

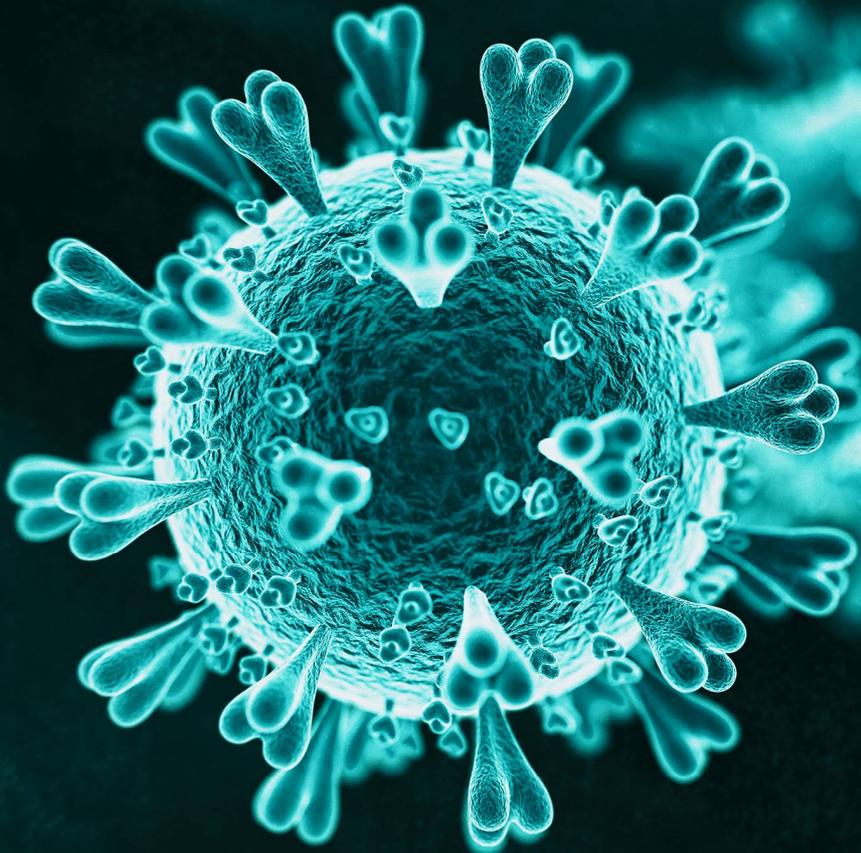


Australia's National
Science Agency

Infectious disease resilience

Co-developing a national Mission

2021



This report

This document is designed to engage senior decision makers across government, industry and research around the topic of zoonotic infectious disease resilience. Specifically, the report was developed to introduce CSIRO's Infectious Disease Resilience Mission to this audience and generate discussions about how CSIRO, in collaboration with the broader health ecosystem, can develop programs of work to further improve Australia's preparedness for future zoonotic infectious disease outbreaks. The report was developed by the CSIRO Futures team using a combination of publicly available material and Mission workshop insights.

About CSIRO Futures

At CSIRO Futures we bring together science, technology and economics to help you develop transformative strategies that tackle your biggest challenges. As the strategic advisory arm of Australia's national science agency, we are uniquely positioned to transform complexity into clarity, uncertainty into opportunity, insights into action.

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Acknowledgement

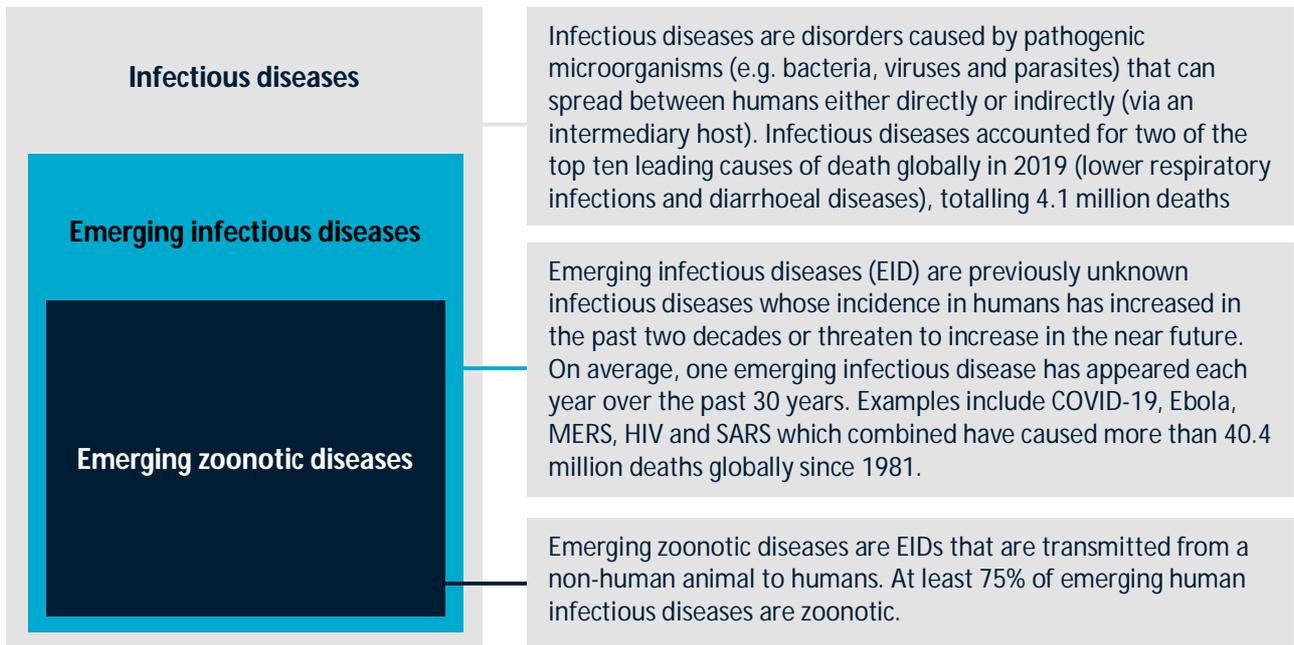
CSIRO acknowledges the Traditional Owners of the land, sea and waters, of the area that we live and work on across Australia. We acknowledge their continuing connection to their culture, and we pay our respects to their Elders past and present.

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1 Introduction to emerging zoonotic diseases

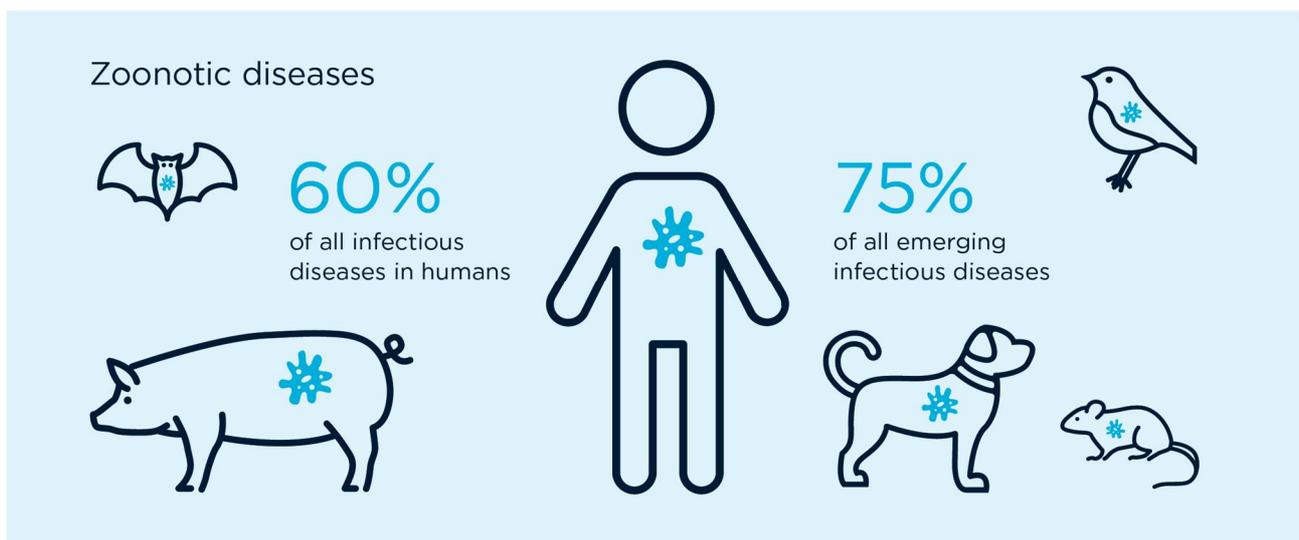
Figure 1 Types of infectious diseases^{1,2}



At least 75% of emerging human infectious diseases are zoonotic³

Zoonotic diseases have the potential to spread rapidly amongst human populations through direct contact, food, water or the environment.⁴ Historical zoonosis examples mostly have origins in domestic animals, poultry and livestock, however changes in the environment and human behaviour are resulting in more of these infections emerging from wildlife species.⁵

Zoonotic diseases have underpinned the most costly pandemics in recent times including SARS (2002), H1N1 'swine flu' (2009), MERS (2012) and COVID-19 (2020). While the most direct impacts of outbreaks include illness, lost lives and financial costs of management, indirect impacts relating to industry revenue losses, lost productivity, delays in accessing healthcare, and the effects on mental health can last well beyond the outbreak being contained or eradicated.



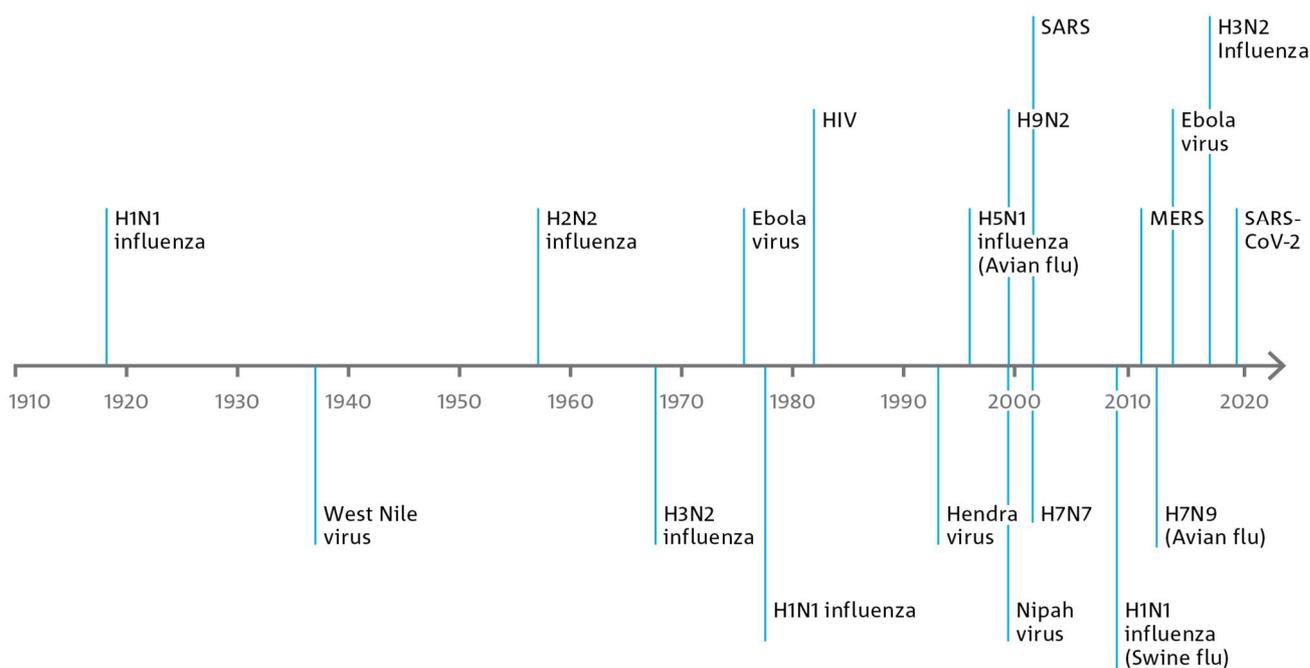
The frequency and complexity of zoonotic disease outbreaks is increasing

The increasing occurrence of major¹ zoonotic disease outbreaks over the last 100 years (Figure 2) has largely been driven by environmental destruction, urbanisation, human encroachment on natural habitats, increased global trade and travel, changing population health profiles and the increased resistance of pathogens to antimicrobial drugs.⁶

The current COVID-19 pandemic represents one of the most widespread and fastest spreading zoonotic disease pandemics in history. To date, Australia has fared comparatively well due to science-informed response activities, early border closures and the public's broad acceptance of social distancing and mask wearing. However, the pandemic has also highlighted limitations of our current health system's response to infectious disease outbreaks, including challenges regarding point of care testing, data sharing, sovereign production and national coordination.

As the risk of zoonotic disease outbreaks continue to rise, it will be important to address the lessons learned from COVID-19 and capitalise on the heightened levels of awareness across government, industry and the general public to further improve Australia's resilience to future outbreaks. CSIRO considers the development of a national Infectious Disease Resilience Mission (see Section 4) as an important element of enhancing Australia's preparedness.

Figure 2: Major infectious disease outbreaks occurring from zoonoses (1910 – 2020)⁵



¹ Major zoonotic disease outbreaks were selected based on a combination of number of infections, number of deaths, infection rate, global threat level and geographic spread.

Impacts of zoonotic pandemics

COVID-19 (2020)

- Over **1.82 million deaths** globally by the end of 2020.⁷
- Estimated to cost global economy **US\$5 trillion in GDP** during 2020.⁸
- Over **\$160 billion** in economic loss to Australia's economy.¹³

Ebola (2014)

- **11,310 deaths** globally.⁹
- In 2015, Guinea, Liberia, and Sierra Leone incurred estimated losses of **US\$2.2 billion in GDP**.¹⁰
- **Tourist arrivals dropped 50%** in Sierra Leone from 2013 to 2014.¹¹

MERS (2012)

- **858 deaths** globally.¹²
- **27 countries** affected, Saudi Arabia worst affected (2106 cases, 780 deaths).¹³
- The 2015 re-emergence in Korea resulted in **US\$12 billion in economic loss** (US\$2.6 billion from tourism).^{27, 14}

H1N1 influenza (1918, 1977, 2009)

- Collectively **50-70 million deaths**.¹⁵
- H1N1 accumulates mutations which has allowed H1N1 to **re-emerge throughout history**; requiring updated vaccines.^{31,32}
- The swine flu (2009) H1N1 pandemic spread to **74 countries** over all six continents **within nine weeks**.¹⁶

SARS (2002)

- **774 deaths** in **26 countries** on five continents.¹⁷
- Cost the world economy approximately **\$US100 billion**. US\$48 billion of which burdened China alone.³⁴

HIV (1981)

- **39 million deaths** globally.¹⁸
- Between 2000 and 2015, **\$563 billion** was spent on HIV/AIDS worldwide.¹⁹
- **Treatment costs US\$326,500** over a person's lifetime from age 35.³⁷

Even without turning into acute pandemics, zoonoses are still responsible for **~2.5 billion cases of illness** and **2.7 million deaths** worldwide, every year.²⁰

2 Global drivers of zoonotic disease risk and resilience

As the world continues to become increasingly interconnected and accessible, a national Infectious Disease Resilience Mission must consider the global landscape. Australia cannot be protected through domestic activities alone.

Increasing animal-human interactions

The expansion of cities and large-scale changes in land use are affecting biodiversity and increasing the interactions between animals of different species as well as humans. These interactions increase the risk of pathogens spreading across species boundaries.²¹ Climate change is also increasing the instances of animal-human interactions by facilitating the movement of animals into new areas.^{22,23}

Higher levels of global trade, travel and freight

The increasing movements of people and goods across borders creates new opportunities for diseases to enter and spread across the globe. Between 2018 and 2037 air transport passenger numbers are forecast to double to 8.2 billion per annum.²⁴ and global air cargo traffic is predicted to grow at 4% annually from 2020 to 2039.²⁵ The growth of ecommerce also presents increased potential for biosecurity breaches, such as disease introduction through illegal animal trade.²⁶

Changing population health profile

The rise of chronic diseases (e.g. chronic respiratory diseases) and the health impacts of climate change are causing populations to be more vulnerable to emerging infectious diseases. The ageing population is a key driver of the rise in chronic disease globally, with 75% of adults aged 65-85 having at least two chronic conditions.²⁷ It is estimated that 16% of the population will be over 65 by 2050.²⁸

Climate change can also reduce the resilience of a population to infectious disease by impacting food security. Ecosystem degradation, which can disrupt agricultural productivity and cause issues such as crop failure, malnutrition, starvation, increased population displacement, and resource conflict can contribute to increased human susceptibility to infectious diseases.²⁹

Increasing demand for animal protein

Animal protein demand is expected to increase by 72% between 2013 and 2050 due to increases in the global population, per capita income and changes in consumer trends.³⁰ To meet this growing demand, livestock farmers will face pressures to increase animal density and new farms are likely to be established close to supply chain partners in urban environments; both increasing the risks of zoonotic pathogens evolving and spreading.³¹

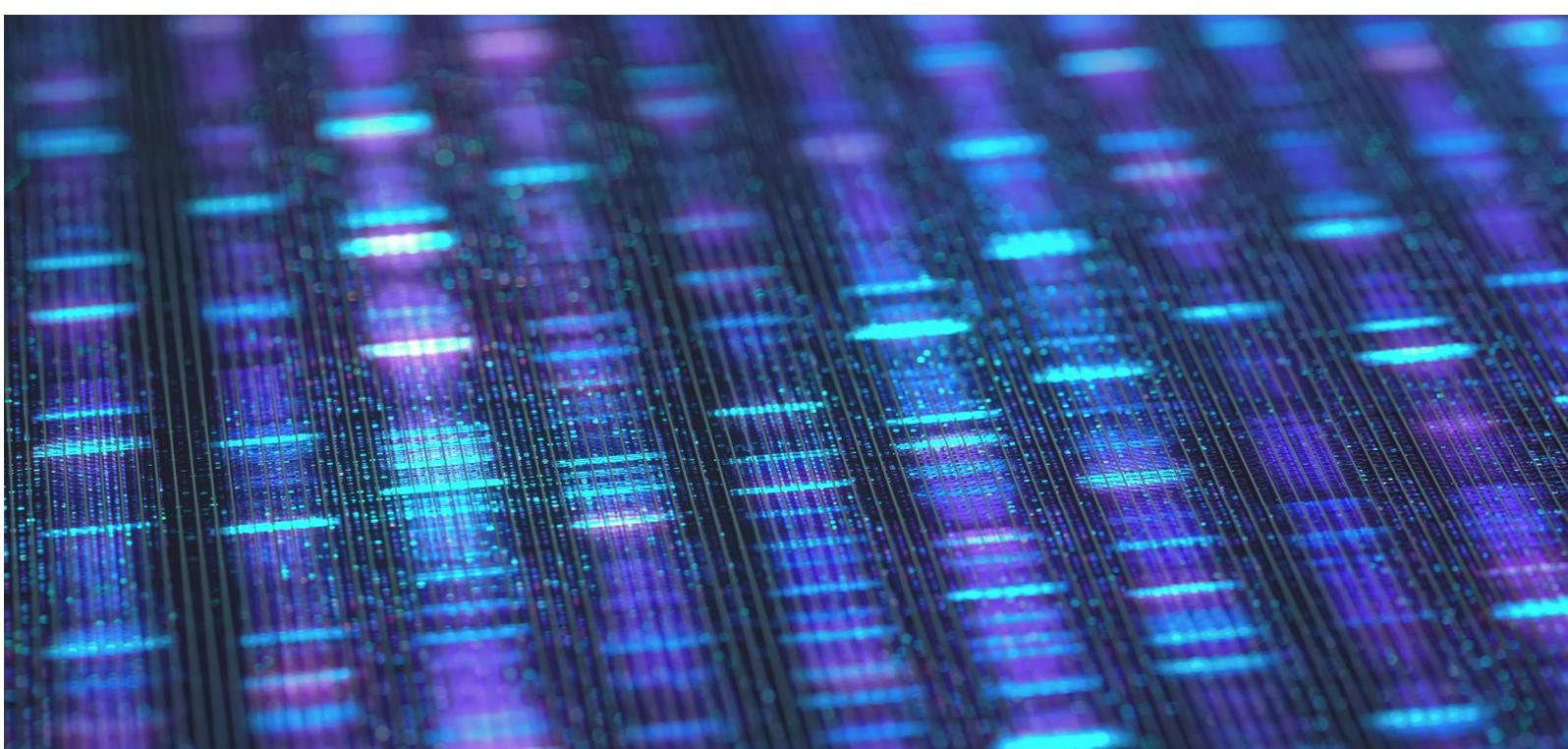
Less sophisticated animal protein supply chains also pose a significant biosecurity risk, with the consumption of bushmeat (the meat of wild animals) being linked to numerous EID outbreaks, such as Ebola, HIV and SARS.³²

Technology advancements

The continued development and adoption of technologies is helping to better understand, predict and manage emerging infectious diseases. For example, recent advancements in next-generation sequencing (NGS) technology are 1,000 times cheaper at sequencing DNA than Sanger sequencing; the previous benchmark technology.^{33, 34} This approach also allows the screening of more samples and detects multiple variants across targeted areas of the genome – an approach that would be more time-consuming using Sanger sequencing.³⁵

NGS has been leveraged in Australia's response to COVID-19 to assess the underlying SARS-Cov-2 virus' genome. Approximately 80% of Victoria's positive cases have had their viral genome sequenced, allowing public health authorities to analyse COVID-19's geographical distribution and genetic variation, helping track and combat clusters.³⁶

Biotechnology advancements have also expedited response activities. For example, several COVID-19 vaccines have taken less than 12 months to develop from pre-clinical development to emergency use authorisation. Prior to this medical breakthrough, the fastest vaccine development timeline took 4 years.³⁷ This was made possible by advancing nanotechnology platforms over traditional vaccine methods.³⁸



3 Australian strengths and weaknesses

Australia's strengths and weaknesses in preparing and responding to emerging infectious diseases have been highlighted during the COVID-19 pandemic. Overall, the nation has been comparatively successful in tackling COVID-19. This success has largely been the result of early border closures and the public's broad acceptance of social distancing, lockdown measures and mask wearing. To provide a wider range of response options in the future, and therefore avoid the economic and social hardships associated with widespread lockdown strategies, Australia can better leverage key strengths across research, infrastructure and regulatory frameworks. A national Infectious Disease Resilience Mission could focus on applying these strengths to solve existing challenges relating to contact tracing, scaled manufacturing capability, and coordinated and digitised responses to assist in reducing the number of lost lives and broader economic and social disruptions of future infectious disease outbreaks.

It is also important that Australia leverages these strengths to support nearby neighbours in the Asia-Pacific region. Building infectious disease resilience across the region reduces the risk of outbreaks and spread for all. These efforts are supported by the Indo-Pacific Centre of Health Security's *Regional Vaccine Access and Health Security* initiative.³⁹

Key strengths

Pre-clinical and clinical trials

Australia's reputation for quality early phase clinical trials is based on comparably high cost efficiency, regulatory speed, flexibility, and being home to world leading key opinion leaders.^{40,41} From 2012-2015, there was a 17.2% growth in Phase I clinical trial volume in Australia, compared to 1.8% globally. This allows Australia to be at the forefront of new pharmaceutical discoveries.

Clinical trials require diverse population cohorts. With over 28% of Australia's resident population born overseas,⁴² Australia has comparative advantages in its access to predominantly English speaking and ethnically diverse patient populations.⁴³ This provides an advantage for clinical trials and the development of health and medical data sets to aid in predicting and managing infectious diseases.

The nation's clinical trial sites and capabilities have played a key role in phase I and II clinical trials for COVID-19 vaccines, with Australian service providers having commenced clinical trials for several global vaccine candidates.⁴⁴ Through the Coalition for Epidemic Preparedness Innovations (CEPI), the CSIRO played a key role in pre-clinical testing of two vaccine candidates by building biological models and quantifying the vaccines' efficacy.⁴⁵

National regulatory environment

Australia's Therapeutic Goods Administration (TGA) has an internationally recognised reputation and globally aligned objectives, making it widely respected for its work in ensuring the availability of high quality, safe and effective therapeutics on the Australian market.⁴⁶ Further, the TGA offers a comparatively simple process for clinical trial commencement which reduces regulatory burden on clinical trial sponsors.⁴⁷

During the early stages of Australia's COVID-19 response, the TGA demonstrated the inherent flexibility within their existing frameworks to act at speed while maintaining safety, efficacy and performance standards. For example, by creating regulatory exemptions and pathways for personal protective equipment (PPE), ventilators, hand sanitisers and diagnostics. They also played a key role in allowing

Australia to have one of the highest testing rates for COVID-19 in the world by securing testing equipment early.⁴⁸

Scientific and medical research infrastructure

Australia has world class scientific, medical and infectious disease research infrastructure. This research infrastructure is directly used by over 65,000 Australian and 12,000 international researchers.⁴⁹

One example is the ACDP, which is the only high containment biosecurity research facility in the southern hemisphere capable of researching and diagnosing a range of exotic pathogens.⁵⁰

In response to COVID-19, The federal and state governments have invested further in medical research infrastructure.⁵¹ Private sector investment is also helping Australia strengthen its position as the medical research leader in the Asia-Pacific region. In 2020, Seqirus - a CSL company – announced plans to build an \$800 million Influenza Vaccine Manufacturing Facility to produce seasonal and pandemic flu vaccines.⁵²

Research capabilities in infectious diseases

Australia stands out as a leader in many infectious disease research disciplines. Since 2016, Australia ranks third for the number of infectious disease resilience related publications,⁵³ fourth for epidemiology related publications⁵⁴ and sixth for COVID-19 related publications.⁵⁵

Australia's broader medical technology, biotechnology and pharmaceuticals sector also supports strengths in infectious disease research. Australia's academic performance from 2016-2019 ranks 7th for medical biotechnology and 9th for nanotechnology.⁵⁶ The nation has also been ranked in the top 5 globally for biotechnology innovation.⁵⁷

In 2020, Australia's Doherty Institute were the first outside of China to grow SARS-CoV-2 in cell culture, which CSIRO then used to establish one of the first biological models of the virus.



Key weaknesses

Rapid testing and contact tracing

Australia's main testing approach during COVID-19 has been reverse transcription polymerase chain reaction (RT-PCR) swab testing which has incurred long result delays of up to 5 days.⁵⁸ R&D into rapid point of care SARS-CoV-2 tests is yet to have found a suitable alternative that provides high sensitivity and specificity like the RT-PCR tests.⁵⁹ The current agreed contact tracing national target of 48 hours from reporting a positive test result to directing close contacts to quarantine is inadequate from the point of view of suppressing community transmission.⁶⁰

Australia's digital contact tracing capabilities have not fully utilised the digital technology available. In some jurisdictions, contact tracing was recorded on paper before being entered into a database, which caused delays and the potential for error.⁶¹ In South Korea, automated tracing helped reduce the amount of time spent per case from one day to ten minutes.⁶² In Australia, text messages to people with COVID-19 and contacts were also not always in the preferred language of the person, and domestic airline passenger lists and contact details were not always accurate, presenting another barrier in managing close contacts.⁶³

Scaled manufacturing capability

Australia lacks end-to-end manufacturing capability for many medical countermeasures (vaccines, therapeutics and diagnostics).⁶⁴ Without the capacity to manufacture and supply Australia's population with sufficient quantities of these products, the nation is dependent on international trade partners who will naturally prioritise their own sovereign needs in times of global pandemics. Australia imports over 90% of medicines, leaving the nation vulnerable to supply chain disruptions.⁶⁵

These dependencies have been highlighted during the COVID-19 pandemic. For example, Australia does not have the capabilities to produce mRNA vaccines, the type of vaccine Moderna is developing for COVID-19.⁶⁶ Australia also relied on trade partners to supply the required amount of COVID-19 testing kits and therapeutics.^{67,68} While it is unrealistic for a nation of Australia's size to develop end-to-end manufacturing capability for each type of vaccine, therapeutic, diagnostic and PPE product, the more realistic solution of housing adaptable industry capabilities (technologies and systems) that can be applied to new outbreaks also remains unmet.

National coordination

The lack of alignment between existing health organisations and strategies at state and federal levels presents a barrier to the efficient preparation and response to infectious disease outbreaks. With state governments largely responsible for COVID-19 response activities, the response and recovery strategies lacked national collaboration regarding leveraging R&D and technology. A national R&D and technology strategy could have provided scale of operations, reduced duplication and clearer, more effective plans for contact tracing. Digital platforms also could have been leveraged to better align messaging between federal and state governments and ensure public information campaigns appropriately considered the variety of languages spoken across Australian communities.^{69,70}

Data sharing and interoperability

Information is predominantly siloed within Australia's health system with limited sharing of data across and between industries, state government, federal government, international partners and the public. While interoperability and data sharing standards continue to emerge, their adoption remains slow. This makes it difficult to track and manage health at an individual and population level.

While COVID-19 fast-tracked the adoption of telehealth tools, many parts of the health system still operate with manual processes or siloed data streams. Existing digital technologies remain underutilised to mitigate these problems. For example, in clinical trial settings, a lack of e-signatures and e-consent form use means that patients need to be onsite more often, enhancing the risk of spreading EIDs.⁷¹

Australia does not have pandemic-related data sharing guidelines, and each state collects and presents data in different formats.⁷² Australia's response to restart the economy during COVID-19 could have been improved by outlining how the use of digital technologies could better manage quarantine and improve contact tracing efficacy. Countries such as South Korea, Japan and Singapore were successful in implementing these technologies, allowing outbreaks to be managed well compared to most other nations despite eventual recurrences.⁷³

Inequity in healthcare access

Disadvantaged populations, and their associated health profiles, can leave them more susceptible to infectious diseases than other groups. This can be for several reasons, including limitations to healthcare access due to geography or financial circumstances, or existing health issues. For example, due to socioeconomic factors Indigenous Australians have an increased prevalence of diabetes, a comorbidity to COVID-19 and other emerging infectious diseases.^{74,75} In Australia, the population groups most likely to be faced with health inequity include Aboriginal and Torres Strait Islander peoples, homeless people, those affected by chronic mental illness or disability (and their carers), unemployed people or those with insecure low-paid employment, people living in remote areas, and some immigrant groups.⁷⁶



4 Infectious Disease Resilience Mission

Mission objectives

In 2020, CSIRO commenced the development of an Infectious Disease Resilience Mission. The aims of the Mission are to support the Australian ecosystem to:

- Increase health security for Australia and the Asia-Pacific region;
- Increase sovereign capabilities and supply chain integrity;
- Create opportunities for jobs and growth; and
- Lessen the economic and social impacts of future infectious disease outbreaks.

Co-designing the Mission

In pursuing the objectives above, CSIRO is seeking to co-design a vision and plan priority programs of work for the Mission with key government, industry and research partners. This will help facilitate coordination of research and development under a national One Health⁷⁷ approach to technology translation and systems improvement.

As input to this planning process, the Mission is seeking to discuss the following questions with potential partners and key government, industry and research stakeholders:

- Where are Australia’s greatest vulnerabilities / areas for improvement?
- Which of these areas should the Mission focus on?
- What existing public and private initiatives/structures should the Mission ensure alignment to, or collaboration with?

The Mission intends to focus on zoonotic diseases and consider programs of work across the four pillars of the EcoHealth security framework⁷⁸ (Figure 3). These workstreams are expected to be refined through the co-design process over the first half of 2021.

Figure 3: Proposed Mission workstreams

Building a healthy, resilient and biosecure Australia				
	Prevent	Detect	Respond	Recover
Health security pillars	Systems, policies, and procedures to determine, assess, avoid, mitigate, and reduce threats and risks by reducing vulnerability and exposure.	Systems, policies, and procedures to gather and analyse information, provide early warning, and inform strategies.	Systems, policies, and procedures aimed at controlling or mitigating the impact of disease and saving lives.	Systems, policies, and procedures to restore and strengthen normal operations.
Proposed Mission workstreams	1 Disease research for insight into how emerging diseases evolve, the pathologies they cause and host responses.	2 Bio-surveillance to build the systems and diagnostics for early detection of potential threats through environmental monitoring and zoonotic disease tracking.	3 Medical countermeasures to focus on rapid development and validation of diagnostics, vaccines and therapeutic products.	
	4 Systems improvements that accelerate decision making using real-time data analytics and social sciences to support resilient communities.			

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