Office of the Prime Minister's Chief Science Advisor
Kaitohutohu Mātanga Pūtaiao Matua ki te Pirimia

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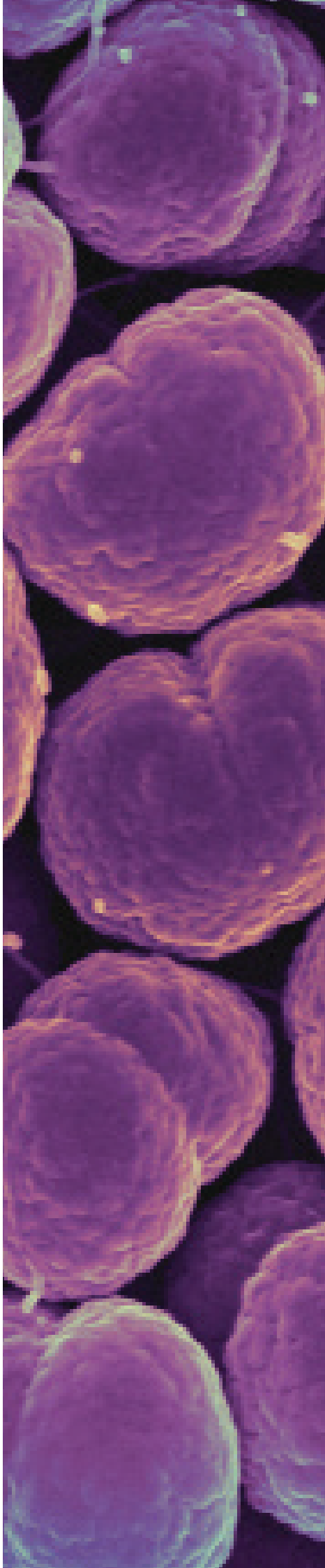
Kotahitanga

Uniting Aotearoa against infectious disease and antimicrobial resistance

A report from the Prime Minister's Chief Science Advisor,
Kaitohutohu Mātanga Pūtaiao Matua ki te Pirimia.

Key messages



December 2021

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Office of the Prime Minister's Chief Science Advisor
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Front cover: Colourised scanning electron micrograph of Neisseria gonorrhoeae bacteria, which causes gonorrhoea. Image credit: National Institute of Allergy and Infectious Diseases, National Institutes of Health/Flickr (CC BY-NC 2.0).
Back cover: Muka face mask by Matthew McIntyre-Wilson, artist, 2020, Wellington. Image credit: Te Papa Tongarewa (ME024617).

Kotahi te aho ka whati, ki te kāpuia e kore e whati.

- Tāwhiao

Foreword

Kia ora koutou,

The threat posed by infectious diseases is well understood. COVID-19 has provided a salient reminder that pathogens continue to threaten the wellbeing of New Zealanders and that health in Aotearoa New Zealand is intimately linked to the international environment. There are many infectious disease threats facing Aotearoa New Zealand besides COVID-19. A range of established, emerging, and re-emerging viruses, bacteria, fungi, and parasites can harm our people, animals, and plants. We need to be prepared.

Increasingly, these pathogens are evolving to resist the effects of the antimicrobials that were developed to kill or control them. The growing threat of antimicrobial resistance, largely driven by overuse and misuse of antimicrobial drugs, is well understood by scientists and healthcare practitioners. We understand how microbes acquire and transmit resistance, the challenges of the drug discovery pipeline, and the deadly future that awaits us if we lose our ability to fight even the most common infections with safe and affordable drugs. In contrast to some of our previous projects in the Office, much of the science is settled, and the evidence needed to inform government action is abundant.

Not only is the science underlying antimicrobial resistance clear – so too are the solutions. The greatest challenge is to focus on infection prevention rather than waiting for people to get sick and then being forced to focus on treatment, as well as curbing inappropriate use of antimicrobials through more judicious use when infection inevitably occurs.

There is an international consensus on these points, with the World Health Organization, the World Organisation for Animal Health, and the Food and Agricultural Organization publishing a global action plan on antimicrobial resistance in 2015, which was endorsed by the United Nations General Assembly in 2016. The World Health Organization considers antimicrobial resistance to be among the top ten health threats facing the globe. Meanwhile, the World Bank has described the global response to antimicrobial resistance as “dangerously inadequate.”

Flowing from this international consensus came our own domestic action plan in 2017, which outlined a series of objectives and actions to help Aotearoa New Zealand combat antimicrobial resistance. But despite the science and solutions being clear, and despite these international and domestic action plans, we fell short at implementation – almost none of the recommendations made in our 2017 action plan have been put into place.

This report is intended to serve as a reminder of the mounting threat posed by infectious diseases and antimicrobial resistance in Aotearoa New Zealand. It brings together international and domestic science and case studies, detailing the infectious disease and antimicrobial resistance landscape globally and at home, where we are in tackling these threats, and how we could do better. There is plenty of room for improvement, as well as many examples of inspiring solutions at home and abroad that could be drawn on or scaled up to help Aotearoa New Zealand unite against these threats.

The panel that guided this project made a number of recommendations, none of which are unexpected or new. The panel’s recommendations have their roots in our 2017 national action plan as well as in international action plans, plans made in other jurisdictions, and solutions advocated for by scientists, practitioners, and industries.

It became clear during this project that tackling infectious diseases and antimicrobial resistance in Aotearoa New Zealand is a matter of rolling up our collective sleeves and getting it done. To achieve this we need leadership, unity, resolve, and resources. The time for action is now: the longer we wait to unite against these threats, the more suffering New Zealanders will face. This is a matter of urgency.

Harms resulting from inaction in the face of these threats will disproportionately affect Māori and Pacific peoples, whose health outcomes are significantly worse compared with other peoples in Aotearoa New Zealand, an inequity that has long been noted but never resolved. We have an obligation to address these inequities. For Māori, we must honour Te Tiriti o Waitangi, working in partnership to achieve equity in health outcomes. For Pacific peoples here, in the Realm, and beyond, we have a duty too, with physical, social, historical, political, and cultural ties that run deep.

A huge thank you to our hard-working panel who came together during a tough year to produce this report, despite the challenges (and the irony) of working on this project during a global pandemic. Ka pai. To the very many members of our wider reference group – thank you too for the detailed reading, the participation in workshops, and the answers to our many questions. This project has been a joy in that, despite the dark material, there is a remarkable consensus on what we need to do tackle this global challenge as it reaches our shores. And finally to the small but perfectly formed OPMCSA team, and especially Ellen Rykers, who stepped up to lead the work mid-year. Thank you for beavering away to produce this report, dispersed across the country and camped in spare rooms, while many of the panel were distracted by the day-to-day pressures of responding to COVID-19.

Ngā mihi nui,

Professor Dame Juliet Gerrard DNZM HonFRSC FRSNZ
Prime Minister's Chief Science Advisor
Kaitohutohu Mātanga Pūtaiao Matua ki te Pirimia

Dr Matire Harwood MBChB
Kotahitanga panel co-chair
University of Auckland and Papakura Marae Health Clinic

Mō tatou, ā, mō kā uri ā muri ake nei.

Executive summary

The age of infectious disease is far from behind us. The health and wellbeing of New Zealanders continues to suffer as a consequence of established, emerging, and re-emerging pathogens. These pathogens impact economically, environmentally, and culturally important plants and animals too. To make matters worse, microbes are evolving to resist the effects of the antimicrobials designed to kill or control them. And the burden of infectious diseases falls unevenly, disproportionately impacting Māori and Pacific peoples as well as old and young people, people with underlying health conditions, pregnant women, people who live in remote rural areas, and those living in hardship.

As resistance to common antimicrobial drugs increases, readily treatable infections will become increasingly challenging to manage. In addition, simple surgical procedures and disease treatments that compromise immunity (e.g. chemotherapy) will become more dangerous: the infections that commonly complicate these procedures and treatments will be hard or impossible to treat. Once antimicrobial resistance (AMR) becomes common, it will impact all of our lives, with even a simple scratch leaving us susceptible to infections that threaten our lives and wellbeing.

Tackling infectious disease and AMR requires kotahitanga – unity, togetherness – across human, animal, plant, and environmental health, bringing everyone in Aotearoa New Zealand along on the journey. The panel that guided this project made recommendations under six themes to help Aotearoa New Zealand unite against the threat of infectious disease and AMR.

These recommendations – which interweave human, animal, plant, and environmental health – draw heavily on recommendations that have been made in the past, including in the 2017 New Zealand AMR Action Plan. We know what needs to be done to unite against infectious disease and AMR in Aotearoa New Zealand – now is the time to act.

Elevate and expand antimicrobial stewardship

Where we are

- No clear national leadership, guidance, tools, or data for antimicrobial stewardship (AMS).
- One of the highest antimicrobial use levels in human health in the world.
- Considerable room to improve AMS practices, especially in human health.
- Knowledge gaps among people who use antimicrobials.
- Undersized AMS workforce.

Recommendations

- Develop a coordinated national approach to AMS across human, animal, and plant health.
- Build AMS capacity and expertise.
- Improve collection and reporting of data on antimicrobial use, including quantity and quality of use.
- Review funding, registration, and access to antimicrobials to align with broader AMR and infectious diseases objectives.

Develop an integrated surveillance and outbreak response system

Where we are

- Infectious disease surveillance is a 'tip of the iceberg' problem.
- AMR surveillance in humans is becoming increasingly sporadic, and isn't routinely conducted in animals, plants, or the environment.
- Information isn't always shared between and within the human, animal, and plant health sectors, or with the international community.

Recommendations

- Establish an integrated surveillance system that brings together information on microbes and infections, including drug-resistant organisms and genes, across human, animal, and plant health, and the environment.
- Share information openly, including with the international community.
- Enhance outbreak responses, informed by stepped up data collection and sharing.

Strengthen infection prevention and control

Where we are

- Avoidable infections occur in humans, animals, and plants (e.g. vaccine-preventable diseases).
- Infections occur in human health facilities, putting already sick people at further risk.
- NZ lacks leadership on infection prevention and control (IPC) and our workforce is underpowered.

Recommendations

- Develop a national approach to IPC and strengthen and expand standards.
- Build IPC capacity and expertise.
- Improve data collection, quality, and reporting on IPC.
- Encourage vaccine uptake, review the vaccine schedule, and increase vaccine use in animal health.

Grow NZ's infectious diseases capability and engage internationally

Where we are

- Our COVID-19 response showed the value of collaboration between scientists, practitioners, and policy makers.
- There is room to increase the number of people with expertise in infectious diseases and AMR in NZ.
- International connections are crucial for our research, practitioner, and policy communities.
- The government is investing $36 million over three years in research focused on COVID-19 and other infectious diseases, through the Strategic Science Investment Fund (SSIF).

Recommendations

- Establish an inclusive infectious diseases network, building on the recently announced SSIF funding for infectious diseases.
- Develop a national strategy for infectious disease that encompasses human, animal, and plant health.
- Build the workforce, including by engaging rangatahi and tamariki.
- Remove barriers to data and information sharing.
- Support researchers, practitioners, and policy makers to engage internationally, including in the Pacific.

Enhance health literacy

Where we are

- COVID-19 has demonstrated that good communication can promote good health.
- Clear and consistent communication on infectious disease and AMR across the nation and throughout human, animal, and plant health is impossible without clear direction.
- Understanding of infectious disease and AMR could be lifted across a range of stakeholders and topics.

Recommendations

- Human health communication should be improved in patient care settings, public communication campaigns, and education.
- Communication should focus on equity and evidence, be co-designed, and be available in multiple languages.
- Communication in animal health should be improved and should align with human health initiatives to ensure consistency.

Reimagine primary care

Where we are

- Logistical, cultural, and economic barriers impede access to primary healthcare and medicine.
- Barriers disproportionately affect Māori and Pacific peoples, rural communities, and materially deprived people.
- AMS practices in the community, where 95% of antimicrobial prescription and use in human health occurs, could be improved.

Recommendations

- Enhance equity and remove barriers to accessing healthcare and medicine.
- Consider making transport to healthcare more accessible, using virtual consultations, and reducing out-of-pocket spending.
- Rethink the approach to prescriptions so that practices align with good AMS principles and national infectious disease and AMR goals.

Our panel

We gratefully acknowledge the efforts of the panel who guided this project. Ngā mihi nui.

Our panel members follow:

- Dr Matire Harwood (Ngāpuhi) (co-chair), University of Auckland and Papakura Marae Health Clinic
- Dr Anneka Anderson (Kāi Tahu, Kāti Māmoe), University of Auckland
- Professor David Murdoch, University of Otago
- Dr Dianne Sika-Paotonu, University of Otago
- Professor Jack Heinemann, University of Canterbury
- Dr Kristin Dyet, Institute of Environmental Science and Research
- Associate Professor Mark Thomas, University of Auckland and Auckland District Health Board
- Distinguished Professor Nigel French, Massey University
- Dr Sharon Gardiner, Canterbury District Health Board
- Associate Professor Siouxsie Wiles, University of Auckland

The Kotahitanga panel and staff from the Office of the Prime Minister's Chief Science Advisor. From left to right: Kristin Dyet, Ellen Rykers, Siouxsie Wiles, Rachel Chiaroni-Clarke, Mark Thomas, Dianne Sika-Paotonu, Nigel French, Juliet Gerrard, Jack Heinemann, Matire Harwood, Sharon Gardiner, George Slim, Anneka Anderson, David Murdoch.

Our reference group

We'd also like to thank the members of our reference group, who generously provided insights and feedback throughout this project. A complete list of the more than 200 experts who made up our reference group can be found in the full report.

Background and context

Infectious diseases are a present and pressing threat. Established, emerging, and re-emerging infectious diseases take a toll on human, animal, and plant health, impacting our social, cultural, economic, and environmental wellbeing. A rising tide of drug-resistant organisms adds to the infectious disease riskscape facing Aotearoa New Zealand and the rest of the world.

Infectious diseases threaten wellbeing

COVID-19 serves as a stark reminder that the age of infectious disease is far from behind us, even as the health burden posed by non-communicable diseases like diabetes and heart disease grows. The 17 million people estimated to have been killed by COVID-19 as of October 2021 join the roughly eight million people who are killed by other infectious diseases around the world each year. COVID-19 also reminds us that microbes know no borders. Health in Aotearoa New Zealand is intimately linked to the international environment.

Infectious diseases don't just cause transient infections and deaths: they can have long-lasting adverse health effects too. Untreated infections with group A *Streptococcus* can cause rheumatic fever and lasting heart damage, sometimes requiring surgery. Bloodstream infections can leave survivors suffering shortness of breath, pain, fatigue, and mental health effects for years. *Campylobacter* infections have been associated with Guillain-Barré syndrome, an autoimmune disorder that affects the nervous system. And the impacts of long Covid are taking a toll on the wellbeing of survivors around the world, the extent of which is not fully understood.

Economically, environmentally, and culturally important plants and animals are vulnerable to infectious diseases too. In the last decade, New Zealanders have seen microbes harm our plants, from kiwifruit to pōhutukawa trees, impacting our economy and cultural heritage. 2017 saw the first cases of *Mycoplasma bovis* detected in cattle on our shores. While not currently in Aotearoa New Zealand, African Swine Fever has been sweeping Asia and spread into the Pacific last year, causing economic losses and protein shortages as pigs die and are culled in response to this highly fatal disease. And there are no solid lines between microbes that harm animals and those that harm people: pathogens can and do cross the species barrier often.

> For detailed examples of infectious diseases that burden Aotearoa New Zealand, see part three of the full report. Section 3.4.1 details the threat posed by bloodstream infections and healthcare-associated infections in human health, section 3.5.1 looks at the economic damage caused by bacteria that infect kiwifruit (Psa) and cows (*M. bovis*), section 3.5.2 looks at the harm done to our native flora by the myrtle rust fungus, and section 3.6 explores infectious disease at the human-animal-environment interface.
>
> *Image: Ramarama infected with myrtle rust. Credit: Peter de Lange/pjd1 via iNaturalist NZ (CC0).*

Antimicrobial resistance makes matters worse

Microbes – predominantly bacteria, but also viruses, fungi, and parasites – are inexorably evolving to resist the effects of the antimicrobials that were developed to kill or control them. This means that infections are becoming harder to treat, and common medical procedures like caesarean sections, hip replacements, and dental surgeries will become increasingly difficult to conduct safely. Each year, approximately 700,000 people around the world die as the result of an infection caused by a drug-

resistant pathogen, a toll that is predicted to reach 10 million by 2050. The World Health Organization (WHO) considers AMR to be among the top ten health threats facing the globe.

The primary driver of AMR is the misuse and overuse of antimicrobials: excessive and inappropriate use of antimicrobials gives microbes ample opportunity to evolve to evade them. When microbes are exposed to antimicrobials, some may survive while others are killed. Those that survive go on to reproduce, giving rise to offspring that are also able to resist the effects of antimicrobial drugs. For bacteria, the genes that confer resistance can be passed to other bacteria, including between bacterial species, spreading AMR further. The solution isn't as simple as developing new antimicrobials: drug discovery is a long, costly, and difficult process; resistance mechanisms developed by microbes typically render whole classes or even multiple classes of antimicrobials ineffective; and even when new antimicrobials are discovered, resistance tends to follow quickly, accelerated by the misuse and overuse of those drugs.

> It's not just antimicrobial drugs that can drive acquisition of AMR. For example, resistance can also develop against antimicrobials found in household cleaning and hygiene products. In addition, many non-antimicrobial compounds have unintended antimicrobial activity or other effects that contribute to AMR, including by facilitating the transfer of resistance genes between bacteria. For more on how AMR develops, including the impact of cleaning and hygiene products, herbicides, and other substances, see section 2.3.2 of the full report.

Aotearoa New Zealand isn't immune from the impacts of AMR. Nearly 1,000 New Zealanders were infected with methicillin-resistant *Staphylococcus aureus* (MRSA) in 2017, with infections caused by this resistant microbe requiring the use of second-line antibiotics, which are often less effective and associated with more side-effects than first-line antibiotics. Some cases of gonorrhoea (a sexually transmitted infection, STI) and a range of urinary tract infections (UTIs) in Aotearoa New Zealand are caused by resistant pathogens. Imported cases of tuberculosis (TB) are becoming increasingly difficult to treat too. AMR can develop in Aotearoa New Zealand and resistant pathogens can be introduced from abroad.

> For more details on AMR in human health in Aotearoa New Zealand, case studies are provided in part four of the full report. These case studies cover the impending threat of drug-resistant STIs and UTIs (sections 4.8 and 4.6), the burden posed by MRSA (section 4.5), and the challenge of treating TB (section 4.7).
>
> *Image: Tuberculosis chest x-ray. Credit: Yale Rosen (CC BY-SA 2.0).*

AMR in Aotearoa New Zealand extends into the animal and plant worlds too. For example, just ten years after Varroa was first detected in bees in Aotearoa New Zealand, a study found that mites in the country could resist the effects of two common miticides. In the plant world, pathogens resistant to commonly used copper-based antifungals and the antibiotic streptomycin have been reported.

There are inequities in the burden posed by infectious disease and antimicrobial resistance

The burden of infectious disease falls most heavily on the shoulders of Māori and Pacific peoples, who are at greater risk of acquiring many infectious diseases (including drug-resistant ones), developing attendant health complications, and being admitted to hospital. For example, adjusted for age, sex, and socioeconomic deprivation, Māori and Pacific peoples are 11.8 and 23.6 times more likely to be hospitalised with rheumatic fever, respectively, when compared with other New Zealanders. This burden is not only felt in terms of health effects: it has ripple effects in people's lives, including missing school or work, which can lead to lost opportunities, financial stress, and mental health impacts. These

disparities stem largely from inequitable access to affordable and quality healthcare, as well as wider social determinants of health such as poverty and housing conditions, issues that have their roots in historical and ongoing inequities and systemic racism. For decades, disparities have been noted, but little progress has been made to close the gaps.

> Despite the government setting targets to reduce the incidence of rheumatic fever, prevalence remains high. Māori and Pacific peoples are disproportionately burdened by rheumatic fever and the heart disease that can result. Housing conditions, access to healthcare, poverty, and racism experienced in the health system all contribute. Read the OPMCSA evidence summary on Group A *Streptococcus* and acute rheumatic fever for more details.

Infectious disease also places a greater burden on old and young people, people with underlying health conditions, and pregnant women. In addition, people who live in remote rural areas in Aotearoa New Zealand and those living in material hardship regardless of ethnicity are less likely to have ready access to affordable and quality healthcare.

The way forward requires unity and leadership

Tackling infectious disease and AMR requires kotahitanga – unity, togetherness – across human, animal, plant, and environmental health, bringing everyone in Aotearoa New Zealand along on the journey. It also requires leadership, resourcing, and implementation. Aotearoa New Zealand has had a national plan for tackling AMR since 2017 but has made little progress on putting it into practice.

The panel involved in this project came up with a range of recommendations to help Aotearoa New Zealand unite against the threat of infectious disease and AMR. In this short report, the panel's recommendations and underlying rationale are laid out, grouped into six themes. Some recommendations are for immediate action (within two years), others should be considered for implementation within 2-3 years, and others for implementation within five years – the panel's proposed timeframes are indicated beside each recommendation. More details can be found in the full report, and on our website.

The following sections of the full report expand on these concepts:

Part two: Background and global context

- Section 2.2: A brief history of infectious disease and antimicrobial resistance
- Section 2.3: Antimicrobial resistance basics
- Section 2.4: Global state of play
- Section 2.5: Future context

Part three: Infectious diseases in Aotearoa New Zealand

- Section 3.4: Infectious diseases impact people significantly
- Section 3.5: Infectious diseases impact animals and plants
- Section 3.6: Infectious disease at the human-animal-environment interface

Part four: Drug-resistant infections in Aotearoa New Zealand

- Section 4.3: Antimicrobial resistance: Are there drug-resistant infections in Aotearoa New Zealand?
- Section 4.5: Case study: Drug-resistant skin and soft tissue infections are already causing significant morbidity in Aotearoa New Zealand
- Section 4.6: Case study: Urinary tract infections that are resistant to antimicrobials
- Section 4.7: Case study: Treating tuberculosis is a growing challenge – what this means for Aotearoa New Zealand
- Section 4.8: Case study: Super-gonorrhoea and the impending threat of drug-resistant STIs in Aotearoa New Zealand

Theme 1: Elevate and expand antimicrobial stewardship

Antimicrobials need to be used wisely to preserve their effectiveness so that they are able to fight infections when we need them. AMS is concerned with using antimicrobials optimally for the benefit of human, animal, and plant health. It also aims to avoid overuse and inappropriate use of antimicrobials to minimise the harms that can occur including AMR and adverse effects. This means making sure antimicrobial drugs are used only when they are needed to prevent, treat, or manage infection: they should not be used when we are confident that they will provide nil or trivial benefit or where appropriate non-antimicrobial alternatives exist. This helps to preserve antimicrobials to benefit future generations. Along with promoting judicious use to combat AMR, using these drugs only when they are needed will also reduce exposure to unnecessary risk from adverse events.

There is a lack of national leadership in our approach to antimicrobial stewardship

Aotearoa New Zealand lacks resourced leadership and coordination of activities related to AMS. There is no national guidance or strategy to support judicious use of antimicrobials in humans, animals, and plants, and there is no national system for monitoring the use of antimicrobials either. The guidance and monitoring that does exist is fragmented between and within the human, animal, and plant sectors, despite the interconnectedness of AMR threats. This means that we are poorly placed to comprehensively appraise the quantity and quality of antimicrobial use and we aren't operating with evidence-based guidelines for AMS rolled out across all aspects of human, animal, and plant health. This gap exists despite the 2017 New Zealand AMR Action Plan calling for a national AMS programme or standard in human and in animal health, and a coordinated national surveillance programme for antimicrobial drug use.

There is room for improvement in our antimicrobial stewardship practices

Key themes in Aotearoa New Zealand's antimicrobial use and AMS practices can be derived from academic and government studies, and by comparing Aotearoa New Zealand's standards and practices to those abroad. Across human, animal, and plant health, there is ample room for improvement.

There are glaring gaps in our approach to antimicrobial stewardship in human health

Aotearoa New Zealand's use of antimicrobial drugs in human health is very high. Among Organisation for Economic Co-operation and Development (OECD) countries, we have the fourth highest level of antibiotic use. Most (95%) of our high consumption is due to antimicrobial dispensing in the community, mainly from general practice, with only 5% of antimicrobial use occurring in hospitals. While there was a 14% drop in community antibiotic prescribing between 2015 and 2018, this followed a 49% increase that occurred over the preceding nine years.

This high use results partially from unnecessary use: antimicrobial drugs are sometimes prescribed where no meaningful health gain could be expected to result. At present, prescribers in Aotearoa New Zealand aren't required to record why they have chosen to prescribe antimicrobial drugs. This makes it difficult to assess the extent and patterns of inappropriate use. However, available evidence suggests that inappropriate use is occurring. For example, seasonal fluctuations seen in antibiotic prescribing

patterns, with prescriptions peaking in winter, suggests antibiotics are being prescribed for viral infections like seasonal influenza and common colds, against which antibiotics are known to be ineffective. And broad-spectrum antibiotics are frequently prescribed for simple UTIs even though these infections are often self-resolving.

There are plenty of weaknesses and gaps in AMS in human health that drive this overuse and misuse of antimicrobial drugs. For example:

- There are no national prescribing guidelines to ensure a consistent approach to AMS across hospitals and community health settings.
- As well as hampering our ability to assess the quality of prescribing, failure to require an indication to be listed on antimicrobial prescriptions misses a chance to encourage conscious prescribing practices.
- As a strategy to lessen inappropriate use of antimicrobials, patients are sometimes asked to delay filling their antimicrobial prescriptions to see if symptoms improve on their own. However, sometimes this might mean that the prescription is filled for a subsequent indication for which antimicrobial drugs might not be appropriate.
- Aotearoa New Zealand, joined only by the US, lets pharmaceutical companies advertise to consumers. Medicines New Zealand reports that prescription antimicrobials haven't been advertised to New Zealand consumers for at least the past 20 years, so advertising is unlikely to be currently contributing to patient expectations for antimicrobials. If direct-to-consumer advertising of antimicrobials does re-occur at some stage in the future, this may contribute to patient expectations for access to antimicrobial drugs.
- Some antimicrobial drugs aren't captured in the national dispensing dataset, creating knowledge gaps and hindering our ability to assess volumes and patterns of antimicrobial drug use.

> Guidelines for antimicrobial prescribing should be based on good evidence and should be consistent across the country. One aspect of prescribing that could benefit from a review of the evidence and a consistent national approach is the duration of antibiotic courses in human health. The justification underlying the traditional length of antibiotic courses – one to two weeks for many illnesses – is not fully understood. Emerging evidence suggests that under some conditions shorter courses may be just as effective as longer ones without elevating the odds of AMR emergence. For more details on the course duration conundrum and other aspects of AMS, see section 5.5.1 of the full report.

Excessive and unnecessary use of antimicrobial drugs at the national level masks underuse in parts of the population. Māori and Pacific peoples are estimated to be under-prescribed antibiotics by up to 29%, and both groups are more than twice as likely as non-Pacific, non-Māori peoples to have not collected a prescription due to cost. With antibiotic treatment of Group A *Streptococcus* being important for preventing strep throat from escalating to rheumatic fever, this has a role to play in the disproportionate burden of rheumatic fever among Māori and Pacific peoples. Access to medicines for people living in remote rural areas is also constrained. Any attempts to decrease our use of antimicrobial drugs should ensure that those decreases occur in the right places (i.e. where antimicrobial drugs are being used inappropriately), not among people who could benefit from access.

There is room for improvement in animal health

Our use of antimicrobial drugs in animals is low compared with other countries, and strong efforts are being made in parts of the agricultural industry to improve practices and reduce use further. Antimicrobial drug use is highest on pig and poultry farms, where high animal densities mean infectious

diseases can spread more readily. This drives higher use of therapeutic or prophylactic antimicrobial drugs in comparison with cattle, sheep, and deer farms, where animal densities are lower. Meanwhile, antimicrobial drugs aren't known to be used in our aquaculture sector. As a proportion of total use in animals, companion animals make a minor contribution.

But data on the quantity and quality of antimicrobial drug use in animals in Aotearoa New Zealand isn't systematically collected, leaving us with blind spots. For example, we don't have data on the volume of antimicrobial drugs used in pig versus poultry farming – available data is aggregated due to the overlap in antimicrobial drugs used in both sectors. In addition, while farmers need a prescription from a vet to access antimicrobial drugs, use decisions on the farm are often up to them, and it can be difficult to access and assess the relevant use data. And while the Ministry for Primary Industries (MPI) reports annually on antibiotic sales, reporting tends to lag by two years, so trends and deviations can't be responded to efficiently.

As well as ample scope to improve data collection, there are opportunities to improve AMS practices in animal health too. For example:

- Animal vaccines exist for a number of infectious diseases. If infections were prevented through widespread animal vaccination, the need to use antimicrobial drugs would reduce. Some sectors use vaccines effectively to reduce their reliance on antimicrobial drugs (e.g. deer farming) while in others vaccine access could be explored further.
- There are opportunities for other disease prevention initiatives to reduce reliance on antimicrobial drugs. For example, antimicrobial drugs are used therapeutically and prophylactically to manage bacterial udder infections in dairy cows. A non-antimicrobial solution – the use of teat sealants to create a physical barrier that prevents bacteria from moving into the udder – can prevent infections effectively. Use of teat sealants is optional: voluntary uptake has been widespread but could be expanded further if mandated.
- Antimicrobial drugs that are important for human health are also used in animals. With many microbes able to infect both humans and animals, AMR in animal microbes poses a potential threat to human health too. Despite this, antimicrobial drugs that are important for human health are used in animals. In 2008, antimicrobial drugs that are critically important for human health were among the most frequently prescribed to pets. And resistance genes against tylosin, one of the most widely used antibiotics in pig and poultry farming, could confer resistance against antibiotics used in human health.

Plants and environmental contamination represent a blind spot

Farmers, home gardeners, and councils use antimicrobials to maintain plant health. Antifungals are used the most widely, with only two antibacterial products registered for use in plants in Aotearoa New Zealand as of 2018. Antimicrobials for use on plants can typically be purchased off the shelf and there is no system to assess how they are used downstream of purchase.

Even the quantity of antimicrobials used in the plant space is difficult to assess – use data isn't collected from farmers or gardeners, and sales data isn't detailed enough to provide useful answers. For example, MPI reported a 14% increase in the purchase of antibiotics for plant use between 2017 and 2018. But there is no guarantee that these products were used in the year of purchase, and this increased volume doesn't account for changes in land use.

In addition, the existence and impacts of antimicrobials in the environment – largely due to contamination from human, animal, and plant use – represents another area that could benefit from stepped up research. Academic studies have found antimicrobials in our environment, but the impacts of this contamination on human, animal, and plant health are understudied.

There are examples of good practice that we could learn from and build on

Good AMS practices can be found by looking at other countries. For example:

- In human health, Australia's National Centre for AMS conducts a survey each year to monitor the quality of antimicrobial prescribing in human health over time. Some hospitals and individual auditors in Aotearoa New Zealand have opted to use this survey, but it hasn't been rolled out nationwide.
- In animal health, Denmark represents an example of good practice in the way antimicrobial use in pig farming is stewarded. For example, vets closely monitor antimicrobial use on farms, allowing good data to be captured on the effectiveness of interventions and therefore enabling prescribing to be well informed, improving the quality of antimicrobial use.
- There are limited examples of good practice in plant AMS to draw on: at the international level, this is a neglected aspect of AMS. More research is needed to establish whether this low prioritisation of plant AMS is justifiable.

While overseas practices can inspire solutions in Aotearoa New Zealand, it is crucial to note that modification for the domestic context may be required. Our unique farming and health systems, our cultural context, and the infectious disease profile of the country all need to be considered.

In addition to solutions abroad, there are some homegrown efforts to strengthen AMS too. These could be leveraged to improve AMS nationwide. For example:

- The Accident Compensation Corporation (ACC) has done some scoping work on the feasibility of developing national guidelines for antibiotic prescribing in human health, hoping to bring consistency to the current range of guidance that has been developed by various parts of the human health sector.
- Starship Children's Health launched an app in 2019 designed to help healthcare providers choose the most appropriate antibiotic treatment plan for their patients. It has been downloaded by clinicians in every District Health Board (DHB).
- Work done by Pharmac and the Health Quality and Safety Commission (HQSC) in collaboration with behavioural scientists found that telling GPs that they prescribe more antibiotics than their peers led to reduced antibiotic prescriptions by over-prescribing GPs.
- DairyNZ has issued guidelines on how to manage udder infections, calling for antibiotics to be used therapeutically for infected cows and, if used prophylactically, to be used in a targeted manner rather than at the whole-herd level, reducing the quantity used.
- The New Zealand Veterinary Association (NZVA) has developed antibiotic prescribing guidelines and an AMS communication campaign to support the pursuit of its aspirational goal to eliminate blanket prophylactic use of antibiotics in animals by 2030.
- Kiwifruit cultivars that are less susceptible to Psa have been used to replace many vines in the country, reducing the need to apply antibiotic treatments. Plant and Food Research also now includes Psa tolerance among its selection traits when breeding new kiwifruit cultivars.

We need a capable and empowered workforce to uphold stewardship standards

The best guidelines and solutions are useless if they aren't implemented by practitioners. We need those who prescribe, dispense, and administer antimicrobials to understand the importance of AMS and be empowered to uphold AMS standards. All people involved in prescribing, dispensing, and administering antimicrobials – from doctors in our hospitals, to local pharmacists, to farmers and vets – need to be considered.

People who prescribe, dispense, and administer antimicrobials in Aotearoa New Zealand don't always have adequate, current knowledge about AMS or the threat of AMR. For example, survey results suggest that there are gaps in nurses' knowledge of AMS which limit their ability to integrate AMS into clinical practice. Similarly, dairy farmers were found to have limited knowledge or concern about the risk of AMR, especially the link between animal and human health.

In addition to knowledge gaps, there is a lack of resourcing to support AMS functions in Aotearoa New Zealand. For example, only some DHBs – predominantly larger ones – have dedicated AMS staff. This under-resourcing is particularly prominent in smaller hospitals, which often lack AMS programmes altogether.

> AMS programmes in hospitals in Aotearoa New Zealand are under-resourced when compared with fulltime equivalent (FTE) recommendations. A 2016 survey found that out of the 20 DHBs in New Zealand, just half had an AMS committee, nine had dedicated AMS pharmacist resource, eight had a lead clinician with AMS responsibility, and only three reported having dedicated AMS ward rounds. For more details on AMS solutions, including the AMS workforce, see section 5.5.1 of the full report.

Our medicine regulators and purchasers have a role to play too

Pharmac, Aotearoa New Zealand's medicines purchaser, has a role to play in making sure Aotearoa New Zealand has access to antimicrobials that are consistent with our AMS goals. For example, recommendations from Pharmac's tender committee drove a shift to smaller sized tubes of topical antibiotics, meaning the amount dispensed better matches what the patient needs, reducing overuse or inappropriate disposal.

In additon, part of Pharmac's mandate involves promoting the responsible use of pharmaceuticals. For example, some antibiotics have had restrictions put in place to support judicious use in the face of emerging resistance, based on recommendations from Pharmac's infectious disease pharmacology and therapeutics advisory committee.

Pharmac should continue to focus on work that promotes AMS. In addition, as the threat of AMR grows, Pharmac will increasingly have to ensure it is working to procure suitable quantities of antimicrobial drugs that are able to treat resistant infections.

The following sections of the full report expand on these concepts:

Part four: Drug-resistant infections in Aotearoa New Zealand

- Section 4.4: Use of antimicrobials in Aotearoa New Zealand

Part five: Prevention and solutions

- Section 5.3: Prevention is better than a cure
- Section 5.5: Treatments
- Section 5.6: Empowering people and building capacity

Panel recommendations for theme 1

(a) Develop a coordinated national approach to AMS to provide overarching governance and leadership. The approach should adopt a strong equity focus and engage Māori and Pacific peoples.	
(i) Establish an Infectious Diseases and AMR Action ministerial portfolio. The Minister with responsibility for Infectious Diseases and AMR Action should work with officials across the Ministry of Health (MoH), Ministry for Primary Industries (MPI), and Ministry for the Environment (MfE), to advance Aotearoa New Zealand's response to AMR and infectious disease.	⩓ Immediate
(ii) Create stronger linkages between the human, animal, plant and environmental health sectors involved with antimicrobial use and with relevant government agencies to enable multi-way knowledge sharing on AMS. This may involve stronger links between the restructured health localities (currently District Health Boards, DHBs) and the veterinary profession.	⩓ Immediate
(iii) Establish a national AMS expert group (equivalent to the current National Infection Prevention and Control Expert Group, NIPCEG) to embed expert advice in policy making. The expert group will develop a national strategy for AMS. The AMS expert group should include dedicated but closely cooperating sub-groups from the human, animal, and plant health sectors, with clear reporting lines to relevant Ministries.	⩓ Immediate
(iv) Establish a national centre for AMS in human health that takes responsibility for leading the human health components of the AMS strategy.	⩓ Immediate
(v) Establish regional AMS groups that engage with the national centre and facilitate regional AMS activities in human health. These groups should have cross-sector representation and a focus on equity.	⩓ Immediate
(vi) Set ambitious targets for equitably reducing the quantity and improving the quality of antimicrobial prescribing for human health as part of the AMS strategy.	⩓ Immediate
(vii) Develop and maintain national antimicrobial prescribing guidance for human health. Considerations: • Development of the guidance should build on the Accident Compensation Corporation (ACC) scoping work, aiming to align existing regional guidance and use a clinician-led collaborative model to facilitate uptake. • The guidance should include treatment of infections due to multi-drug resistant organisms (MDROs) and include a strong AMS and equity lens. • Development of paediatric guidance may offer a first step to this initiative, using Starship Children's Health's already-existing guidance as the starting point.	⩓ Immediate

(viii) Develop new clinical care standards for AMS to address gaps in the current health and disability standards with extension to cover all health professionals involved with antimicrobial use including doctors, nurses, pharmacists, midwives, and dentists in the community. Ensure these standards have a strong equity focus.	⩓ Immediate
(b) Build AMS capacity and expertise at all levels. Support implementation of AMS across the human and animal health systems and plants and the environment, including but not limited to: primary care, aged residential care, public and private hospitals, dentistry, optometry, midwifery, pharmacy, veterinary care, agriculture, and biosecurity.	
(i) Establish clinical leadership roles focused on AMS (and alongside infection prevention and control) at the director level of all DHBs (or equivalent) and link these through the national centre for AMS.	⩓ Immediate
(ii) Require all DHBs (or equivalent), private hospitals and Primary Health Organisations (PHOs) to report annually and transparently on their goals, activities, and outcomes with respect to AMS.	⩓ Immediate
(iii) Set minimum full-time equivalent (FTE) requirements (considering roles for pharmacists, doctors and nurses as appropriate) for AMS at all hospitals (both public and private) and PHOs.	⩓ Immediate
(iv) Provide support for dedicated AMS pharmacists embedded within PHOs and/or General Practice (GP) clinics.	⩓ Immediate
(v) Formalise a system for connecting aged residential care and community healthcare workers with antimicrobial stewardship expertise at regional and national levels.	⩓ Immediate
(vi) Set targets for equitably increasing the AMS workforce. Ensure this is resourced appropriately.	⩓ Immediate
(vii) Enhance AMS education for all health professionals involved with antimicrobial use through the tertiary curriculum and continuing professional development and support health professionals to upskill in this area.	⩓ Immediate
(viii) Focus on sustainable susceptibility by developing a more holistic view of AMS. This may include investigating the chemical microbial exposome and testing products (e.g. pesticides) for their antimicrobial activity.	━ 5 years
(c) Improved antimicrobial data governance: collection, quality, and reporting.	
(i) Monitor and report transparently the quantity of antimicrobials used throughout the human health sector, and ensure this data includes ethnicity to monitor equity-based outcomes. This may require various health services including hospitals, clinics, and pharmacies to provide data in a standardised way and will require some data gaps to be resolved (e.g. practitioner supply orders, community pharmacy trimethoprim sales).	⩓ Immediate
(ii) Develop and implement a platform to display human health antimicrobial usage data in both community and hospital settings (from individual prescriber to national level), and an equivalent for antimicrobial usage in animal and plant health. Make these platforms publicly accessible and ensure they are presented in a useful way.	⩓ Immediate

(iii) Implement the hospital National Antimicrobial Prescribing Survey (NAPS) in both public and private hospitals, with modification for local context. Require all hospitals to participate, and for the results to be published publicly by the national centre for AMS on the new platform described under **1(c)(ii)**.	⌃⌃ Immediate
(iv) Evaluate other existing (and future) NAPS modules for applicability in other settings including aged residential care, veterinary care, and primary care. Aim to implement applicable modules with modification for the local context or make an alternative auditing system available if the NAPS modules are unsuitable.	⌃ 2-3 years
(v) Introduce a requirement for inclusion of a meaningful indication within all antimicrobial prescriptions, as well as treatment durations or review or stop dates. This could be implemented through updated clinical care standards (see recommendation **1(a)(vii)**).	⌃ 2-3 years
(vi) Implement mechanisms to provide prescriber benchmarking and feedback on both quality and quantity of antimicrobial prescribing, delivered through the national centre for AMS.	⌃⌃ Immediate
(vii) Develop a system to enable collection of antimicrobial use data in animals and plants. This could be first implemented as sentinel surveillance at selected veterinary practices before being rolled out more widely.	⌃⌃ Immediate
(viii) Develop a national centralised platform to collate data on antimicrobial use in animals and plants.	⌃ 2-3 years
(d) Review funding, registration, and access to antimicrobials.	
(i) Review Pharmac antimicrobial restrictions in the community and ensure they align with DHB hospital restrictions and AMS principles.	⌃⌃ Immediate
(ii) Review antimicrobial products and registered uses across both human health and veterinary sectors to ensure they align with AMS principles and ensure requirements for registration of products in the future have a strong AMS focus.	⌃⌃ Immediate
(iii) Prioritise AMS under Pharmac's factors for consideration, including by actively seeking to fund drugs that align with AMS principles. This may involve subsidising antimicrobials that facilitate oral management of infections in the community in line with AMS principles.	⌃⌃ Immediate
(iv) Establish a transparent national supply of rarely used antimicrobials for treating infections due to MDROs in a timely manner, accessible to all DHBs (or equivalent).	⌃⌃ Immediate
(v) Ban direct-to-consumer advertising of antimicrobial medicines.	⌃⌃ Immediate
(vi) Investigate innovative approaches to promote AMS among those who prescribe, dispense and use antimicrobials, with a view to making the national approach to tackling AMR proactively AMS focussed.	➖ 5 years

Theme 2: Develop an integrated surveillance and outbreak response system

We need to know what's out there in the infectious disease and AMR landscape if we are to understand our risks, implement risk mitigations, and detect and respond to outbreaks quickly. We need comprehensive information collection and sharing to achieve this, as well as clear processes for acting on that information.

We could do a better job at infectious disease surveillance…

The infectious disease landscape in Aotearoa New Zealand is understood through the work of the MPI (for animal and plant health) and the Institute of Environmental Science and Research (ESR, for human health), as well as other laboratories, health providers, and the academic community. There is room for better connections between those monitoring human, animal, and plant health. Even within each sector, data isn't always shared. For example, most diagnostic work in animal health is conducted by private labs and can be difficult for government agencies and academic researchers to access.

In addition, our understanding of infectious disease in Aotearoa New Zealand is a 'tip of the iceberg' problem: only a small portion of infected humans, animals, and plants are detected. For example, in a waterborne *Campylobacter* outbreak in Havelock North in 2016, 953 cases sought medical care, but up to 8,320 people were estimated to have been infected. And Aotearoa New Zealand's current approach to screening for one of the world's most concerning types of drug-resistant bacteria, carbapenemase-producing Enterobacterales, almost certainly isn't broad enough to detect all carriers.

Opportunities exist to reduce the extent of our infectious disease blind spots. For example, FluTracking is a survey used in Australia and New Zealand to monitor trends in influenza- and COVID-like symptoms. There is scope for similar disease surveillance innovations to be explored, such as a FluTracking equivalent for water- and food-borne illnesses, improving our understanding of infectious disease trends. In addition, patient screening – where sick people are tested for a range of infections when presenting to a healthcare facility – could be increased for priority infections, as could wastewater testing to identify trends in infectious disease incidence and geographic distribution. This would need to be met with expanded lab capacity. Biotech developments like whole genome sequencing – which is becoming increasingly affordable and rapid – and PCR diagnostic kits have increased the speed of laboratory diagnosis and can also facilitate wider and faster infectious disease surveillance and outbreak management.

Not only does stepped up testing help us to understand our infectious disease landscape better and identify when outbreaks are occurring, but it also links closely to AMS. If infections can be diagnosed rapidly and easily, it is more likely that sick humans, animals, and plants will be given the appropriate antimicrobial drugs based on lab confirmation of the cause of illness and susceptibility tests to promptly identify which antimicrobial drugs the causative pathogens are likely to respond to.

…and antimicrobial resistance surveillance

As with infectious diseases generally, there is room for improvement in our surveillance of drug-resistant pathogens across human, animal, and plant health. AMR monitoring in human health is by far the most advanced, with ESR conducting routine surveillance of resistant organisms. Meanwhile, MPI doesn't routinely test for AMR in animals or plants, so our knowledge of the extent of AMR in plants

and animals isn't comprehensive or timely. And Aotearoa New Zealand doesn't routinely or methodically test the environment for resistant pathogens either.

Even in human health, reporting of AMR is imperfect, becoming increasingly sporadic due to competing priorities and because the growing prevalence of infections caused by drug-resistant pathogens is stretching screening capacity. The system would benefit from timely, regular, prioritised reporting and a central database to hold information about AMR organisms and genes over time and across humans, animals, plants, and the environment, allowing trends to be monitored and transmission pathways to be traced.

For a detailed readout of recent antibacterial resistance surveillance findings from ESR, see part four, section 4.3.2 of the full report. This section of the report details key drug-resistant microbe groups found in humans in Aotearoa New Zealand, including one group (bacteria with acquired carbapenemases) considered by WHO to critically require the development of new treatments to manage given its broad resistance profile, as well as seven high priority and four medium priority drug-resistant bacteria groups. Section 2.4.2 provides more detail on WHO's list of most concerning drug-resistant pathogens.

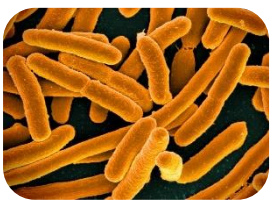


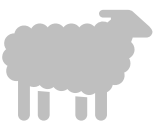
Image: E. coli, which can express acquired carbapenemases. Credit: NIH Image Gallery (CC BY-NC 2.0).

We need systems in place that allow us to respond to information effectively

If our infectious disease and AMR surveillance systems are stepped up, this will provide us with more actionable insights in the face of an outbreak or rise in incidence of disease-causing microbes, AMR organisms, and AMR genes. To make the most of these insights, a strong and joined up response system is needed.

Among other things, a strong response system must involve clear communication and free flows of information, including between the human and animal sectors in situations involving animal-infecting microbes (both pathogenic and commensal) that have scope to spill into humans and cause disease. Plans that exist in silos are unhelpful. Existing work such as the Food and Agricultural Organisation's (FAO) food safety risk communication handbook could help inform aspects of our own integrated response system.

Aotearoa New Zealand's biggest recorded *Campylobacter* outbreak occurred in 2016 in Havelock North. Up to 8,320 people were estimated to have been infected after sheep faeces containing *Campylobacter jejuni* washed into an aquifer in heavy rain. As well as causing a spike in diarrhoea in Havelock North and the surrounding area, the outbreak led to four deaths and three cases of Guillain-Barré syndrome. See section 3.6 of the full report for more details about the importance of close connections between the human and animal health sectors when responding to zoonotic disease events, including a case study on the Havelock North *Campylobacter* outbreak.



Our data has value to the international community

Infectious diseases and drug resistant microbes know no borders. Data we share about the presence of pathogens and AMR organisms and genes in Aotearoa New Zealand could help other countries understand the global riskscape. Making sure the data we collect can be integrated into international databases like the Global AMR and Use and Surveillance System (GLASS) is a way that we can support global health security and international efforts to combat AMR.

AMR has received significant global attention in the past decade. For details of key international reports and initiatives that focus on AMR, including GLASS, see section 2.4.3 of the full report. Aotearoa New Zealand doesn't currently participate in WHO's GLASS initiative.

It is particularly important that we make our infectious disease and AMR data available to Pacific Island countries and territories. Close physical, social, historical, political, and cultural connections to these countries and territories require us to work in partnership with our neighbours to tackle infectious diseases and AMR. Infectious diseases spread from Aotearoa New Zealand to other Pacific nations, and vice versa. Samoa's devastating measles outbreak in 2019, spreading through a massively under-vaccinated population and killing at least 83 people, was seeded by a traveller from Aotearoa New Zealand, highlighting the importance of keeping information about our infectious disease landscape flowing to the rest of the Pacific so that appropriate risk mitigations can be put in place. In 2020, with our borders closed in response to the COVID-19 pandemic, rheumatic fever hospitalisation among Pacific peoples in Aotearoa New Zealand reduced considerably. This may indicate that rheumatic fever cases among Pacific peoples in this country are at least sometimes imported from Pacific Island countries, a link that is worth exploring further.

The following sections of the full report expand on these concepts:

Part two: Background and global context

- Section 2.2: A brief history of infectious disease and antimicrobial resistance
- Section 2.4: Global state of play

Part three: Infectious diseases in Aotearoa New Zealand

- Section 3.3: Our context
- Section 3.4: Infectious diseases impact people significantly
- Section 3.5: Infectious diseases impact animals and plants
- Section 3.6: Infectious disease at the human-animal-environment interface
- Section 3.7: Knowledge and capability gaps

Part four: Drug-resistant infections in Aotearoa New Zealand

- Section 4.3: Antimicrobial resistance: Are there drug-resistant infections in Aotearoa New Zealand?

Part five: Prevention and solutions

- Section 5.4: Detection

Panel recommendations for theme 2

(a) Establish an integrated surveillance system for microbes (including those that are drug-resistant), antimicrobial drugs, infections, and genes that encode resistance across human health, food production, animal health, and the environment. Surveillance of antimicrobial use is primarily addressed in theme 1.	
(i) Ensure the Institute of Environmental Science and Research (ESR) is resourced to coordinate an integrated surveillance system and diagnostic laboratories are supported to contribute, including retaining culturing capability and boosting whole genome sequencing (WGS) capability.	⌃⌃ Immediate
(ii) Identify and track priority microbes, antimicrobial drugs, infections, and genes that encode resistance. Develop guidelines for adding and removing from these priority lists.	⌃ 2-3 years
(iii) Standardise data systems across public and private human health diagnostic labs and veterinary diagnostic labs to facilitate efficient data sharing and the ability to compare data.	⌃ 2-3 years
(iv) Implement simplified permission mechanisms for timelier data and isolate sharing between human health, animal health, and food production.	⌃⌃ Immediate
(v) Publish regular reports on AMR threats in a timely manner. This should include reports on nationally standardised antimicrobial susceptibility testing	⌃⌃ Immediate

to support AMS efforts such as the development of national antimicrobial prescribing guidance.	
(vi) Implement regular environmental reporting that includes surveying for priority and emerging microbes, drugs, and genes. This may begin with a comprehensive baseline survey, followed by regular wastewater testing at sentinel sites such as aged residential care, hospitals, ports, farms with animals and/or irrigation, water bodies used for recreation, and mahinga kai sites.	⩓ Immediate
(vii) Build on and expand existing patient screening systems for priority microbes, genes, infections, and diseases. Develop mechanisms to update screening requirements in a systematic way, based on new evidence.	⩓ Immediate
(viii) Connect the national surveillance system to global surveillance efforts such as the World Health Organization's (WHO's) Global AMR and Use and Surveillance System (GLASS).	⩓ Immediate
(b) Enhance outbreak responses.	
(i) Enhance existing protocols for responding to an outbreak of a disease or MDRO at both regional and national levels, including enhancing lab capability across the country. Ensure that responses incorporate infectious diseases, microbiology, predictive/risk-based modelling, public health, and infection prevention and control (IPC) expertise including, where relevant, animal health expertise. Boost field epidemiology expertise in public health units to support this.	⩓ Immediate
(ii) Develop and implement national guidelines for managing carbapenemase-producing Enterobacterales (CPE) in the community, including in aged-care facilities.	⩓ Immediate
(iii) Develop a decision tree or threshold at which MPI is required to implement a public health response in collaboration with the public health agency. This may be based on the Food and Agriculture Organization (FAO) risk communication guidelines and may also be supported by enhanced connections and agreed protocols with media.	⩓ Immediate
(iv) Investigate ways to improve and expand collection of data and risk factor information from patients presenting with food- and water-borne illnesses (and the wider public) to better support timely outbreak tracing. This may involve creating a FluTracking equivalent for food- and water-borne illnesses.	⩓ Immediate

Theme 3: Strengthening infection prevention and control

Preventing infections before they occur is the best way to optimise health outcomes and preserve the effectiveness of antimicrobial drugs. With COVID-19 launching IPC into the public consciousness, now is a great time to capitalise on that enhanced attention to meet broader health objectives.

Avoidable infections take place in our communities and healthcare facilities

There are many examples of avoidable infections occurring in Aotearoa New Zealand. Our first lockdown for COVID-19 saw cases of other respiratory infections plummet, highlighting that basic public health measures can reduce the burden of respiratory infections that have previously been viewed as inevitable. Gonorrhoea, which can largely be prevented through the use of condoms during sex, nearly doubled in prevalence between 2013 and 2019. And in 2019, the country saw a measles outbreak despite the availability of a highly effective, government-funded vaccine.

In addition, preventable infections occur in our healthcare facilities, with healthcare-associated infections (HAIs) being one of the most frequent adverse events following medical care. HAIs – ranging from sepsis, to surgical site infections (SSIs), to UTIs – can be life-threatening and, as with other infections, disproportionately burden Māori patients. Given that people in healthcare settings are typically particularly vulnerable to the ill-effects of infectious diseases due to their already compromised health, HAIs are a major threat, but Aotearoa New Zealand lacks a comprehensive picture of the frequency of these events, and it is likely that they are underreported. To fill our domestic data gap, HQSC has recently completed the first ever national HAI point prevalence survey across all DHBs and is currently analysing the data gathered. HQSC intends to use that data to inform its future IPC work plan. If this survey becomes routine, Aotearoa New Zealand will be better placed to evaluate the effectiveness of IPC practices and target areas for interventions.

> Data limitations aside, HQSC has previously appraised its major IPC programmes on hand hygiene, bloodstream infections, infections caused by intravenous (IV) lines, and SSIs. Through these programme reviews, it is clear that central leadership, resourcing, and commitment to evidence-based IPC in Aotearoa New Zealand can improve patient outcomes and save money. For more details on these HQSC programmes, see section 5.3.1 of the full report.

Avoidable infections occur in the plant and animal worlds too. While our biosecurity systems keep the vast majority of pests and pathogens out of the country, incursions can and do occur, such as the introduction of Psa in 2009, probably in pollen imported from China, and the introduction of *M. bovis* from an unknown source. Vaccines for animal health could be used more widely to prevent disease. And improving husbandry practices and considering reducing the density of animals in pig and poultry farms, as well as achieving animal welfare goals, could reduce disease transmission through herds and flocks.

Vaccines and infection prevention and control tools can reduce disease and overuse of antimicrobials

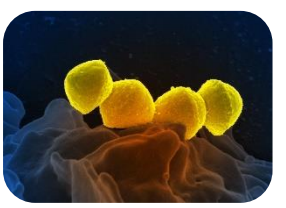
Aotearoa New Zealand could do a better job of preventing infectious diseases by optimising the use of vaccines and IPC tools and practices. In human health, ensuring currently approved vaccines are used as widely as possible is one of the most effective disease prevention measures at our disposal. Government-funded childhood vaccines aren't taken up by all New Zealanders. Just 88% of two-year-

olds are fully vaccinated for their age, dropping below 90% for the first time in a decade. Uptake is lowest among Māori and Pacific peoples. There are many barriers to uptake, including access to clear and culturally appropriate information about vaccinations (covered under theme 5) and access to healthcare facilities (covered under theme 6). Further, attitudes towards vaccination have become increasingly polarised both in Aotearoa New Zealand and abroad. In addition, there is scope for Aotearoa New Zealand to reflect on our national immunisation schedule, evaluating whether a case could be made to add new vaccines.

Not all infections can be prevented by vaccines. For example, the world doesn't have a vaccine against group A *Streptococcus*. Prioritising the development and acquisition of a vaccine against this pathogen will help combat rheumatic fever in Aotearoa New Zealand, improving health and wellbeing and moving towards greater health equity. The government's recent announcement of $10 million to support the development of a vaccine against group A *Streptococcus*, which will complement work already happening in Australia, is a welcome investment. The COVID-19 vaccine experience has showed that sustained funding and prioritisation of vaccine development has scope to remove barriers to innovation and facilitate vaccine discovery.

In addition to vaccines, other IPC tools and practices could be used to prevent infections in Aotearoa New Zealand. Ensuring healthcare facilities are appropriately ventilated, implementing IPC staffing requirements in health settings, installing air filtration or other remedial systems in high-risk transmission environments, communicating effectively with the public about simple IPC measures like hand hygiene and safer sex, and standardising cleaning and disinfection practices in healthcare and other community settings such as aged care homes could be considered. Further, with cold, crowded, damp houses creating ideal conditions for the transmission of many infectious diseases, taking a holistic approach to IPC that considers housing and infrastructure would pay dividends.

> There is strong evidence internationally and in Aotearoa New Zealand that crowded housing, inadequate heating and insulation, cold, mould, and dampness, and transient housing (including rentals and state housing) are associated with rheumatic fever. For more details, check out section 6.2 of the OPMCSA evidence summary on Group A *Streptococcus* and acute rheumatic fever in Aotearoa New Zealand.
>
> *Image: Group A* Streptococcus*. Credit: NIH Image Gallery (CC BY-NC 2.0).*



IPC could be elevated in animal and plant health too. Initiatives like the use of teat sealants on dairy farms, Psa-tolerant kiwifruit cultivars, and enhanced use of animal vaccines (all discussed under theme 1) could be considered. In addition, many of the principles that apply to IPC in human health can also be transferred to animal and plant health – and vice versa. Recognising these connections and enabling knowledge transfer between these sectors can support disease management across human, animal, and plant health in Aotearoa New Zealand.

Aotearoa New Zealand lacks national leadership on infection prevention and control

There are no strong and widely adopted national standards relating to IPC. While there are IPC requirements for the human health sector, these aren't compulsory for other settings where people may be at high risk of infection. And there is no equivalent set of standards for the vet sector, only guidelines. This leads to variable practices across hospitals, GP clinics, aged residential care, sheltered living, prisons, schools and early childhood education centres, tattoo parlours, beauty parlours, and

other community settings, and in animal and plant health. It also leads to lost opportunities for sharing lessons, with IPC principles across human, animal, and plant health having many similarities.

To fill this gap in the human health sector, the National IPC Expert Group (NIPCEG), originally established to respond to COVID-19, has been given the responsibility of setting a national IPC strategy. To achieve optimal effect, NIPCEG's expert advice needs to be embedded into policy, and connections with the veterinary and biosecurity professionals should also be considered.

The following sections of the full report expand on these concepts:

Part two: Background and global context

- Section 2.2: A brief history of infectious disease and antimicrobial resistance
- Section 2.3: Antimicrobial resistance basics
- Section 2.4: Future context

Part three: Infectious diseases in Aotearoa New Zealand

- Section 3.4: Infectious diseases impact people significantly
- Section 3.5: Infectious diseases impact animals and plants
- Section 3.6: Infectious disease at the human-animal-environment interface

Part four: Drug-resistant infections in Aotearoa New Zealand

- Section 4.4: Use of antimicrobials in Aotearoa New Zealand

Part five: Prevention and solutions

- Section 5.3: Prevention is better than a cure
- Section 5.5: Treatments

Panel recommendations for theme 3

(a)	**Develop a coordinated national approach to IPC to provide overarching governance and leadership.**	
(i)	Create stronger linkages between the human, animal, plant, and environmental health sectors, and with relevant government agencies to enable multi-way knowledge sharing on IPC. This may involve stronger links between the restructured health localities (currently DHBs), the veterinary profession, and biosecurity.	⌃⌃ Immediate
(ii)	Formalise and provide ongoing support for the national IPC expert group (NIPCEG; focused on human health) to embed expert advice into policy making.	⌃⌃ Immediate
(iii)	Establish a national centre dedicated to IPC with responsibility for implementing the national IPC strategy.	⌃⌃ Immediate
(b)	**Strengthen and expand standards related to IPC.**	
(i)	Strengthen and adapt existing facility design standards for hospitals, GP clinics, aged residential care, sheltered living, prisons, schools and early childhood education centres, tattoo parlours, beauty parlours, and other community settings to improve IPC.	⌃ 2-3 years
(ii)	Maintain and develop (where appropriate) evidence-based standards related to cleaning and disinfection procedures for hospitals, GP clinics, aged residential care, sheltered living, prisons, schools and early childhood education centres, tattoo parlours, beauty parlours, and other community settings. Require regular audits to be undertaken by IPC experts to ensure standards are being met.	⌃ 2-3 years

(c) Build IPC capacity and expertise at all levels. Support implementation of IPC across the human, animal, plant, and environmental health systems, including but not limited to: primary care, aged residential care, public and private hospitals, dentistry, optometry, midwifery, biosecurity, pharmacy, and veterinary care.	
(i) Establish leadership roles focused on infection prevention and control (and alongside AMS) at the director level of all DHBs (or equivalent).	⩓ Immediate
(ii) Require all DHBs, private hospitals, and PHOs to report annually on their IPC goals, activities, and outcomes.	^ 2-3 years
(iii) Implement minimum FTE requirements for IPC at all hospitals (both public and private).	^ 2-3 years
(iv) Establish IPC nurse practitioner roles and develop associated training pathways.	^ 2-3 years
(v) Require each DHB (or equivalent) to establish a community IPC workforce to support IPC in a range of community settings and undertake audits as per recommendation **3(b)(ii)**.	^ 2-3 years
(vi) Set targets for equitably increasing the IPC workforce. Ensure this is resourced appropriately.	⩓ Immediate
(vii) Develop an initiative to upskill community care providers on IPC.	⩓ Immediate
(viii) Support farmers to implement alternatives to antimicrobials, such as for dry cow therapy and treatment of necrotic enteritis in poultry.	⩓ Immediate
(ix) Review the agricultural compounds and veterinary medicines registration system to allow expediting of antimicrobial alternatives that don't have food safety or residue issues, such as vaccines and probiotics, where international data supporting use of these alternatives exists.	⩓ Immediate
(x) Review current animal husbandry practices and investigate ways these could be improved to reduce infection.	⩓ Immediate
(d) Improve data governance: collection, quality and reporting.	
(i) Standardise national reporting for surgical site infections (SSIs).	⩓ Immediate
(ii) Build on and expand existing point prevalence surveys and ensure these are carried out regularly.	⩓ Immediate
(iii) Investigate options for rolling out a national standardised IPC surveillance and alert system, potentially using the ICNet system already used by some DHBs.	^ 2-3 years
(iv) Investigate new ways of collecting IPC data, such as phone apps for on-ward surveys.	^ 2-3 years
(e) Immunisation	
(i) Continue to develop and improve an ongoing, accessible, and culturally safe communication campaign to encourage vaccine uptake in human health, with a strong focus on equity and underserved people. The communications campaign should: • be evidence-based; • be based on behavioural science; • include evaluation (including through Indigenous frameworks); • be multi-pronged with a range of different media, including face-to-face communications; • be co-designed with Māori and Pacific peoples; • be available in multiple languages; and • build on and align with existing initiatives.	⩓ Immediate
(ii) Support equity in immunisation and evaluate how equitable immunisation can be championed within the health reforms, including by identifying and removing barriers to access.	⩓ Immediate

(iii) Make vaccines available for seasonal workers entering Aotearoa New Zealand in order to protect the incoming workers and people in Aotearoa New Zealand against infectious disease outbreaks.	⩓ Immediate
(iv) Review the immunisation schedule as part of a wider infectious diseases strategy, in collaboration with existing initiatives.	⩓ Immediate
(v) Prioritise the development and acquisition of a vaccine for group A *Streptococcus* (GAS).	⩓ Immediate
(vi) Develop an ongoing, accessible communications campaign to encourage wider use of vaccination in animals and develop best immunisation practice guidelines for vets. The communication campaign should: • be evidence-based; • be based on behavioural science; • include evaluation; and • be multi-pronged with a range of different media, including face-to-face communications.	⩓ Immediate
(vii) Investigate barriers to vaccine use in animal husbandry and implement strategies to increase vaccine coverage. This may involve subsidising animal vaccines for zoonotic diseases.	⩓ Immediate

Theme 4: Grow Aotearoa New Zealand's infectious diseases capability and engage internationally

Aotearoa New Zealand's ability to manage infectious disease and AMR threats relies heavily on the strength of our workforce of researchers and practitioners. There is excellent mahi going on in Aotearoa New Zealand in the infectious disease and AMR space, in academia, among practitioners and in the policy community. These efforts can be optimised if they are joined up, including across the human, animal, plant, and environment interface, and with valuable inclusion of mātauranga Māori and international insights. We need to invest in this crucial workforce – and foster collaboration and cross-pollination within it, and with the international community – to optimise infectious disease and AMR management.

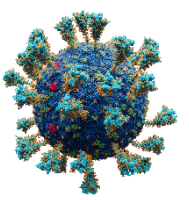
Our COVID-19 response has shown the value of science

In the face of COVID-19, scientists, health practitioners, and policy makers have worked together to develop evidence-based policy responses. While human health experts have taken centre stage, animal health experts have been drawn on too, helping to evaluate the risk posed by COVID-19 infections in animals and transferring epidemiological insights from outbreaks in the animal world, such as *M. bovis*, to experts in human health. The scientific effort has been interdisciplinary, involving modellers, public health experts and practitioners, infectious disease experts, immunologists, geneticists, and more.

With Aotearoa New Zealand charting a unique COVID-19 course compared with most other countries, having our own scientific expertise to help develop policies has been key. We couldn't just take COVID-19 advice off the shelf from another country. Scientific evidence and COVID-19 experiences overseas have been important sources of information for our COVID-19 management strategy, but these insights have needed expert interpretation within our own context.

With the global research community heavily focused on COVID-19, it is crucial to make sure that funding, space, and focus on other infectious diseases as well as non-communicable diseases is maintained to avoid always being prepared for the last health crisis rather than the next one.

> The Covid-19 pandemic has seen funding and attention diverted and researchers pivoting away from their usual areas of interest, sometimes at the expense of other pressing infectious and non-infectious diseases of concern. For more details on the impacts of COVID-19 on the infectious disease and AMR landscape, including the 'Covidisation' of research, see section 2.4.2 of the full report.
>
> *Image: Scientifically accurate model of the SARS-CoV-2 virus. Credit: Alexey Solodovnikov and Valeria Arkhipova via Wikimedia (CC BY-SA 4.0).*



Our community of researchers and practitioners must be strengthened

Our workforce of infectious disease researchers and practitioners can continue to be strengthened. Fostering the next generation of researchers and practitioners through a focus on education at the primary, secondary, and tertiary levels, as well as ongoing education among the professional workforce, will support this. Among practitioners, there is room to increase the number of people with expertise in infectious disease, AMR, AMS, and IPC, as discussed under themes 1 and 3. Ensuring this expertise is distributed throughout the country, including in rural healthcare settings where expertise in these fields is often limited, is important for supporting health equity. And ensuring that workforce

diversity reflects the diversity of Aotearoa New Zealand will be important for ensuring that the workforce is able to serve all New Zealanders.

In addition to strengthening our research workforce, those researchers need resources and systems that enable their work. The recently announced Strategic Science Investment Fund (SSIF) platform, through which the government will be investing $36 million over three years in a programme of research focused on COVID-19 and infectious diseases, is a promising step towards supporting the investment we need. And the Ministry of Business, Innovation and Employment's (MBIE) Future Pathways consultation on Aotearoa New Zealand's research system affords an opportunity to further raise the profile of infectious disease work.

Information flows between researchers and practitioners in human, animal, and plant health can help Aotearoa New Zealand grow our understanding of the infectious disease and AMR risk profile and identify solutions. As discussed under theme 2, barriers to data flows need to be identified and overcome to achieve this. This includes making data and samples held by private sector actors available to the government and making infectious disease and AMR data and samples more readily accessible to academic researchers too.

> There is already lots of good research happening in Aotearoa New Zealand to help us unite against infectious disease and AMR. We are taking part in the global search for new antibiotics, exploring antimicrobial surface coatings, evaluating the effectiveness of IPC interventions, designing evidence-based approaches to curb pathogen spread, and much more. Drawing on domestic expertise, including mātauranga Māori, and engaging with experts overseas through collaborations is important to supporting this mahi. More on the role of research and evidence in the response to infectious disease and AMR can be found throughout the full report.

There is scope for Aotearoa New Zealand to explore whether our current capacity to make drugs and vaccines is suitable. For example, we don't have the capacity to make human vaccines at scale (although we do make some animal vaccines). With COVID-19 driving many countries to invest in sovereign vaccine manufacturing capacity, with a particular focus on mRNA vaccines, the emergence of a globally distributed vaccine manufacturing model is important to be aware of as we think about how we will secure access to the biomedical products in the future, including in the next pandemic.

Our workforce is made stronger by international connections

Research and innovation can be strengthened if people, ideas, and resources are brought together and diversity is embraced. Recent data capturing the proportion of Aotearoa New Zealand's research publications with international co-authors shows that our offshore academic collaborations are strong and growing. Supporting researchers, practitioners, and policy makers to continue to connect and engage internationally is important to strengthening our infectious disease capability, knowledge, and practices.

As a small country, Aotearoa New Zealand relies heavily on our international connections. For example, we often engage in research collaborations, education, and capacity building activities with Australia. Connections with the Pacific are particularly important for us too, as described under theme 2. Working in partnership with Pacific Island countries and territories to bolster infectious disease capabilities is something we already do across human, animal, and plant health – for example, through the Polynesian Health Corridors programme – and should remain a focus.

The following sections of the full report expand on these concepts:

Part two: Background and global context

- Section 2.4: Global state of play
- Section 2.5: Future context

Part three: Infectious diseases in Aotearoa New Zealand

- Section 3.3: Our context

Part five: Prevention and solutions

- Section 5.3: Prevention is better than cure
- Section 5.6: empowering people and building capability

Panel recommendations for theme 4

(a) Build on the newly announced Strategic Science Investment Fund (SSIF) to establish an inclusive infectious diseases network with diverse representation from academia and frontline practitioners, focused on both capacity building and research.	
(i) The SSIF should harness both research excellence and operational aspects (e.g. outbreak response capacity). Clear links to policy and a focus on capability development should be embedded in its design.	^ 2-3 years
(ii) The network should adopt a holistic approach to infectious diseases with representation across human, animal, plant, and environmental health.	^ 2-3 years
(iii) Engage with iwi and Indigenous knowledge including mātauranga Māori.	^ 2-3 years
(iv) Ensure the network has strong connections and integration with policy makers.	^ 2-3 years
(v) Create a searchable database of people and their expertise to encourage collaboration.	^ 2-3 years
(b) Develop a national strategy for infectious diseases. This strategy may be led by the infectious diseases network.	
(i) Ensure this strategy has a focus on equity.	^ 2-3 years
(ii) Ensure this strategy integrates with the New Zealand AMR Action Plan, as well as the associated workstreams in AMS and IPC.	^ 2-3 years
(iii) As part of the strategy, develop national research priorities for infectious diseases and AMR, and identify gaps in Aotearoa New Zealand's expertise.	^ 2-3 years
(iv) Include communications as part of the strategy.	^ 2-3 years
(v) Review the immunisation schedule as part of this strategy (see recommendation **3(e)(iv)**).	^ 2-3 years
(c) Build Aotearoa New Zealand's infectious diseases workforce.	
(i) Set targets and allocate resources for equitably increasing the infectious diseases workforce (including infectious disease, AMS and IPC expertise) across frontline health practitioners, academia, and government agencies. See also recommendations **1(b)(vi)** and **3(c)(vi)**.	^ 2-3 years
(ii) Investigate approaches to improving the availability of infectious diseases expertise to clinicians working in both hospitals and community settings in regional areas (outside main centres). This might include: • providing opportunities for physicians to undertake infectious diseases training in regions rather than only large centres; • requiring minimum FTE in infectious diseases across hospitals (considering roles for doctors, pharmacists, and nurses as appropriate); and/or	^^ Immediate

• a formal advice system to ensure hospital and community clinicians in the regions can access infectious disease and microbiology expertise in a timely manner. This may include increased use of telemedicine and virtual ward rounds.	
(iii) Enhance infectious diseases topics including AMS, AMR, and IPC into tertiary curricula for all health professions and ongoing professional development.	⌃⌃ Immediate
(iv) Establish scholarships and fellowship positions for tertiary education in the infectious diseases field, including both clinical and lab-based.	⌃⌃ Immediate
(v) Investigate ways of engaging rangatahi and tamariki in AMR and infectious disease conversations through hui and workshops, resources, and curricula at primary, intermediate, and secondary level.	⌃ 2-3 years
(d) Understand and remove barriers to quality improvement work and data sharing.	
(i) Streamline and standardise ethics requirements and processes for quality improvement work and enhance access to routinely collected data as a tool for quality improvement.	⌃⌃ Immediate
(ii) Ensure microbial isolates and metadata can be shared in an ethical and efficient way.	⌃⌃ Immediate
(iii) Enable the Food Safety Science and Research Centre to conduct research for public health, including mātauranga Māori, that is not dependent on industry funding.	⌃⌃ Immediate
(e) Strengthen international connections.	
(i) Support two-way knowledge sharing between Aotearoa New Zealand and the Pacific to lift capability across the region.	⌃⌃ Immediate
(ii) Support researchers, practitioners and policy makers to connect and engage internationally to inform best practice.	⌃⌃ Immediate
(f) Evaluate Aotearoa New Zealand's biomedical manufacturing infrastructure needs.	
(i) Investigate the costs and benefits of developing onshore capability to manufacture biomedical products under an emerging scenario of a globally distributed model (e.g. to manufacture mRNA vaccines under license for local use).	⌃ 2-3 years

Theme 5: Enhance health literacy

AMR and infectious disease management in Aotearoa New Zealand is everyone's responsibility. We need to ensure all New Zealanders have the tools to be part of the mission, so bolstering health literacy and improving communication across all segments of society is key.

COVID-19 has demonstrated that good communication can promote good health outcomes

Aotearoa New Zealand's approach to public communication in the early stages of the pandemic was praised. Our approach to communication helped us sustain our elimination strategy for over a year and a half. The use of experts and community leaders to deliver key public health information helped foster trust and compliance, as did timely and transparent sharing of information and the disclosure of the evidence underpinning key decisions. Our clear alert level system helped the public to understand what was required at different levels of community transmission and why. And the prominent use of sign language and te reo Māori made public health messages more widely accessible to different segments of society. Lessons from the COVID-19 experience about how to effectively approach public health and risk communication could be applied to communicating about AMR and infectious disease more broadly.

Clear and consistent communication requires leadership

Our current lack of national leadership in infectious disease and AMR across human, animal, and plant health makes it impossible to devise clear and consistent communication strategies. Just as the clear COVID-19 alert level system flowed into clear downstream communications, a national direction on infectious disease and AMR could inform effective and consistent communication with the ability to promote health and wellbeing.

As a product of our current lack of leadership in infectious disease and AMR, communications are disjointed between and even within the human, animal, and plant sectors, limiting opportunities to get everyone on the same page about the national approach to combatting infectious disease and AMR threats. For example, in human health there is a range of conflicting antimicrobial use guidelines, which has scope to create confusion for prescribers, dispensers, and users of antimicrobial drugs, potentially leading to behaviours that deviate from best practice in AMS.

It's key to involve many stakeholders in the conversation

Everyone in Aotearoa New Zealand has a role to play in combatting infectious disease and AMR. This means communication campaigns and efforts to boost health literacy need to consider a wide range of people, including healthcare workers, vets, farmers, aged residential care providers, patients, teachers, and the general public, including tamariki and rangatahi. Research into the level of awareness and understanding of AMR by different stakeholders in Aotearoa New Zealand is limited. But available evidence suggests that there are variable levels of understanding and prioritisation of infectious diseases and AMR, as touched on under theme 1, leaving plenty of space to lift health literacy so that everyone has the tools they need to make informed health decisions that consider the rising tide of AMR.

A range of topics could benefit from strong communication

Across the infectious disease landscape, there is a number of topics for which effective communication could benefit the wellbeing of people in Aotearoa New Zealand. For example:

- The relationship between the overuse and misuse of antimicrobials and the threat of AMR.
- Important infections like sepsis, STIs, and rheumatic fever, including the associated risk and how to prevent and treat infections effectively.
- The role of interventions like vaccinations and safe food handling in securing health.

> Evidence from a UK study demonstrates that interventions to promote understanding of AMR amongst members of the public can reduce their demand for antibiotics that they don't need. Use of an online teaching tool was able to reduce people's incorrect beliefs about their personal need for antibiotics and increase their concern about the harms of antibiotics (e.g. side effects) and awareness of AMR. For more details on health literacy, see section 5.6.1 of the full report.

Communications must be tailored appropriately to work effectively

While consistent messaging is important to avoid confusion and ensure that people are getting the right messages, communication methods and media need to flex depending on the context, topic, target audience, and desired outcome. For example, some messages may be better communicated through face-to-face conversations between a patient and healthcare worker while others may be effectively disseminated in nationwide advertising campaigns.

Accounting for Aotearoa New Zealand's linguistic, educational, and cultural diversity is crucial if we want to lift health literacy equitably across the whole population. In particular, considering how to communicate about health effectively with Māori and Pacific peoples is crucial given the disproportionate infectious disease burden carried by these groups. The best source of knowledge when designing communication strategies to reach specific stakeholders is to consult those stakeholders directly – co-design helps communication strategies hit the mark.

The following sections of the full report expand on these concepts:

Part four: Drug-resistant infections in Aotearoa New Zealand

- Section 4.4: Use of antimicrobials in New Zealand

Part five: Prevention and solutions

- Section 5.6: Empowering people and building capacity

Panel recommendations for theme 5

(a) Strengthen communications: Human health.	
(i) Enhance and expand ongoing, accessible, and culturally safe communications campaigns aimed at: • healthcare workers including prescribers, pharmacists, and nurses; • patients and the public; and • aged residential carers. Among other things, these campaigns should consider focussing on: • AMR; • antimicrobial use including topical antimicrobials and managing patient expectations around antimicrobial use; • important infections (or sequelae) such as sepsis, sexually transmitted infections (STIs), and rheumatic fever; and • IPC measures such as vaccines (see also **3(e)(ii)**) and safe food handling.	⩓ Immediate

The communications plans should be: • equity-focused; • evidence-based; • based on behavioural science; • evaluated (including through Indigenous frameworks); • multi-pronged with a range of different media, including face-to-face communications; • co-designed with Māori and Pacific peoples; • available in multiple languages; and • coordinated and aligned to animal health and agriculture initiatives (where relevant) to ensure consistent messaging.	
(ii) Develop accessible and culturally safe tools to help health professionals discuss prescribing decisions with patients in a shared decision-making model. These tools could be developed and embedded as part of national antimicrobial prescribing guidelines so that messaging aligns.	^ 2-3 years
(iii) Increase support for primary, intermediate, and secondary school teachers to access resources on AMR and infectious diseases for teaching science, and to utilise them in integrated, student-centred pedagogies. This may involve developing curriculum components for primary, intermediate, and secondary school. See also recommendation **3(c)(iv)**.	^ 2-3 years
(iv) Trial a public-facing, timely risk communication tool for infection risk associated with food and water. This may build on the industry Environmental Risk Information Services (ERIS) platform.	^^ Immediate
(b) Strengthen communications: Animal health and agriculture.	
(i) Strengthen existing communications campaigns aimed at vets on AMR, antimicrobial use, vaccines, and IPC, and expand to new audiences including farmers and pet owners. Ensure there is coordination and alignment with human health initiatives for consistent messaging.	^^ Immediate

Theme 6: Reimagine primary care

Primary care – healthcare provided in the community for people making an initial approach to the health system for advice or treatment – is where the majority of health interactions occur in Aotearoa New Zealand, including 95% of antimicrobial drug prescription and use. Ensuring primary care services are optimally set up to equitably detect and treat infectious diseases and foster AMS is key to improving health outcomes.

In addition, achieving widespread primary healthcare coverage can save money by preventing diseases or treating them early, reducing the need for more expensive health interventions down the line. The upcoming restructure of the health system affords opportunities for improvement.

We must tackle barriers to primary care and medicine access

Not everyone in Aotearoa New Zealand can readily access primary health services. Māori and Pacific peoples, materially deprived individuals and families, and rural communities are disproportionately likely to come up against barriers to access, contributing to inequitable health outcomes.

There are many barriers to access. Some are practical or logistical, such as the location of services, limited time available for appointments, and the time required for the appointment and travel in the face of competing demands like work, school, and childcare. For rural communities, accessing health services is more difficult than for urban dwellers in major centres, who are more likely to live close to healthcare facilities that meet their needs. Where appropriate, using virtual consultations for patients for whom travel is a barrier is just one that healthcare access could be expanded.

> Telemedicine, while improving access to healthcare services, may have unintended impacts on antimicrobial use. In the UK, a massive increase in the use of telemedicine consultations occurred as a result of COVID-19 between April and August 2020. When adjusted for the number of consultations, a 6.7% increase in antibiotic prescriptions was observed compared with the same period in 2019. This suggests that antibiotics are more likely to be prescribed in remote consultations than in person, possibly resulting from reduced diagnostic certainty due to an inability to examine patients and perform investigations, causing clinicians to take a precautionary approach to prescribing.

Economic barriers also play a prominent role, particularly for people in low-income households. Māori are more likely to cite cost as a barrier to accessing primary care, and Pacific children are more likely than non-Pacific children to experience unmet need for a GP visit due to cost. With GP check-ups now being fees free for children under 14 years, this is likely at least partially due to the cost of travel or time off work for caregivers. And Māori and Pacific peoples are less likely to fill a prescription because of cost compared with the rest of the population. In an example of good practice, Australia has implemented a programme called Closing the Gap under its Pharmaceutical Benefits Scheme (PBS), which provides medications to Indigenous patients at a lower out-of-pocket cost.

Communication that isn't appropriately tailored for different subsets of the population can serve as a barrier to primary healthcare access too, particularly where communication doesn't consider linguistic, educational, and cultural diversity, as discussed under theme 5. In addition, concerns that they may encounter racism or culturally inappropriate care can deter people from seeking health services, and experiences of racism in the health system – institutionalised and otherwise – can reduce the utility of the healthcare experience and deter future health seeking behaviour.

Antimicrobial stewardship practices in the community could be improved

Given that most antimicrobial drugs are prescribed by primary healthcare providers, improving AMS in these settings is key to addressing overuse and misuse of antimicrobial drugs, and overcoming under-prescription disparities that affect certain subsets of the population as well. AMS is covered extensively under theme 1.

The following sections of the full report expand on these concepts:

Part three: Infectious diseases in Aotearoa New Zealand

- 3.4: Infectious diseases impact people significantly

Part four: Drug-resistant infections in Aotearoa New Zealand

- Section 4.4: Use of antimicrobials in New Zealand

Part five: Prevention and solutions

- Section 5.5: Treatments
- Section 5.6: Empowering people and building capability

Panel recommendations for theme 6

(a) Enhance equity and remove barriers to accessing healthcare and appropriate antimicrobial therapies.	
(i) Investigate and implement mechanisms to make transport to healthcare more accessible.	⌃⌃ Immediate
(ii) Encourage and facilitate more virtual consultations to make healthcare more accessible, building on experience gained through the COVID-19 pandemic.	⌃⌃ Immediate
(iii) Increase mobile clinics and school-based clinics, with a focus on equity and reaching underserved communities.	⌃⌃ Immediate
(iv) Investigate mechanisms for removing financial barriers to prescription antimicrobials. These may include: • removing the $5 co-payment for people with a community services card; • lowering the threshold for the prescription subsidy scheme; • implementing a programme for Māori and Pacific peoples similar to the Closing the Gap programme under Australia's Pharmaceutical Benefits Scheme (PBS); and/or • extending the age limit for free prescriptions to people 25 and under.	⌃ 2-3 years
(b) Rethink prescriptions.	
(i) Investigate making delayed antimicrobial prescriptions with clear criteria standard practice and integrate advice on this into antimicrobial prescribing guidance (see recommendation **1(a)(vi)**). Evaluate the best approach for doing this including providing specific dates within the prescription between which the antimicrobial can be collected.	⌃ 2-3 years
(ii) Require the prescriber to include a meaningful indication for antimicrobial use within the prescription. Evaluate approaches to standardising this using a set of indication codes.	⌃ 2-3 years
(iii) Support embedding AMS pharmacists within hospitals and the community (e.g. PHOs, GP clinics) to improve prescribing practices.	⌃ 2-3 years
(iv) Make prescriber benchmarking or feedback standard practice in hospitals and in the community and investigate how this can be displayed on dashboards or through the patient management software. See also recommendation **1(c)**.	⌃ 2-3 years

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