Globalisation of One Health and Emerging Infectious Diseases

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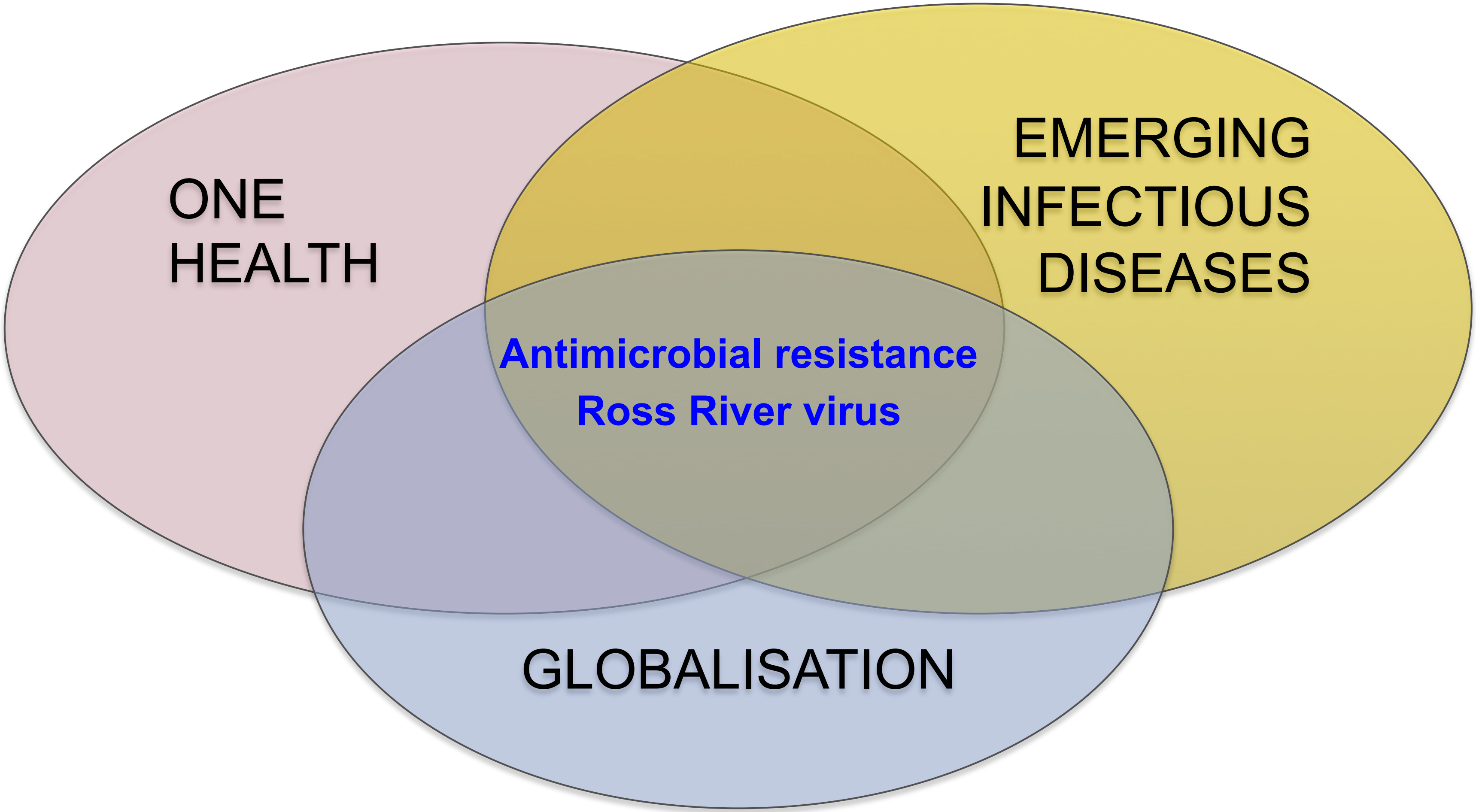
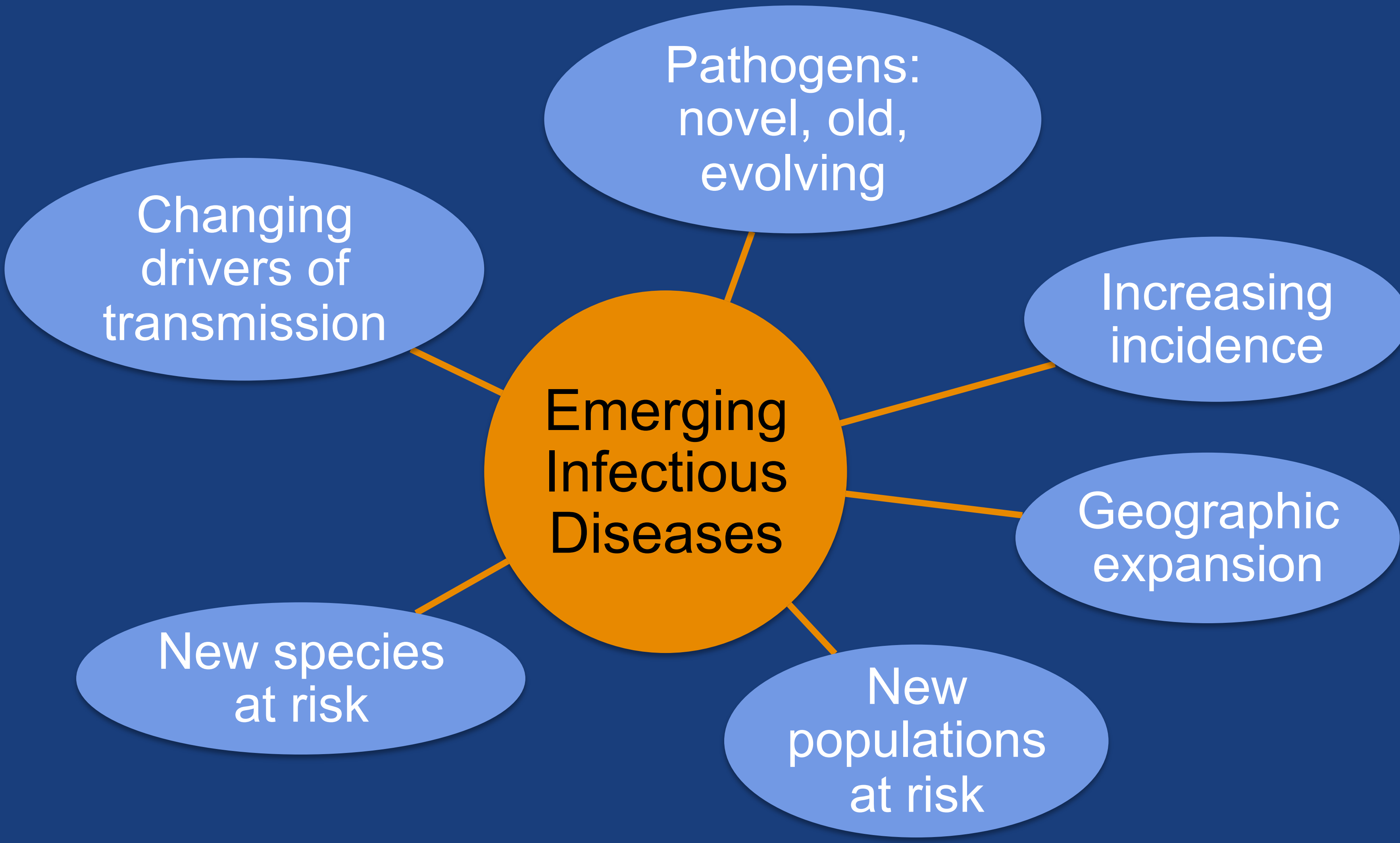
Department of Global Health,
Research School of Population Health,
The Australian National University

4th One Health Aoteoroa Symposium, Wellington, Dec 2018

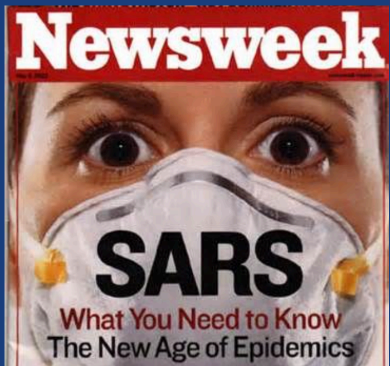
Outline

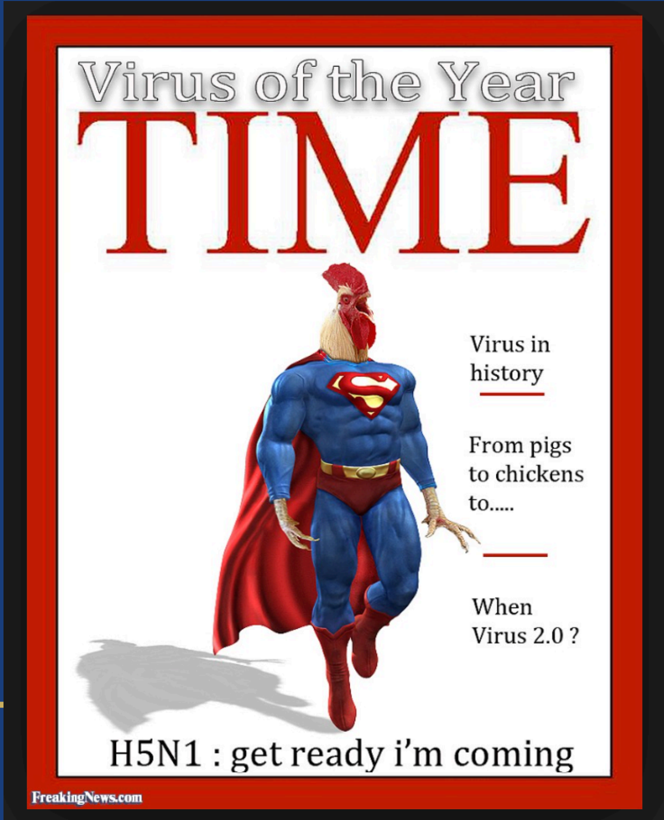

ONE HEALTH
EMERGING INFECTIOUS DISEASES
Antimicrobial resistance
Ross River virus
GLOBALISATION

Emerging Infectious Diseases (EIDs) include…



Examples of dramatic outbreaks of EIDs

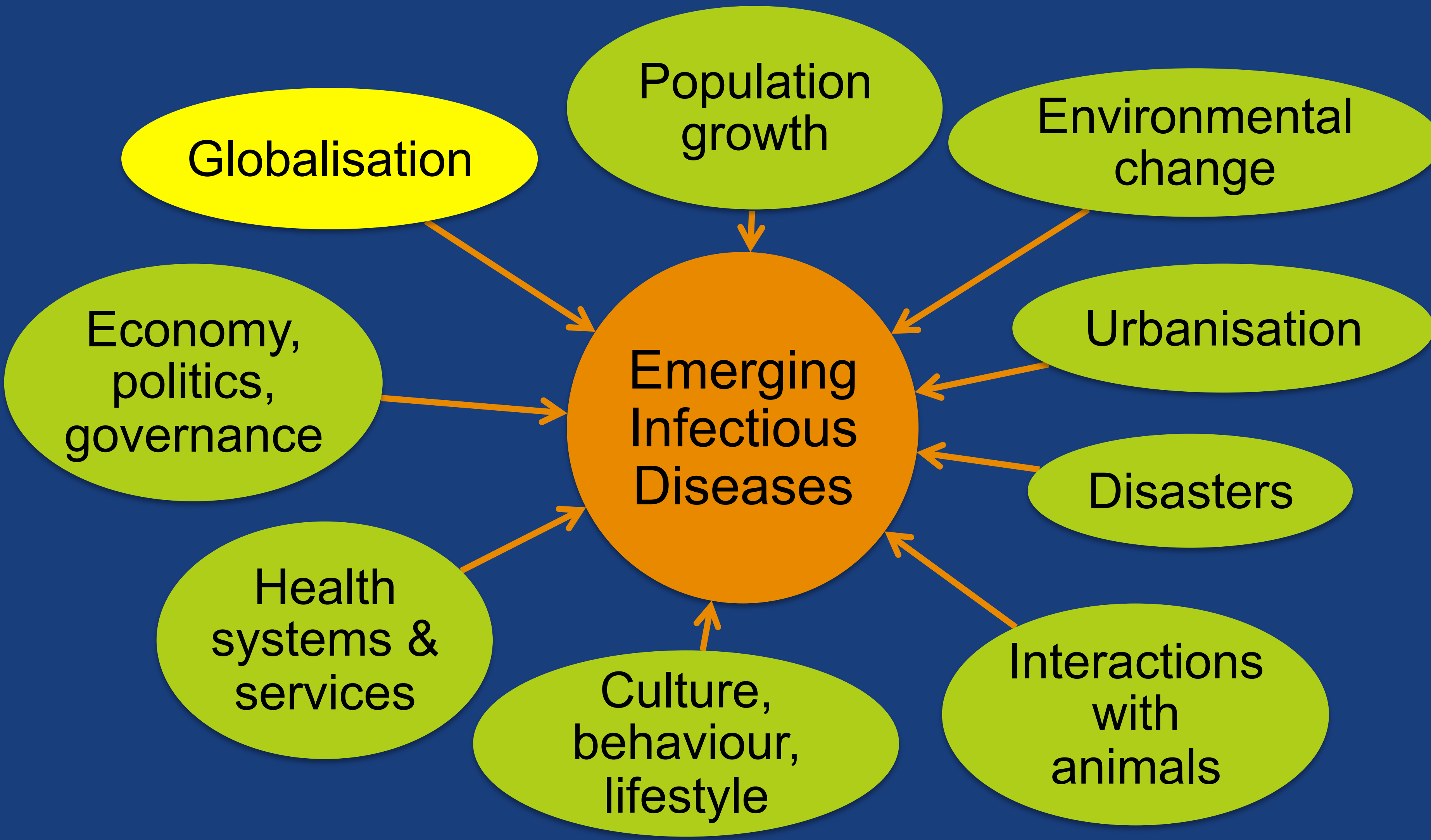




Zoonoses account for >60% of EIDs

Jones KE, Patel NG, Levy MA, Storeygard A, Balk D, Gittleman JL, et al. Global trends in emerging infectious diseases. Nature 2008;451(7181):990-3.

Human activities are the major drivers of EIDs



Globalisation

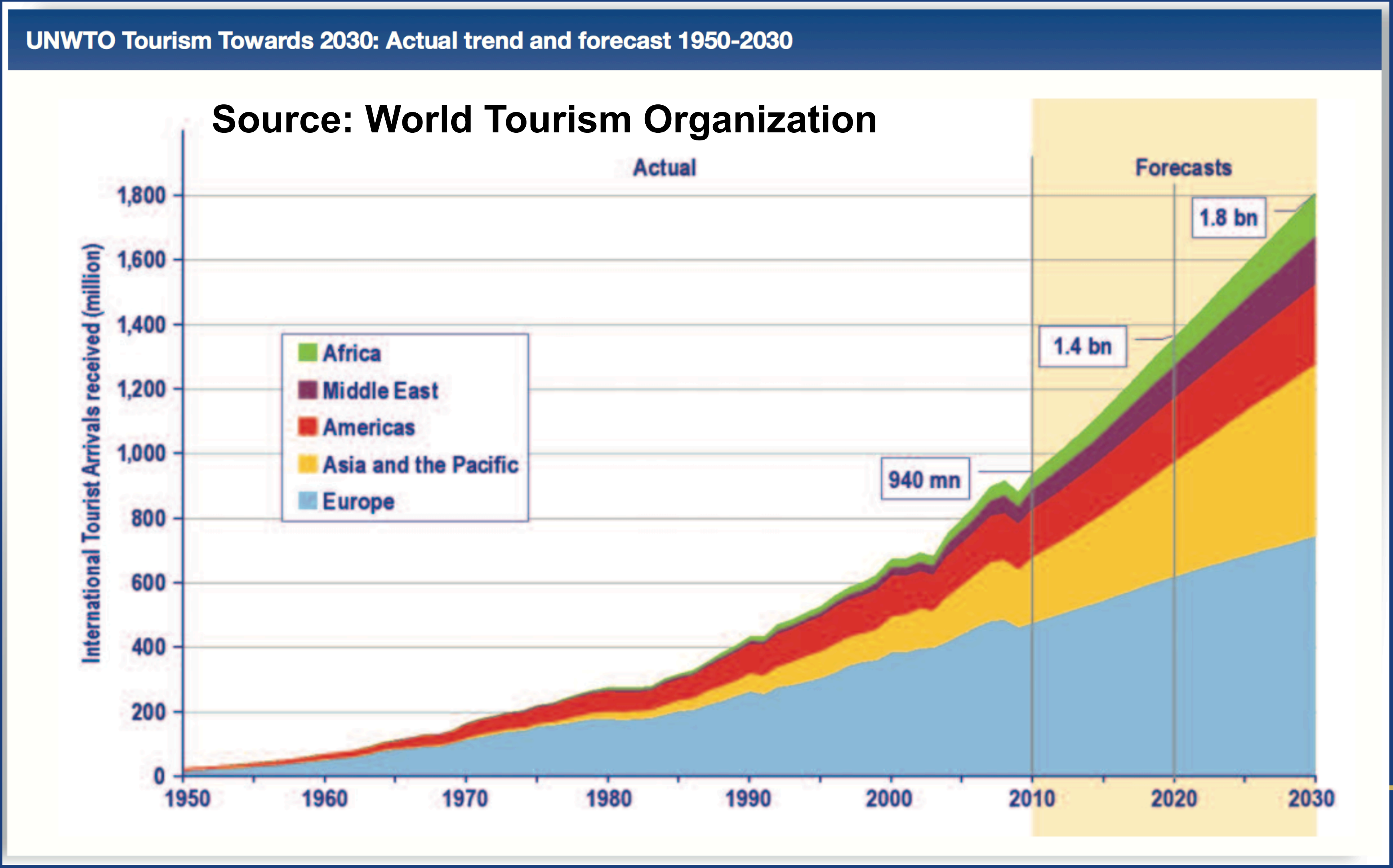
- Increased global interconnectedness of people, governments, and economies
- Enabled by advances in transportation and communication
- Unprecedented growth in international flow of people, animals, vectors, pathogens, food, ideas, knowledge, information, technologies, culture, ……
- Unprecedented volume, speed, and reach

↓

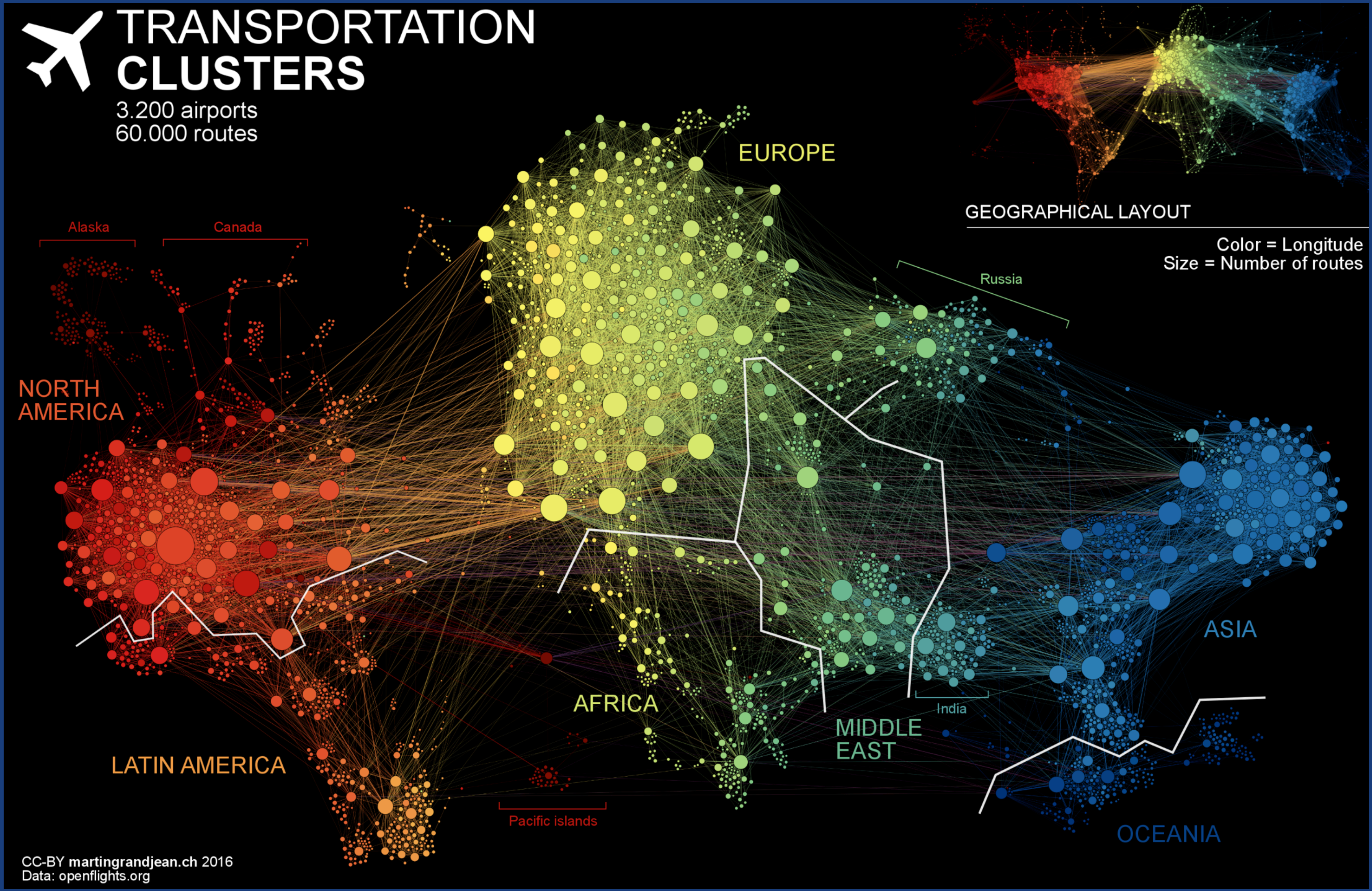
- One Health interactions can have global-scale influences
- Need to expand our thinking from local to global

Global Travel – Unprecedented Volumes

- In 2016, 1.5 billion international tourism departures



Global Travel – Unprecedented Reach & Speed

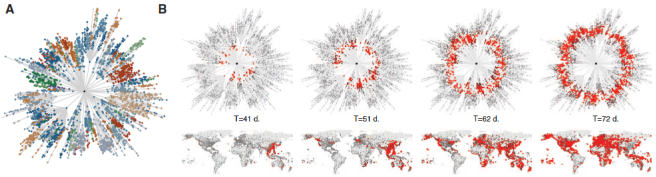


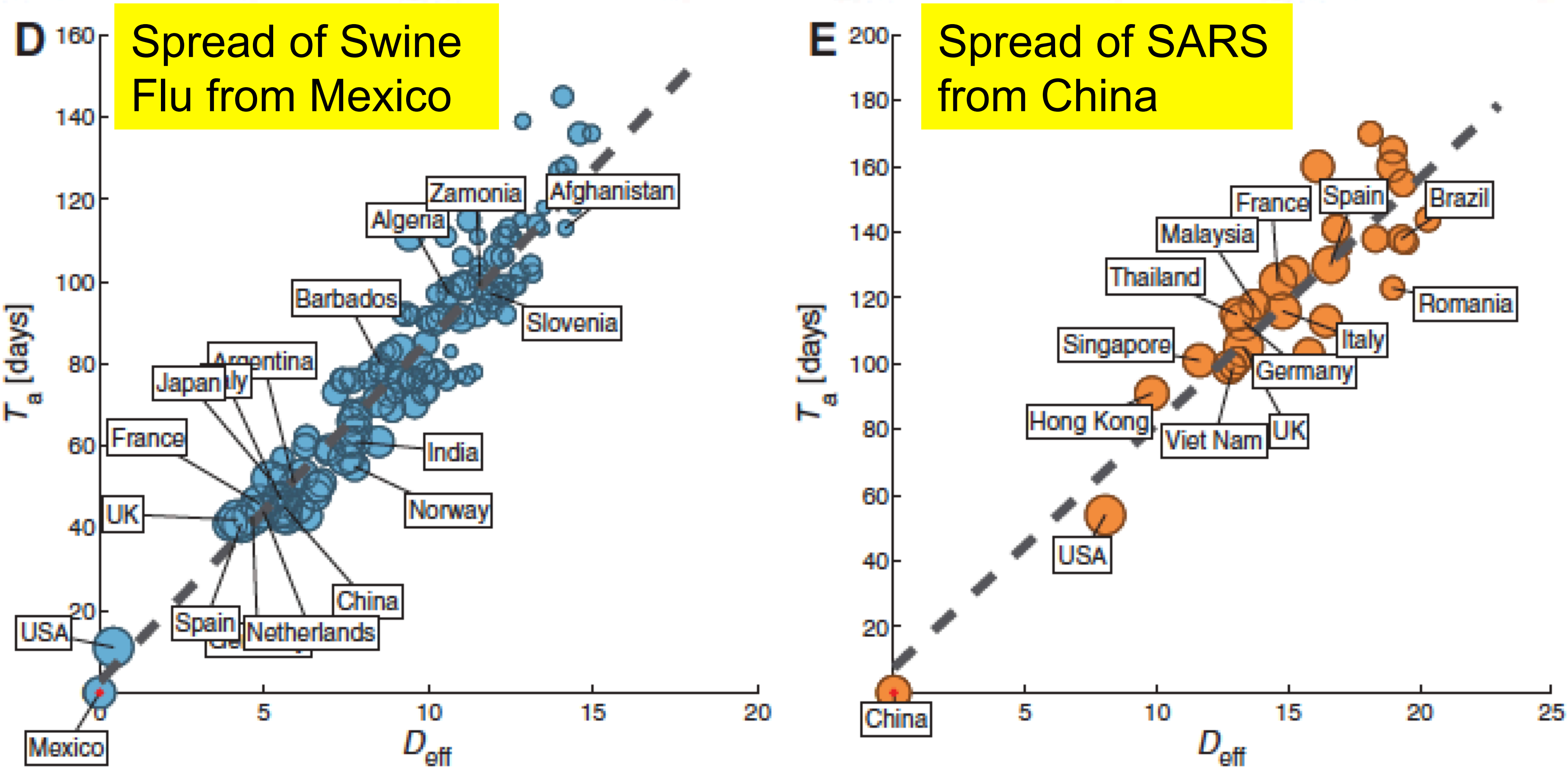
Source: www.visualcapitalist.com

Effective distance vs time to arrival of EID

Science AAAS

The Hidden Geometry of Complex, Network-Driven Contagion Phenomena
Dirk Brockmann and Dirk Helbing
Science **342**, 1337 (2013);
DOI: 10.1126/science.1245200





Effective distance vs time to arrival of EID

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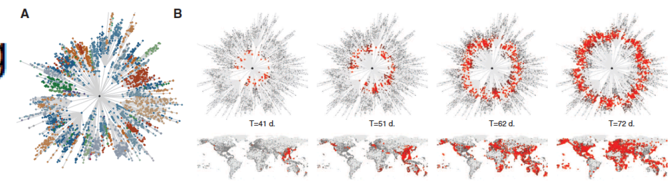
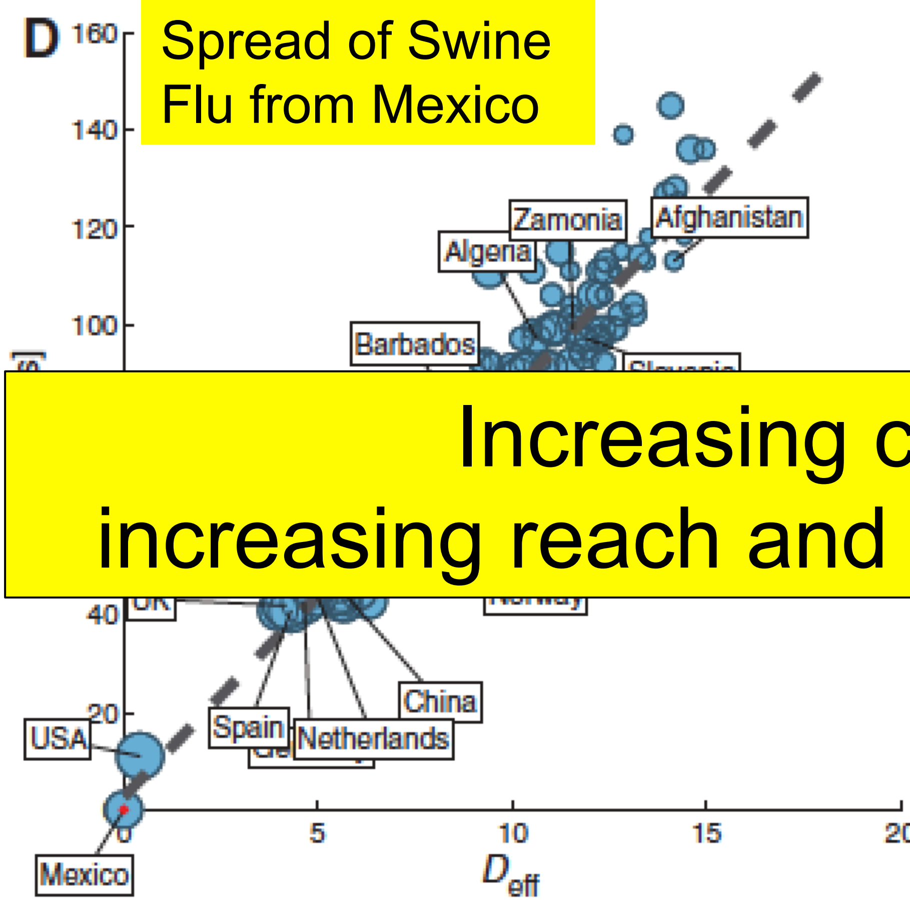
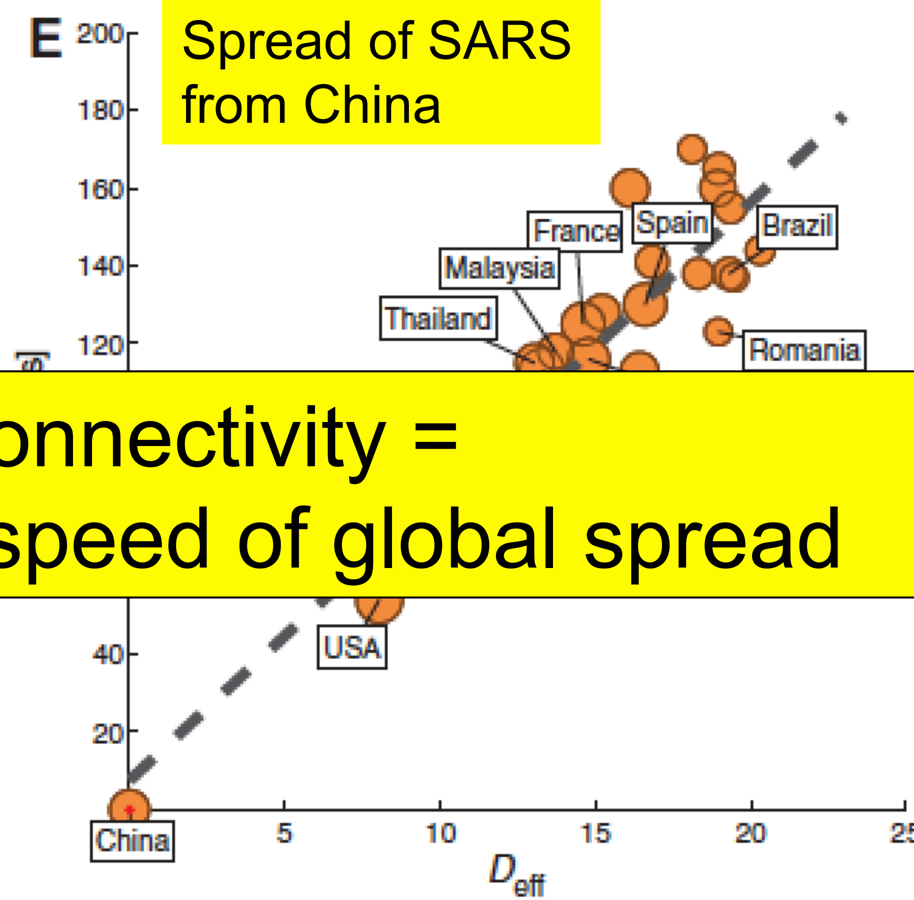


Spread of Swine Flu from Mexico



Spread of SARS from China



Increasing connectivity =
increasing reach and speed of global spread

Links between Travellers & EIDs

- As victims –
  - Travellers at risk infection if travelling to high-risk destinations
- As carriers and transmitters –
  - Major role in global dissemination of pathogens
  - Change in global distribution of diseases
  - Seed virgin soil outbreaks
- As sentinels –
  - Provide signals of disease epidemiology at travel destinations
  - Provide early warning of emergence/outbreaks
- Sometimes as all three

ANTIMICROBIAL RESISTANCE

Antimicrobial Resistance

A One Health Problem

Role of travellers in global spread of AMR

Current Infectious Disease Reports (2018) 20: 29
https://doi.org/10.1007/s11908-018-0634-9

TROPICAL, TRAVEL, AND EMERGING INFECTIONS (L CHEN AND A BOGGILD, SECTION EDITORS)

Travel and the Spread of Drug-Resistant Bacteria

Kevin L. Schwartz[1,2,3] · Shaun K. Morris[2,4,5]

Journal of TRAVEL MEDICINE

EDITORIAL

Multidrug-Resistant Bacteria Without Borders: Role of International Trips in the Spread of Multidrug-Resistant Bacteria

Jordi Vila MD, PhD*†

Médecine et maladies infectieuses 48 (2018) 431–441

General review

Travel and acquisition of multidrug-resistant Enterobacteriaceae

Voyages et acquisition d'entérobactéries multirésistantes

L. Armand-Lefèvre[a,b,*], A. Andremont[a,b], E. Ruppé[a,b]

Role of travellers in global spread of AMR

Finland:

Antimicrobials Increase Travelers' Risk of Colonization by Extended-Spectrum Betalactamase-Producing *Enterobacteriaceae*

CID 2015

Anu Kantele,[1,2,3,4] Tinja Lääveri,[1,2] Sointu Mero,[5] Katri Vilkman,[2,3] Sari H. Pakkanen,[3] Jukka Ollgren,[6] Jenni Antikainen,[5] and Juha Kirveskari[5]

USA:

Antimicrobial resistance acquisition after international travel in U.S. travelers

Dana M. Blyth[1*], Katrin Mende[1,2,3], Ashley M. Maranich[4], Miriam L. Beckius[1], Kristie A. Harnisch[1], Crystal A. Rosemann[1], Wendy C. Zera[1,2,3], Clinton K. Murray[1] and Kevin S. Akers[1,5]

Australia:

Eur J Clin Microbiol Infect Dis (2010) 29:1501–1506
DOI 10.1007/s10096-010-1031-y

ARTICLE

Colonisation with *Escherichia coli* resistant to "critically important" antibiotics: a high risk for international travellers

K. Kennedy · P. Collignon

THE LANCET
Infectious Diseases

Log in

ARTICLES | VOLUME 17, ISSUE 1, P78-85, JANUARY 01, 2017

Import and spread of extended-spectrum β-lactamase-producing Enterobacteriaceae by international travellers (COMBAT study): a prospective, multicentre cohort study

Maris S Arcilla, MD † • Jarne M van Hattem, MD † • Manon R Haverkate, PhD • Martin C J Bootsma, PhD • Perry J J van Genderen, PhD • Abraham Goorhuis, PhD • et al. Show all authors • Show footnotes

Published: October 14, 2016 • DOI: https://doi.org/10.1016/S1473-3099(16)30319-X • Check for updates

Netherlands ~2000 travellers

- Overall: 34.3% colonised
- Travel to South Asia: 75.1% colonised
- Risk factors
  - Used antibiotics during travel: Odds ratio 2.69
  - Traveller's diarrhoea: Odds ratio 2.31
  - Pre-existing chronic bowel disease: Odds ratio 2.10
- Probability of transmission to household member 12%

Acquisition rates of MRE by region of travel

L. Armand-Lefèvre et al. / Médecine et maladies infectieuses 48 (2018) 431–441

Systematic Review

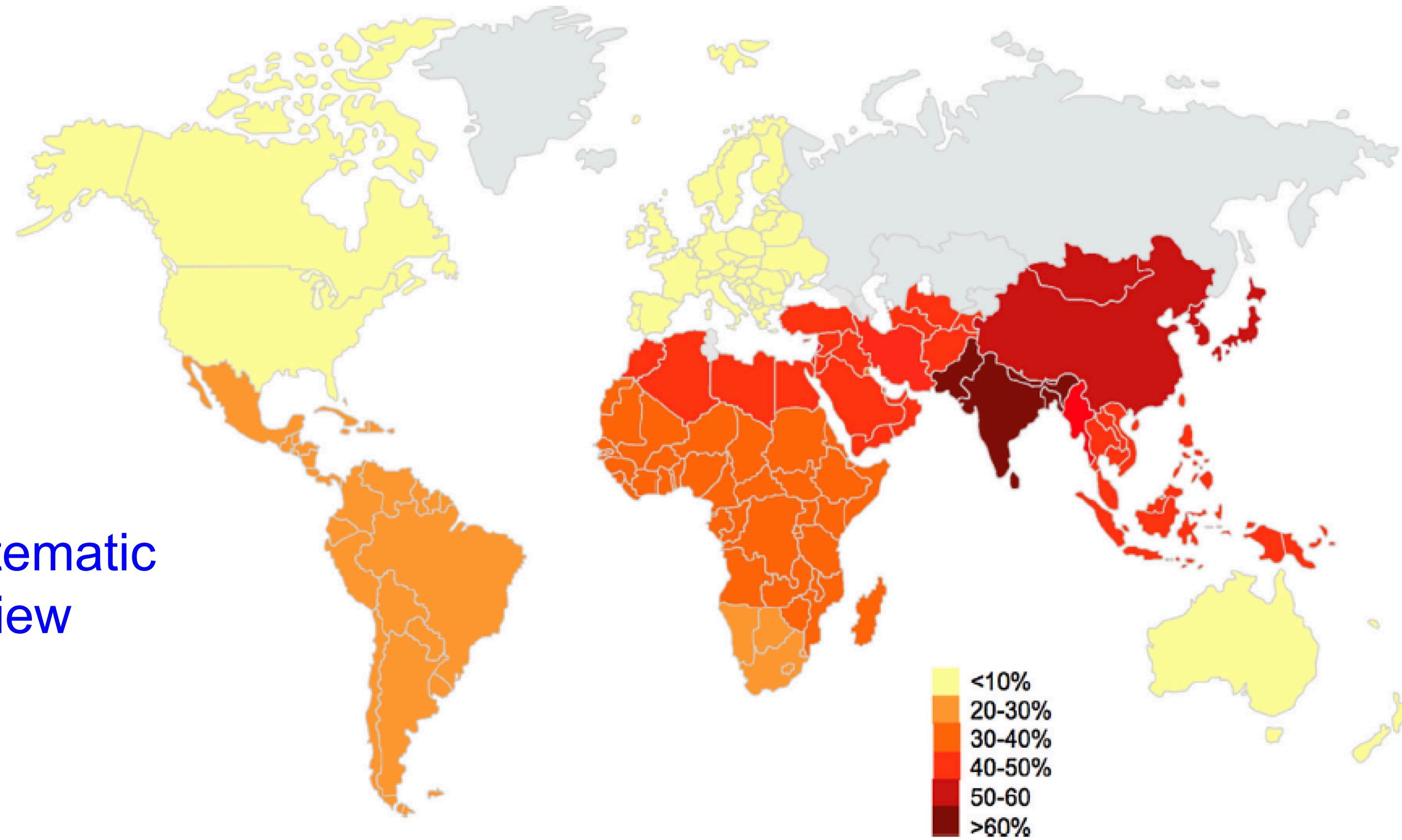


Fig. 1. Acquisition rates of multidrug-resistant Enterobacteriaceae (MRE) depending on the destination of travel (based on the most recent and important studies).
Taux d'acquisitions d'entérobactéries multi-résistantes (EMR) en fonction des régions de voyage (fondé sur les études les plus récentes et présentant le plus grand nombre de patients inclus).

Armand-Lefevre et al. Travel and acquisition of multi-drug resistant Enterobacteriaceae. Medecine et maladies infectieuses 2018.

Duration of colonisation post-travel

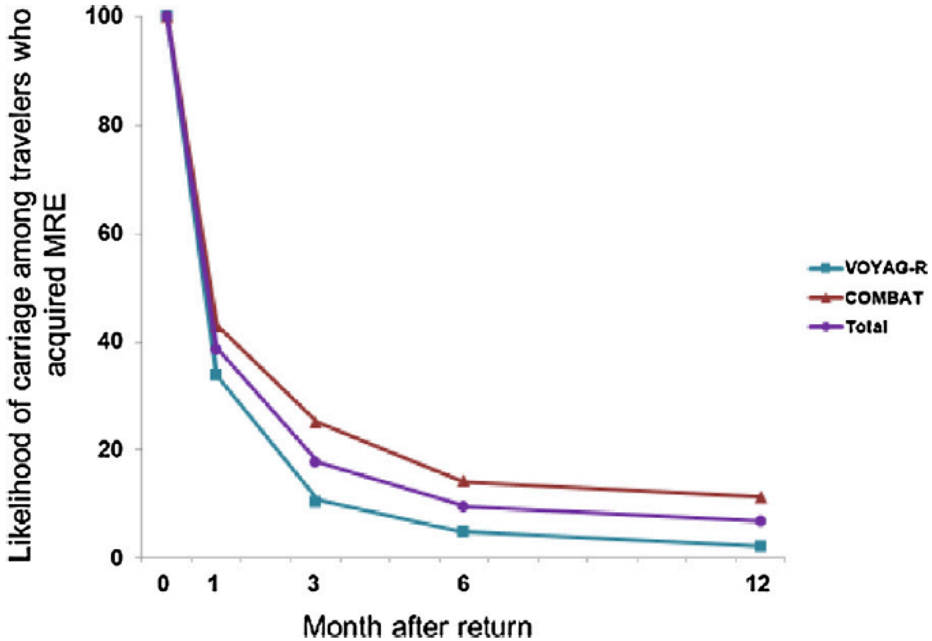


Fig. 3. Dynamic of clearance of intestinal carriage of multidrug-resistant Enterobacteriaceae (MRE) after traveling abroad [30,32].

COMBAT study (Achilla et al)

- Median duration of colonisation 30 days
- 11.3% remained colonised at 12 months

Possible consequences of colonisation

- Infection in that individual:
  - Invasive infections, especially post-operative
  - Higher risk of treatment failure
  - Longer hospital stays, greater mortality
- Spread to household contacts
- Spread through hospitals
- Spread through environment

Journal of Travel Medicine
International Society of Travel Medicine
Promoting healthy travel worldwide
Established 1991
Journal of Travel Medicine, 2017, Vol 24, Suppl 1, S29–S34
doi: 10.1093/jtm/taw101
Review

Review

Travel-acquired ESBL-producing *Enterobacteriaceae*: impact of colonization at individual and community level

Paul-Louis Woerther, MD PhD[1], Antoine Andremont, MD PhD[2], and Anu Kantele, MD PhD[3,4,5,*]

Woerther et a. Travel-acquired ESBL-PE: impact of colonization at individual and community level. J Travel Med 2017.
Vila J. MDR bacteria without borders: role of international trips in the spread of MDR bacteria. J Travel Med 2018.
Schwartz & Morris. Travel and spread of drug-resistant bacteria. Current Infectious Disease Reports 2018.

Impact of medical tourism on spread of AMR?

Estimated >10 million people travel each year for medical care

Clinical Microbiology and Infection 23 (2017) 673.e1–673.e8

Contents lists available at ScienceDirect

Clinical Microbiology and Infection

journal homepage: www.clinicalmicrobiologyandinfection.com

ELSEVIER

Original article

Patients hospitalized abroad as importers of multiresistant bacteria—a cross-sectional study

T. Khawaja [1], J. Kirveskari [2], S. Johansson [3], J. Väisänen [3], A. Djupsjöbacka [3], A. Nevalainen [2], A. Kantele [1, 3, 4, *]

Risk factors for colonisation:

- Travel to tropics & subtropics (55% vs 17% in temperate zones)
- Destination: Highest in South Asia (77.6%)
- Surgical intervention
- Antibiotic use

% of studies focusing on drivers of AMR

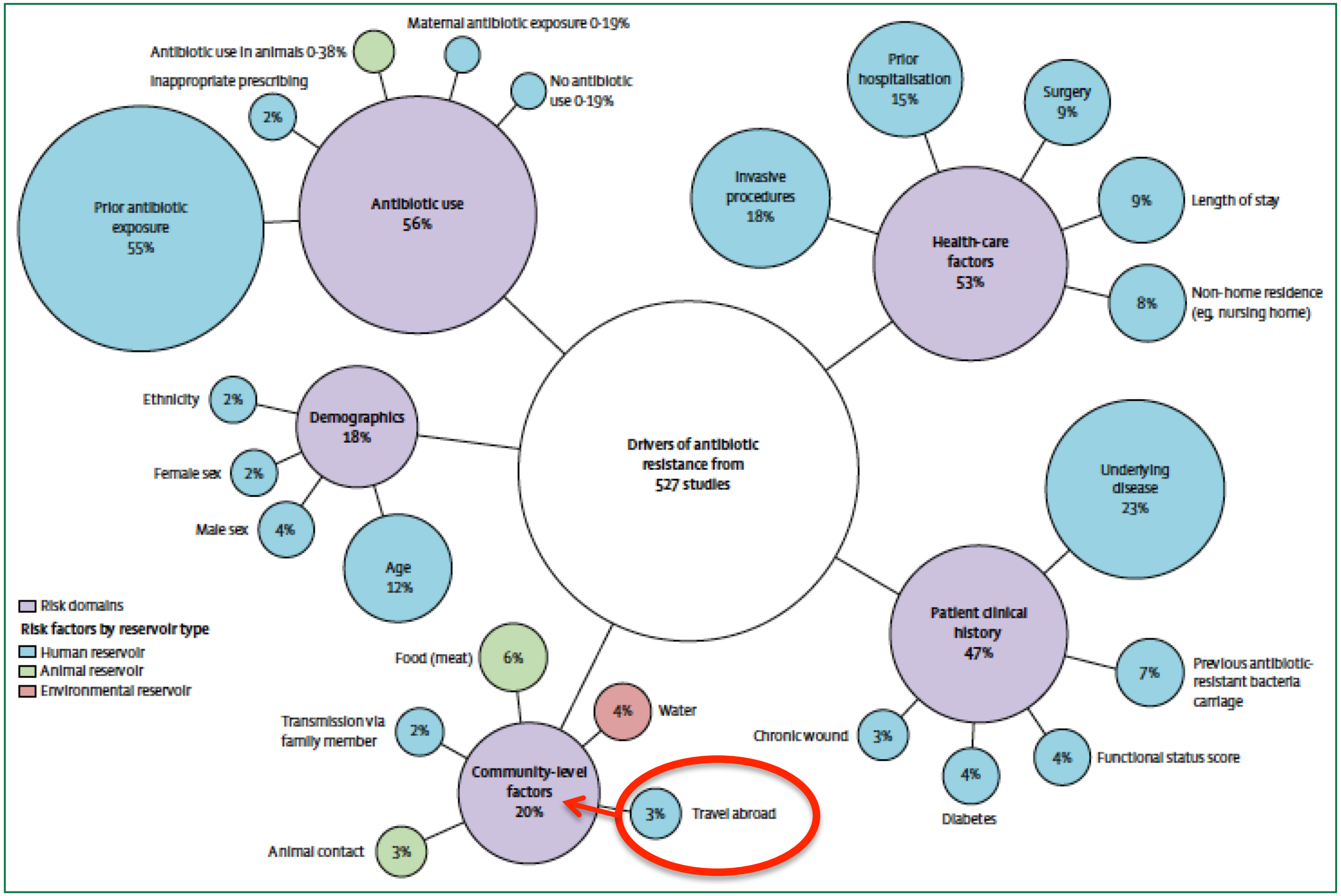
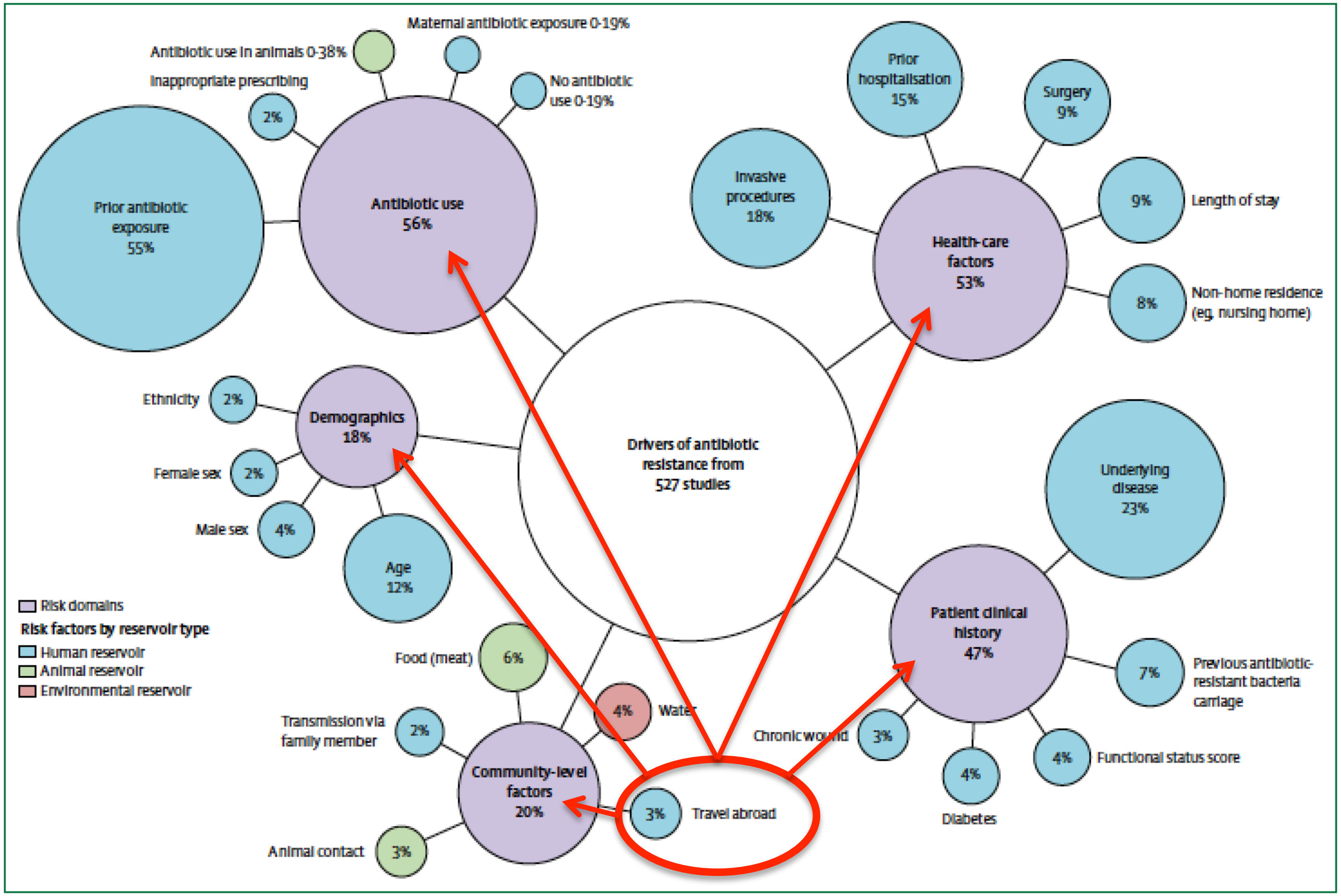


Figure 3: Percentage of studies quantifying drivers of antibiotic resistance in humans
Bubble size represents the percentage of studies out of the total number of primary studies (n=527) for both the risk domains and their individual risk factors. For ease of presentation and clarity, only the top five risk factors from the individual risk domains are shown; therefore, these percentages might not add up to the total risk domain percentage. Because a single study could report a variety of risk factors across all the domains, the domains include duplicate studies and thus these percentages add up to more than 100%. Distances between bubbles are arbitrary.

Chatterjee et al. Quantifying drivers of antibiotic resistance in humans: a systematic review. Lancet Infectious Diseases 2018

% of studies focusing on drivers of AMR



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Chatterjee et al. Quantifying drivers of antibiotic resistance in humans: a systematic review. Lancet Infectious Diseases 2018

SCIENTIFIC REPORTS

OPEN

Meta-genomic analysis of toilet waste from long distance flights; a step towards global surveillance of infectious diseases and antimicrobial resistance

Received: 17 December 2014
Accepted: 17 April 2015
Published: 10 July 2015

Thomas Nordahl Petersen[1], Simon Rasmussen[1], Henrik Hasman[2], Christian Carøe[1], Jacob Bælum[1], Anna Charlotte Schultz[2], Lasse Bergmark[2], Christina A. Svendsen[2], Ole Lund[1], Thomas Sicheritz-Pontén[1] & Frank M. Aarestrup[2]

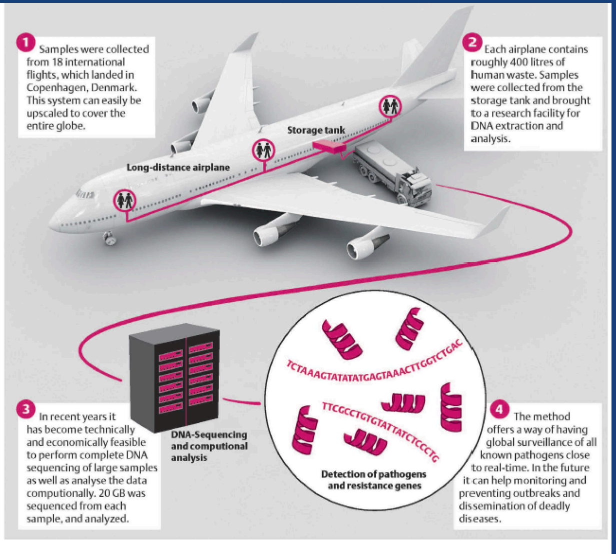
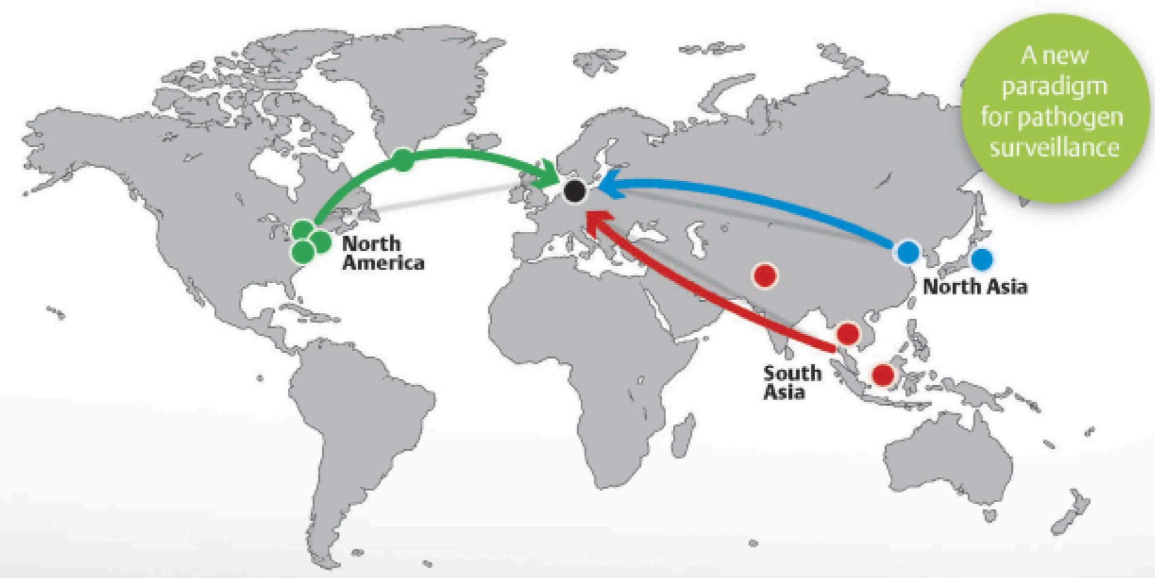


Figure 1. **Origin of the 18 long-distance flights with destination being the international airport in Copenhagen, Denmark, as well as the analytic procedure applied.** Figure created in Adobe Illustrator.



ONE SPOT GLOBAL RESISTANCE GENE AND PATHOGEN SURVEILLANCE

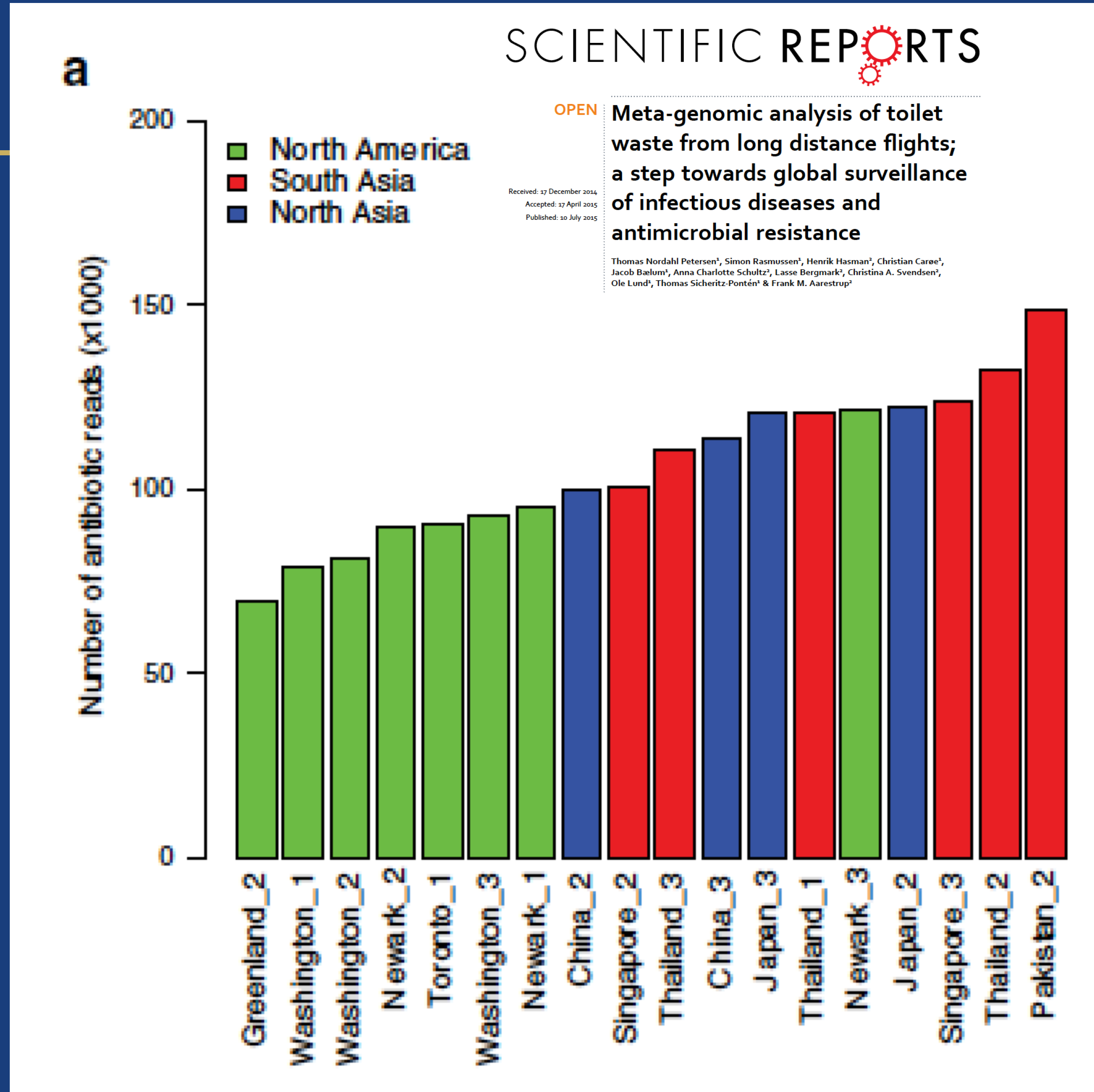
Human waste from long-distance airplanes is an attractive material for monitoring the occurrence, prevalence and dissemination of antibiotic resistance genes and pathogens.

Tested toilet waste from flights arriving at Copenhagen from:

- Beijing
- Tokyo
- Islamabad
- Bangkok
- Singapore
- New York
- Washington DC
- Toronto
- Greenland

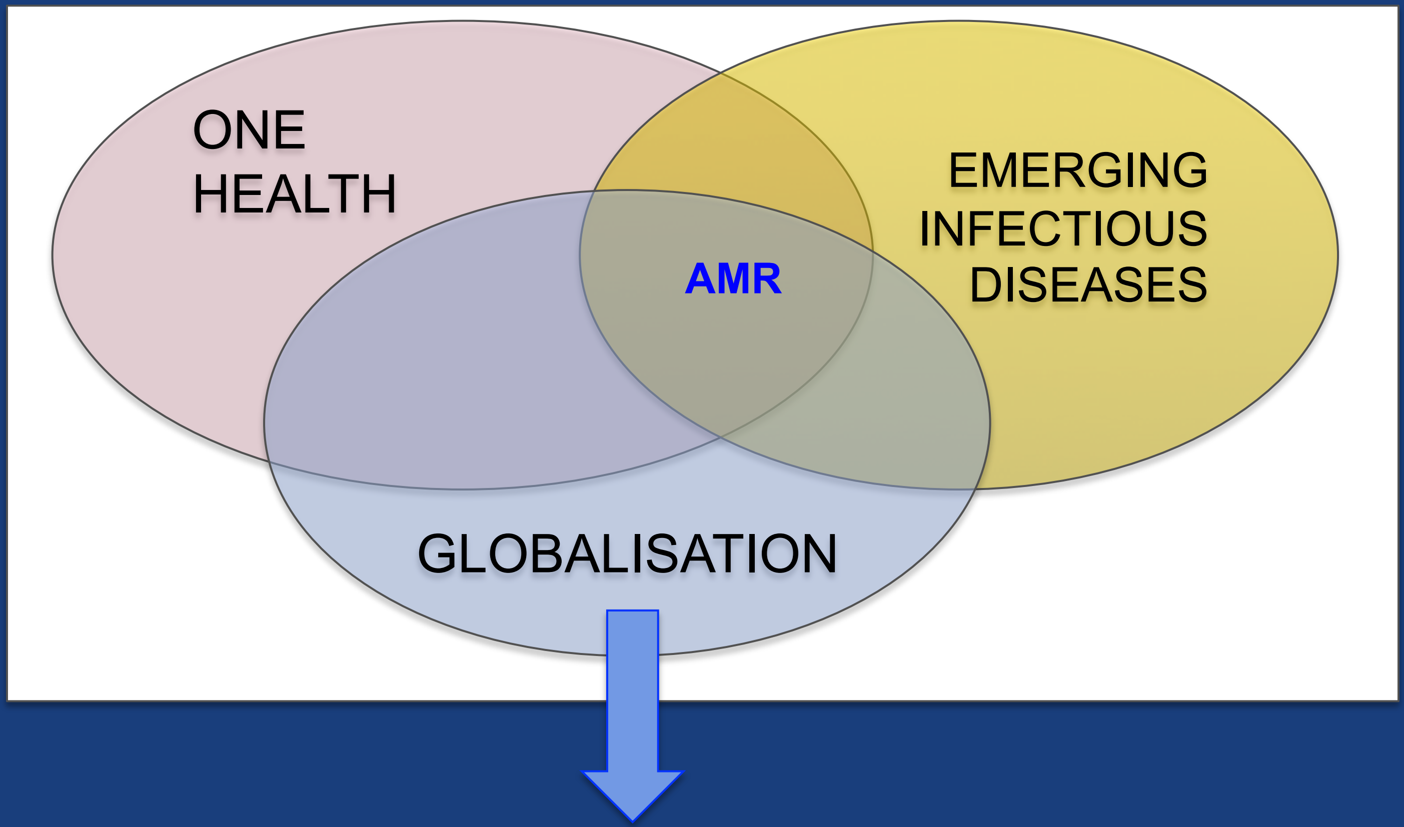
Antibiotic resistance genes detected

- Red = South Asia
- Blue = North Asia
- Green = North America, Europe



Antimicrobial Resistance

Australian National University



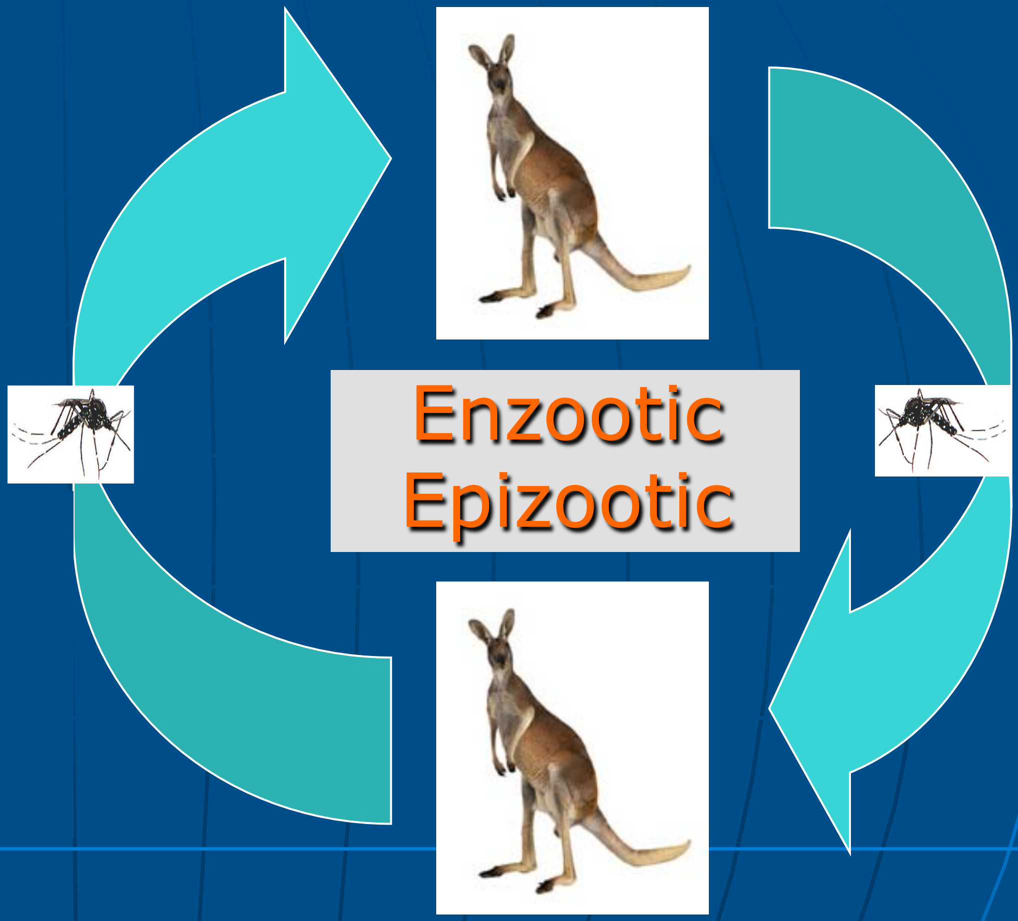
- Travellers as victims, carriers, transmitters, and sentinels
- MDR bacteria from around the world are silently invading our homes, communities, and environments

ROSS RIVER VIRUS

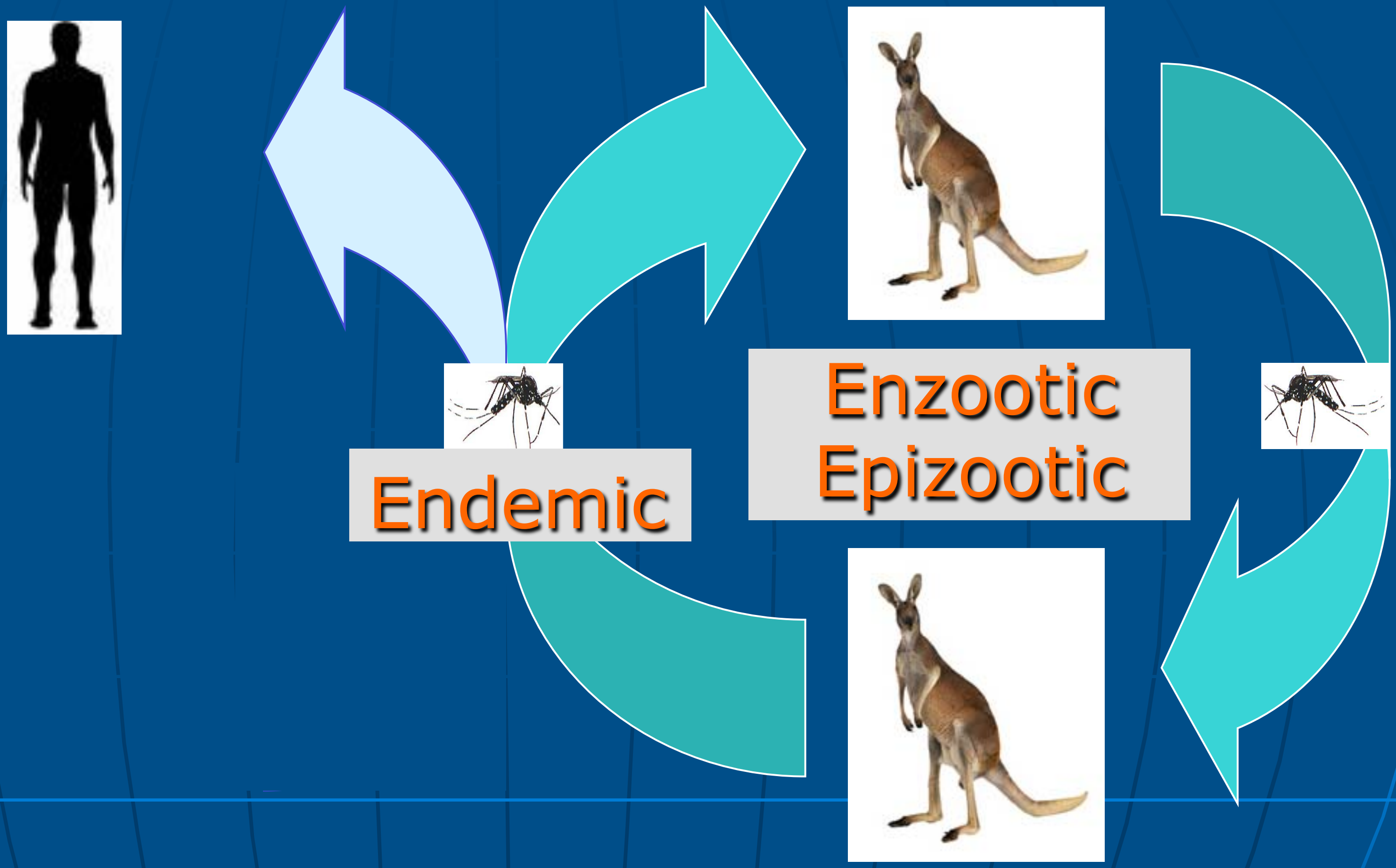
Ross River virus (RRV)

- Endemic in Australia and Papua New Guinea
- Primary reservoir hosts: kangaroos, wallabies
- Primary mosquito vectors: *Aedes* and *Culex*
  ~40 mosquito species implicated as potential vectors
- Common symptoms: painful swollen joints, fever, fatigue, rash
- 55-75% of cases are asymptomatic
- Can cause debilitating joint pain lasting for months
- Infection results in lifelong immunity
- Deaths are rare, but significant morbidity and economic costs

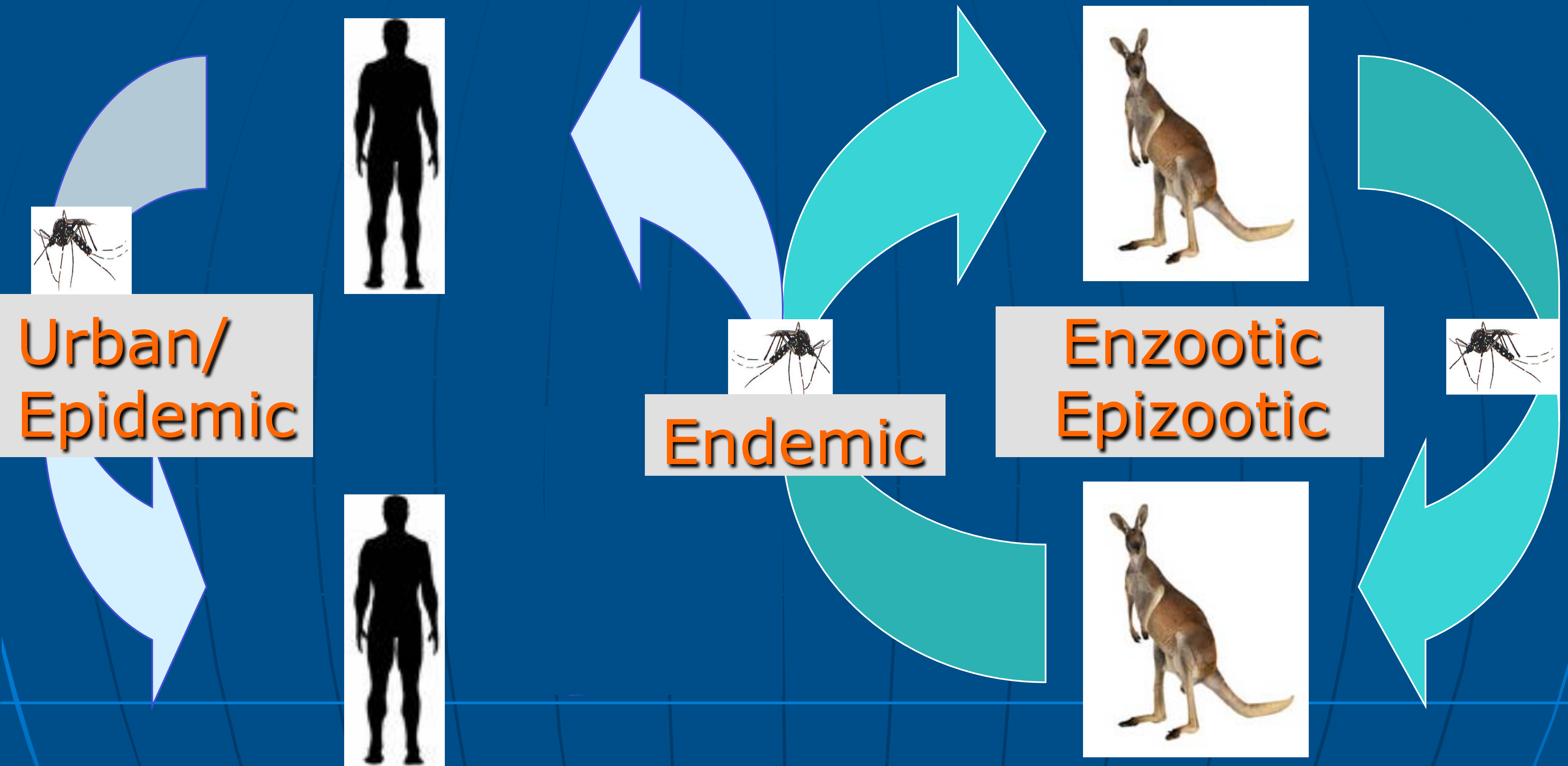
Pathways of Ross River virus infection



Pathways of Ross River virus infection

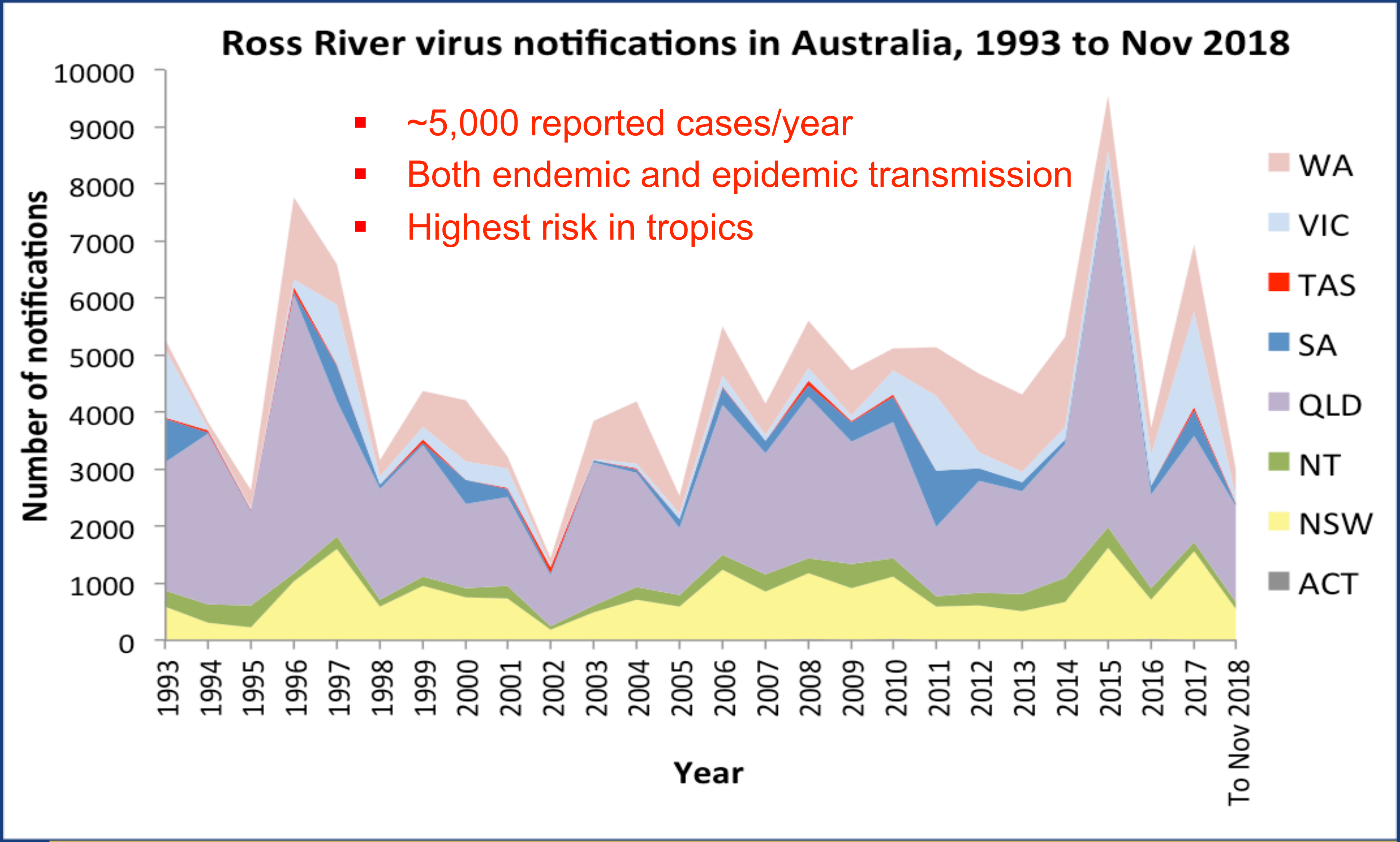


Pathways of Ross River virus infection



During epidemic transmission: non-marsupial animals can also act as short-term amplification hosts

Ross River Virus in Australia



National Notifiable Diseases Surveillance System, accessed 8 Dec, 2018

Ross River Virus – Pacific Islands

- Massive “virgin soil” epidemic in 1979/1980
  - Imported into Fiji by viraemic traveller from Australia
  - >500,000 reported cases
  - >90% of population in Fiji, 69% in Cook Islands, 44% in American Samoa, 33% in New Caledonia

Am. J. Trop. Med. Hyg., 30(5), 1981, pp. 1053–1059

AN EPIDEMIC OF ROSS RIVER VIRUS INFECTION IN FIJI, 1979

J. G. AASKOV, J. U. MATAIKA, G. W. LAWRENCE, V. RABUKAWAQA, M. M. TUCKER, J. A. R. MILES, AND D. A. DALGLISH
Queensland Institute of Medical Research, Bramston Terrace, Herston, Brisbane, Australia 4006, and Wellcome Virus Laboratory, Suva, Fiji

Am J Trop Med Hyg. 1981 Nov;30(6):1294-302.

Epidemic polyarthritis (Ross River) virus infection in the Cook Islands.

Rosen L, Gubler DJ, Bennett PH.

Trans R Soc Trop Med Hyg. 1981;75(3):426-31.

Ross River virus (Togaviridae: Alphavirus) infection (epidemic polyarthritis) in American Samoa.

Tesh RB, McLean RG, Shroyer DA, Calisher CH, Rosen L.

Ongoing RRV transmission in Pacific Islands?

- After virgin soil outbreak, RRV transmission assumed to have ceased because no known competent reservoir hosts, and no further reports of outbreaks, but ……
- Intermittent reports of RRV in travellers returning from Pacific Islands:
  - 5 New Zealanders after travelling to Fiji, 1979-2009[1]
  - 2 Canadians after travelling to Fiji, 2003-2004[2]
  - German traveller after visiting Pacific Islands, 2009[3]

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Travel Medicine and Infectious Disease
Volume 10, Issue 3, May 2012, Pages 129-134

Imported cases of Ross River virus disease in New Zealand – A travel medicine perspective

Colleen Lau [a, b], Philip Weinstein [a, c], David Slaney [c, d]

Ross River Virus Disease Reemergence, Fiji, 2003–2004

Philipp Klapsing,*† J. Dick MacLean,* Sarah Glaze,‡ Karen L. McClean,‡ Michael A. Drebot,§ Robert S. Lanciotti,¶ and Grant L. Campbell¶

We report 2 clinically characteristic and serologically positive cases of Ross River virus infection in Canadian tourists who visited Fiji in late 2003 and early 2004. This report suggests that Ross River virus is once again circulating in Fiji, where it apparently disappeared after causing an epidemic in 1979 to 1980.

[1]Lau et al. TMID 2012. [2]Klapsing et al. EID 2005. [3]Proll et al. Dtsch Med W 1999.

American Samoa

- Suspicion from local clinicians and entomologists that RRV might still be circulating after the 1979-1980 outbreak (44% attack rate)
- No RRV diagnostic tests available

Animal species:

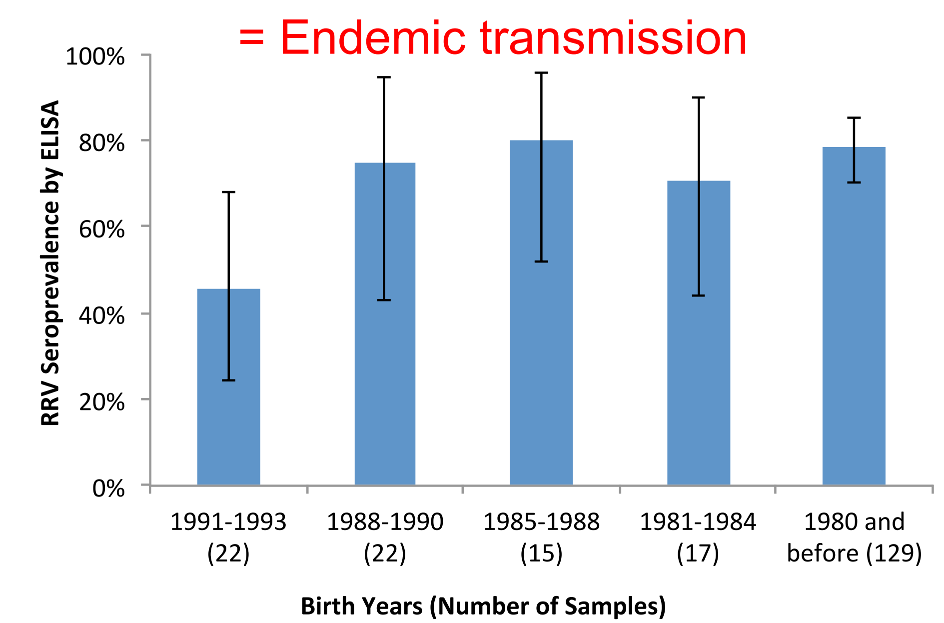
- *Bats (endemic)*
- *Rodents*
- *Dogs, cats*
- *Pigs*
- *(Cows, horses)*

Competent vectors:

- *Culex annulirostris*
- *Aedes aegypti*
- *Aedes polynesiensis*

RRV Seroprevalence, American Samoa 2010

- 145 out of 196 samples ELISA IgG positive
- Seroprevalance 74%
- Seroprevalence 63% in people born after 1980 outbreak and had lived their whole lives in AS



International Journal of Infectious Diseases 57 (2017) 73-

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International Journal of Infectious Diseases

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

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International Society for Infectious Diseases

New evidence for endemic circulation of Ross River virus in the Pacific Islands and the potential for emergence

CrossMark

Colleen Lau[a,*], Maite Aubry[b], Didier Musso[b], Anita Teissier[b], Sylvie Paulous[c], Philippe Desprès[d], Xavier de-Lamballerie[e], Boris Pastorino[e], Van-Mai Cao-Lormeau[b], Philip Weinstein[f]

Similar findings in French Polynesia & Fiji

International Journal of Infectious Diseases 37 (2015) 19–24

Contents lists available at ScienceDirect

International Journal of Infectious Diseases

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

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INTERNATIONAL SOCIETY FOR INFECTIOUS DISEASES

Silent Circulation of Ross River Virus in French Polynesia

Maite Aubry [a,*], Jérôme Finke [b], Anita Teissier [a], Claudine Roche [a], Julien Broult [c], Sylvie Paulous [d], Philippe Desprès [d,e], Van-Mai Cao-Lormeau [a], Didier Musso [a]

EMERGING INFECTIOUS DISEASES®

CDC > EID journal > Volume 23 > Number 10—October 2017

Volume 23, Number 10—October 2017

Research Letter

Ross River Virus Seroprevalence, French Polynesia, 2014–2015

Maite Aubry, Anita Teissier, Michael Huart, Sébastien Merceron, Jessica Vanhomwegen, Claudine Roche, Anne-Laure Vial, Sylvianne Teururai, Sébastien Sicard, Sylvie Paulous, Philippe Desprès, Jean-Claude Manuguerra, Henri-Pierre Mallet, Didier Musso, Xavier Deparis, and Van-Mai Cao-Lormeau

Silent circulation?

How can such high infection rates go undetected for so long?

- Symptoms of RRV overlap with many other infectious and non-infectious diseases that are common in the tropics
- Diagnostic tests for RRV not available in PICTs
- Poor awareness and low clinical index of suspicion
- RRV usually asymptomatic in young children
- High seroprevalence = good herd immunity = no outbreaks

Global Implications of Findings

- Non-marsupials are capable of acting as reservoirs and sustaining endemic transmission
- All animal species in American Samoa are pan-global in distribution, i.e. RRV could potentially become endemic anywhere with competent mosquitoes
- Potential virgin soil outbreaks

BioScience

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Volume 68, Issue 4
April 2018

Another Emerging Mosquito-Borne Disease? Endemic Ross River Virus Transmission in the Absence of Marsupial Reservoirs

Emily J Flies ✉, Colleen L Lau, Scott Carver, Philip Weinstein

BioScience, Volume 68, Issue 4, 1 April 2018, Pages 288–293,
https://doi.org/10.1093/biosci/biy011
Published: 07 March 2018

Risk of local transmission of RRV in NZ?

Four requirements for *epidemic* transmission:

- ✓ Competent mosquito vector
- ✓ Suitable climate
- ✓ Susceptible population
- ✓ Importation of virus

VECTOR-BORNE AND ZOONOTIC DISEASES
Volume 14, Number 2, 2014
© Mary Ann Liebert, Inc.
DOI: 10.1089/vbz.2012.1215

Exploring the Potential for Ross River Virus Emergence in New Zealand

Daniel M. Tompkins[1] and David Slaney[2,3]

For *endemic* transmission, also need competent reservoir host

Risk of Ross River Virus Importation into NZ

Australian and New Zealand Journal of
Public Health
Open Access
The Journal of the Public Health Association of Australia Inc.

Open Access

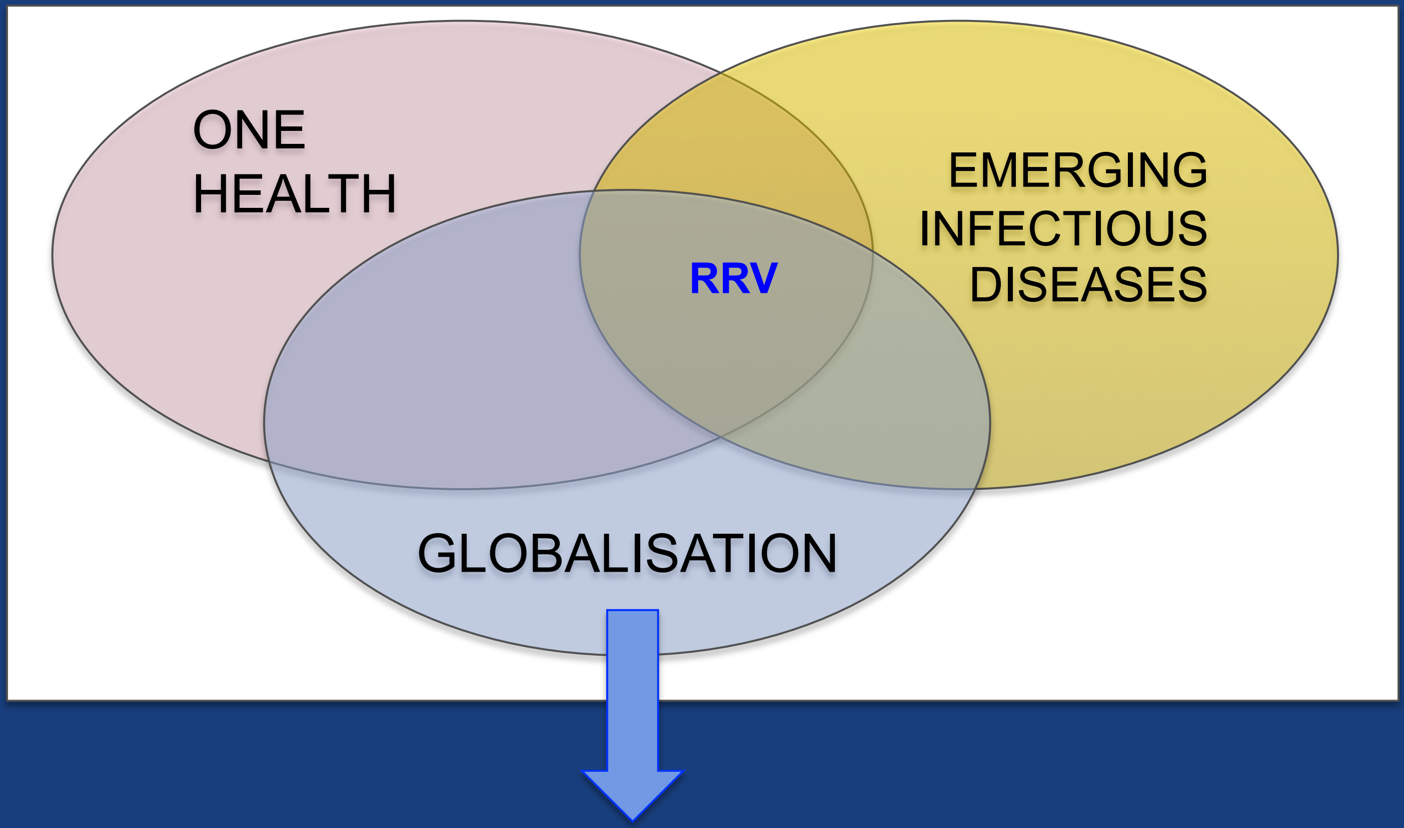
Infectious Disease: The risk of Ross River and Barmah Forest virus disease in Queensland: Implications for New Zealand

Louise A. Kelly-Hope, Brian H. Kay, David M. Purdie, Gail M. Williams

First published: 25 September 2007 | https://doi.org/10.1111/j.1467-842X.2002.tb00274.x

- Estimated 100 viraemic travellers enter NZ from Queensland each year
- ….that was in 2007, and only from QLD
- ….what about from Pacific Islands?
- ….and the increase in number of travellers to NZ?

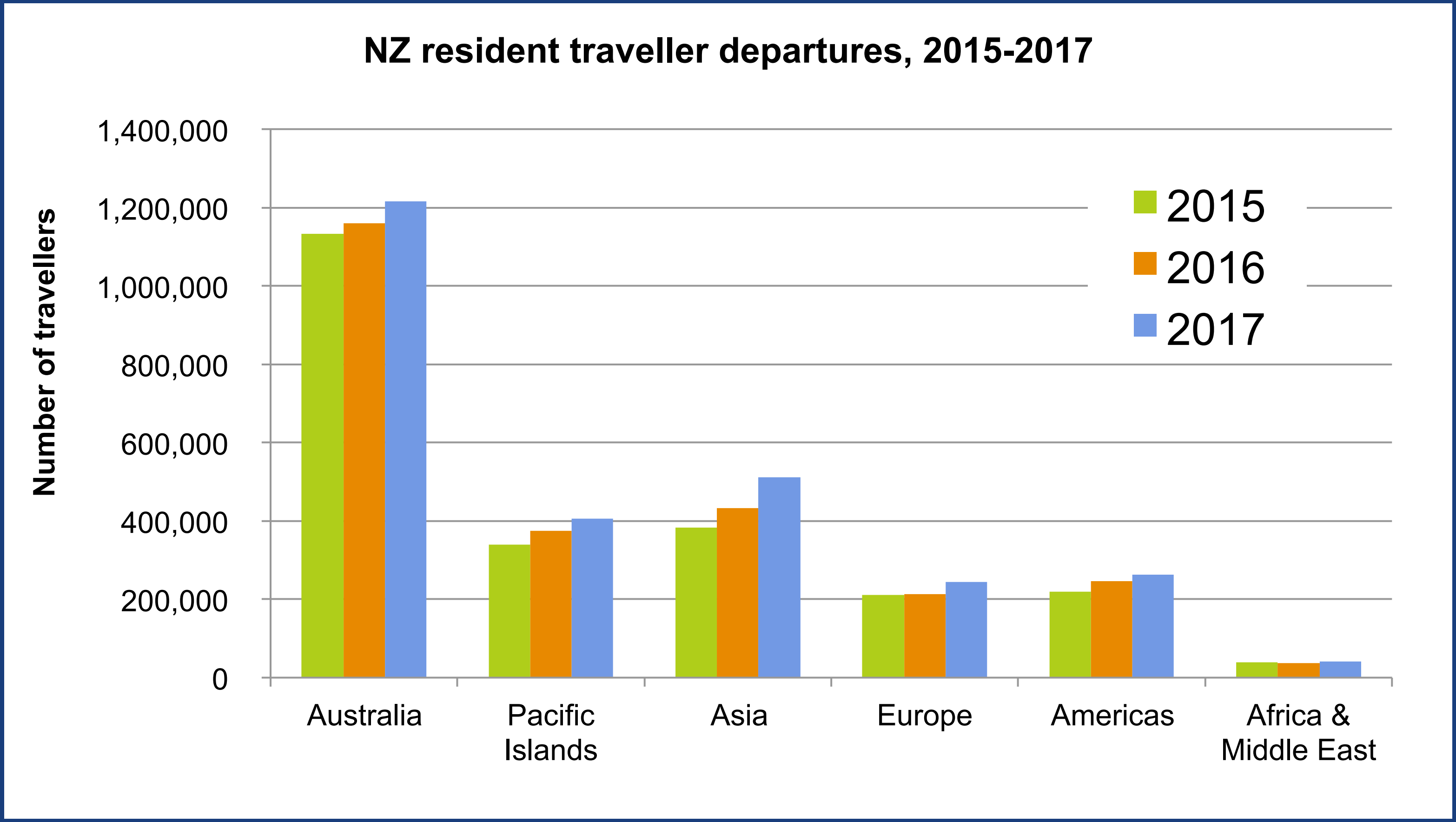
Ross River Virus



- Travellers as victims, carriers, transmitters, and sentinels
- Potential for global emergence, especially in places with extensive connectivity with Australia and Pacific Islands

NZ Resident Departures – 2015 to 2017

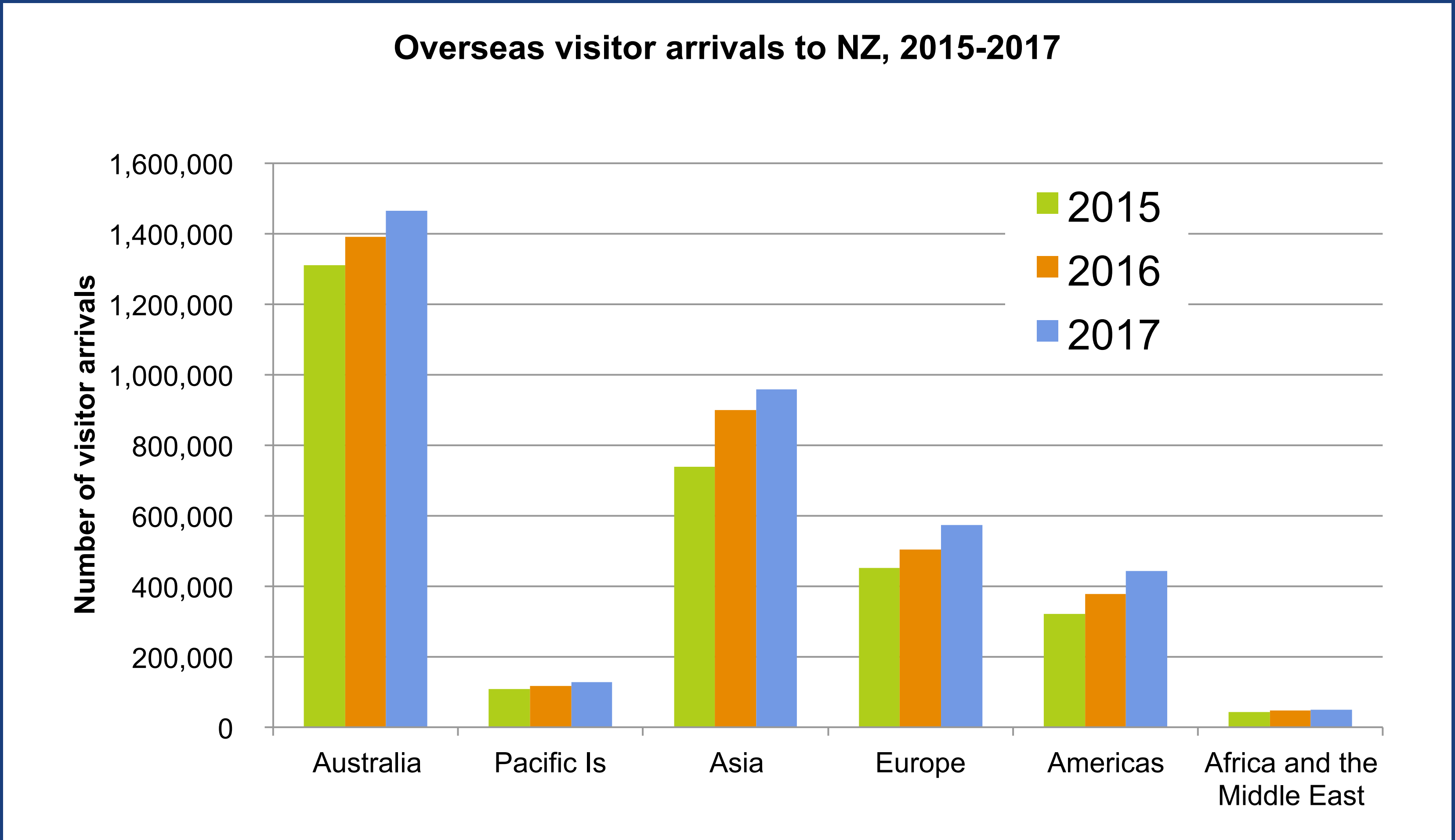
- Total resident departures: increased from 2.39M in 2015 to 2.83M in 2017 (18%)
- Total annual departures to Asia: increased from 383K in 2015 to 512K in 2017 (34%)



Source: www.stats.govt.nz

NZ Overseas Visitor Arrivals – Global

Total overseas visitor arrivals increased from 3.06M in 2015 to 3.69M in 2017 (21%)



Source: www.stats.govt.nz

Conclusions

- Globalisation has significant impact on the emergence and transmission of EIDs
- One Health and EIDs are no longer local issues
- Local One Health efforts are important, but not enough for sustainable gains
- Need to expand One Health thinking and efforts from local to regional and global
- Asia Pacific especially important to Australia and NZ because of extensive connectivity

Rainmaker Mountain, American Samoa

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