Pandemic Risk Modeling

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Topics for discussion

- What is the current environment with respect to pandemics?
- Which Milliman projects had a key pandemic modeling component?
- What makes this risk difficult to model?
- What methodology is being used to model pandemics?
- What data exists for calibrating the model?
- Are there any other models out there?
- How bad can it get?

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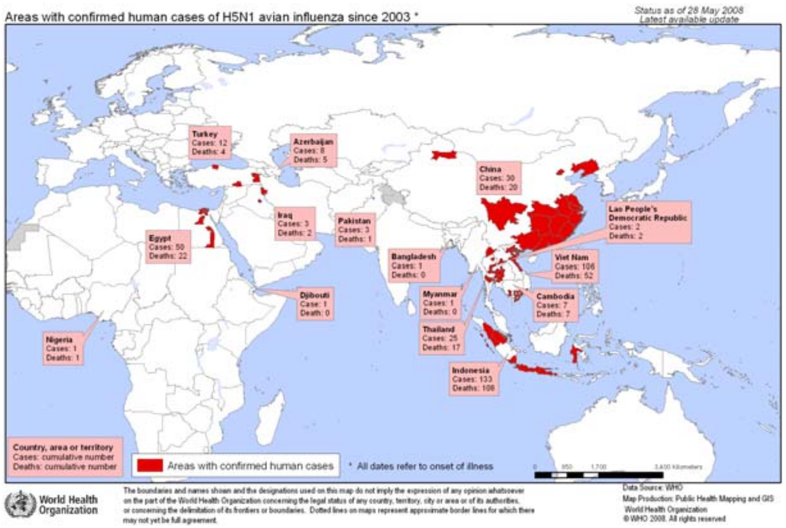
Current environment

- In the past 25 years, at least 30 previously unknown diseases have emerged including HIV, SARS, Ebola, and Hepatitis C and E
- H5N1 of great concern because
  - it caused greatest number of human cases in recent years
  - it exhibits all features required to start a pandemic except the ability to efficiently transmit between humans
- As of May 2008 (according to WHO)
  - 383 laboratory confirmed cases
  - 241 deaths
  - 15 countries



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Current environment - H5N1 timeline

- Mid-2003
  - Outbreaks of highly pathogenic H5N1 began in South-east Asia
- July 2005
  - Virus spreads to affect poultry in Russia and Kazakhstan
- October 2005
  - Virus is reported in Turkey, Romania and Croatia
- March 2006
  - WHO confirms five deaths in Azerbaijan
- May 2006
  - WHO confirms first case of infection in Africa (Djibouti)
- February 2007
  - WHO confirms first human death in Africa (Nigeria)
- April 2008
  - Japan reports H5N1 in wild swans

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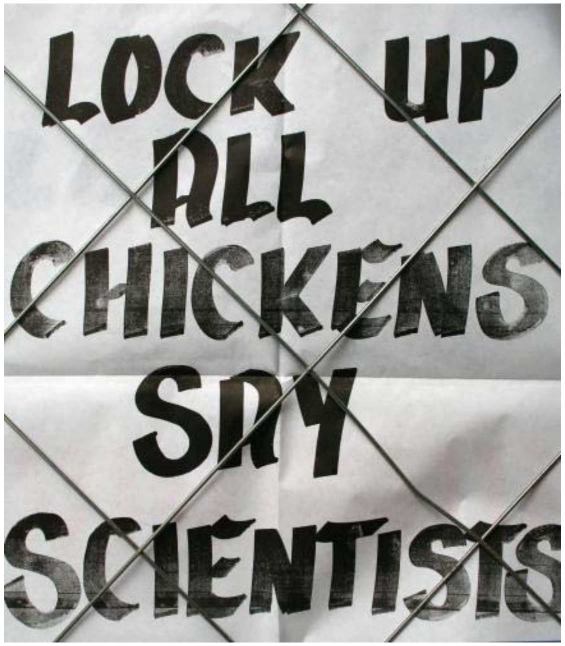
Current environment - Media



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Milliman pandemic modeling projects

- Mortality catastrophe bond projects

Company	Structure	Bond Notional	Countries Covered
Swiss Re	VITA I	$400m	France, Italy, Switzerland,UK, US
Swiss Re	VITA II	$362m	Canada, Germany, Japan, UK, US
Swiss Re	VITA III	$2,000m	Canada, Germany, Japan, UK, US
AXA Gie	Osiris	$442m	France, UK, US
Scottish Re	Tartan	$155m	US

- With mortality catastrophe bonds, investors lose principal when general population mortality increases beyond pre-specified levels
- For mortality catastrophe bonds - bond design, risk analysis, rating agency presentations, investor road shows and calculation agent
- Economic capital modeling and mortality stress testing

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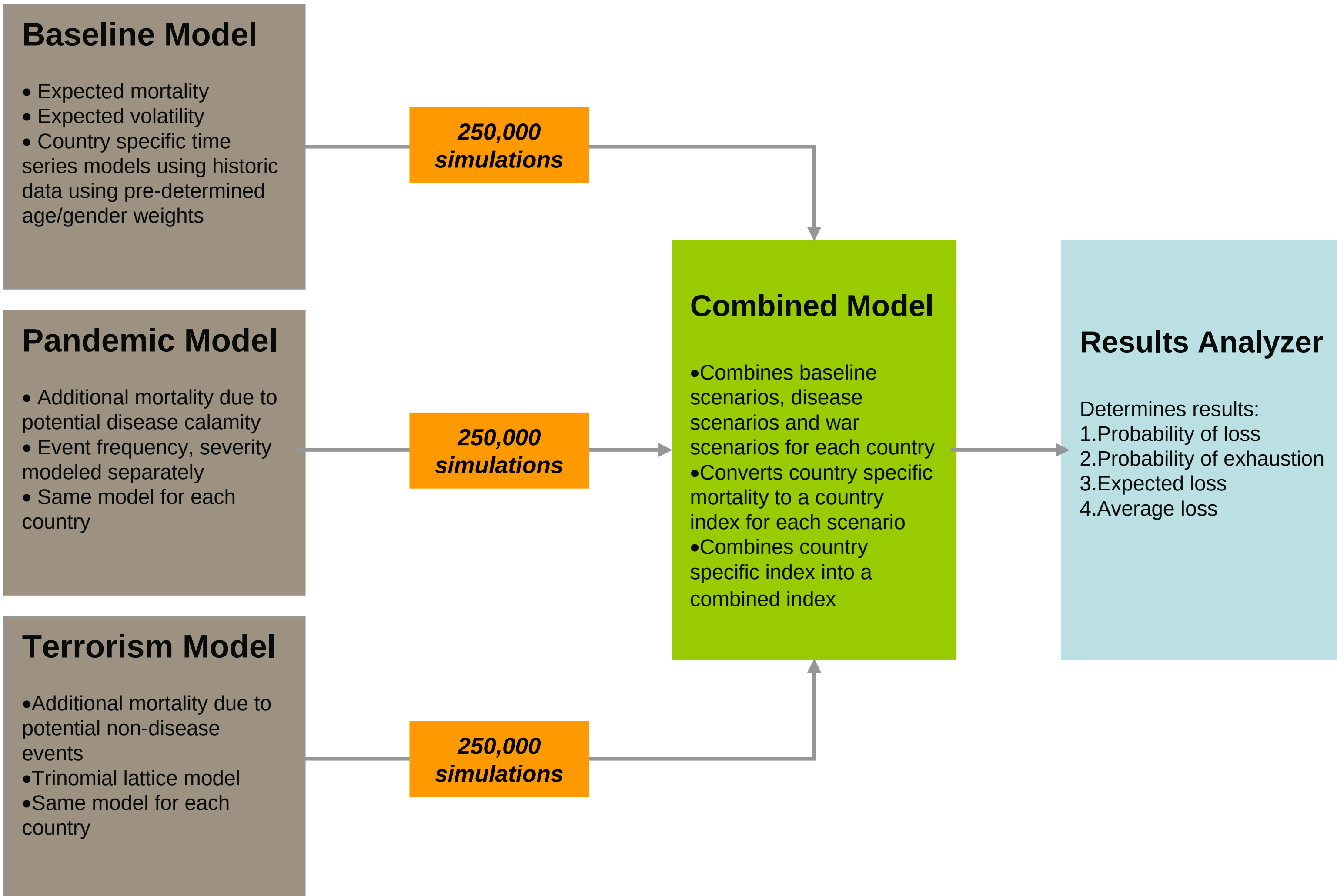
Modeling difficulties

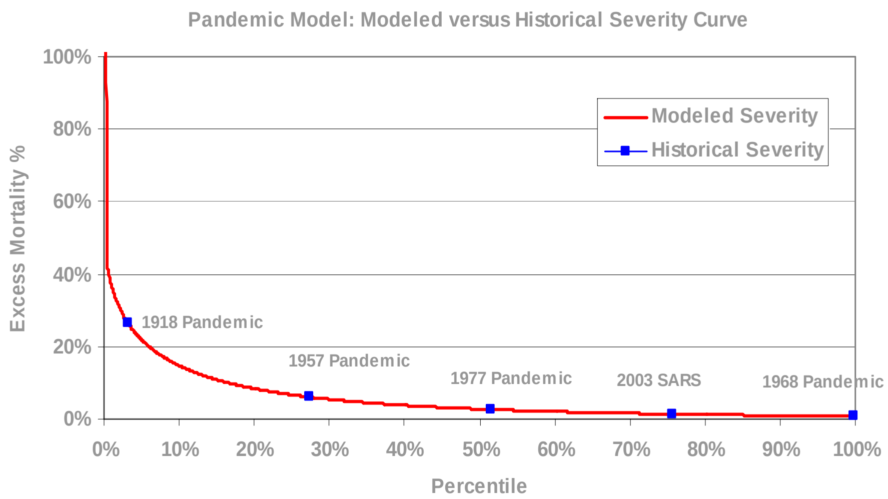
- What data is available for calibration?
- When does the pandemic start and when does it end?
- How lethal and infectious is the virus?
- How large is the affected region?
- What is the governmental response?
- How does individual behavior affect the pandemic?

Modeling methodology - Overview



Modeling methodology - Pandemic model

- Actuarial model based on a ‘frequency and severity’ approach
- Frequency and severity modeled separately based on historical occurrences of influenza epidemics
- Frequency set at 7.38% per annum based on 31 influenza epidemics over the last 420 years
- Disease epidemics occur in all countries at the same time with the same severity
- Severity curve reflects the age and gender distribution of the underlying cohort being modeled
- Severity modeled using an exponential curve



Modeling methodology - Frequency data

- Pandemics in the past
  - 31 in the last 420 years
  - 4 in the last 100 years
- Pandemic does not become more likely because a long time has passed since the last one - virus mutation is a random process
- Debate as to whether current risk level is elevated due to H5N1 prevalence in bird populations

Year	Description
1580	First recorded influenza pandemic began in Europe
1700's	Influenza pandemics in 1729-1730, 1732-1733 and 1781-1782
1800's	Influenza pandemics in 1830-1831, 1833-1834 and 1889-1890
1918	Spanish Flu
1957	Asian Flu
1968	Hong Kong Flu

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Modeling methodology - Severity data

- Data points used for the severity curve: 1918, 1957, 1968, 1977 and SARS 2003
- Severity curve data is sourced from the CDC (except SARS 2003)
- Severity data is based on US population experience and applied proportionately to other countries
- Seasonality element is modeled using a multiple-state model based on epidemiological progression of influenza during a typical influenza season

Modeling methodology - Model results

Percentile	Probability	Mortality Increase		Number of US Deaths	
		Model 1	Model 2	Model 1	Model 2
0.1	1 in 13,500 years	420%	427%	9,660k	9,820k
0.5	1 in 2,700 years	42%	45%	970k	1,040k
1.0	1 in 1,350 years	37%	39%	860k	900k
3.2	1 in 420 years	27%	29%	620k	670k

- Results are sensitive to age and gender distribution
- Higher increases for Model 2 due to younger age weighting for Model 2 cohort

Distribution of Maximum Additional Mortality		
Range		Proportion of Scenarios
Lower Percentage	Upper Percentage	
0	**10**	98.53%
10	**20**	0.91
20	**30**	0.33
30	**40**	0.15
40	**50**	0.04
50	**75**	0.01
75	**100**	0.01
100+		0.02

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Other models - Swiss Re internal model

- Combination of actuarial and epidemiological model
- Model starts by estimating excess mortality rates using data from 20th century pandemics
- Excess rates are then adjusted for health changes since prior pandemics, vaccines, etc.
- For a 1-in-500 year event Swiss Re Internal Model estimates excess US deaths of 300k (Milliman Model = 650k)
- Swiss Re defines recurrence of 1918 pandemic as a 1-in-500 year event

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Other models - Lancet 2006 article

- Model published in The Lancet, Volume 368, December 2006
- Statistical model relates excess mortality to per-head income and absolute latitude
- Model calibrated to vital registration data for the 1918 pandemic only
- Model projects excess mortality rates for several countries
- Recurrence of 1918 pandemic would cause 380k US deaths
- Model does not specify the probability of the recurrence of a 1918 pandemic

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Other models - RMS model

- Epidemiological model

- Model based on
  - medical research
  - medical trials
  - clinical data
  - published government containment plans

- Model projects
  - virus infectiousness and lethality
  - effects of human behavior and containment plans

How bad can it get?

- In most analyses 1918 pandemic sets the upper limit

- Why was it so bad?
  - No antibiotics, vaccines, etc. were available
  - World War I
  - Outbreaks of contagious disease

- Why it could be worse
  - No biological or logical reason why not
  - Random genetic mutation could produce a more lethal virus

- Why it may not be worse
  - Medical management has improved
  - Virological research and knowledge has grown rapidly
  - Surveillance networks have been established
  - Vaccines have been available since the 1950's

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