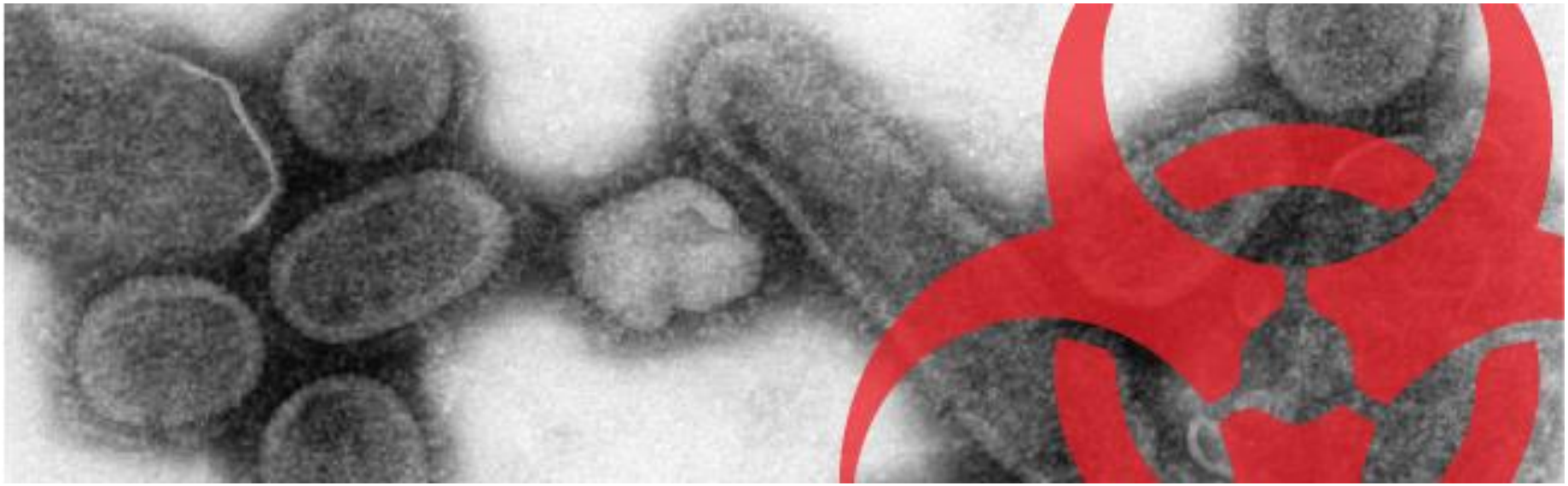


Are You Ready for the Next Pandemic?

Nita Madhav, MSPH, CCM

Doug Fullam, ASA

Agenda

- Science behind pandemic emergence
- AIR Pandemic Flu Model – In Depth
- Modeling a “Modern-Day” Spanish Flu Pandemic
- AIR Pandemic Flu Model validation and benchmarking
- Case studies

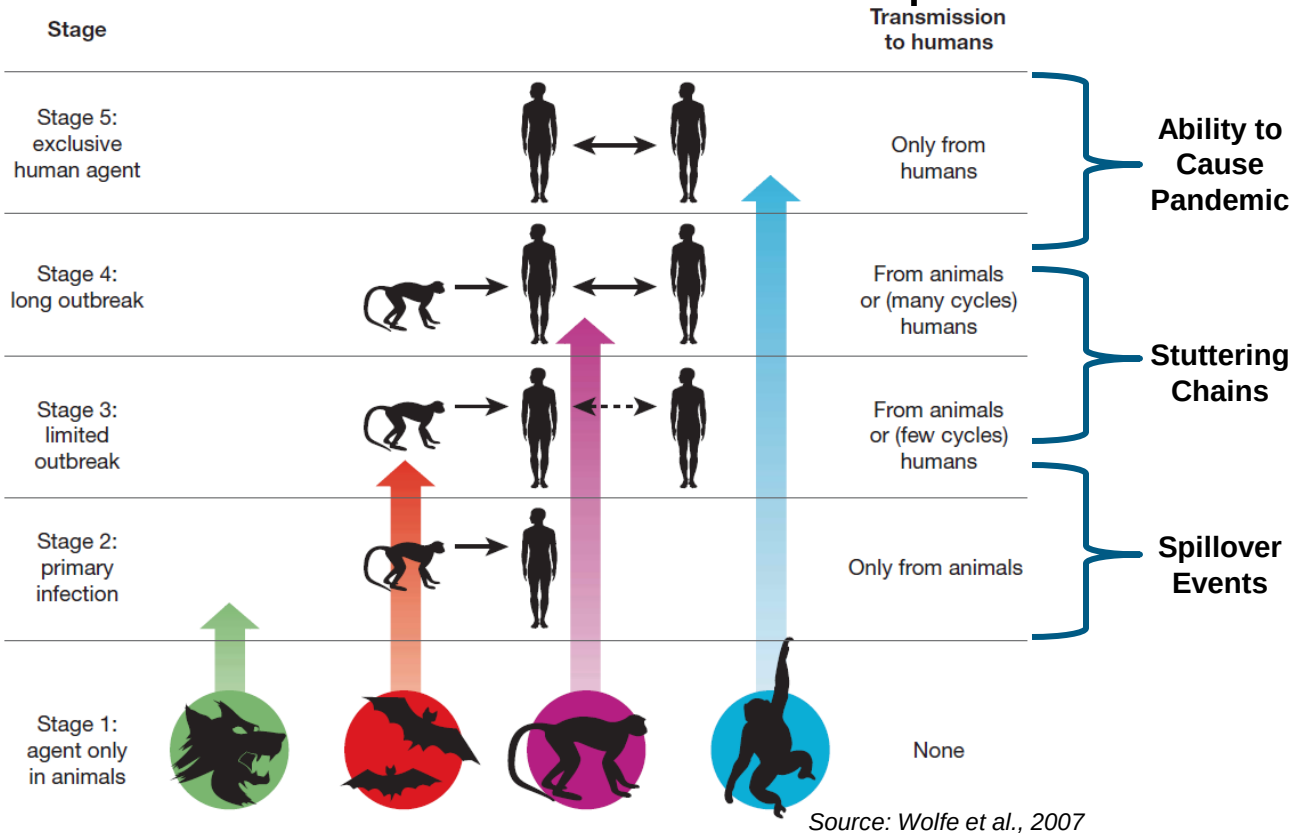
Pandemics Can Be Significant Drivers of Loss to the Insurance Industry

- Pandemics are low-frequency events with potentially high severity and impact
- Potential insurance impacts include:

• Life	• Workers' Compensation	• Disability	• Travel and Event Cancellation
• Health	• Personal Accident	• Business Interruption	• Tuition Reimbursement

Emerging Infectious Diseases Are a Constant Threat

- 5-6 infectious diseases emerge or re-emerge per year
- The majority of these diseases are of animal origin
- Some of these diseases could cause a pandemic

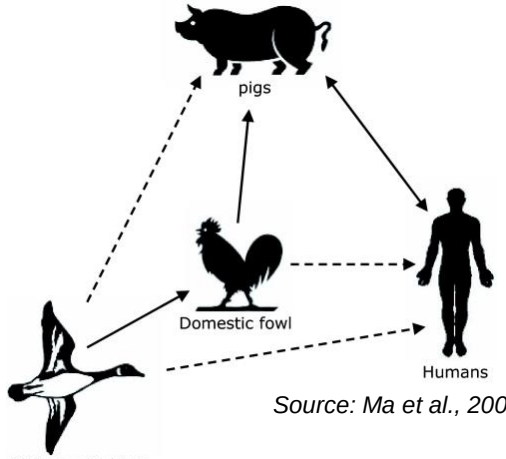


Source: Wolfe et al., 2007

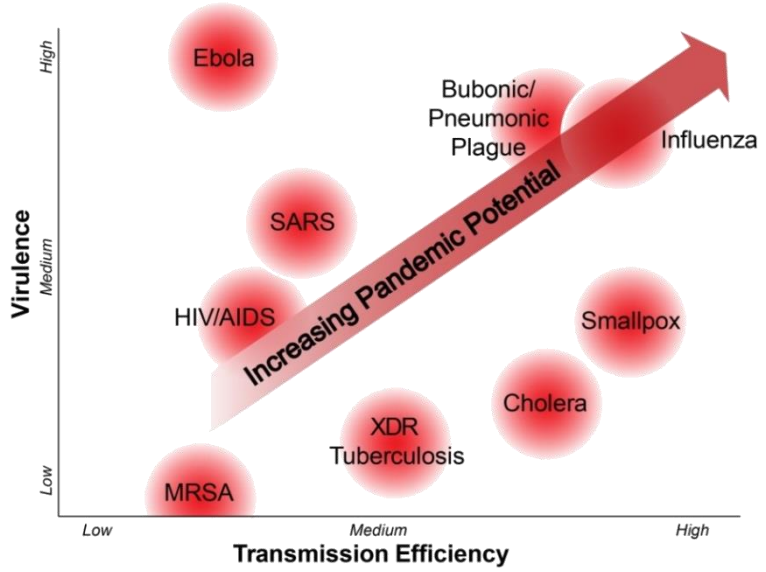
Influenza Has Significant Potential to Cause a High-Severity Pandemic

- New influenza strains arise from genetic mutations
  - Frequent re-assortment between human and animal strains
  - Low-fidelity replication results in many genetic variants
- Little to no human immunity to pandemic strains
- Novel influenza viruses have the potential for both high transmission efficiency and high virulence

Interchange of Animal and Human Influenza A Viruses



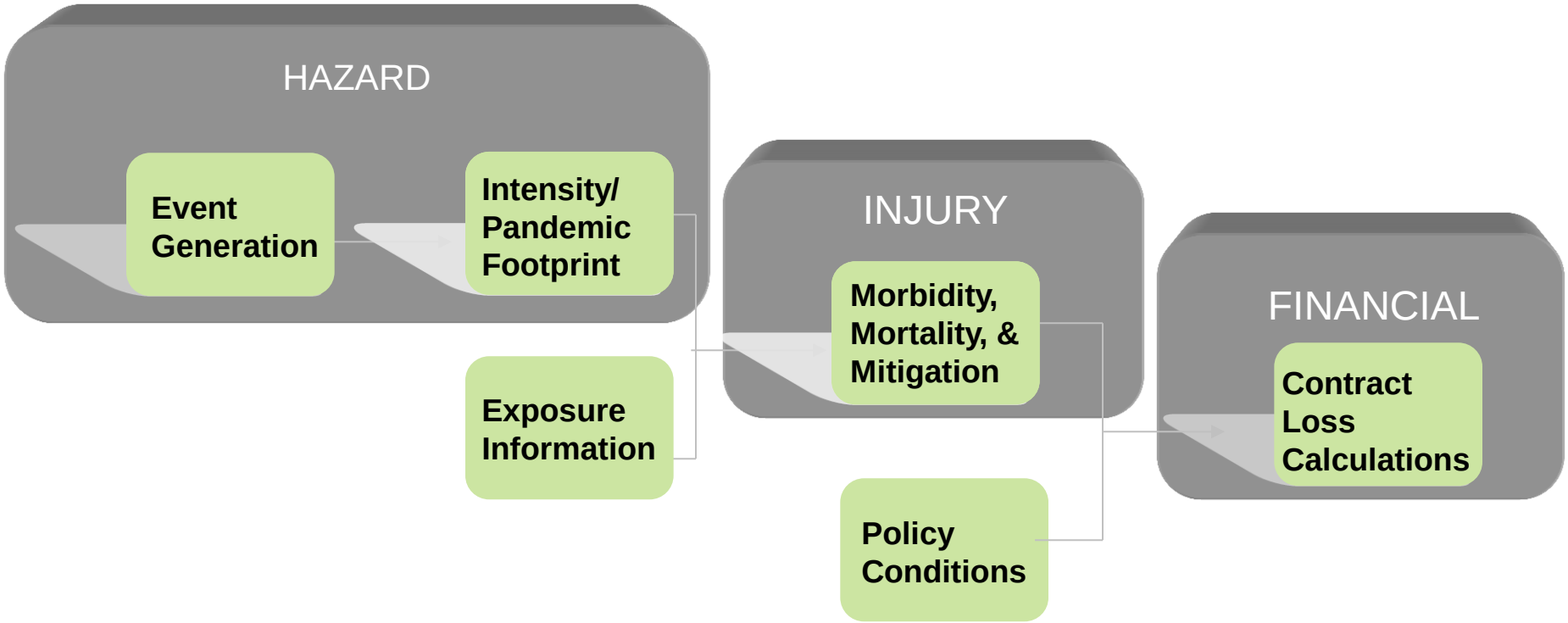
Source: Ma et al., 2008



Probabilistic Modeling Enables a More Robust Understanding and Management of Pandemic Risk

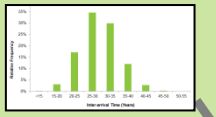
- Challenges of modeling pandemic risk
  - Extended duration and multiple waves
  - Wide geographical extent, leading to correlation between countries
  - Historical events are infrequent and significant changes have occurred since historical events have taken place
- Advantages of probabilistic modeling
  - "Fills in the gaps" from relying solely on infrequent historical data
  - Better accounts for changes since historical times
  - Incorporates the very latest in scientific research

AIR Pandemic Flu Model Follows the AIR Catastrophe Modeling Framework

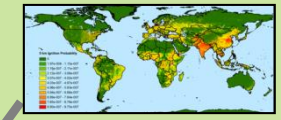


Peer-Reviewed, Fully Probabilistic AIR Pandemic Model Estimates Morbidity and Mortality Risk

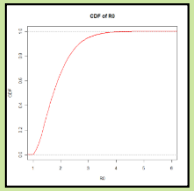
Stochastic Event Generation



Annual Frequency

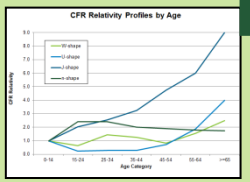


Location Frequency



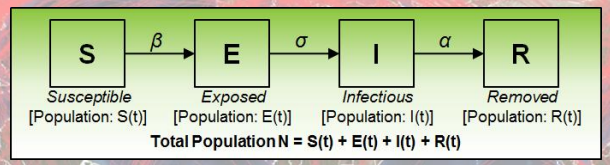
Transmission Ability

Stochastic Catalog



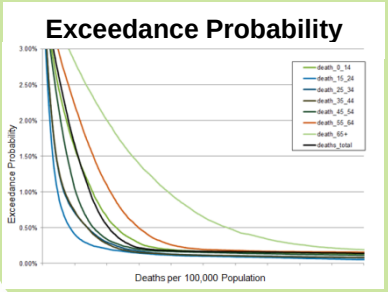
Virulence by Age/Gender Cohort

SEIR Model Coupled with Long-/Short-Range Travel and Mitigation Measures



Pharmaceutical Interventions	Non-Pharmaceutical Interventions
Vaccines	Travel Restrictions
Antivirals	Airport Closures

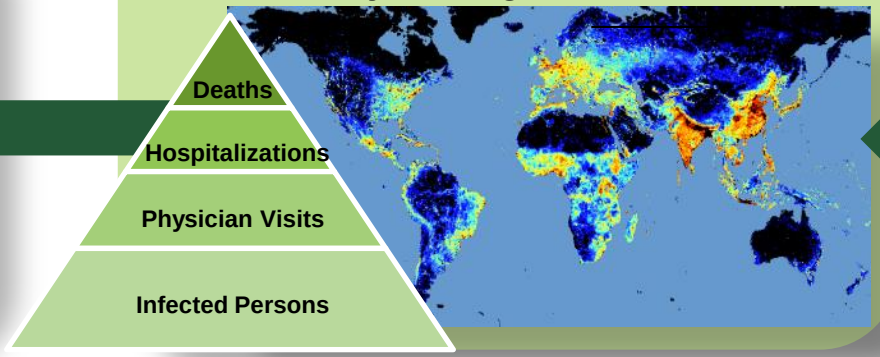
Financial Impact & Portfolio Analytics



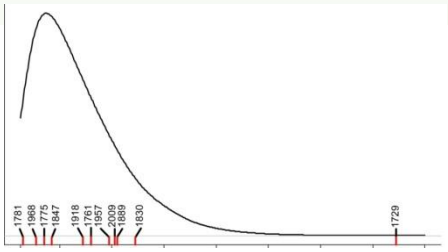
Life Insurance Losses

Health Insurance Losses

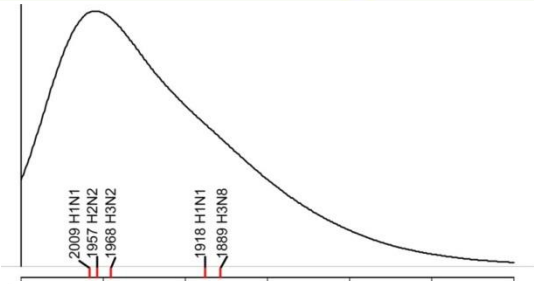
Event Footprint by Illness Severity and Age/Sex Cohorts



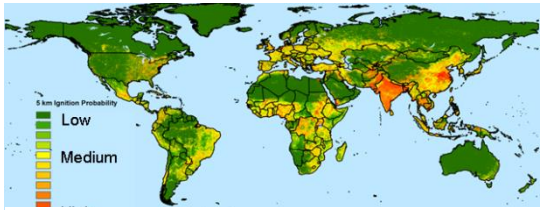
Event Generation Begins with a 500,000 Year Stochastic Catalog Including 18,000 Influenza Pandemics



Annual Frequency

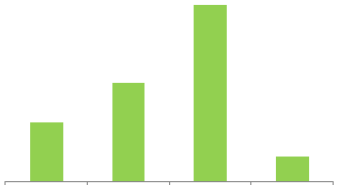


Human-to-Human Transmissibility

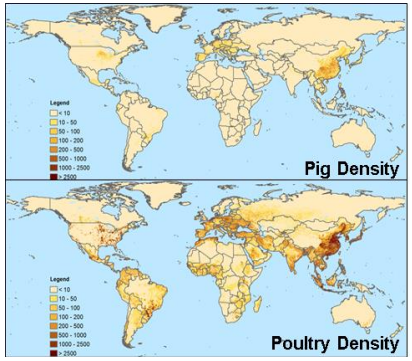


Spatial Ignition Frequency

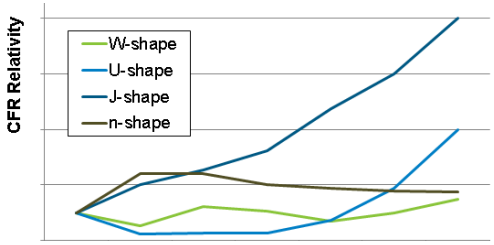
Stochastic Catalog



Virulence

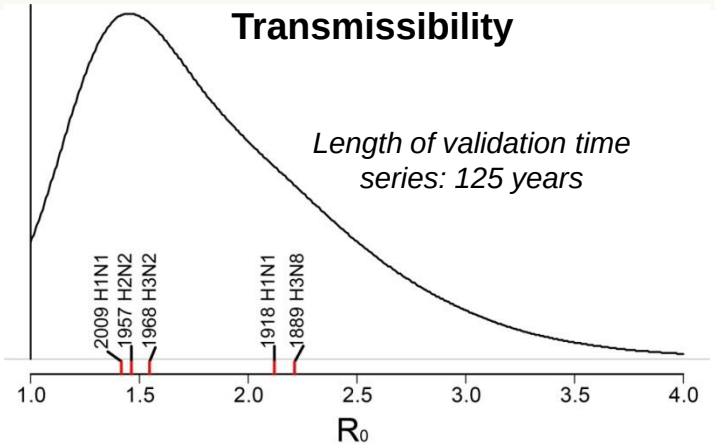


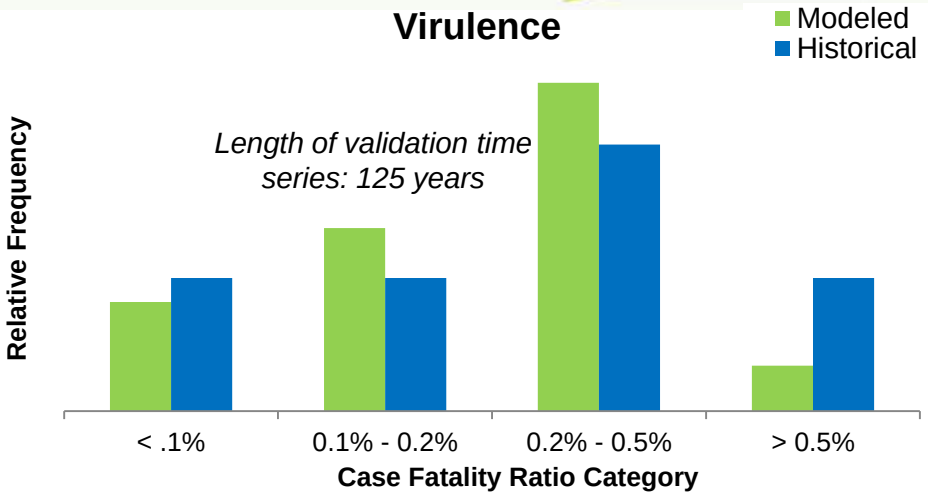
Animal-to-Human Transmissibility

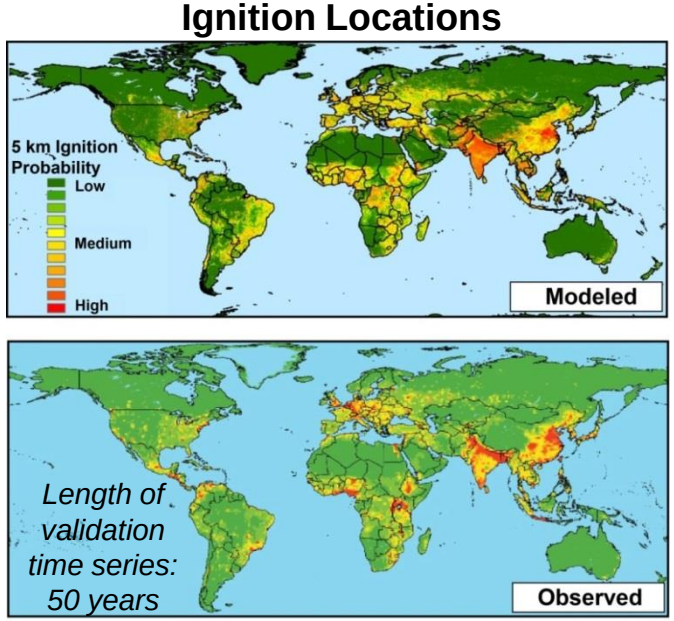


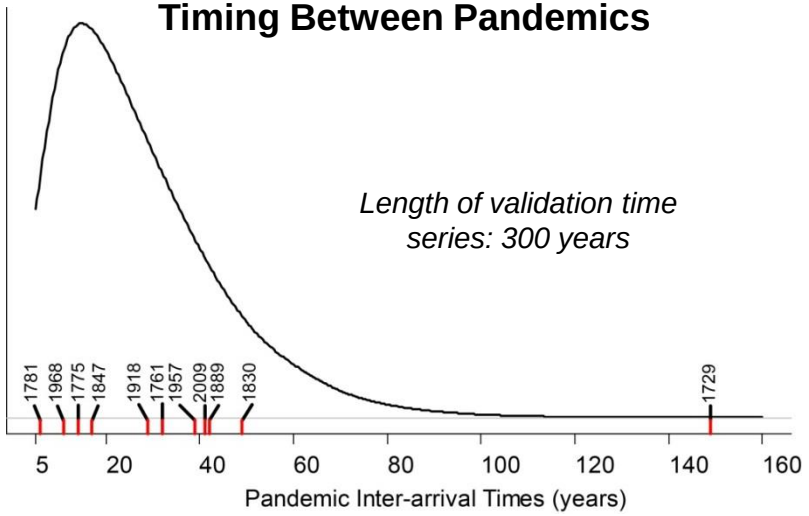
Virulence Profile by Age

Each Component of the Stochastic Catalog Is Extensively Validated Using Available Data

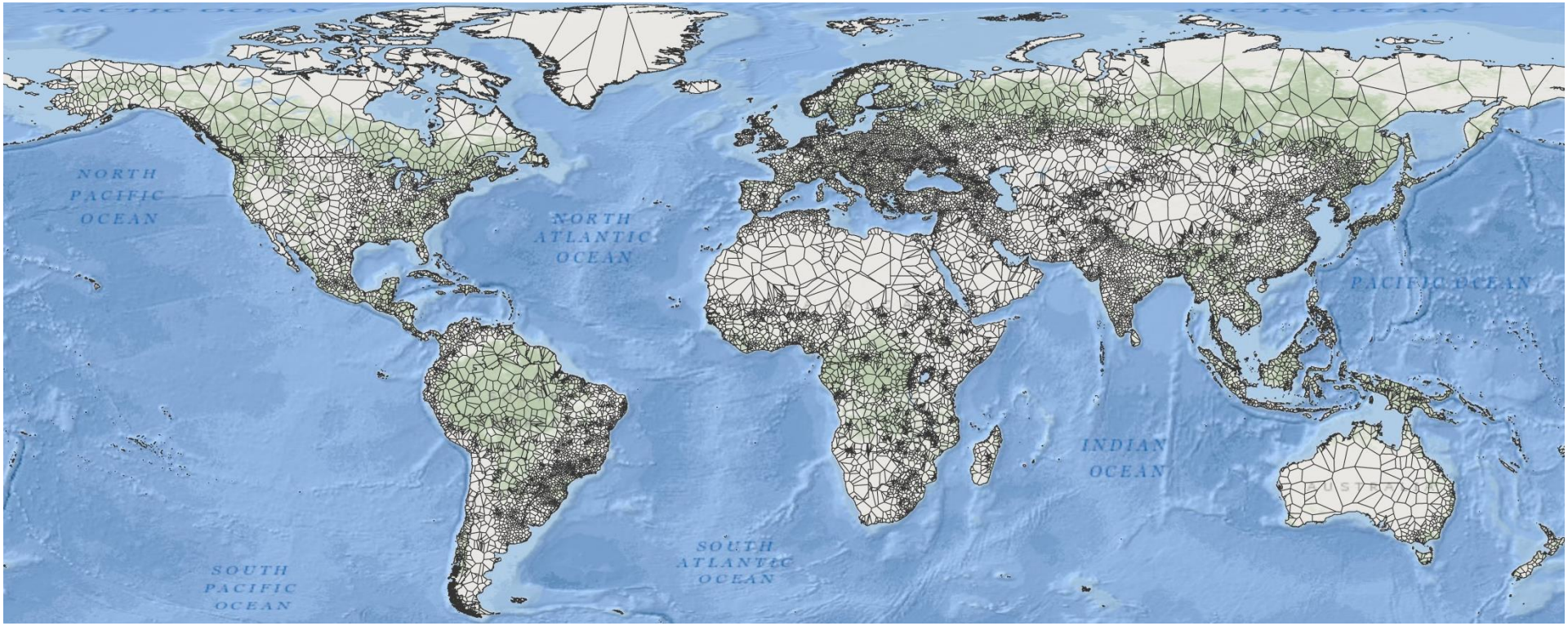






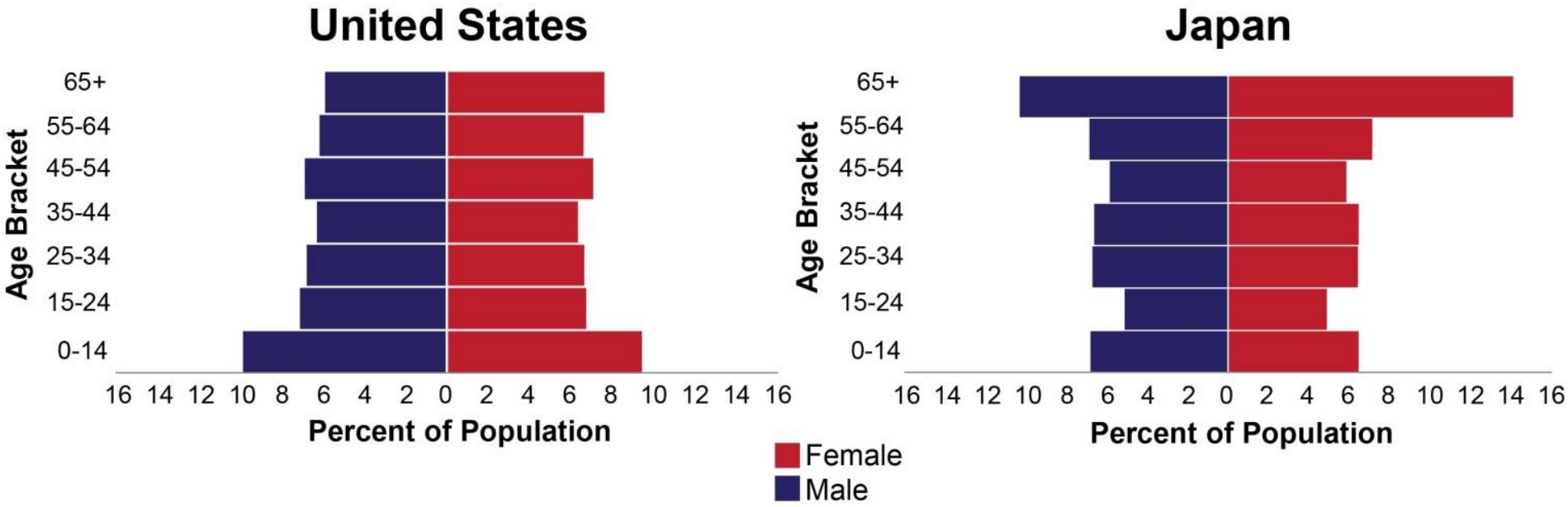


High-Resolution Industry Exposure Database (IED) Includes Demographic and Location Data



High-Resolution Industry Exposure Database (IED) Includes Demographic and Location Data

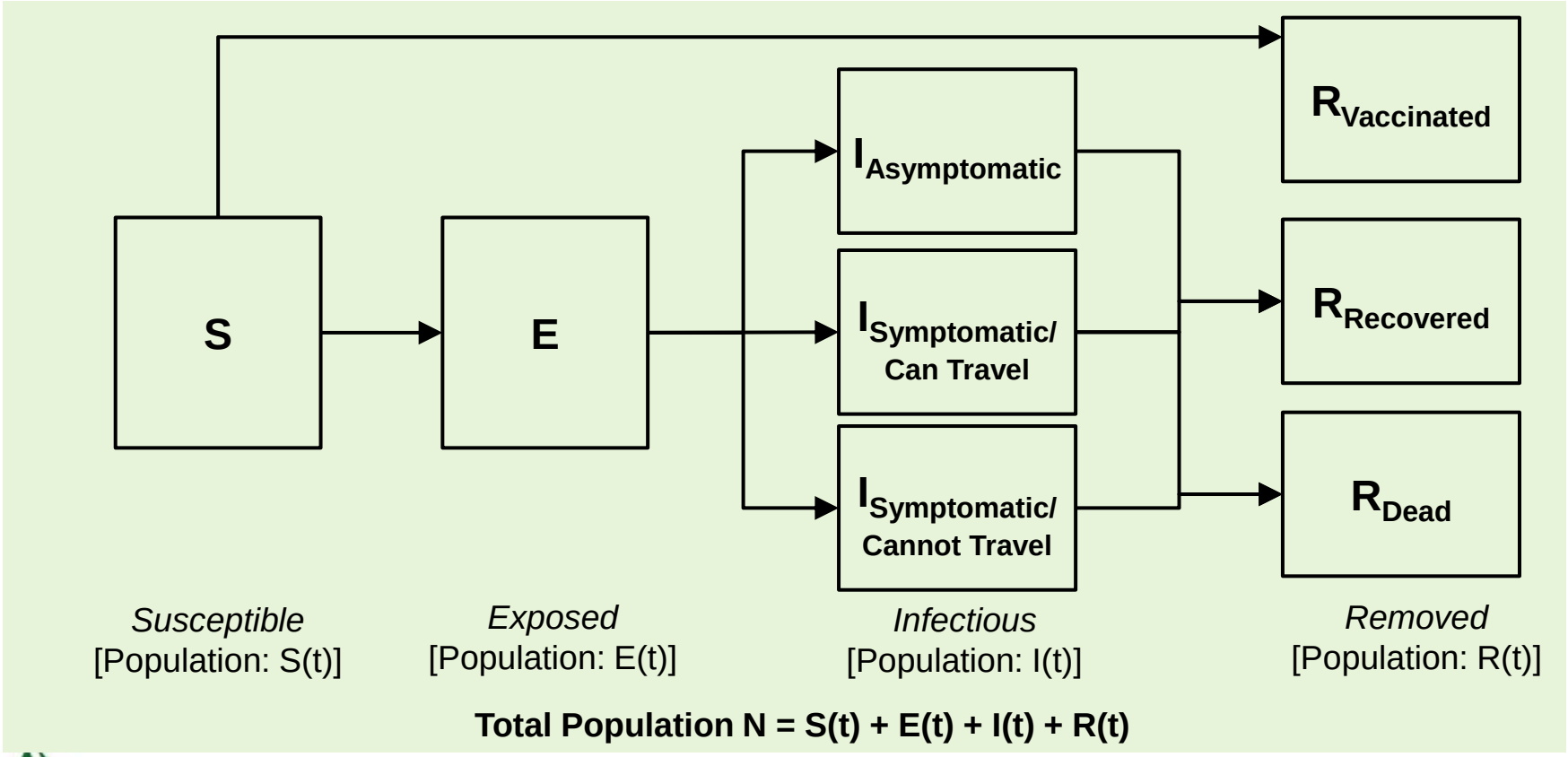
- Population by 14 different age and sex cohorts at high resolution



- Large demographic differences between countries
- Significant implications for influenza pandemic severity

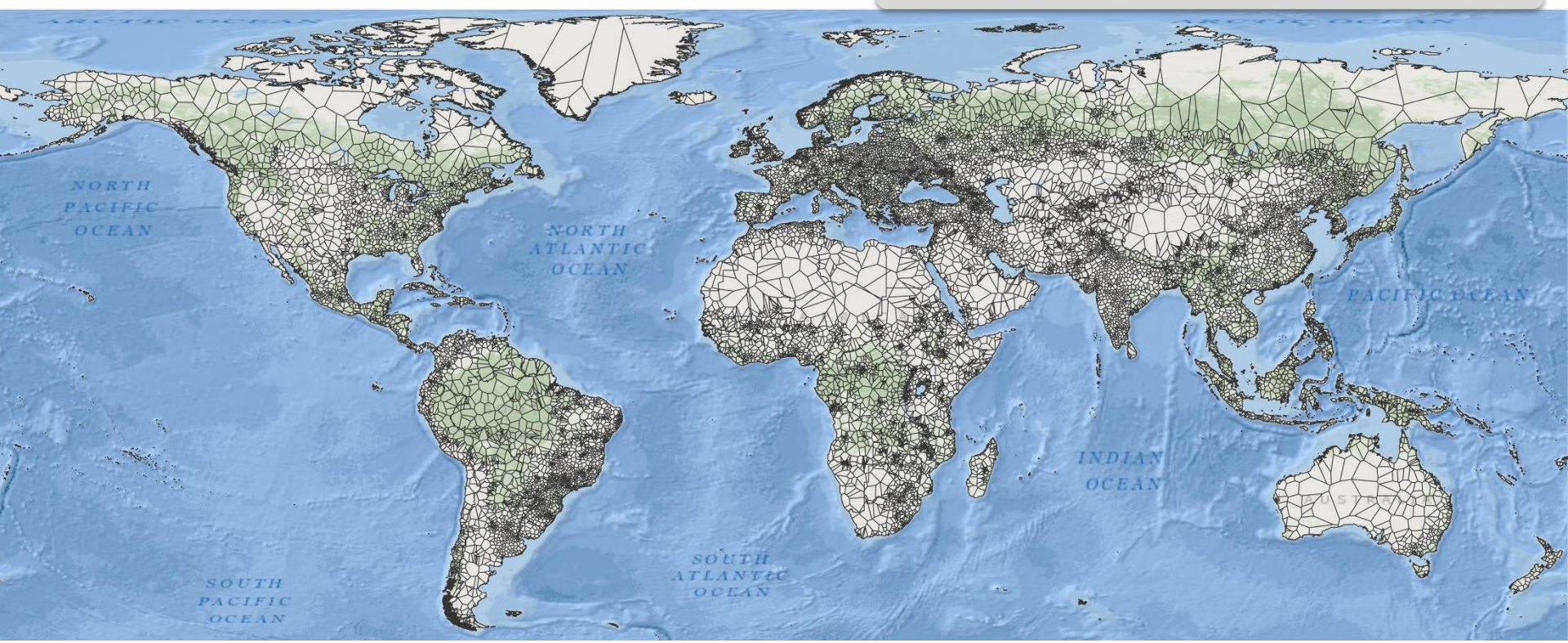
Epidemiologic Components Captured with Susceptible-Exposed-Infectious-Removed (SEIR) Model

- SEIR model operates at a daily time step
- Eight compartments by age and gender cohort
- Mitigation measures applied during run-time



Explicit Modeling of Population Movement Drives Geographic Spread of Disease

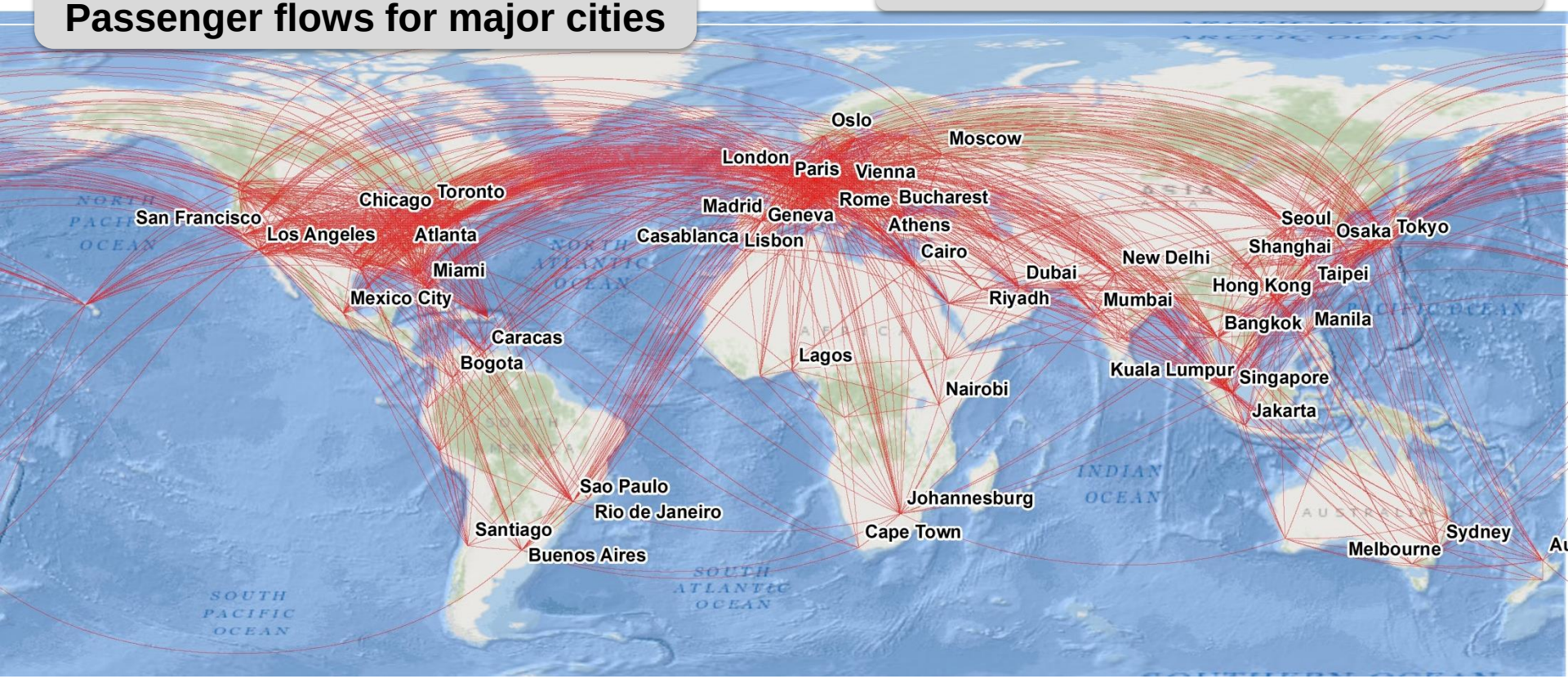
High-Resolution Exposure Data



Explicit Modeling of Population Movement Drives Geographic Spread of Disease

Long-range travel—Passenger flows for major cities

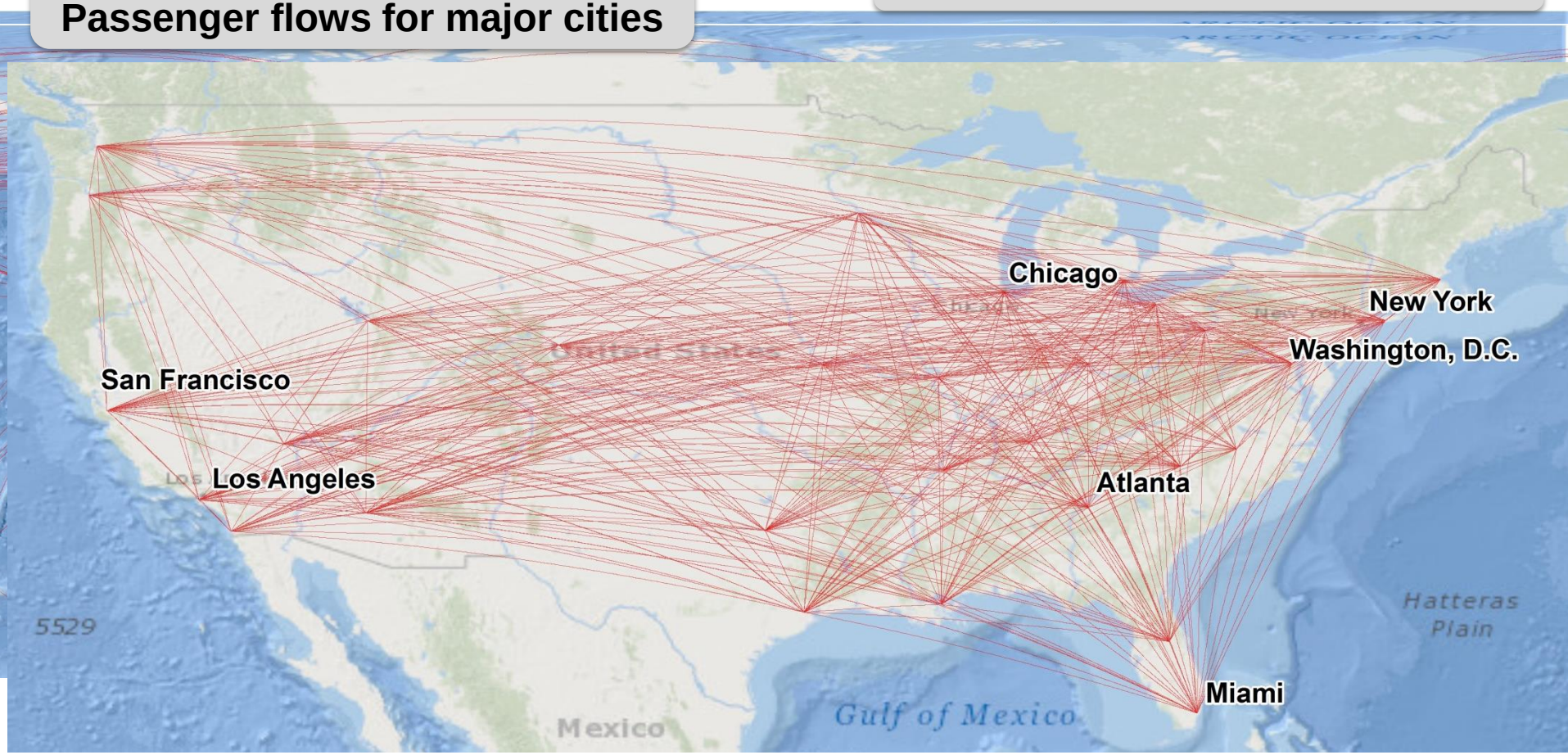
High-Resolution Exposure Data



Explicit Modeling of Population Movement Drives Geographic Spread of Disease

Long-range travel—Passenger flows for major cities

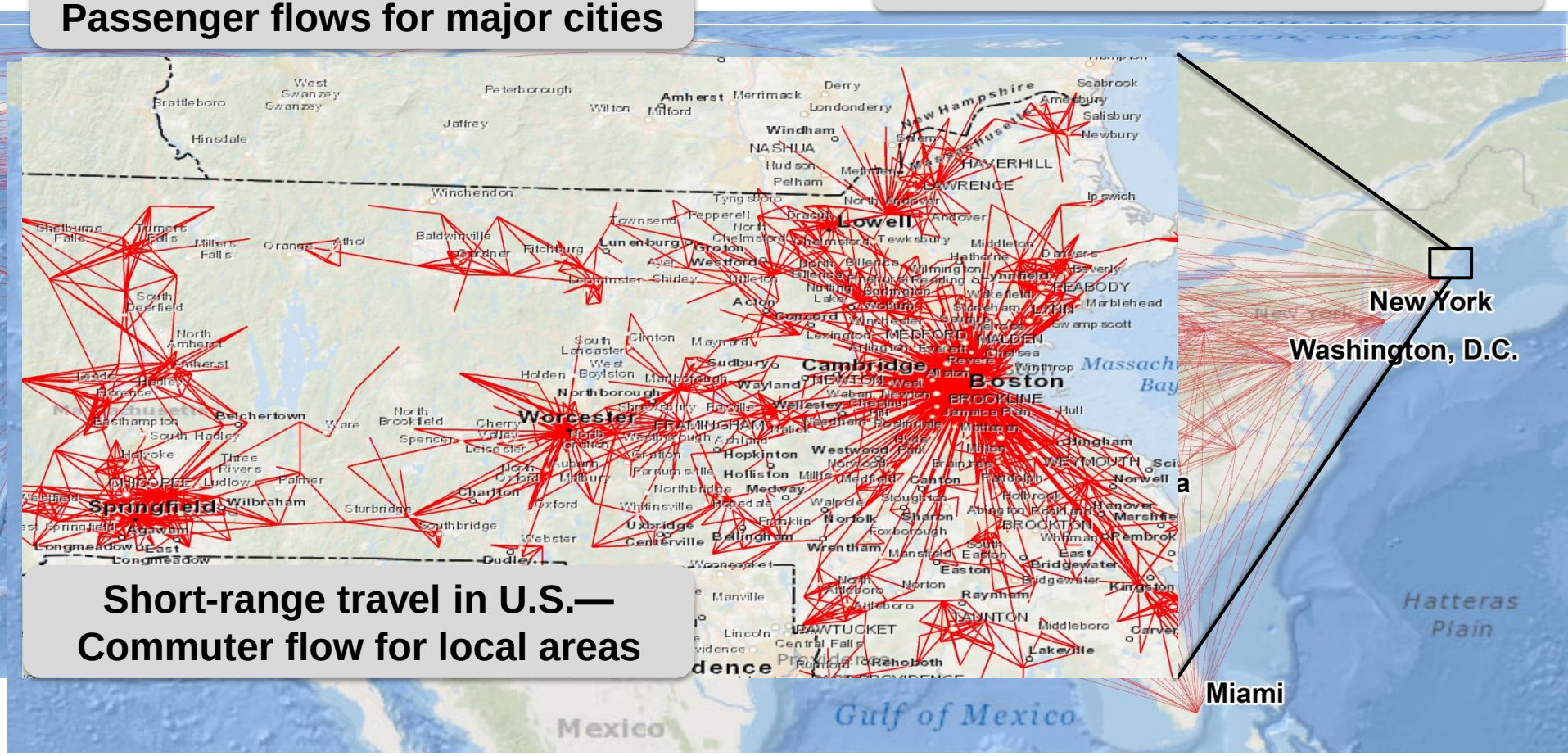
High-Resolution Exposure Data



Explicit Modeling of Population Movement Drives Geographic Spread of Disease

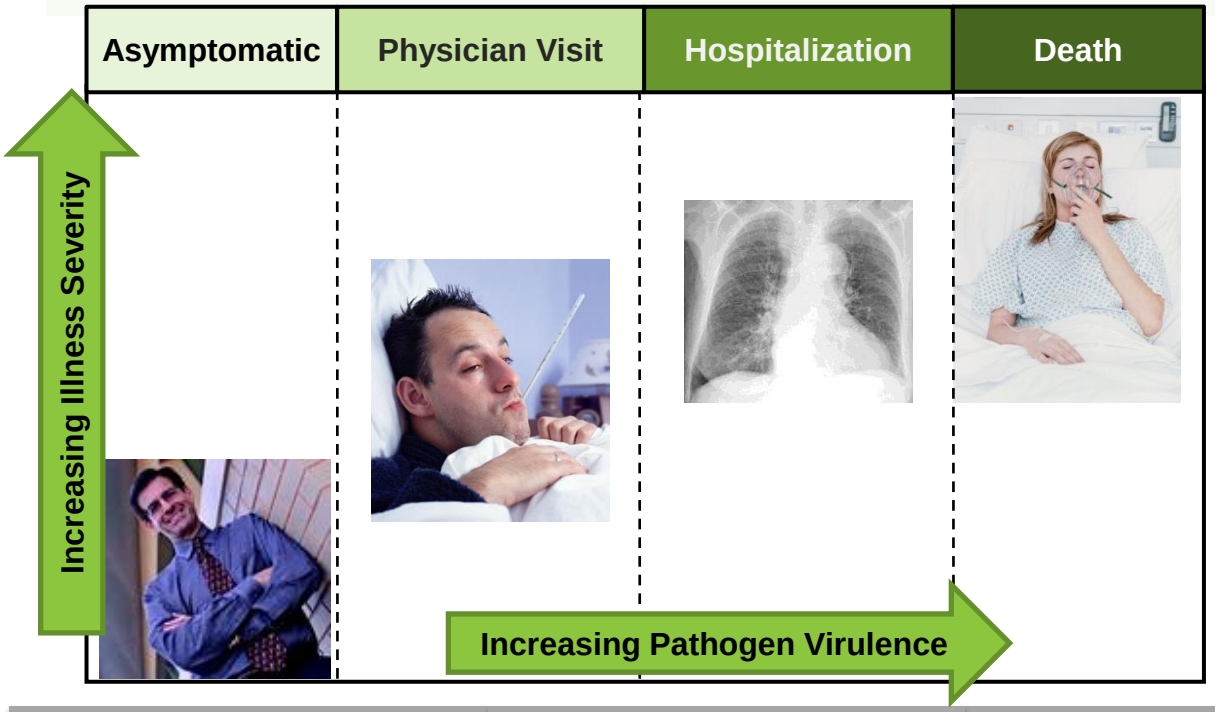
Long-range travel—Passenger flows for major cities

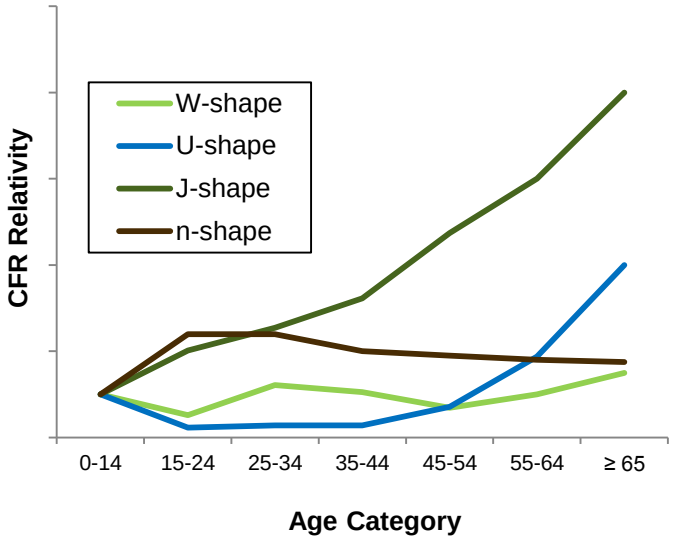
High-Resolution Exposure Data

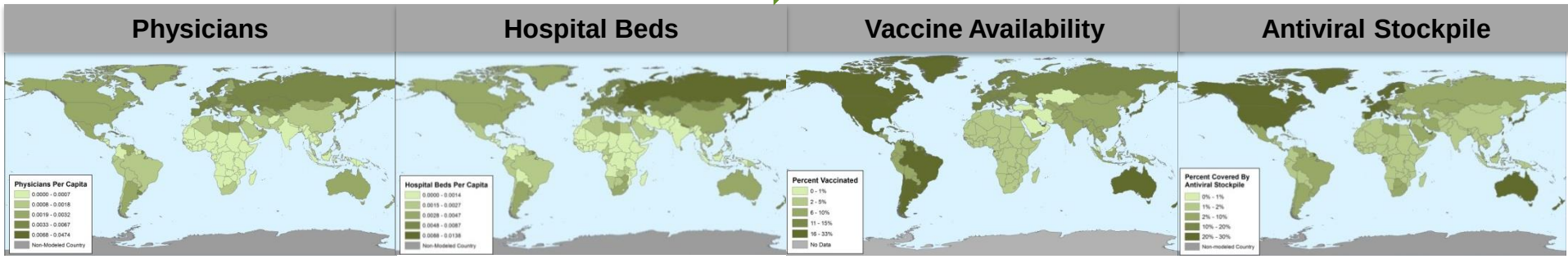


Short-range travel in U.S.—Commuter flow for local areas

Pathogen Virulence, Age, Healthcare, and Mitigation Affect Illness Severity

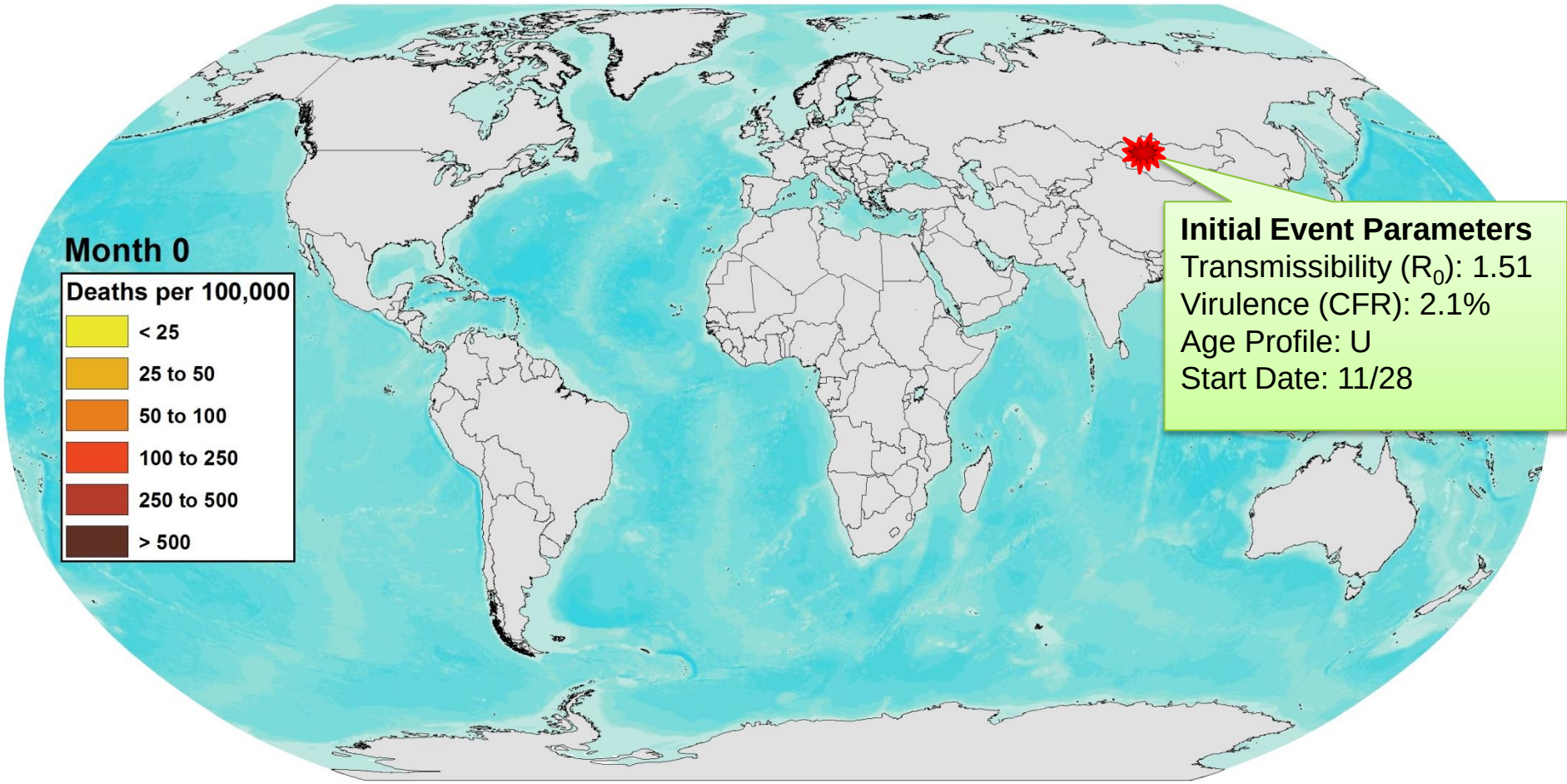






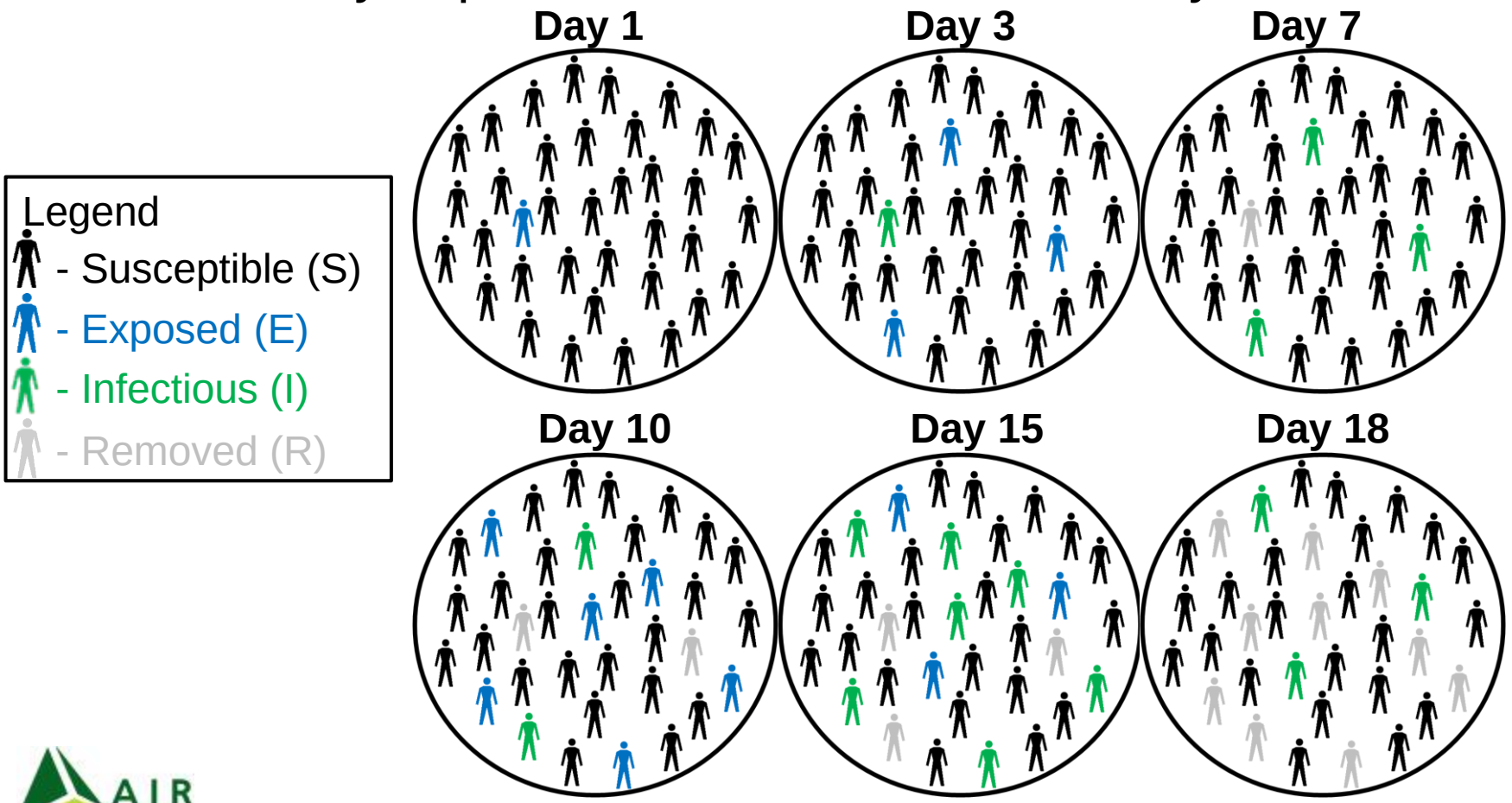
Explicitly modeled non-pharmaceutical interventions include airport closures and travel restrictions

AIR Models the Entire Duration of Each Influenza Pandemic

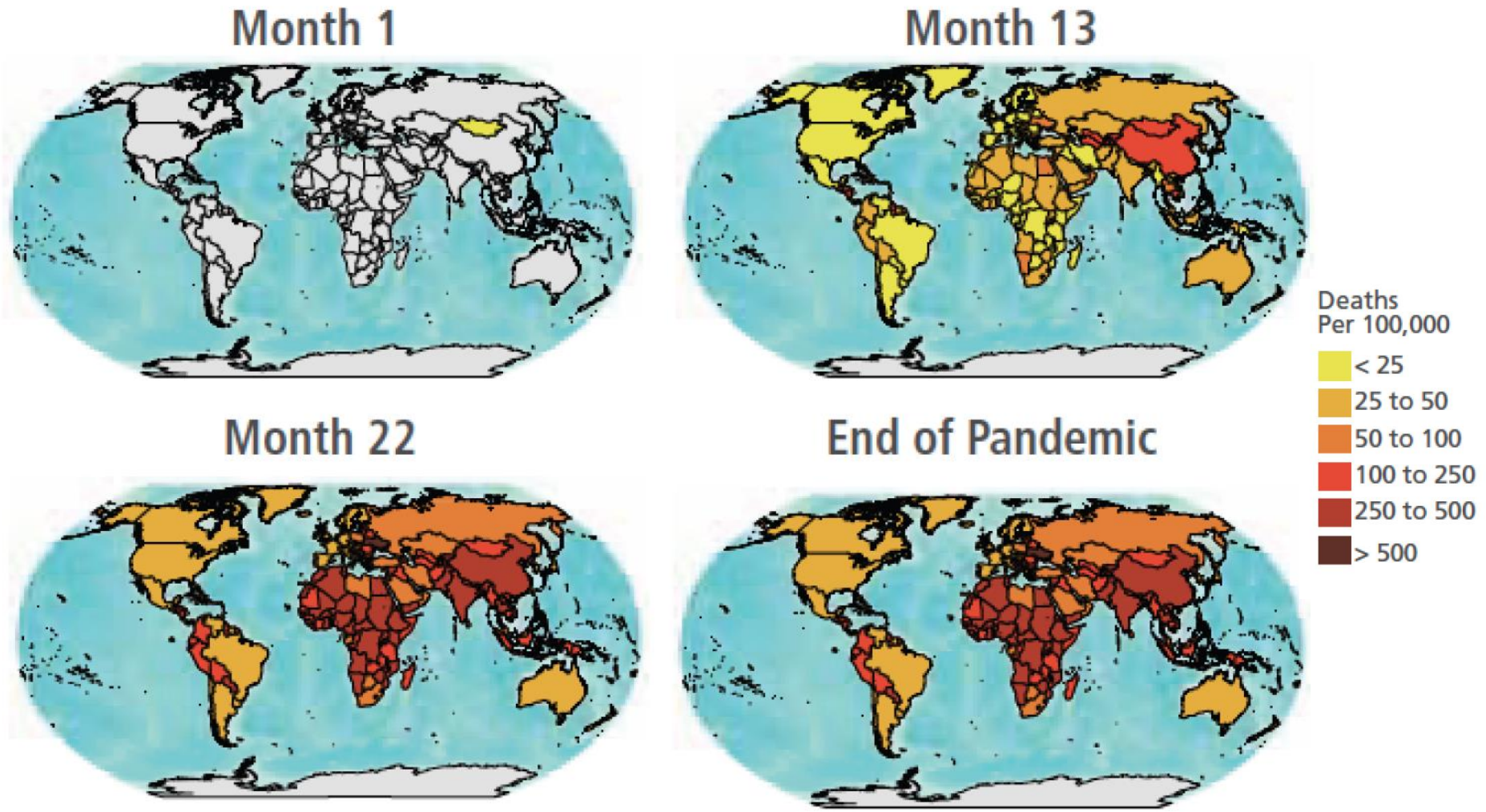


Epidemiologic "Susceptible-Exposed-Infectious-Removed" Modeling Occurs at Each Location

- Fundamental technique of epidemiologic modeling
- Realistically captures disease transmission dynamics

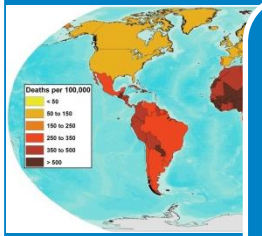


AIR Models the Entire Duration of Each Influenza Pandemic

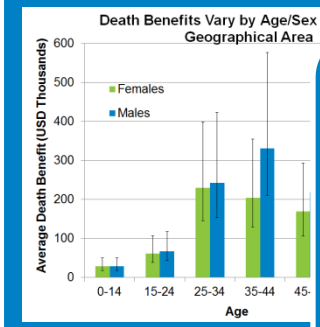


Financial Module Estimates Portfolio-Level Insurance Losses

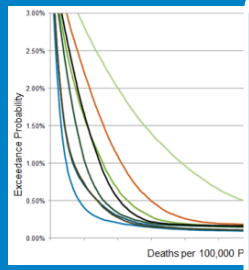
Pandemic Mortality



Death Benefits



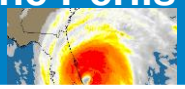
Gross Payouts



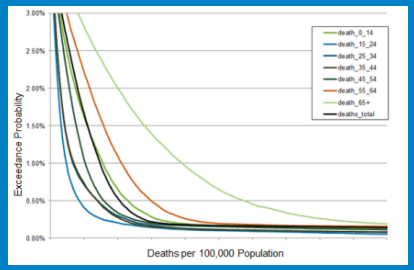
Reinsurance Terms

- Catastrophe Excess of Loss
- Aggregate Excess of Loss
- Quota Share
- Surplus Share

Roll-Up with Other Life and P&C Catastrophe Perils

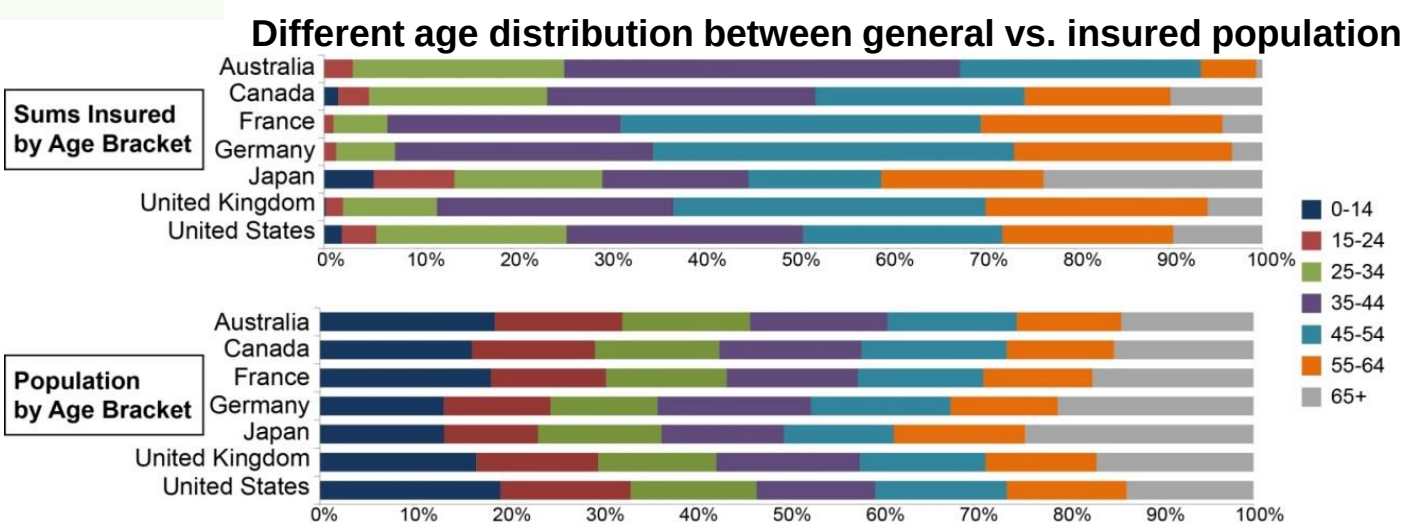


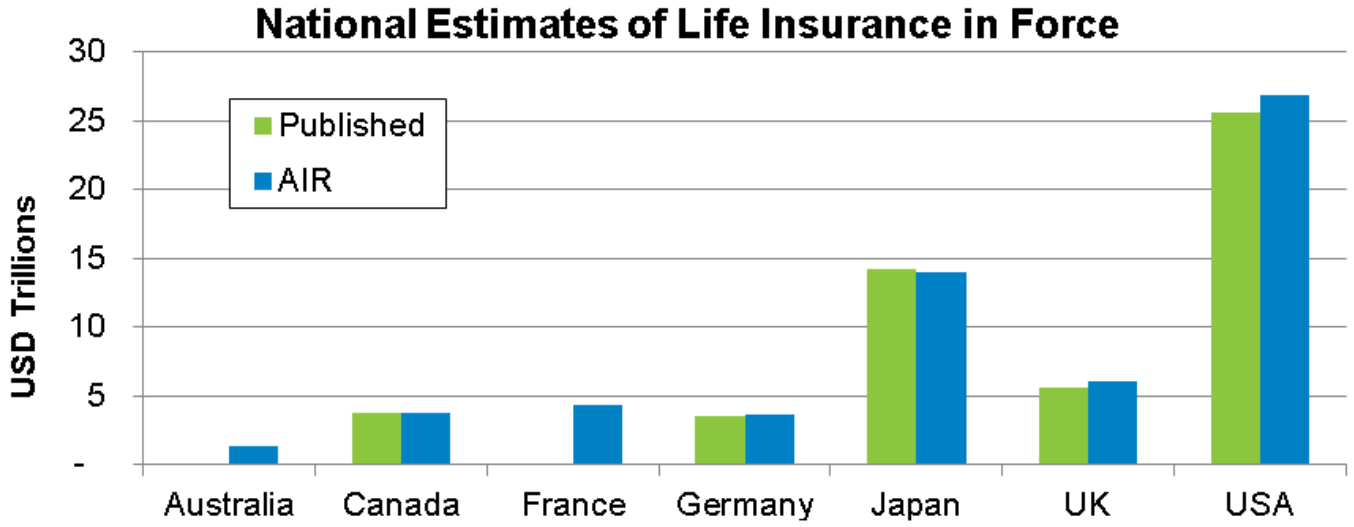
Portfolio Net Losses



Financial Module Loss Estimation Process

IEDs Account for Differences in Life Insurance by Age and Sex Bracket in Each Country





Model Has Been Externally Peer-Reviewed by a Panel of Experts

"This model is sophisticated and draws on much of the best work available for anticipating the range of outcomes that may occur from a flu pandemic."

Dr. Marc Lipsitch
Professor of Epidemiology
Director of the Center for Communicable Disease Dynamics
Harvard University

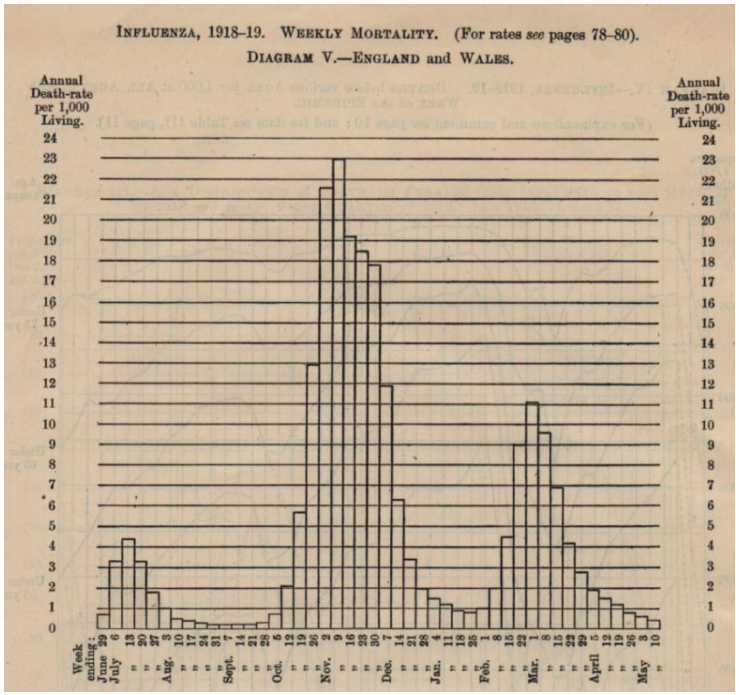
"Overall, the AIR pandemic model is remarkably detailed, based on sound scientific principles, and of genuine utility to the insurance industry."

Dr. Joshua Plotkin
Associate Professor of Biology and Computer Science (with tenure)
University of Pennsylvania

High Transmissibility and Virulence Were Hallmarks of the 1918 "Spanish Flu" Pandemic

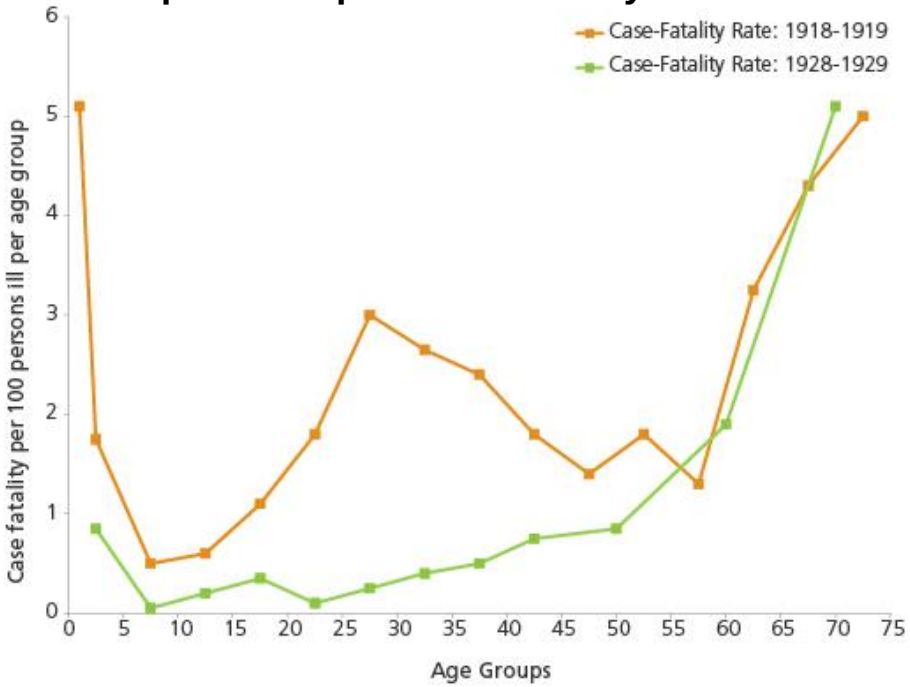
- One of the most significant mortality catastrophes in history
- Caused 20–100 million deaths globally

Three Waves of Infection



Source: Registrar-General 1920

Unique W-shaped Case-Fatality Ratio Profile



Source: Taubenberger and Morens, 2006

Circumstances Surrounding the 1918 Pandemic Exacerbated Its Severity

- State of medical science
  - Influenza virus had not been discovered
  - Few treatment options
- World War I
  - Censoring of information
  - Diversion of health care workers
  - Trench warfare, troop movements

SPANISH INFLUENZA--A NEW NAME FOR AN OLD FAMILIAR DISEASE

Simply the Same Old Grip That Has Swept Over the World Time and Again—The Last Epidemic in the United States Was in 1889-90.

ORIGIN OF THE DISEASE.

Spanish influenza, which appeared in Spain in May, has swept over the world in numerous epidemics as far back as history runs. Hippocrates refers to an epidemic in 412 B. C. which is regarded by many to have been influenza. Every century has had its attacks. Beginning with 1831, this country has had five epidemics, the last in 1889-90.

THE SYMPTOMS.

Grip or influenza as it is now called, usually begins with a chill followed by aching, feverishness and sometimes nausea and dizziness, and a general feeling of weakness and depression. The temperature is from 100 to 104, and the fever usually lasts from 3 to 5 days. The germs attack the mucous membrane, or lining of the air passages—nose, throat and bronchial tubes—there is usually a hard cough, especially bad at night, oftentimes a sore throat or tonsilitis, and frequently all the appearances of a severe head cold.

THE TREATMENT.

Go to bed at the first symptoms—take a purgative, eat plenty of nourishing food, remain perfectly quiet and don't worry. Nature herself is the only "cure" for influenza and will

heat of the body liberates the ingredients in the form of vapors. These vapors, inhaled with each breath, carry the medication directly to the parts affected. At the same time, VapoRub is absorbed through and stimulates the skin, attracting the blood to the surface, and thus aids in relieving the congestion within.

NO OCCASION FOR PANIC.

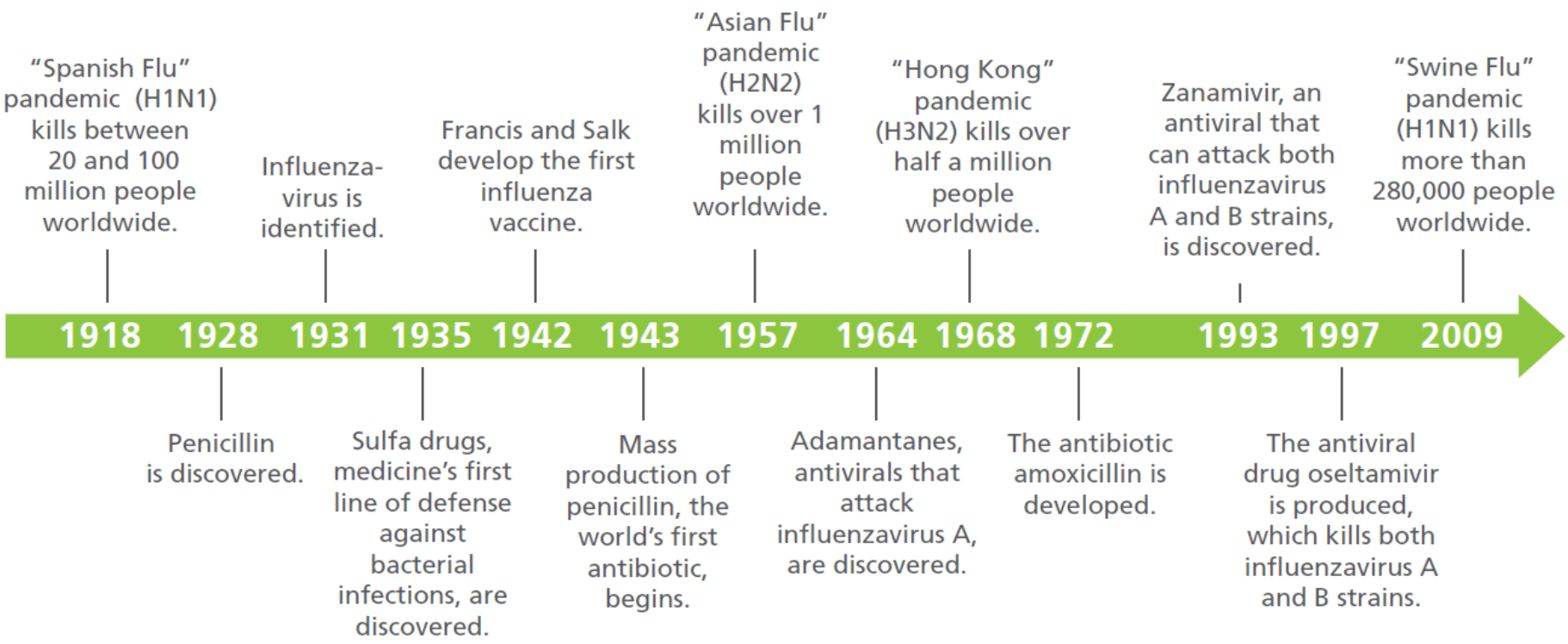
There is no occasion for panic—influenza or grip has a very low percentage of fatalities—not over one death out of every four hundred cases, according to the N. C. Board of Health. The chief danger lies in complications arising, attacking principally patients in a run down condition—those who don't go to bed soon enough, or those who get up too early.

HOW TO AVOID THE DISEASE.

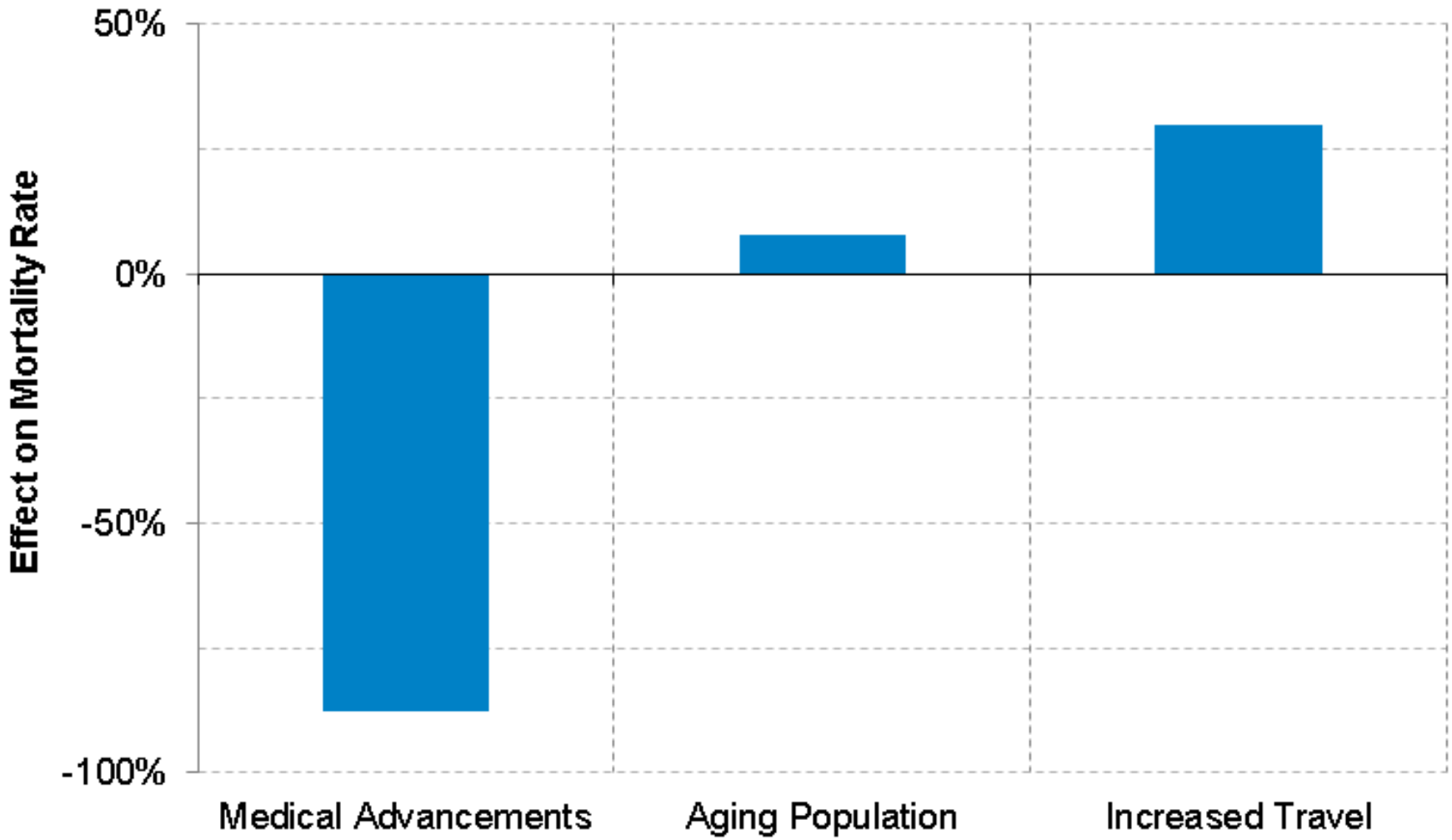
Evidence seems to prove that this is a germ disease, spread principally by human contact, chiefly through coughing, sneezing or spitting. So avoid persons having colds, which means avoiding crowds—common drinking cups, roller towels, etc. Keep up your bodily strength by plenty of exercise in the open air, and good food.

KEEP FREE FROM COLDS.

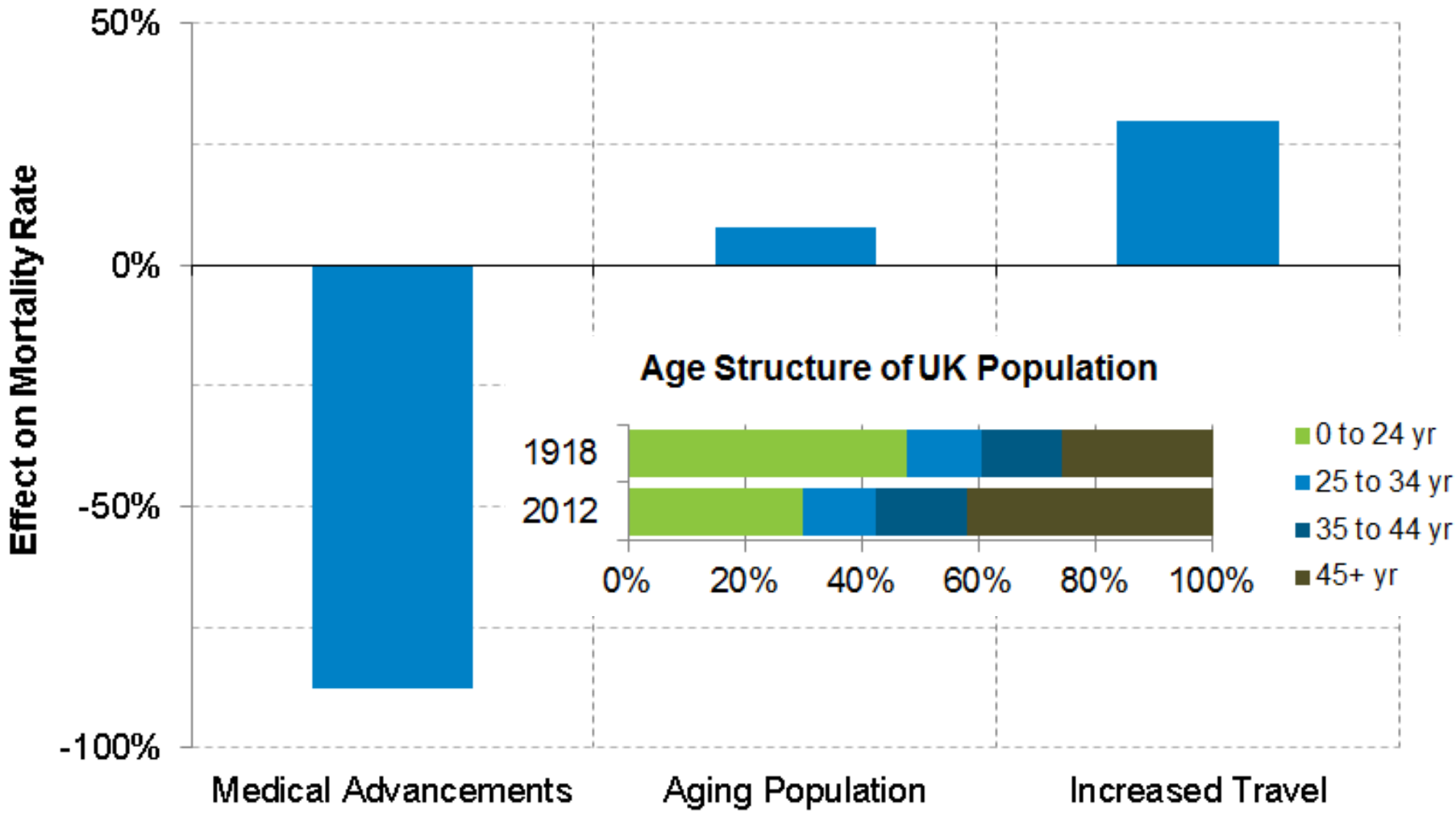
Significant Changes Have Occurred Since 1918



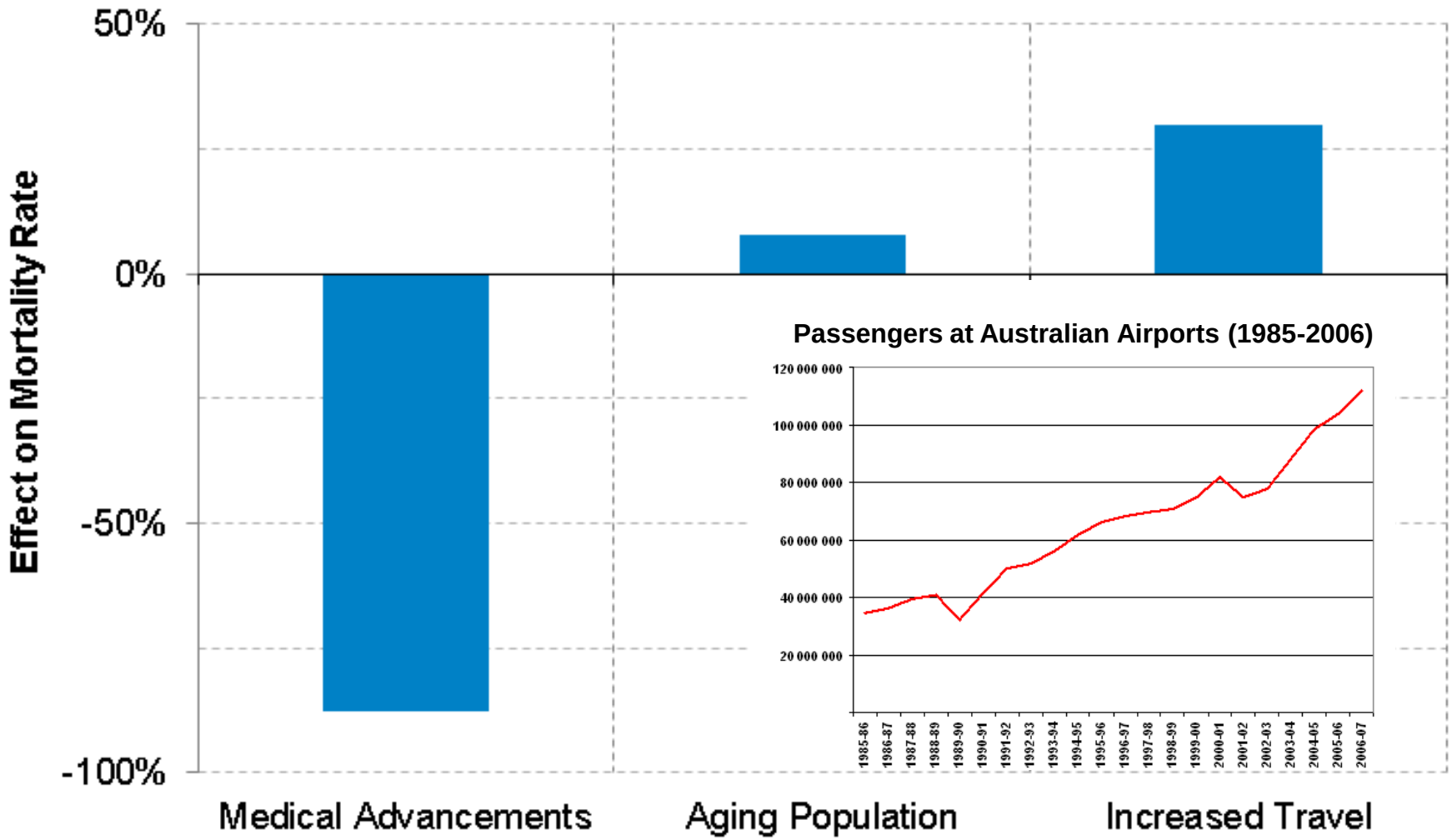
Significant Changes Have Occurred Since 1918



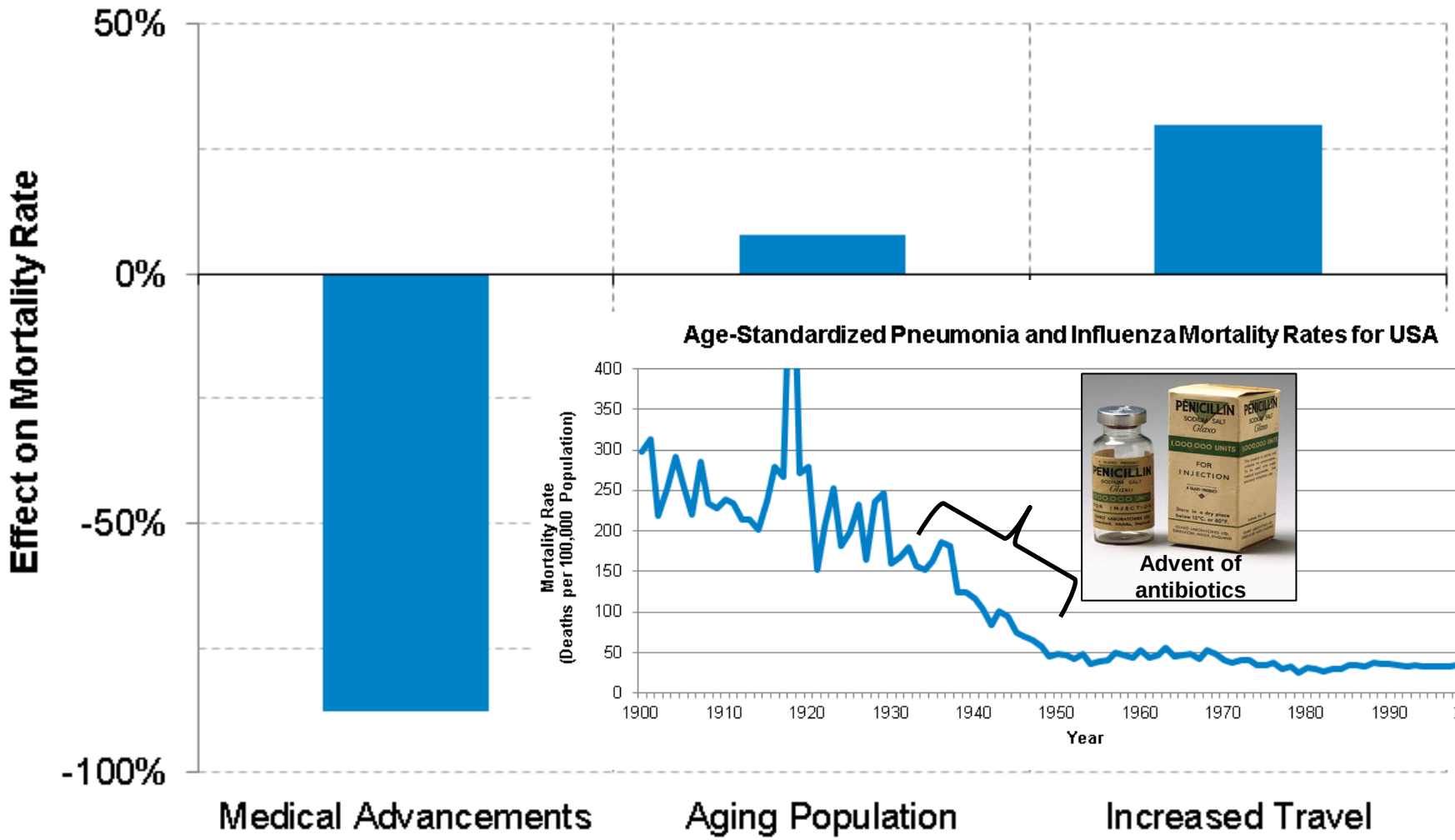
Significant Changes Have Occurred Since 1918



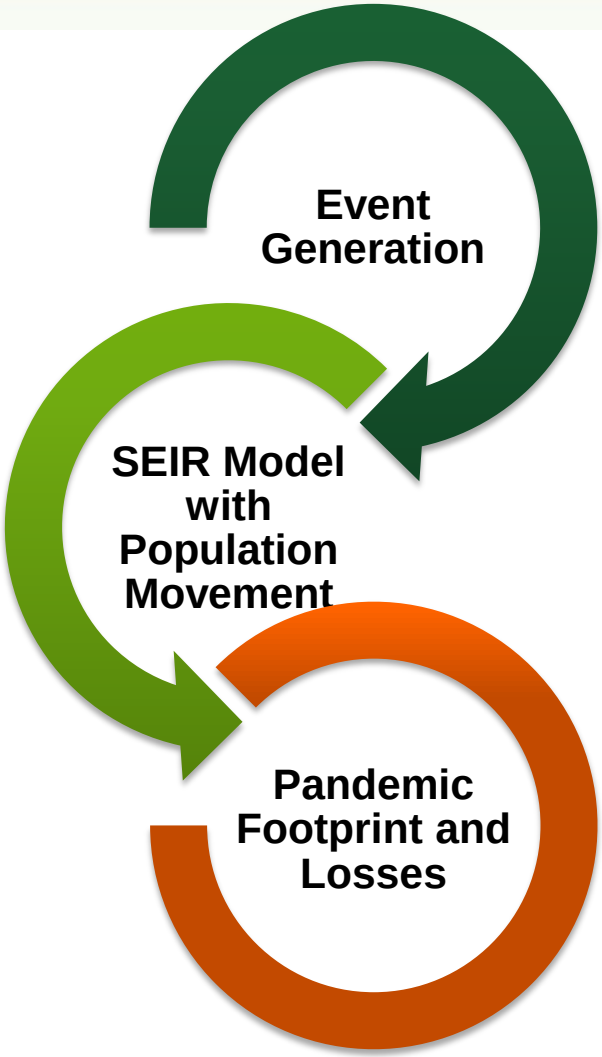
Significant Changes Have Occurred Since 1918



Significant Changes Have Occurred Since 1918

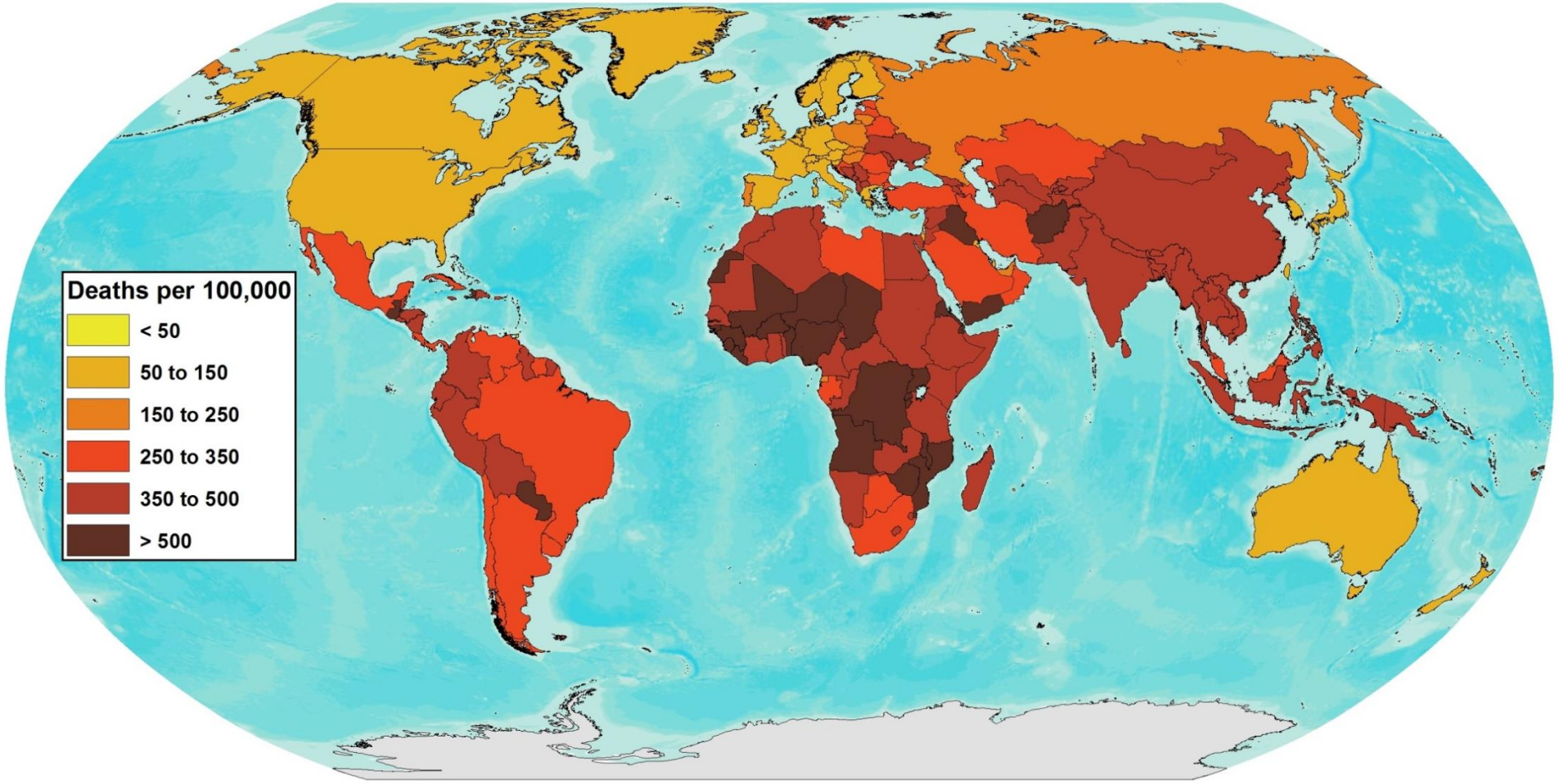


AIR Modeling Accounts for Changes Since 1918



- Event generation includes parameters consistent with a modern-day 1918 pandemic
- SEIR model with population movement includes population, demographic, and travel changes since 1918
- Estimated pandemic footprint and losses therefore account for changes since 1918

A 1918-Like Event Occurring in the Present Day Would Cause 21–33 Million Deaths Worldwide



More information available on AIR website:
"Modeling a Modern-Day Spanish Flu Pandemic."*AIRCurrents*: Feb 2013.

AIR Estimates USD 34B–60B in Life Insurance Payouts for Additional Death Claims in 7 Key Countries

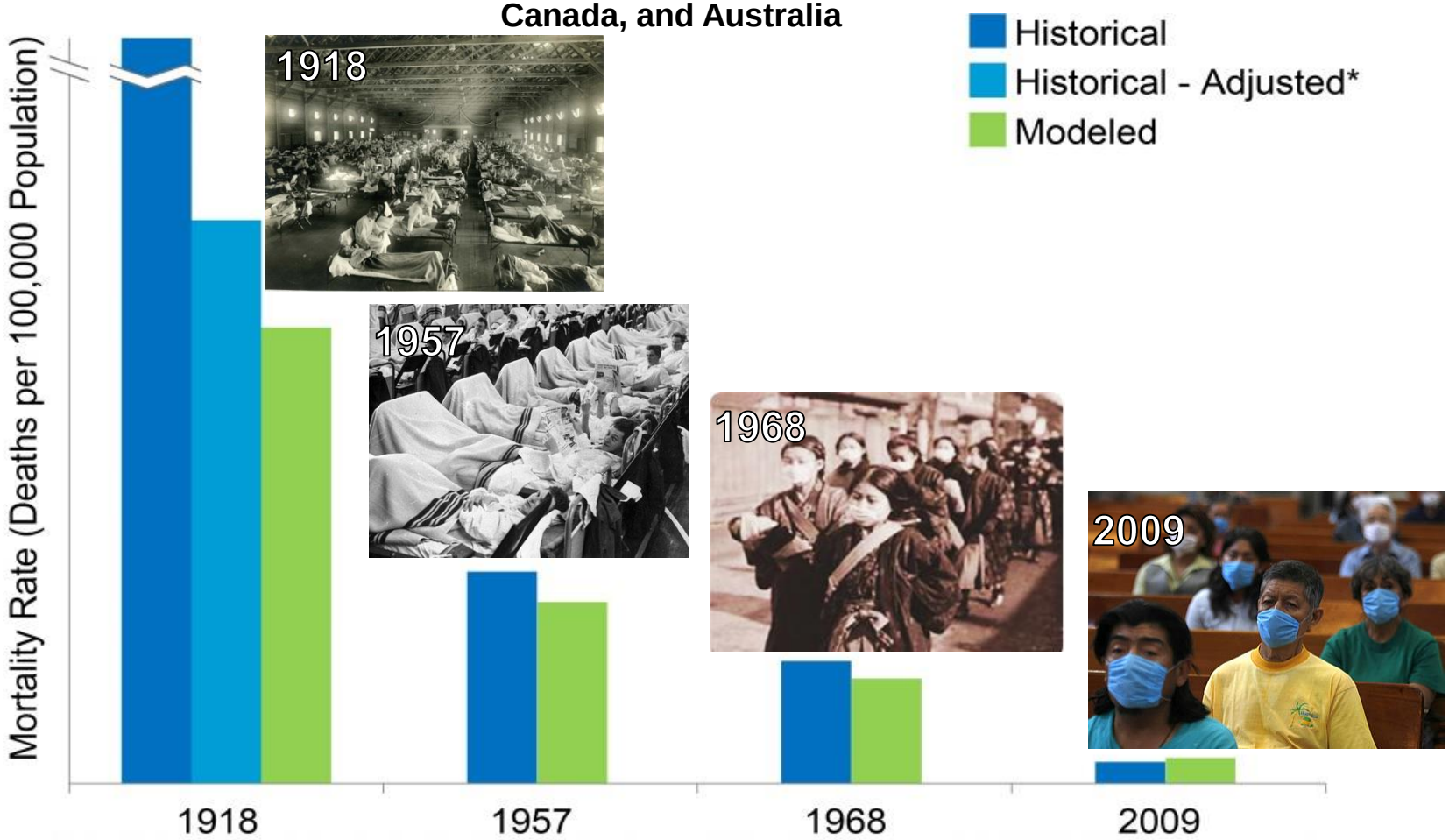
Country	Number of Deaths	Life Insurance Payout (USD billions)
Australia	15,000 – 26,000	0.8 – 1.4
Canada	20,000 – 37,000	2.1 – 3.8
France	36,000 – 62,000	2.1 – 3.7
Germany	48,000 – 85,000	1.8 – 3.3
Japan	83,000 – 145,000	8.9 – 15.2
UK	36,000 – 64,000	3.1 – 5.5
U.S.	188,000 – 337,000	15.3 – 27.8

AIR estimates are comparable to a 2003 American Council of Life Insurers study estimating $14.5 – $19.3 billion USD in increased life insurance death claims from a modern 1918-type event

More information available on AIR website:
"Modeling a Modern-Day Spanish Flu Pandemic." *AIRCurrents*: Feb 2013.

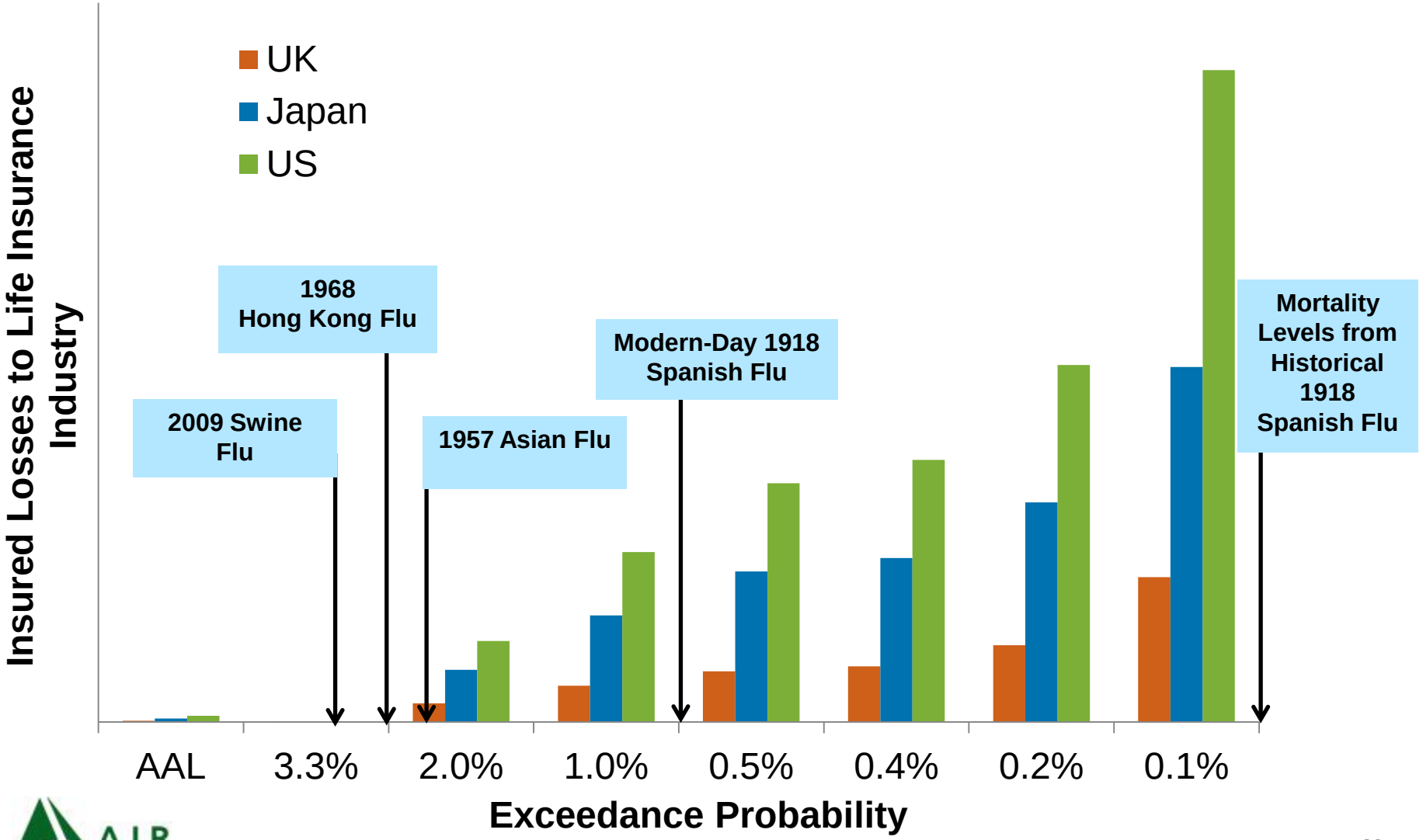
Model Results Compare Well Against Mortality Estimates from Historical Influenza Pandemics

Modeled vs. Observed Mortality Rates for Combined Data from the U.S., UK, France, Japan, Germany, Canada, and Australia



** The historical adjusted value for the 1918 pandemic was obtained from Murray et al. (2006). This value represents one published estimate of the mortality rate a 1918-like event would inflict, if it were to occur today.*

Recent Influenza Pandemics Do Not Represent a Worst-Case Scenario for Mortality or Insured Losses



Case Studies

There Are Many Applications for the AIR Pandemic Flu Model

- Reinsurance/insurance-linked securities (ILS) contracts
  - Industry loss warranties (ILW)
  - Modeled loss
  - Indemnity loss
  - Parametric loss
- Life insurance cash flow projections
- Enterprise risk management studies
  - Risk to employees
- Asset liability management studies

Case Study 1 – Impact to an Insurance Portfolio

Situation

- Primary insurer, ABC Corp., writes life insurance business using the standard actuarial tables
- Most of their business is in term insurance products

Problem

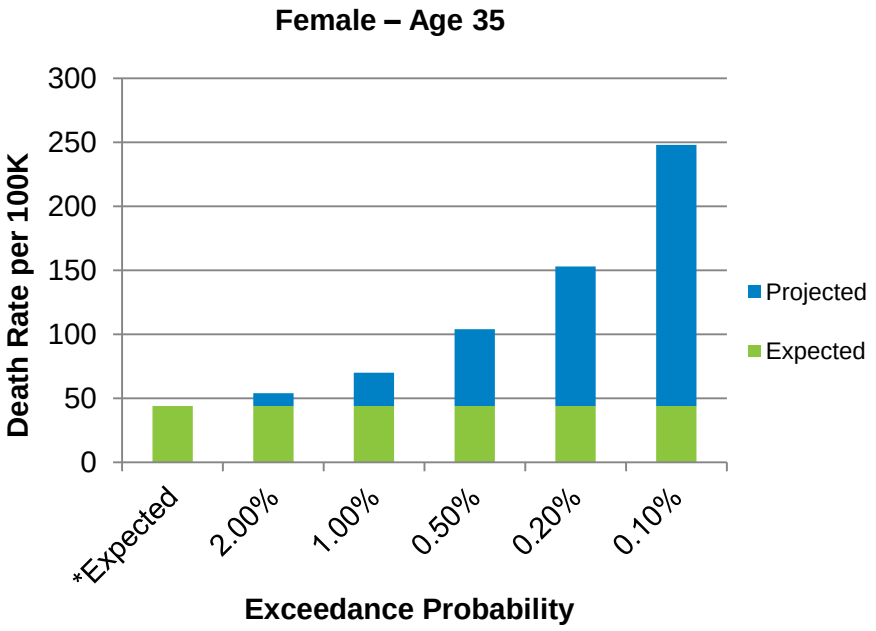
- The primary insurer is worried about increase in benefit payments due to pandemic influenza outbreak

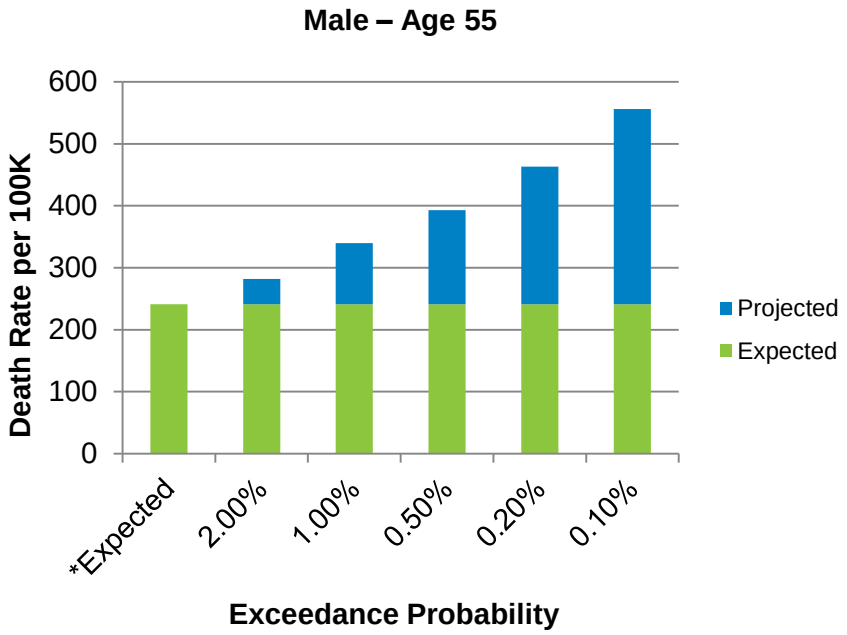
Solution

- Using the AIR Pandemic Flu Model, ABC Corp can assess the impact from an outbreak over the course of a specific year, or over the life of the contract

Increase to Estimated Death Rate for a Given Age/Sex Cohort Can Be Several Fold

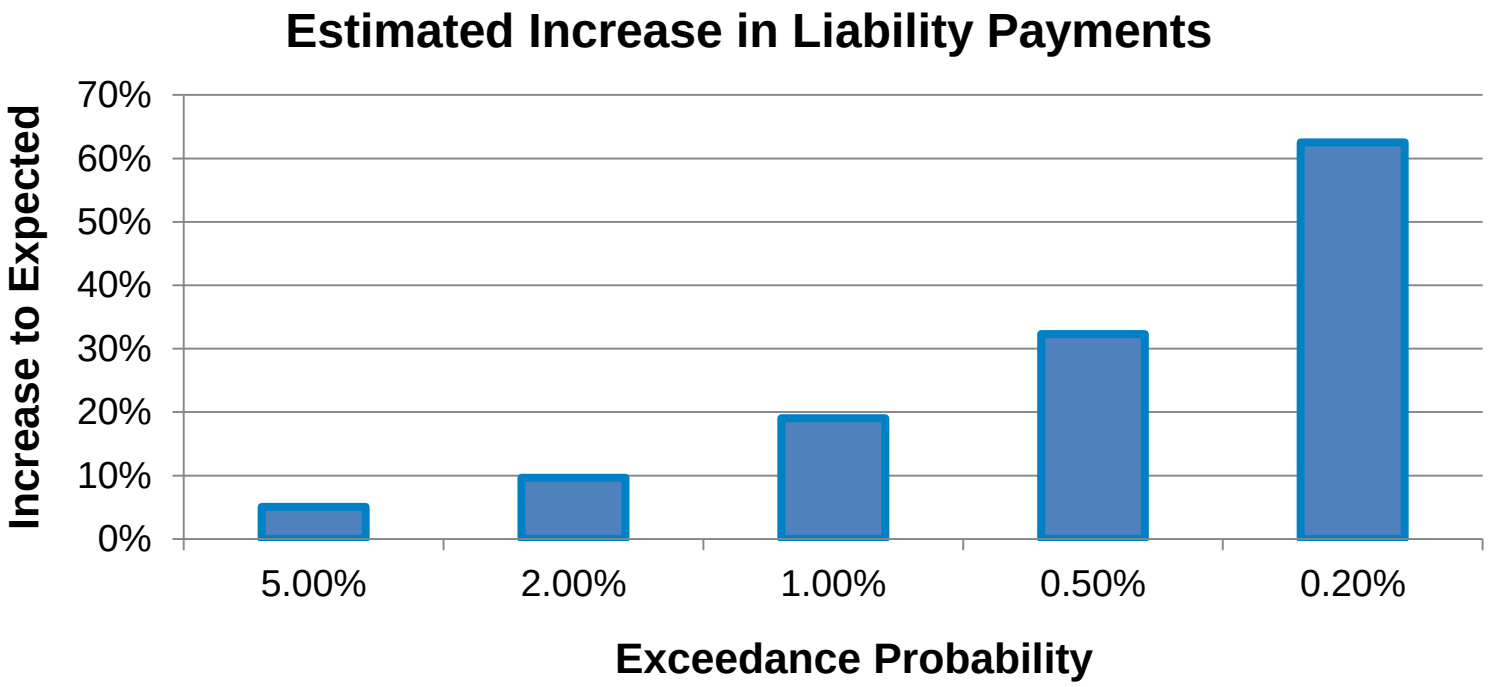
- Standard actuarial tables do not adequately quantify the tail risk of pandemic influenza





* Expected: Society of Actuaries RP 2000 Projected to 2023 with Scale BB

Increase in Estimated Liability Payments for the Life of a 20-Year Term Insurance Contract



Case Study 2 – Impact on a Reinsurance Contract

Situation

- Reinsurer XYZ mostly writes P&C business
- As of late, they have focused on diversifying their overall portfolio
- They have been asked to participate on a reinsurance contract that covers excess mortality

Problem

- XYZ currently has a longevity model to help them address the change in the expected mortality rate, but they do not have a pandemic influenza model

Solution

- Layering together the AIR Pandemic Flu model with a longevity model can build a more robust tool for XYZ, thus enabling them to evaluate the risk and determine if they would like to participate

Combination of AIR Pandemic Flu Model with a Longevity Provides a More Robust Assessment of the Risk

Exceedance Probability	Deaths Per 100k - Longevity Only	Deaths Per 100k - Longevity and Pandemic Influenza	Increase
0.20%	216	310	44%
0.50%	213	261	23%
1.00%	212	232	9%
5.00%	207	209	1%
50.00%	196	196	0%
95.00%	185	185	0%
99.00%	181	181	0%
99.50%	180	180	0%
99.80%	178	178	0%

Note the significant increase to the tail end of the distribution

Sample Financial Terms and Deal Structure for Excess Mortality Reinsurance/ILS Contract

Cedant	ABC Corp
Attachment Point	102.5%
Exhaustion Point	107.5%
Total Limit Placed	$100m
Cover Type	CDC Mortality
Covered Perils	Excess Mortality - U.S.
Inception	1/1/2014
Expiration	12/31/2014
Index	Death Rate_{2014} / Death Rate_{2013} (DR weighted by age and sex cohort provided by ABC Corp and normalized to deaths per 100k)

Incorporating the AIR Pandemic Flu Model Dramatically Increases the Overall Risk Metrics

- Combining pandemic influenza and longevity provides a broader representation of the risk associated with the transaction

Metrics	Longevity Only	Pandemic Influenza and Longevity
Prob (Attach)	5.59%	7.74%
Expected [Loss]	1.36%	3.99%
Prob (Exhaust)	0.01%	1.36%

Summary

- An influenza pandemic has the potential to be a significant mortality catastrophe
- The AIR Pandemic Flu Model has several key features:
  - Global in scope
  - Pandemics last multiple years and exhibit multiple waves of infection
  - All components extensively validated using available data
  - Externally peer-reviewed by renowned scientists
- Utilizing the AIR Pandemic Flu Model enables a more robust understanding and management of pandemic risk

Additional Reading on the AIR Website

- The H1N1 Influenza Pandemic: Implications for Catastrophe Modeling
- Modeling a Modern-Day Spanish Flu Pandemic
- AIR Pandemic Flu Model Brochure