laboratory Network, CDNA drafts standard case definitions that are basic to the National Notifiable Disease Surveillance System. These networks are supported by a wide range of expert sub-committees and advisory bodies.

The jurisdictional surveillance information is received by the Surveillance Branch within the Office of Health Protection. That Office has a number of other Branches that may be involved in national responses to emergencies. They include Pandemic Preparedness and the Health Emergency Management Branch. The latter has responsibility to manage the Department's participation in and contribution to whole-of-Government response to health emergencies and the health aspects of other emergencies including contributing to the Australian Health Protection Committee (AHPC), the Australian Emergency Management Committee (AEMC) and the Australian Government Disaster Recovery Committee (AGDRC). AHPC is responsible for coordinating the national response to preventing and responding to public health emergencies including communicable disease threats. It provides advice to the Australian Health Ministers' Advisory Council. The NIR, which is the IHR focal point (Fig 6) can operate continuously when a national response to a health emergency is required. It receives all material from both national and international sources and is able to brief up to Ministers, the Prime Minister and whole-of-government committees. It briefs down to jurisdictions and relevant professional groups.

High level laboratory support

There are networks of service laboratories for human and animal diagnostic work. Where highly pathogenic organisms are suspected they have the capacity to safely package specimens for transport to respective high security laboratories for confirmatory testing. Again the importance of international research links is emphasised for there will be many instances when specimens will be sent to and received from, other laboratories for detailed characterisation. For example, the WHO Collaborating Centre for Reference and Research on Influenza at the Victorian Infectious Diseases Reference Laboratory (VIDRL) is one of four such centres worldwide and analyses seasonal and potential pandemic influenza viruses submitted by many countries, particularly in the Asia-Pacific region.

Australian containment facilities

Australia as an island and with a significant geographical dislocation from other large land masses and people, has been relatively free of both animal and human disease. However with increased human mobility in particular, Australia cannot afford to rely on this premise.

One significant advantage of this disease free status has been in the livestock trade and this has enabled Australia to be a premier global exporter of both livestock and livestock products. In part to help protect this position, Australia opened in 1985, the Australian Animal Health Laboratory (AAHL), a high containment facility designed specifically to work with important infectious agents of animals and those that also affect man, that do not occur in Australia. It houses laboratories with differing levels of biosecurity for containment of infectious agents that affect animals and/or humans (PC3 for animals alone and PC4 for animals and humans) and overall there is approximately one hectare of laboratory and animal accommodation within the secure facility. At the time of opening, and through to the present time, it remains one of the most advanced high containment facilities in the world and sets world best practice in a range of biocontainment and biosafety procedures and processes. In 2008, AAHL opened a specialised Diagnostic Emergency Response Laboratory (DERL) specifically designed to deal with a surge demand for testing during an emergency disease outbreak. Under NCRIS, AAHL is receiving an AU$8 million upgrade.

AAHL currently has a complement of 280 staff, with around 160 scientists. These are engaged both in routine diagnosis activities, maintenance of a response capacity and an extensive underpinning research program.

In addition, the AAHL facility, Australia also has a dedicated human high containment laboratories at VIDRL and the Institute of Clinical Pathology and Medical Research at Westmead Hospital and a reasonably extensive network of both animal and human diagnostic laboratories. Whilst there is a continuing need to integrate this network and ensure its ability to respond to a national emergency, it does currently contain all the key capabilities to manage a major disease outbreak. Other PC3 level facilities include Scientific and Forensic Services (QHealth), James Cook University and QIMR, which currently has limited capacity but will have Australian Biosecurity Response Facility from 2012.

Appendix 5: Glossary

AAHL	Australian Animal Health Laboratory
AB CRC	Australian Biosecurity Cooperative Research Centre
ABIN	Australian Biosecurity Intelligence Network
Adjuvant	(re vaccine) A substance added to a vaccine that enhances the induction of immunity
AEMC	Australian Emergency Management Committee
AGDRC	Australian Government Disaster Recovery Committee
AHA	Animal Health Australia
AHPC	Australian Health Protection Committee
Antiviral	Medication that inhibits or stops the growth and reproduction of viruses
APEC	Asia-Pacific Economic Cooperation
ASEAN	Association of Southeast Asian Nations
AusAID	Australian Government Overseas Aid Program
AUSVETPLAN	Australian Veterinary Emergency Plan
Biosecurity	Precautions taken to minimise the risk of introducing an infectious disease into animal or human populations
BSE	Bovine spongiform encephalitis
CCEAD	Consultative Committee on Emergency Animal Disease
CDNA	Communicable Diseases Network Australia
CRC	Cooperative Research Centre
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CVO	Chief Veterinary Officer
DAFF	Australian Government Department of Agriculture, Fisheries and Forestry
DEEWR	Australian Government Department of Education, Employment and Workplace Relations
DERL	Diagnostic Emergency Response Laboratory
DFAT	Australian Government Department of Foreign Affairs and Trade
DIISR	Australian Government Department of Innovation, Industry, Science and Research
DoHA	Australian Government Department of Health and Ageing
EAD	Emergency Animal Disease

Endemic	A condition constantly present to a greater or lesser extent in a particular locality
Epidemic	An outbreak of disease or its occurrence at a level that is higher than previously existed
FAO	United Nations Food and Agriculture Organization
FSANZ	Food Standards Australia New Zealand
Globalisation	Growth of interconnectivity across national, geographical and cultural borders and boundaries
GOARN	Global Outbreak Alert and Response Network
IHR	World Health Organization International Health Regulations
Incubation period	The period between infection and the appearance of symptoms
MRSA	Methicillin resistant *Staphylococcus aureus*
NCRIS	National Collaborative Research Infrastructure Strategy
NIR	National Incident Room
NMG	National Management Group
NSW DPI	New South Wales Department of Primary Industries
OCPPO	Office of the Chief Plant Protection Officer
OIE	World Organisation for Animal Health
Pandemic	An epidemic that is geographically widespread; occurring throughout a region or throughout the world
Pathogen	A microbial agent which can cause disease, such as some viruses or a bacteria
PHERP	Public Health Education and Research Program
PLANTPLAN	National Emergency Response Plan for Plant Industries
PM&C	Australian Government Department of the Prime Minister and Cabinet
QDPI&F	Queensland Department of Primary Industries and Fisheries (now within the Department of Employment, Economic Development and Innovation)
Q fever	a highly infectious disease carried by animals which can be transmitted to humans
QIMR	Queensland Institute of Medical Research
Quarantine	Enforced isolation of infected or potentially contagious individuals in order to prevent disease spread
Reservoir	Anything (human, animal, plant, soil or other substance) in which an infectious agent normally lives and multiplies

SARS	Severe Acute Respiratory Syndrome
serotype	a microbial variant defined by immunological tests
Vector	A living agent that carries and transmits disease causing organisms between human or animal hosts (e.g. mosquitoes, ticks, midges, fleas)
VIDRL	Victorian Infectious Diseases Reference Laboratory
WHO	World Health Organization
Zoonosis	An animal infectious disease that can be transmitted to humans (plural: zoonoses)