Pandemic planning and preparedness: a One Health perspective.

Nigel French, Fiona Callaghan, Kristin Dyet, Jemma Geoghegan, David Hayman, Sue Huang, Amanda Kvalsvig, Howard Maxwell, Michael Plank, Pippa Scott, Michael Baker, Te Pora Thompson, Euan Russell

Te Niwha
Te Kunenga ki Pūrehuroa MASSEY UNIVERSITY
E/S/R Science for Communities He Pūtaiao, He Tāngata
University of Otago Te Whare Wānanga o Otāgo New Zealand
UC University of Canterbury Te Whare Wānanga o Waitaha Christchurch New Zealand
Manatū Hauora Ministry of Health

Report

Available on teniwha.com

Spreadsheet coming soon

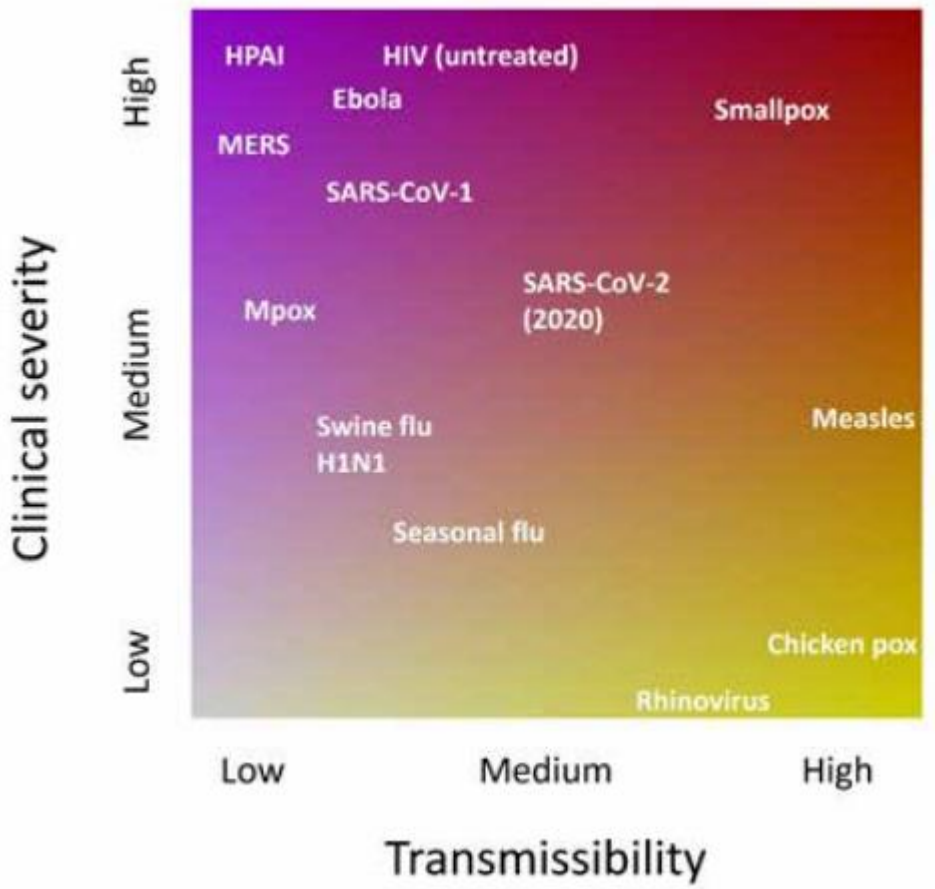
Pandemic preparedness in New Zealand

- Ministry of Health published influenza pandemic plan in 2017
- Plan intended to “be adopted and applied to any pandemic event”
- Experiences with COVID-19 - need to be better prepared for wider range of agents and scenarios
- Plan assumed influenza could not be eliminated
- Needs to be recognised and planned for

Te Niwha

Agent and pandemic typologies

- **Agent typology**
  - Included many zoonotic pathogens
  - Characteristics of pathogen and disease
    - Transmissibility
    - Severity
    - Controllability
    - Visibility
    - Certainty of knowledge



Agent and pandemic typologies

- **Pandemic scenario typology**
  - Included zoonotic diseases
  - Determines strategy
  - Determines control measures

Pandemic Type	Examples (*PHEIC)
A. Pandemic IDs transmitted between people with short to medium incubation periods	
1. ID with well-established pandemic potential	Pandemic influenza 1918, 1957, 2009*
2. Poorly characterised emerging ID with pandemic potential	SARS 2002, MERS-CoV 2012, COVID-19 2020*, Ebola 2014*, Mpox 2022*
3. Synthetic or weaponised ID with pandemic potential	Synthetic bioterrorist agent (e.g. gain-of-function influenza viruses), or stored agent that could be weaponised (e.g. smallpox)
4. Well characterised ID with re-introduction potential	Diphtheria 1998, Polio 2014*, Measles (post-elimination)
B. Pandemic IDs transmitted between people with predominantly asymptomatic transmission, with long incubation periods	
5. ID with high asymptomatic transmission, long latency and pandemic potential	HIV/AIDS 1981
6. Increase in serious antimicrobial resistance	Drug resistant tuberculosis (MDR / XDR / TDR), *Candida auris*
C. Pandemic IDs predominantly transmitted from animals, vectors, food, and water	
7. Exotic vector-borne and zoonotic ID with moderate to high introduction potential	Arboviral diseases e.g., Zika 2016*, Dengue, Chikungunya

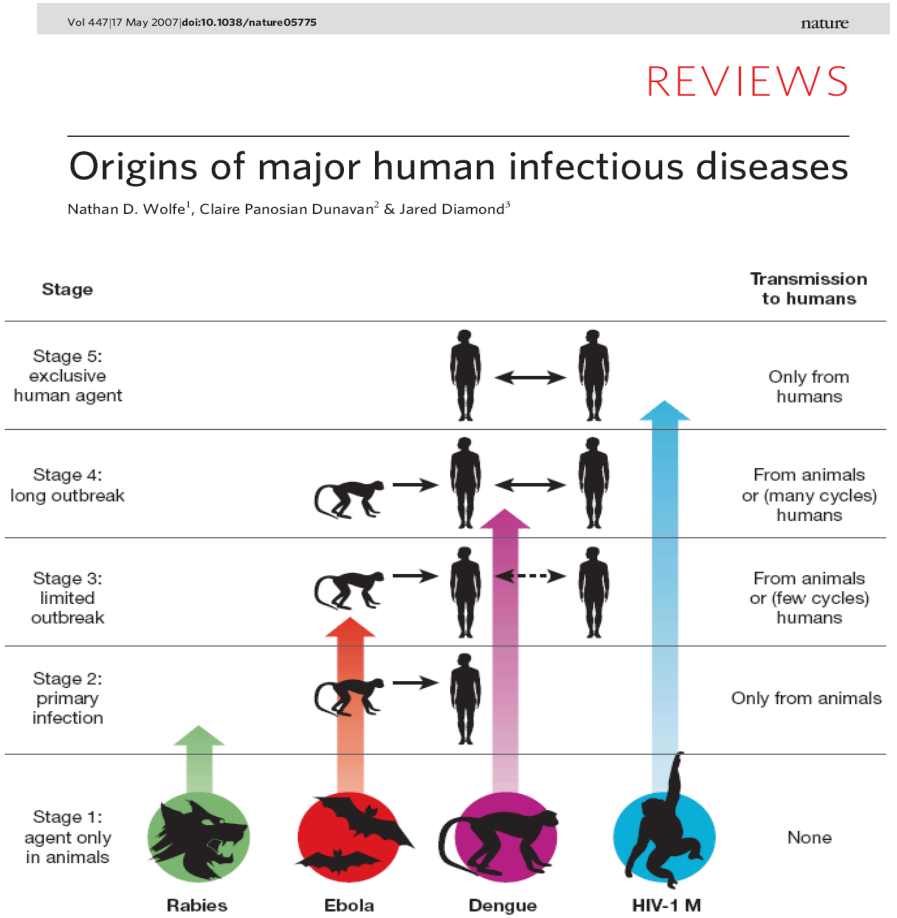
Source: Adapted from Baker's 2016 "Pandemics: Would a typology improve our ability to prepare and respond?"[11]

Te Niwha

Typology for zoonotic pathogens causing pandemics/PHEICs?

Maintenance/reservoir hosts – sustained transmission $R_0>1$

- **A.** Maintained in animals ($R_{0a}>1$) spillover to humans ($R_{0h}<1$)
- **B.** Maintained in animals and humans (R_{0a}, $R_{0h}>1$)
- **C.** Maintained in humans ($R_{0h}>1$) occasional spillover/spillback to animals ($R_{0a}<1$)
- Emergence A->B->C
- All stages could cause pandemic (and panzootic?)
- Emergence could involve multiple chains/pathways and intermediate hosts



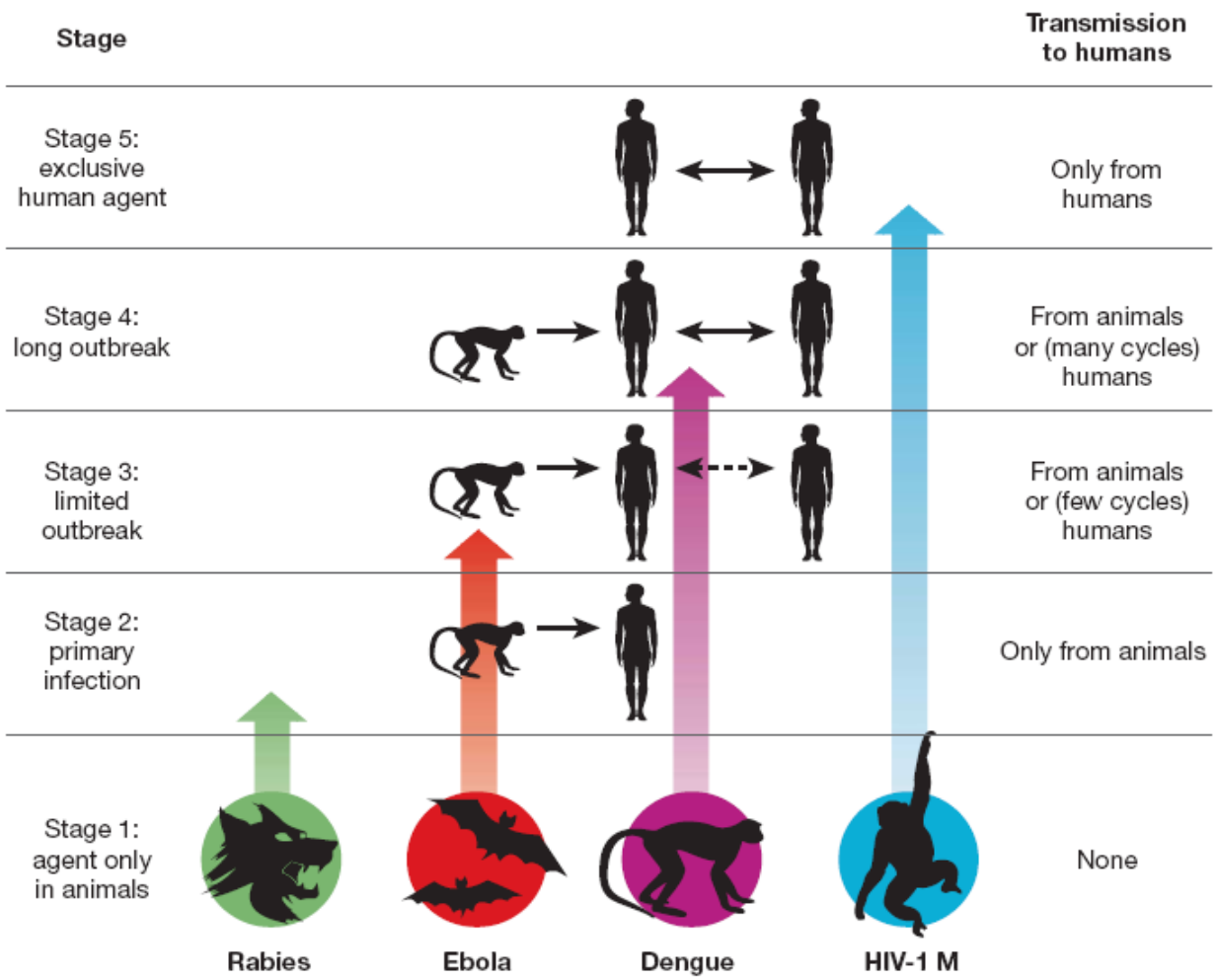
Te Niwha

Vol 447|17 May 2007|doi:10.1038/nature05775 nature

REVIEWS

Origins of major human infectious diseases

Nathan D. Wolfe[1], Claire Panosian Dunavan[2] & Jared Diamond[3]



Nature **447**, 279–283 (2007)

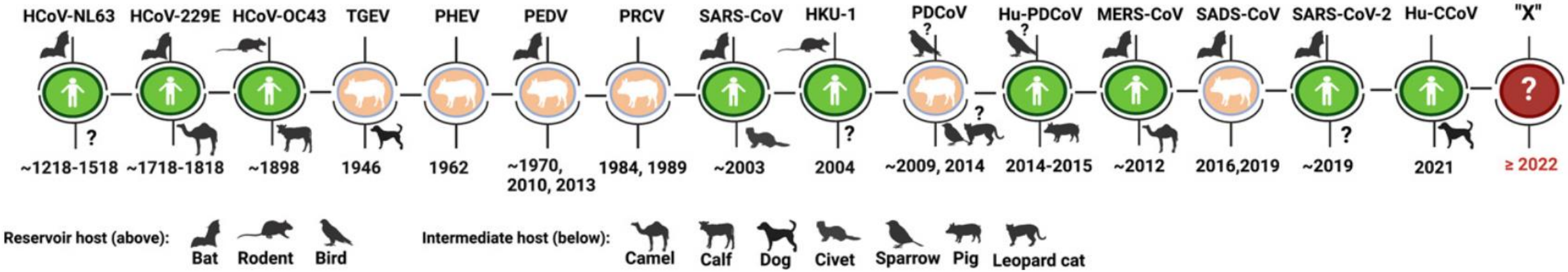
SARS-CoV-2?
Stage 5 with spillover/
Spillback to animals?

Te Niwha

PNAS PERSPECTIVE OPEN ACCESS

Pandemic origins and a One Health approach to preparedness and prevention: Solutions based on SARS-CoV-2 and other RNA viruses

Gerald T. Keusch[a,1], John H. Amuasi[b,c,d], Danielle E. Anderson[e], Peter Daszak[f], Isabella Eckerle[g,h], Hume Field[f,i], Marion Koopmans[j], Sai Kit Lam[k], Carlos G. Das Neves[l,m], Malik Peiris[n], Stanley Perlman[o], Supaporn Wacharapluesadee[p], Su Yadana[f], and Linda Saif[q,1]



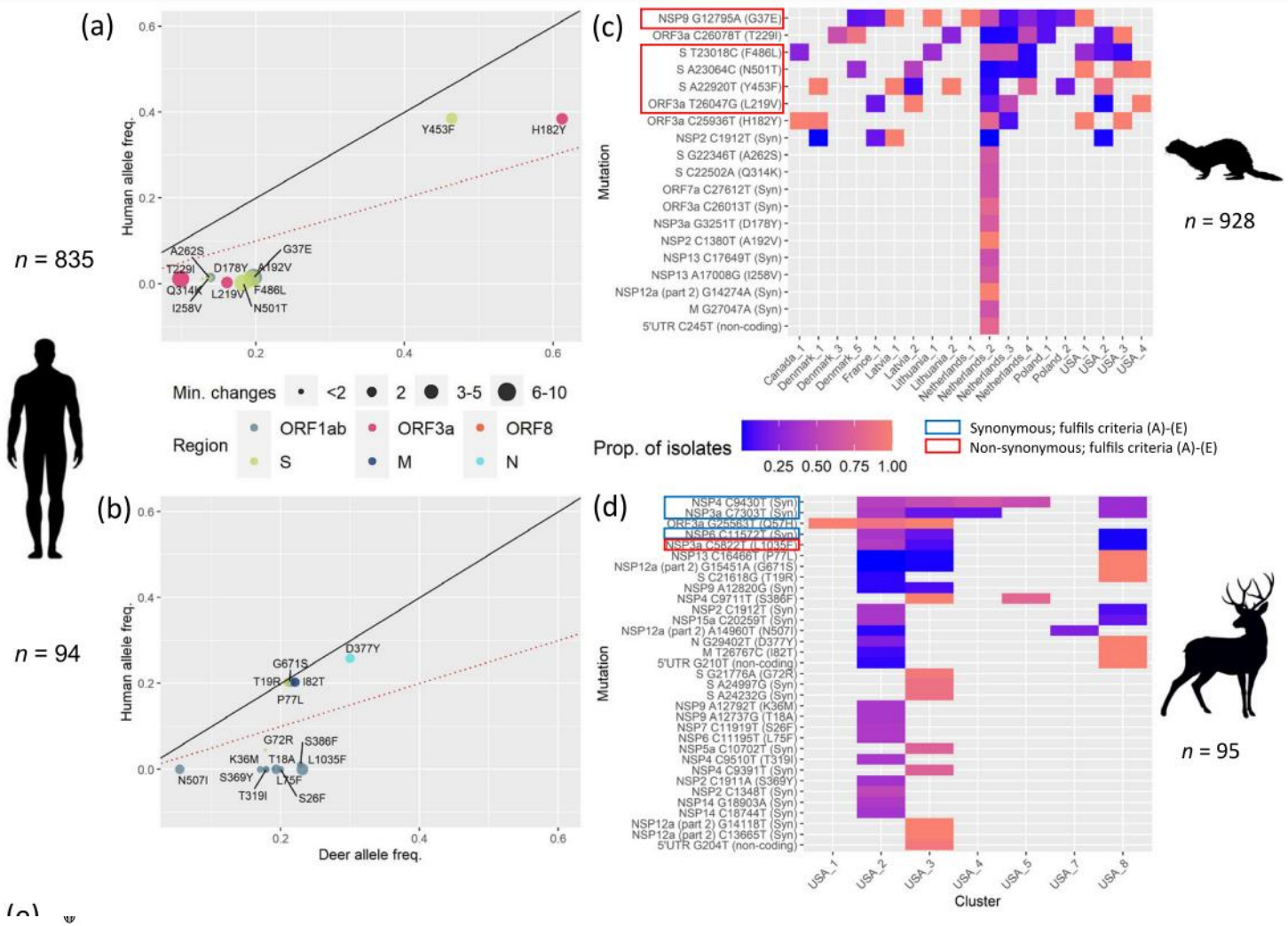
Timeline of the emergence of coronaviruses in people and livestock over the last millennium

Te Niwha

Counterfactuals for SARS-CoV-2

- What would have happened and how would we prepare for alternative scenarios?
- **Scenario A**. SARS-CoV-2 caused major multispecies panzootic with repeated spillover to humans (airborne, food, water, contact)
- **Scenario B.** SARS-CoV-2 featured sustained transmission in both humans and animals
- **Scenario C**. What actually happened (?) (initial spillover then almost exclusively human-human with some spillback to animals)

SARS-CoV-2 Spillback/reverse zoonotic transmission



nature COMMUNICATIONS

ARTICLE

https://doi.org/10.1038/s41467-022-30698-6 OPEN

Transmission of SARS-CoV-2 from humans to animals and potential host adaptation

Cedric C. S. Tan[1,2✉], Su Datt Lam[3,4], Damien Richard[1,5], Christopher J. Owen[1], Dorothea Berchtold[1], Christine Orengo[4], Meera Surendran Nair[6,7], Suresh V. Kuchipudi[6,7], Vivek Kapur[7,8], Lucy van Dorp[1,9] & François Balloux[1,9]

nature microbiology

Article

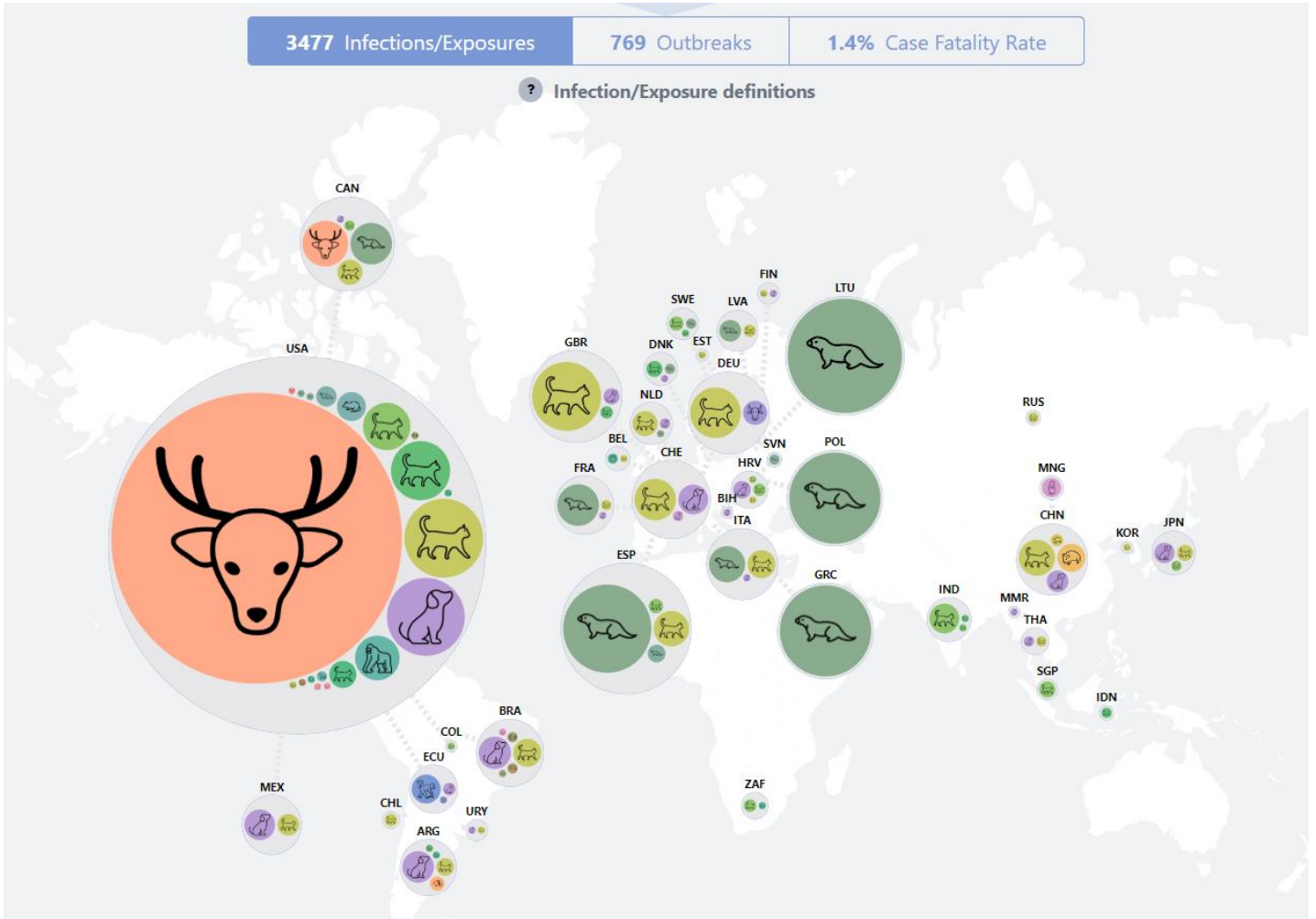
https://doi.org/10.1038/s41564-022-01268-9

Divergent SARS-CoV-2 variant emerges in white-tailed deer with deer-to-human transmission

Pickering et al 2023

SARS-ANI VIS

A Global Open Access Dataset of Reported SARS-CoV-2 Events in Animals



Te Niwha

https://vis.csh.ac.at/sars-ani/

Identifying and mitigating spillover risks – a global effort

- Geoghegan, J et al Virological factors that increase the transmissibility of emerging human viruses. *Proc. Natl Acad. Sci. USA* **113** (15) 4170-4175 (2016)
- Sánchez, C. A. et al. A strategy to assess spillover risk of bat SARS-related coronaviruses in Southeast Asia. *Nat. Commun.* **13**, 4380 (2022).
- Ruiz-Aravena, M. et al. Ecology, evolution and spillover of coronaviruses from bats. *Nat. Rev. Microbiol.* **20**, 299–314 (2022).
- Wilkinson, D. A., Marshall, J. C., French, N. P. & Hayman, D. T. S. Habitat fragmentation, biodiversity loss and the risk of novel infectious disease emergence. J. R. Soc. Interface (2018).
- Grange, Z. L. et al. Ranking the risk of animal-to-human spillover for newly discovered viruses. *Proc. Natl Acad. Sci. USA* **118**, e2002324118 (2021).
- Carlson, C. J. et al. Climate change increases cross-species viral transmission risk. *Nature* **607**, 555–562 (2022).
- Keusch, G. T. et al. Pandemic origins and a One Health approach to preparedness and prevention: Solutions based on SARS-CoV-2 and other RNA viruses. *Proc. Natl Acad. Sci. USA* **119**, e2202871119 (2022).

Te Niwha

NZ's contribution to global effort

nature communications

Article

https://doi.org/10.1038/s41467-023-42627-2

Using drivers and transmission pathways to identify SARS-like coronavirus spillover risk hotspots

Received: 31 May 2023

Accepted: 17 October 2023

Renata L. Muylaert[1], David A. Wilkinson[2], Tigga Kingston[3], Paolo D'Odorico[4], Maria Cristina Rulli[5], Nikolas Galli[5], Reju Sam John[6], Phillip Alviola[7] & David T. S. Hayman[1]

Muylaert et al 2023

- Characterised drivers associated with risk of spillover of zoonotic SARS-like coronaviruses
  - Landscape change
  - Host distribution
  - Human exposure
- Inform surveillance and mitigation activities
- Examined access to healthcare within defined clusters and scenarios

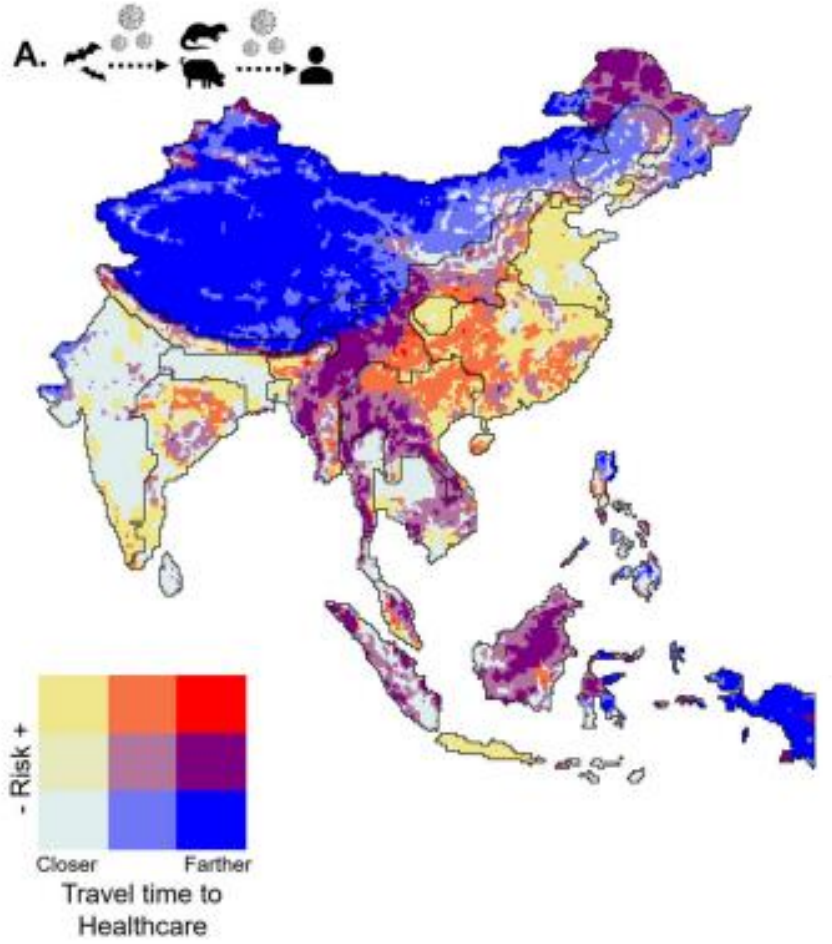


Fig. 4 | Bivariate map showing the risk scores from hotspot data and access to healthcare. A. Black lines divide the limits for the 19 clusters identified by the multivariate spatial cluster analysis; Scenario 4 is represented in the map.

Preparation for future pandemics and PHEICs

Develop and maintain **core capabilities**

- **Surveillance (human and animal)**
- **Māori communities**
- Pacific Peoples
- Diagnostics
- **Modelling**
- **Genomics**
- **Vaccines**
- Therapeutics
- Contact tracing
- Primary healthcare and hospitals
- **Communication**
- Leadership and decision making
- Borders and quarantine
- Legal framework
- **One Health considerations**
- Bioterrorism

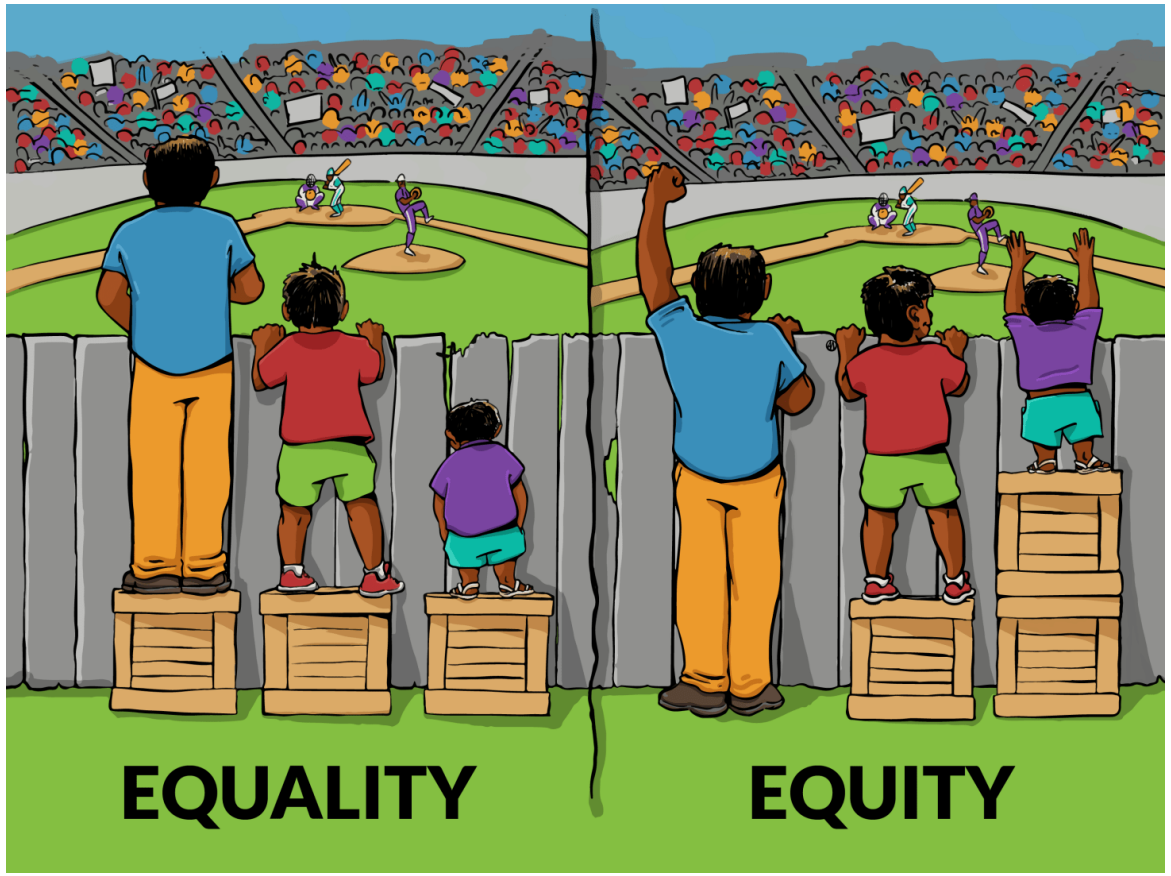
Preparation for future pandemics and PHEICs

- **Reactive preparedness** (capacity to stand up an effective pandemic response very rapidly if need be)
  - Assessment of the controllability and impact of an emerging pandemic to determine an appropriate response
- **Proactive preparedness** (having resources already in day-to-day operation that prevent the spread of infectious diseases).
  - Surveillance – humans and animals
  - Maximise controllability and minimise impact
  - Housing, ventilation, immunisation
    - Humans and animals!
  - Primary care and hospital resources
  - Borders and biosecurity

Features of Aotearoa New Zealand

Characteristics directly relevant to preparedness and development and implementation of a pandemic plan include:

- Te Tiriti o Waitangi obligations
- History of racism and colonisation with negative impact on health equity
- Regional links with other Pacific nations and obligations to Pacific Realm nations
- Our relative isolation as an island nation
- Population relatively compliant to reasonable, proportionate and clearly justified public health measures



Interaction Institute for Social Change | Artist: Angus Maguire

Te Niwha

Surveillance

- Early warning systems
- Surveillance in the early stages of a pandemic
- Wastewater surveillance
- Surveillance of vector-borne diseases
- Surveillance of domestic animals and wildlife
- Surveillance-informed severity assessment
  - Morbidity/mortality Impact
  - Disease seriousness
  - Virus transmission
- Behavioural surveillance data and insights

Source Christal Varley, Stuff

Source ESR

One Health 17 (2023) 100617

Contents lists available at ScienceDirect

One Health

journal homepage: www.elsevier.com/locate/onehlt

Developing One Health surveillance systems

One Health High-Level Expert Panel (OHHLEP), David T.S. Hayman [a], Wiku B. Adisasmito [b], Salama Almuhairi [c], Casey Barton Behravesh [d,1], Pépé Bilivogui [e], Salome A. Bukachi [f], Natalia Casas [g], Natalia Cediel Becerra [h], Dominique F. Charron [i], Abhishek Chaudhary [j], Janice R. Ciacci Zanella [k], Andrew A. Cunningham [l], Osman Dar [m,n], Nitish Debnath [o,p], Baptiste Dungu [q], Elmoubasher Farag [r], George F. Gao [s], Margaret Khaitsa [t], Catherine Machalaba [u], John S. Mackenzie [v,w], Wanda Markotter [x,*], Thomas C. Mettenleiter [y,*], Serge Morand [z,aa], Vyacheslav Smolenskiy [ab], Lei Zhou [s], Marion Koopmans [ac]

Sykdomspulsen One Health - A real time surveillance system in an infrastructure coping with half a million analysis a day

Clemence Koren, David Swanson, Gry Marysol Grøneng, Gunnar Rø, Petter Hopp, Malin Jonsson, Richard Aubrey White

https://aca.pensoft.net/article/68891/

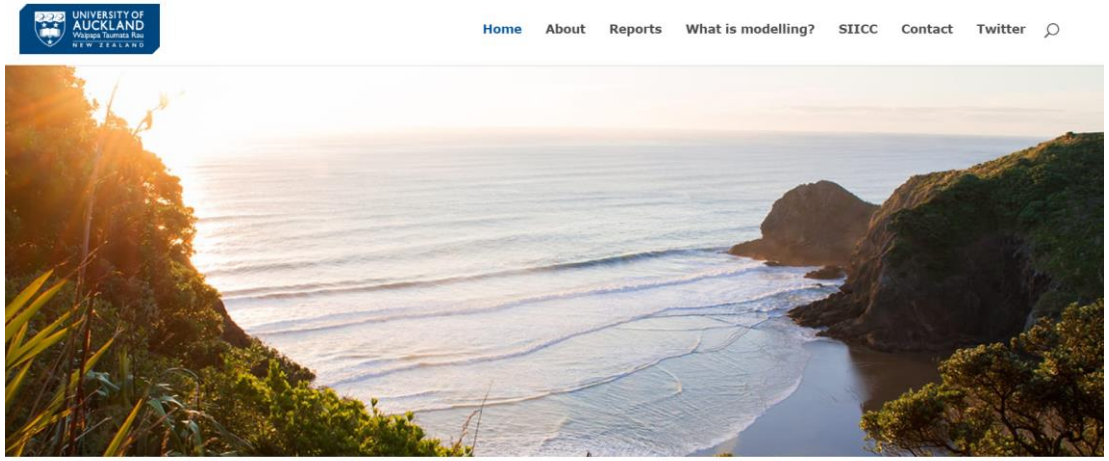
Key figures

Daily automated updates of Sykdomspulsen:

- Intake from more than 15 data sources
- 2,000,000,000 rows of data and results (1TB)
- 800 database tables
- Over 1 million analyses
- Over 370 reports produced before breakfast

Modelling

- Compartmental SIR
- Branching process models
- Network models
- Assessment of impact
- Effectiveness of control measures
- Situational awareness
- Informing policy measures
- Strategy development
- Interpreting epidemiological and clinical data streams



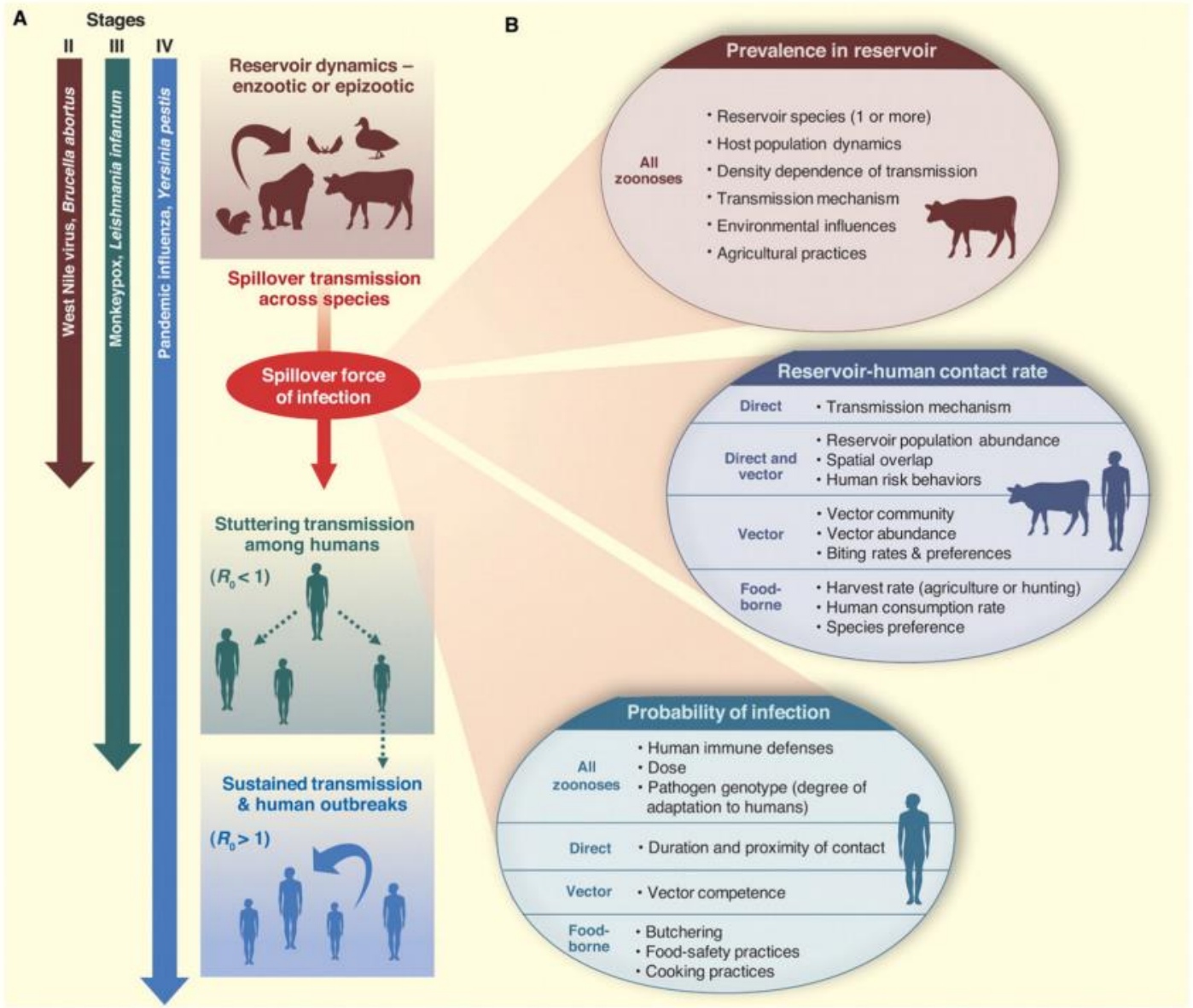
Covid-19 Modelling Aotearoa

A transdisciplinary group of academic researchers and scientists who worked to help Aotearoa New Zealand face the Covid-19 pandemic.

Te Niwha

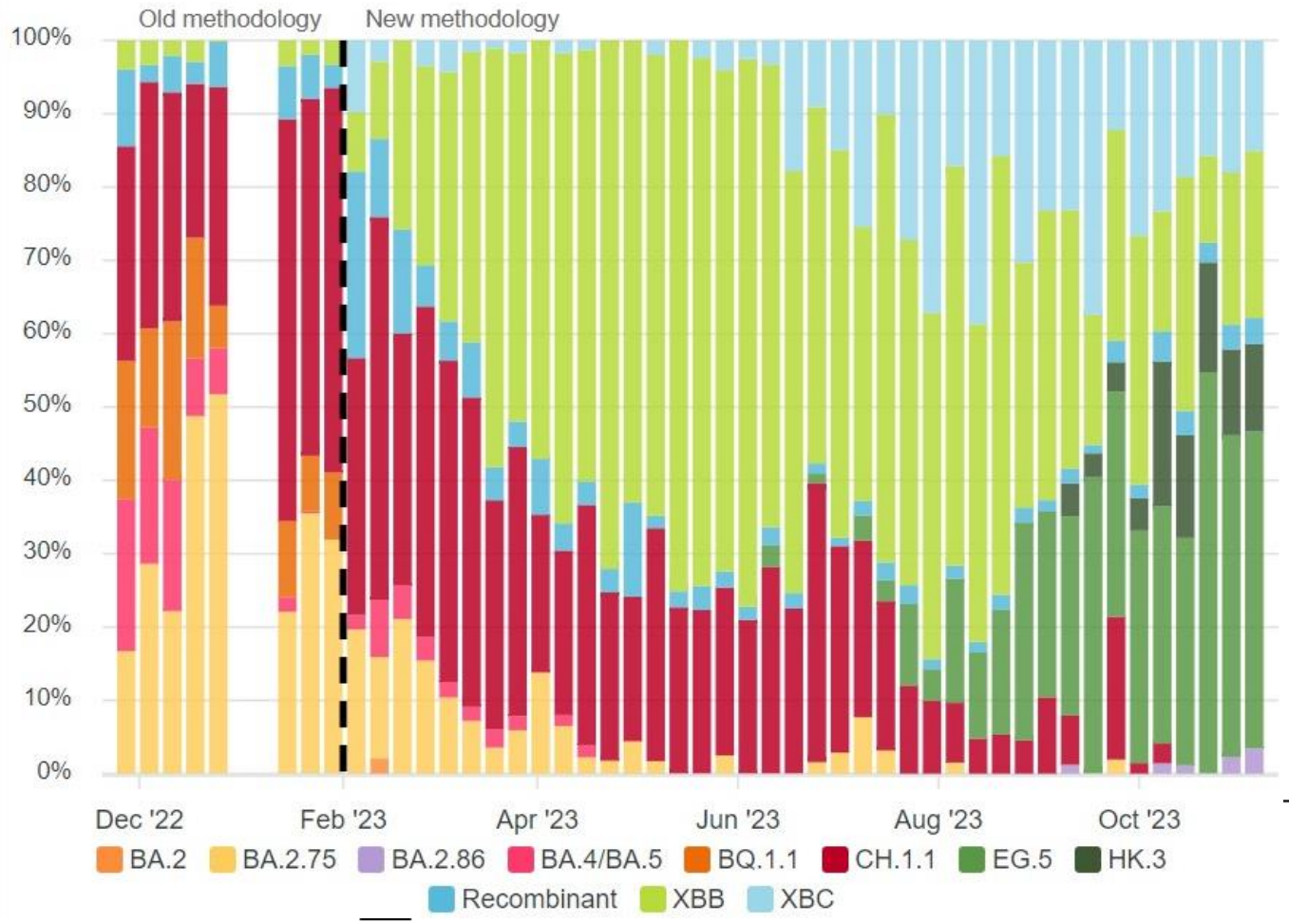
Modelling

- Single host for COVID models
- Modelling requires understanding of populations and interactions/transmission within and between hosts
- Multi-species models common in veterinary literature
  - FMDv
  - *Mycobacterium bovis*
  - Livestock and wildlife
- General frameworks and models less common for zoonoses
- Whole population models unfeasible?



Lloyd-Smith, J. O. et al. Epidemic dynamics at the human-animal interface. *Science* **326**, 1362–1367 (2009).

Genomics – played important role in COVID response

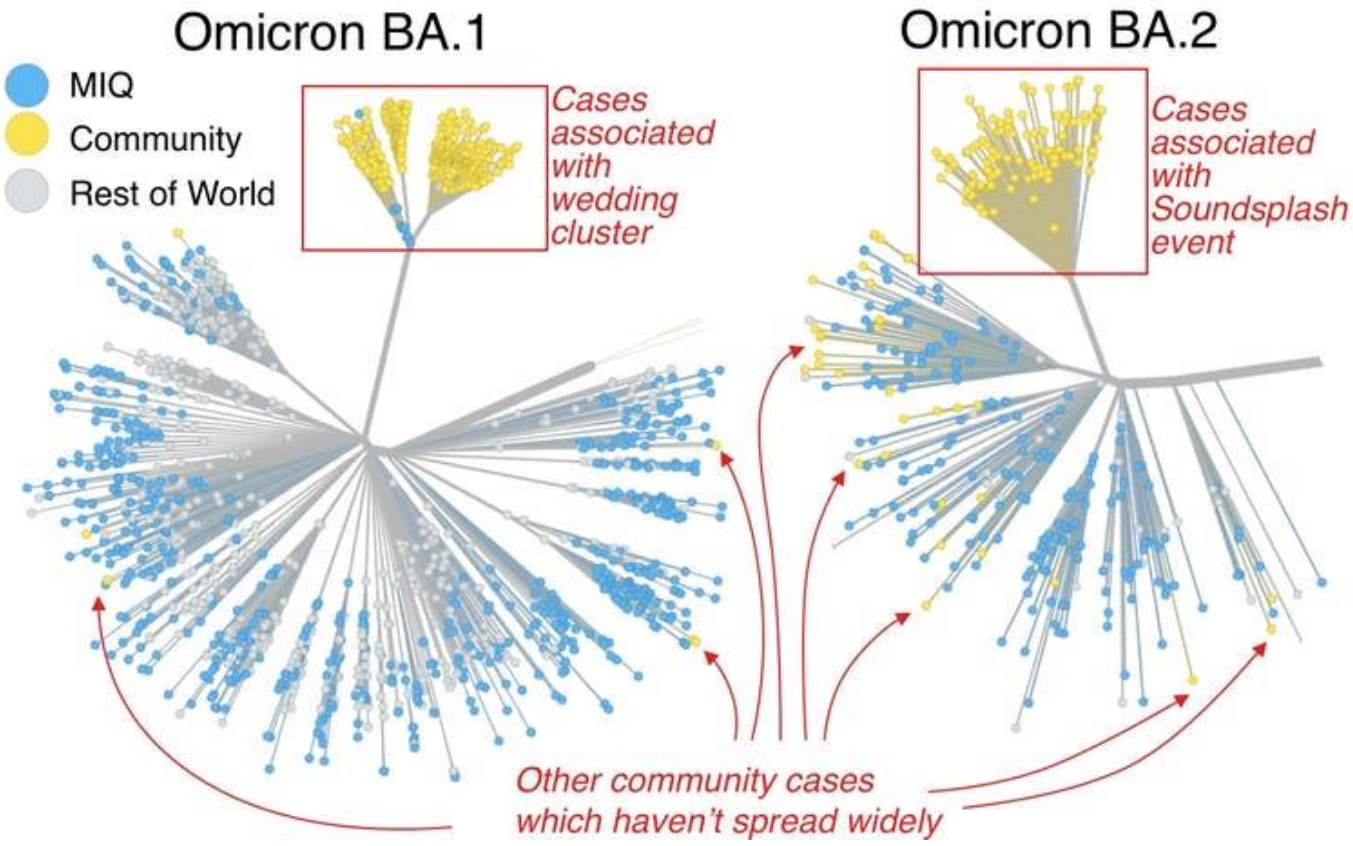


- Clinical cases
- Wastewater
- Operates differently during different phases
  - Early phase – WAIFW
  - Later phases – population level movements
- Informed therapy (monoclonals) and vaccination

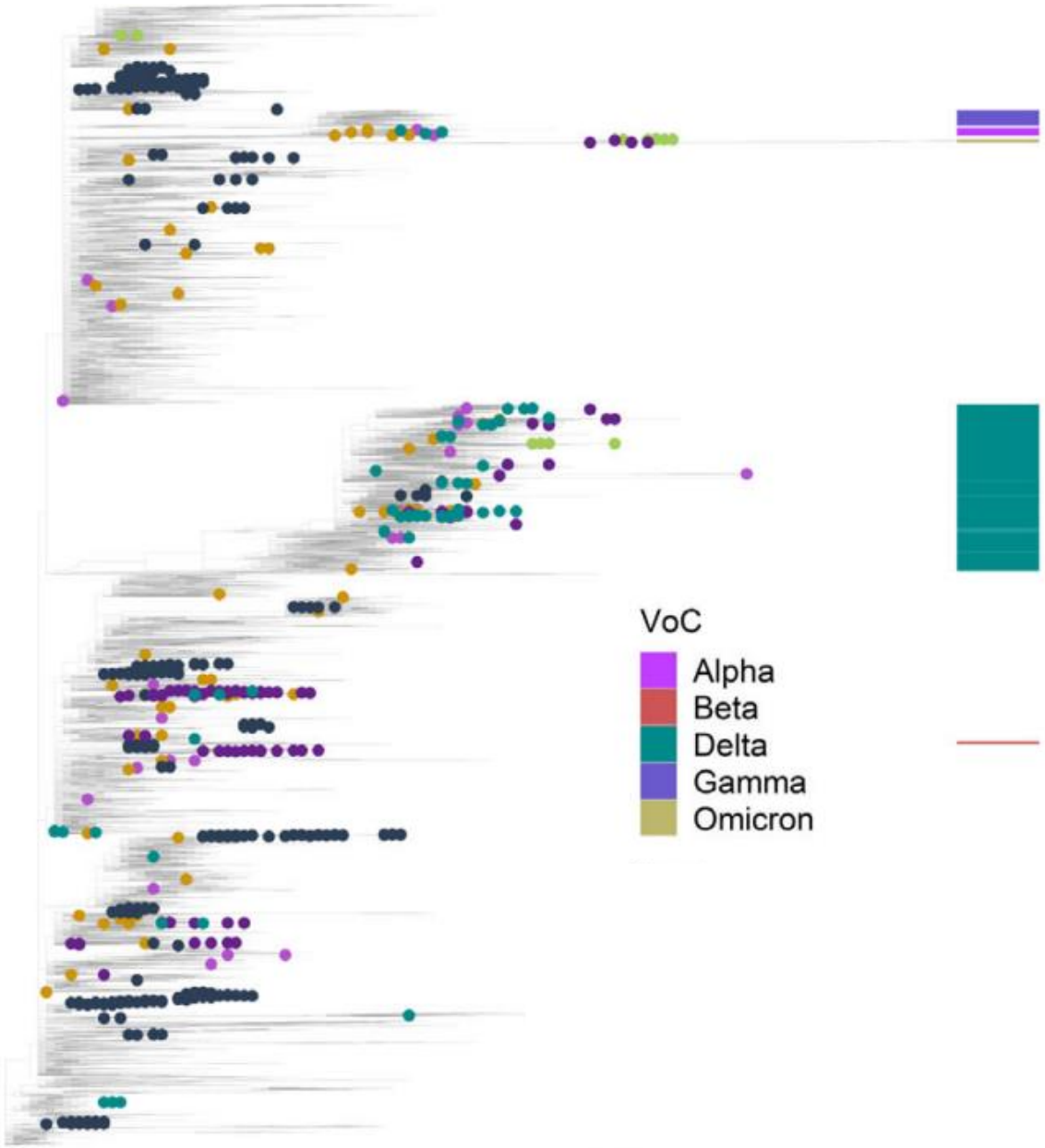
Te Niwha

One Health genomics challenges

- Sampling most important populations
  - Multiple host species
  - Farm animals, pets, livestock
  - Taonga species
  - eNA approaches
- Modelling
  - Ancestral state reconstruction
    - Infer within and between species transmission
    - Identify reservoir hosts
    - Superspreading events?



Te Niwha



nature COMMUNICATIONS

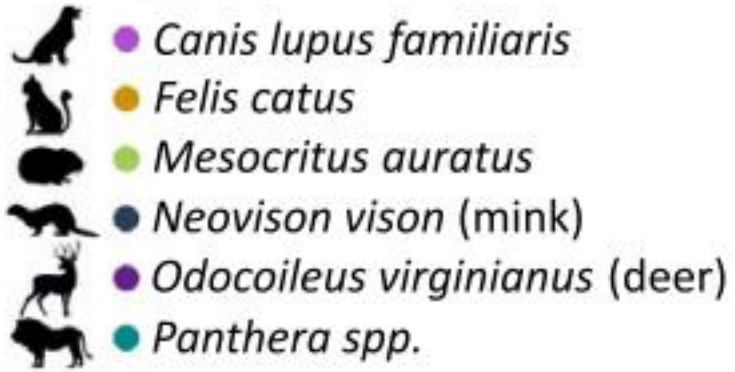
ARTICLE

https://doi.org/10.1038/s41467-022-30698-6 OPEN

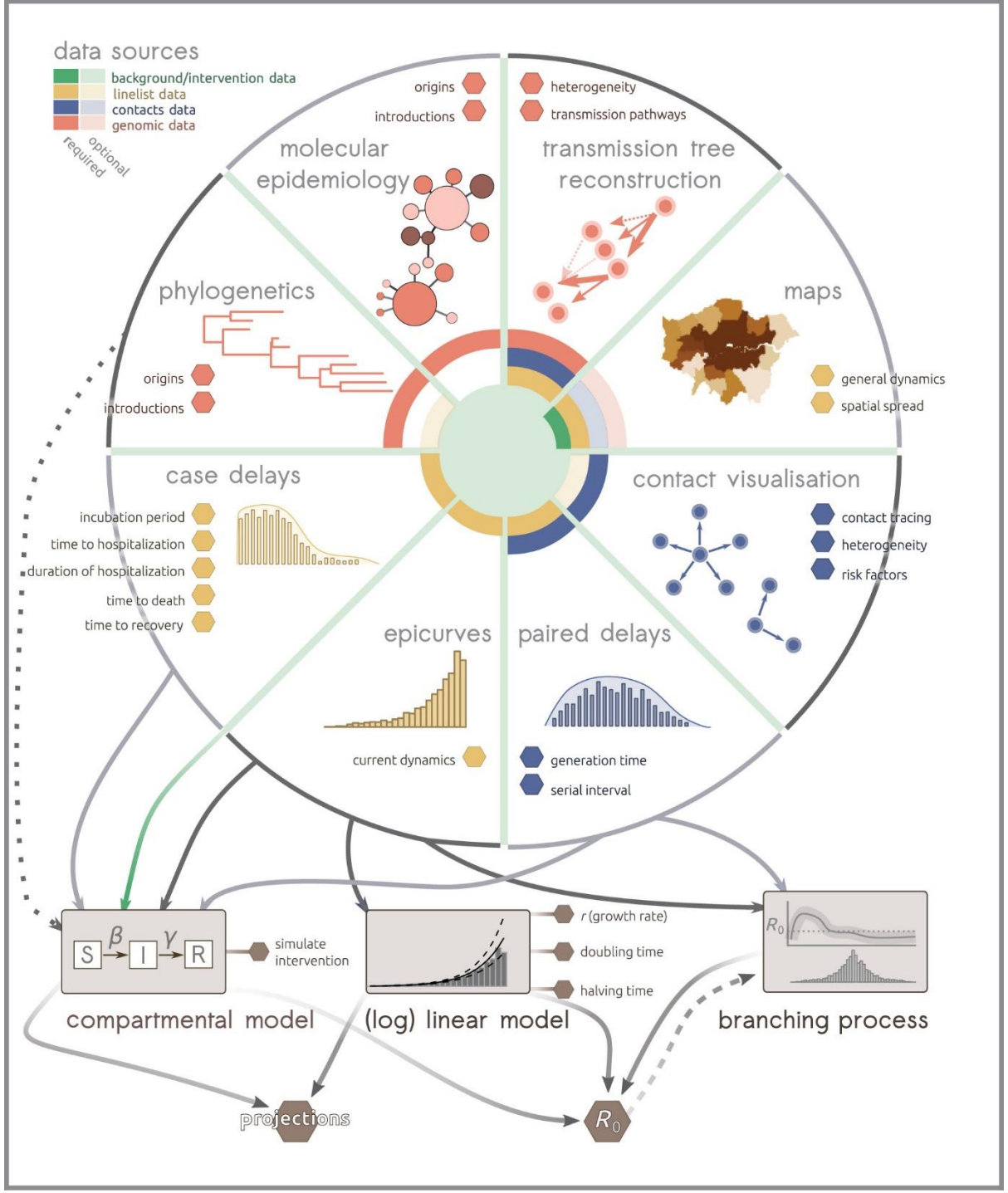
Transmission of SARS-CoV-2 from humans to animals and potential host adaptation

Cedric C. S. Tan[1,2✉], Su Datt Lam[3,4], Damien Richard[1,5], Christopher J. Owen[1], Dorothea Berchtold[1], Christine Orengo[4], Meera Surendran Nair[6,7], Suresh V. Kuchipudi[6,7], Vivek Kapur[7,8], Lucy van Dorp[1,9] & François Balloux[1,9]

Multiple emergence and onward transmission in animals
From Tan et al 2022 *Nat Comms*



Example of outbreak analytics workflow incorporating surveillance, diagnostics, modelling, genomics and contact tracing



Source: Outbreak analytics: a developing data science for informing the response to emerging pathogens, Volume: 374, Issue: 1776, DOI: (10.1098/rstb.2018.0276)

Te Niwha

Vaccines

- Equitable access
- Community-led initiatives
- Case for local production?
  - **Reduces the dependence on international supply**
  - More likely to be included in a **multinational, distributed manufacturing model**
  - If pandemic persists beyond 2-3 years, would have the potential to develop vaccines **tailored to the New Zealand population** (e.g. considering subpopulations with higher prevalence of adverse reactions to globally-available vaccines).
  - Enhance our ability to develop and deliver **vaccines for domestic animals and wildlife**. This could be useful for zoonotic diseases (e.g. H5N1 vaccination of poultry).

Communication – misinformation and disinformation

Source New York times

Te Niwha

SARS and misinformation

2 WORLD NEWS THE TIMES SATURDAY MAY 10 2003

Fearful Chinese slaughter pets in Sars hysteria

One Health – existential pandemic threats

Photo: Owen Humphreys/PA Images via Getty Images

Te Niwha

The next pandemic – influenza A (HPAI)?

- **WHO**: **"In 2023, Europe has been experiencing a large epidemic of A(H5N1) viruses in birds, with outbreaks reported in domestic birds, wild birds, and mammals across 24 countries. Outbreaks in wild and domestic birds continue to be reported through May 2023."**

Te Niwha

How should we prepare?

- Strategy? Control measures?
- Surveillance, humans, wildlife, livestock
- Vaccination?
- MoH, MPI, DOC, MFaT – All of Government response
- Mobilise veterinary workforce
- Health and safety of workers
- Taonga and endangered species?
- Culling of livestock
- Impact on farming and food production

H5N1 has spread among poultry and wild birds for 25 years, Director-General Tedros Adhanom Ghebreyesus told reporters in a virtual briefing, but the recent reports of infections in mink, otters and sealions "need to be monitored closely".

Te Niwha

Highly impacted populations

Transmission

- Health workers, border workers, frontline…
- Domestic animal workers(vets, vet nurses, extension workers, farmers)
- Wildlife (DoC staff, wildlife vets, community groups)

Welfare and economic impacts

- Farming community, rural communities
- Trade
- Food consumers

Te Niwha

Pandemic response

Impact assessment, strategy development and control measures

- Highly dynamic
  - **Goal** and **principles** remain consistent
  - **Strategy** may shift as circumstances change **Control measures** may change rapidly as epidemiological situation changes, new interventions become available etc.

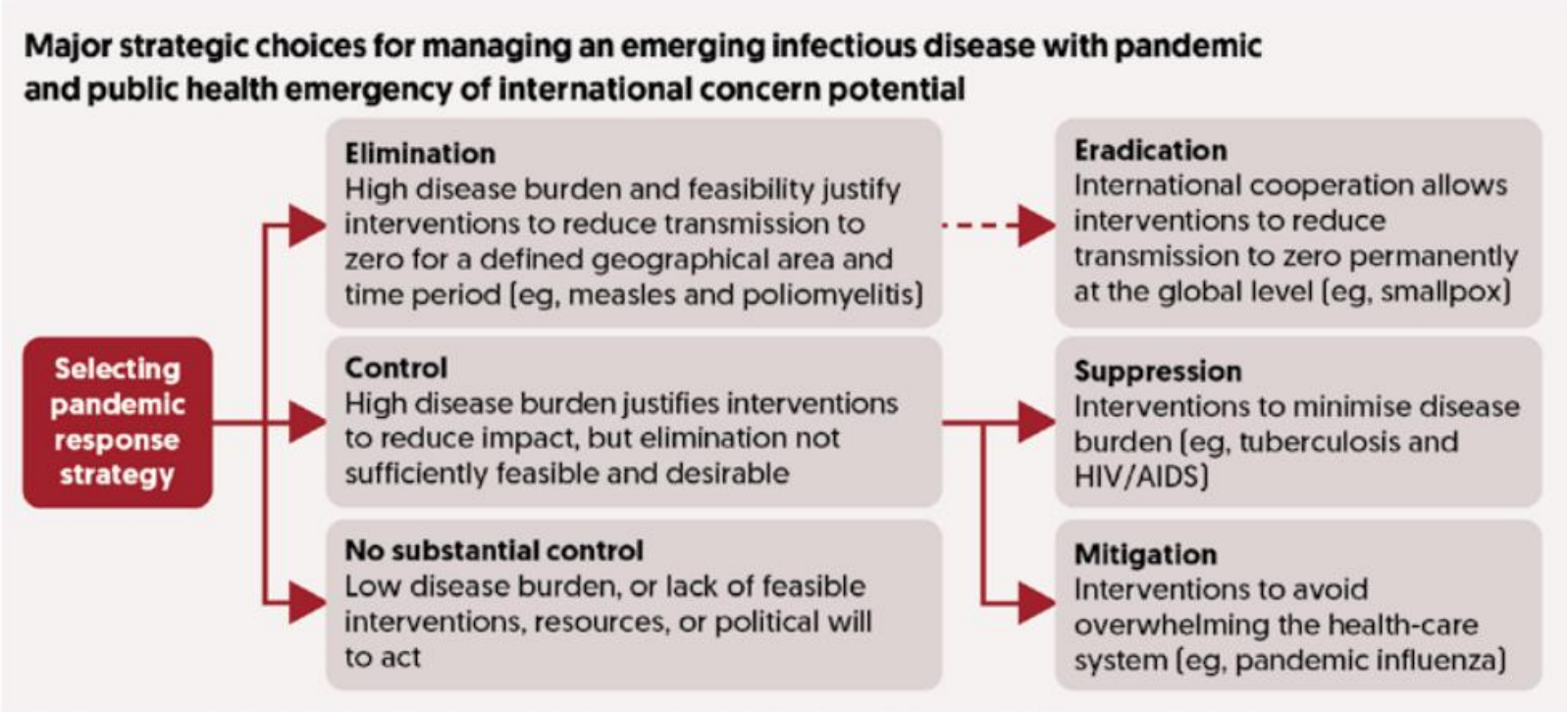


Figure 13. Pandemic response strategic choices. Source: Baker 2023 [81].

Preparing for pandemic zoonoses

- “The approach requires the active collaboration between fields of expertise that do not typically collaborate. Expertise in human, animal, and ecosystems health is required, but equally important is the input from social scientists, experts in land-use and agricultural systems, virologists, epidemiologists, climate change experts, anthropologists, economists and agronomists, and decision makers from civil society.”
- Need for simulation exercises.

Acknowledgements

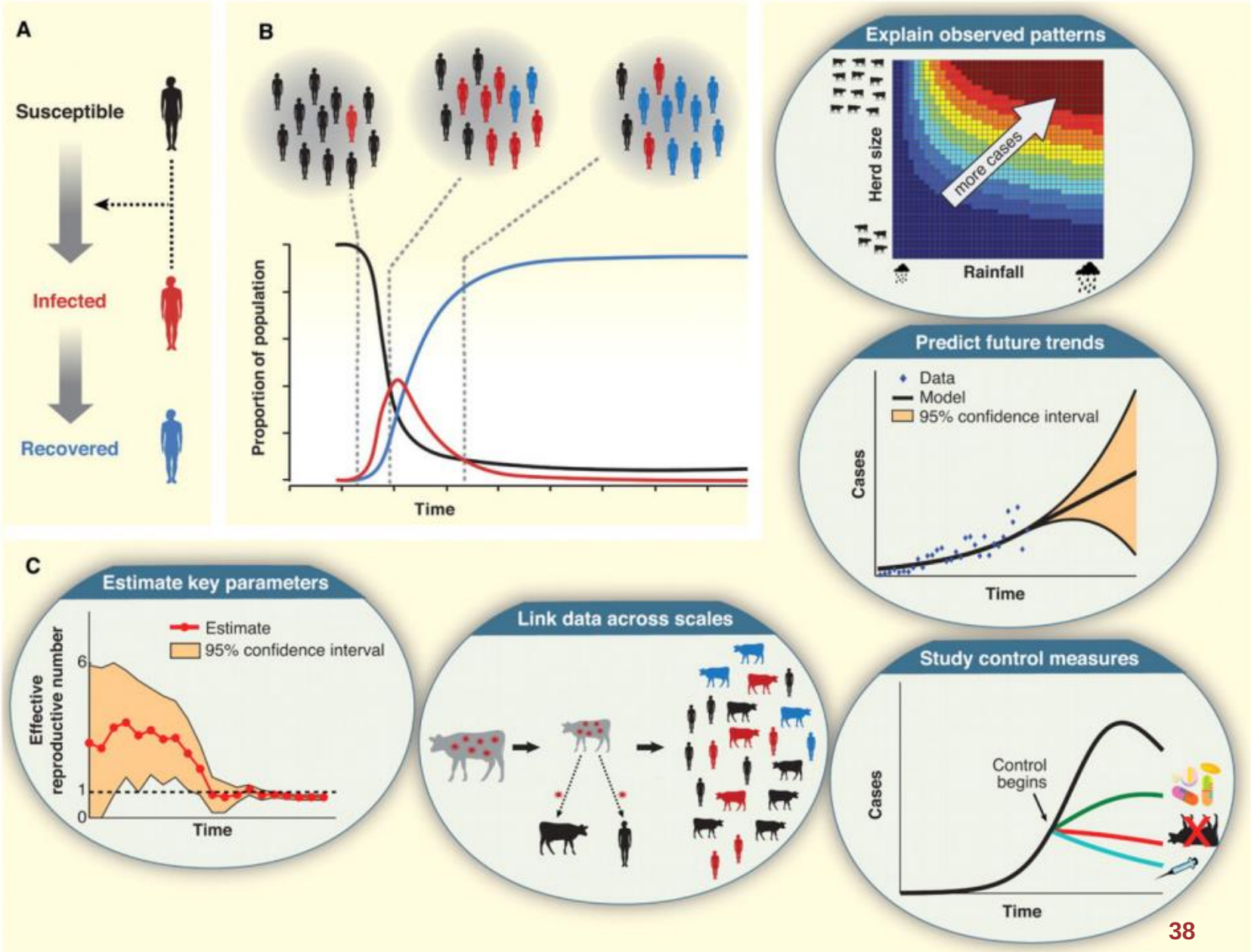
- **Dr Fiona Callaghan** (Chief Science Advisor Epidemiology, Te Pou Hauora Tūmatanui - Public Health Agency)
- **Dr Kristin Dyet** (Senior Scientist, Antimicrobial Reference Laboratory, ESR)
- **Professor Jemma Geoghegan** (Professor of Virology, University of Otago/ESR)
- **Professor David Hayman** (Professor of Infectious Disease Ecology, Massey University)
- **Professor Sue Huang** (Director, WHO National Influenza Centre, ESR)
- **Associate Professor Amanda Kvalsvig** PhD MRCPCH (Research Associate Professor, Public Health, University of Otago)
- **Dr Howard Maxwell** PhD candidate (Scientific Officer for Māori Health Advancement, University of Otago)
- **Professor Michael Plank** PhD FNZMS (Professor of Applied Mathematics, University of Canterbury)
- **Dr Pippa Scott** PhD (Principal Advisor, Te Pou Hauora Tūmatanui - Public Health Agency)
- **Professor Michael Baker** MBChB, FNZCPHM, FAFPHM, FRACMA, DComH, DObst (University of Otago)
- **Te Pora Thompson** (Director, Te Niwha)
- **Dr Euan Russell** PhD (Senior Advisor, Te Pou Hauora Tūmatanui - Public Health Agency)

Executive summary and report

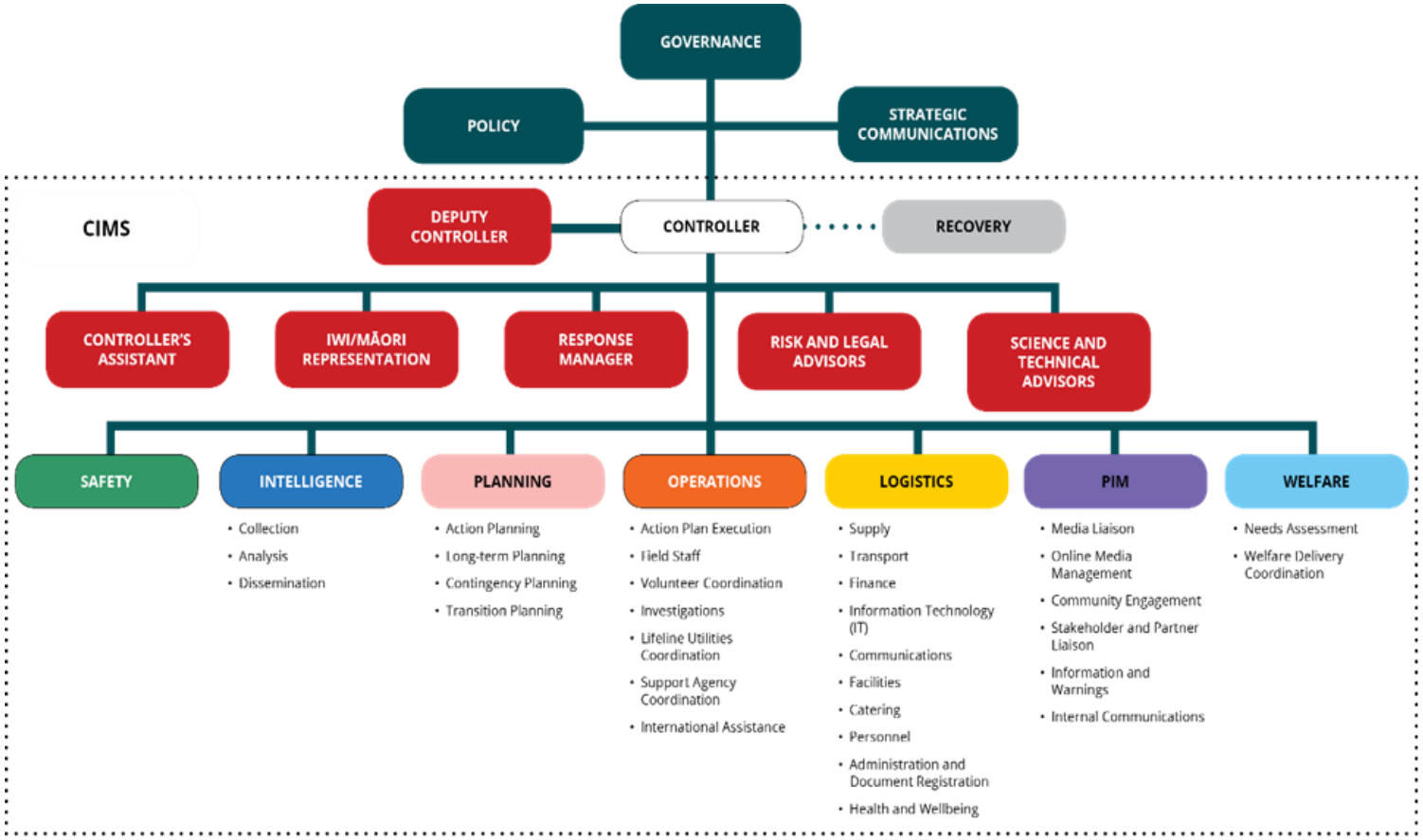
https://teniwha.com/

Te Niwha

Lloyd-Smith, J. O. et al. Epidemic dynamics at the human-animal interface. *Science* **326**, 1362–1367 (2009).



Leadership and decision making



Te Niwha