IAN AXFORD (NEW ZEALAND) FELLOWSHIPS *in* PUBLIC POLICY

Building Bridges to Protect Health: Enhanced Partnerships among Animal, Human, and Ecosystem Health Sectors in New Zealand

Prepared by
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Established by the
New Zealand government in 1995
to facilitate public policy dialogue
between New Zealand and
the United States of America

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Ian Axford (New Zealand) Fellowships in Public Policy

Established by the New Zealand Government in 1995 to reinforce links between New Zealand and the US, Ian Axford (New Zealand) Fellowships in Public Policy provide the opportunity for outstanding mid-career professionals from the United States of America to gain firsthand knowledge of public policy in New Zealand, including economic, social and political reforms and management of the government sector.

The Ian Axford (New Zealand) Fellowships in Public Policy were named in honour of Sir Ian Axford, an eminent New Zealand astrophysicist and space scientist who was patron of the fellowship programme until his death in March 2010.

Educated in New Zealand and England, Sir Ian held Professorships at Cornell University and the University of California, and was Vice-Chancellor of Victoria University of Wellington for three years. For many years, Sir Ian was director of the Max Planck Institute for Aeronomy in Germany, where he was involved in the planning of several space missions, including those of the Voyager planetary explorers, the Giotto space probe and the Ulysses galaxy explorer.

Sir Ian was recognised as one of the great thinkers and communicators in the world of space science, and was a highly respected and influential administrator. A recipient of numerous science awards, he was knighted and named New Zealander of the Year in 1995.

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Hillery A. Harvey
Wellington, August 2010

EXECUTIVE SUMMARY

This report provides recommendations to improve human, animal, and ecosystem health[1] in New Zealand through a common sense approach that acknowledges the interdependence of people, domestic animals and wildlife, and the environment. The report encourages coordinated actions that reduce wastage and duplicative efforts, thus avoiding potentially costly gaps that result from parallel or disjointed approaches.

Context for connected health[2]

Whereas government agencies are bound by administrative authority, pests and pathogens are restricted only by the laws of nature. Health issues cross disciplines. Human health determinants often sit outside the human health sector's traditional jurisdiction. The same is true for animal and ecosystem health. Consider antimicrobial resistance, food safety and security, water systems, disease ecology, and the effects of climate change and agricultural production systems on soil, air, and waterways. Consider erosion, loss of natural habitats, invasive plants and animals, increased development, population growth, and emerging infectious diseases. Current and future threats require coordinated transdisciplinary[3] action. The context is set for connected health.

Integrating human, animal and ecosystem health disciplines will better address today's dynamic health threats. This report highlights successful New Zealand transdisciplinary health efforts and maps out steps toward greater integration. The desired outcome of this report is a guide that will help protect the health of New Zealand's people, production animals, wildlife, and environment by urging and guiding transdisciplinary interactions.

Learning from success

Lessons can be learned from examining past efforts. In New Zealand, past actions against specific health threats have demonstrated that using complementary skills, interests, and resources to address cross-cutting health issues is crucial to success. Coordinated transdisciplinary actions have resulted in striking achievements in the control of bovine brucellosis, bovine tuberculosis, and echinococcosis. More recently, transdisciplinary health research and response efforts have successfully reduced campylobacteriosis cases, addressed pandemic influenza, and eradicated the southern saltmarsh mosquito.

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[1] **Ecosystem**: A dynamic complex of plant, animal, and microorganism communities and their nonliving environment interacting as a functional unit. **Ecosystem health**: A measure of the stability and sustainability of ecosystem functioning or ecosystem services that depends on an ecosystem being active and maintaining its organisation, autonomy, and resilience over time. Ecosystem health contributes to human well-being through sustainable ecosystem services and conditions for human health. (Millenium Ecosystem Assessment, 2005, *Ecosystems and Human Well-being: A Framework for Assessment*)

[2] For the purposes of this report, **health** is interpreted in the broader sense to include human, animal, and environmental health.

[3] For the purposes of this report, **transdisciplinary** describes an integrated, holistic approach that crosses disciplinary boundaries. Transdisciplinary is distinct from multi-disciplinary and cross-disciplinary in that the boundaries between disciplines are diffuse while expertise is engaged, and the approach is dependent upon frequent communication and efficient and aligned execution of a common goal.

Several state-of-the-art New Zealand organisations already conduct their work, teaching and researching under the paradigm that transdisciplinary collaboration is the fastest path to success. These include the New Zealand Centre for Conservation Medicine (NZCCM), the Massey University EpiCentre, the National Centre for Biosecurity and Infectious Diseases (NCBID), and others.

Challenges and opportunities

New Zealand and the world face innumerable health challenges. Climate change and human activities, such as the Deepwater Horizon oil spill (Gulf of Mexico, 2010) and the continued encroachment of wildlife habitat risk further destabilisation of ecosystems, presenting unforeseen health threats.

Adding to these challenges is the task of educating policy-makers and the general public about the interdependence of human, animal, and ecosystem health. Increased awareness will increase support for prevention efforts that in time will reduce the need for more costly and potentially unsuccessful response efforts.

In 2010-2011, the New Zealand Food Safety Authority (NZFSA) merges with the Ministry of Agriculture and Forestry (MAF). The value proposition, or primary benefit, of the amalgamation is:

> Strengthening the integrity and performance of the biological value chain, covering animals, plants, food and related sectors and their contribution to New Zealand's economy, environment, and social wellbeing.[4]

The value proposition is entirely consistent with an outcome of increased coordination among human, animal and ecosystem health disciplines in New Zealand. The value proposition is also consistent with biosecurity as defined by the World Health Organization (WHO) and Food and Agriculture Organization (FAO) of the United Nations:

> What is biosecurity? A strategic and integrated approach to analysing and managing relevant risks to humans, animals, and plant life and health and associated risks to the environment. It is based on recognition of the critical linkages between sectors and the potential for hazards to move within and between sectors, with system-wide consequences.[5]

In addition to improving New Zealand's biological value chain, joining the NZFSA and MAF presents an opportunity to maintain and build upon the country's outstanding biosecurity reputation. The restructuring also provides the two agencies an opportunity to strengthen links with other health-related organisations, including the Ministry of Health (MOH), the Department of Conservation (DOC), the Ministry for the Environment (MFE), and others.

New Zealand has an opportunity to improve coordination and management of zoonotic disease, a significant threat that affects multiple links in the biological value chain. At the moment, zoonotic diseases such as leptospirosis fall into the cracks between animal and human health; no single sector steps forward to lead a coordinated effort to control these diseases that affect production animals, wildlife, and humans. The broadened mandate provides MAF-NZFSA with an opportunity to

[4] MAF (2010), 'Amalgamation of MAF and NZFSA', slide 2
[5] International Food Safety Authorities Network (INFOSAN) (2010), p.1

lead a coordinated effort to address such threats to New Zealand.

Emergent themes

The project identified several themes based on meetings, discussions and interviews with key stakeholders and subject experts:

1. Improved partnerships are needed among human, animal and ecosystem health disciplines.
2. The current political climate is right to expand transdisciplinary coordination: without exception, individuals who contributed to the project are enthusiastic to engage their counterparts in other health disciplines.
3. A dual top-down, bottom-up approach is needed for health: policy-makers need to drive the change; educators must teach the importance of health interdependence to tomorrow's professionals; leaders are needed who can lead across disciplines.
4. All parties must help diffuse anthropogenic boundaries between health disciplines by collectively addressing health threats according to disease pathway.

Recommendations

The individuals who contributed to this report included policy-makers, researchers, educators and community members, ranging in expertise across human, animal, and ecosystem health. Individuals across the spectrum expressed interest in the project and anticipation in seeing the report. Chapter five contains recommendations useful to policy-makers; independent researchers; people who make decisions about funding, research and education programmes; and community practitioners. Detailed recommendations are divided into policy, research, education, and community sections. The overarching recommendation is to manage broad impact health issues according to biology, rather than according to government mandates, legislation, or lines drawn on a map.

Policy recommendations include the establishment of a director-general-level interagency governance group, whose primary function would be to develop and orchestrate collaborative strategies for managing health threats. The governance group would comprise high-level representatives from key stakeholder agencies and institutes. A chairperson capable of leading across disciplines would head the group. The governance group would define agency roles and responsibilities, prioritise activities, generate a collective strategy, and oversee execution.

Other policy level recommendations include integrating surveillance, investigation, and response; conducting cost analysis of integrated approaches; strengthening international ties; and "mainstreaming" ecosystem health.

Research level recommendations include establishing a zoonotic disease research steering committee to advise the governance group; consolidating interdisciplinary research and training; improving wildlife health coordination; and increasing funding of collaborative research.

Education level recommendations include developing transdisciplinary leaders;

providing integrated courses to undergraduates, graduate trainees, and career professionals; and providing interdisciplinary scholarship opportunities and mentoring programmes for graduate students.

Community level recommendations include strengthening links between human and animal health practitioners and regional council members; incorporating transdisciplinary approaches into daily practice; and encouraging integrated and reciprocal communications approaches with media and members of the public.

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PREFACE

Photograph by Te Ara, the Encyclopaedia of New Zealand, © Crown Copyright 2006-2010 Ministry for Culture and Heritage, New Zealand (used with permission).[6]

The iconic New Zealand landscape: sheep and cattle companionably graze rolling green pasture. An outwardly simple scene, maintaining the health of this ecosystem – the land, water, air, plants, animals, micro-organisms – is critically important to New Zealanders' personal and collective prosperity and health.

Featured prominently is a tōtara tree, a native New Zealand species historically used by Māori for carvings, canoes and houses, and later by European settlers to build railroads and fences. Before human arrival in New Zealand this landscape would have been covered by tōtara and other towering native tree species, the dominant components of a diverse and productive ecosystem. With the arrival of Europeans, farmland and grazing replaced native ecosystems to create this idyllic pastoral scene. The sheep and cattle represent New Zealand's lamb, wool, beef and dairy industries, while the distant tree plantation represents New Zealand's critical timber industry. The aesthetically-pleasing landscape beckons thousands of visitors each year who inject millions of dollars into New Zealand's thriving tourism industry.

Absent from the photo are the extensive support system and network of stakeholders tasked with maintaining or improving this outwardly charming rural scene.

Farmers ensure animals' well-being, provide food, land and arrange optimal healthcare. Veterinarians and their assistants oversee the animals' health and reproduction. Agriculture industry personnel and farm advisors oversee farm activities and production. The Department of Labour ensures workplace safety and prevention practices. The NZFSA ensures that meat and dairy products are safe to eat. Local regional councils monitor the health of the land and surrounding ecosystem. MAF

[6] Te Ara, The Encyclopaedia of New Zealand (2010), http://www.teara.govt.nz/en/sheep-farming/9/4

leads the protection and sustainable development of New Zealand's biological resources by safeguarding the livestock and their environment from exotic pests and diseases.[7] Scientists conduct research that supports the health and well-being of the animals and the land. The MOH and district health authorities address issues that affect human health. DOC manages ecosystems and generally advocates for the protection and enhancement of ecological values. Finally, consumers within New Zealand and around the globe enjoy the resulting meat, dairy and wool products.

Collectively, these efforts require significant time, money and other resources all directed toward a single outcome: health. The system ensures human, animal, and ecosystem health and, by transference, New Zealand's economic health.

Threats to the ecosystem include erosion – evidenced by the slips in the photo's foreground. Erosion reduces the productivity, the available grazing area in this case, of the land. Sediment from erosion can negatively impact the health of the stream in the foreground. The proximity of the pasture animals can negatively impact the water and aquatic health of the stream and also contribute to further erosion.

Other ecosystem threats include demographic and land use changes, pests, toxins, and of particular interest to humans, pathogens.

Although most of these threats affect all three elements – human, animal, and ecosystem – mandates and mechanisms to effectively deal with prevention, surveillance, and response across agencies are insufficient. At the moment, respective agency strategies to address broad impact health threats such as zoonotic diseases are not coordinated or aligned.

With health the most critical factor binding humans, animals, and ecosystems, is the current fragmented approach to health practical? Health in the broad sense is an undertaking too big for a single group to perform; a single entity with a broad leadership role would reduce fragmentation and encourage a more cohesive approach to protecting New Zealand's human, animal, and ecosystem health and economic interests.

Going back to the photo, an approach to health as collective and interdependent as the ecosystem itself would improve the health of each component.

[7] MAF (2009), pp.12-13

INTRODUCTION

In 2008 the FAO, World Organisation for Animal Health (OIE), WHO, United Nations Children's Fund (UNICEF), World Bank, and UN System Influenza Coordination, developed a strategy to address emerging infectious diseases centred on the interdependence of human, animal, and ecosystem health. The resulting *One World, One Health*[8] strategic framework states:

> Only by breaking down the barriers among agencies, individuals, specialties and sectors can we unleash the innovation and expertise needed to meet the many serious challenges to the health of people, domestic animals, and wildlife and to the integrity of ecosystems.[9]

Within New Zealand, the Ministry of Agriculture and Forestry Biosecurity (MAFBNZ) is uniquely tasked with protecting environmental, commercial, cultural, human health, and social outcomes.[10] Given the 2003 Biosecurity Strategy's broad health vision – "New Zealanders, our unique natural resources, our plants and animals are all kept safe and secure from damaging pests and diseases" – biosecurity naturally aligns with the *One Health* paradigm.[11]

New Zealand's biosecurity system is world-class. MAFBNZ defines biosecurity as "the exclusion, eradication or effective management of pests and diseases posing risks to the economy, environment, and human health".[12] Developed and developing nations alike could stand to learn from New Zealand's unique and successful experiences in biosecurity.

This report offers observations of coordination among New Zealand's human, animal, and ecosystem health disciplines. The work is based on a seven-month project conducted while I was an Ian Axford (New Zealand) Public Policy Fellow hosted by the MAFBNZ. The report provides an informal, qualitative evaluation based on discussions with a representative group of individuals responsible for health in these disciplines. The report is not intended to be a formal and comprehensive analysis based on quantitative research.

The report's goal is to help protect the health of New Zealand's people, production animals, wildlife and environment by urging and guiding transdisciplinary interactions.

The Ian Axford Fellowship provides policy professionals from the United States of America (US) an opportunity to conduct research in New Zealand while gaining an inside view of New Zealand public policy, its generation and implementation. Axford Fellows offer US perspectives while learning from New Zealand professionals in policy and related fields. Practical first-hand knowledge gained during the fellowship

[8] The phrase *One World, One Health* is trademarked by the Wildlife Conservation Society. For the purposes of this document, the term *One Health* is used to describe the interdependence of human, animal, and ecosystem health.
[9] FAO, OIE, WHO, UN System Influenza Coordination, UNICEF, The World Bank (2008), p.52
[10] MAFBNZ (2003), p.16
[11] Ibid. p.8
[12] Ibid. p.5

project will be applicable to the development and implementation of similar policies in the US.

In the US I work in the field of human infectious disease and vaccine research. The policy experience I bring to New Zealand centres around emerging infectious diseases, primarily seasonal and pandemic influenza preparedness and response. For the past six years, I have facilitated the incorporation of influenza research into US public health policy. This work cemented my understanding of the inherent links among animal, human, and ecosystem health and the importance of disease prevention and research at the human-animal-ecosystem interface.

Experience tells us that specialists across human, animal, and ecosystem health disciplines sometimes have disparate interpretations of how to achieve health and well-being for their particular subjects. The same happens within disciplines across professional levels.

For example, researchers may caution that more evidence and analysis are needed to generate solid policy, or that critical data is being ignored. Policy developers may feel that researchers fail to grasp the need for practical applications of science and technology. Field practitioners may feel (or prefer to be) completely disconnected from the entire process.

Such issues are only exacerbated in today's often urgent and timeline-bound health policy arenas. Across the board, failure to acknowledge earnest contributions breeds scepticism and cynicism. I echo the words of Paul Goren, 2009 Ian Axford Fellow in education policy, who eloquently stated his project goal:

> …to connect the worlds, of practice, policy, and research in ways that lead to improvement, bringing together these three communities who at times have different perspectives and competing theories of change.[13]

Connecting human, animal, and ecosystem health disciplines is an imposing challenge, but one attainable if all maintain sight of the common goal: improved health for all.

Project methodology was straightforward. Informal qualitative interviews were conducted with key contacts from human, animal, and ecosystem health disciplines. The discussions included representatives in government policy, academic research and education, professional organisations, and the community. In addition to individuals from my host agency, MAFBNZ, I spoke with representatives from MOH, MFE, DOC, Department of Labour (DOL), NZFSA, Institute of Environmental Science and Research (ESR), and the NCBID. I met with members of the New Zealand Veterinary Association (NZVA), the New Zealand Centre for Conservation Medicine (NZCCM) at Auckland Zoo, and community public health officers. Researchers, professors and graduate students from Massey University, The University of Auckland, and Victoria University of Wellington all spent valuable time with me.

[13] Goren, P. (2009)

I gained information about past successful transdisciplinary projects through asking guided questions. For example: How were accomplishments made? How did existing coordination address the issues? What roles, responsibilities and gaps were addressed? Were opportunities for improvement identified? What are the current needs for better coordination among health disciplines in New Zealand? What sensitivities, barriers, and solutions currently exist?

To understand the inner workings of MAFBNZ, I joined my project mentors at regular meetings of Post-Border Response, the Response Group, and Post-Border Information Sharing. I occasionally attended meetings of members of the Executive Leadership Team, the Biosecurity Ministerial Advisory Committee (BMAC), and the MAFBNZ Strategy and Transformation Team. I attended and presented my project proposal at a meeting between the MOH and MAFBNZ, during which the two agencies discussed cross-cutting health and biosecurity issues and exchanged information on strategic and operational issues of mutual interest.

MAFBNZ is a decision-maker regarding responses to exotic (non-indigenous or non-native to New Zealand) organism and pest incursions. I participated in an investigation and response discussion regarding a human infected with an exotic strain of *Leptospira* from an unknown source. The teleconference attendees followed a Response Prioritisation Tool to determine whether progression to initiate a response was warranted. At the time, a decision was made to conduct further surveillance to determine the infection source and to communicate the potential health risk to local veterinarians and public health authorities.

Another interesting case study in which I participated involved a Christchurch veterinarian and her assistant who developed severe psittacosis following handling of apparently healthy cockatiels. I facilitated collaboration between the MAFBNZ incursion investigator, the regional medical officer of health, and the veterinarian. Analysis of this 2010 occupational exposure incident in conjunction with a 2009 psittacosis outbreak in wild birds in Auckland demonstrated the human health links to an animal health situation.

My work on this case study helped provide a human health perspective and resulted in two publications, one for a biosecurity audience and another for a veterinary audience. The articles reviewed the two incidents, presented personal protection guidelines and discussed the importance of awareness of psittacosis as an important zoonotic concern in individuals who are occupationally at risk.[14, 15]

I was also invited to write about my background experience, interest in *One Health*, and fellowship project in MAFBNZ's *Biosecurity* magazine and the NZVA Food Safety, Animal Welfare & Biosecurity newsletter.[16, 17]

I gained a wealth of knowledge about New Zealand's management of human, animal, and ecosystem health through attending meetings and workshops across agencies.

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[14] Rawdon et al (2010), *Biosecurity*
[15] Rawdon et al (2010), *Vetscript*
[16] Harvey (2010), *Biosecurity*
[17] Harvey (2010), *FAB News*

Throughout February and early March 2010 I participated in MAFBNZ *Future of Pest Management* discussions and a workshop, during which leptospirosis was discussed as a case study for improving pest management systems in New Zealand.

I attended the New Zealand World Trade Organisation/Sanitary Phytosanitary One Day Workshop hosted by the MAF International Team.

I spent one day at the *Workshop on Wildlife Health Management Strategy for the Department of Conservation*, which identified current and future needs for management of wildlife health. Participants developed prioritised task lists for DOC and mechanisms to achieve these tasks, and highlighted opportunities for collaboration across agencies.

I attended the *Symposium on Health Surveillance: Information for Action in the 21st Century*. The Symposium featured presentations from surveillance experts from multiple New Zealand government agencies, several universities, regional District Health Boards, the World Bank, and a keynote presentation from the US Centers for Disease Control and Prevention (CDC).

In March 2010, Biosecurity Minister Hon David Carter officially opened NCBID's new centralised coordination and emergency response centre. I had the honour of attending this event, and the launch of the new MAFBNZ Biosecurity Surveillance Strategy 2020 in February. In May I attended the Fourth National Environmental Information Forum hosted by the MFE. This interagency forum aimed to improve "accessibility, quality, and consistency of environmental data and information" through sharing best practices and enforcing partnerships among government agencies and research institutes who collect and report data". In June I attended a seminar hosted by Victoria University of Wellington at which the New Zealand Prime Minister's Chief Scientific Advisor, Sir Peter Gluckman, delivered a talk entitled "Integrity in Science: Implications from and for the Climate Change Debate".

In February I presented my project proposal and obtained feedback at the NZVA Food Safety, Animal Welfare and Biosecurity Special Interest Branch meeting. My mentor and I discussed with veterinarians opportunities that arise within animal health to engage the public health sector and the public on crossover health issues. Topics included smoking cessation, antibiotic resistant infections, and other conditions such as obesity and diabetes that affect people and their pets.

In March I presented a seminar for a joint MAFBNZ and MOH audience that focused on my recent work in the US on seasonal and pandemic influenza preparedness and response. I discussed how this work provided the impetus for my Axford project and the importance of the *One Health* paradigm to combating emerging zoonotic diseases like influenza.

The MAFBNZ BMAC invited me to present my project, its current status, and potential recommendations during their May quarterly meeting. The 13-member committee is an independent advisory group tasked with providing feedback to the Biosecurity Minister regarding the overall biosecurity system. This presented an ideal opportunity for me to obtain feedback and suggestions from a diverse group of key professionals in biosecurity, including representatives from animal production and industry, tourism, policy, economics, conservation, human health, Māori, regional councils, academic research, transportation, communications, and public interest.

In June, I was invited to deliver a seminar during the annual MAF/Massey University scientific meeting. In addition, I led a panel discussion about *One Health* in New Zealand, this year's meeting topic. The panel consisted of a physician from MOH, veterinary and infectious disease researchers, and the principal advisors of conservation and human health, MAFBNZ.

Throughout the project, interview participants and colleagues were exceptionally open, generous and forthcoming with their time and information. Every meeting and conversation increased my understanding of the larger picture and contributed greatly to the project. Recommendations in this report stem from these discussions and meetings.

This report is organised into five chapters, loosely based on the questions that structured each interview. Chapter one provides background from two perspectives, science and place. The scientific background describes why the *One Health* concept is critical to health. The remainder of chapter one covers background information specific to human, animal and ecosystem health disciplines in New Zealand, including the missions, mandates, roles and responsibilities of New Zealand government agencies and other institutes and centres.

Chapter two discusses examples of past successful efforts to reduce health threats in New Zealand including elimination of hydatids (parasitic tapeworms) and brucellosis (a fever-inducing bacterial disease affecting humans and animals), eradication of the southern saltmarsh mosquito (SSM) – known to be a vector of Ross River Virus, and bovine tuberculosis.

Chapter three features examples of effective cross-health sector responses to specific health threats such as *Campylobacter* and the 2009 H1N1 influenza outbreak. These examples are presented as potential models for addressing other health threats in New Zealand. This chapter also describes several New Zealand institutes and centres that embody the *One Health* paradigm, including the NZCCM and the Massey University EpiCentre.

Chapter four highlights opportunities for improved health interfacing and coordination in New Zealand, using leptospirosis as a case study. This chapter characterises ecosystem health as the foundation for healthy humans and animals and illustrates the importance of "mainstreaming" this fundamental concept among policy-makers, animal and human health professionals, and the public. Chapter four also reviews the unique opportunities the amalgamation of NZFSA with MAF offers for improving human-animal-ecosystem health interfaces, and the potential opportunities NCBID has to bolster future partnerships in zoonotic diseases.

Finally, chapter five lays out recommendations for a convergent path forward for New Zealand human, animal, and ecosystem health. Results or actions are intended to be sustainable, based on consensus where possible, and to draw and improve upon existing mechanisms. Important themes that underpin the recommendations are that different entities should complement, rather than interfere with, others' activities and that "respect for roles, mandates, and expertise of each sector is critical to a successful collaboration".[18]

This report is written for consideration by policy developers and executors in organisations responsible for human, animal, and ecosystem health in New Zealand and the US. Intended audiences include New Zealand and US researchers and practitioners in veterinary, public, and ecosystem health interested in improving health across disciplines. This report will increase transdisciplinary awareness and facilitate cross-sector collaborations.

The views presented in this report reflect my perspective, which may differ from individuals and organisations cited in the report, including MAFBNZ, Fulbright New Zealand and the US National Institutes of Health.

My background is in human public health. Efforts were made to capture and reflect views from animal and ecosystem health disciplines, however, bias likely remains. Most examples I cite involve communicable diseases. An ecologist or veterinarian would have chosen different examples, conducted the research, and written this report quite differently. Methodology aside, they likely would have drawn similar conclusions.

My hope is that this report will cultivate greater collaboration among human, animal, and ecosystem health disciplines by increasing professionals' awareness and appreciation for the views and techniques outside their own areas of expertise. I have attempted to reflect this attitude throughout the project. After all, awareness and appreciation of others' expertise is the cornerstone of this project's success.

[18] WHO (2008), p.6

1 CONTEXT FOR CONNECTED HEALTH

Building Bridges to Protect Health

Scientists widely recognise the inherent link between human and animal health. Zoonotic pathogens – organisms from a non-human animal source – represent three-quarters of emerging infectious diseases in humans.[19] Recent zoonoses of global health concern include HIV/AIDS, antibiotic-resistant bacteria and 2009 H1N1 pandemic influenza.

Perhaps less recognised within the human and animal health disciplines, but arguably more important, is the dependence of human and animal health on ecosystem health. A healthy ecosystem provides the foundation necessary for healthy humans and animals. Maintaining ecosystem health can prevent health threats that include toxins, pests, communicable diseases, and increasingly common non-infectious diseases such as asthma attributed to poor air quality. Challenges include improving animal health to protect agricultural interests, increasing occupational and food safety, and reducing biosecurity threats while maintaining or restoring healthy ecosystems.

Despite the interdependence of human, animal, and ecosystem health, communication shortfalls across respective disciplines lead to unnecessary health, environmental, and economic burdens. The organisations designed to protect health within each discipline often fail to communicate with one another about common threats. Cohesive policies that weave together veterinary, human, and ecosystem health efforts are urgently needed as demographic changes and altered land-use practices further stress ecosystems and introduce opportunities for communicable diseases and other threats to emerge.

Efforts to bring health disciplines together in the interest of public and economic health are underway around the globe, including in the US and New Zealand.

The *One Health* paradigm is a global initiative to safeguard human, animal, and ecosystem health by finding an interface and joining forces.[20] Historically, the "one medicine" philosophy, which recognised no boundaries between health disciplines, was espoused until the 20th century when the disciplines diverged significantly.[21, 22, 23] The fields then became increasingly disparate due to physical boundaries imposed by urbanisation and philosophical boundaries stemming from medical innovations that led to the belief that technology and treatment of symptoms were the primary answer to human health and disease.

The 2009 H1N1 influenza pandemic and the threat of a more lethal H5N1 influenza pandemic brought into sharp focus the links between human and animal health and disease. That wild birds are the natural hosts for influenza A viruses underscores the importance of understanding influenza disease ecology. Discovering how avian viruses become transmissible among humans and developing prevention measures

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[19] Jones et al (2008)
[20] FAO, OIE, WHO, UN System Influenza Coordination, UNICEF, The World Bank (2008)
[21] Enserink (2007)
[22] Kahn et al (2007)
[23] Kahn et al (2008)

requires expertise and collaboration across human, animal, ecology, and microbiology disciplines.

Influenza is only one example. Population increases and changes in natural ecosystems and agricultural practices contribute to the emergence of zoonotic pathogens and demonstrate the complexity of human-animal-ecosystem interactions. As a result, pests, toxins, and pathogens are introduced to new hosts, and diseases emerge or spread to areas once safe due to geographic isolation.

The staggering complexity of the factors involved in health and disease emergence can only be addressed by finding common ground among the different disciplines involved in human, animal, and ecosystem health preservation.

Human, Animal, and Ecosystem Health in New Zealand

> …new threats will emerge across all sectors; nature is not standing still…[24]

New Zealand's economy depends heavily upon agriculture and tourism. A cursory examination of goals across several New Zealand government agencies reflects this focus.

Robust dairy, meat and fruit production rely on healthy farm animals, safe production processes, and safe products. The NZFSA 2007 profile states:

> In New Zealand nearly 80 percent of the food we produce is exported. It provides just over half the country's export earnings and underpins our economy. So protecting consumers and our reputation as a supplier of safe and suitable food is imperative.[25]

The tourism industry takes advantage of New Zealand's uniquely unspoiled and pristine landscapes and "clean green" image to tempt visitors from all over the world. Couched in this light, it is easy to understand why both the health and well-being of New Zealand's people, and the health of their economy as sustained through agriculture and tourism, is dependent upon healthy ecosystems – land, air, water, and wildlife.

In his Ministerial Foreword within the MAF Statement of Intent, the Hon David Carter writes:

> More than any other developed country, New Zealand depends on the success of its land-based industries and the biosecurity system that underpins them.[26]

The MFE website states:

> The environment supports New Zealand's economy through our use of natural resources. At the same time, the health of the environment is affected by the

[24] MAFBNZ (2003), p.15
[25] NZFSA (2007), p.5
[26] MAF (2009), p.3

> way every New Zealander behaves.[27]

Likewise, the MAFBNZ profile states:

> Every year many thousands of visitors flock to our shores. They expect our environment to be clean, green, and safe. Yet any one of them could jeopardise that by bringing pests or diseases across our borders. At the same time, trade is thriving with products moving to and from markets around the world daily.
>
> Yet while we're critically dependent on that success in the world market – it also comes with biosecurity threats. It's a balancing act between protecting New Zealand and New Zealanders and encouraging the tourism and international trade that are vital to our economy.[28]

As a consequence of this interdependence, a long list of government agencies are tasked with the economically critical responsibility of managing human, animal, and ecosystem health (see table below). The length of the list illustrates the task's complexity. The table reflects information gleaned from government websites and discussions with government professionals across sectors. It is unlikely to represent a complete list.

Table 1. Roles, Responsibilities and Activities Related to Human, Animal, and Ecosystem Health in the New Zealand Government

Agency	Mission, Mandate or Role[29]	Selected Core Activities & Functions
Accident Compensation Corporation (ACC)[30]	• Prevent injury • Ensure people get injury treatment • Help injured return to everyday life as soon as possible	• Receives clients' injury claims • Coordinates the help client benefits • Pays weekly compensation (a regular form of income, calculated at a percentage of clients' usual earnings) • Helps pay for treatment and medical costs, from general practitioner visits and specialist fees to x-rays, prescription costs, and hospital emergency services • Collects levies to help pay for provided services • Helps businesses and communities become safer
Animal Health Board (AHB)[31, 32]	• Manages implementation of the National Pest Management Strategy (NPMS) for bovine tuberculosis (TB) with the aim of achieving 0.2% annual period prevalence of TB-infected cattle and deer herds by 30 June 2013	• Controls vectors (wild animal) • Detects herd diseases • Controls infected herd movement • Monitors and enforces compliance • Conducts research: diagnostics, vector control methods, and knowledge sharing • Oversees operational contracts

[27] MFE (2010), http://www.mfe.govt.nz/about/about.html
[28] MAFBNZ (n.d.), p.3
[29] Mandates and roles can come from legislation, Cabinet decisions, MOUs or policy
[30] ACC (2010)
[31] AHB (2010), http://tbfree.ahb.org.nz/Default.aspx?tabid=84
[32] AHB (2010), http://tbfree.ahb.org.nz/Default.aspx?tabid=83

Crown Research Institutes (CRIs)[33]	• Government-owned, science-based businesses designed to grow the New Zealand economy[34]	8 CRIs: • AgResearch – a life sciences research organisation with an increasing emphasis on product development and commercialisation. Its expertise in modern biotechnologies is founded on a legacy in the biological sciences of agriculture. • Plant and Food Research (Rangahau Ahumāra Kai) – a science company formed in December 2008 through the merger of HortResearch and Crop & Food Research. Provides research and development that adds value to fruit, vegetable, crop and food products. • Institute of Environmental Science and Research, Ltd (ESR) (Manaaki Tangata Taiao Hoki)–provides specialist science solutions related to public health, environmental health and forensic science. Its particular capabilities are in chemical and microbiological contaminants and disease and hazards surveillance. • Scion – provides research and technology solutions to all levels of forest and wood products industries, including biomaterials science, alternative species, and plantation resources. Forest Research has recently extended its focus beyond wood to meet the growing consumer demand for renewable materials and products from plants. • Institute of Geological and Nuclear Sciences (GNS) (Te Pū Ao) – an earth systems science enterprise whose focus includes geological hazards and tectonics, environment and land use, and earth and ocean resources for economic growth. • Industrial Research Ltd (IRL) – undertakes world-class science, development, and technology commercialisation in areas of communication, information and electronic technologies, advanced materials and performance, intelligent devices and systems, biochemical technologies, energy technologies, complex measurement, and analysis. • Landcare Research (Manaaki Whenua) – research- es six areas: biodiversity and ecosystem processes; greenhouse gases and carbon storage; sustainable business and government; biosecurity and pest management; rural land use; and urban environmental management. • National Institute of Water and Atmospheric Research (NIWA) (Taihoro Nukurangi) – provides a scientific basis for the sustainable

[33] MORST (2010), http://www.morst.govt.nz/rst-links/crown-research-institutes/
[34] MORST (2010), http://www.morst.govt.nz/current-work/CRI-Taskforce/CRI-Taskforce-Terms-of-Reference/

		management and development of New Zealand's atmospheric, marine, and freshwater systems and associated resources.
Department of Conservation (DOC)[35]	• Leading central government agency responsible for the conservation of New Zealand's natural and historic heritage	• Manages land and other natural and historic resources • Preserves indigenous freshwater fisheries and protects recreational fisheries and freshwater habitats • Advocates conservation of natural and historic resources • Promotes the benefits of conservation (including Antarctica and internationally) • Provides conservation information • Fosters recreation and tourism to the extent use is consistent with natural or historic resource conservation Includes: • Preparedness planning, e.g. H5N1 • Surveillance – largely passive • Reporting – Huia database management (by contract) • Consultation on Import Health Standards (IHS) • Disease management protocols for translocation of native animal species
Department of Labour (DOL)[36]	• Leadership role in occupational health and safety to prevent serious harm from workplace exposure • Administers and enforces the Health and Safety in Employment (HSE) Act in most work places	• Provides workplace safety assistance, information, and guidance • Conducts workplace visits, notifications, and investigations • Enforces labour laws • Provides training • Provides health and safety public consultations • Issues hazard alerts • Provides mechanisms for reporting workplace safety issues, hazards, and diseases • Develops the Workplace Health and Safety Strategy • Provides secretariat support to the National Occupational Health and Safety Advisory Committee (NOHSAC) • Conducts research with the Health Research Council to address major knowledge gaps identified by NOHSAC and other key stakeholders, particularly in relation to occupational health • Manages the Workplace Support Contact Centre to provide a single contact point for customers who need fast, reliable, practical information and assistance on workplace matters including employment relations and occupational health and safety. The contact centre will build on the success of the Employment Relations Infoline

[35] DOC (2010)
[36] DOL (2010)

		• Responds to recommendations from the *Ministerial Inquiry into the Management of Certain Hazardous Substances* • Works with ERMA and the Ministry for the Environment to identify the best ways to inform employers and employees of their obligations under the Hazardous Substances and New Organisms (HSNO) Act • "Special Investigators" Reality TV Series DOL work was featured in a ten-part television series made by Greenstone Pictures. The series follows health and safety inspectors when they are called out to serious harm accidents or fatalities
Environmental Risk Management Authority (ERMA)[37]	• Achieve effective prevention or management of environmental, public health, and safety risks associated with importation, manufacture, and use of hazardous substances and introduced organisms	• Achieves cost-efficient and effective decisions on applications under the HSNO Act which take appropriate account of benefits, costs, and risks to New Zealand • Promotes compliance with the Act and with the Authority's decisions • Promotes public understanding and knowledge of risks associated with new organisms and hazardous substances and how to prevent or manage them • Enhances the HSNO Act as an effective legislative framework for the prevention or management of HSNO risks
Ministry of Agriculture and Forestry (MAF)[38]	• To lead the protection and sustainable development of New Zealand's biological resources for all New Zealanders • MAF is tasked by the NZ Government with a "whole of system" leadership role, encompassing economic, social, cultural, health, and environmental outcomes[39]	• Agriculture and forestry competitiveness and innovation – oversees, in partnership with relevant industry groups, research and development, product and market development, commercialisation, technology transfer, and ag-related education and skills development; West Coast forestry; and tenure review. • Animal welfare – develops animal welfare strategies, standards and policies that reflect the expectations of New Zealand and international best practices, and protects New Zealand's trading reputation and competitive advantage. • Climate change – contributes to the review of climate change emissions trading schemes with a view to developing agriculture and forestry policies that balance environmental responsibilities with economic reality, facilitate more efficient and flexible land use, and have particular reference to the treatment of agriculture and forestry in any "post-Kyoto" international agreement. • Water policy and infrastructure – contribute to co-ordinated cross-sector policy advice to Ministers on water and supports increased investment in water storage and distribution infrastructure.

37 ERMA (2010)
38 MAF (2009), pp.9-13
39 MAFBNZ (2007), p.6

		• Strengthening rural communities – provides support for rural communities by increasing cross-government understanding of rural circumstances and needs. MAF seeks to influence policy development in three key areas: provision of connection infrastructure, access to services, and compliance • Trade – maximises and safeguards trade opportunities, including the negotiation and implementation of enduring and ambitious multilateral and bilateral agreements and averting negative effects of other countries' trade measures. • New Zealand's integrity and global reputation– enhances the integrity of New Zealand's unique ecosystems, and supports primary industries meeting growing demands for product and systems assurance, and assures quality, safety, environmental and ethical credentials. • Māori participation in agriculture, forestry and biosecurity – improves Māori economic performance (agriculture and forestry productivity) and increases Māori engagement in the biosecurity system. • Border operations – reviews biosecurity border operations and redesigns systems to generate greater productivity, reduce compliance costs on industry and government, and facilitate and streamline passenger and cargo flows, while maintaining world-leading biosecurity standards. MAF seeks efficiencies and opportunities for greater cooperation through the Border Sector Governance Group network. • Incursion response management – establishes the highest possible standards of biosecurity incursion response, protection, and detection. The focus is on performance improvement, ensuring that participants have clear roles and responsibilities and a shared understanding of priorities.
Ministry of Agriculture and Forestry Biosecurity (MAFBNZ)[40, 41, 42, 43]	• Lead protection and sustainable development of NZ biological resources • Protect NZ's natural advantage by making timely and informed risk management decisions and delivering effective interventions	• Conducts pre-border risk reduction measures • Mitigates border risks • Surveillance and investigations – active and passive • Conducts incursion response • Manages pests • Establishes policy • Gathers and exchanges information about emerging global risks, negotiates

[40] MAF Biosecurity New Zealand is the division of MAF charged with leadership of the New Zealand biosecurity system. It encompasses facilitating international trade, protecting the health of New Zealanders and ensuring the welfare of the NZ environment, flora and fauna, marine life and Māori resources.

[41] MAFBNZ (2010), http://www.biosecurity.govt.nz/biosec/org#who-we-are

[42] MAFBNZ (2007)

[43] MAFBNZ (n.d.)

	• Protect human health, economic, socio-cultural and environmental values. • Account for the end to end management of the biosecurity system Includes: • Coordination and implementation of the Biosecurity Act • International assurances and audit • Unwanted Organism declarations • Enforcement of HSNO provisions relating to purposeful importation of new organisms. • Exigency actions (biosecurity emergencies)	international treaties and multilateral agreements, facilitates trade access • Manages risk prior to and at the border, including trade export inspection and official assurances • Manages animal welfare and risks and impacts of pests and diseases already established in New Zealand Includes: • World Organisation for Animal Health (OIE) reporting • Research – e.g. wildlife disease
Ministry for the Environment[44] (MFE)	• Environmental stewardship for a prosperous New Zealand • Vision for a prosperous New Zealand where a healthy environment enhances social and economic wellbeing • Works to achieve high environmental standards for New Zealand, while sustaining and enhancing social and economic development • Government's principal adviser on the environment and on international matters that affect the environment	MFE is not involved in day-to-day environmental management MFE-provided services: • Environmental management systems, including laws, regulations and national environmental standards • National direction through national policy statements and strategies • Guidance and training on best practice • Information about the health of the environment. MFE target outcomes: • Healthy New Zealand air, water, land, and communities • Capitalisation on New Zealand's natural environmental advantages • Effective management and sustainable use of New Zealand's natural resources • Minimisation of risks to people, the economy, and the environment from pollution, contamination and other environmental hazards
Ministry of Fisheries (MFish)[45, 46]	• Ensures New Zealand's fisheries and aquatic ecosystems stay healthy and sustainable • Principal advisor on fisheries management for New Zealand Government • Provides or procures services to maintain the integrity of New Zealand fisheries • Discharges the Crown's obligations under the 2004	• Researches fisheries • Manages process for fisheries access and allocation • Ensures compliance with the rules and regulations that govern and protect New Zealand's fisheries • Provides advice on policy and statutory decisions about New Zealand fisheries management and aquaculture and New Zealand's position on international fisheries management • Provides compliance services, including education, enforcement, and prosecution

[44] MFE (2010), http://www.mfe.govt.nz/about/about.html
[45] MFish (2010)
[46] MFish (2009)

	Māori Aquaculture Settlement and the 1992 Treaty of Waitangi (Fisheries Claims) Settlement Act	• Provides observer services • Purchases research and registry services • Provides scientific research oversight and quality assurance • Collects catch effort, area, method, and other information • Monitors delivery of contracted and devolved fisheries registry services
Ministry of Health (MOH)[47]	• Manages and develops New Zealand's health and disability system to fairly provide high-quality and responsive services to all citizens • Advises Minister on health policy • Funds and regulate health services • Provides leadership across health system to improve performance • Manage formal relationship with 21 District Health Boards (DHBs)[48]	• Advises Minister on strategy, policy and system performance related to improving health outcomes, reducing disparities, ensuring fairness, and increasing participation; nationwide planning; co-ordination and collaboration across the sector; and implementation of the four key strategies that are in place – Health, Disability, Māori Health, Primary Health Care • Acts on behalf of the Minister to monitor and improve the performance of health sector Crown entities and DHBs • Funds and purchases health support services on behalf of the Crown • Administers legislation and regulations on behalf of the Crown • Administers health benefit payments and service agreements on behalf of DHBs and the Ministry funding agreements, including approximately 90 million transactions each year to pharmacists, general practitioners, midwives, and other health providers • Collects and analyses health information for DHBs and Ministry's national oversight, which includes management of health surveys and information registries that receive around 20 million data entries per year • Service Minister's offices and ministerial advisory committees Includes: • Maintaining international links • Updating public on risks • Updating legislation in keeping with risk • Developing treatment protocol/policy • Monitoring disease, including zoonotic diseases • Investigating outbreaks and cases

[47] MOH (2009), *Statement of Intent 2009-2012*
[48] The DHBs are responsible for meeting the health needs of the people in their local communities and districts. They plan, fund and provide health services within their areas, including public hospitals and the majority of public health services.

Ministry of Civil Defence and Emergency Management (MCDEM)[49]	Works with stakeholders to increase the capability of communities and individuals to prepare for, respond to, and recover from disasters. MCDEM uses risk-based approaches built on existing practices to develop civil defence and emergency management	• Provides strategic policy advice on disaster management, including social and economic costs of disasters • Ensures New Zealand disaster management capacity • Provides civil defence emergency management support • Coordinates approach, for both national- and community-level disaster planning for reduction, readiness, response, and recovery • Manages central government response and recovery functions for large scale events beyond the capacity of local authorities
NZ Food Safety Authority (NZFSA)[50, 51, 52]	To protect consumers and enhance New Zealand's position as a trusted supplier of food by providing an effective food regulatory programme covering food and food-related products produced and consumed in New Zealand as well as imports and exports of food products. In pursuing this mandate the overriding priority will always be to protect consumers.	• Provides the Minister for Food Safety with policy advice on food and food-related issues • Sets science-driven standards for food safety and suitability, as required by legislation and New Zealand's trading partners • Implements programmes to ensure compliance with all safety and suitability requirements • Enforces legislative requirements • Provides official assurances to importing countries • Provides effective communication with stakeholders and advice on safe, suitable, and nutritious food for consumers Includes: • Food safety risk management • Consultation on Import Health Standards (IHS) • Outbreak investigation
Te Puni Kōkiri, the Ministry for Māori Development[53, 54]	Principal advisor on Crown-Māori relations through leadership of Māori public policy and management of relationships and information towards Māori succeeding as Māori including: • Māori leveraging their collective assets for economic transformation • Māori utilising their skills, knowledge, and talent for increased innovation • A flourishing Māori culture and Māori identity • Māori families who are strong, healthy and connected • Mutually beneficial partnerships between Māori	• Monitor policy and legislation • Leads Māori public policy • Advises on policy affecting Māori well-being • Serves as principal advisor on Government Case Māori relations

[49] MCDEM (2010)
[50] The NZFSA was amalgamated into the MAF on 1 July 2010
[51] NZFSA (2010), http://www.nzfsa.govt.nz/about-us/
[52] NZFSA (2007), p.4
[53] Te Puni Kōkiri (2010), http://www.tpk.govt.nz/en/about/who-we-are/
[54] Te Puni Kōkiri (2010), http://www.tpk.govt.nz/en/about/who-we-are/strategic/

	and local, national, and international stakeholders	

The separate mandates listed above often overlap and can conflict. To my knowledge, there is not a single overarching health-focused entity tasked with coordinating these activities which are vital to the health and well-being of New Zealand's population, environment, and economy.

In addition to the agencies included in the table, important surveillance, research and conservation efforts are conducted across New Zealand local government, universities and research centres, community and professional organisations, other non-governmental organisations (NGOs), and industry. Coordination with corresponding government efforts varies considerably.

The New Zealand agriculture industry has its own mandate to protect markets and maintain healthy production systems through research, surveillance and lobbying activities. As a member of the World Trade Organisation (WTO), New Zealand maintains an interest in contributing to international standards for food safety and protecting the health of humans, animals and plants while balancing trade benefits.[55] The 2005 International Health Regulations require that New Zealand protect human health, trade, and biodiversity through activities including international surveillance, reporting to member states, investigation and response, and trade facilitation with international agencies, e.g. the FAO, WHO, and the OIE.

The New Zealand biosecurity system facilitates international trade, "protecting the health of New Zealanders and ensuring the welfare of our environment, flora, fauna, marine life and Māori resources".[56]

Given the scope and importance of New Zealand biosecurity, MAFBNZ has an enormous task in leading the effort. As the MAFBNZ profile states, "Building a biosecurity system is a collaborative project. It takes a whole country".[57] As the lead agency, MAFBNZ strives to take advantage of the strengths and expertise within other stakeholder groups, including government agencies such as the MOH, DOC, MFE and others; industry sector groups such as importers, exporters, transport and travel, marine and tourism operators; primary production organisations; local government; the public health sector; and environmental groups.[58]

The following paragraph, taken from a recent Chatham House paper about controlling zoonotic diseases, captures the situation in many countries, including New Zealand:

> Today, responsibility for human health is mostly under the sole purview of ministries of health/public health, while that for livestock and poultry and international trade lies with ministries of agriculture in the public sector, and increasingly with agricultural companies in the private sector. Ministries of natural resources/environment/interior are responsible for wildlife and environmental health and ecotourism. These sectors and agencies are guided by different missions. However, the drivers of zoonotic disease emergence and

[55] MAF, Ministry of Foreign Affairs and Trade, NZFSA (2009), pp.2-3
[56] MAFBNZ (n.d.)
[57] Ibid. p.5
[58] Ibid. p.5

actions required to effectively prevent, detect or control them cross over the mandates of these and often other ministries. Over the last several decades, these entities, in virtually all countries, have been unable to undertake, integrate and/or coordinate their efforts effectively to prevent, detect and control emerging zoonotic infections early, either in animal or human populations.[59]

However, New Zealand is uniquely poised to address emerging zoonotic infections and health at the human-animal-ecosystem interface for multiple reasons. New Zealand is:

- dependent on its agricultural base
- dependent on its reputation for environmental integrity
- a developed country
- internationally respected for its biosecurity systems
- located in the Pacific, a region of global interest with regard to emerging infectious diseases
- strongly linked to the international agencies leading *One Health*
- small, with manageable public health and research communities conducive to communication and the exchange of ideas.

New Zealand has an opportunity to serve as a model to guide other nations, including the US, in coordinating efforts to prevent, identify, and control zoonotic disease outbreaks.

[59] Pappaioanou, M. (2010), p.5

2 LESSONS FROM THE PAST – THE IMPORTANCE OF AN INTEGRATED APPROACH

Increasingly complex interactions among humans, animals, and the environment have contributed to growing global concern about the emergence of new infectious disease threats. Studying past successes in the control and eradication of such diseases and their associated vectors can help inform future control efforts. The four following examples were chosen because of their significance to New Zealand's collective health. They illustrate collaborative achievements across disciplines while also covering lessons learned. They describe successful control efforts of both endemic conditions and exotic incursions.

Bovine brucellosis

A noteworthy achievement, New Zealand successfully eliminated bovine brucellosis (*Brucella abortus*) from cattle in the late 1980s.[60, 61]

Brucellosis is a bacterial disease that infects cattle, sheep, goats, pigs, and dogs. The zoonotic strains are transmitted to humans by ingestion of contaminated un-pasteurised dairy products or meat from infected animals. Contact with infected animal secretions through inhalation of air-borne bacteria or through skin breaks are possible transmission routes in occupational settings such as meat processing facilities.

In humans, symptoms include chronic fever, sweating, fatigue, weight loss, and joint and muscle pain. Once diagnosed, infection is treated with combination antibiotics.[62]

In livestock, brucellosis reduces production due to increased rates of abortion and infertility.[63]

The WHO considers brucellosis, which is globally distributed, a major zoonosis involving livestock. Like other zoonoses, the most rational approach for prevention involves coordination of control activities between public health and animal health sectors. Control measures include immediate public health authority notification, joint investigations, public education, pasteurisation of dairy products, and occupational hygiene. Control measures in high prevalence areas include surveillance, culling, and vaccination.[64]

Bovine brucellosis was first reported in New Zealand during the late 19th century and was a major cause of production and herd loss to dairy and beef farmers. A 1907 New Zealand Department of Agriculture report estimated that "the disease caused greater loss to dairy farmers than all other diseases put together".[65]

A vaccine became available in the 1940s. Voluntary livestock vaccination rates

[60] Davidson (2002)
[61] Mackereth (2003)
[62] WHO (2010), http://www.who.int/zoonoses/diseases/brucellosis/en/index.html
[63] FAO (2003), p.3
[64] WHO (2010), http://www.who.int/zoonoses/diseases/brucellosis/en/index.html
[65] Davidson (2002)

increased steadily during the following two decades. However, a 1966 slaughterhouse survey showed infection rates in cattle remained at about 15 per cent.[66] At the same time, annual incidence of human *Brucella abortus* infections was estimated at 110 cases, costing an estimated NZ$350 000 annually.[67]

In 1966, compulsory vaccination of calves preceded the "test and slaughter" practices that were part of the bovine brucellosis eradication programme. Due to high infection prevalence at the time, culling infected animals would have presented huge economic losses to farmers.

By the early 1970s testing became mandatory nationally. Along with testing, farmers were required to have veterinarians investigate all abortions in their herds. Investigations ceased to be compulsory once abortion incidence became low.

In 1975, because the majority of herds in New Zealand were accredited brucellosis-free, and because false positives became a problem in immunised animals, eradication efforts shifted away from routine testing and vaccination of calves was no longer required. Vaccination was still encouraged, however, for at-risk or non-accredited herds.

Complete eradication was achieved during the 1980s through careful surveillance and culling affected herds.

New Zealand has been free of bovine brucellosis since 1989 when the last sero-positive herds were depopulated.[68] The success of the eradication programme resulted in both economic gains, due to increased productivity and overseas marketability, and public health gains. Only 12 human brucellosis notifications have occurred in New Zealand since 1997, and these infections are believed to have been acquired outside New Zealand.[69] MAF continues to partner with public health authorities to monitor infection-sources of suspect cases.

Given the high distribution of the disease prior to the programme, eradication of bovine brucellosis represents a remarkable achievement for New Zealand and reflects the value of good collaborative efforts among government personnel, farmers, veterinarians, and laboratory workers in animal and public health sectors.[70, 71]

Bovine tuberculosis

Understanding the link between production animal health and the role of the wildlife disease vector underpins New Zealand's ongoing success in reducing bovine tuberculosis (TB).

Mycobacterium bovis, the causative agent of bovine TB, can infect most mammals, including cattle, deer, possums, ferrets, and humans. Infection is characterised by the

[66] Adlam (1978)
[67] Shepherd et al (1979)
[68] Davidson (2002)
[69] ESR (2010), p.11
[70] Davidson (2002)
[71] Adlam (1978)

development of tubercles, or bacteria-filled lesions, in lymph nodes and other organs.

Symptoms of infection include swollen lymph nodes, low grade fever, chronic cough, laboured breathing, weakness and loss of appetite, wasting, and occasionally death. The disease causes reduced productivity in livestock.

Transmission occurs via close contact between animals, chiefly by inhalation or ingestion of organism-laden excretions. Infected wild animal populations such as possums serve as disease vectors or maintenance hosts, providing a continuous source of infection for livestock.[72, 73]

The WHO considers bovine TB a neglected endemic zoonosis.[74]

Most industrialised countries have managed to eradicate bovine TB through test-and-slaughter programmes.[75] Such programmes, along with dairy pasteurisation, have led to greatly decreased human disease incidence.

In developing countries, however, where bovine TB is endemic in livestock, the human disease burden is not well understood. Rates of human infection with bovine TB are increasing. In humans, bovine TB can be clinically mistaken for human TB. Bovine TB, however, does not respond as well to the usual human TB drug cocktails. Similar to human TB, human disease progression is associated with HIV infection.[76]

Though infection in humans in New Zealand is rare, bovine TB is present in domestic animals and wildlife. The New Zealand Animal Health Board calls bovine TB "one of New Zealand's most serious animal health problems, affecting domestic cattle and deer herds throughout the country".[77]

In New Zealand, bovine TB was first recognised by the veterinary community in the 1880s. Unsustained efforts toward eradication consisted of voluntary "test and removal" beginning in the late 19th century. Until the 1940s, policy targeted reducing public health risk through milk testing and mandatory pasteurisation.

Concerns about international marketability of dairy and beef products and public health led to a national eradication plan. The plan incrementally introduced compulsory cattle herd testing and slaughter programmes, beginning in the 1950s, with all herds being tested by 1977. Voluntary testing and slaughter of domestic deer herds began in 1985 and became mandatory in 1990.[78]

Despite an extensive national mandatory test-and-slaughter programme – which was proving highly successful against brucellosis during this time – bovine TB persisted.

The answer to this mystery lay in understanding the disease epidemiology,

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72 FAO (2000)
73 AHB (2010), http://tbfree.ahb.org.nz/Default.aspx?tabid=118
74 WHO (2010), http://www.who.int/zoonoses/vph/en/
75 Ibid.
76 Cosivi et al (1998)
77 AHB (2010), http://tbfree.ahb.org.nz/Default.aspx?tabid=118
78 Davidson (2002)

transmission pathways, and most importantly the role of wildlife hosts who share the environment with production animals. Possums are the reservoir host for *M. bovis* and transmit infection to cattle. Possums can also transmit infection to deer.[79]

A fascinating historical account from an internationally-renowned animal health and epidemiology expert illustrates the importance of lessons learned from this disease in the New Zealand setting (this person was directly involved in New Zealand bovine TB control efforts in the late 1980s):

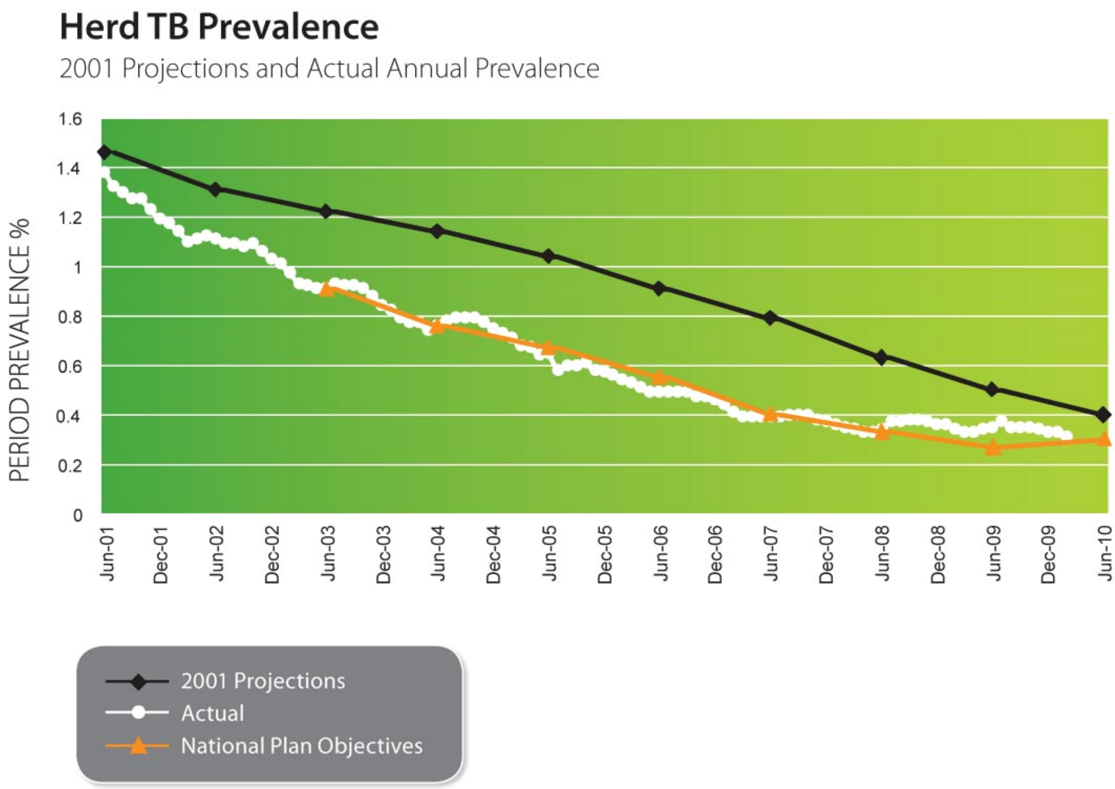
> Tuberculosis is a perfect example of a disease in New Zealand which has all three components to it [human, animal, and ecosystem health]. When the wildlife reservoir was first discovered in New Zealand it was very controversial. There was great reluctance within the government to accept that there was a wildlife reservoir. Now it is well-accepted and all of that is forgotten. In reality it was a serious failure of surveillance and detection of a wildlife reservoir of an animal and human disease.
>
> In the early 1980s the government, which had been investing money in control, decided control had been effective and was unaware that there was a wildlife reservoir. Cut backs were made on control measures. There was a massive [bovine TB] resurgence which has now been brought under control by a much more integrated approach.
>
> So initially, bovine TB was an example of a non-integrated approach. Now New Zealand is a world role model of effective integration of wildlife control and animal control and human health protection. It is a good example now, but required a massive change of attitude in the 1980s.
>
> People were saying this disease is impossible to control and this was because the epidemiology had not been done. No one had ever actually determined the epidemiological mechanism of transmission of *M. bovis* under New Zealand conditions. There were lots of questions: Were pigs involved? Were ferrets involved? Were possums really important? What the [veterinary epidemiology] team showed was that possums were critically important and the work subsequently showed that pigs and ferrets were not epidemiologically important. And that the mechanism of spread did not involve grazing contaminated pasture; it was direct airborne spread through contact with sick possums.
>
> Talks were given around the country to convince farmers. A video was made in which a possum was sedated, causing it to behave the way fieldwork had shown how a tubercular possum behaves in the terminal stages, the last six to eight weeks of the disease. The video showed cattle investigating and licking the possum. Deer would pick it up and throw it around. The studies showed hierarchical behaviour in the cattle. The cattle at the bottom of the pecking order would not explore novel things and did not get infected. The cows at the top of the pecking order got TB. Genetic sequencing data showed how the disease was spread and which mechanisms were important.

[79] Davidson (2002)

> Once it became clear and accepted, the current control strategy is based around this epidemiological understanding. It is very different from previous beliefs that the possums contaminated the pasture and the cattle ate the pasture and got infected. That is absolutely wrong. There is no spread in the pasture. While feral pigs and ferrets can be quite heavily infected, they are epidemiologically trivial in the transmission of the disease. Whereas possums are critically important, deer are the underlying reservoir, infecting possums, infecting cattle. We only have the disease in areas where there are wild deer in New Zealand. We don't have the disease in the areas where there are no feral deer.
>
> This was an example of veterinary-ecosystem collaboration to perfection.[80]

The expert indicated that once the role of possums in maintenance of bovine TB in New Zealand was recognised, strong focus was applied to their control. Incidence of the disease has fallen steadily, with the current management scheme directed at eradication by 2013. The graph shows that the actual annual prevalence of bovine TB currently meets the national plan objectives.

TB Programme Projections, Objectives, and Actual Prevalence of New Zealand Bovine TB-infected Cattle Herds[81]



Current eradication efforts rely to some extent upon similar "test and cull" techniques used for bovine brucellosis, including testing cattle and deer for TB and controlling movement of infected herds. Just as critical for success are vector monitoring and population control.[82, 83]

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[80] Author interview, 10 March 2010
[81] AHB (2010), http://tbfree.ahb.org.nz/Default.aspx?tabid=167
[82] AHB (2010), http://tbfree.ahb.org.nz/Default.aspx?tabid=121

Bovine TB eradication efforts demonstrate lessons learned about the importance of an integrated approach among sectors for successful management of a disease that infects wildlife, domestic animals, and humans. Like many other zoonoses, bovine TB underscores the importance of understanding the emergence of disease from wildlife.

Echinococcosis

Early this decade, New Zealand gained provisional freedom from echinococcosis. Also called hydatids, echinococcosis is a zoonotic infection caused by parasitic tapeworms of the genus *Echinococcus*.

Among humans, echinococcosis primarily affects farm workers. Disease severity ranges from asymptomatic to fatal, depending on factors such as organs affected, size and placement of cysts, and presence of complications such as secondary bacterial infection.

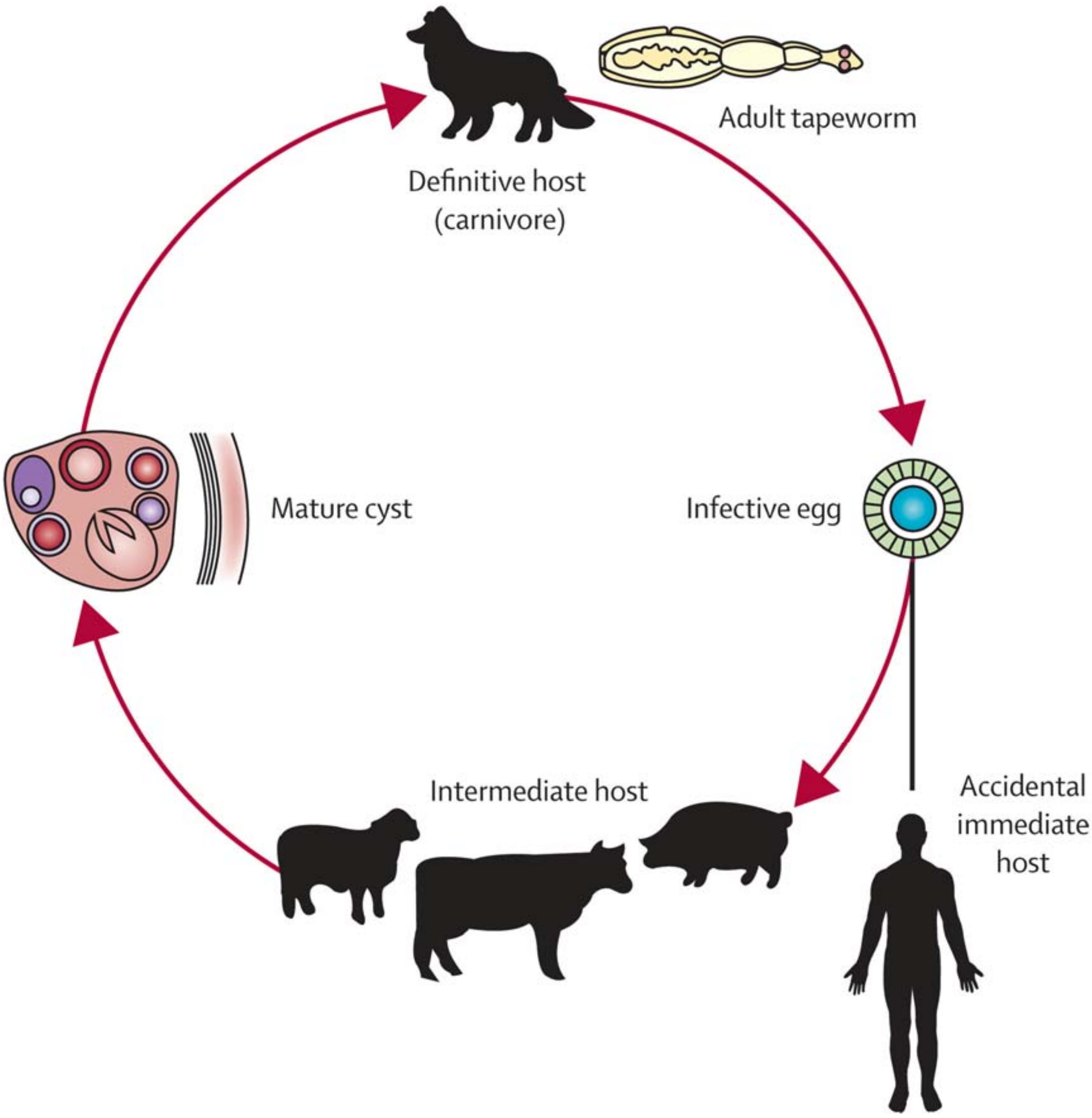
Symptoms can include fever, chronic cough, asthma-like symptoms, chest pain, jaundice, mobility problems, bone fragility, pancreatitis, anaphylaxis, and vision problems. Treatment options include surgery and chemotherapy to remove cysts or destroy tapeworms.[84]

Domestic animals and wildlife susceptible to *Echinococcus* infection include sheep, goats, cattle, pigs, horses, dogs, and rodents. Similar to humans, animal disease severity varies and depends on organs affected. Often infection in animals is asymptomatic, or at least unnoticed, within a herd or flock setting.[85]

Hydatids route of transmission is through ingestion of eggs or cysts from the faeces or organs of infected animals. Like other infectious diseases, control of echinococcosis depends on good understanding of the transmission pathways in the environment. The figure below illustrates the life cycle pattern of *Echinococcus* species, and demonstrates how this disease inextricably links humans, animals, and the environment.

[83] AHB (2010), http://tbfree.ahb.org.nz/Default.aspx?tabid=122
[84] WHO (2001)
[85] Ibid.

Cystic Hydatid Disease Transmission: Life Cycle of *E. granulosus*[86]



Similarly to other zoonotic disease transmission cycles, hydatids first take advantage of overlapping production and companion animal environments. Then they cross over to humans through overlapping human and companion animal environments. In addition to sound epidemiology, understanding the role environmental conditions play greatly influences control efforts. For example, scientists have learned that climate – specifically humidity and temperature variations – birds, and insects can affect viability of eggs and transmission.[87]

Echinococcus granulosus is distributed globally. Today, prevalence ranges from sporadic to high within endemic areas of North and South America, Europe, Asia, Africa, and Australia.[88]

Following introduction by sheep imported from the United Kingdom (UK) in the 19th

[86] Craig et al (2007), p.387
[87] WHO (2001), p.147
[88] Ibid. p.103

century, hydatid disease remained highly prevalent in sheep and dogs in New Zealand until the middle of the 20th century. Echinococcosis in humans was also a public health problem.

At the turn of the 20th century, community medical and veterinary practitioners aimed control efforts at encouraging farmers to change the way dogs were fed in order to disrupt transmission cycles, i.e. not feeding dogs uncooked offal.

A national control effort did not become mandatory until the 1959 Hydatids Act, when an estimated 80 per cent of adult sheep and 10 per cent of dogs carried *E. granulosus*.[89] The Act instituted requirements to diagnose and treat infected dogs, change feeding practices, regulate slaughter procedures on farms, conduct post-mortem surveillance in slaughterhouses and infection source follow-up, and educate dog owners about hydatids.

Later, the 1993 Biosecurity Act regulated the movement of animals from infected farms.

Local health practitioners (human and veterinary), willing slaughterhouse management, and cooperative dog owners successfully contributed to New Zealand's provisional freedom from hydatids. Rural communities endured the heaviest echinococcosis burden, and were willing and effective partners in its control. MAF, aware of the risk of reintroduction, maintains vigilance through continued slaughterhouse surveillance, treatment of imported dogs, and the continued ban on feeding dogs offal.[90, 91]

Southern saltmarsh mosquito

New Zealand's eradication of the southern saltmarsh mosquito (SSM) is possibly the first time a country has eradicated this mosquito species.[92] This notable achievement was made through effective collaborations among public health professionals, ecologists, local government officials, and staff across New Zealand government agencies, including MAFBNZ, MOH, and DOC.

SSM, or *Aedes camptorhynchus*, is the primary vector for Ross River virus, endemic to Australia and other parts of the South Pacific. SSM also transmits Murray Valley encephalitis virus and other arboviruses.

Ross River virus causes a usually non-fatal but debilitating chronic arthritic infection in humans. The virus also infects livestock, fruit bats, and possums. Epidemics are associated with high temperatures and heavy rainfall.[93]

The SSM was found for the first time in New Zealand in 1998 in the Hawkes Bay city of Napier following complaints about mosquitoes with particularly vicious bites. Concern that the mosquitoes might spread Ross River virus spurred New Zealand

89 Kasper (1990)
90 Davidson (2002)
91 Pharo (2002)
92 Ryall and Carter (2010)
93 Kuhn et al. (2005), p.36

public health officials to launch efforts to eradicate the SSM before it became well-established.

Following identification of the mosquito, response and eradication required sound scientific knowledge and environmental monitoring of the mosquito, including information about its aquatic habitats and breeding habits.[94, 95]

In 1999, the MOH launched an eradication programme that included identification and surveillance of potential habitats and targeted application of the pesticide *Bacillus thuringiensis* var. *israelensis* (*Bti*).[96]

In 2006, MAFBNZ assumed programme leadership when the New Zealand government transferred biosecurity management to MAFBNZ.[97, 98]

The eradication programme depended upon extensive SSM surveillance to detect mosquito larvae and adults. Experienced personnel collected samples from mosquito breeding habitats. The programme targeted mosquitoes with the compound S-methoprene, which inhibits SSM development and subsequent ability to reproduce. The compound is distributed to mosquito breeding areas by helicopter, on foot, or quad bike. By 2010, the programme eliminated SSM in over a dozen sites around New Zealand, costing an estimated NZ$70 million.[99, 100]

In addition to MAFBNZ-led surveillance and eradication efforts, the MOH operated a national surveillance programme outside of the eradication zones and continues public education about how to avoid mosquito bites. The national surveillance programme was transferred to MAFBNZ in July 2010.[101]

The MAFBNZ and MOH ministers jointly announced successful eradication of SSM on 1 July 2010.[102]

Vector-borne diseases have been recognised as an important infectious disease threat confronting New Zealand.[103, 104] A clear understanding of this threat contributed to efforts behind recent successful efforts to eradicate the SSM.

Of interest, *Aedes aegypti* is well-established in Australia. *A. aegypti* is the primary mosquito vector for dengue and yellow fever, globally significant arbovirus diseases. Though suitable habitat and climate exists in New Zealand, this particular mosquito vector has not been detected. As previous interceptions have shown, the threat of *A. aegypti* introduction to New Zealand requires similar vigilance to that shown toward

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[94] MOH (1999), pp.4-5
[95] Mackereth and Hearnden (2001)
[96] MOH (1999), p.5
[97] Bicknell (2006)
[98] Yard (2008)
[99] Ibid.
[100] Author interview, 11 June 2010
[101] Author interview, 11 June 2010
[102] Ryall and Carter (2010)
[103] Crump et al. (2001)
[104] Derraik et al. (2009)

A. camptorhynchus.[105, 106] Should future mosquito incursions occur in New Zealand, the successful SSM programme will undoubtedly be used as a model for eradication efforts.

The examples described in this chapter demonstrate multiple key requirements of successful eradication efforts, including sound understanding of disease epidemiology, adequate surveillance and appropriate response, understanding of the benefits by industry and members of the community, and especially collaboration between public health, ecosystem, and veterinary health disciplines. Lessons from successful control efforts are relevant to other countries and to New Zealand, as health sectors around the globe grapple with new or newly introduced organisms that threaten human, animal, and ecosystem health.

[105] Derraik (2004)
[106] Derraik et al. (2009)

3 EXISTING COORDINATION

Chapter three presents several examples of effective human-animal-ecosystem health discipline collaboration ongoing in New Zealand. The intent is to offer potential models to stimulate thought and discussion when coordinating future actions against health threats.

The chapter first presents ongoing responses to *Campylobacter* and influenza and then describes several New Zealand institutes and centres that embody the *One Health* paradigm.

Campylobacter in New Zealand – The value of the Enteric Zoonotic Diseases Research Steering Committee

The Enteric Zoonotic Diseases Research Steering Committee's successful coordination of research, surveillance, and public health efforts aimed at reducing campylobacteriosis in New Zealand demonstrates the value of facilitating transdisciplinary collaboration.

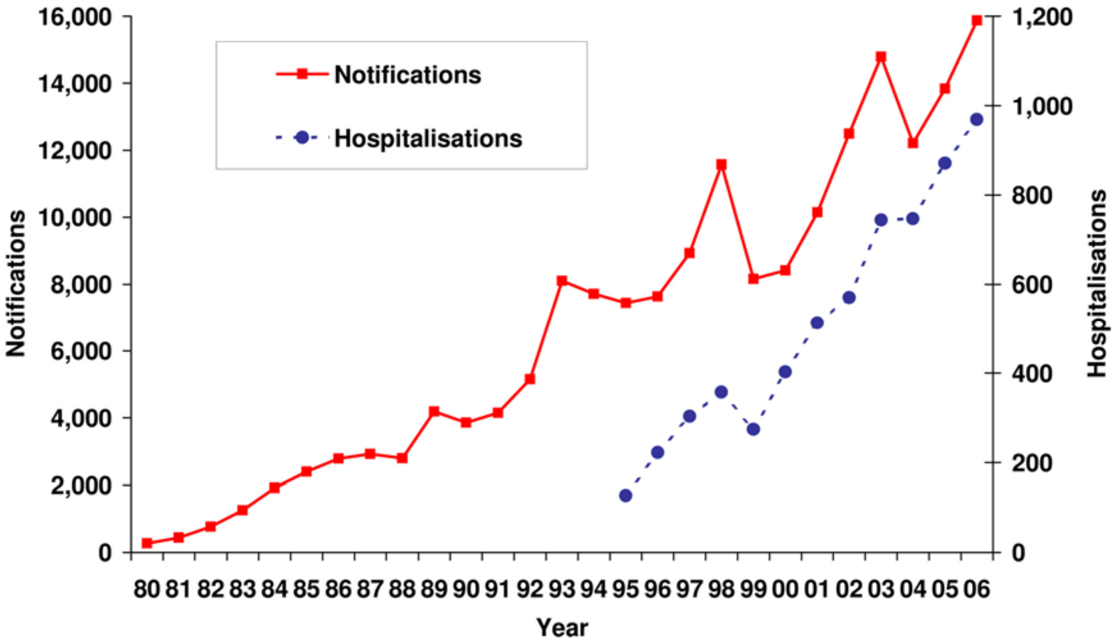
Campylobacteriosis, caused by *Campylobacter* bacteria, is the most common human bacteria-related diarrhoeal illness in developed and developing countries. Although seldom disease-causing in animals, *Campylobacter* infects most warm-blooded wild and domestic animals. Humans become infected through ingestion of contaminated un-pasteurised milk, water, or undercooked meat – particularly poultry.[107, 108]

Symptoms, including diarrhoea, abdominal pain, nausea and vomiting, may appear two to five days after infection and last up to a week. Rare but serious complications include bacteraemia, pancreatitis, hepatitis, arthritis, paralysing Guillain-Barré syndrome, and death. Very young, elderly, and immune-compromised people are at increased risk of severe disease.[109]

Human *Campylobacter* infections have been increasing in developed countries, according to the WHO, for reasons that remain unclear.[110, 111] Infection rates in New Zealand, steadily increasing since 1980, peaked in 2006 at over 15 000 notifications (see graph below).[112]

[107] WHO (2000)
[108] CDC (2009)
[109] WHO (2000)
[110] Ibid.
[111] Olson et al (2008)
[112] Baker et al (2007), *New Zealand Medical Journal*

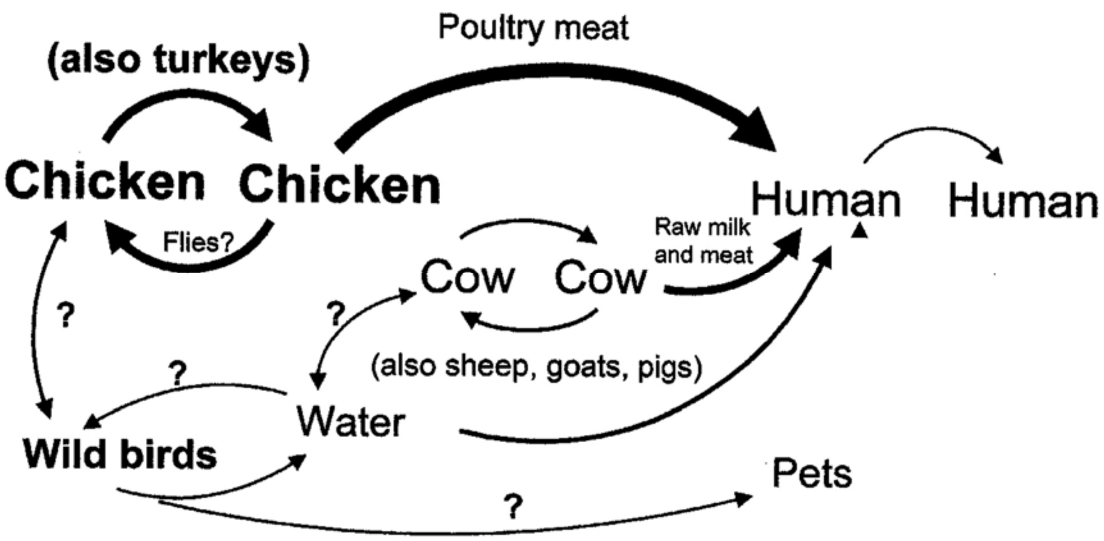
New Zealand Campylobacteriosis Notifications (1980-2006) and Hospitalisations (1995-2006)[113]



The disturbing upward trend prompted researchers and the New Zealand government to take action.

Identifying the infection source(s) was the first challenge before effective control measures could be implemented. The figure below shows the complex *Campylobacter jejuni* transmission pathways, which involve animal, human, and environmental components. The multiple arrows and question marks underscore the challenge of identifying the exact infection route in humans, which can originate from multiple sources.

Campylobacter jejuni **Transmission Pathways[114]**



[113] Baker et al (2007), *New Zealand Medical Journal*, p.75
[114] Olsen et al (2008), p.181

The human health impact combined with the range of animal hosts and exposure pathways demanded a transdisciplinary approach to identify the primary infection source and to develop and implement subsequent control efforts.

Based on campylobacteriosis notifications and hospitalisations data routinely collected by ESR and the New Zealand Health Information Service (NZHIS), university public health researchers compiled and published several articles showing evidence of an association between fresh – as opposed to frozen – poultry products and the spike in *Campylobacter* infections.[115, 116, 117]

The publications called for the food regulatory agency, NZFSA, to take action. Media reports on the researchers' findings helped catalyse public support for government control efforts.

The Enteric Zoonotic Diseases Research Steering Committee provided a collaborative network to uphold key partnerships. Funded by the MOH and led by NZFSA, the committee comprised representatives from industry, academic research, and several government agencies including MAF.

With funding support from the NZFSA, Manawatu community public health professionals partnered with Massey University EpiCentre veterinarians and ESR surveillance experts in 2005 to initiate a collaborative *Campylobacter* surveillance study. The Manawatu subtyping (source attribution) study engaged the expertise of microbiologists, molecular biologists, epidemiologists, population geneticists, and mathematicians.[118]

The surveillance study's goal was to definitively identify the infection source for development of appropriate control programmes. The study matched *Campylobacter* subtypes isolated from human infections with subtypes isolated from certain environmental and food sources. Food samples were collected from fresh meat (poultry, beef, and lamb) in retail stores. Environmental water samples were collected from river swimming locations.[119]

The Manawatu study demonstrated that human *Campylobacter* infections were primarily food-borne, rather than from water or other environmental sources, and that the main implicated source, causing up to 80 per cent of human cases, was poultry.[120, 121, 122]

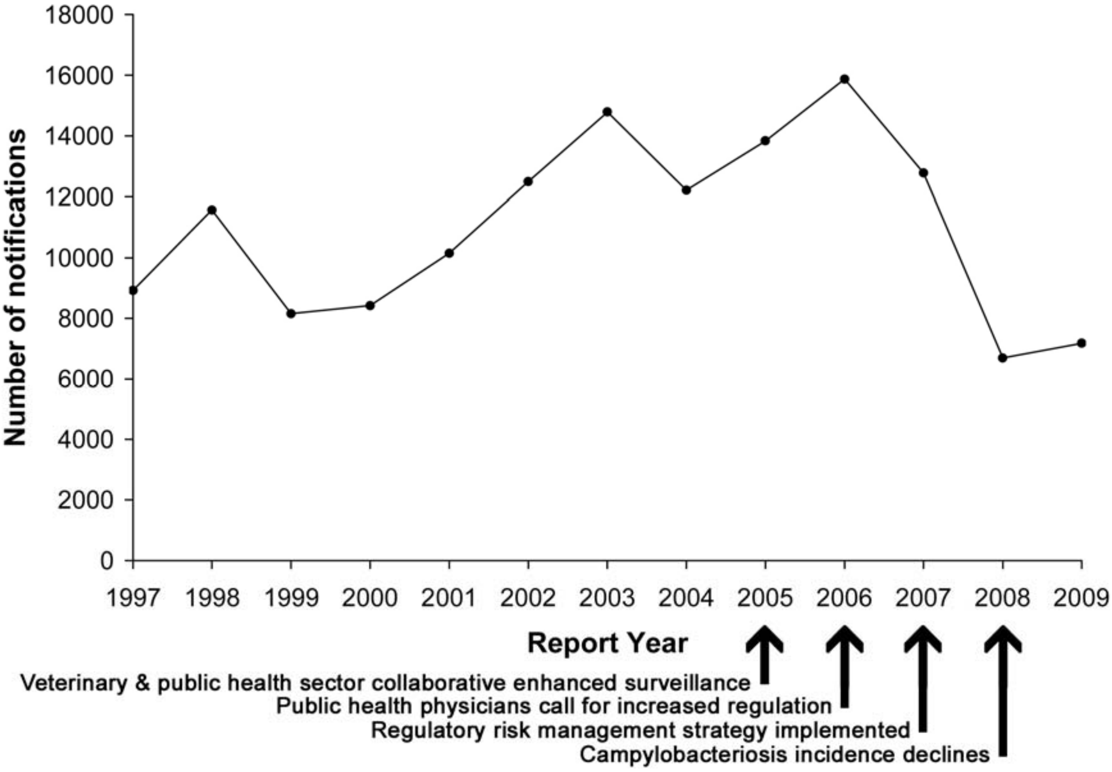
In response, the NZFSA collaborated with the New Zealand poultry industry to make improvements in poultry production and primary processing, with the aim of reducing *Campylobacter* contamination levels in poultry meat. The NZFSA's *Campylobacter*

[115] Baker et al (2006)
[116] Baker et al (2007), *The New Zealand Medical Journal*
[117] Baker et al (2007), *The New Zealand Journal of Medical Laboratory Science*
[118] Author interview, 11 March 2010
[119] Author interview, 10 March 2010
[120] French (2008)
[121] Mullner et al (2009), *Risk Analysis*
[122] Mullner et al (2009), *Infection, Genetics and Evolution*

in Poultry Risk Management Strategy included actions to improve on-farm biosecurity and hygienic practice in primary processing.[123]

Evidence shows that these interventions may have worked.[124] A significant decline in human campylobacteriosis notifications was observed during 2007-2008 (see graph below).

Annual Campylobacteriosis Notifications, 1997-2009[125]



The timeline arrows super-imposed with the incidence graph (above) show how an integrated *One Health* approach likely contributed to successful reduction of this important food-borne zoonotic disease. The effort encompassed human and animal health disciplines across academic research, national and community government, and industry. Partnerships reached across the areas of research, surveillance, response, and communications.

Despite the striking success of the collaborative effort, public health researchers urge caution and sustained vigilance to ensure a continued decline in campylobacteriosis on par with other developed nations such as Australia and the US.[126] Although the Manawatu study identified poultry as the primary source of human disease, it also found that other animal sources such as sheep and cows account for disease transmission, probably due to environmental and occupational exposures.[127, 128, 129, 130]

[123] Sears (2010)
[124] Ibid.
[125] ESR (2010), p.11
[126] Baker et al (2007), *The New Zealand Medical Journal*
[127] French (2008)
[128] Mullner et al (2009), *Risk Analysis*

Given the dramatic success of the programme so far, the collective *Campylobacter* effort could serve as a model to address other diseases that arise from the intersection of humans, animals, and the environment.

Despite its success and praise by multiple group members, the Enteric Zoonotic Diseases Research Steering Committee was recently disbanded.[131] Re-establishing this committee or its equivalent would help address other enteric health threats to New Zealand, including salmonellosis and verotoxigenic *Escherichia coli* (VTEC).

H5N1 and 2009 H1N1 Influenza – the contribution of the National Centre for Biosecurity and Infectious Diseases

New Zealand's influenza pandemic response planning exemplifies transdisciplinary collaboration across human and animal health sectors.

For more than a decade, scientists had been carefully monitoring the highly lethal but weakly contagious H5N1 influenza virus in Southeast Asia when the 2009 H1N1 pandemic influenza virus emerged in North America and quickly spread to New Zealand and around the globe. Fearing this new virus would cause worldwide devastation if it turned out to be as virulent as the 1918 H1N1 influenza virus, New Zealand and other countries quickly deployed existing H5N1 planning strategies to respond to H1N1.

Seasonal influenza causes significant health and economic burdens. The WHO estimates seasonal influenza causes 250 000 to 500 000 deaths globally every year, with related costs at US$71 to 167 billion.[132]

Influenza pandemics, in contrast, result in higher mortality and associated burdens. The three pandemics of the 20th century collectively caused tens of millions of deaths – 1918 (at least 50 million), 1957 (one to two million), and 1968 (700 000).

Such sobering figures, combined with steady reports of H5N1's spread among wild bird populations around the world, convinced public health communities in New Zealand and other nations to forge pandemic preparedness plans. The plans encompass surveillance, communications, and vaccines and antiviral medicine development and distribution.

The resulting New Zealand influenza pandemic preparedness plan was internationally well-regarded and served as a model for other countries developing their own plans.[133]

To test the plan, the MOH hosted a government-wide influenza pandemic table-top exercise that allowed agencies to review and execute their roles in a practice situation. To sustain these important interactions, the MOH continues to lead interagency pandemic group meetings with MAFBNZ and NZFSA.

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[129] Mullner et al (2009), *Infection, Genetics, and Evolution*
[130] French (2010)
[131] Author interviews: 11 March; 11 May; 16 June; 18 June 2010
[132] WHO (2003)
[133] MOH (2010), *New Zealand Influenza Pandemic Plan: A framework for action*

New Zealand's pandemic planning in particular exemplified collaboration across human and animal health sectors. Dr Doug Lush, Principal Advisor Human Health, MAFBNZ, writes:

> Within New Zealand, detailed planning for human pandemic influenza has been led by the Ministry of Health for over a decade. Increasingly, the planning has included other government agencies in recognition of the broad impact that pandemics can have on economies and society. MAF Biosecurity New Zealand (MAFBNZ), the Department of Conservation (DOC) and New Zealand Food Safety Authority (NZFSA) are important partners in fostering the OWOH [One World, One Health] approach.
>
> Detailed preparedness planning for animal H5N1 influenza has been undertaken by MAFBNZ in collaboration with the poultry industry. Planning for animal and human disease has been well coordinated at the surveillance and response level with good information sharing between MAFBNZ, MOH, DOC and NZFSA.
>
> The importance of the human, animal, wildlife interface is explicitly acknowledged in the New Zealand Influenza Pandemic Action Plan (NZIPAP) at a strategic level.[134]

Beyond planning and strategy, New Zealand also exhibited cross-sector influenza response activities during the first wave of the 2009 H1N1 pandemic and at the research level with regard to avian influenza.

When the 2009 H1N1 virus outbreak began in April 2009, New Zealand was one of the first countries to confirm cases. Infections stemmed from a group of students returning from a trip to Mexico in late April. The MOH led a government-wide response that delayed a widespread New Zealand outbreak for four to five weeks.[135, 136] From the beginning, MOH, MAFBNZ, NZFSA, and others shared information and communication strategies to ensure consistent public messaging and to clarify roles.

NCBID played a major role responding to the first wave of the 2009 H1N1 influenza infections by exerting its capability as a frontline diagnostic testing centre during an emergency response. The five week delay allowed NCBID time to pool resources and prepare equipment, supplies and staff to manage an effective and efficient laboratory response.[137] The MAFBNZ Investigation and Diagnostic Centre (IDC) and the ESR WHO National Influenza Centre components of NCBID joined forces to manage up to 350 potential influenza samples per day with a 24-hour turnaround time.[138] During the 2009 H1N1 response "laboratory staff from animal and human health backgrounds worked side by side within the NCBID laboratory".[139]

[134] Lush (2009), p.14
[135] Author interview, 22 April 2010
[136] Baker et al (2009)
[137] Author interview, 22 April 2010
[138] O'Keefe (2009)
[139] Lush (2009), p.14

In addition to agencies joining forces for the human aspect of the 2009 H1N1 response, MAFBNZ, MOH, and NZFSA worked together to implement biosecurity measures on farms to prevent infected workers transmitting 2009 H1N1 to pigs.[140] Although uncommon, H1N1 transmission from humans to pigs was reported by several countries including the US, Canada, and Australia.[141, 142, 143] To date, New Zealand has reported zero cases of 2009 H1N1 through reverse zoonosis.

During the 2009 H1N1 pandemic response, New Zealand also took an integrated approach to data sharing. The MOH WebEOC (Emergency Operations Centre) is the primary New Zealand health sector tool used to manage real-time information during local, regional or national emergencies.[144] The MOH provided MAFBNZ access to WebEOC, "which allowed MAFBNZ to monitor the ongoing outbreak and provide updates on the biosecurity aspects...".[145]

NCBID was established in 2004 to "provide centralised coordination and emergency response for disease outbreaks, biosecurity investigations, chemical and biological threats and events".[146] Four organisations collaborate to form NCBID: MAF Biosecurity Investigation and Diagnostic Centre (IDC); Crown Research Institutes ESR and AgResearch; and the state-owned enterprise, AsureQuality.

In addition to providing emergency response capability, NCBID conducts interdisciplinary research and investigation into zoonotic diseases. That wild birds are the natural hosts for influenza A viruses underscores the importance of influenza ecology in understanding the origins of this disease. At the research level, clarity around how avian viruses become transmissible among other hosts such as swine and humans will require expertise across animal, human, and ecology disciplines.

In 2007 NCBID launched a project to study the ecology of avian influenza viruses in backyard poultry in New Zealand. MAFBNZ, ESR, AgResearch, MOH, community authorities, iwi, and the public were consulted to develop the research plan. The project uses surveillance techniques, including questionnaires and sample collection from farms where wild waterfowl share the environment with domestic fowl, to provide information about the ecology of low pathogenic avian influenza in New Zealand. The project will facilitate early detection of influenza A viruses and encourage sharing of methods and scientific experience.[147] So far, these efforts have revealed a potentially important route of transmission for avian influenza viruses in New Zealand between backyard poultry living in proximity to wild waterfowl habitats.[148]

Collaborative pandemic influenza preparedness efforts in New Zealand have been comprehensive, comprising ecosystem research, surveillance, diagnostics, information sharing, and communications. The outcome presents a concrete example of how a

[140] Ibid. p.15
[141] United States Department of Agriculture (2009)
[142] OIE (2009)
[143] Australian Pork (2009)
[144] MOH (2009), http://www.moh.govt.nz/moh.nsf/indexmh/emergencymanagement-webeoc
[145] Lush (2009), p.15
[146] NCBID (2010), http://www.ncbid.govt.nz/
[147] Cork et al (2007)
[148] Zheng et al (2010)

One Health approach strengthens preparedness and response to a health emergency.

The EpiCentre at Massey University

The WHO defines veterinary public health as: "the sum of all contributions to the physical, mental and social well-being of humans through an understanding and application of veterinary science".[149] Through veterinary and medical schools, transdisciplinary education is urgently needed to generate more professionals who can provide leadership across human, animal, and ecosystem disciplines.

In 1928, a small agricultural college called Massey University opened in Palmerston North. Today, Massey is New Zealand's largest residential university with campuses in Palmerston North, Auckland, and Wellington. Massey is internationally known for its research and education programmes that span subjects including agriculture, veterinary health, and aviation.

The Massey University EpiCentre and mEpiLab[150] are part of the Massey University Institute of Veterinary, Animal and Biomedical Sciences. "The EpiCentre is the largest veterinary epidemiology training and research centre in Australasia and is widely considered to be one of the leading groups in the world".[151]

Massey University's EpiCentre and mEpiLab partnerships embody the *One Health* approach to education. Research and training across veterinary health, public health, and food safety occurs through the EpiCentre's Master of Veterinary Studies Epidemiology and Public Health programme.

> The MVS degree provides specialist skills in the application of epidemiological methods to the investigation, analysis, and solving of health and food safety problems and offers opportunities to apply these skills to the prevention and control of animal diseases and human diseases arising from interaction with animals. The degree takes a "health management" approach, and candidates are exposed to a range of epidemiological applications covering most parts of the world and a variety of animal species, both domestic and wild.[152]

EpiCentre courses bridge disciplines, teaching case studies that integrate human, animal, and ecosystem health.[153] Research projects join experts from local public health services, veterinary health, and food safety and biosecurity agencies.[154] The EpiCentre conducts field work across production, companion, and wildlife animals, both within New Zealand and internationally. Cross-fertilisation of expertise is facilitated through co-joint research appointments between the EpiCentre and ESR and through graduate student work that spans veterinary health and human health food

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149 WHO (2010), http://www.who.int/zoonoses/vph/en/

150 In 2010 the molecular epidemiology component of the EpiCentre, with its laboratory facilities in the Hopkirk Research Institute, became an independent group called mEpiLab. The EpiCentre and mEpiLab continue to work in close collaboration on infectious disease epidemiology and veterinary public health issues.

151 EpiCentre (2010), p.1

152 Ibid. p.5

153 Author interview, 5 February 2010

154 Author interview, 10 March 2010

safety.

In addition to research themes on food safety and zoonoses, the EpiCentre is internationally known for its expertise on global disease issues and epidemiology.

At the international level, the EpiCentre is setting up a "One Health in Epidemiology for Asia" joint Masters programme in seven South Asia countries with funding through the World Bank from the Animal and Human Influenza Facility.[155] The Masters of Veterinary Medicine (Biosecurity) and Masters of Public Health (Biosecurity) programme will target veterinary and medical professionals with expertise in disease control and policy experience from relevant government ministries or NGOs in South Asia. Much of the curriculum will be delivered using an online learning management system but will also include in-person meetings and activities. Major themes will cover animal health biosecurity bridged with human health examples. The programme will focus on scenario-based learning to encourage students to apply what they have learned and to use the theory they are taught.

This joint Masters programme supports a "*One Health* sustainability" goal to establish *One Health* hubs, upheld by both the World Bank and the EpiCentre. These networks will enable participants to continue communicating with one another. The hope is that within and across countries, the health and agriculture ministries will begin collaborating on surveillance and risk analysis. Within this goal, the programme aims toward policy making, communication, and risk management. The EpiCentre has reached out to MAFBNZ for expertise in teaching case studies.

The New Zealand Centre for Conservation Medicine

The New Zealand Centre for Conservation Medicine (NZCCM) embodies the vision and intellect of its senior veterinarian and founder, Dr Richard Jakob-Hoff. The Centre is based at the Auckland Zoo in a NZ$4.6 million state-of-the-art facility where the public is invited to view the activities of the veterinary hospital, including surgery and laboratory work through floor-to-ceiling glass windows or strategically placed closed-circuit television cameras. The (animal) patient wards feature convertible habitats appropriate for small, medium, large, water-loving, digging, nocturnal, grazing, climbing, shy, gregarious, heat-loving, or cool temperature clients. The expert personnel include veterinarians, veterinary residents, nurses, post-graduate and undergraduate students, and community volunteers. The staff have huge enthusiasm for both sharing their knowledge and vision and in their commitment to the animals under their care.

The Centre aims to be an international centre of excellence in conservation medicine.[156] Headquartered in Auckland, the Centre's collaborative projects reach across New Zealand and around the world.

A global first of its kind, its mission comprises three components:

1. Provide best practice veterinary services to all animals in our care.
2. Play a key role in the conservation of New Zealand's native fauna by

[155] Author interview, 11 March 2010
[156] NCZZM (2009)

providing quality wildlife referral and consultancy services.

3. Act as a hub that facilitates international collaboration and research, focused on enhancing the health of people, animals and the environment.[157]

A fledging organisation, opened only three years ago, the Centre has tackled its mission in leaps and bounds.

One of the Centre's initial projects serves as a prototype for transdisciplinary collaboration. Coordinated by NZCCM partner, Landcare Research, the project involved veterinarians, ecologists, epidemiologists, and entomologists from NZCCM, DOC, MAFBNZ, ESR, Massey University, New Zealand BioSecure, and AgResearch. Through serological, parasitological and microbiological surveys, this project investigated the ecology of vector-borne diseases in New Zealand native wildlife, including gannets, red-billed gulls, white-fronted terns, penguins, a range of passerines, New Zealand fur seals, and several feral mammals.

The project brought together a wealth of knowledge and unique professional experience and perspectives. So far, the research has provided new information about the host ranges of arthropod-born flaviviruses and the tick-borne blood parasite, *Babesia*. Additional unprocessed data will generate much new information. Due to the project's success, funding was extended and the group intends to work collectively on future projects.[158]

A critical factor in the success of such a project is leadership. Jakob-Hoff comments on the effect of good leadership on successful collaboration and sustainability:

> The collaborative environment depends on who is leading the project. In this case, Dan Tompkins [Landcare Research]. Dan is a good collaborator and loves it. He encourages a collegial and informal atmosphere. He ensured communications were taking place and were circulating. Now that the group is firmly established, we will work together on future projects.[159]

Scientific meetings play an important role in catalysing such collaborations. Going back a few years, key collaborators for this project met during the 2005 first National Symposium on Conservation Medicine, co-hosted by the Auckland Zoo with Unitec New Zealand. Jakob-Hoff states:

> The workshop connected people, but it also raised areas of overlap and interest. There's nothing more effective than getting people in the same place to talk about a topic of mutual interest. Over the years you build up networks, and because New Zealand is small it is easy to stay in touch with each other and you are forever crossing each other's paths.

The Symposium also led to collaborative work that shed light on which species are carrying or vectoring avian malaria in New Zealand and their geographic distribution. Avian malaria has led to the extinction of several bird species in Hawaii and is considered a significant threat to native species conservation efforts in New Zealand.

[157] NCZZM (2009)
[158] Author interview, 22 March 2010
[159] Author interview, 22 March 2010

Jakob-Hoff made an important discovery regarding native species preservation in New Zealand. With collaborative help from DOC, NZCCM, MAFBNZ, AgResearch, and scientific colleagues in Australia, the UK, and Hawaii (US), Jakob-Hoff identified *Babesia* in kiwi. *Babesia* had previously not been identified in New Zealand. Ticks serve as the arthropod vector for this protozoan.

Babesia is of significant economic importance in Australia, affecting cattle and dogs in the Northern Territory. For this reason, a critical question arising from its discovery in New Zealand was whether the ticks found on the infected kiwis were cattle ticks or kiwi ticks. Further investigation revealed that the ticks were kiwi ticks, thus reducing the likelihood that kiwi serve as a potential *Babesia* reservoir for New Zealand cattle.

Jakob-Hoff insightfully discusses how wildlife health naturally fosters collaboration on future non-wildlife health issues:

> One thing that seems to encourage people to work together is wildlife itself. Wildlife is neutral. It is nobody's territory and it is not an economic thing so people let go of some of the reserve they might have if it had been a pig or a cow or a horse. There is something about wildlife being for the greater good. The Auckland Zoo has a positive profile in New Zealand for being a conservation zoo. When the zoo puts out a request for assistance, people want to help.
>
> NZCCM has a fantastic opportunity to be a broker for collaboration with other people. NZCCM identifies in their mission a hope to act as a hub to facilitate international collaboration and research focused on enhancing the health of people, animals, and the environment. NZCCM has an opportunity to act as strong glue to which others can stick.[160]

Craig Pritchard, NZCCM Manager, echoed these thoughts as he described a recent project in which NZCCM partnered with a human health laboratory to conduct diagnostic testing for the centre. He indicated that NZCCM has a strong ecosystem health foundation and hoped to build further networks with the human health sector.

As a result of the partnership, quality assurance issues were identified between diagnostic laboratories. This led to the NZCCM facilitating a meeting to standardise avian and reptilian haematology test methods between diagnostic laboratories. Several of these laboratories were business competitors. Pritchard said "NZCCM served as a neutral territory and managed to get all of the players around the same table".[161] The outcome of this effort led to more consistent methodologies across groups, and therefore more accurate and reliable results. The data from these laboratories contributes to DOC's National Wildlife Health Database, which the NZCCM manages. Ensuring high quality, comparable results is very important and especially critical for accurate surveillance efforts.

The NZCCM is about to embark on an Auckland Zoo staff zoonotic disease survey, utilising a commercial human health laboratory to conduct the testing. The results from this survey are intended to inform occupation health and safety policy and

[160] Author interview, 22 March 2010
[161] Author interview, 22 March 2010

protocols.

NZCCM takes an ecosystem health approach to a collaborative project proposal for the island reserve, Tiritiri Matangi. Tiritiri Matangi sits northeast of Auckland in the Hauraki Gulf off the end of the Whangaparaoa Peninsula. Decades ago the island was cleared of native vegetation and used for farms and pasture. As a predator-free island sanctuary that was rezoned for conservation in the 1970s. Today, Tiritiri Matangi provides a protected environment for reintroduction and population rebuilding of native and endangered native species, including the rare flightless bird, the takahē.

NZCCM provides medical and surgical care for sick and injured animals on the island as well as technical advice for screening and quarantining animals that are being trans-located.

Jakob-Hoff hopes to gain a better understanding of the island's ecosystem and pathogens by studying the environmental factors that influence pathogen proliferation, distribution, and host resistance.

Seeing a great opportunity for a collaborative study, Jakob-Hoff organised a meeting with Supporters of Tiritiri Matangi (the community island managers), DOC, scientists from Massey University and the local regional council. The meeting was held to develop a pilot study of ecosystem health on Tiritiri and other Hauraki Gulf island sanctuaries with a view to developing a model applicable to other parts of New Zealand. The study will centre on health screens for native species in nature reserves that also can be used for non-native species. Thinking long-term, Jakob-Hoff sees health screening efforts as a tool to develop an evergreen pathogen map of New Zealand. The map would indicate sites where a pathogen, its hosts and susceptible contacts are located, allowing more informed risk-based decision making.[162]

And Numerous Others…

Additional good examples of transdisciplinary coordination exist in New Zealand. A few more are briefly described here:

- Co-joint appointments: As mentioned above, cross-fertilisation of ideas and experience between animal and human health is facilitated through co-joint personnel appointments between the Massey University EpiCentre and ESR.
- Liaison positions: MAFBNZ appointed principal advisors of human health and conservation to interface with public health and conservation sectors, respectively. Such interfacing facilitates communication and collaboration across disciplines at the agency level and increases awareness of roles and activities across agencies.
- Shared detailees across agencies: During the 2009 H1N1 outbreak, several MAFBNZ veterinarians were temporarily detailed to the MOH to share their background and expertise with public health professionals. On at least one occasion, such exchanges led to permanent employment.
- ESR: As a science advisor and partner to MOH, NZFSA, and MAFBNZ, ESR

[162] Author interview, 22 March 2010

maintains a cross-health disciplinary approach. Examples of ongoing ESR research include investigating how the environment impacts human health and pathogen discovery using novel technology to identify emerging pathogens. ESR also maintains flexibility that is critical to helping New Zealand respond to current infectious disease challenges such as recent *Salmonella* outbreaks in wild and production animals and 2009 H1N1 influenza.

- Vectors and vector borne diseases: Two recent reports were the result of cross departmental research pool funds from the New Zealand Foundation for Research, Science and Technology (FRST).[163, 164] These projects engaged MAFBNZ, DOC, MOH, Landcare Research, the NZCCM, and others. The studies assessed the risk of vector-borne diseases in New Zealand through surveillance of vectors and vertebrate hosts at multiple locations. The resulting outcomes and recommendations set the stage for future surveillance strategies designed to identify threats to New Zealand's biodiversity and human health.
- Smoking cessation in pet owners: Second-hand cigarette smoke can cause lung cancer and respiratory problems in pets. A 2009 study showed that some pet owners are motivated to quit smoking if they understand the health risks smoking presents to their pets.[165] A joint effort between the MAFBNZ principal advisor human health, MOH, and the NZVA aims to motivate pet owners to stop smoking for the sake of their companion animals.[166] This programme enables veterinarians to distribute to their human clients advice as well as certificates for obtaining subsidised nicotine replacement therapy from their pharmacist.[167]

[163] Mackereth et al (2007)
[164] Tompkins et al (2010)
[165] Milberger (2009)
[166] Author interview, 15 March 2010
[167] MOH (2010), https://smokingcessationabc.org.nz/sc/introduction.html

4 OPPORTUNITIES FOR STRENGTHENING LINKS

Implementing transdisciplinary health strategies – those that interface human, animal, and ecosystem health – requires comprehensive, efficient, and sustained collaboration among all stakeholders. This chapter explores opportunities that could potentially guide future transdisciplinary programmes.

Leptospirosis – An opportunity for better coordination

> What astonished me when I asked for those [leptospirosis] stories was how traumatised people continued to be long after the illness had gone. Men and women were talking to me and crying over the phone over how this disease had impacted their lives. For some of these people the illness had occurred 20 to 30 years ago but they were still distraught and overwhelmed by the disease because it had completely changed their lives.

Above, Noeline Holt of Rural Women New Zealand[168] puts a human face on this potentially devastating disease.[169] Leptospirosis not only impacts the person infected, but impacts their families and communities through months of physical recovery and loss of work and income.

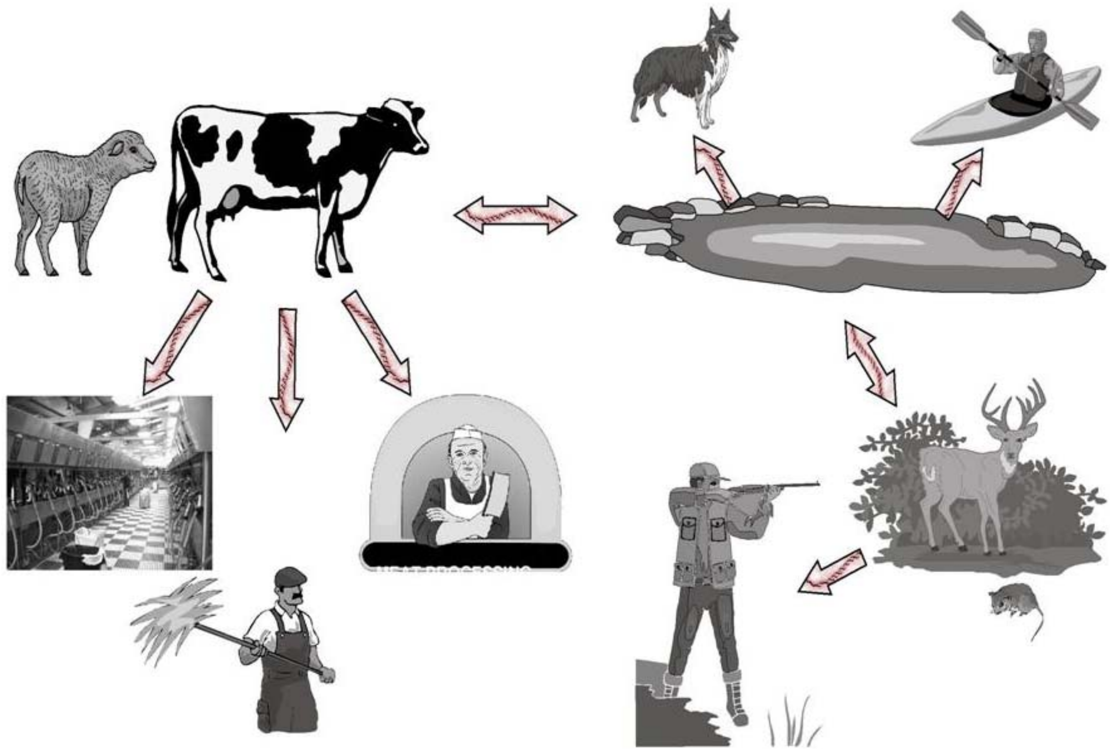
Every year about 100 human cases of leptospirosis are reported in New Zealand. The disease affects production animals, wildlife, and humans. Though organisations within each discipline are separately responsible, there is not a coordinated leptospirosis programme. The *Leptospira* bacteria's ability to inhabit humans, animals, and waterways makes this pathogen a perfect target for strengthened and sustained coordination among human, animal, and ecosystem health disciplines in New Zealand.

The schematic below illustrates the complexity and interdependence of animal, human, and ecosystem health in the context of leptospirosis.

[168] Rural Women New Zealand, formerly Women's Division of Federated Farmers, http://www.ruralwomen.org/about_us.htm

[169] Holt (2010)

Leptospirosis Transmission Pathways



Each arrow illustrates a potential transmission pathway. Double arrows reflect sources of environmental contamination. The pond represents a contaminated water source that can infect pets, outdoor enthusiasts, and wildlife. Adding to the complexity, additional routes of transmission exist that are not shown in the picture. Other production animals such as pigs or goats can serve as maintenance hosts. Human exposures can also occur following flooding or from other occupational settings, e.g. veterinary.

An animal is unlikely to show illness if infected with a well-adapted reservoir strain, complicating surveillance and control measures. Infected production animals lead to occupational exposure in dairy and meat processing personnel and in farm workers. This transmission pathway accounts for most human leptospirosis infections in New Zealand.

New Zealand's most common production animals – deer, cattle, and sheep – serve as maintenance hosts for the *Leptospira* strains that cause disease in humans. Serology studies show that infection with *Leptospira* is prevalent in these animals.[170, 171] Not surprisingly, leptospirosis is the most common occupational infectious disease prompting health authority notification in New Zealand.

In 2008 there were 121 human leptospirosis notifications, increased from about 60 in 2007.[172] Most (88.4 per cent) were associated with occupational exposure such as farm or meat processing work. Most human isolates were *Leptospira* strains that

[170] Benschop (2009)
[171] Dreyfus (2010)
[172] ESR (2009), p.22

primarily infect cattle, deer, sheep, and pigs. Strains found in wildlife hosts such as possums, rats and mice accounted for a smaller number of human infections.

The true human prevalence of leptospirosis is difficult to gauge. Under-reporting of leptospirosis challenges understanding of the actual disease burden and hinders control measures. Clinical symptoms mimic more common ailments such as influenza. Severity ranges from mild with non-specific symptoms to severe with encephalitis or respiratory failure. Contributing under-reporting factors include lack of recognition by clinicians, inadequate diagnostics, and failed notification procedures.

For decades there has been focus on leptospirosis in New Zealand dairy and veterinary sectors. Exactly who (which sector or agency) leads efforts at a given time has varied and evolved according to the current central government and policy.[173] Dairy herd vaccination began in 1979 which led to a significant reduction in human incidence, from greater than 600 notifications per year to about 100.[174] Prior to 1984 MAF played a strong advisory role in leptospirosis prevention and education programmes, raising vaccination awareness in dairy farmers and veterinary practitioners.[175]

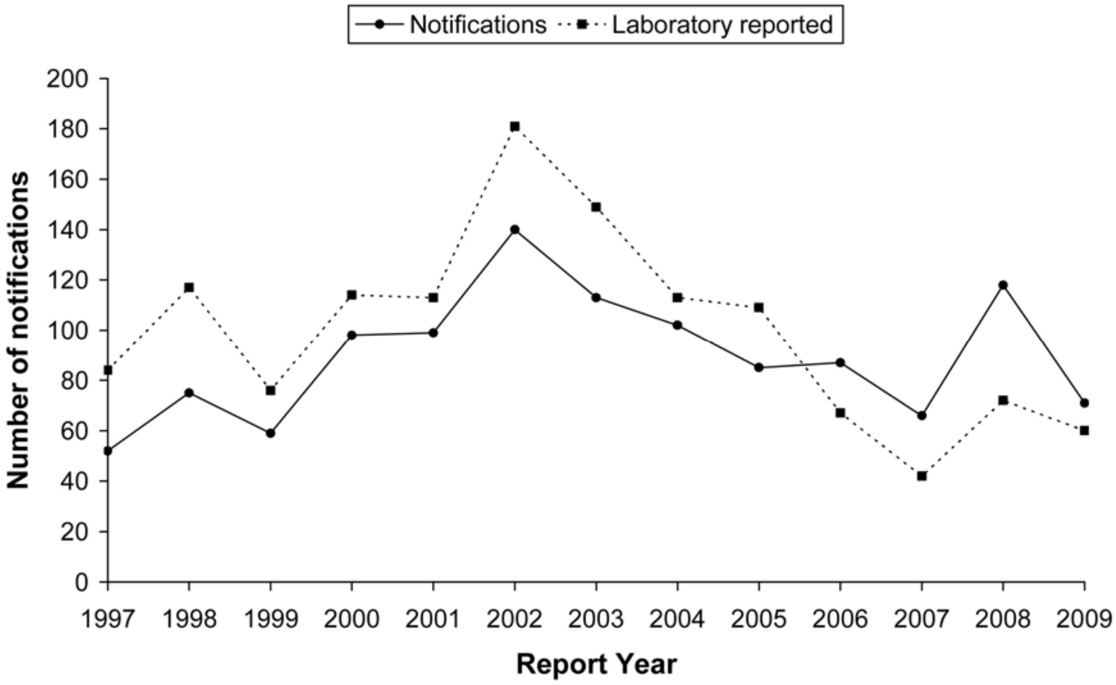
In the mid-1980s, the New Zealand government became less focused on education and more focused on its regulatory role.[176] Organisations such as the NZVA stepped up with programmes like the Leptosure® programme.[177]

Leptosure® is a comprehensive risk management programme developed for dairy farms that includes vaccination of cattle and pigs, biosecurity control of stock and other host species, farmer and veterinary staff awareness through education, rodent control, personal hygiene and care, effluent management and waterway protection.[178]

Despite the Leptosure® programme and other control efforts, human leptospirosis cases continue (see graph below).

[173] Brown (2010), pers. comm.
[174] Leptosure® (2010)
[175] Brown (2010), pers. comm.
[176] Ibid.
[177] Ibid.
[178] Leptosure® (2010)

Annual Leptospirosis Notifications and Laboratory-reported Cases, 1997-2009[179]



A recent analysis of annual leptospirosis trends worldwide ranks New Zealand ninth in a list of countries with highest incidence.[180] The death of a meat-processing (freezing) worker in 2006 followed by an increase in notifications in 2007 resulted in media interest and subsequent publicity of the potential severity of the disease.[181] Such incidents have spurned public organisations such as Rural Women New Zealand to raise research funds.

Veterinary researchers, who understand the importance of transdisciplinary interactions when addressing a disease like leptospirosis, have reached out to colleagues in human health and industry to conduct collaborative projects to better understand the true prevalence and infection sources.[182, 183]

Massey University veterinary researchers are coordinating a national multi-plant cohort study in meat-workers to determine risk factors for *Leptospira* infection in this occupationally-exposed group. The study receives considerable support from meat companies, occupational physicians, and the meat workers union.[184]

The Health Research Council of New Zealand announced in June 2010 they are funding a Massey University-led study to determine the most appropriate testing regime for leptospirosis in humans.[185] Jackie Benschop, lead-investigator, who is co-jointly appointed by Massey University Veterinary Sciences and ESR, states, "close collaboration between veterinary researchers and human health sector clinicians and

[179] ESR (2010), p.23
[180] Pappas et al (2008)
[181] New Zealand Herald (2007)
[182] Benschop (2009)
[183] Dreyfus (2010)
[184] Author interviews, 11 March and 8 July 2010
[185] Author interview, 8 July 2010

laboratories is a key element of this work".

As research progresses, appropriate mechanisms to reduce the incidence of the disease in animals and subsequently humans will need to be developed and implemented. Surveillance will need to continue. The most efficient path toward this end is to establish a network of key players with a chosen leader or coordinator for routine communication and science-driven action.

The question arises: Who will lead efforts to control and further reduce leptospirosis incidence in New Zealand – MOH, MAFBNZ, DOL, DHBs, industry, farmers, others? Lack of a clear answer suggests leptospirosis presents both a need and an opportunity to forge more sustained and cohesive health interface approaches in New Zealand.

Intuitively, each of the above entities should be involved and have good awareness of what the others are up to. Leadership should be clear from the start. The innovation and expertise of each should be engaged from the beginning to develop a clear strategy forward.

A coordinated transdisciplinary leptospirosis effort could serve as a model for addressing other complex cross-over health issues, including other zoonoses, pests, toxins, and other ecosystem health threats. Many such health threats have mechanisms of spread or transmission that are as complex and intertwined as leptospirosis. These threats must also be addressed through transdisciplinary collaboration.

Mainstreaming Ecosystem Health

Policy-makers need public support to advance transdisciplinary health policy. For that support to exist, the public must understand the links between human, animal, and ecosystem health.

Ecosystems affect human and animal health. Human and animal activity affects ecosystem health. Few would debate the interdependence but the links often are not considered by policy-makers, members of the public, and medical and veterinary professionals. As humans encroach more on natural terrestrial and marine ecosystems, as the population increases, and as the effects of anthropogenic climate change are realised in the next few decades, the health of the Earth's ecosystem will impact everyone, in developed and developing countries alike.

To address such challenges, the links must be understood. The balance of human and ecosystem health must be defined into actionable problems with straightforward solutions. Clear data-driven communication must occur to raise awareness. A need exists for good communicators who can provide leadership and speak articulately about the links between human, animal, and ecosystem health.

Health and economic well-being depend on ecosystem services. Examples of ecosystem services include clean air, safe water for drinking and recreation, food, natural energy, land, and forest products. The interdependence is often overlooked and needs integrating into health discussions. Ecosystem professionals must find ways to convey benefits of healthy ecosystems to the public and policy makers. In other words, experts must mainstream ecosystem services.

In 2001 the United Nations initiated the Millennium Ecosystem Assessment. The effort brought together more than 1360 experts from around the world. Over the next four years the group assessed current conditions of the world's ecosystems, the consequences of ecosystem change, "and the scientific basis for action needed to enhance conservation and sustainable use [of ecosystems]".[186] In other words, the goal of the assessment was to answer the question of how human health depends on ecosystems, and conversely, how ecosystem health depends on human activity.

In New Zealand, recent collaborative efforts model the concept of the Millennium Ecosystem Assessment. The projects examine the reciprocal links between ecosystem health and human health and social-cultural well-being. The examples listed here and similar collaborations provide opportunities for the ecosystem health sector to interface with public health, production animal, and wildlife health sectors:

- The Centre for Public Health Research at Massey University conducts environmental health surveillance related to respiratory health effects of exposure to household dampness and mould and air pollution and studies of companion animal health as a predictor of human health.[187, 188]
- The Bay of Plenty District Health Board conducted environmental surveillance to determine how farm run-off can impact food safety and water quality of adjacent waterways. This effort investigated estuary shellfish contaminated by nearby dairy farm run-off.[189]
- The Population and Environmental Health Programme at ESR conducts collaborative studies to investigate the effects of land use and climate change on human health by measuring incidence of various infectious diseases as environmental indicators. This work will help answer questions about ecological drivers for infectious disease in New Zealand, especially zoonotic diseases including murine typhus and leptospirosis.[190, 191, 192]
- The Kaimai Catchments Project, a joint endeavour between DOC, Environment Bay of Plenty, Environment Waikato, local iwi, and Territorial Local Authorities, conducts assessment of how land and pest management impacts ecosystem services such as water quality.[193, 194]
- The MFE routinely monitors quality of air, drinking water, and fresh water swimming spots and the health effects of timber treatment.[195] MFE monitors soil health of productive land use sites through the Soil Health Environmental Snapshot project.[196] MFE conducts several ongoing joint projects with MAF,

[186] Millennium Ecosystem Assessment (2005), http://www.millenniumassessment.org/en/About.aspx#
[187] Douwes (2010), Symposium on Health Surveillance
[188] Douwes (2010), MAF-Massey Day
[189] Shoemack (2010)
[190] Author interview, 17 February 2010
[191] Author interview, 23 April 2010
[192] Slaney (2010)
[193] Forest and Bird (2010)
[194] Environment Bay of Plenty (2010)
[195] Author interview, 21 April 2010
[196] MFE (2010), http://www.mfe.govt.nz/environmental-reporting/report-cards/soil-health/2010/index.html

including the Dairying and Clean Streams Accord which measures pollution of micronutrients and pathogens in surface and ground waterways from dairy farms.[197]

- Another MFE project is the Cultural Health Index for Streams and Waterways, developed in conjunction with Māori representatives. The tool incorporates indicators to determine overall health of waterways traditionally used by Māori with indicators used by western scientific methods. The index can then be used to inform iwi decisions about management of the water source and surrounding land.[198]

- The University of Auckland Centre for Biodiversity and Biosecurity at the School of Biological Sciences is involved in studies that examine how biodiversity and ecosystems affect human well-being, specifically, how threats like invasive species stress natural ecosystems, damage crops, and negatively affect people's livelihood.[199] These studies are ongoing in the Pacific Islands through the international collaborative Pacific Invasives Initiative.[200]

Such studies underscore the need for healthy ecosystems to support long-term habitation for production animal and human health, both within an island ecosystem and globally. Outcomes are linked between ecosystem health/conservation and human health/livelihood. New Zealand relies on healthy agricultural ecosystems for a robust economy that depends on supplying food both domestically and internationally. These projects are critical to reconcile agricultural and environmental interests in New Zealand to find a sustainable well-managed balance between market forces and health.

An area of concern and debate in New Zealand is changes in land use, particularly the conversion of land for dairy farming intensification. Some take the view that such changes are inevitable. Regardless, coordinated transdisciplinary studies should be conducted to analyse potential affects, determine how to minimise negative impacts, and address risks. This issue provides a perfect opportunity to explore how land use changes impact ecosystems across the spectrum including effects on animal welfare, the health of the immediate environment, and resulting human health issues.

To embed these links, the next challenge is to communicate the knowledge gained from these studies with policy-makers and the public.

Environmental reporting induces people to think about the links between the ecosystem and human health. MFE routinely produces environmental reports on indicators that directly affect human health, such as water quality. Such reports can easily be jointly undertaken by agencies such as MFE and MOH to reinforce these necessary partnerships.

Another mechanism to imbue the interdependence of ecosystems and health is performance measurement. At some level, all government agencies strive toward health outcomes, whether animal, human, environment, economic, or social/cultural.

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197 MFE (2010), http://www.mfe.govt.nz/issues/land/rural/dairying.html
198 MFE (2003)
199 Author interview, 23 March 2010
200 Pacific Invasives Initiative (2010)

Agencies with oversight roles should reach across sectors to jointly pursue those outcomes; this will underscore the connection on how good and poor ecosystem health can positively or negatively impact human health.

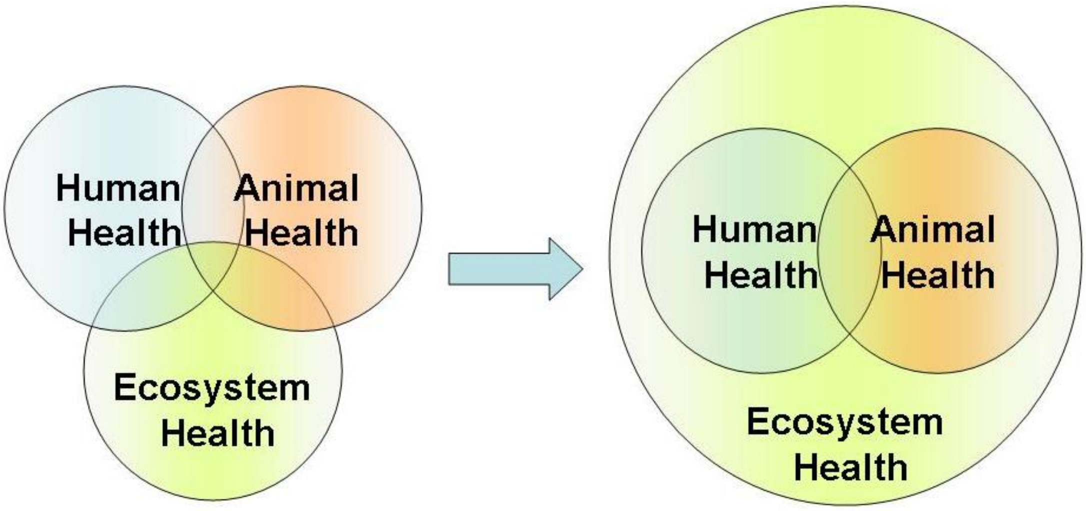
Dr Erik van Eyndhoven, Principal Advisor Conservation, MAFBNZ states:

> At first, the links may be difficult to communicate but we must strive to integrate the connections into our way of working. One of the key parts of that is to continue to quantify the links so that the crucial data is present that forms the basis for action. Intuitively the links between animal, human, and ecosystem health exist, but we need to quantify them and make them more tangible and then find ways of feeding them into the way that we report that has got some merit to give policy a firm scientific foundation.[201]

Visual conceptualisation of the links between human, animal, and ecosystem health can be useful. Below, the schematic on the right portrays the intersection of the three disciplines.[202] The minor overlap in the illustration does not reflect the true degree of interdependence.

Conceptualising the ecosystem as it upholds human/animal health presents a more accurate view and drives home the necessity of a preventative approach to ecosystem health and its direct impact on human/animal health. The second graphic portrays the more realistic viewpoint that 1) the overall ecosystem *includes* humans and animals, and 2) that a healthy ecosystem is the necessary foundation upon which healthy animals and humans depend.[203]

Conceptualising Health Links



The minor overlap in the schematic on the right does not reflect the true degree of interdependence. The left schematic illustrates that a healthy ecosystem is the foundation for healthy animals and humans.

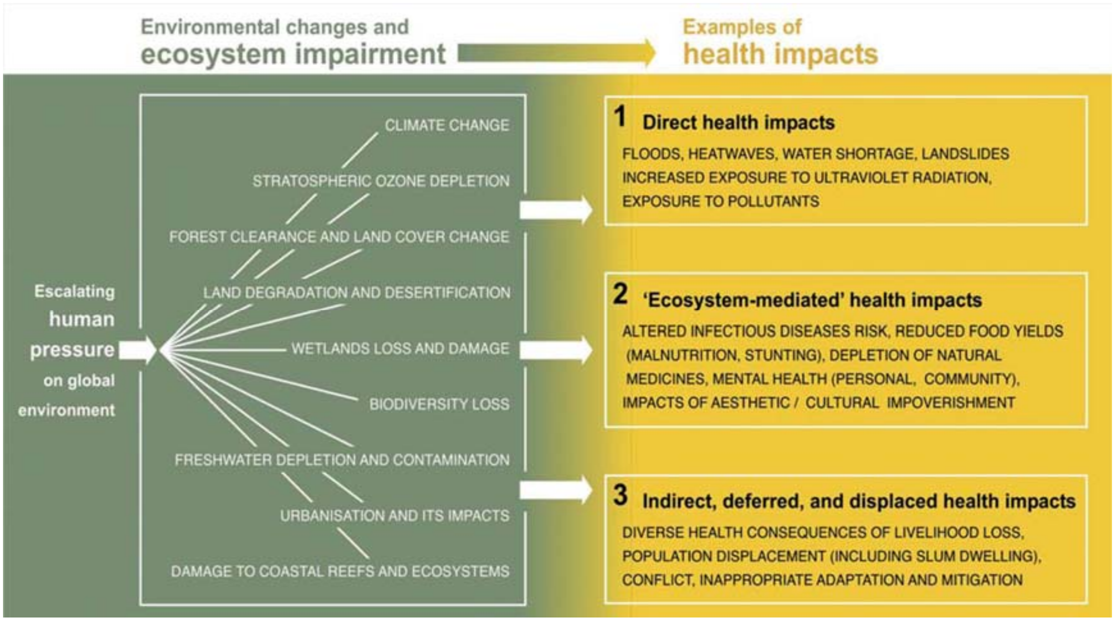
[201] van Eyndhoven (2010)
[202] Adapted from Aguirre et al (eds) (2002), cover and p.10
[203] Adapted from Rabinowitz and Conti (2010), p.2

Of note, underpinning the bidirectional impacts of human and ecosystem health, the Millennium Ecosystem Assessment found that:

> …human actions are depleting Earth's natural capital, putting such strain on the environment that the ability of the planet's ecosystems to sustain future generations can no longer be taken for granted.[204]

The figure below from the WHO Millennium Ecosystem Assessment report presents a summary for decision makers on how ecosystems affect human health and, notably, vice versa.

Harmful Effects of Ecosystem Change on Human Health[205]



This figure describes the causal pathway from escalating human pressures on the environment through to ecosystem changes resulting in diverse health consequences. Not all ecosystem changes are included. Some changes can have positive effects (e.g. food production).[206]

The findings show human activity impacts ecosystems and conversely, that human and animal health depends on ecosystems. Consider that few natural ecosystems will exist in the future that are not in some way modified or degraded by anthropogenic climate change or direct human activity. A more realistic conceptualisation of the interdependent circles is illustrated below.

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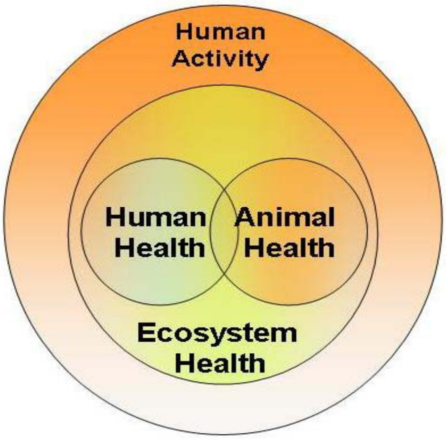
[204] Millennium Ecosystem Assessment (2005), http://www.millenniumassessment.org/en/About.aspx#
[205] WHO (2005), p.1
[206] Ibid., p.1

Conceptualising Health Links



A healthy ecosystem is the foundation for healthy animals and humans. Conversely, ecosystem health depends upon human activity.

Solutions to the challenges ahead are unknown but will certainly require transdisciplinary expertise.

New Zealand Food Safety Authority Merges with Ministry of Agriculture and Forestry

In 2010 the NZFSA and MAF merge into a single agency, guardian of New Zealand's "biological value chain". The biological value chain applies to "animals, plants, food and related sectors."[207] As the slide below illustrates, New Zealand's economic, environmental, and social well-being are built around the biological value chain.

[207] MAF (2010), 'Amalgamation of MAF and NZFSA', slide 2

The Importance of New Zealand's Biological Value Chain [208]

Aside from the commonality of the two agencies' missions, the New Zealand government gives several reasons for the MAF-NZFSA fusion: a larger combined agency will be better positioned to endure financial strain; agencies responsible for related issues will be better aligned; and despite having common goals, separate agencies are prone to divergent or uncoordinated approaches. The latter reasons dovetail with the *One Health* paradigm and provide context for the implications of food safety as it relates to human health joining with agriculture and animal health.

The links of the biological value chain exist beyond producer-to-consumer, or "paddock-to-plate," an oft-heard phrase in the New Zealand agricultural production sector. The fusion of MAF with NZFSA presents opportunities to incorporate environmental, wildlife, and population health links in the chain. As we have learned from bovine tuberculosis and other communicable diseases, wildlife health can impact production animal health. Diseases like leptospirosis remind us that production animal health can impact human health in an occupational setting, not just at a food safety or consumer level. Production animals and wildlife alike require quality air, water, food, and living conditions. The newly merged agency will hopefully prevent intense farming practices from negatively affecting animal welfare or ecosystem services required by humans (air, water quality, conservation, and biodiversity).

With the MAF-NZFSA fusion, the resulting single agency has a tremendous opportunity to connect all the links of the biological value chain into a single strong line, pulling in the same direction toward healthier humans, animals, and ecosystems.

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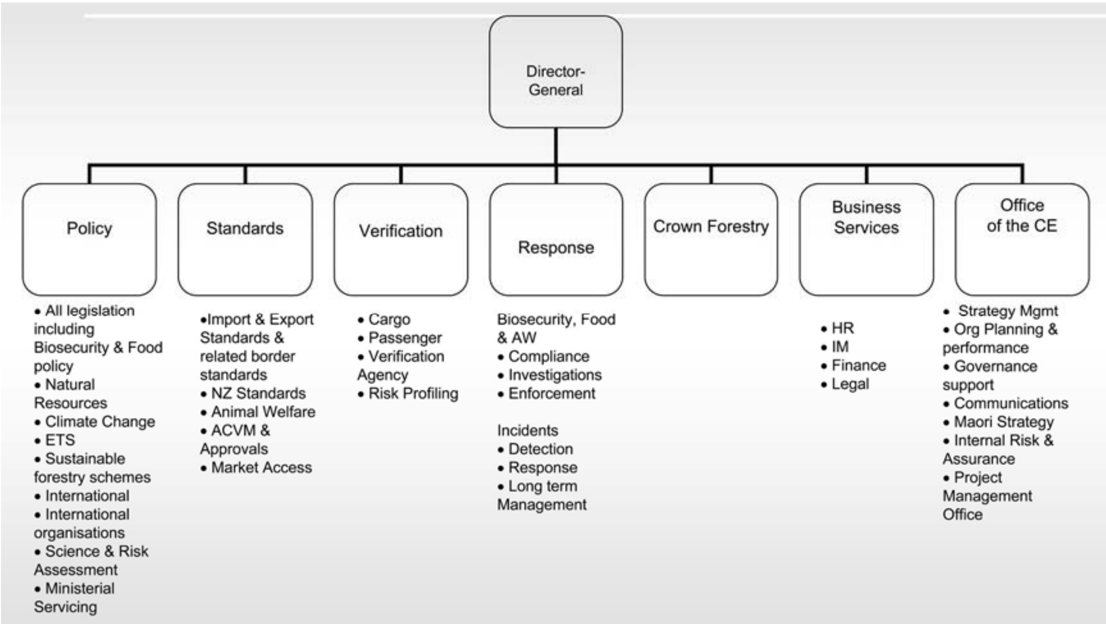
[208] MAF (2010), 'Amalgamation of MAF and NZFSA', slide 3

The new MAF-NZFSA agency has an opportunity to firstly integrate systems to minimise duplication, secondly engage in a more comprehensive upstream prevention-orientated approach rather than expensive reactive case-by-case approaches, and thirdly ensure that focus is given to routine and sustained interactions with other agencies on cross-cutting issues. One could argue that the latter opportunity, though critical to a robust biological value chain, is not immediately apparent in the proposed restructuring option shown below.

Preferred Option for Merged MAF-NZFSA Agency Structure [209]



In this regard, an opportunity exists for the new MAF-NZFSA to transparently define its new role as it fits in with other agencies, especially on cross-cutting issues. MAF traditionally has a relationship with DOC and these ties are in the process of being strengthened. NZFSA traditionally has a strong relationship with MOH. Stronger MAF ties with MOH are underway. MFE interacts with MOH and DOC and MAF. The new MAF-NZFSA agency should define where it fits in functionally with these other agencies.

Depending on the final structure and to-be-determined name of the merged MAF-NZFSA agency, there is potential for loss of positive momentum due to the current absence of the term “biosecurity” in the proposed structure. New Zealand enjoys a well-deserved national and global reputation for its biosecurity systems. As the primary New Zealand government agency charged with this critical task, the new agency should capitalise on New Zealand’s internationally-recognised reputation by retaining the term and brand “biosecurity”.

Looking forward through a *One Health* lens, MAF-NZFSA could use the restructure as an opportunity to refine the New Zealand definition of biosecurity by adopting the FAO and WHO definition:

What is biosecurity? A strategic and integrated approach to analysing and

[209] MAF-NZFSA (2010), p.7

> managing relevant risks to humans, animals, and plant life and health and associated risks to the environment. It is based on recognition of the critical linkages between sectors and the potential for hazards to move within and between sectors, with system-wide consequences.[210]

This definition could be interpreted to incorporate food safety and animal welfare and is entirely consistent with an agency that serves as guardian of the country's biological value chain. The definition would also underscore the importance of the roles of other agencies that make critical contributions to the value chain, including MOH, DOC, MFE, and others. In any case, "biosecurity" as a term that represents great accomplishment for New Zealand should be retained and maintained.

Other areas of opportunity for health integration that arise from the amalgamation include risk assessment, research, surveillance, preparedness, communication, and response.

National Centre for Biosecurity and Infectious Diseases – Zoonoses in the future

As discussed in chapter three, NCBID played an important part in New Zealand's response to the 2009 H1N1 influenza outbreak. NCBID executed its intended role in coordinating an emergency response to a new threat and providing scientific expertise in virology and epidemiology, and state-of-the-art testing capability. The contribution NCBID made as a response centre during the 2009 pandemic speaks well for New Zealand's ability to handle future emergent biosecurity threats.

Key NCBID functions:[211]

- Provides scientific and technical assessments of animal disease including zoonoses (diseases that spread from animals to humans) and diseases of native animals
- Tests samples for exotic and emerging diseases and pests under biosecure conditions
- Manages investigation, diagnosis, and control of emerging and exotic diseases of animals
- Manages investigation of reports of introduction of exotic environmental pests (includes reptiles, amphibians, invertebrates)
- Assesses epidemiology of exotic and emerging diseases
- Tests development and validation relating to MAFBNZ's core role
- Manages New Zealand's exotic disease and pest reporting system

When NCBID was established in 2006, the chief executives of its member organisations agreed that a critical NCBID vision is to "…provide an environment that fosters collaboration among New Zealand's experts in infectious animal and

[210] INFOSAN (2010), p.1
[211] MAFBNZ (2010), http://www.biosecurity.govt.nz/biosec/pubs-news/pubs/biosecurity/issue-97, p.8

human disease..."[212] With its commitment to collaborate across animal and human health, NCBID is well placed to play a central leadership role to foster such efforts in New Zealand.

The *NCBID–Wallaceville Strategic Plan 2010 to 2015* draft future objectives include: (1) become a zoonotic disease research and investigation hub under the *One Health* paradigm through its scientific programme and collaborations with off-site partners; (2) Build and strengthen its international reach and reputation; and (3) Serve as a *One Health* coordinating entity in New Zealand.[213]

Toward such goals, NCBID could lead or coordinate an interdisciplinary network of New Zealand biosecurity or infectious disease research centres. Academic or other institutes with expertise in zoonotic diseases, animal, human, and ecosystem health that are located off site could choose to become autonomous members of a greater "interdisciplinary network of New Zealand centres of excellence for biosecurity and infectious diseases". Each entity would bring its own expertise, international reputation, personnel, interests, background, and perspective to the network.

The ongoing and future projects among the different centres would not all have to be joint or collaborative. However, the independent projects that are not collaborations would be coordinated so they are complementary and not duplicative. Such partnerships could help ensure funding through collaborative research projects as well as facilitating the exchange of ideas and information and filling research gaps. The wealth of expertise provided by such a network would help New Zealand consolidate and fine tune its research and response efforts to address dynamic and emerging health issues, including zoonotic diseases and other threats.

[212] Ibid. p.8
[213] NCBID (2010), *NCBID Strategy – Version 5, DRAFT*

5 RECOMMENDATIONS TOWARD A CONVERGENT PATH

The project uncovered several major themes based on meetings, discussions and interviews with key stakeholders and subject experts:

- New Zealand must strengthen partnerships among its human, animal, and ecosystem health disciplines.
- Professionals are enthusiastic to engage their counterparts in other health disciplines.
- Improvements in human-animal-ecosystem health partnerships require a top-down, bottom-up approach.
- Visionary leadership that can build bridges between human, animal, and ecosystem health disciplines is critical.
- Forward-thinking individuals are essential in every discipline and at every level. Mutual respect among disciplines is crucial.

The following recommendations reflect these themes.

The recommendations are based on extensive discussions with New Zealand policy-makers, researchers, educators, and community members, ranging in expertise across human, animal, and ecosystem health. The recommendations reflect my own perspective, which may differ from individuals and organisations cited in the report. The primary goal of the recommendations is to increase transdisciplinary awareness and to facilitate collaborations. The recommendations are provided to stimulate thought and provoke discussion when coordinating transdisciplinary action to ensure human, animal, and ecosystem health.

Broad Brush Strokes – The biggest lesson from the smallest stakeholder

New Zealand has long recognised the links among human, animal, and ecosystem health. The past two decades have demonstrated examples of transdisciplinary health discipline collaborations. As the world's health challenges become increasingly dynamic, New Zealand expert consensus indicates a need for even greater coordination.

The smallest stakeholder, i.e. the microbe in the context of zoonotic disease, offers the biggest lesson: health threats, such as pests and pathogens, are restricted only by the laws of nature. *Effective* disease management strategy must align with biology; not government mandates, legislative prerogatives, or lines drawn on a map.

Radical change is necessary to improve interagency communications and better coordinate health efforts across disciplines – less provocative than major restructuring but more progressive than forming a new committee. Too often, separate government agencies devise and execute disease management strategies without regard for what other agencies are doing. Currently, a given health threat lands on the desk of a single agency and then the paths of communication are defined by that agency's individual mandate. Communication with interagency counterparts is often an after-thought. As a consequence, the roles of secondary agencies are ad hoc, dispersed, and too often retrospective. The lack of coherence leads to efforts falling short of what is possible.

The successful efforts illustrated in this report have a common trait: each was process-oriented, involved decentralised decision-making, and remained flexible throughout execution. Flexibility is a necessary trait for addressing today's dynamic health threats and can easily be lost if the solution is made overly bureaucratic. A balance must be achieved.

When taking steps towards a more focused, coordinated transdisciplinary health system, consider the broader concepts from *The Strategy-Focused Organization*.[214] No single agency or organisation must control all aspects of a coordinated transdisciplinary effort. Agencies retain their internal missions, objectives, and internal performance measures. A coordinated transdisciplinary effort, however, enables key agency decision-makers to collectively devise and align with an overall strategy, which is then mapped out in a way that allows individual agencies to determine how they will contribute to the strategy and more importantly, how their contribution would link with other agencies in order for the overall effort to succeed.[215] Once a strategy is agreed upon, the next step, execution, is just as critical.

Strategies integrated from the beginning diffuse artificial boundaries among health disciplines and identify confused, missing, or duplicated responsibilities. Potentially costly gaps are discovered early on and avoided. With responsibilities defined, agencies have fewer questions about roles. An organised, well-coordinated strategy allows more efficient execution better equipped to meet goals.

This approach will allow a more thorough and proactive approach to health in New Zealand.

Policy Level Recommendations

The researchers, the people on the ground, individuals within organisations who represent farmers and other community members, and the health professionals who administer care understand the importance of the links among human, animal, and ecosystem health. Most scientists see this collaboration as the only way forward. Now, policy-makers need to understand and embrace the importance, and then drive change from the top.

1. **Establish collective vision and execute:**
    a) **Develop a joint strategy for execution:** Each agency considers itself quite different from any other. The key to an integrated approach is to establish common goals. This needs to be accomplished at a high level with a strategy that holds each agency accountable for its role and empowers each agency to affect operational change. A sense of "we are all doing this together" is essential to press individual agency decision-makers to move forward.

[214] Kaplan and Norton (2001)
[215] Ibid. p.187

b) **Establish health-interface governance group:** A director-general-level interagency governance group should be established with representatives from MAF (including NZFSA), MOH, DOC, MFE, DOL, NCBID and other key agencies and institutes. For overarching reach, representatives should have centrally located positions within each agency, such as within the offices of the director general, chief executive, or equivalent. The governance group would jointly develop a strategy that agencies would be accountable for fulfilling. The shared agenda would bind them collectively. An evaluation framework to measure deliverables would monitor progress, avoid wasted efforts, and help sustain momentum. Within each agency, annual budget planning would ensure interagency expectations are met. Risk assessment would be built in to leverage limited resources. The group would identify efforts likely to benefit from cost-sharing and those that are better funded as separate but coordinated efforts. A high level group is better positioned to address issues that compound already complex challenges – for example legal issues surrounding targeted human surveillance around a production animal disease outbreak.

c) **Appoint an overarching leader:** A full-time chairperson should be appointed to lead the governance group. Outstanding leadership skills are required to execute coordination across disciplines. Experts from the Harvard School of Public Health and US CDC recently put forward a model to guide government connectivity called "meta-leadership". They describe meta-leaders as able to "provide guidance, direction, and momentum across organisational lines that develop into a shared course of action and a commonality of purpose among people and agencies that are doing what may appear to be very different work".[216] Such an individual could serve as chairperson of the governance group.

d) **Set priorities:** A high-profile and high-impact area for initial focus is zoonotic disease. For example, the governance group could develop a shared vision with shared priorities for a zoonotic disease over the next three years. A useful initial focus might be *Salmonella* or verotoxigenic *Escherichia coli* (VTEC). Both organisms cause significant human and animal health burdens in New Zealand.[217, 218, 219, 220, 221] Both have interdependent animal, human, and environmental disease pathways that must be addressed collectively for success. These organisms present costly health impacts in other countries including the US. New Zealand is well placed to set an example of how to jointly combat these diseases in animals and humans.

e) **Identify barriers**: Conduct a formal analysis of the gaps and

[216] Marcus et al (2006)
[217] Baker et al (1999)
[218] ESR (2010)
[219] NZFSA (2010)
[220] Author interview, 10 March 2010
[221] Holmes (2010)

barriers to transdisciplinary health coordination. Barriers identified during this project are listed at the end of this chapter.

f) **Future focus:** After an initial focus on zoonotic disease, the governance group would be well placed to address other health challenges, such as pests, toxins, and the impacts of climate, environmental, and land use changes on human and animal health.

g) **Doing the work:** The governance group would provide operational strategy and direction for lower level working groups to execute. Researchers should be engaged early for input on science-driven strategy.

2. **Establish performance measures:**

   a) Encourage *One Health* or transdisciplinary goals and linkages.

   b) Establish shared high-level outcomes.

   c) Define success.

3. **Strengthen international reach:** Strengthen global support for transdisciplinary health strategies by reaching out to international organisations, including WHO, OIE, FAO, and the Convention on Biological Diversity Secretariat. Leverage the expertise of the *One Health* liaisons and committees within these organisations.

4. **Conduct cost analysis:** Assess how integrated approaches to health affect expenditures, maximise benefits and improve health. Conventional wisdom suggests prevention and early intervention strategies are a far cheaper way to address health threats; however, true cost analyses will lend credence to transdisciplinary approaches.

5. **Mainstream ecosystem health:**

   a) Communicate the interdependence of ecosystem and environmental health with human and animal health.

   b) Increase public and policy-maker awareness and understanding through environmental reporting as a joint effort among MFE, MOH, MAF, and public communication experts.

   c) Develop tools and methods to facilitate mainstreaming ecosystem health; for example, clearly define and communicate the value of ecosystem services – clean air, safe water for drinking and recreation, food, natural energy, land, and forest products.

6. **Improve information sharing**: Explore ways to improve information sharing. For example, the Australian Wildlife Health Network publishes a weekly newsletter that encapsulates wildlife health issues.[222]

7. **Conduct interagency meetings:** Conduct routinely scheduled interagency meetings to discuss critical cross-cutting issues, as exemplified by the MOH-MAF health-interface meetings.

8. **Engage the private sector:** Public-private partnerships leverage industry expertise and cost-sharing. See MAFBNZ's Government-Industry

[222] Australian Wildlife Health Network (2009)

Agreement (GIA) Initiative.[223]

9. **Integrate surveillance:** Once a human-animal-ecosystem health foundation is established, surveillance provides a platform for innovation, efficiency and other collaborations. Key tasks to integrate surveillance:

    a) Convey to decision-makers the importance of robust surveillance as the foundation for prevention, early detection, and targeted more efficient response.

    b) Improve disease reporting across disciplines. Establish routine and sustained cross-disciplinary data-sharing mechanisms. Coordinate human health and biosecurity surveillance systems, including animal and environment monitoring. Use targeted approaches, identifying the most important questions to answer about specific issues. A potentially useful model or starting point for integrating data from different disciplines to inform decision making is Statistics New Zealand's *A Social Statistics Programme for New Zealand*.[224]

    c) Develop collaborative databases. Review successful models. For example, the Highly Pathogenic Avian Influenza Early Detection Data System (HEDDS) housed by the US Geological Survey National Wildlife Health Center is an interagency product that "provides a data repository into which partners from different organisations and agencies can voluntarily contribute their AI (avian influenza) surveillance data. This data can then be rolled together and summarised for mapping and reports".[225]

    d) Conduct risk, cost-benefit, and cost-effectiveness analysis to optimally allocate surveillance resources. Explore novel analysis tools – for example recently introduced "portfolio theory" surveillance techniques.[226, 227, 228]

    e) Determine baseline prevalence data – current or existing values to serve future comparison – in wildlife and production animals to guide surveillance decisions about locations, routine vs. targeted vs. passive vs. active.

    f) Examine the need to improve surveillance of common endemic and exotic diseases, and consider the increasingly blurred distinction between endemic and exotic.

    g) Examine the need to improve routine syndromic surveillance in animals for early detection of threats that may impact human health, animal welfare, or trade.

    h) Increase upstream risk factor surveillance to facilitate prevention efforts and reduce treatment costs. An example of an upstream risk

[223] MAFBNZ (2010), http://www.biosecurity.govt.nz/biosec/new-post-border/gia
[224] Statistics New Zealand (2010)
[225] National Biologic Information Infrastructure Wildlife Disease Information Node (2010)
[226] Prattley et al (2007)
[227] Author interview, 10 March 2010
[228] Morris (2010)

factor is excessive household dampness, which is associated with respiratory disease.

i) Examine the need to improve occupational surveillance systems to proactively prevent occupational disease and injury.[229]

j) Establish a framework to address surveillance-related ethics issues such as balancing individuals' privacy rights with community health and safety. Not taking action can also present an ethical problem.[230]

k) Consider the value of animals as predictors of human health, for example diseases like obesity, diabetes, communicable diseases.

10. **Integrate outbreak investigation and response**: Clarify roles and responsibilities. Map out notification of events and core coordination.

11. **Consider re-establishment of the New Zealand Public Health Veterinary Service:** Determine value of re-establishing New Zealand Public Health Veterinary Service. Given New Zealand's economic dependence on production animals, leadership and coordination through the Public Health Veterinary Service would ensure veterinary health activities meet animal health and welfare needs. Veterinary service officers would liaise with their human health counterparts for planning related to risk assessment, surveillance, and ecosystem health. They would also provide a public veterinary face to communicate health information and risks – a critical task during emergency situations such as animal disease outbreaks that threaten production animal health, human health or the economy.

12. **Tap international resources:**

a) *Achieving Effective Inter-Sectoral Collaboration to Prevent, Detect and Control the Emergence and Spread of Zoonotic Diseases* – an April 2010 Chatham House working paper offers tangible solutions to facilitate the development of effective integrated intersectoral systems.[231]

b) *Zoonotic Diseases: A Guide to Establishing Collaboration between Animal and Human Health Sectors at the Country Level* – a 2008 high-level document published by WHO.[232]

c) *One Health: A New Professional Imperative* – the 2008 American Veterinary Medical Association (AVMA) final report of the One Health Initiative Task Force contains five steps toward improved transdisciplinary collaboration and 12 recommendations that can be considered in a New Zealand context.[233]

d) *One World One Health™: from ideas to action* – the 2009 report resulting from a Public Health Agency of Canada (PHAC) expert consultation. The report includes specific recommendations for

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229 Pearce et al (2005)
230 Lee (2010)
231 Pappaioanou (2010)
232 WHO (2008)
233 AVMA (2008)

integrating best practices across surveillance, communications, emergency response, interagency and cross-sector partnerships, control of existing and emerging infectious diseases, and strategic research.[234] Key recommendations from the PHAC report are applicable to other countries including New Zealand and the US:

- Foster political will. Multi-level, multi-ministry political will is crucial to driving the OWOH concept forward.
- Support partnership and collaboration. Finding new ways to work together to build new attitudes is essential and requires leadership and commitment to make multidisciplinary collaboration a common practice.
- Encourage data sharing and integration. Integrated data-sharing eliminates "data silos" and "data hugging".
- Build capacity (infrastructure and skills). Building knowledge, skills, and OWOH attitudes at the local level is important. There is a need to encourage the academic community to develop and implement integrated curricula and to foster transdisciplinary collaboration.
- Develop communication strategies/plans. Media should be engaged as a partner. This will require investment in training. Working with the media is critical to getting information to the public and other target audiences.
- Provide incentives for reporting adverse events. Incentives are important to encourage key actors to report in a timely manner.
- Encourage stakeholder and community engagement. Engagement of stakeholders and communities in OWOH concepts requires that all parties understand their roles and contributions.
- Develop supra-country approaches. Health threats do not stop at the border. In addition to a multidisciplinary/ transdisciplinary approach, the integration of efforts, data, etc. also needs to take a trans-boundary/regional approach.[235]

Research Level Recommendations

13. **Establish Zoonotic Diseases Research Steering Committee:** This interdisciplinary advisory committee would be similar to the former Zoonotic Enteric Diseases Research Steering Committee.[236] Consider these points:

    a) Broaden the scope to include all zoonoses, not just enterics or those that impact food safety.

[234] PHAC (2009)
[235] Ibid., p.3
[236] Zoonotic Enteric Diseases Research Steering Committee (n.d.)

b) Establish a leader or coordinating agency.

c) Ensure members represent human medicine, veterinary medicine, and ecology. Include representatives from relevant government agencies, industry, research institutions and centres, research funding agencies, policy advisors, regulators, health protection officers, regional councils, and farmers.

d) Prioritise projects. Emphasise big issues.

e) Provide scientific input to the governance group described in this report's Policy Level Recommendations. The value of this advisory committee lies in science and research.

f) Facilitate strengthening links among New Zealand organisations responsible for wildlife health.

14. **Consolidate interdisciplinary research and training:** Creating a centre for infectious disease research and training activities at Massey University, New Zealand's only veterinary school and already a collaborative hub for state-of-the-art emerging infectious diseases research, is a logical step toward consolidating research and training-focused activities. A Massey University infectious disease research centre could be a complementary partner or member of the larger "network of New Zealand centres of excellence for biosecurity and infectious diseases" described in the NCBID section of chapter four.

15. **Improve wildlife health coordination:** Improve links among New Zealand wildlife health organisations. Establish a virtual group coordinated by an existing agency.[237] This group could work toward a cohesive, collaborative approach to examining wildlife health in New Zealand and its bearing on domestic animal and human health. As a start, the following organisations should be engaged (not a comprehensive list): MAFBNZ, DOC, MFE, NZCCM, New Zealand Wildlife Health Centre at Massey University, Landcare Research, community veterinarians, community groups (especially Māori), university research groups, ESR, AgResearch, and Ecogene.[238]

16. **Fund collaboration:** Direct research funds toward collaborative activities. The paucity of funding can be used to encourage collaboration rather than competition. Collaborative activities could be viewed more favourably as funding decisions are made. Deliberate effort should be made to avoid partitioning off competitive groups through funding decisions. Increase opportunities such as those afforded by the Cross-Departmental Research Pool.[239]

17. **Broaden scope of research programmes:** Research programmes that already integrate animal and human health issues should broaden their scope to encompass disease ecology and the ecosystem health perspective.

18. **Increase co-joint appointments:** Increase co-joint appointments between health disciplines; for example, veterinary and human health-focused

[237] Hall (2010), pers. comm.
[238] Hall (2010), pers. comm.
[239] MORST (2010), http://www.morst.govt.nz/funding/cdrp/

organisations could co-fund faculty and staff positions.

19. **Schedule interdisciplinary meetings to share research:** Organise regular scientific meetings where researchers from human, animal, and ecosystem health disciplines present and discuss their research. In addition to the exchange of information and perspective, regular meetings facilitate collaboration through development of personal relationships and good rapport.

Education Level Recommendations

A "new generation" of professionals is needed who understand and can communicate the importance of transdisciplinary health goals. These professionals will provide the transdisciplinary leadership necessary for application of the *One Health* paradigm.

20. **Develop transdisciplinary leaders:** Support professional development of individuals who have the leadership skills to articulate, engage, and lead across disciplines. Teach "meta-leadership", a strategy to "overcome traditional silo thinking", and that "connects the purposes and work of different organisations".[240]
21. **Teach scenario-based interdisciplinary learning:** Teach scenario-based learning courses that present case studies integrating human, animal, and ecosystem health for students who have taken classes on ecology, human, and animal health.
22. **Provide cross-discipline scholarship opportunities:** Provide cross-discipline scholarship opportunities for graduate students. For example, fund a student who plans to conduct a research project that investigates a health issue that affects human and animals.
23. **Provide cross-discipline mentoring programmes:** Provide cross-discipline mentoring programmes for graduate students. For example, a graduate student might have a mentor in veterinary health science and a secondary mentor in ecology to conduct a research project that crosses both fields.
24. **Provide integrated continuing education to established career professionals:** Provide classroom-based and online continuing education opportunities for veterinarians and general practitioners that teach the interdependence of animal, human, and ecosystem health. See scenario-based learning above.
25. **Broaden educational scope:** Educational opportunities that already cover animal and human health need to broaden their scope to include disease ecology and ecosystem health. Academic institutions with a primary focus on biodiversity, conservation, animal health and agriculture need to integrate human health aspects into curricula.

Community Level Recommendations

26. **Strengthen links between animal and human health practitioners:**

[240] Marcus et al (2006)

Community medical, public health, and veterinary practitioners should meet or communicate regularly to address specific crossover issues, such as appropriate use of antimicrobials.

27. **Strengthen links between health practitioners and ecosystem professionals:** Human and veterinary health professionals should regularly meet or communicate with Regional Councils and regional DOC officers to focus on broad impact health issues.

28. **Incorporate transdisciplinary approach into daily practice:** Veterinary practitioners should explore their comfort level in addressing animal-related human health issues with their human clients – through discussion or sharing information and resources, not treatment. Crossover health issues might include:

    a) Zoonotic infections, including occupational risks for leptospirosis, psittacosis, toxoplasmosis, and other diseases.

    b) Reverse zoonoses, which are transmitted from farm worker to production animal or from owner to pet. One example is methicillin-resistant *Staphylococcus aureus* (MRSA).

    c) Lifestyle habits that negatively impact pet health; for example, smoking cessation discussed in chapter three.

    d) Non-communicable diseases for which pet and owner are both at risk due to lifestyle. Examples include obesity, diabetes, cardiovascular problems.

    e) Domestic abuse. Pet neglect or abuse sometimes indicates child neglect or abuse. This subject presents a challenge but may be worth exploring – potentially, a veterinarian could share telephone numbers or brochures with information about assistance resources. An analogous reporting arrangement already exists between two New Zealand agencies: the Royal New Zealand Society for the Prevention of Cruelty to Animals and New Zealand's Child, Youth and Family.[241]

    Conversely, human medical practitioners should ensure their awareness of patients who might be at occupational risk for diseases including communicable zoonoses and other conditions that might be associated with work environment: for example, leptospirosis in an abattoir worker, psittacosis in a pet-shop worker or veterinarian. If a physician is aware of potential exposure risk as well as symptoms of the disease, the condition may be recognised, diagnosed, and treated earlier and more appropriately. This can prevent illness progression as well as further transmission of infection.

29. **Encourage a "culture of partnership" through communication:** An integrated transdisciplinary health approach is critical to communication with communities and the public. Health threats occur in the community so communities need to be engaged. Regarding the difficulties of surveillance and management of wildlife diseases, a Wildlife Services epidemiologist

[241] Child, Youth and Family (2008)

from the US Department of Agriculture writes:

> The science-related difficulties often pale in comparison to the political difficulties…Overcoming these difficulties usually requires great efforts in interagency team building with involvement and education of the public. Indeed, when tackling an emerging disease issue in wildlife, competent, energized, and proactive public affairs specialists are as important as wildlife and animal health professionals.[242]

Communication presents an important opportunity for an integrated approach. A public who understands the links between human, animal, and ecosystem health can facilitate threat prevention, surveillance, and response:

a) Engage social scientists and public affairs specialists who can articulate health information and health risks across human, animal, and ecosystem disciplines to educate and communicate with the public, both around prevention as well as facilitation of responses.

b) Engage members of the community. Human behaviour significantly influences management of zoonotic diseases. Communicate information and risks.

c) Communication should be reciprocal. Glean public opinion through mechanisms such as focus groups, phone lines for comments and surveys, and online requests for comments. Address concerns about real and perceived health impacts.

d) Engage media. Members of the media need to be part of the solution.

Barriers

Through discussions with key stakeholders and subject experts, the project identified the following barriers to transdisciplinary health coordination:

1. Lack of leadership with transdisciplinary expertise – for example individuals with training background and experience in human health, animal health, *and* ecosystem health.
2. Inadequate research funding.
3. Insufficient epidemiology. Better baseline prevalence data could improve understanding of disease pathways and epidemiology in the New Zealand setting.
4. Lack of awareness of important links to other disciplines: lack of understanding the value of others' input and getting beyond "patch-protection", ignorance and egos to engage expertise and perspective.
5. Inadequate common diagnostic platforms and tools for monitoring and detecting health threats.
6. Inadequate risk assessment of emerging threats. Improved methods are

[242] Rhyan and Spraker (2010), p.36

needed to adequately evaluate the consequences of changes in climate, farming, and land use practices.

7. Insufficient information-sharing mechanisms and capacity. Improved methods are needed for routine information sharing between agencies. More resources are needed to publish important findings.
8. Legislative impediments.
9. High personnel turnover, leading to the loss of institutional knowledge and breakdown of relationships across agencies.
10. Unclear understanding of agency roles and responsibilities. Defining agency roles must be in the interest of efficiency and collaboration, rather than territory protection or reluctance to take on new responsibility.
11. Inconsistent jargon. Different disciplines have alternative meanings for the same words – for example, “risk”, “endemic”, “conservation health”.
12. Lack of concisely stated answers to the question: “What does the environment do for public health?”
13. Insufficient mutual acknowledgement of others’ input and contributions.
14. Potential conflicts between industry and public health, animal welfare, and ecosystem health and economic health interests.
15. Weak relationships between government agencies and academic research: agencies should engage researchers early on for science-driven policy decisions (see successful *Campylobacter* effort in chapter three).
16. Inadequate engagement of ecology perspective.
17. Inaccurate assumption that “all the necessary information or data must exist before action can be taken”: In an urgent or evolving situation, acknowledge information gaps and move forward with action using best available information while continuing to collect data; actions can then be refined as necessary based on new data.
18. Reluctance to share data that needs publishing for continued funding and concerns about misinterpretation or misuse of data.
19. Insufficient ability to communicate science to inform policy. Scientists need to understand the dynamics of how decisions get made and communicate their findings accordingly.
20. Public perceptions of risks. Community attitudes can alter health threat control efforts.
21. Inconsistent analysis methods among disciplines. For example, human surveillance data is often lower throughput with large amounts of background data, whereas animal surveillance data may have higher sample numbers, with less background data.
22. Lack of mandated support for transdisciplinary groups at policy level and research level, i.e. lack of consensus to move toward integrated approach.
23. Policy tendency toward reactive retrospective response, as opposed to proactive prospective actions. Moving toward proactive position requires different competencies and skills and ways of working than traditional

reactive approaches.

24. Lack of integration of health outcomes into discussions of environmental and agricultural interests.

6 IN CONCLUSION

Increased use of strategies that coordinate human, animal, and environmental health disciplines will improve health for all. Failure to effectively control health threats stems from separate strategies that conform to administrative authority instead of disease biology.

Collective ecosystem health, including that of humans and animals and the environment, requires a unified, convergent, approach across disciplines.

New Zealand offers good examples of past and ongoing transdisciplinary health collaborations. These successes, described in chapters two and three, offer excellent models for confronting present and future health threats.

Policy recommendations include creating a director-general-level interagency governance group comprising representatives from MAF, MOH, and other key agencies and institutes. Once established, the governance group would provide guidance for lower level working groups. The governance group's initial focus should be zoonotic diseases or another high-profile, high-impact area.

Other policy-related recommendations include integrating surveillance activities; establishing transdisciplinary performance measures; mainstreaming ecosystem health; and strengthening relationships with international organisations who lead *One Health*.

Research recommendations include establishing a zoonotic research steering committee to support and advise the health-interface governance group; improving links among New Zealand wildlife health organisations; and increasing funding of collaborative research.

Education recommendations include developing a new generation of health professionals who can provide transdisciplinary leadership; teaching student scientists scenario-based concepts that demonstrate the value of integrating human, animal, and ecosystem health; and providing transdisciplinary scholarship, mentoring, and continuing education programmes.

Community recommendations include strengthening links among human and animal practitioners and ecosystem professionals; incorporating transdisciplinary approaches into health care practice, for example, veterinarians dispensing information about health issues common to humans and pets; and engaging the media to help educate the public.

Ecology and ecosystem health must be brought front and centre. Whereas policy-makers easily see connections between animal and human health, the connections between ecosystem health and human and animal health are more subtle but no less important. Articulating these connections and their relationship to environmental conservation, biodiversity, and economic health, is a major challenge.

Successful partnerships among human, animal, and ecosystem health disciplines must encompass multiple levels in government, academia, and the community. Because such an endeavour falls across traditional disciplinary boundaries, the effort must be understood, appreciated, and guided by policy-makers. At the same time, methodically building awareness through transdisciplinary education would promote the *One Health* paradigm by generating more professionals who are aware of the interdependence of human, animal, and ecosystem health.

New Zealand's small public health and research community is conducive to communication and the exchange of ideas. Its biosecurity systems are well-established. New Zealand's example can provide a model to guide other nations, including the US, in the holistic coordination of efforts to prevent, identify, and control environmental pests, toxins and zoonotic disease threats.

The 2008 *One World, One Health* strategic framework states:

> Only by breaking down the barriers among agencies, individuals, specialties and sectors can we unleash the innovation and expertise needed to meet the many serious challenges to the health of people, domestic animals, and wildlife and to the integrity of ecosystems.[243]

Interviews conducted for this project revealed a recurrent theme: successful policy, actions and outcomes rely most on successful collaborations and interpersonal relationships.

Sir Ian Axford, patron of the Fulbright New Zealand public policy fellowship and internationally known for his achievements in astrophysics, passed away in March 2010. Former New Zealand Prime Minister and Chair of the Ian Axford Fellowships in Public Policy Board, Jim Bolger, said:

> Ian Axford was a great New Zealander and his outstanding research is a beacon for others to follow. But Ian was much more than a scientist, he had a bigger vision, one of encouraging others to see that by working together we produced a better world.[244]

Senator J. William Fulbright said:

> The essence of intercultural education is the acquisition of empathy – the ability to see the world as others see it, and to allow for the possibility that others may see something we have failed to see, or may see it more accurately.[245]

When confronting threats to human, animal, and ecosystem health, emulate these two visionaries from New Zealand and the United States. Understand, collaborate, succeed.

[243] FAO, OIE, WHO, UN System Influenza Coordination, UNICEF, The World Bank (2008), p.52
[244] Fulbright New Zealand (2010), p.1
[245] Fulbright (1989), p.217

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APPENDIX A: ACRONYM LIST

AI	Avian Influenza
ACC	Accident Compensation Corporation
AHB	Animal Health Board
AVMA	American Veterinary Medical Association
BMAC	Biosecurity Ministerial Advisory Committee
CDC	Centers for Disease Control and Prevention (US)
CRI	Crown Research Institute
DHB	District Health Board
DOC	Department of Conservation
DOL	Department of Labour
ERMA	Environmental Risk Management Authority
ESR	Institute of Environmental Science and Research, Ltd
FAO	Food and Agriculture Organisation of the United Nations
FRST	Foundation for Research, Science and Technology
GIA	Government-Industry Agreement
GNS	Institute of Geological and Nuclear Sciences
HEDDS	Highly Pathogenic Avian Influenza Early Detection Data System
HSE	Health and Safety in Employment
HSNO	Hazardous Substances and New Organisms Act
IDC	Investigation and Diagnostic Centre
IHS	Import Health Standards
INFOSAN	International Food Safety Authorities Network
IRL	Industrial Research Ltd
MAF	Ministry of Agriculture and Forestry
MAFBNZ	Ministry of Agriculture and Forestry Biosecurity
MCDEM	Ministry of Civil Defence and Emergency Management
MFE	Ministry for the Environment
MFish	Ministry of Fisheries
MOH	Ministry of Health
MORST	Ministry of Research, Science and Technology
MRSA	methicillin-resistant *Staphylococcus aureus*
MVS	Master of Veterinary Studies
NOHSAC	National Occupational Health and Safety Advisory Committee
NCBID	National Centre for Biosecurity and Infectious Diseases
NGO	non-government organisation
NIWA	National Institute of Water & Atmospheric Research
NOHSAC	National Occupational Health and Safety Advisory Committee
NZ	New Zealand
NZCCM	New Zealand Centre for Conservation Medicine
NZFSA	New Zealand Food Safety Authority
NZHIS	New Zealand Health Information Service
NZVA	New Zealand Veterinary Association

OIE	World Organisation for Animal Health
OWOH	One World One Health
PHAC	Public Health Agency of Canada
SSM	southern saltmarsh mosquito
TB	Tuberculosis
UK	United Kingdom
UNICEF	United Nations Children's Fund
US	United States of America
VTEC	verotoxigenic *Escherichia coli*
WebEOC	Emergency Operations Centre
WHO	World Health Organisation
WTO	World Trade Organisation