Emerging Infectious Disease Challenges

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STAR-IDAZ Foresight workshop on Emerging Infectious Disease Challenges

The Pirbright Institute receives strategic funding from BBSRC.

What do we mean by “disease emergence”?

A disease which is rapidly increasing in incidence, distribution or both.

High impact human pathogens:

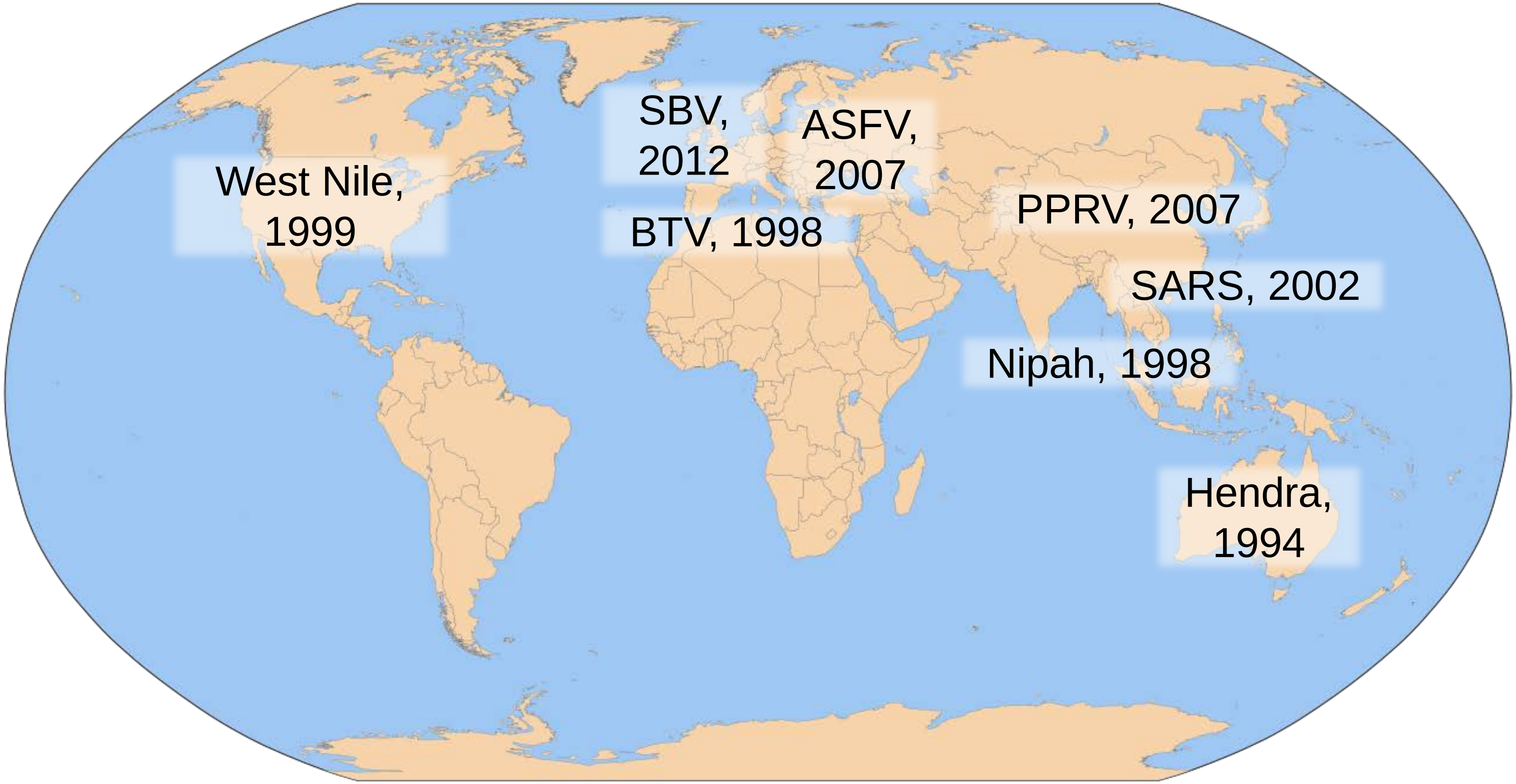
- 66% zoonotic, 67% emerging

High impact domestic animal pathogens:

- 67% zoonotic, 57% emerging

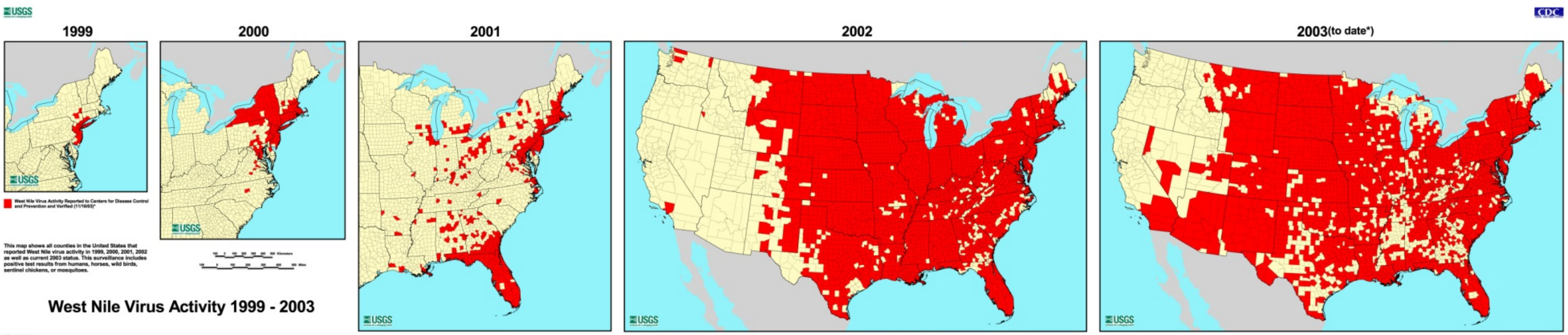
McIntyre et al. (in press) PLoS ONE

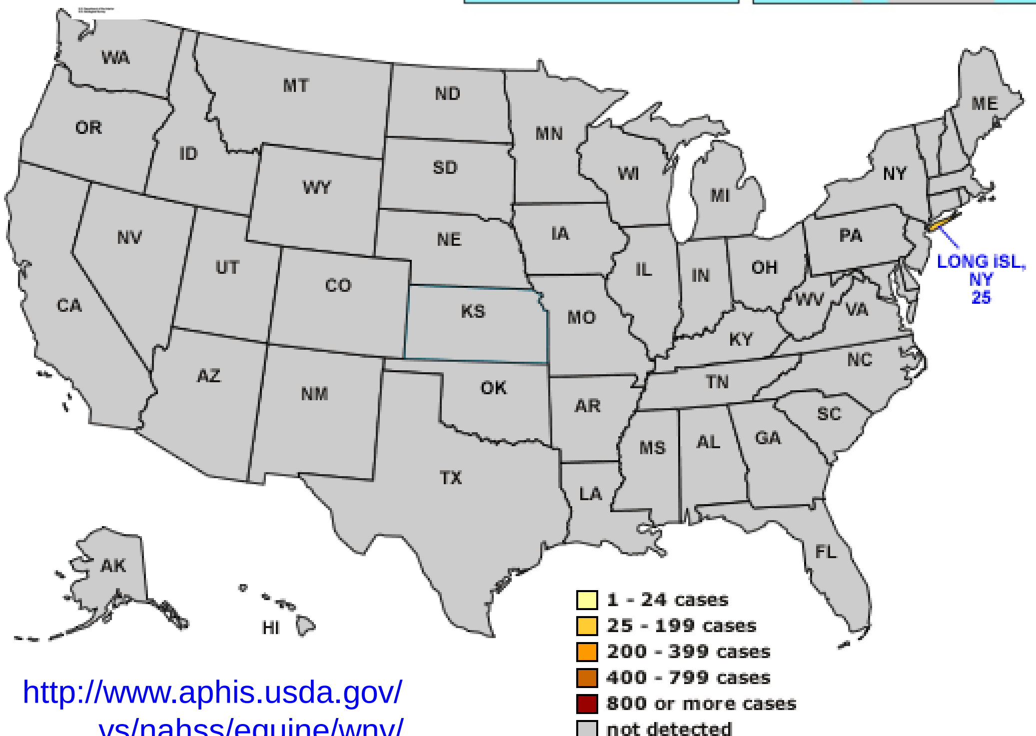
Recent infectious disease emergence events



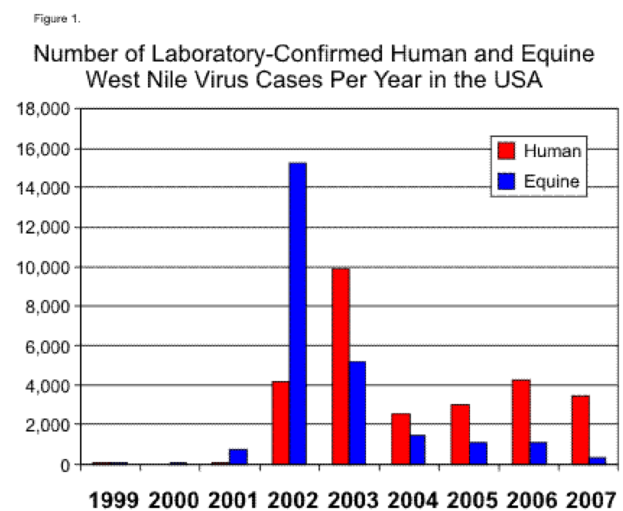
Source: own work

1999: West Nile in US





http://www.aphis.usda.gov/vs/nahss/equine/wnv/



“Equine Disease Quarterly”, July 2008

http://www.ca.uky.edu/gluck/q_jul08.asp

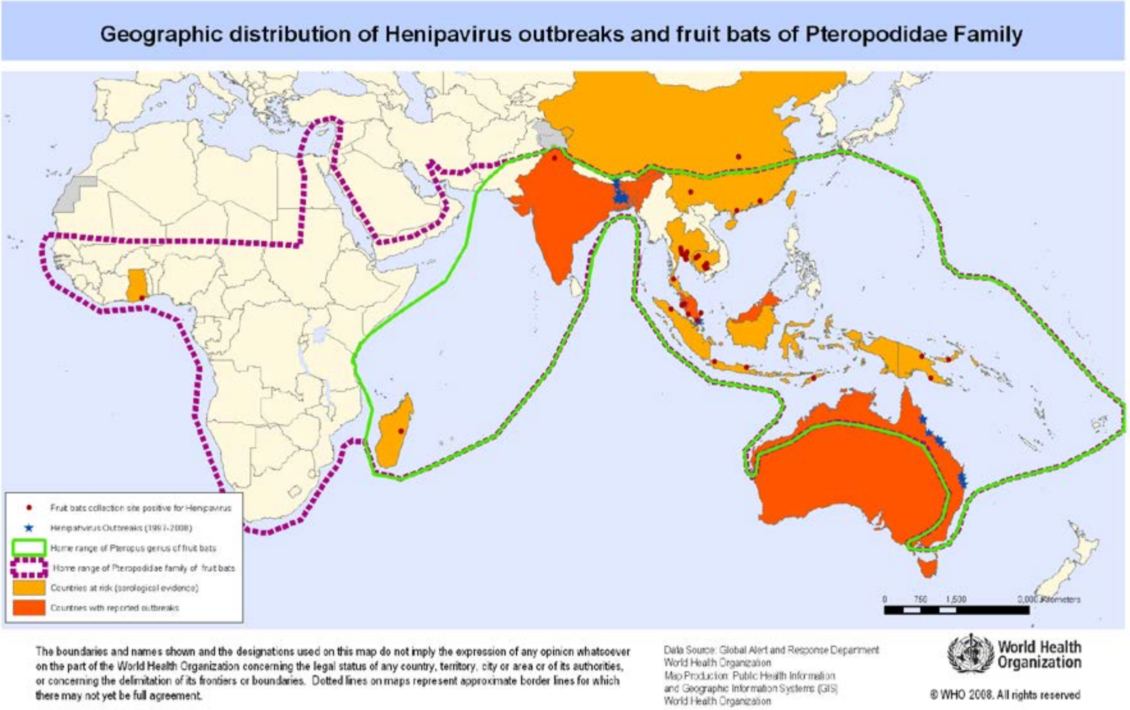
1999: West Nile in US (contd)

- 37,088 cases reported to CDC from 1998-2012
- 18,000 hospitalised
- 1,500 deaths
- Clinical presentations: fever, meningitis, encephalitis, acute flaccid paralysis
- Annual burden: $56M
- Total burden, 1998-2012: $778M.

J. E. Staples, M. Shankar, J. J. Sejvar, M. I. Meltzer, M. Fischer. **Initial and Long-Term Costs of Patients Hospitalized with West Nile Virus Disease**. *American Journal of Tropical Medicine and Hygiene*, 2014; DOI: 10.4269/ajtmh.13-0206

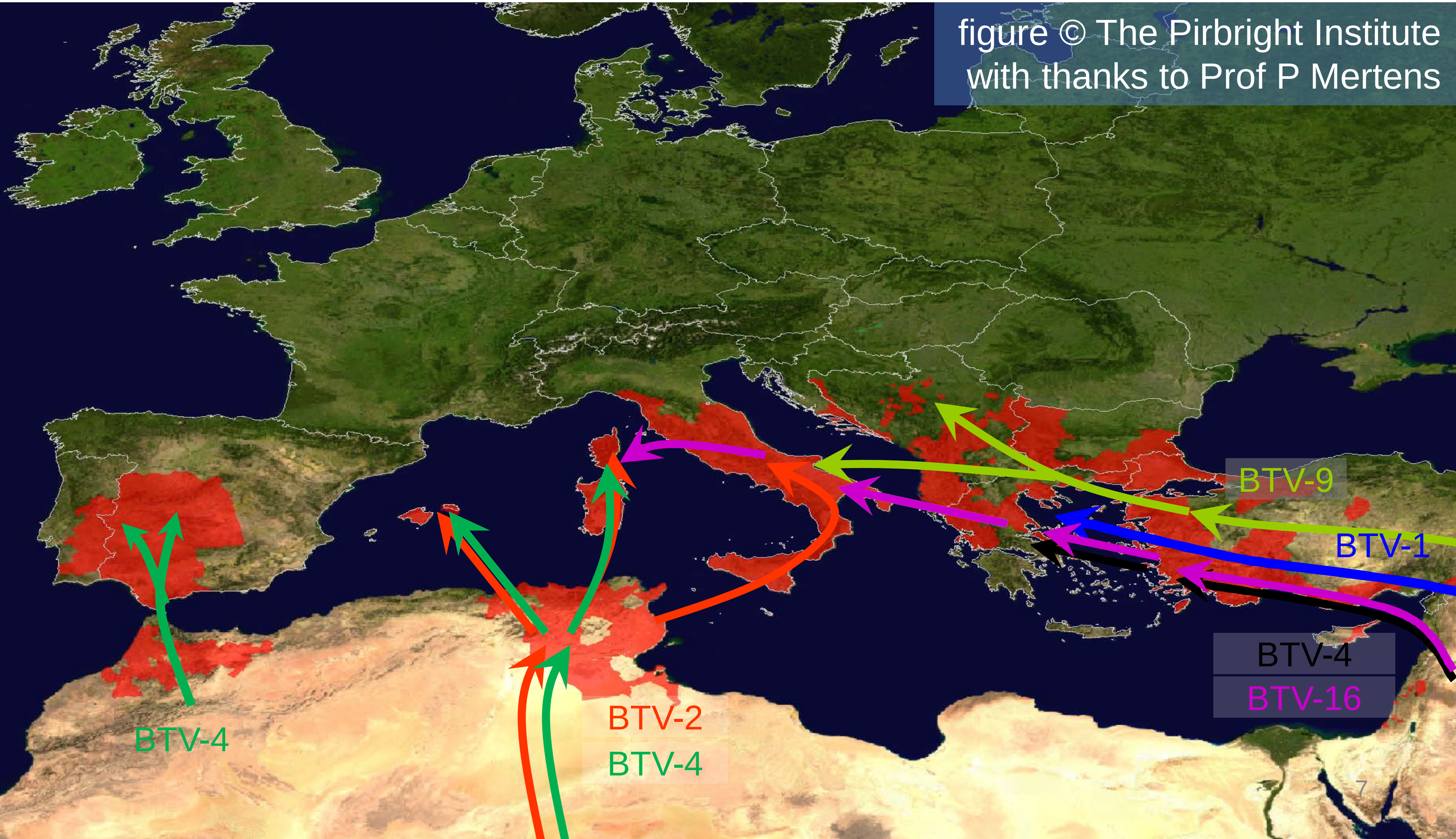
1998: Nipah virus, Malaysia

- 1.1M pigs culled (of national herd of 2.4M)
- Over 100 human deaths.
- $100M+ cost
- Massive changes to industry



Source: WHO (http://www.who.int/csr/disease/nipah/en/)

Bluetongue in Europe, 1998-2005:

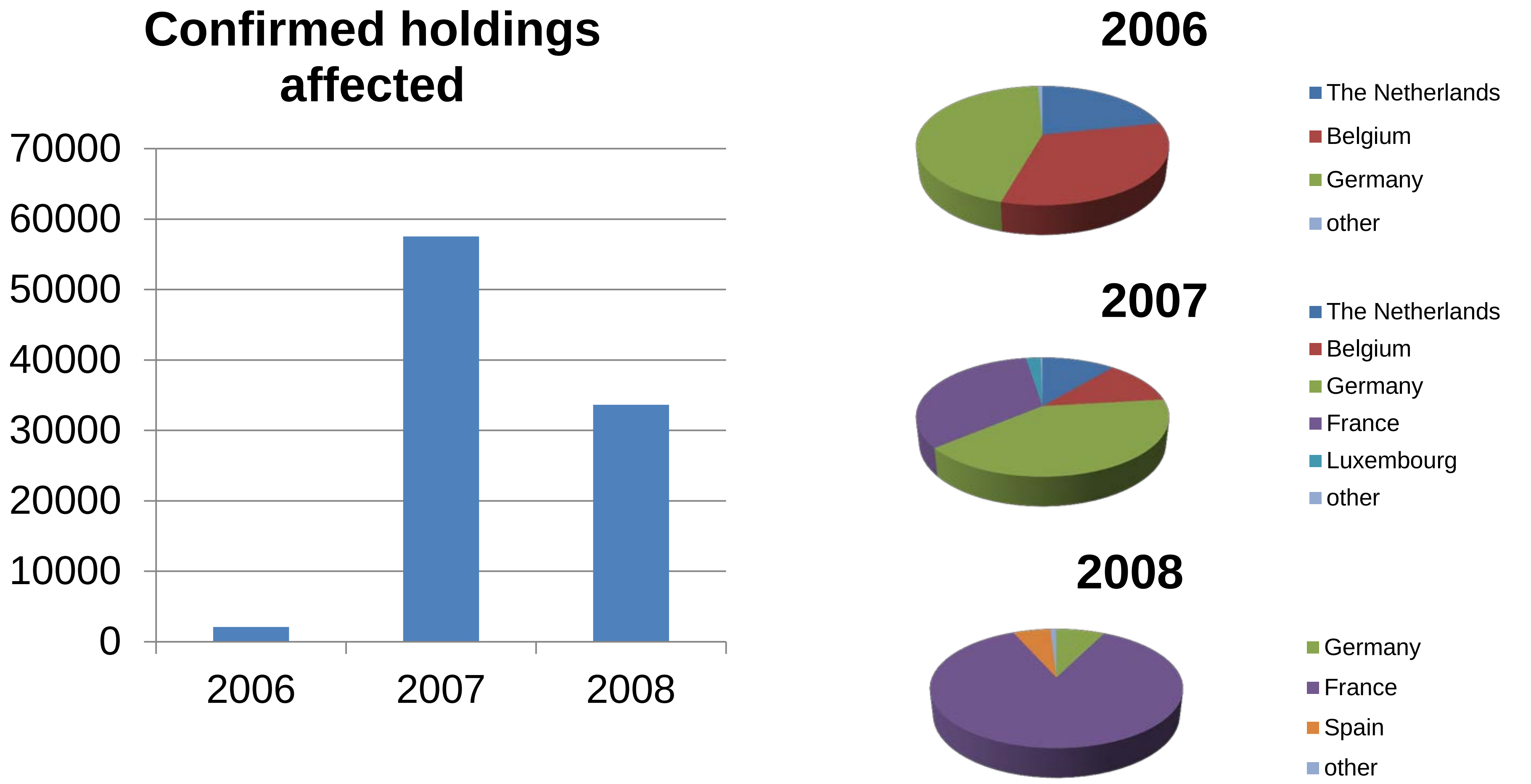


Bluetongue in Europe, 1998:2005

Year of first isolation	Source of sample	Serotype	Probable route of introduction
1998	Greece, Bulgaria, Turkey, Bosnia, Kosovo, Serbia	BTV-9	C
1999	Sardinia, Corsica, Sicily, mainland Italy, Balearics	BTV-2	B
1999	Greece	BTV-4	C
1999	Greece	BTV-16	C
2001	Greece	BTV-1	C
2001	Corsica, Sardinia, Sicily	BTV-2	B
2002	Mainland Italy	BTV-16	Vaccine-derived
2003	Corsica, Menorca	BTV-4	B
2004	Spain & Portugal	BTV-4	A
2004	Corsica, Sardinia, Sicily	BTV-16	Vaccine-derived
2004	Cyprus	BTV-16	C
2006	Belgium, Netherlands, Germany, France, Luxembourg, UK, Denmark, Switzerland…	BTV-8	Unknown
2006	Bulgaria	BTV-8	Unknown
2006	Sardinia	BTV-1	B
2007	Spain	BTV-1	A
2008	Switzerland	BTV-25	Special
2008	Netherlands	BTV-6	Unknown

Progression of bluetongue in Europe, 2006-2008

from Wilson & Mellor (2009) Phil Trans R Soc B



Costs of BTV infection

DIRECT:

- fallen stock
- weight loss
- reduced milk yield
- abortions

INDIRECT:

- movement restrictions
- international trade restrictions
- control and treatment costs

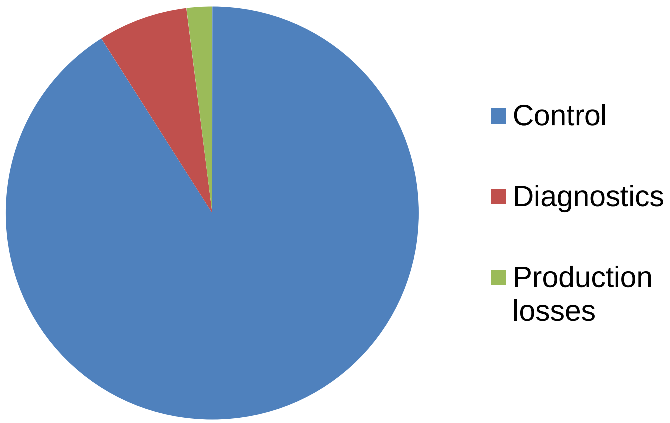
BBSRC Food Security

Costs associated with BTV: Netherlands as a case study

2006

Net cost approx. €30m

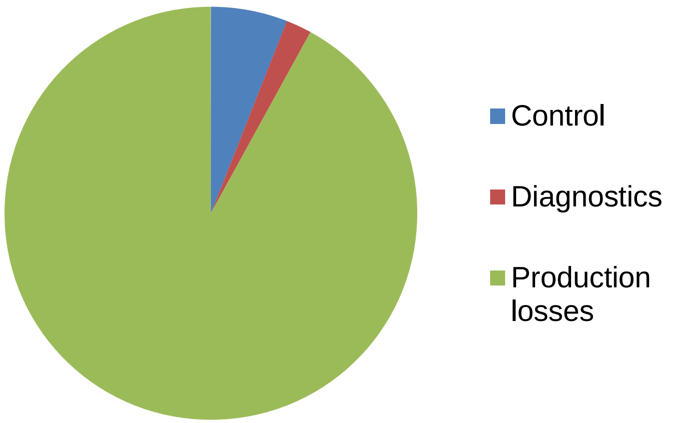
88% of costs borne by cattle industry



2007

Net cost approx. €170m

85% of costs borne by cattle industry



with thanks to Prof A Velthuis, Wageningen University

2002: SARS

Total economic loss: $40billion?

	Temporary Shock				Persistent Shock over 10 years			
	Total Effects	Demand Shift	Cost Rise	Country Risk	Total Effects	Demand Shift	Cost Rise	Country Risk
United States	−0.07	−0.01	−0.06	0.00	−0.07	−0.01	−0.06	0.00
Japan	−0.07	−0.01	−0.06	0.00	−0.06	−0.01	−0.06	0.01
Australia	−0.07	0.00	−0.06	0.00	−0.06	0.00	−0.06	0.01
New Zealand	−0.08	0.01	−0.08	0.00	−0.08	0.00	−0.08	0.00
Indonesia	−0.08	0.01	−0.09	0.00	−0.07	0.01	−0.08	0.00
Malaysia	−0.15	0.01	−0.16	0.00	−0.17	0.01	−0.15	−0.02
Philippines	−0.10	0.04	−0.14	0.00	−0.11	0.03	−0.13	−0.02
Singapore	−0.47	−0.02	−0.45	0.00	−0.51	−0.01	−0.44	−0.05
Thailand	−0.15	0.00	−0.15	0.00	−0.15	0.00	−0.15	0.00
China	−1.05	−0.37	−0.34	−0.33	−2.34	−0.53	−0.33	−1.48
India	−0.04	0.00	−0.04	0.00	−0.04	0.00	−0.04	0.00
Taiwan	−0.49	−0.07	−0.41	−0.01	−0.53	−0.07	−0.39	−0.07
Korea	−0.10	−0.02	−0.08	0.00	−0.08	−0.01	−0.08	0.00
Hong Kong	−2.63	−0.06	−2.37	−0.20	−3.21	−0.12	−2.37	−0.71
ROECD	−0.05	0.00	−0.05	0.00	−0.05	0.00	−0.05	0.00
Non-oil developing countries	−0.05	−0.01	−0.04	0.00	−0.05	0.00	−0.04	0.00
Eastern Europe and Russia	−0.06	−0.01	−0.05	0.00	−0.05	−0.01	−0.05	0.00
OPEC	−0.07	−0.01	−0.05	0.00	−0.09	−0.01	−0.06	−0.02

Probable cases of SARS by country, 1 November 2002 – 31 July 2003.

Country or Region	Cases	Deaths	SARS cases dead due to other causes	Fatality (%)
China *	5,328	349	19	6.6
Hong Kong *	1,755	299	5	17
Canada	251	44	0	18
Taiwan **	346	37	36	11
Singapore	238	33	0	14
Vietnam	63	5	0	8
United States	27	0	0	0
Philippines	14	2	0	14
Mongolia	9	0	0	0
Macau *	1	0	0	0
Kuwait	1	0	0	0
Republic of Ireland	1	0	0	0
Romania	1	0	0	0
Russian Federation	1	0	0	0
Spain	1	0	0	0
Switzerland	1	0	0	0
South Korea	4	0	0	0
Total	***8273***	***775***	***60***	***9.6***

(*) Figures for the People's Republic of China exclude the Special Administrative Regions (Macau SAR, Hong Kong SAR), which are reported separately by the WHO.

Source: WHO (http://www.who.int/csr/sars/en/)

2006: *Culicoides*-borne virus incursions into Europe continue

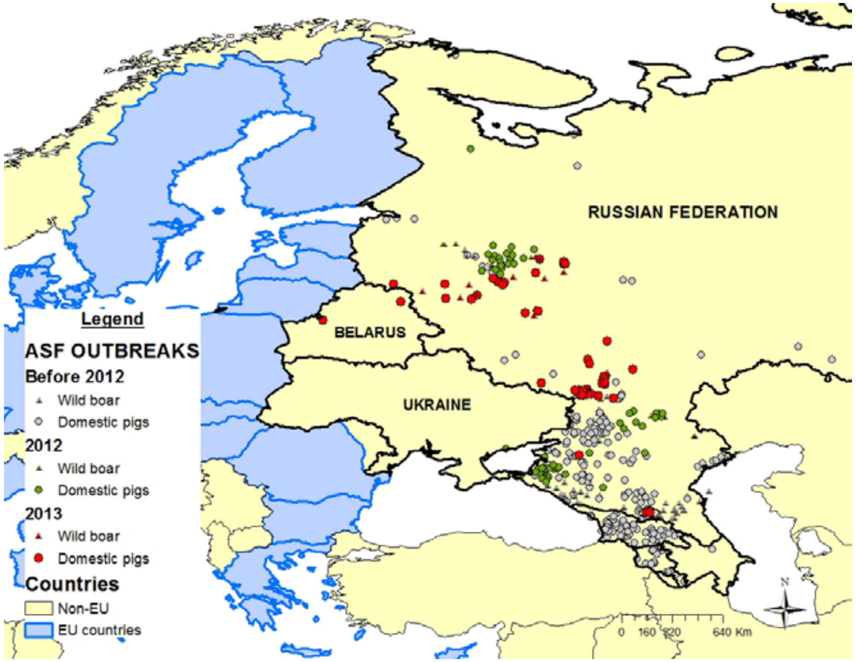
Strain	Probable Incursion Route	Clinical Impact	Economic Impact	Resolution
BTV-8 (2006-9)	?	High (Cattle & Sheep)	High	Vaccination
BTV-1 (2008-)	Ruminant/Culicoides movement	Medium (Sheep)	Medium	Vaccination
BTV-11 (2008)	Illegal Vaccine Use	Low	Low	-
BTV-6 (2008)	Illegal Vaccine Use	Low	Low	-
BTV-25 (2008)	?	Low	Low	-
BTV-14 (2011-)	?	Medium	?	-
SBV (2011-)	?	High	Medium-low	Endemic
BTV-27?	?	?	?	?

2007: African swine fever

Introduction thought to be consequence of improper waste treatment

Spread rapid, various routes including wildlife

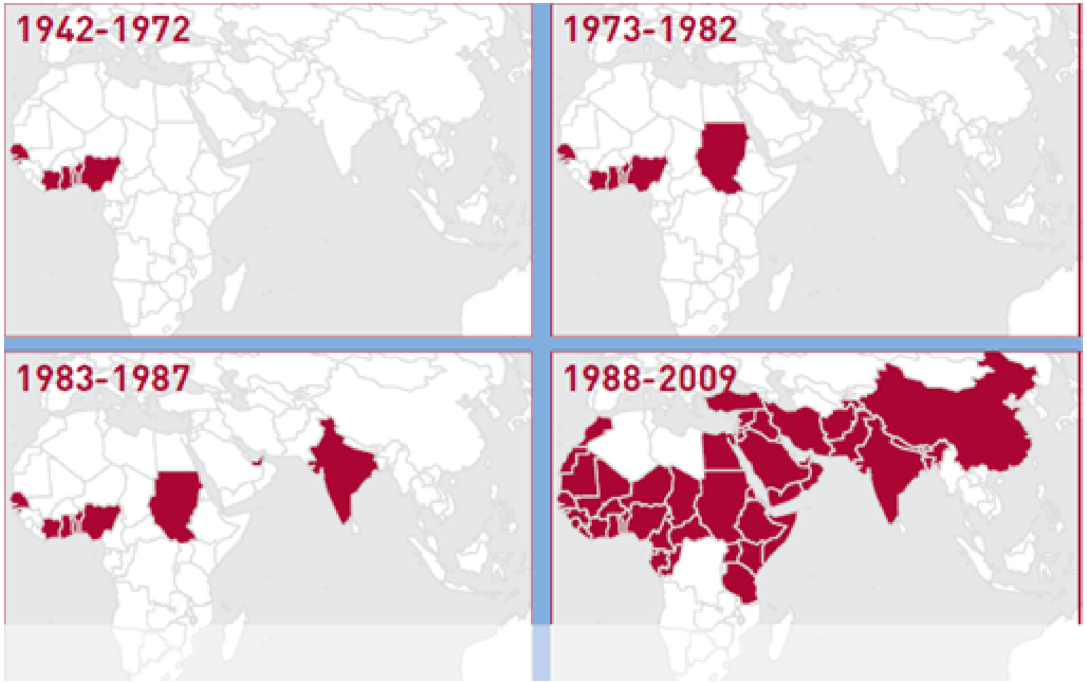
No vaccine



Source: ASForcewebsite (http://asforce.org/course/assets/img/module1/map2.jpg)

2008: Peste des petits ruminants (“goat plague”, “ovine rinderpest”)

- Rapidly emerging in China
- Huge economic impact
- Single serotype
- No carriers
- Candidate for eradication?*



Source: FAO (2009)

*OIE/FAO, May 2014 (Global Framework for the Progressive Control of Transboundary Animal Diseases)

Key questions

Introduction: How are pathogens getting in? How can this be reduced?

Spread: How fast and far are they likely to spread? How can this be reduced?

Impact: How much impact are they likely to have? How can this be reduced?

Factors affecting likelihood of introduction

Epidemiological knowledge (e.g. AHSV in Spain)

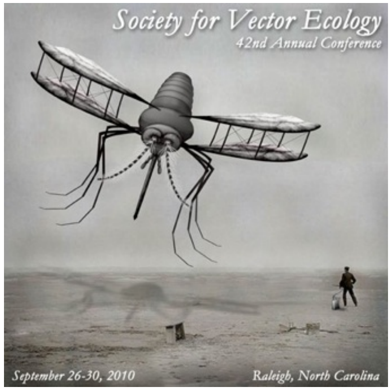
Infected vectors

- aerial dispersal, e.g. BTV-8 in UK
- Via trade

Live vaccines (e.g. BTV in Italy)

Contaminated materials (e.g. canine AHSV in Africa)

Improper disposal of waste (ASFV)



Factors affecting rate of spread

Animal movement

Production

Biosecurity

Climate

Vector establishment

Increases in host population

Habitat change

Factors affecting impact of outbreak

Direct losses

Public perception

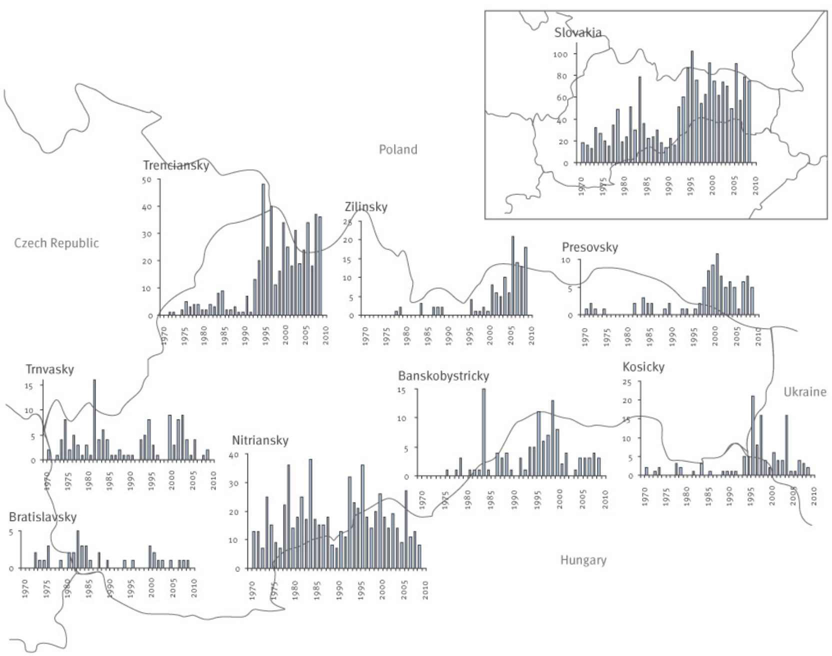
Trade restrictions

International response

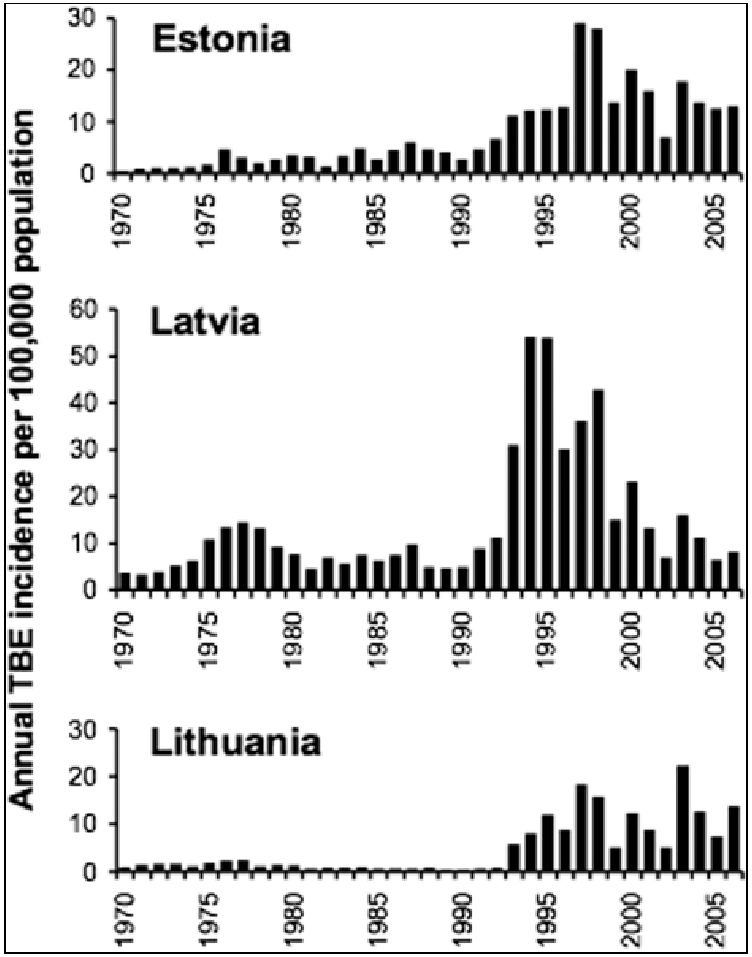
Emergence of TBEV in Eastern Europe since mid-1990s

FIGURE 1

Annual numbers of tick-borne encephalitis cases since 1970 in all Slovakia (inset) and each kraj (region), showing the typical spatial and temporal heterogeneity in incidence within one country



Source: Public Health Authority of the Slovak Republic.



Source: Sumilo et al. (2007)

Epidemiology is complex

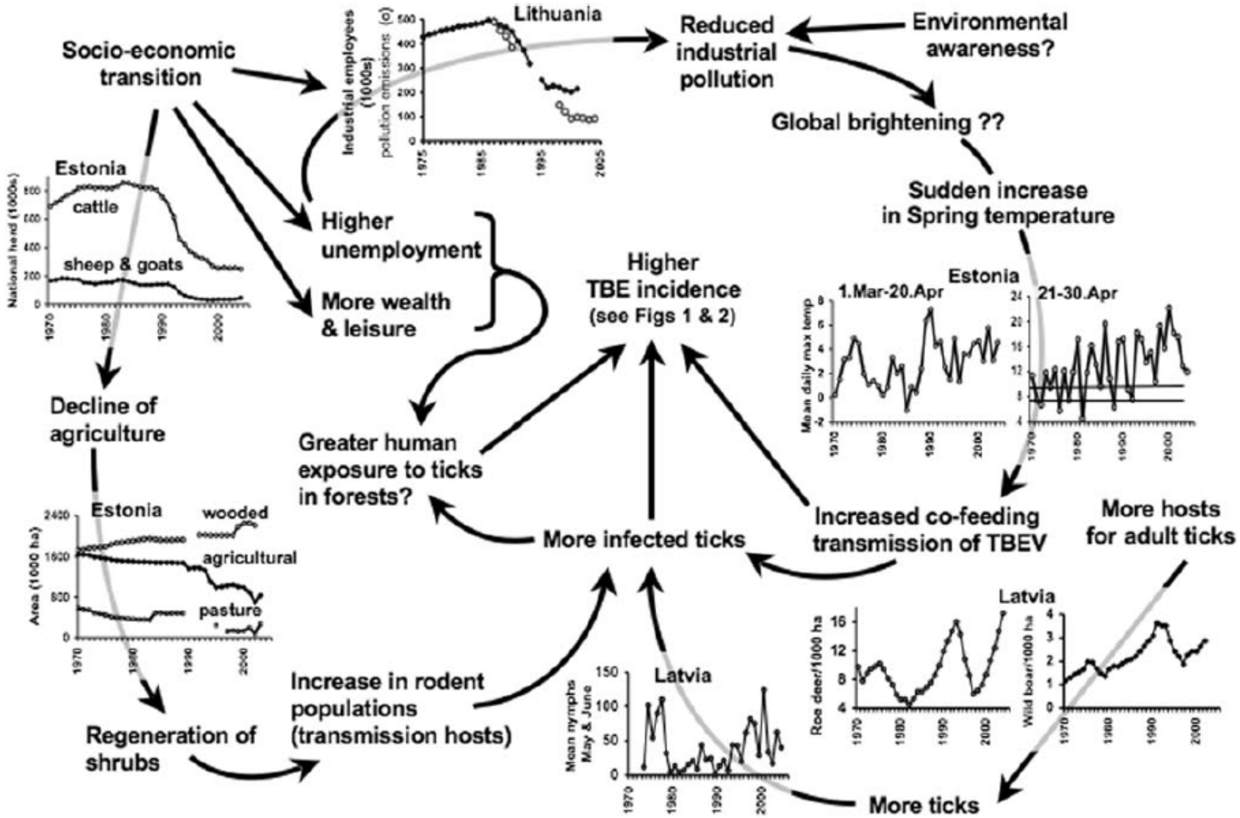


Figure 8. Hypothetical explanation for the epidemiology of TBE in the Baltic countries. Examples of data from Estonia, Latvia and Lithuania indicate some factors that may act independently but synergistically to cause the emergence of tick-borne diseases.
doi:10.1371/journal.pone.0000500.g008

Sumilo et al. (2007) "Climate Change Cannot Explain the Upsurge of Tick-Borne Encephalitis in the Baltics." PLoS ONE **2**(6): e500.

Why now?

Disease introduction now happens more often, and spread happens faster, because of:

- Increasing travel
- Increasing trade
- Increasing population
- Intensification of production

However, diagnostics and control technologies can also be developed and deployed more rapidly.

Impact-based prioritisation

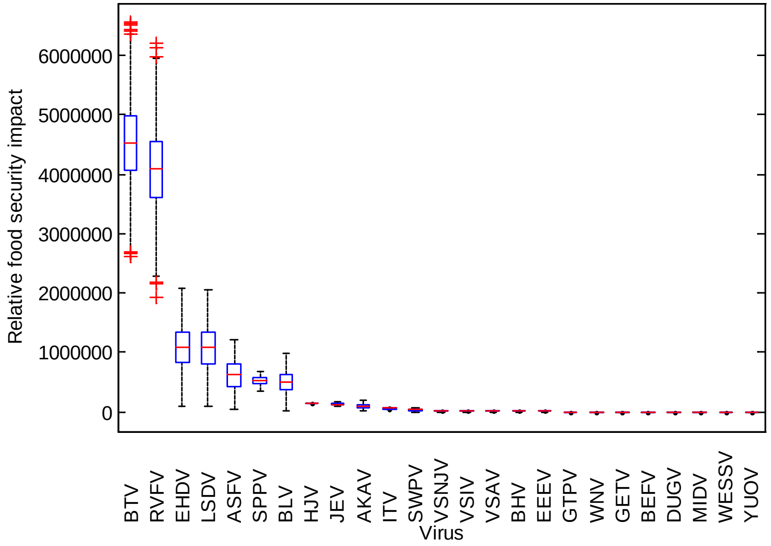
Top viruses by industry

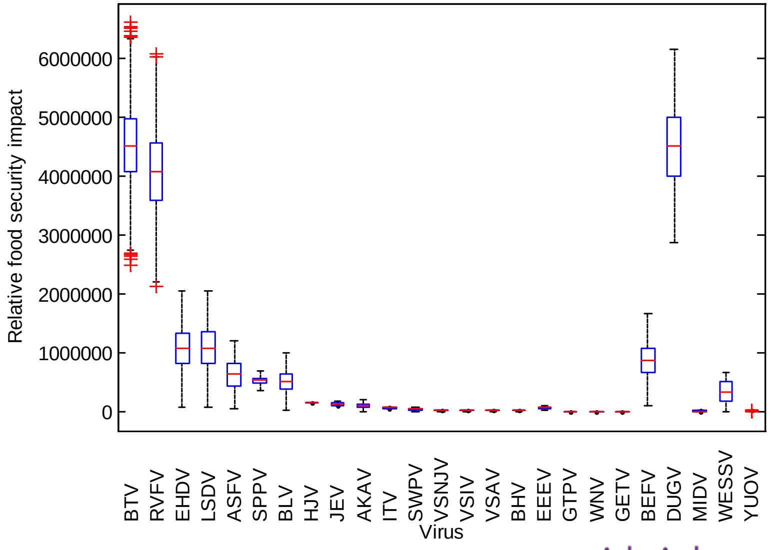
<u>horse</u>: AHSV, VEEV, WNV (EEEV)

<u>cattle</u>: RVFV, BTV/EHDV/LSDV

<u>pig</u>: ASFV

<u>small ruminant</u>: BTV, RVFV (NSDV)





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Key strategies for control

Syndromic surveillance

International cooperation:

- Data sharing
- Harmonised diagnostic criteria
- Collaboration on control programmes

Rapid response

- “Flexible” research areas
- SBV vaccine (~18mth)

Novel approaches (GM etc).

Summary

- Diseases are emerging all the time
- Their impact can be high or low
- They do not respect international borders
- Costs by sector, type and country may change as an outbreak evolves
- Minimising the overall impact of disease emergence requires:
    - Efficient use of resources
    - Capacity for rapid response
    - International collaboration

Acknowledgements

Thanks to:

Peter Mertens (Pirbright) for information on historical BTV incursions into Europe

Marie McIntyre (Liverpool) for sharing preliminary results of the Enhanced Infectious Diseases (EID2) project

Thank you for listening