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Emerging Disease Futures: The Driving Forces

one world • one health

November, 2005
Beijing

Bio Economic Research Associates (bio-era)

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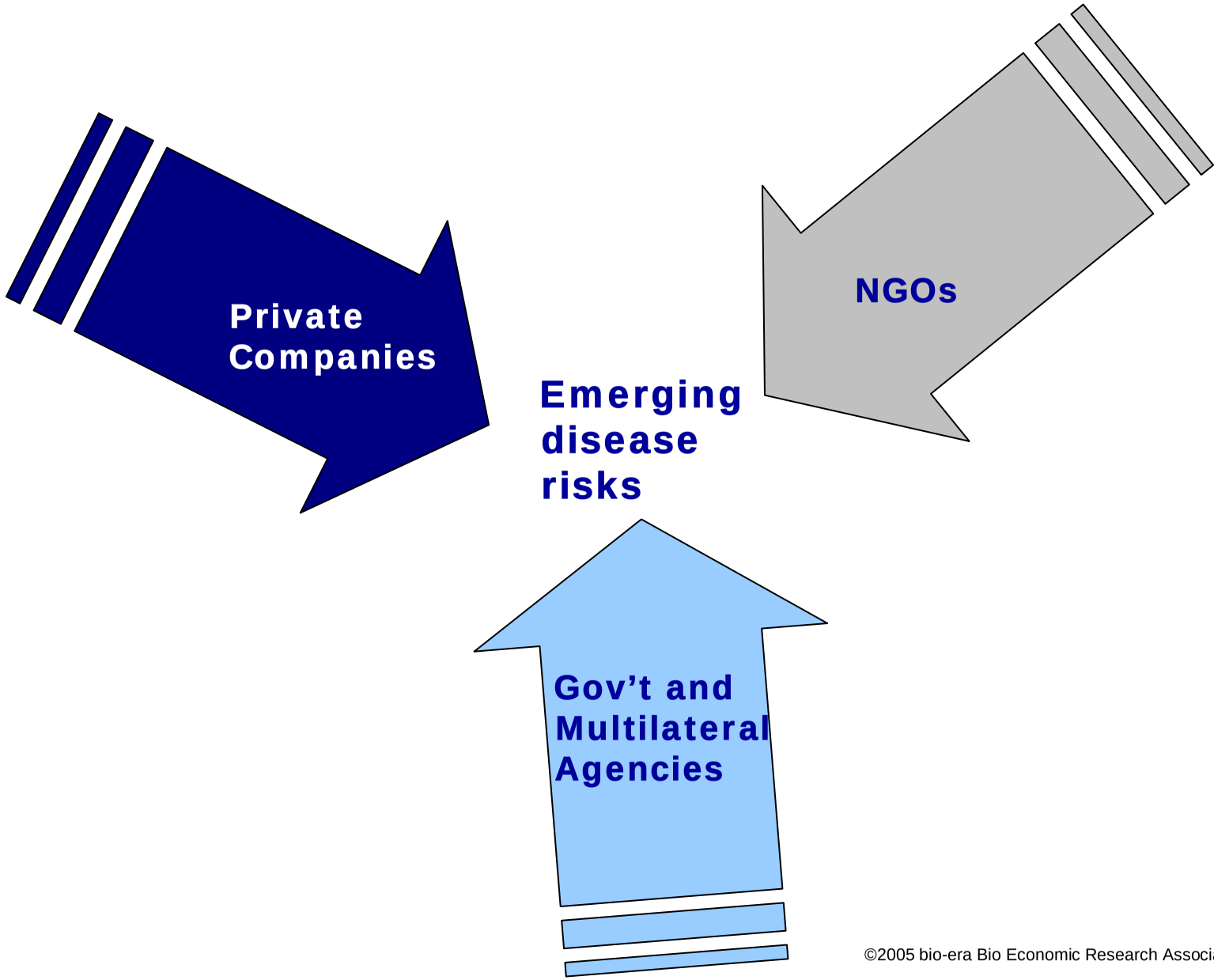
The Driving Forces: Biology and Borders

- **Pathogen exchanges among livestock, wildlife, and humans**
- **Globalization of trade and travel**
- **Growth and structure of livestock industry**
- **Viral evolution**

Multi-Stakeholder Coalitions



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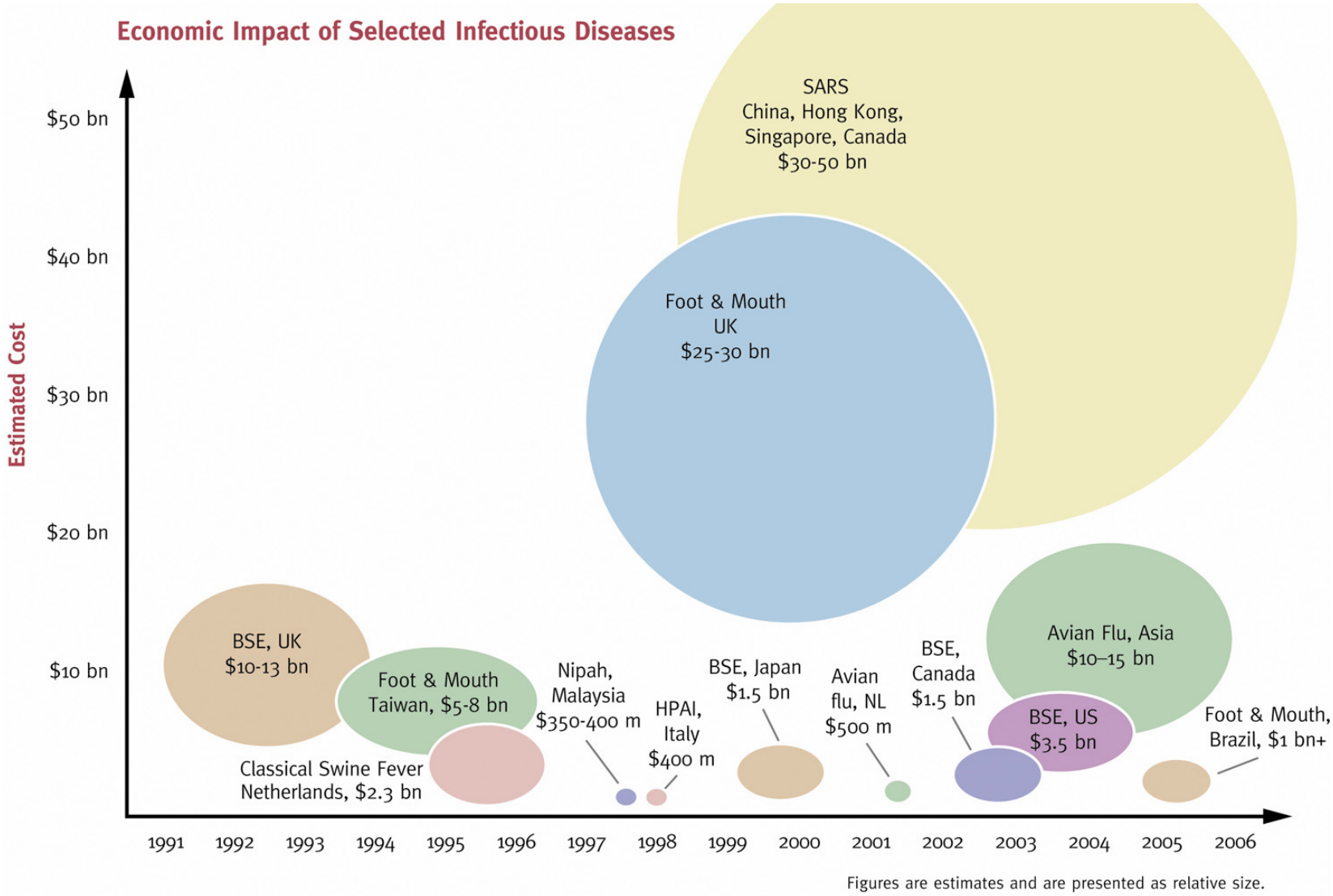

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Estimates of Economic Impact of a Pandemic

- **Asian Development Bank (Asian implications, excluding Japan—2005)**
  - — Mild pandemic: Up to $110 billion in lost consumption; $15 billion in death and incapacity, 2.6% of GDP
  - — Severe shock $297 billion in short-term losses, 6.8% of GDP
- **Dai-Ichi Life (November 2005)**
  - — Costs to Japanese economy $12 billion
- **World Bank (November 2005)**
  - — Total costs to global economy exceed $800 billion
- **Conference Board of Canada (October 2005)**
  - — “A flu pandemic on a large scale would throw the world into a sudden and possibly dramatic recession.”
  - — No quantitative estimates
- **ING Bank**
  - — “Large swathes of economic activity would simply cease.”
  - — “A realistic scenario might involve GDP declines of tens of percent.”
  - — “Fear of infection would result in the greatest economic damage.”

Estimates of Economic Impact of a Pandemic (continued)

- **U.S. Centers for Disease Control (1999):**
  - — $71-167 billion (1995 US$) cost to the U.S. economy; (current $: $88-206 billion)
  - — Based on estimates of case numbers, hospitalizations, deaths and associated costs
  - — Assumes 89,000–207,000 U.S. deaths; 314,000-734,000 hospitalizations
- **U.S. Health and Human Services *(Pandemic Influenza Strategic Plan - 2005)***
  - — Mild case: $181 billion in direct and indirect health costs alone
  - — “Worst case”: Up to $450 billion cost to the U.S. economy
  - — Assumes 1.9 million deaths, and 9.9 million hospitalizations for worst case

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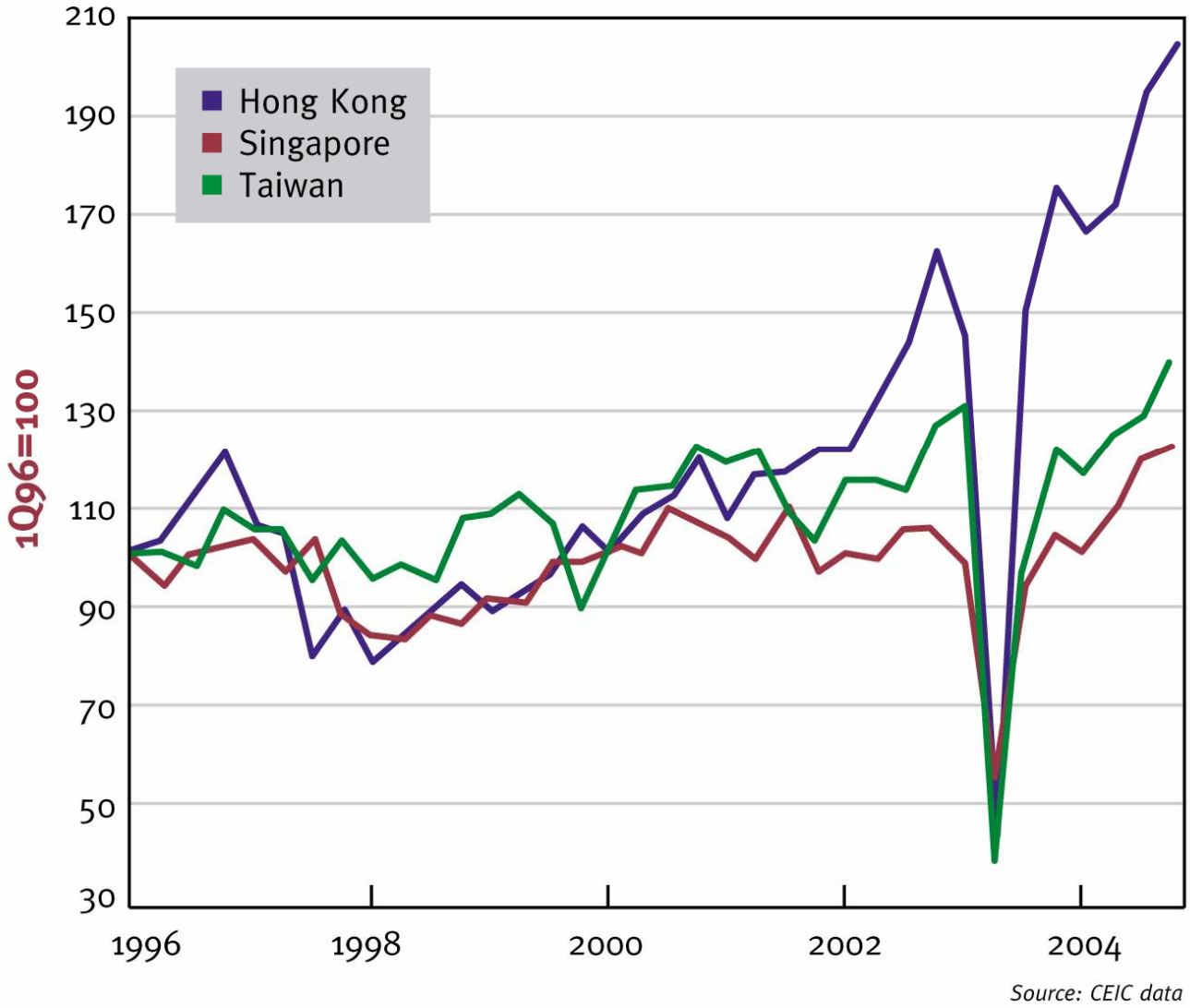
Decline in tourist arrivals during SARS



Source: CEIC data

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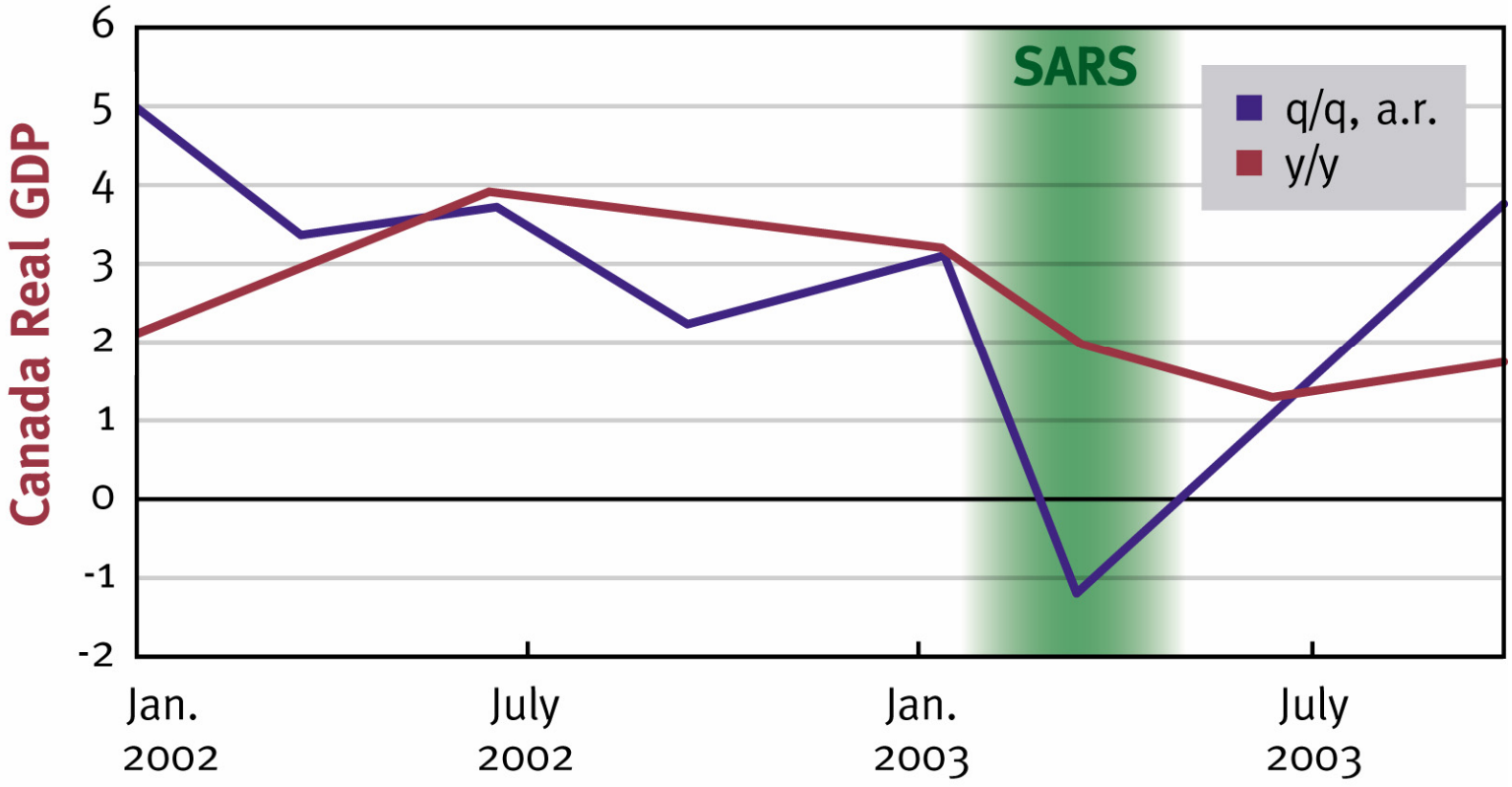
The Effect of SARS on the Canadian Economy



Sources: BMO Nesbitt Burns

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Lessons Learned from SARS

- Economic effects spread faster than the disease
- Direct health-related costs were on 1–2% of economic costs
- Public fears were amplified by uncertainty
- The most open economies were the hardest hit
- Secondary disruption of supply chains was significant
- Control measures at national borders were ineffective
- The economic rebound was swift

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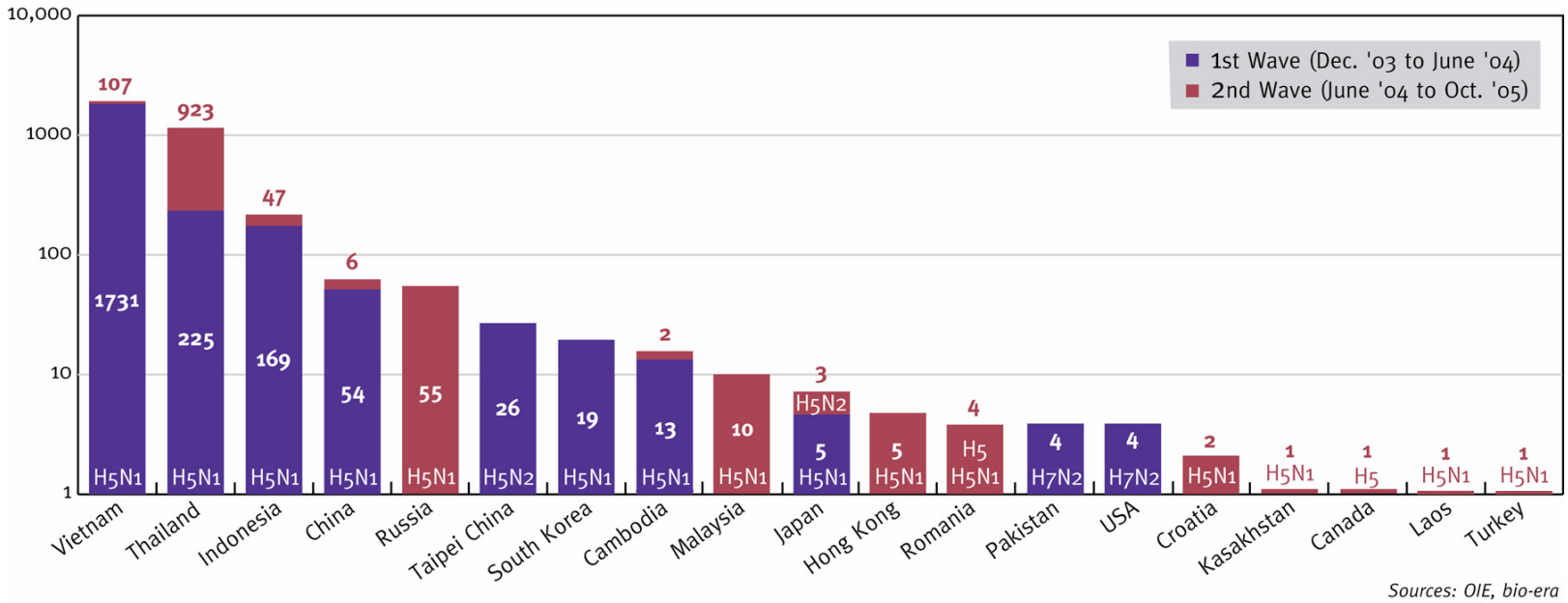
Avian Flu Outbreaks by Country Since December 2003



Sources: OIE, bio-era

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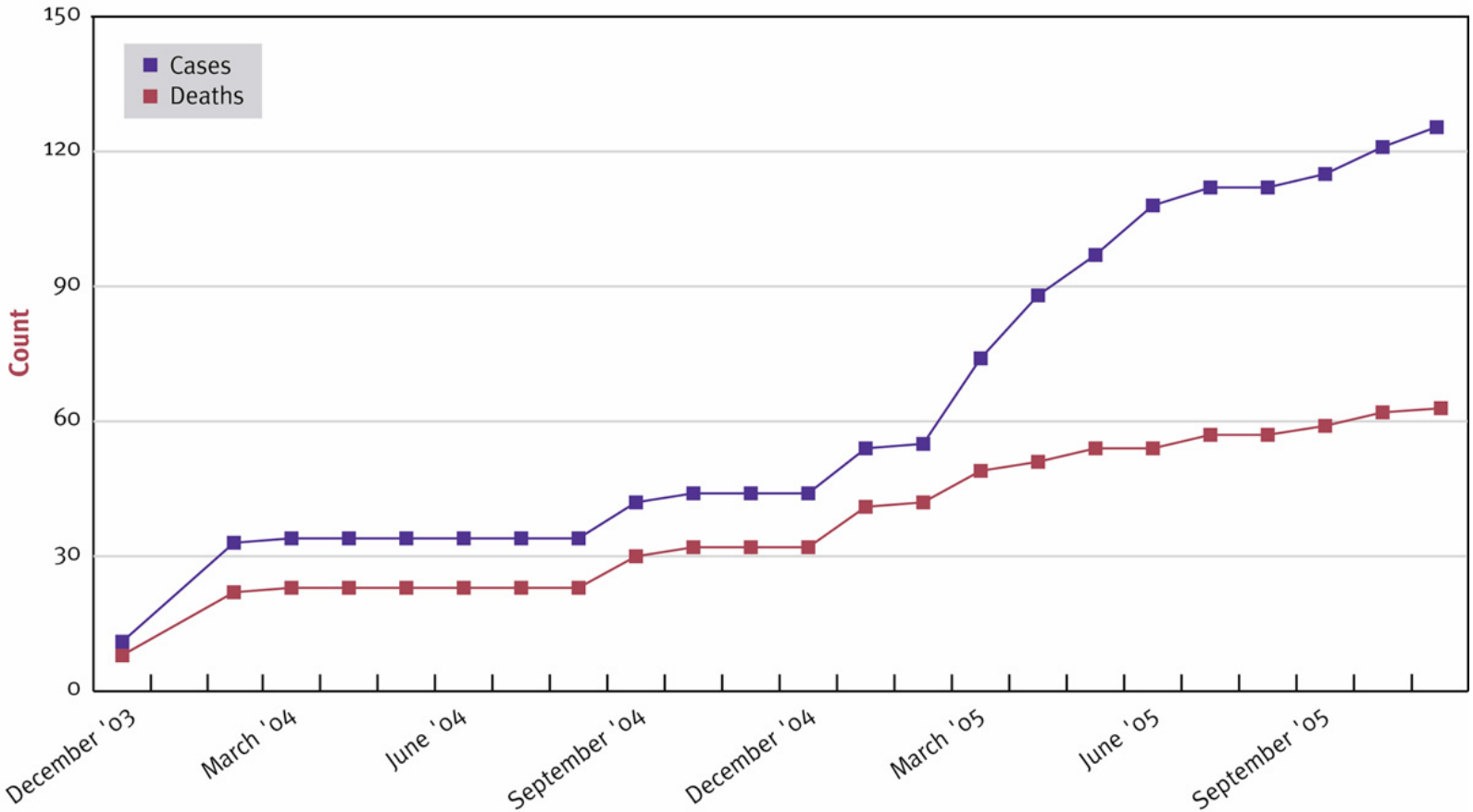
Laboratory-confirmed Human Cases of H5N1 Avian Influenza Since December 2003



Source: http://www.who.int/csr/disease/avian_influenza/country/en/

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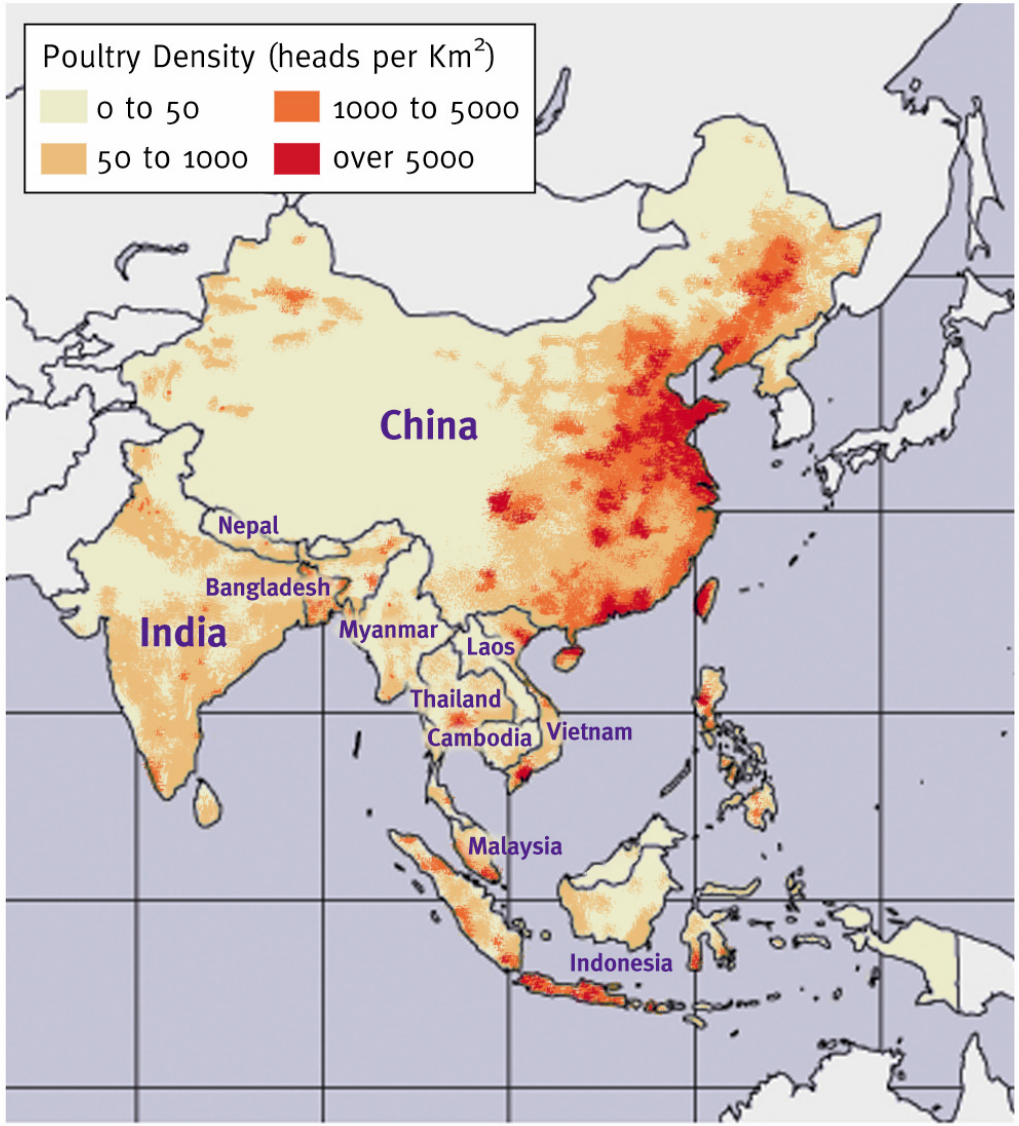
Poultry Density in Asia



Source: FAO

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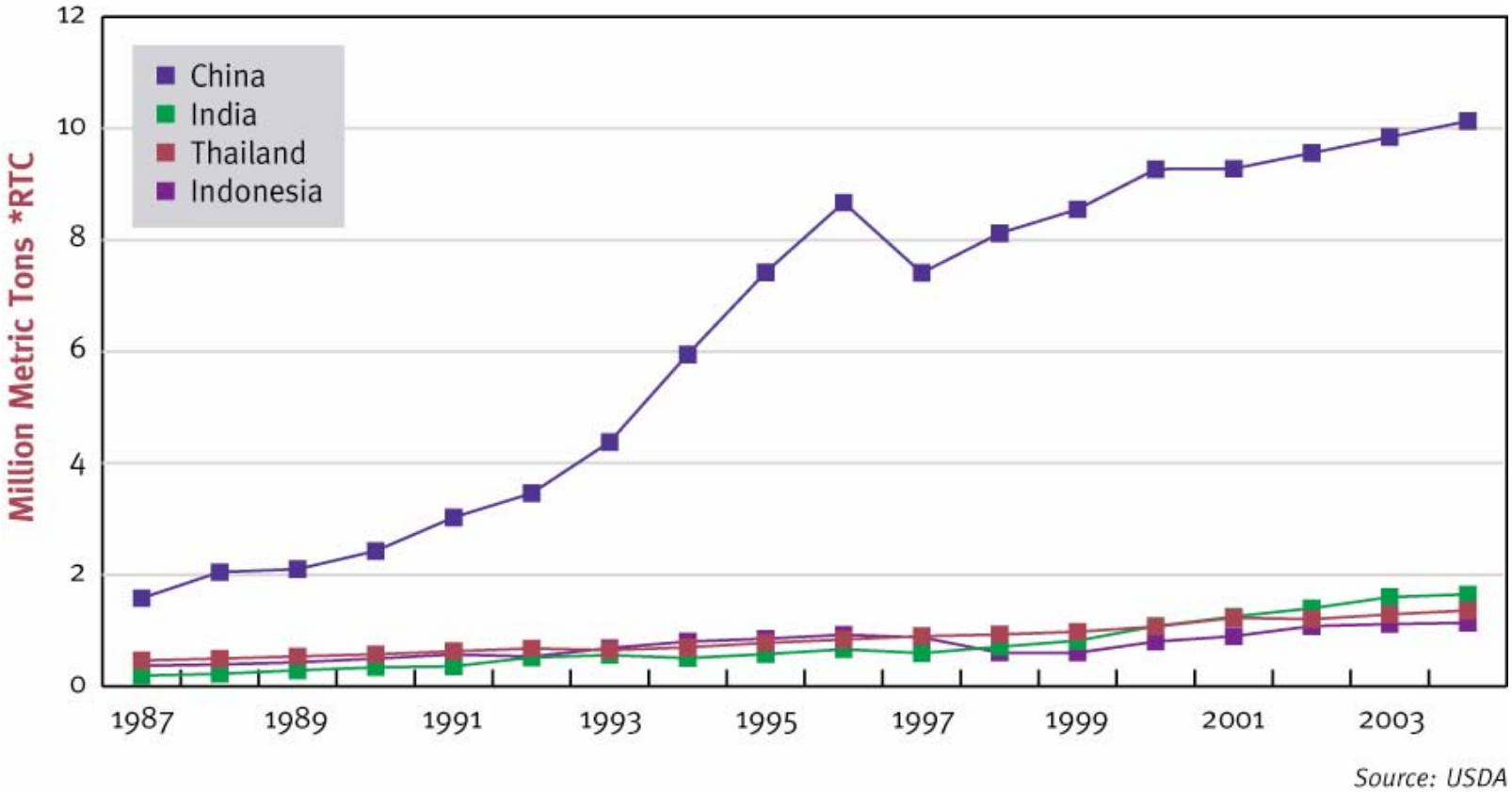
Chicken Meat Production, 1987-2004



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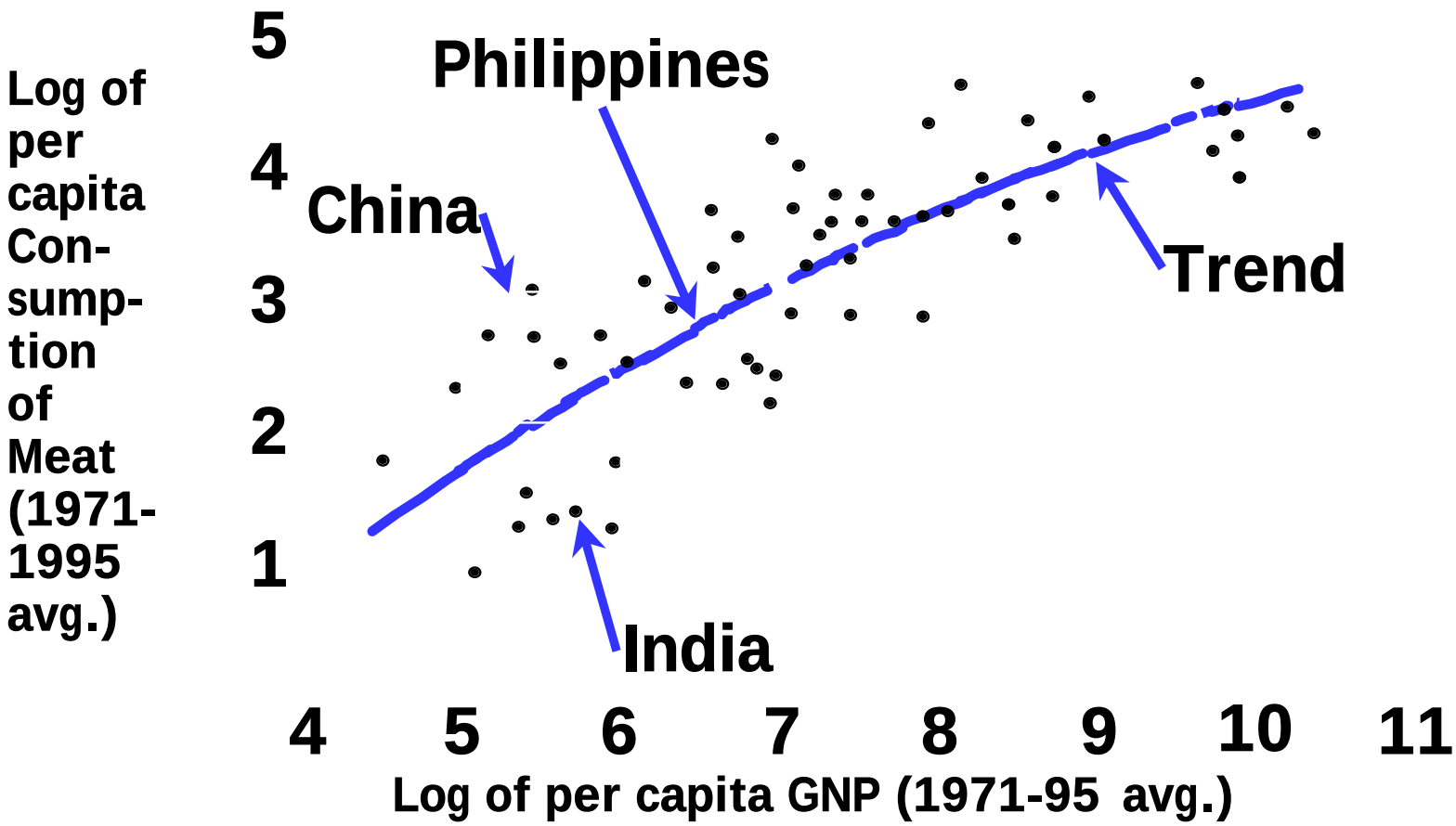
Meat Consumption and Income Trends



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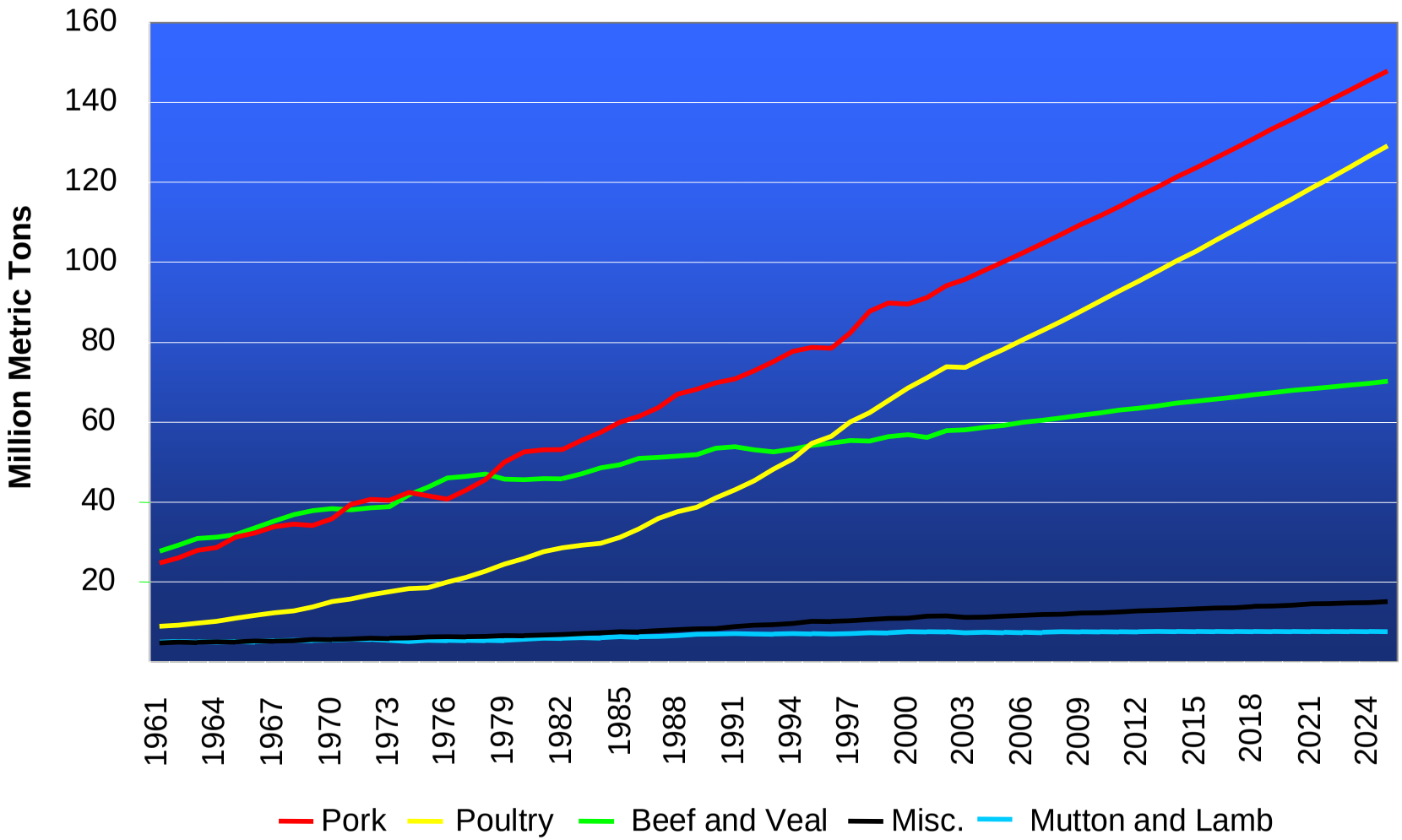
Projected Global Meat Production to 2025



Source: Center for Global Food Issues

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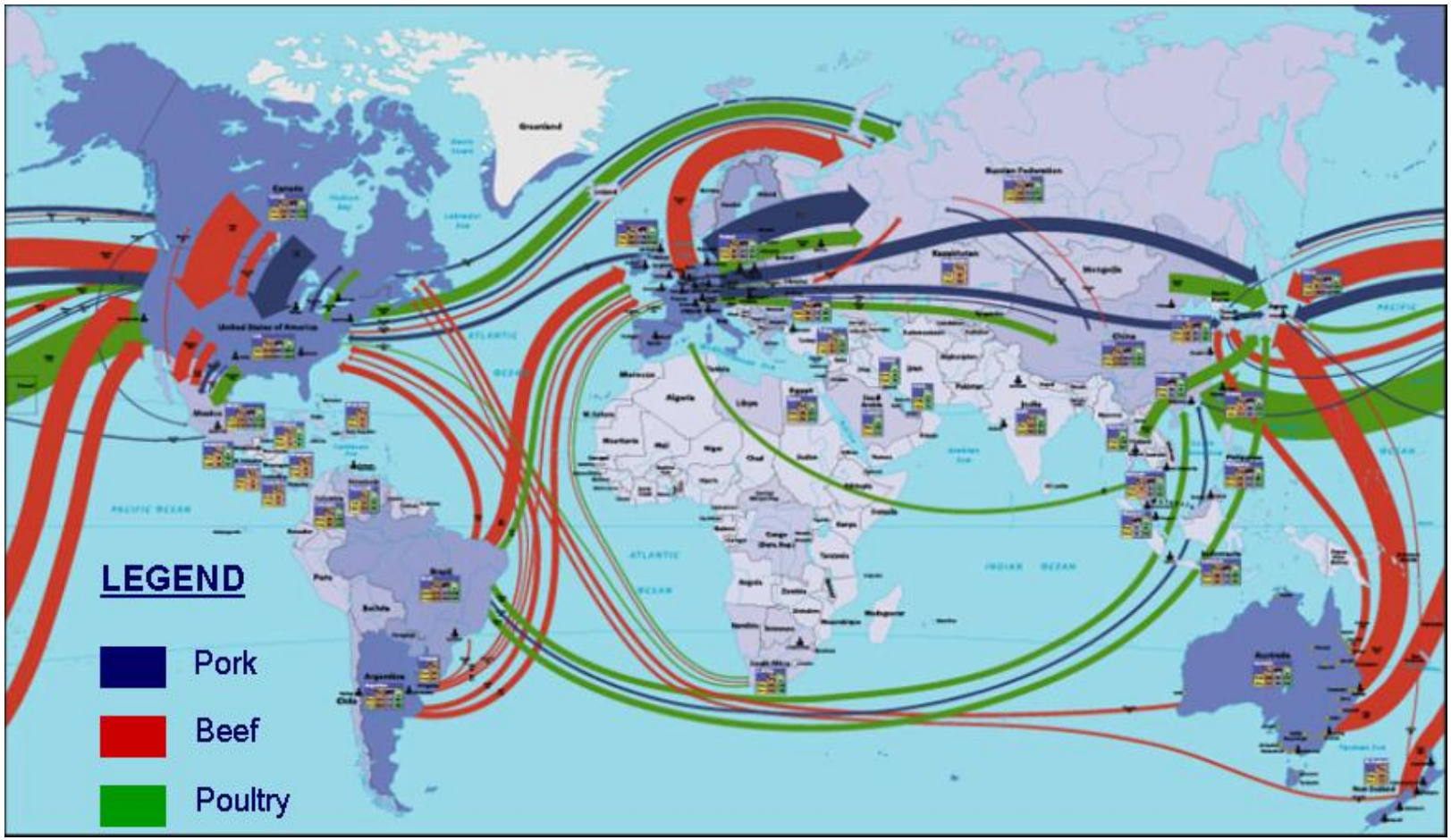
Global Meat Trade is Highly Concentrated



Source: Center for Global Food Issues

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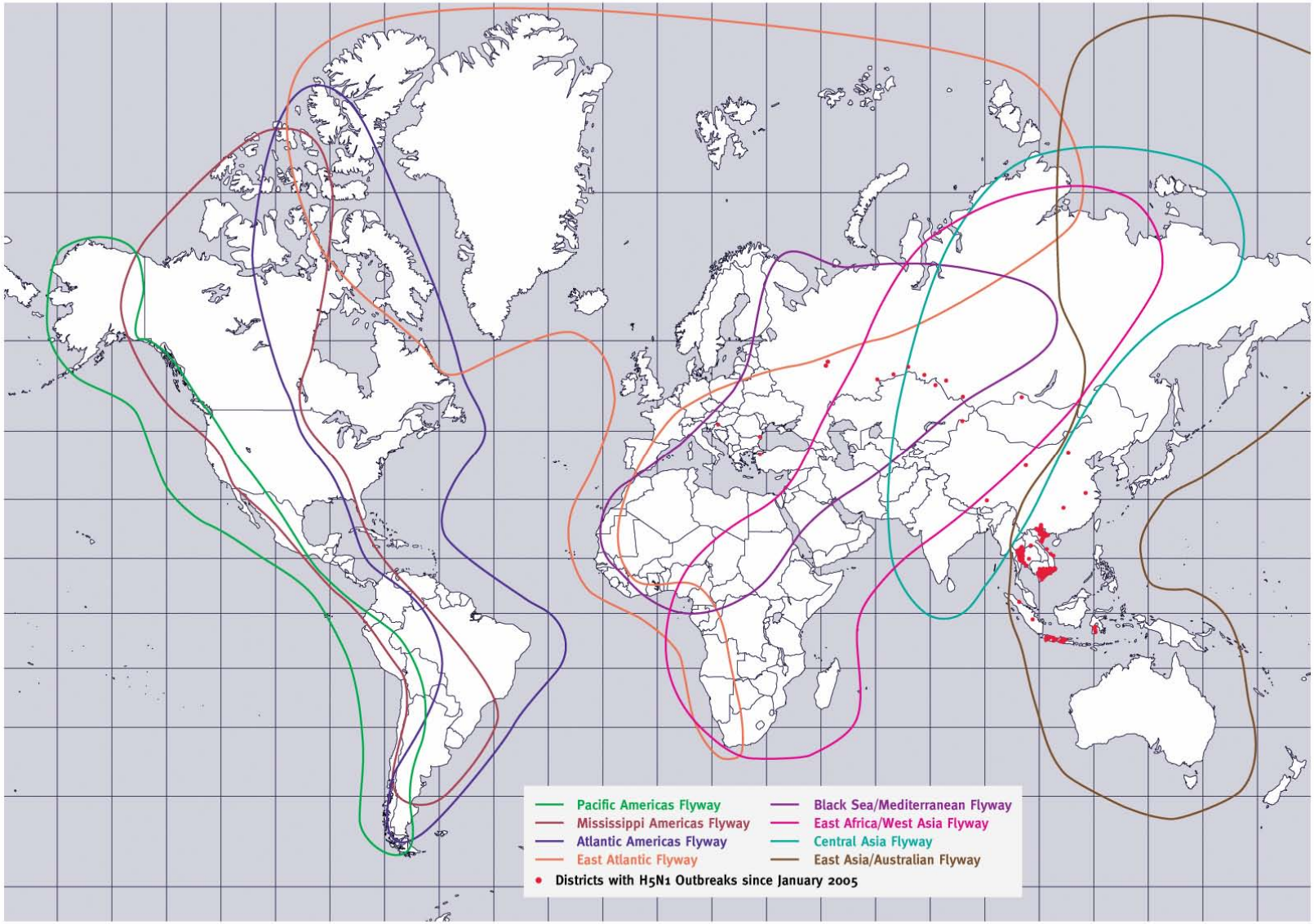
H5N1 Outbreaks in 2005 and Major Migratory Flyways



Sources: AI Outbreaks — OIE, FAO, and government sources; Flyways — Wetlands International

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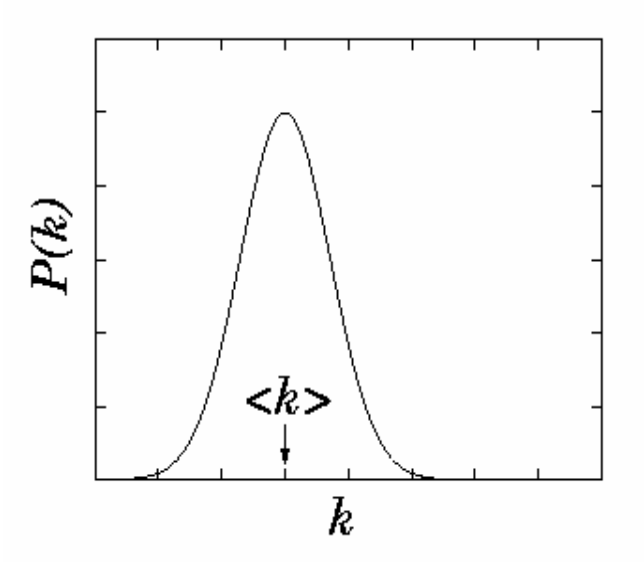
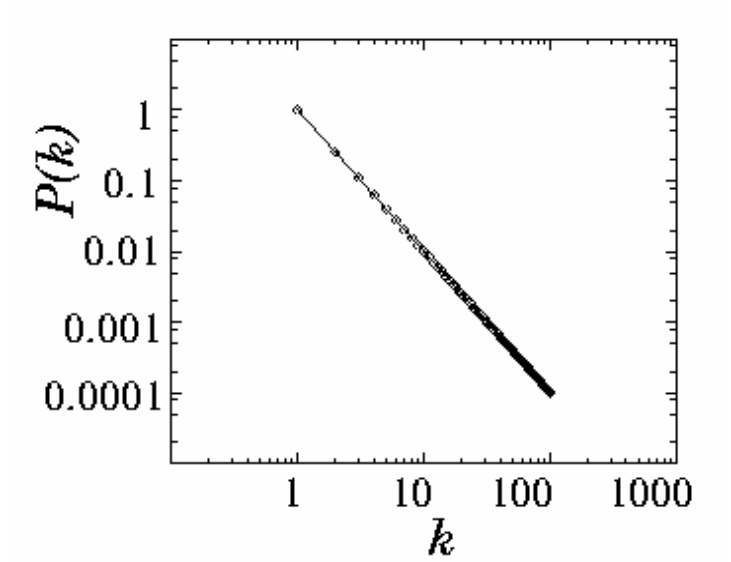
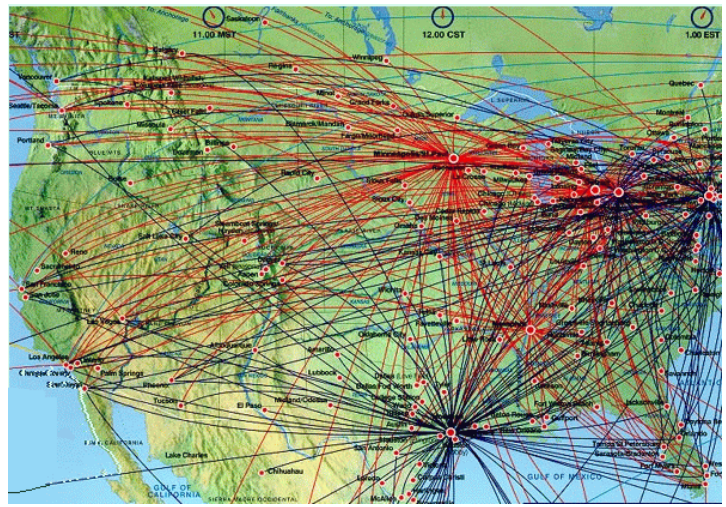
Poisson distribution



Power-law distribution



Exponential Network



Scale-free Network

Control and Mitigation Methods Are Evolving Quickly

- Mass culling has been effective, but at a high cost
- Trade embargoes are crude tools to control disease
- New monitoring and detection systems are being put in place
- Vaccination is now being used, but evolutionary implications are unknown
- Rapid testing technologies have been developed

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H5N1 Avian Influenza: Scenario Elements

Driving Forces

- Viral mutation, recombination and reassortment
- Human susceptibility to influenza pandemic
- Pathogen exchange among wildlife, livestock, and humans
- Globalization of trade and travel
- Increasing meat demand and livestock populations

Major Uncertainties

- Evolution of H5N1 to highly human-transmissible form
- Speed of dissemination of a pandemic
- Effectiveness of antiviral drugs in treating pandemic strain
- Effectiveness of human vaccines in treating pandemic influenza

Predetermined Elements

- H5N1 endemic in parts of Asia
- Human H5N1 infections will continue to occur
- H5N1 continues to evolve in the environment
- Vaccine manufacturing capacity with current technology is limited

Prime Movers

- H5N1 virus
- WHO and world public health community
- Suppliers of unapproved treatments
- FDA and other regulators
- Poultry farmers/industry

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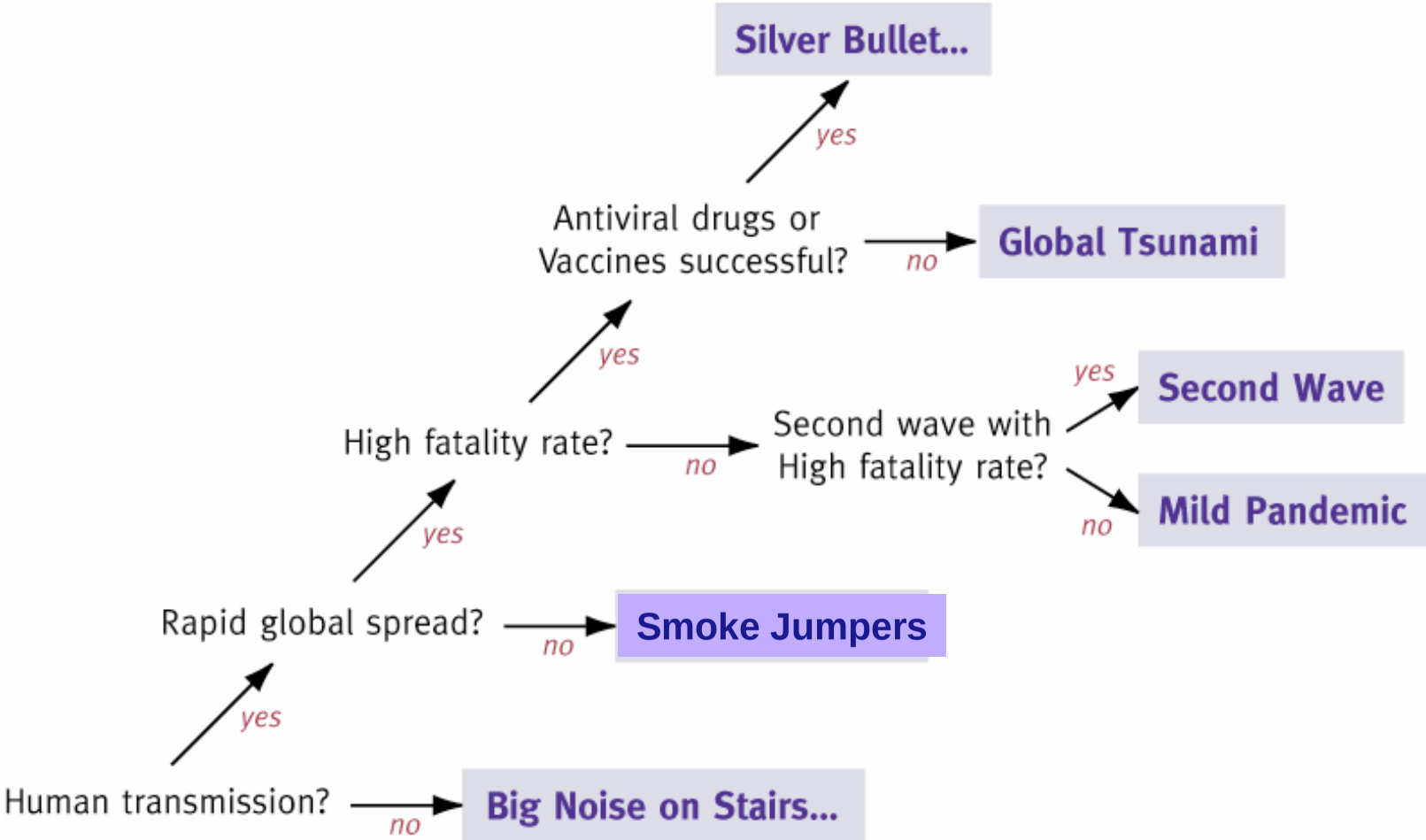
The Scenarios Map: Structuring the Landscape



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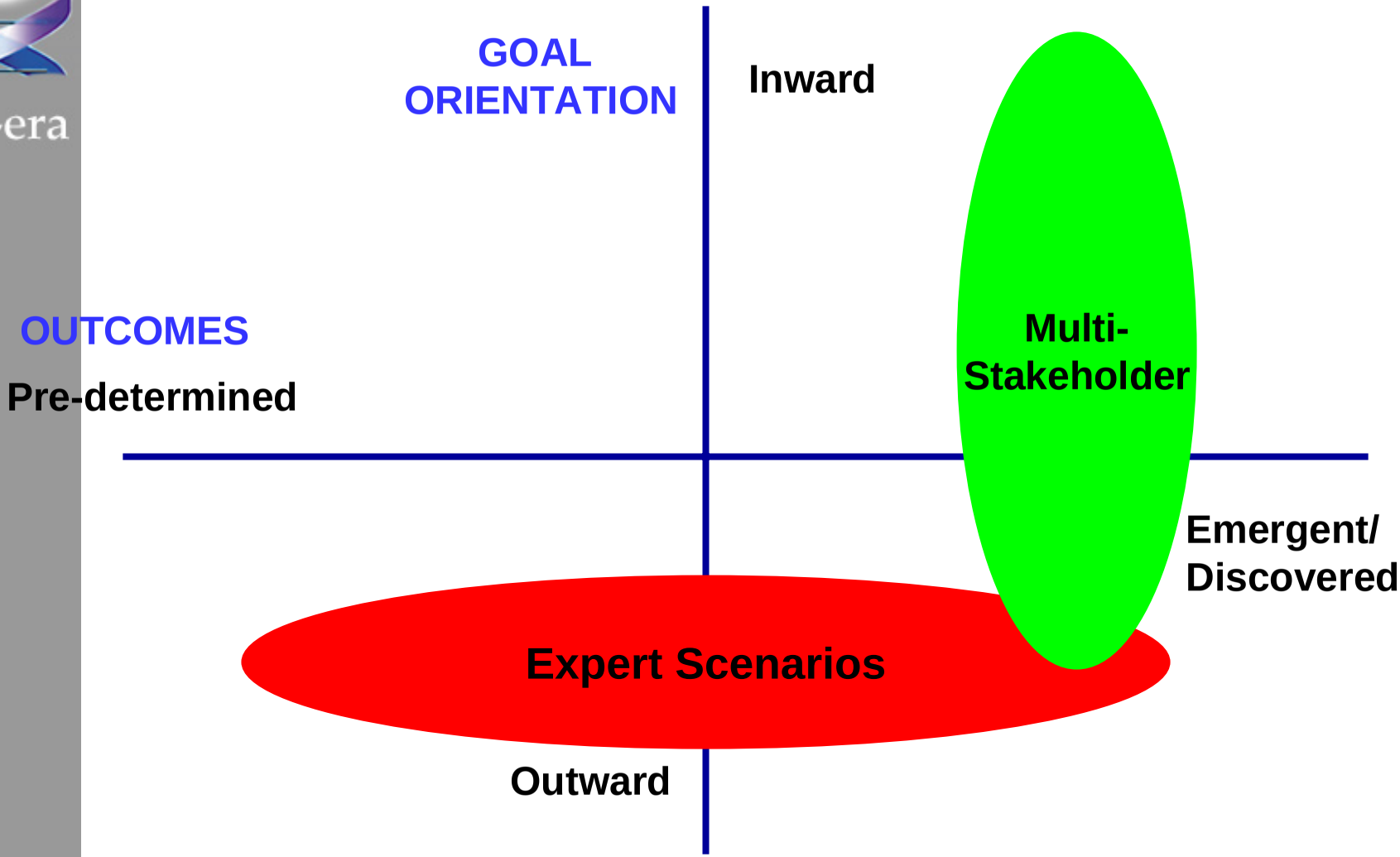
Taking the Long View: Key Areas for Planning and Collaboration

- **Monitoring and surveillance: high performance, low cost, widely available field-testing equipment**
- **Leveraging knowledge about livestock biosecurity: best practices**
- **Improving animal waste and waste water management: infrastructure and operational practices**
- **Strengthening environmental and health perspectives in supply chain planning and management**

Expert vs. Multi-stakeholder Scenarios



New Tools to Manage Biosecurity Risks

	Commodity Price Risk
Fundamentals analysis	Supply/demand, trade & investment
Scenario planning	Signposts, market dynamics
Intelligence/monitoring	Market benchmarks, basis risk
Financial risk management	Futures, options, derivatives, forward markets, insurance
Operational management	Flexibility, supply chain management

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New Tools to Manage Biosecurity Risks

	Commodity Price Risk	Biosecurity Risk
Fundamentals analysis	Supply/demand, trade & investment	Evolutionary biology, ecology, epidemiology
Scenario planning	Signposts, market dynamics	Emergence & florescence
Intelligence/monitoring	Market benchmarks, basis risk	Sentinels, testing, global tracking
Financial risk management	Futures, options, derivatives, forward markets, insurance	Futures, options, derivatives, forward markets, insurance
Operational management	Flexibility, supply chain management	Exclusion, defense, emergency response, supply chain management

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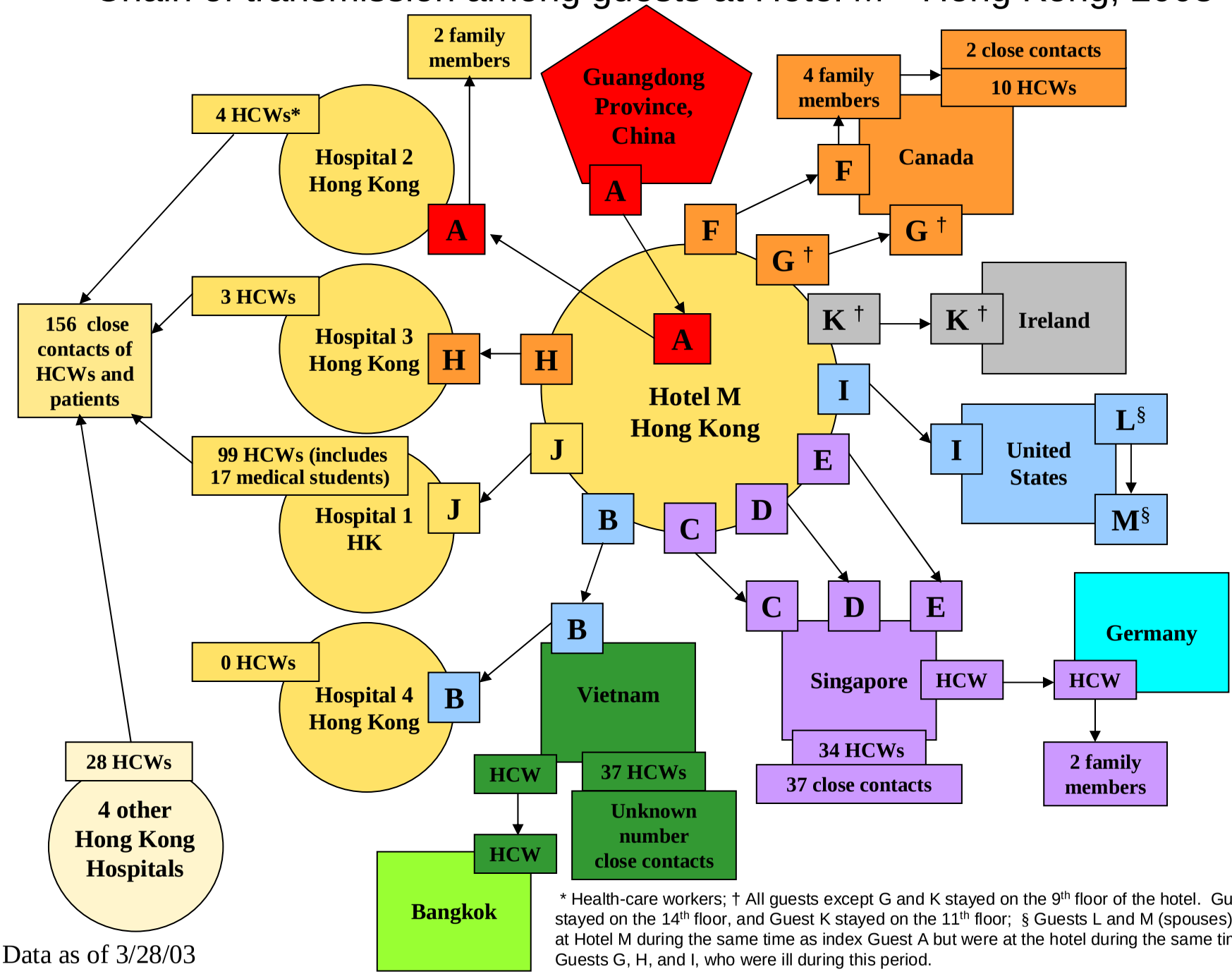
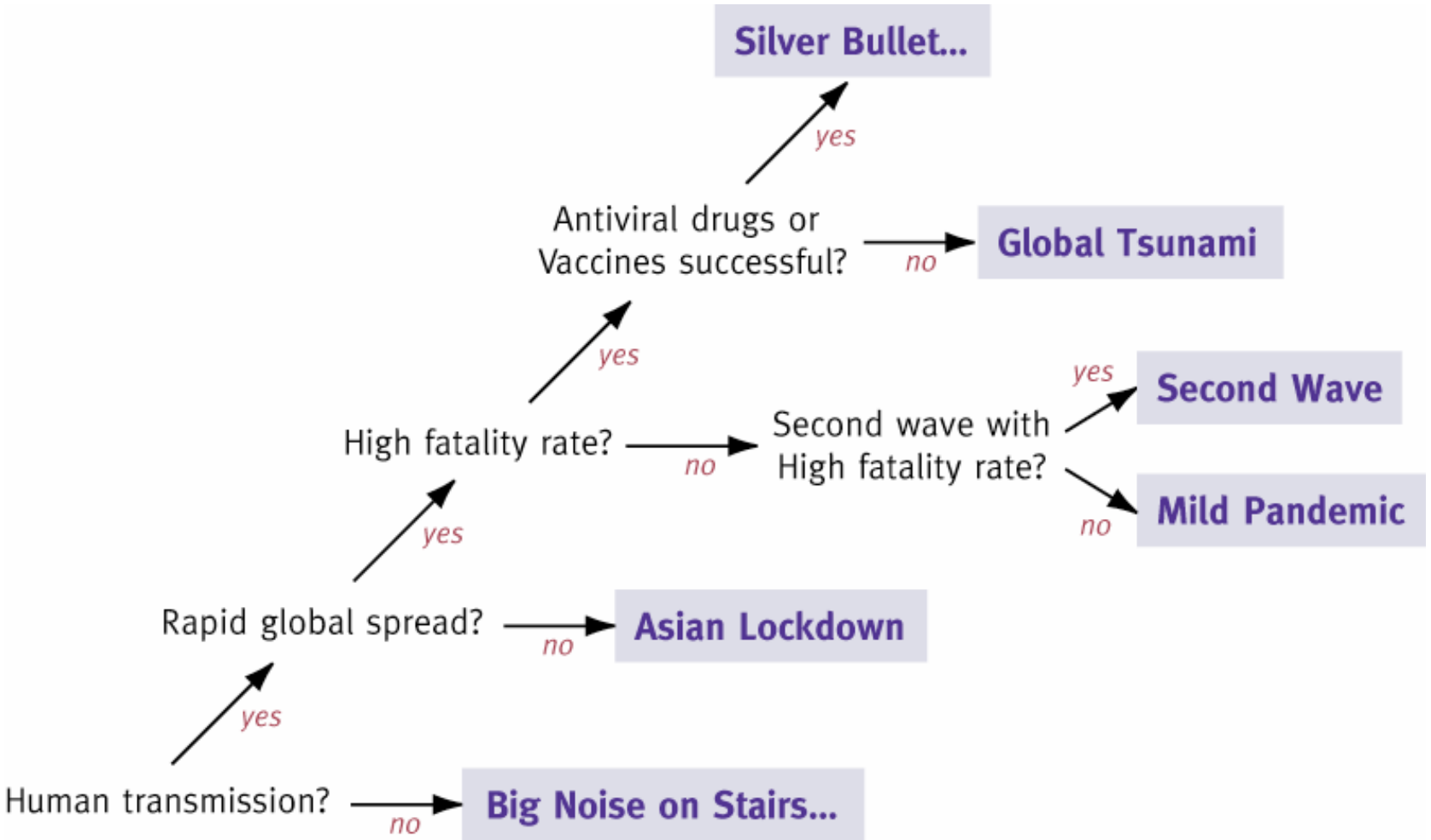
Chain of transmission among guests at Hotel M—Hong Kong, 2003



* Health-care workers; † All guests except G and K stayed on the 9th floor of the hotel. Guest G stayed on the 14th floor, and Guest K stayed on the 11th floor; § Guests L and M (spouses) were not at Hotel M during the same time as index Guest A but were at the hotel during the same times as Guests G, H, and I, who were ill during this period.

Data as of 3/28/03

The Scenarios Map: Structuring the Landscape



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Laboratory-confirmed Human Cases of H5N1 Avian Influenza, December 2003 to Present

	Unofficial*		Official†	
Country	Total Cases	Deaths	Total Cases	Deaths
Cambodia	4	4‡	4	4‡
Indonesia	10	6	9	5
Thailand	20	13	20	13
Vietnam	95	43	92	42
Total	**129**	**66**	**125**	**64**

* Reported by media or government sources.
† Calculated from WHO reports of confirmed human cases.
‡ 2 Patients became ill in Cambodia, but died in a Vietnamese hospital.

Source: Center for Infectious Disease Research and Policy (CIDRAP), Univ. of Minnesota

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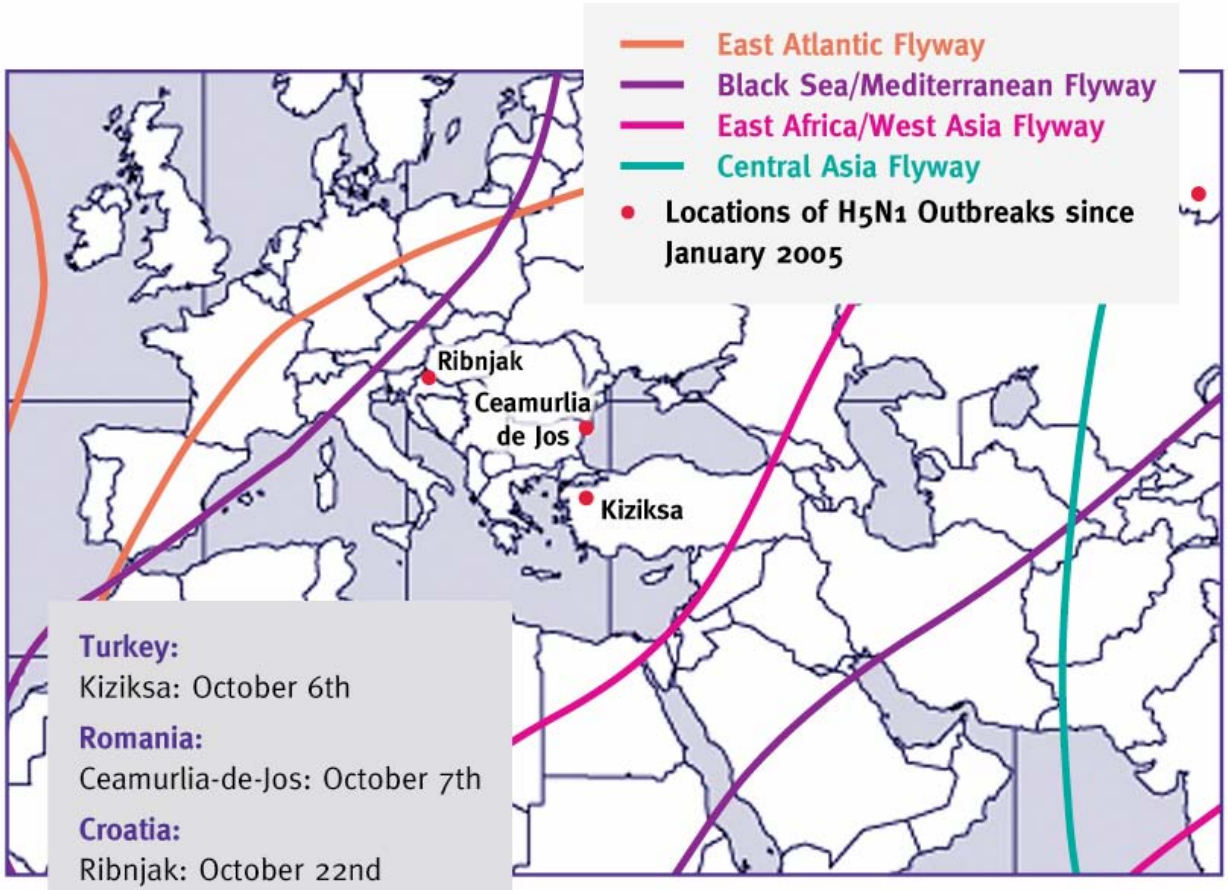
H5N1 Outbreaks in 2005 and Major Migratory Flyways, Europe and Asia



Source: OIE, FAO, Wetlands International

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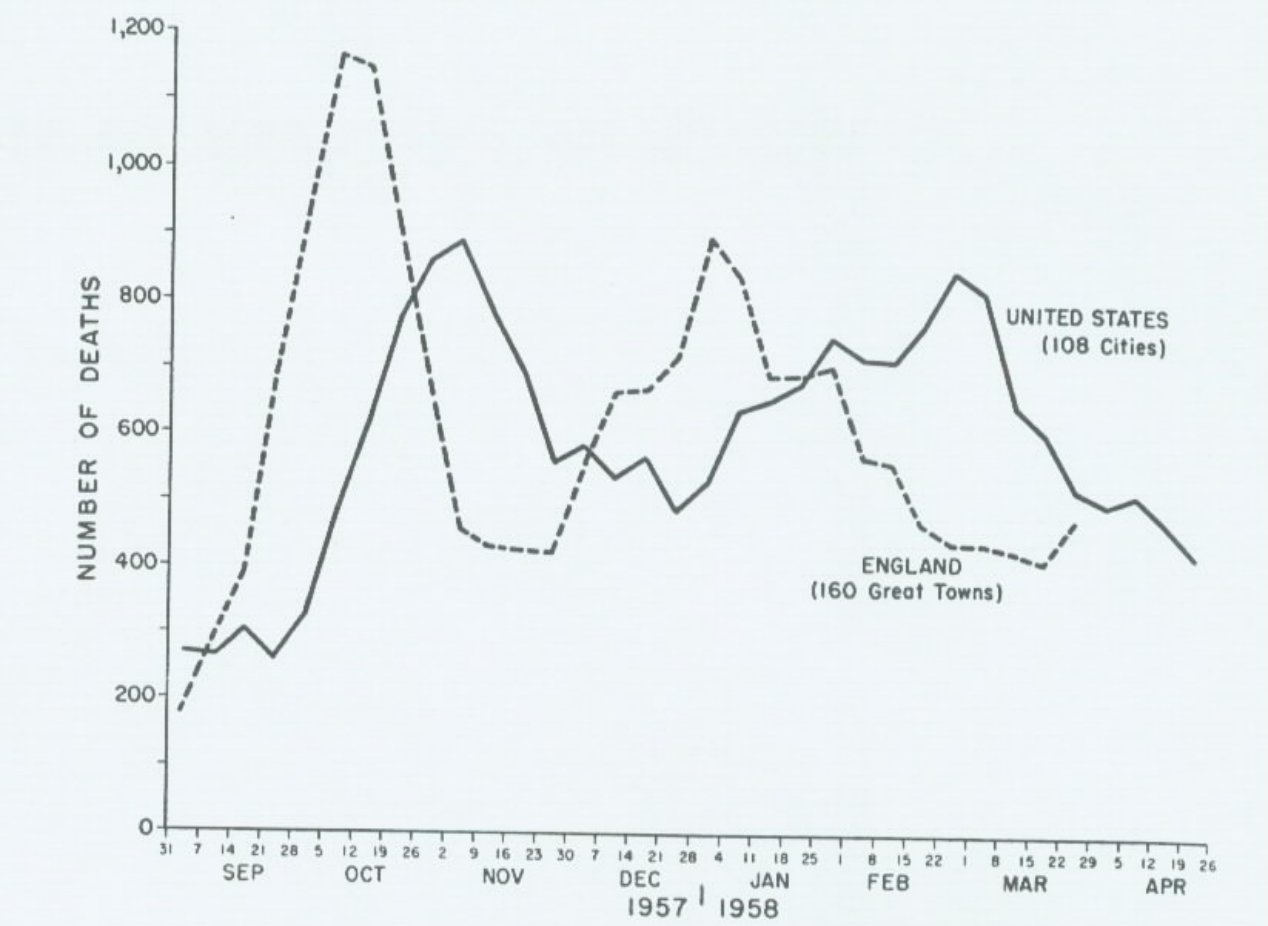
WHO Pandemic Phases

Phase 1	An influenza virus subtype that has caused human infection may be present in animals. If present in animals, the risk of human infection or disease is considered to be low.
Phase 2	No new influenza virus subtypes have been detected in humans. However, a circulating animal influenza virus subtype poses a substantial risk of human disease.
Phase 3	Human infection(s) with a new subtype, but no human-to-human spread At most, rare instances of spread to a close contact.
Phase 4	Small cluster(s) with limited human-to-human transmission Spread is highly localized, suggesting that the virus is not well adapted to humans.
Phase 5	Larger cluster(s), but human-to-human transmission is still localized Virus may not yet be fully transmissible.
Phase 6	Pandemic phase: increased and sustained transmission in the general population

Source: WHO

Influenza Waves in Rapid Succession



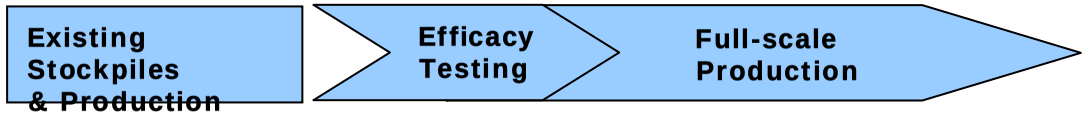
Source: CDC

Timelines for Pandemic Response Measures

Disease Progression

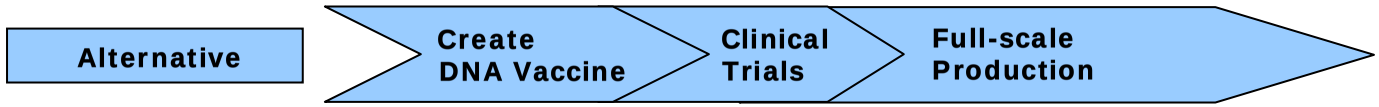
Hypothetical Pandemic: ***~6 Months*** (Modeled for 2000)

Vaccine Development



Doses: 100 mn Timetable: ***4-6 Months***

Doses: 100 mn Timetable: ***9-12 Months***



Doses: 150 mn Timetable: ***3-9 Months***

Antiviral Drug Use & Supply

Doses: 100 mn Timetable: ***4-6 Months***

Source: bio-era, National Geographic

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Existing and Planned Stockpiles of Vaccines and Antiviral Drugs*

Country	Product	Comments
Australia	Tamiflu	3.5 million five-day treatment courses.
	Relenza	3.95 million five-day treatment courses
Canada	Tamiflu	35 million doses.
	H5N1 vaccine	"Several thousand" doses ordered for clinical testing.
China	H5N1 vaccine	Developing and testing H5N1 vaccine; planned stockpile levels unknown.
France	Tamiflu	13 million five-day treatment courses.
	H5N1 vaccine	2 million doses.
Hong Kong	Tamiflu	2.7 million doses stockpiled; additional purchases planned to reach 18 million doses in 2007.
	Relenza	300,000 doses stockpiled; additional purchases planned to reach 2 million doses in 2007.
Italy	H5N1 vaccine	2 million doses ordered.
Japan	Tamiflu	Plans to stockpile 20 million doses.
Netherlands	Tamiflu	220,000 doses stockpiled; 5 million doses ordered.
New Zealand	Tamiflu	835,000 doses ordered; to be delivered by year-end.
Singapore	Tamiflu	350,000 courses planned.
South Korea	Tamiflu	700,000 doses; 900,000 by January 2006.
Taiwan	Tamiflu	230,000 doses; 700,000 additional planned.
Thailand	Tamiflu	700,000 courses; 3 million planned by 2007.
United States	Tamiflu	2.3 million courses stockpiled; up to $3.1 billion approved for additional supplies.
	H5N1 vaccine	8,000 doses delivered for clinical trials; 2 million doses ordered. Up to $3.3 billion approved for additional supplies.
United Kingdom	Tamiflu	14.6 million courses; to be delivered over the next 2 years.

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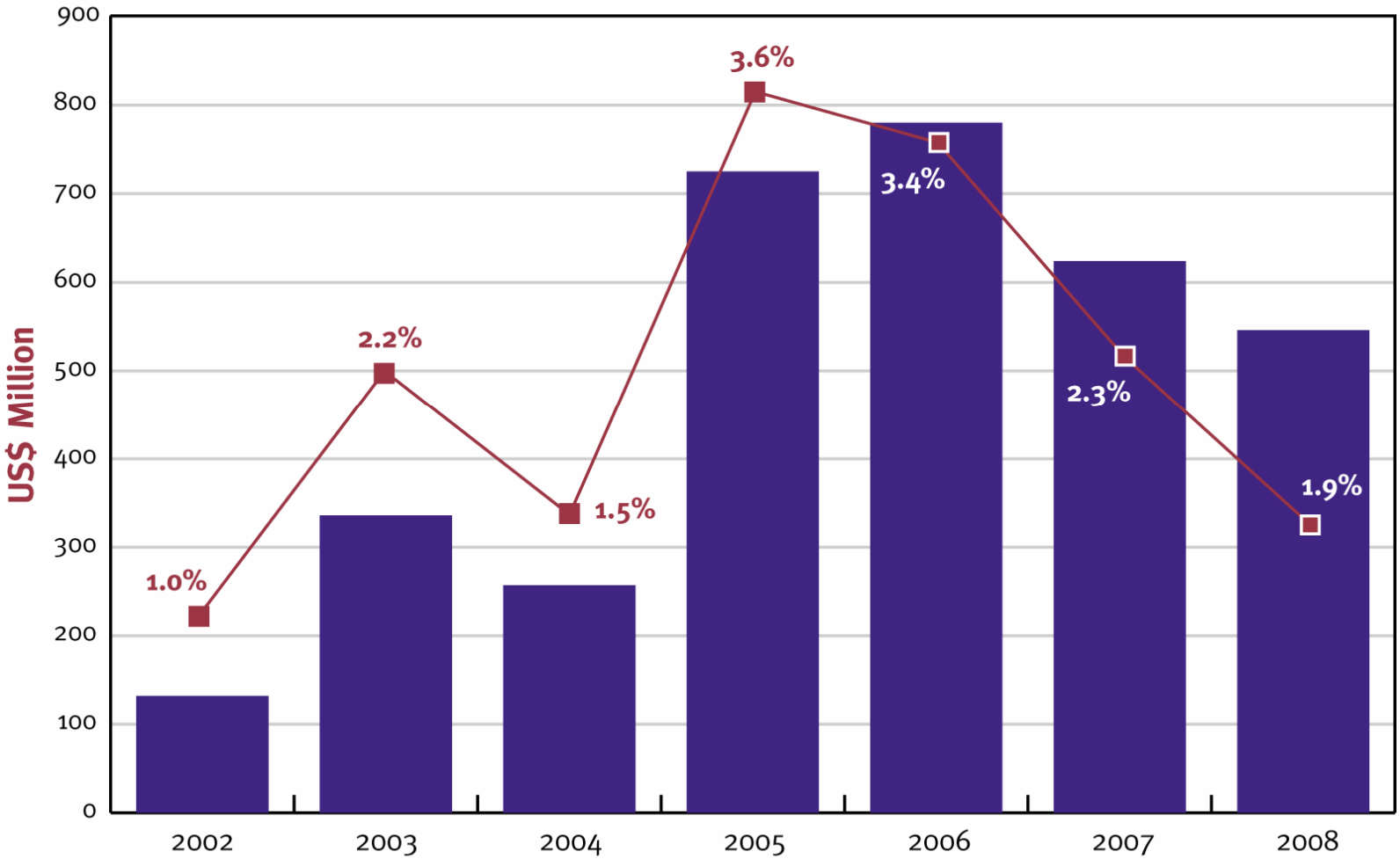
Tamiflu Revenues/Forecast and % of Roche's Total Pharma Sales



Sources: Roche, Julius Baer

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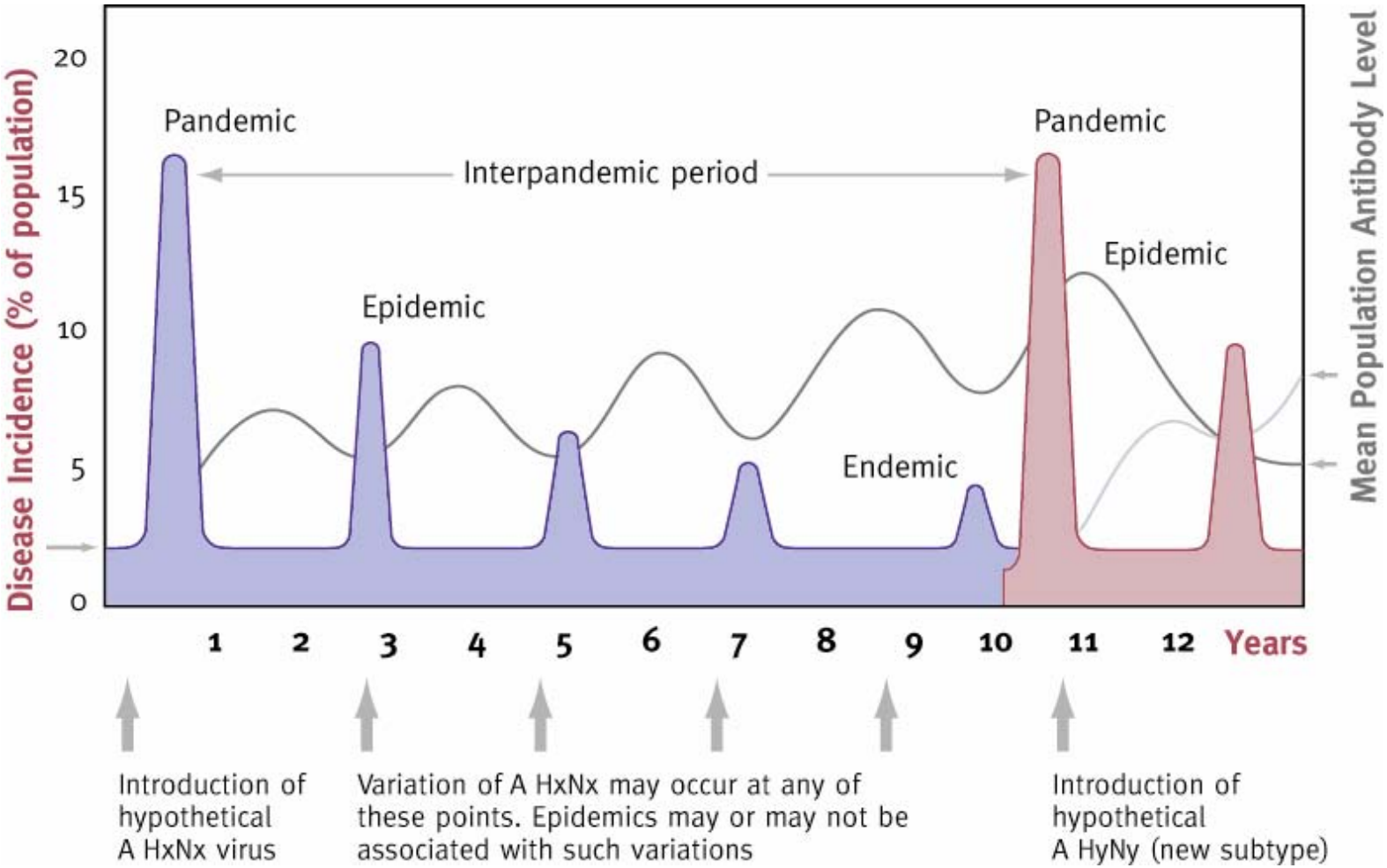
Disease Cycles: Pandemics and Epidemics



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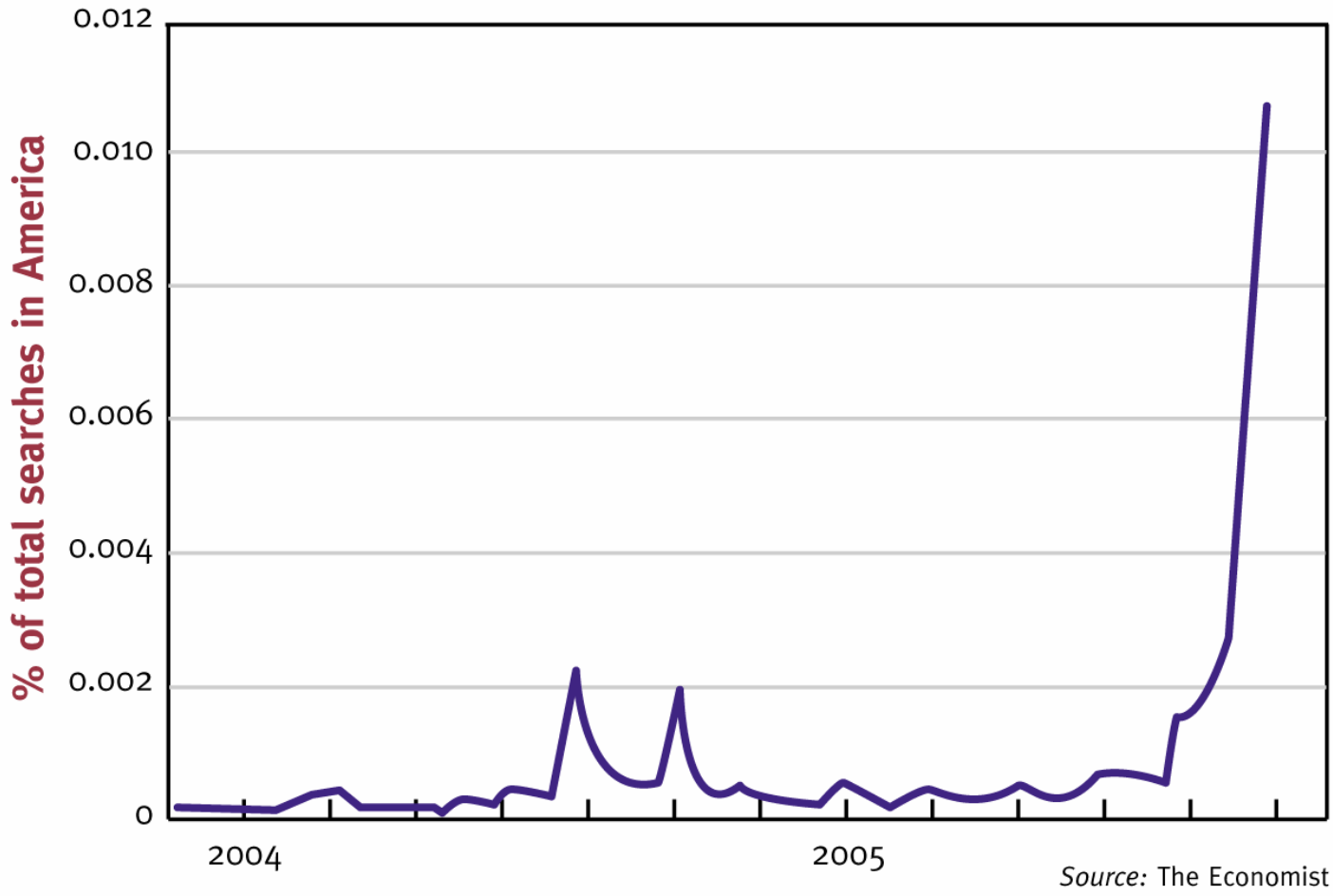
Internet searches for terms "bird flu" or "avian flu"



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Myth #1: An H5N1 Pandemic Is Inevitable

Some experts claim an H5N1 pandemic is inevitable; others assert that "we're just one mutation away" from a pandemic

- **Scientific evidence is mixed on how rapidly efficient human-to-human transmission could evolve (see Ewald; *Scientific American*)**
- **H5N1 has existed in Asia since 1997 without causing a pandemic (there are clear reasons for heightened concern, but it remains uncertain whether a pandemic will emerge)**
- **If the disease evolves slowly, effective countermeasures could become available**

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Myth #2: Closing National Borders Could Stop the Spread of a Pandemic

Some countries have developed plans to close national borders in the event of a pandemic

- **Modeling of disease spread based on simulations of contact networks indicate that border closures are likely to have modest impacts on the rate of disease spread (see Ferguson; Imperial College)**
- **Border screening for SARS was largely ineffective in detecting cases; influenza is significantly more difficult to detect in its early stages**
- **Uncoordinated border control policies could cause serious economic damage**

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Myth #3: A Pandemic Would Be a Devastating Economic Event

Some analysts assert that a pandemic would immediately trigger a global economic depression

- **Changes in the global economy have increased risks and response capabilities, making prediction of economic consequences extremely difficult: the range of possible outcomes is very wide**
- **The direct costs of a moderate pandemic are almost certainly manageable from a macroeconomic perspective**
- **Timing is critical, as control measures are being rapidly developed**
- **A "second wave" of disease could cause significant economic damage**

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Myth #4: The Economic Damage Depends on the Severity of the Disease

Most estimates of the health-related costs of a pandemic are based on assumptions about mortality and morbidity

- **SARS caused ~8,000 infections and 800 deaths globally, but resulted in $30–50 billion in economic damages**
- **Secondary economic impacts of the disease and supply chain disruptions could be the most significant economic consequences**
- **The financial and economic outcomes are sensitive to behaviors of investors, consumers, and governments in the earliest stages**

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Myth #5: Tamiflu and Vaccines Are The Best Tools to Control the Disease

Many governments have focused on stockpiling Tamiflu (Oseltamivir) and H5N1 vaccines to control the disease

- **H5N1 vaccines now being developed may not be effective; new vaccines may not be available in time**
- **Tamiflu *may* be effective, but is available in limited supply**
- **"Social distance" and community hygiene strategies are proven to be effective in reducing infection rates**
- **Preventing the emergence of the disease at its source, the animal-human interface is the best preventative strategy**

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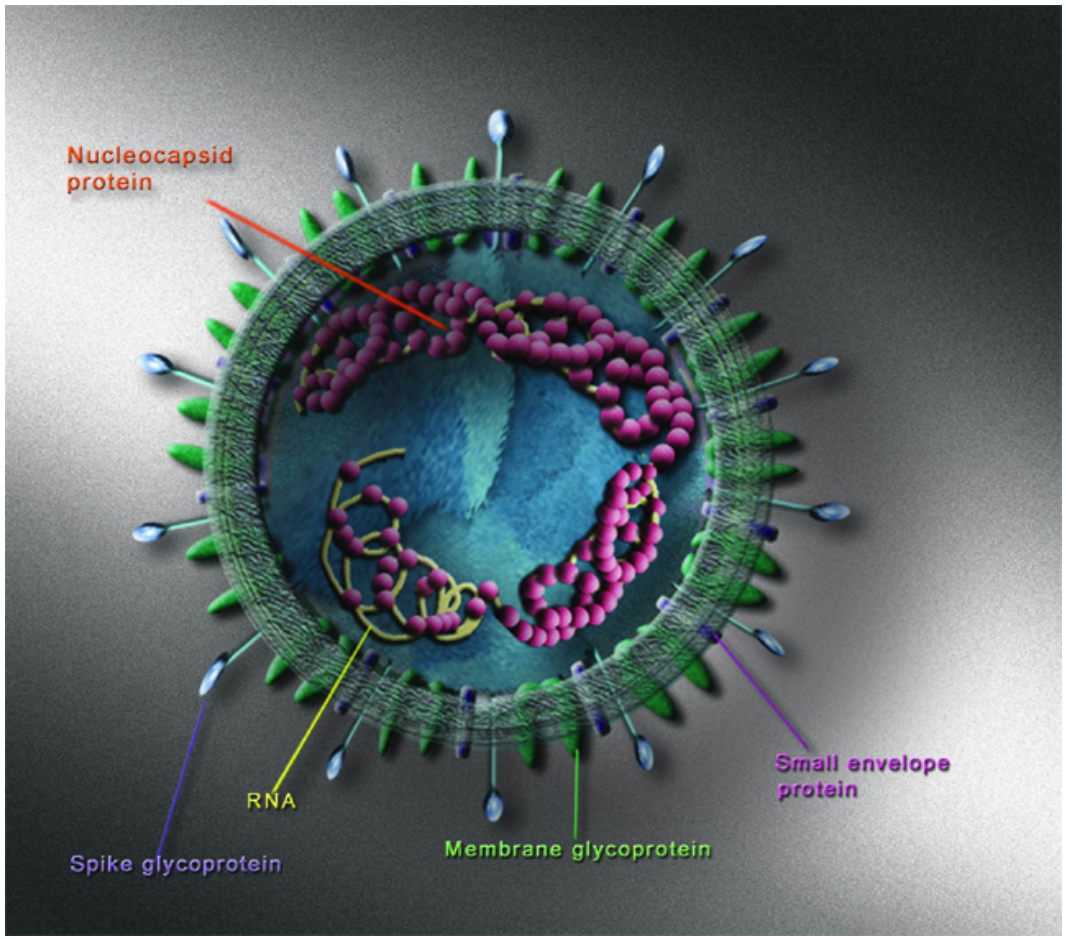
SARS: Lessons Learned



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Stage	Features	Shocks
Pandemic Alert	Increasing global demand for countermeasures Marked declines in poultry demand in areas of active H5N1 infection	Mild, and largely localized Fear-based reactions cause mostly local disruptions
Emergence	Global media focus Trade and travel disruptions, with unpredictable secondary effects on global supply chains.	Serious shocks to national and regional economies that surround the emergence event Some fear-driven spillover into global financial markets
Containment Efforts	Countermeasures to prevent spread are rushed into outbreak area Lack of access to stockpiles could threaten coordinated, cooperative response	If containment efforts fail, the inadvertent compounding of fear becomes a major threat
Global Spread	Despite containment efforts, disease begins global spread Timing of spread is unpredictable, but local epidemics mostly run their course in about 4-6 weeks	The depth of the shock to the global economy will depend on the severity and duration of the pandemic, the reactions of governments, and the extent to which fear effects are minimized
Abatement & Recovery	Normal economic activity begins to resume as fears and disease abate Timing will depend on damage, and whether fear of a second wave of disease can be addressed	Indications of a second wave of disease spreading could interrupt the recovery unless effective countermeasures are available

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Public Health Resources in Affected Countries Are Severely Limited

Cost Comparisons for Vietnam	
Total per capita health expenditure (annual)	$21
Rapid test to detect influenza A	$8
Test to detect H5 subtype	$30
Treatment course, antiviral drugs	$30–40
Projected cost, domestically produced vaccine	$1-2

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A Vital Linkage in the *Economic Transmissibility* of Avian Flu

Biology and Borders: Government Plans to Restrict Trade and Travel at National Borders

- **Hong Kong**
  - Reconsidering a plan to seal its borders with China in the event of human-to-human transmission
  - Currently considering other control measures, including travel restrictions and temperature checks at borders
    - *November preparedness exercise will assess the need to close schools, public places, and restrict nonessential services and activities.*
- **Australia**
  - Preparedness plan calls for the implementation of entry screening and possible exit screening:
    - *Health declaration cards*
    - *Thermal scanning*
    - *Aircraft commanders required to declare the health of all incoming passengers*
- **New Zealand**
  - Public suggestion of border closures from the Ministry of Economic Development

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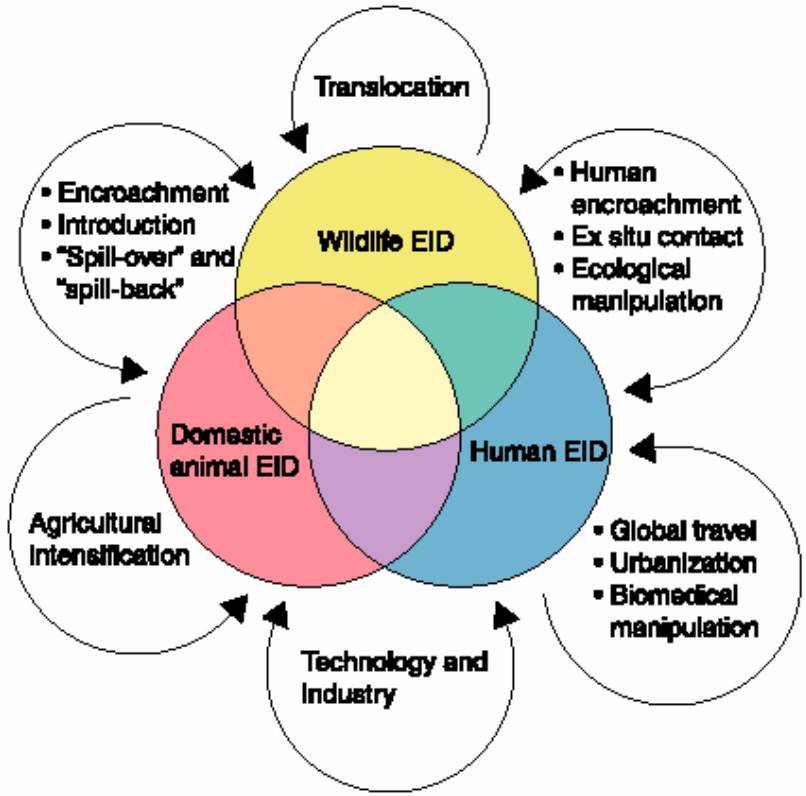
The Story of Emerging Infectious Disease:
Increasing Interactions Between Wildlife, Livestock, & Human Populations

- **Fundamental forces are driving new infectious disease threats**
- **Emerging diseases are causing increasingly significant economic disruptions**
- **Avian influenza poses especially large potential risk**



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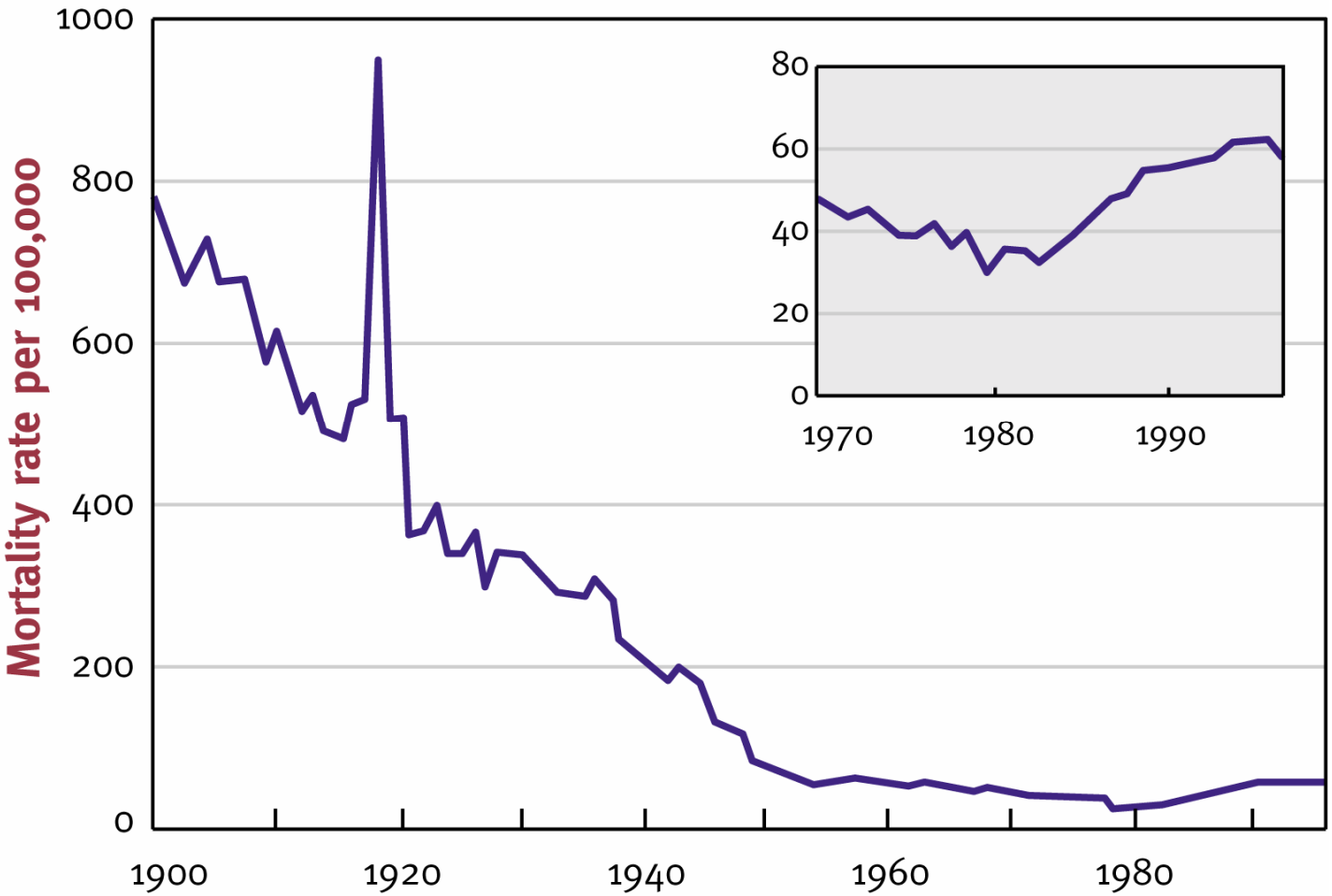
Infectious disease mortality in the U.S., 1900 to 1996



Source: Centers for Disease Control & Prevention