A GLOBAL LOOK AT PANDEMIC RISK

Webinar

Sponsored by the Academy's Health Practice International Committee (HPIC)

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Presenters

- Eddy Rubin, M.D., Ph.D., FACMG
  - Chief Science Officer, Metabiota
- Petra Wildemann, IFoA, SAV, DAV
  - Head of Business Development Europe and UK for Risk Products, Metabiota
- Paul Nunn
  - Head of Catastrophic Risk Modeling, SCOR Global P&C

- **Moderator**: Susan Mateja, MAAA, FSA
  - Chairperson, Health Practice International Committee

A Global Look at Pandemic Risks

A pandemic is an epidemic of infectious disease that has spread through human populations across large regions, multiple continents, or even worldwide

- More frequent than you think: In the last decade there have been 474 human disease outbreaks

- New threats continue to arise: Zika virus infection and microcephaly

- Public health experts believe we are at greater risk than ever of experiencing large-scale outbreaks and global pandemics like those we've seen before: SARS, swine flu, Ebola and Zika

A Global Look at Pandemic Risks

Historical Background

World Wide Examples of Pandemics

Modeling & Quantifying Risks

Types of Insurance & Other Ways to Mitigate Costs

Role of Big Data

Role of the Actuary

Epidemics: Humans, Animals, Viruses, and their Interfaces

Eddy Rubin, M.D., Ph.D., FACMG

American Academy *of* Actuaries

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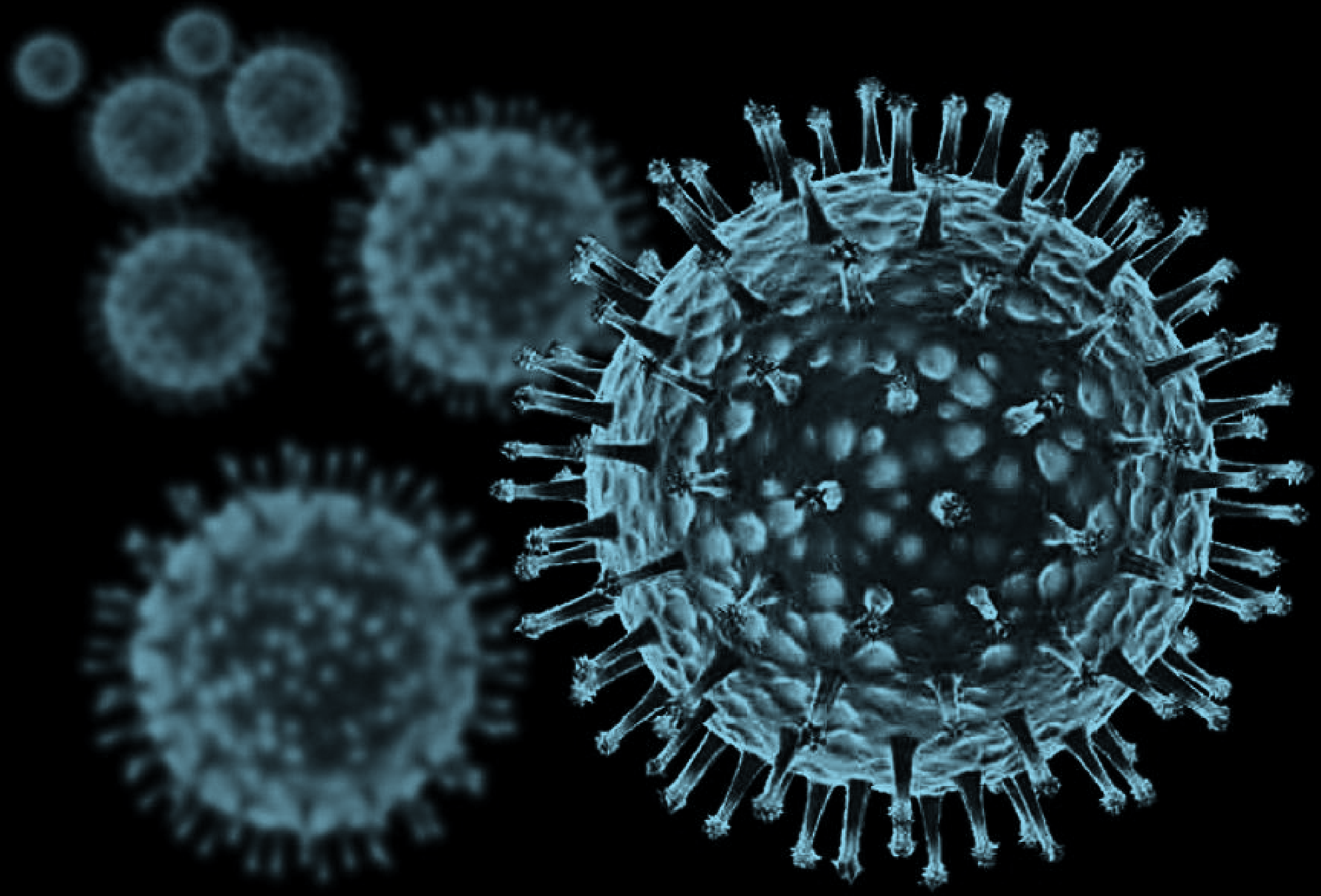
EPIDEMICS

Humans, Animals, Viruses and Their Interfaces



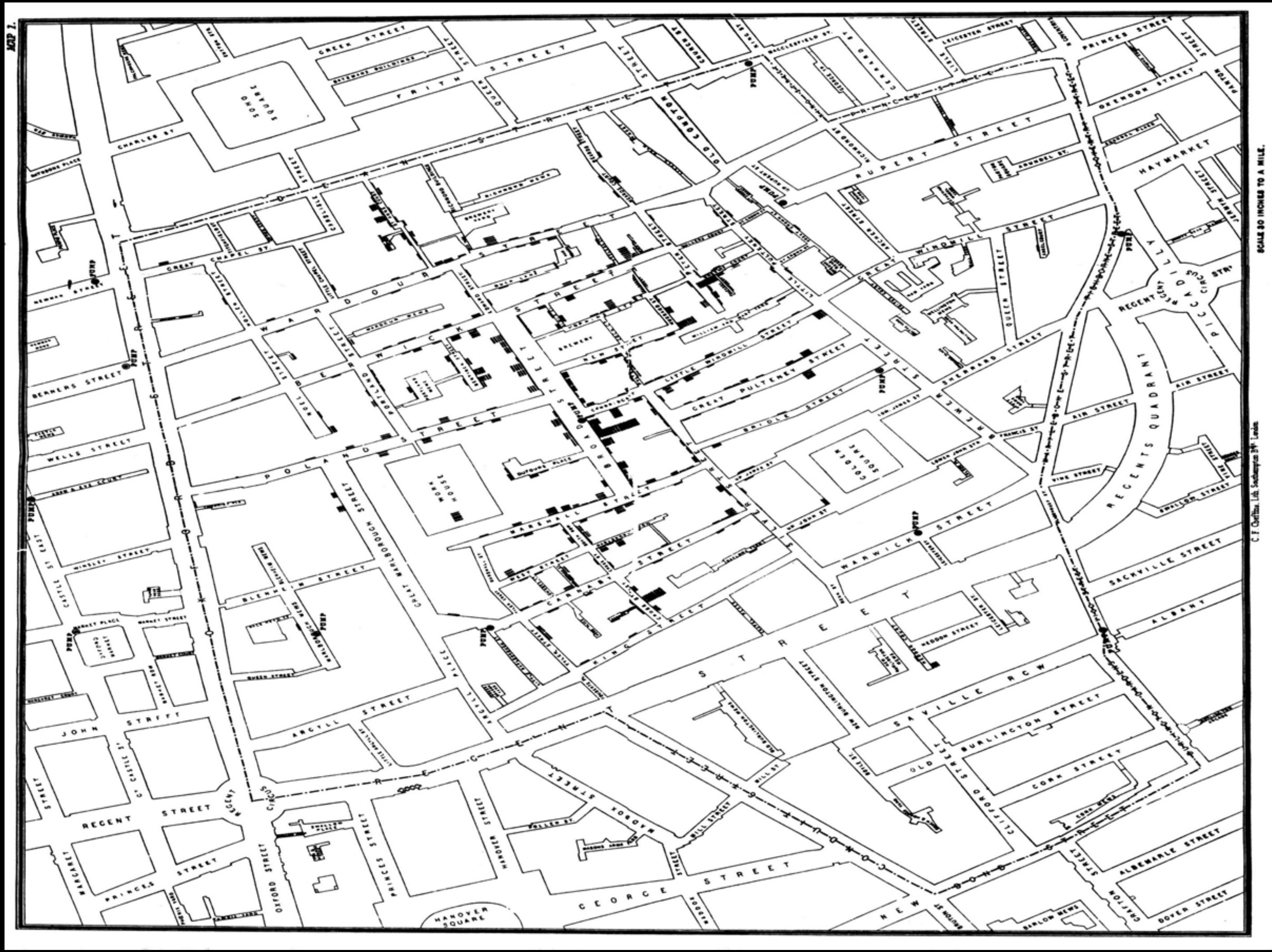
Eddy Rubin, MD, PhD
Chief Scientific Officer
Metabiota

EPIDEMIC PRIMER

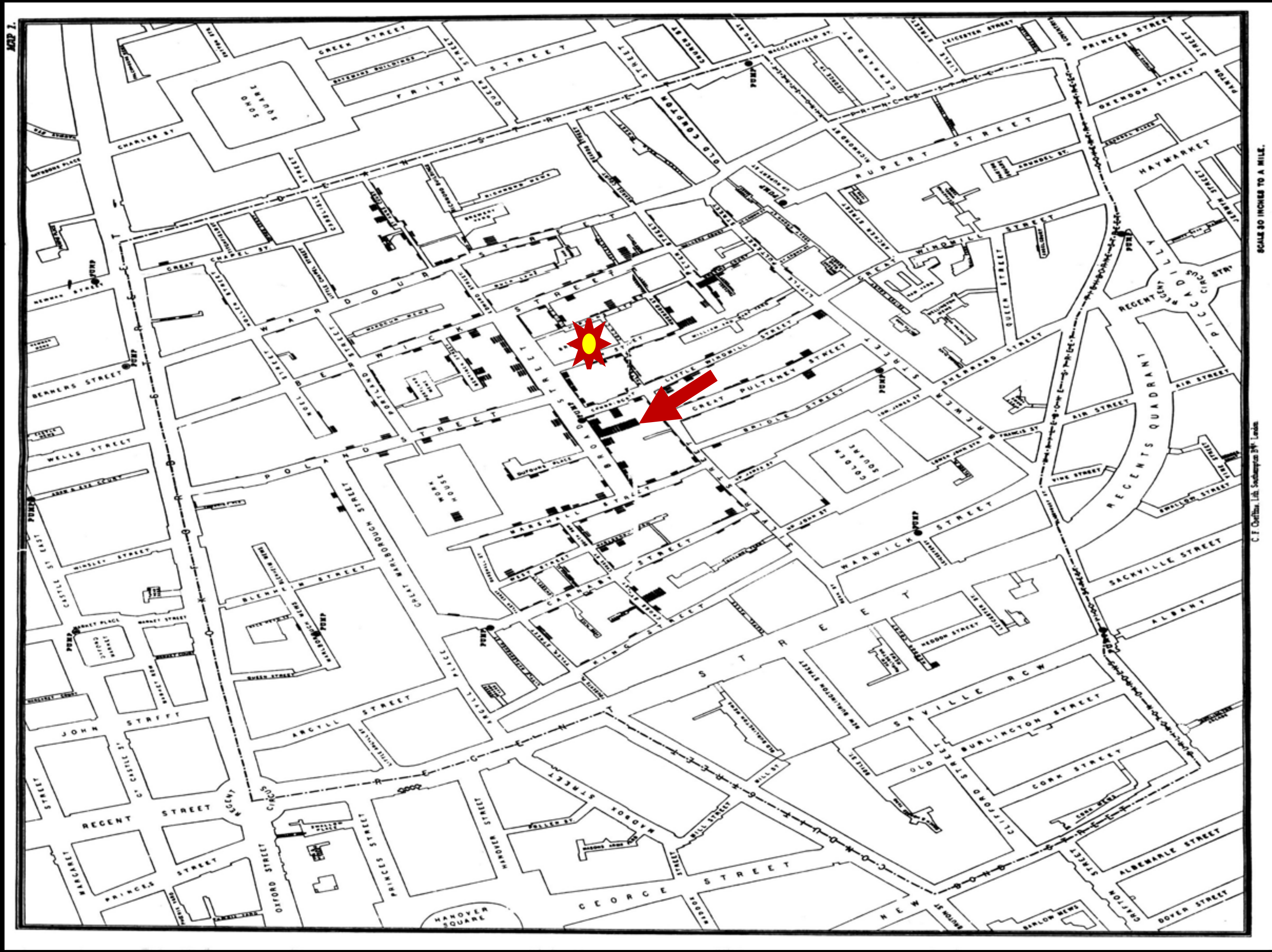
- Where we were
- Where we are
- How we got here
- Where we are headed

LONDON - 1854

JOHN SNOW'S "GHOST MAP"



JOHN SNOW'S "GHOST MAP"



USING DATA TO FIND THE SOURCE

US SURGEON GENERAL WILLIAM STEWART (1955)

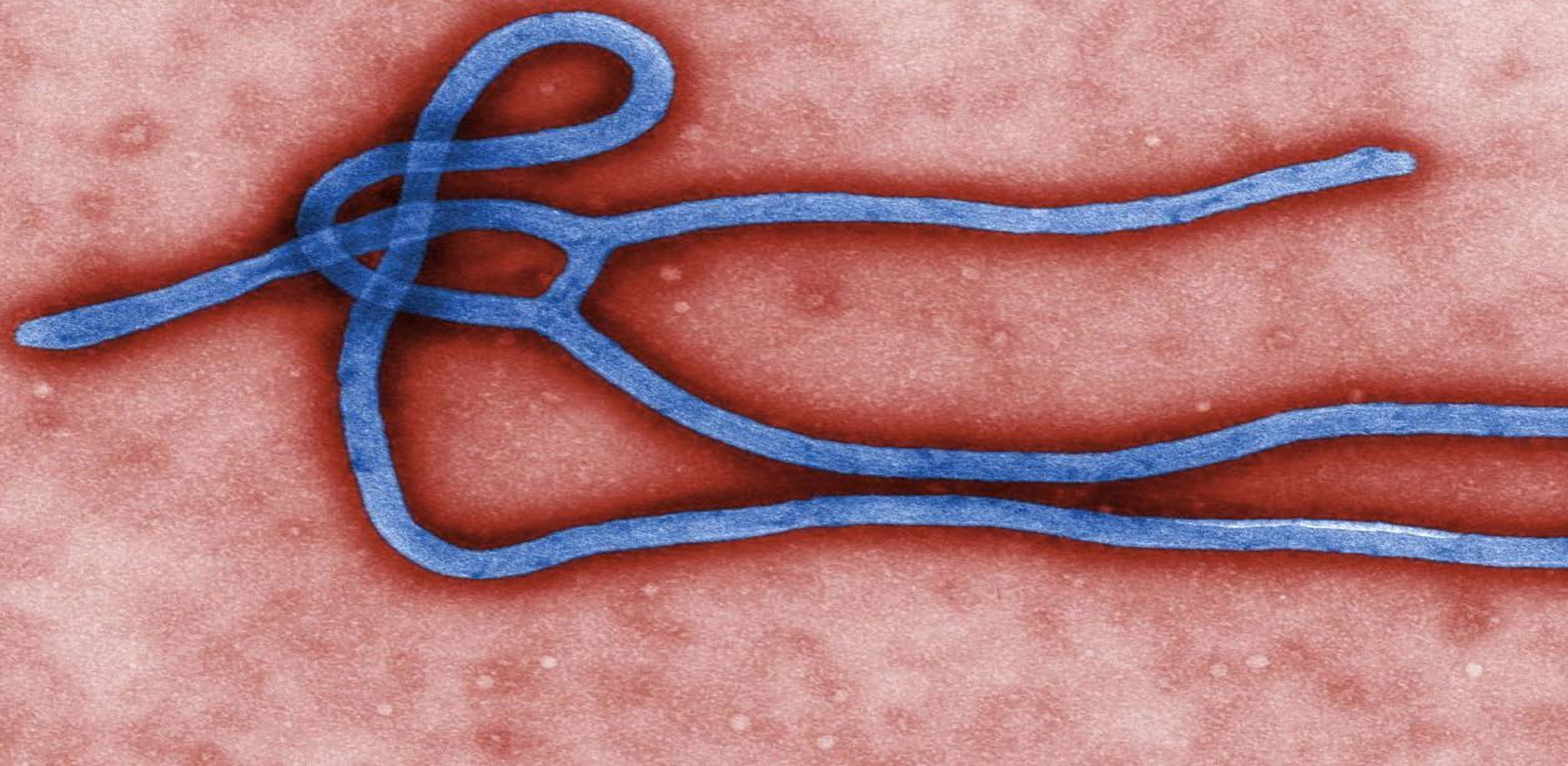
“ It is time to close the book to infectious diseases, and declare the war against pestilence won. ”

ZIKA

> 35 COUNTRIES TO DATE

W. AFRICAN EBOLA OUTBREAK (2013-2015)

28,000 CASES (LARGEST PREVIOUS OUTBREAK <300)

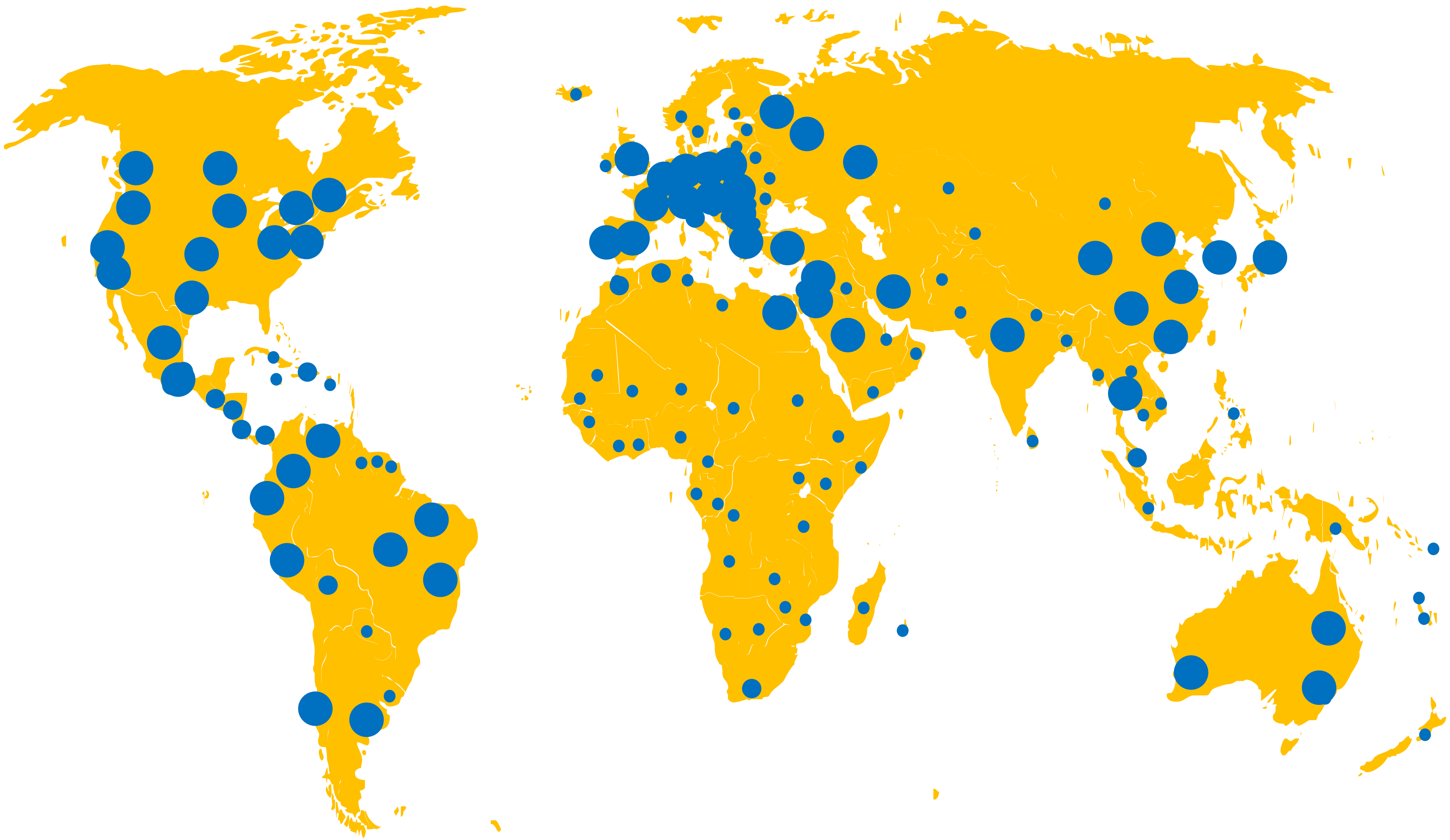


MERS (2013-2014)

21 COUNTRIES 30% FATALITY RATE

H1N1 (SWINE FLU) 2009-2010

NEARLY 2 BILLION PEOPLE INFECTED *(~150,000 DEATHS)*



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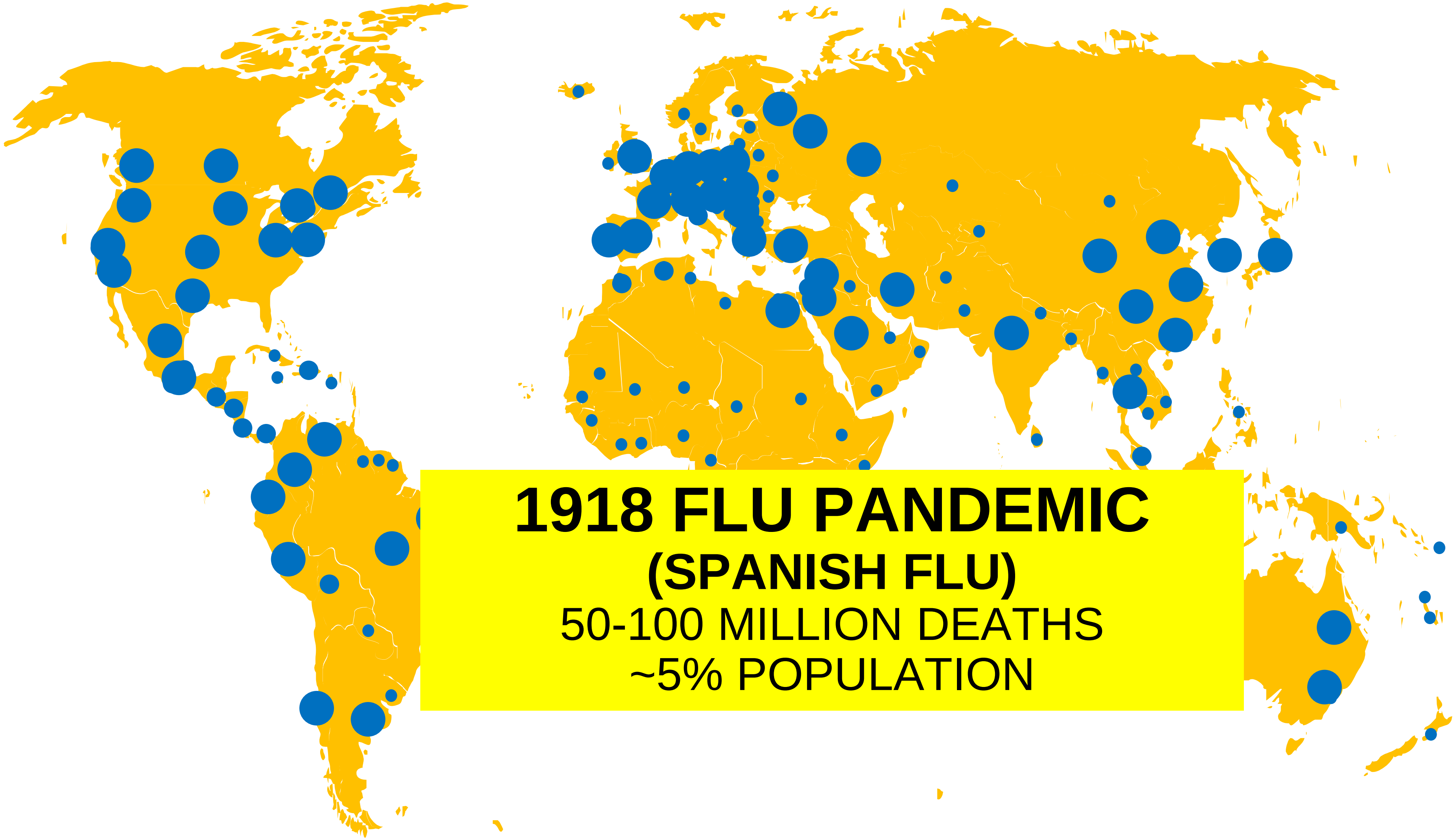
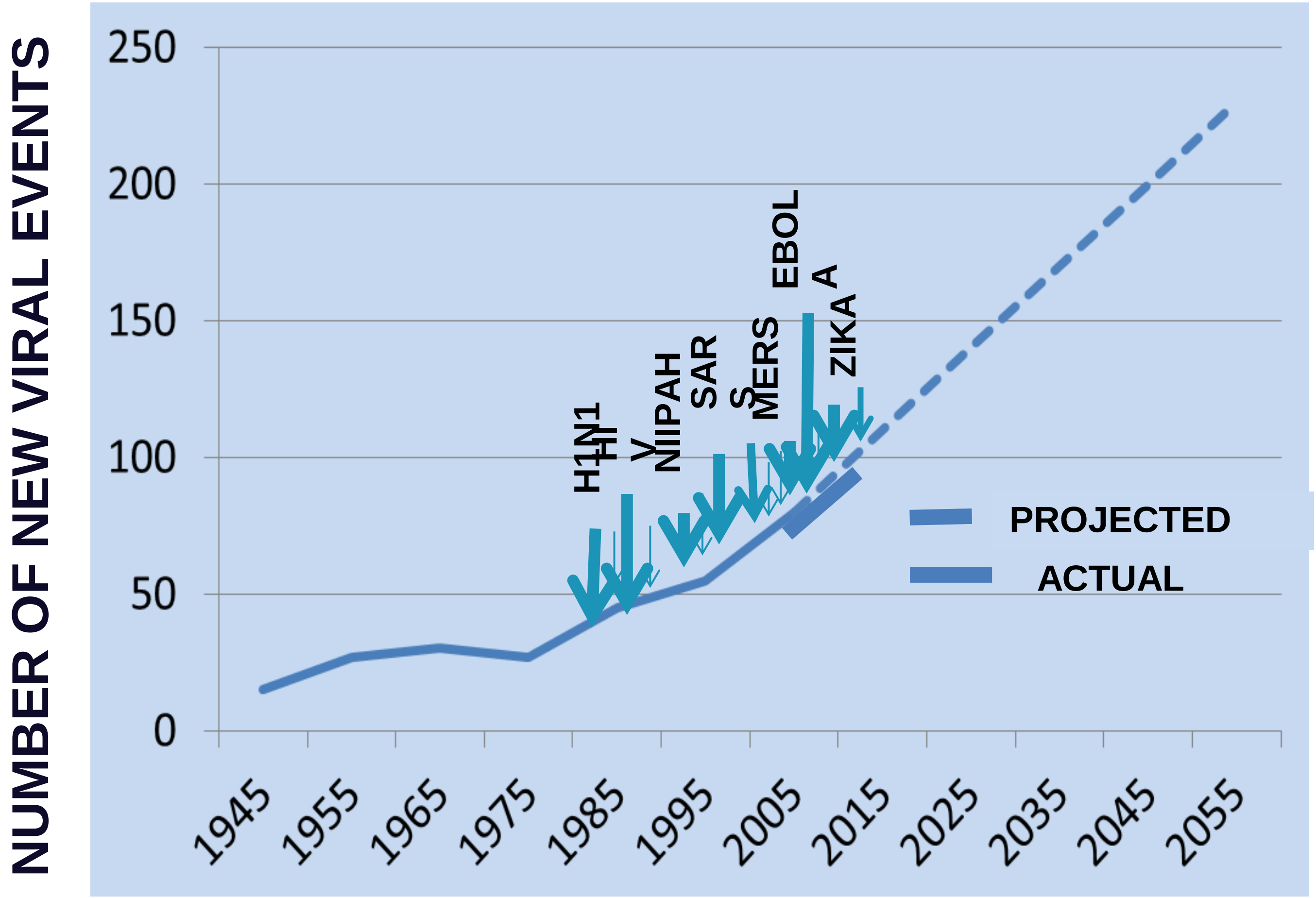


AVIAN INFLUENZA

H7N9

VIRAL OUTBREAKS ARE INCREASING IN A PREDICTABLE WAY



WHERE DO THE THREATS COME FROM?

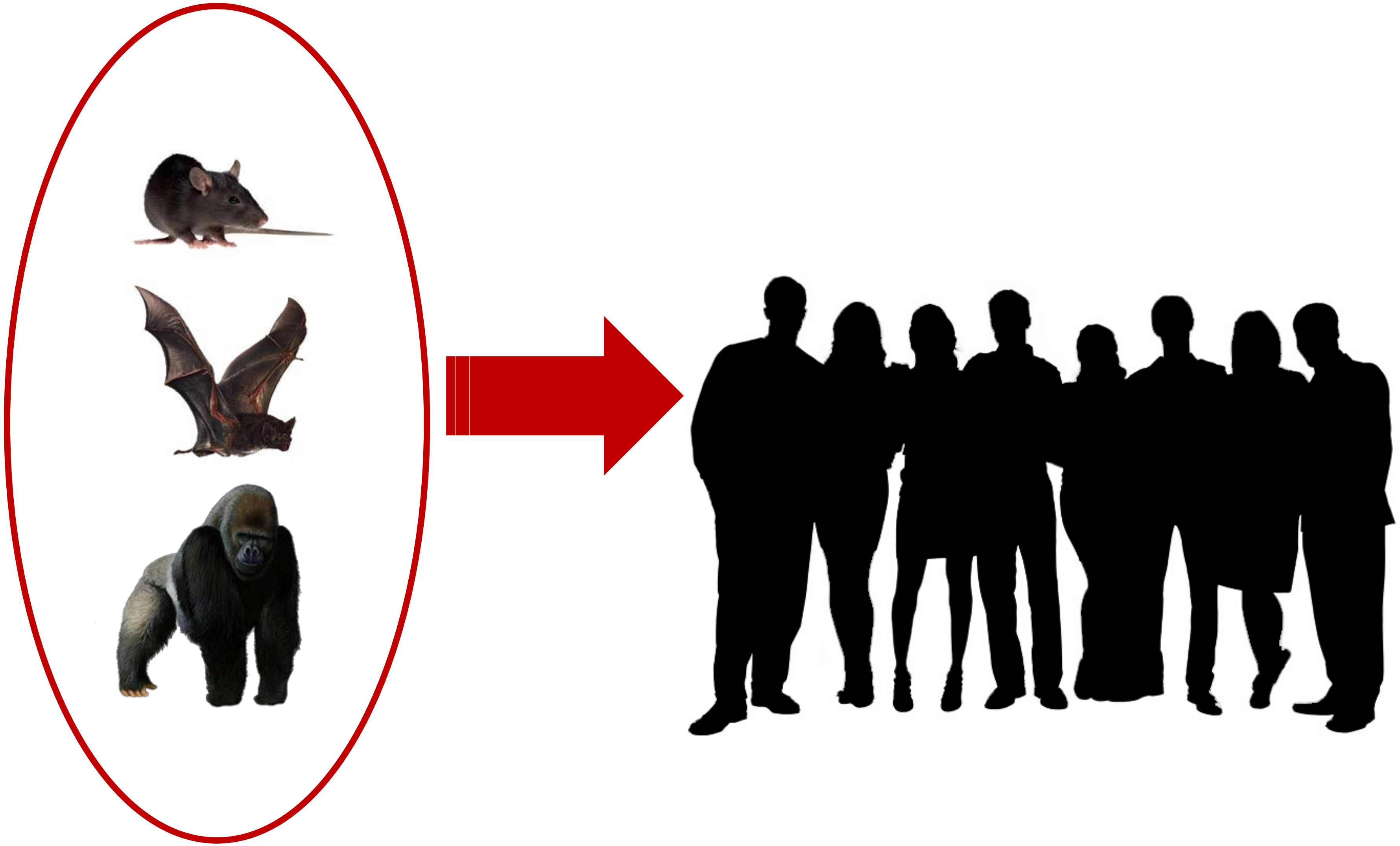
ZOONOSIS

VIRUSES TRANSMITTED FROM ANIMALS TO HUMANS

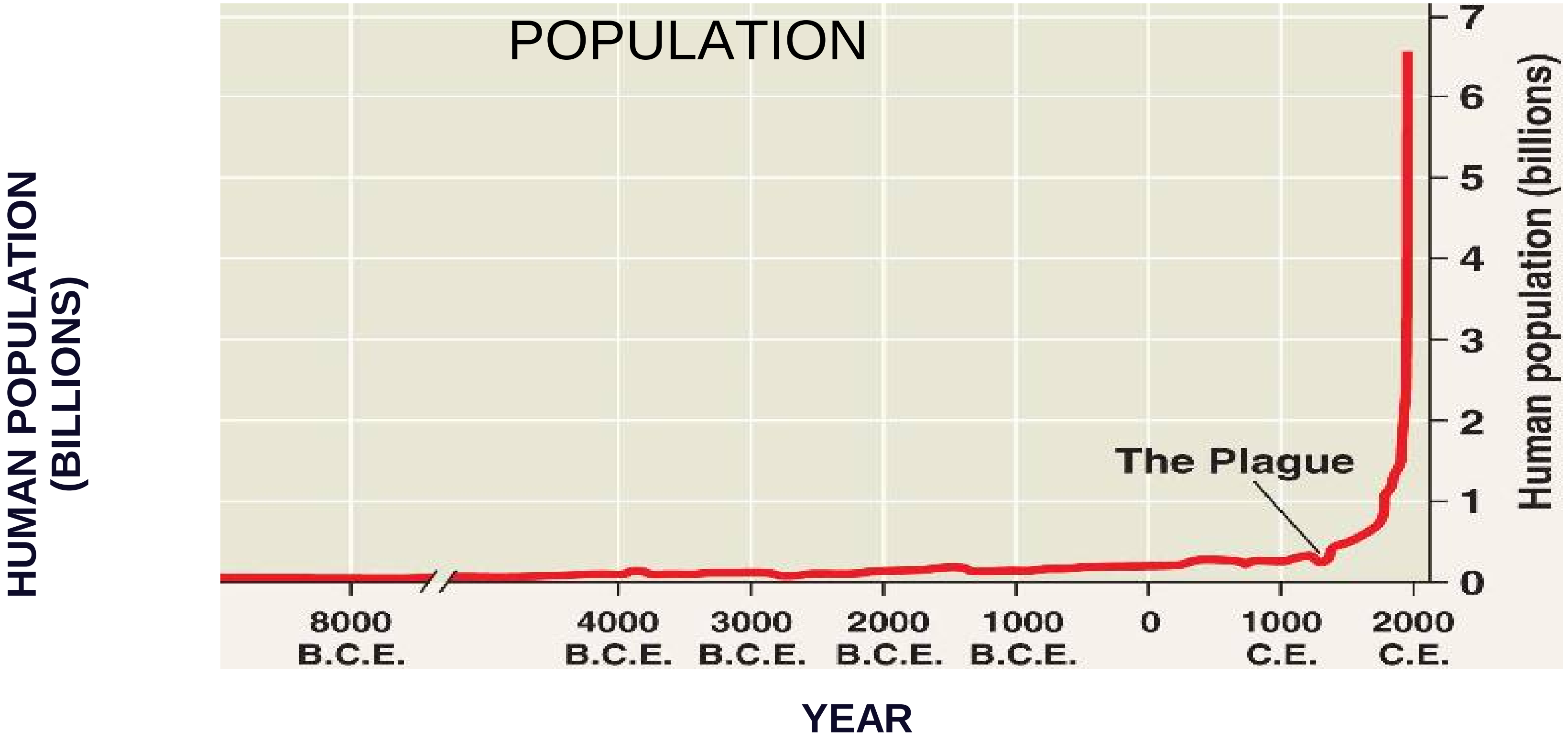
WHERE DO THE THREATS COME FROM?

ZOONOSIS

VIRUSES TRANSMITTED FROM ANIMALS TO HUMANS

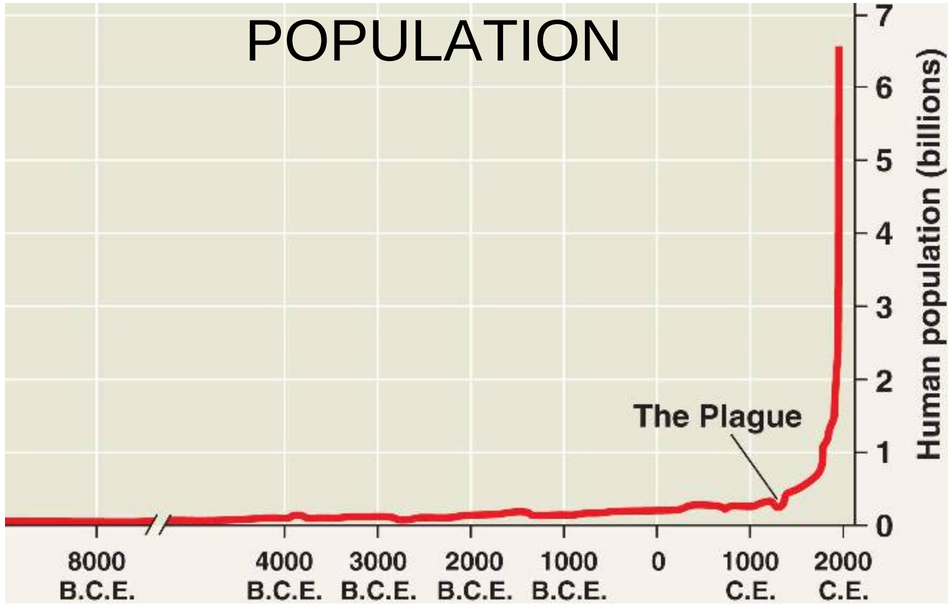


INCREASE IN SPILL OVER EVENTS



INCREASE IN SPILL OVER EVENTS

HUMAN POPULATION (BILLIONS)



YEAR

INTENSIVE AGRICULTURE

HABITAT CHANGES

NATURAL RESOURCE EXTRACTION

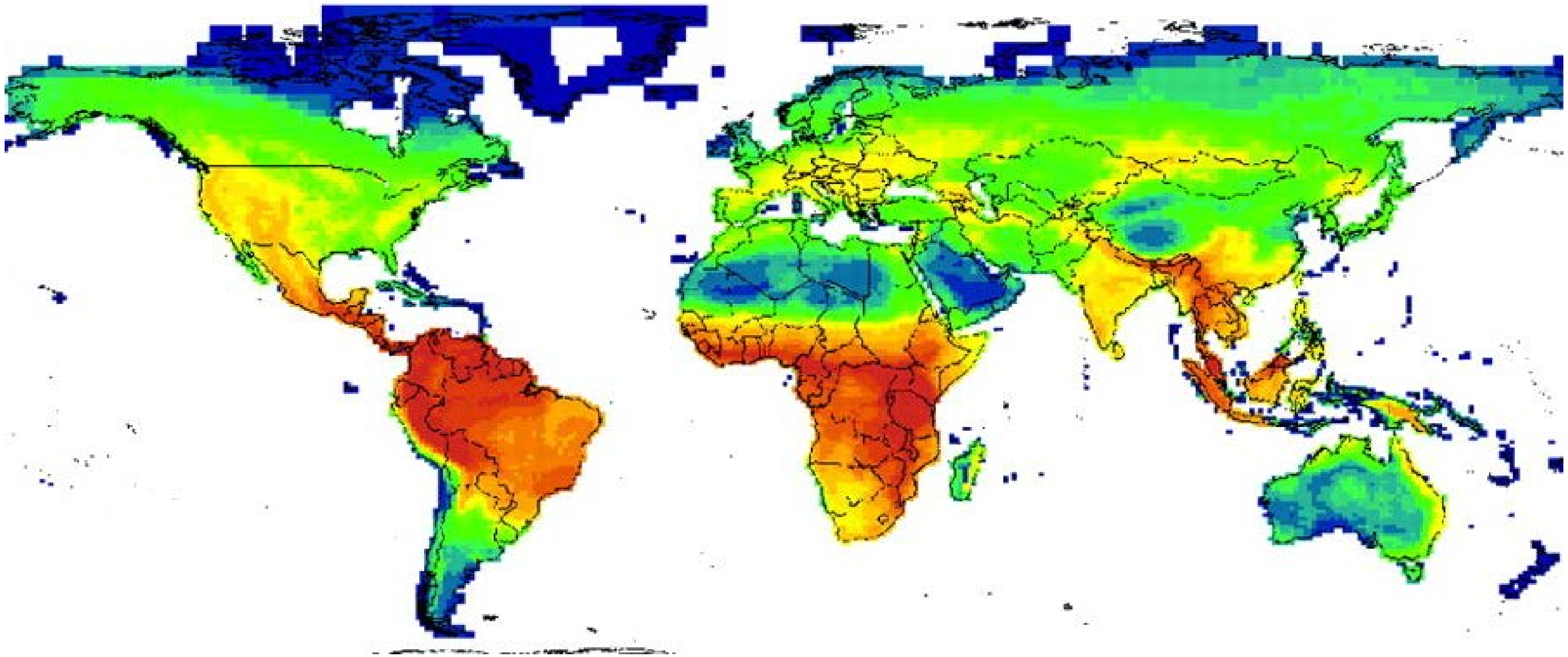
HUMAN ANIMAL CONTACT

GLOBAL TRAVEL

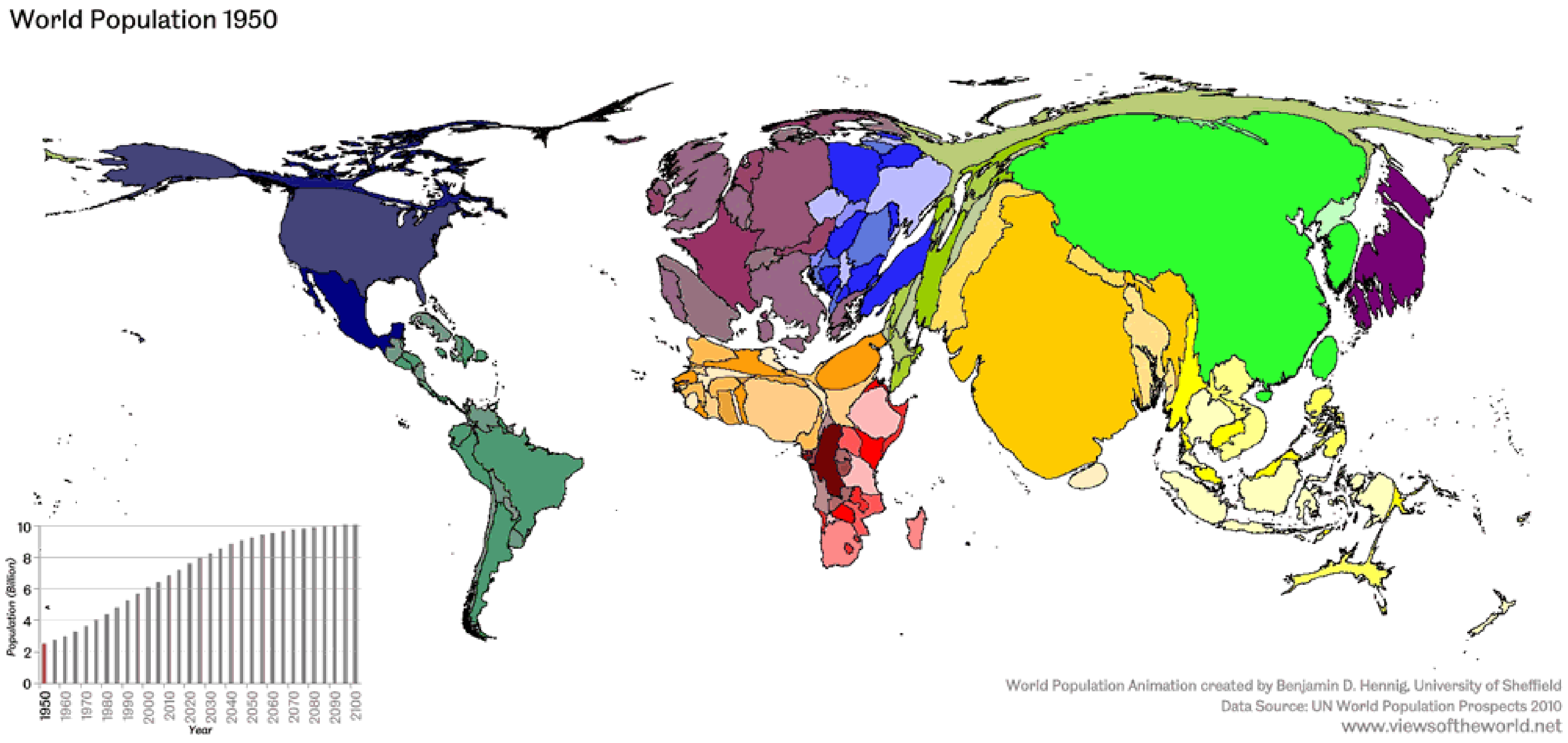
TURNS LOCAL OUTBREAKS INTO “GLOBAL EPIDEMICS”

“HOT SPOTS”

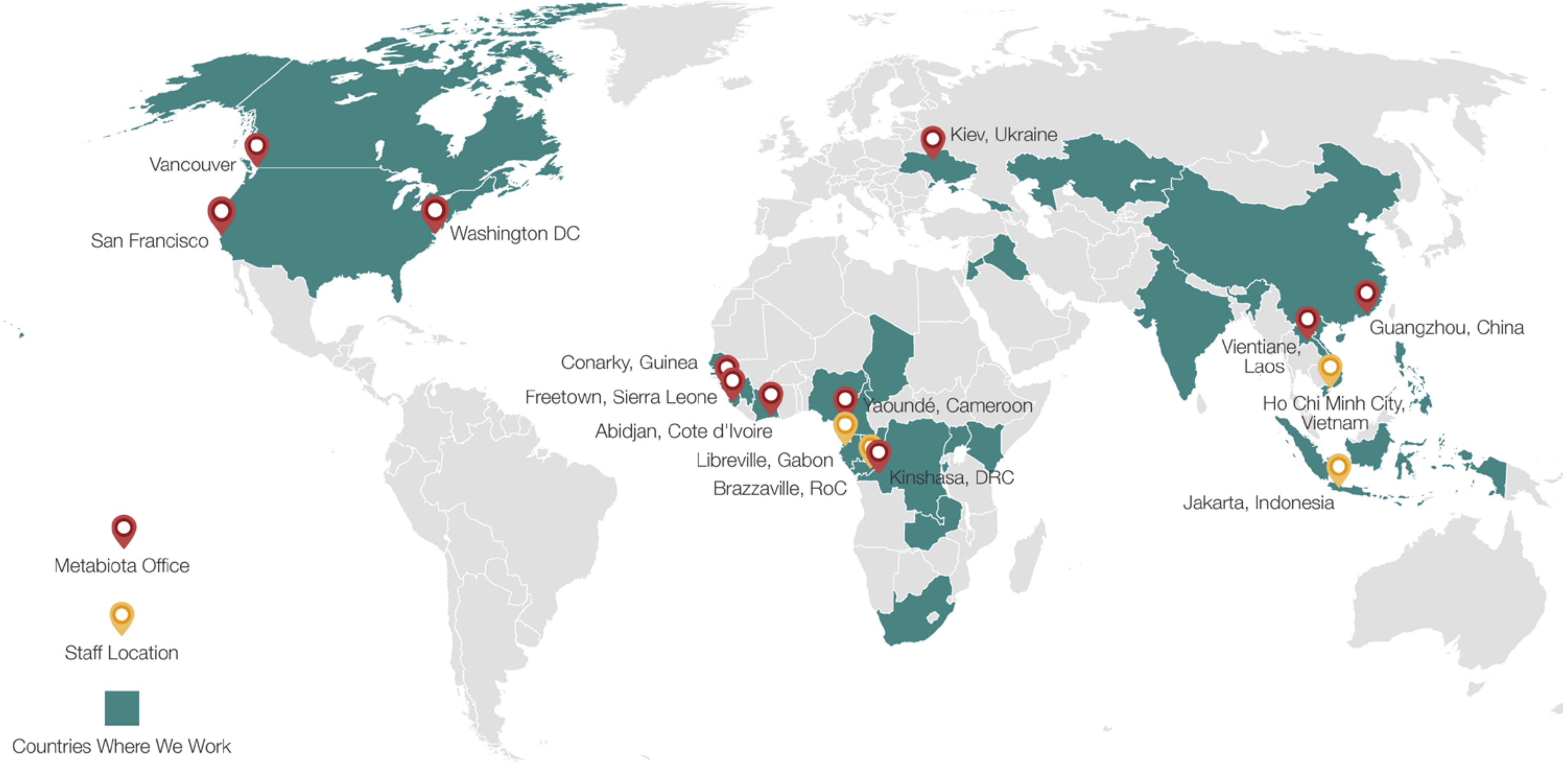
VIRAL DIVERSITY IS CLOSELY RELATED TO MAMMALIAN DIVERSITY, ALLOWING FOR GEOGRAPHIC TARGETING



DISTRIBUTION OF POPULATION CHANGE (1950-2100)



METABIOTA'S SURVEILLANCE & LABORATORIES IN "HOT SPOT" REGIONS



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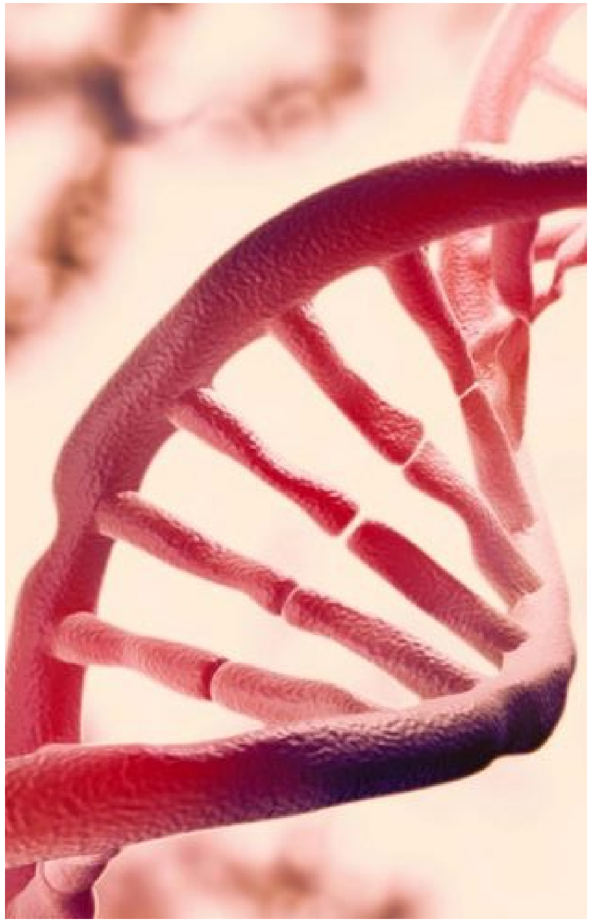
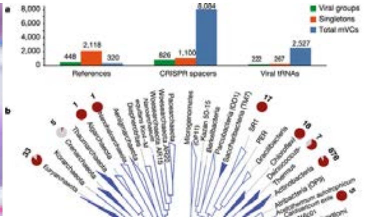
Our mission in Central Africa

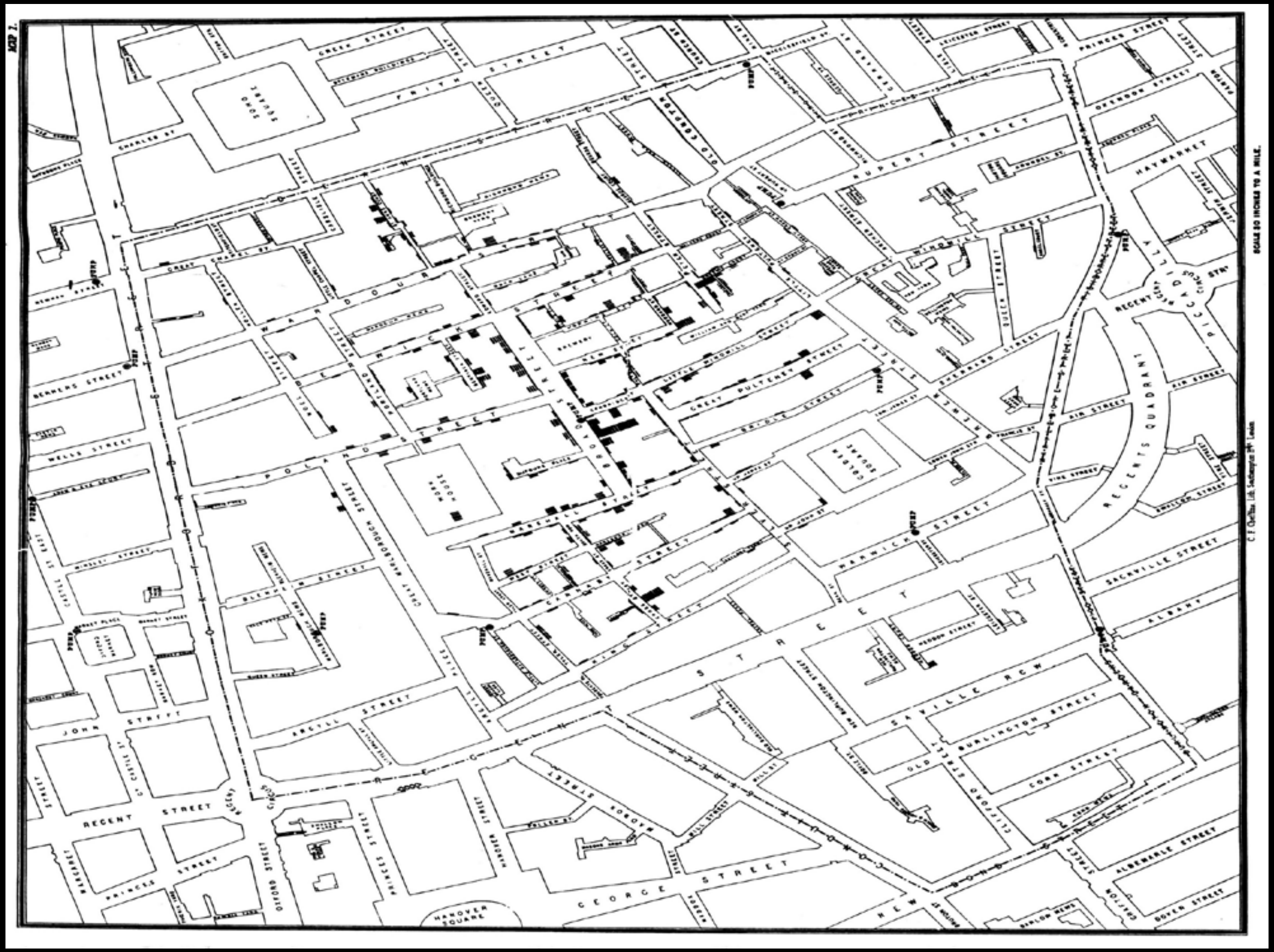
THE GLOBAL VIROME PROJECT



- A COLLABORATION TO DOCUMENT AND CHARACTERIZE VIRTUALLY ALL THE VIRUSES CIRCULATING IN WILDLIFE THAT POSE A THREAT HUMANS
- AN AUDACIOUS BUT DOABLE VISIONARY PROJECT
- THE POTENTIAL TO CHANGE THE WAY WE DO SCIENCE



HOW WOULD JOHN SNOW VIEW TODAY’S WORLD?



Thank you

Large-Scale Risks in Reinsurance

Petra Wildemann, IFoA, SAV, DAV

Large-Scale Risks in Reinsurance

Petra Wildemann,

Actuary SAV, DAV, IFoA (Affiliate)

Head of Business Development EMEA, Risk Products

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Risks in Reinsurance Agenda

- Reinsurance and Catastrophic / Pandemic Risks
- Cases of Tail Events
- Risks you can see and risks you can't see
- Elements of Modeling

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Classes of Insurance in Personal Lines

Property

First policies ≈ 1666 following great fire of London

Casualty

1848 policies offered to railroad passengers to cover risk of death

Life

Actuarial and statistical analytics enabled in 1750s

Health

Employers in US began providing benefit in 1950s

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Key Principles of Insurance

Moral Hazard

- Incentive to guard against risk

Risk

- Uncertainty about potential future loss (timing, size,

Peril

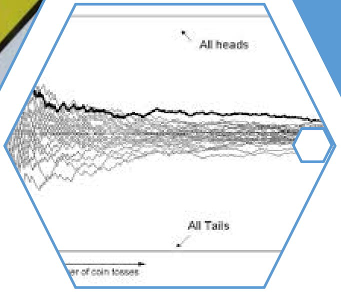
- Cause of loss

Adverse Selection

- Those with greater risk more willing to pay to transfer it

Information Asymmetry

- Entities know more about their individual risks than insurance companies



Law of Large Numbers

- Large, homogenous groups allow for greater certainty in estimating risks

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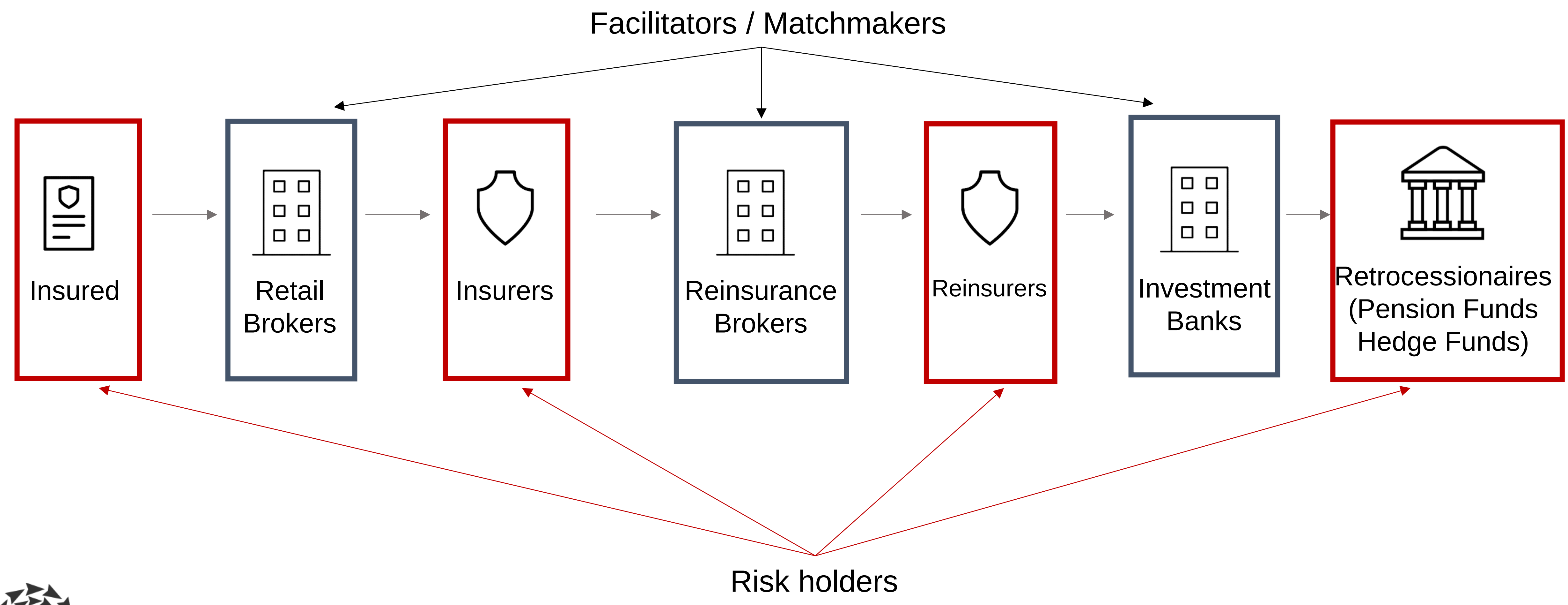
Insurance Value Chain from Personal Lines to Capital Funds



Classes of Reinsurance

- Coverage intended for insurance providers
- Reinsurance policy reduces the losses sustained by insurance companies by allowing them to recover all, or part, of the amounts they pay to claimants
- Reinsurers help insurance providers avoid financial ruin
  - When many policyholders make claims during a catastrophic event
  - When few policy holders make concurrently very large claims

Facultative
- individual risk
- specified risk
- contract

Treaty
- specified period of time
- all risks within the coverage

Proportional
- prorated share of the premium
- portion of losses
- agreed percentages for premium and losses
- ceding commission

Non-proportional
- exceeding a specified limit

Excess-of-Loss
- losses exceeding a retained limit
- "catastrophic" events
- per occurrence or accumulative

Risk-Attaching
- covers all established losses

Loss-Occurring
- type of a treaty coverage
- all losses occurred

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Large-Scale Risks Assigned to Reinsurers

- Cover large risk-bound geographical areas
  - Mostly all are affected, once one is affected
  - Exceptions for individual items
- Prevent effective use of normal-based distributions
  - Introduction of correlations
  - Change of traditional insurance distributions
- Extending beyond boundaries of a single region or country
  - Multi-national
  - Globally joint efforts
- Challenges
  - Different national entities with different regulations, facilities, capabilities and profiles
  - Considerations such as international traffic and quarantines, public immunizations and vaccinations

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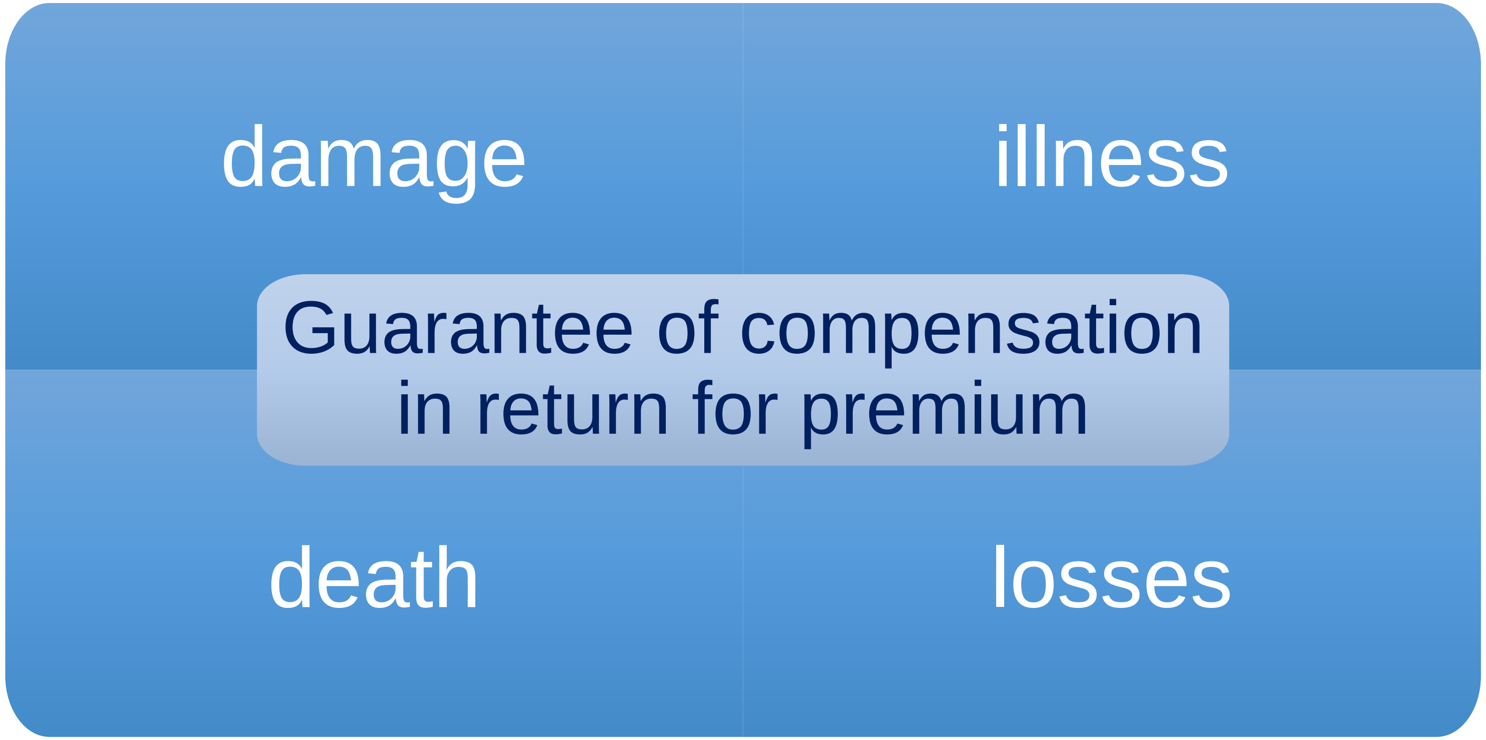
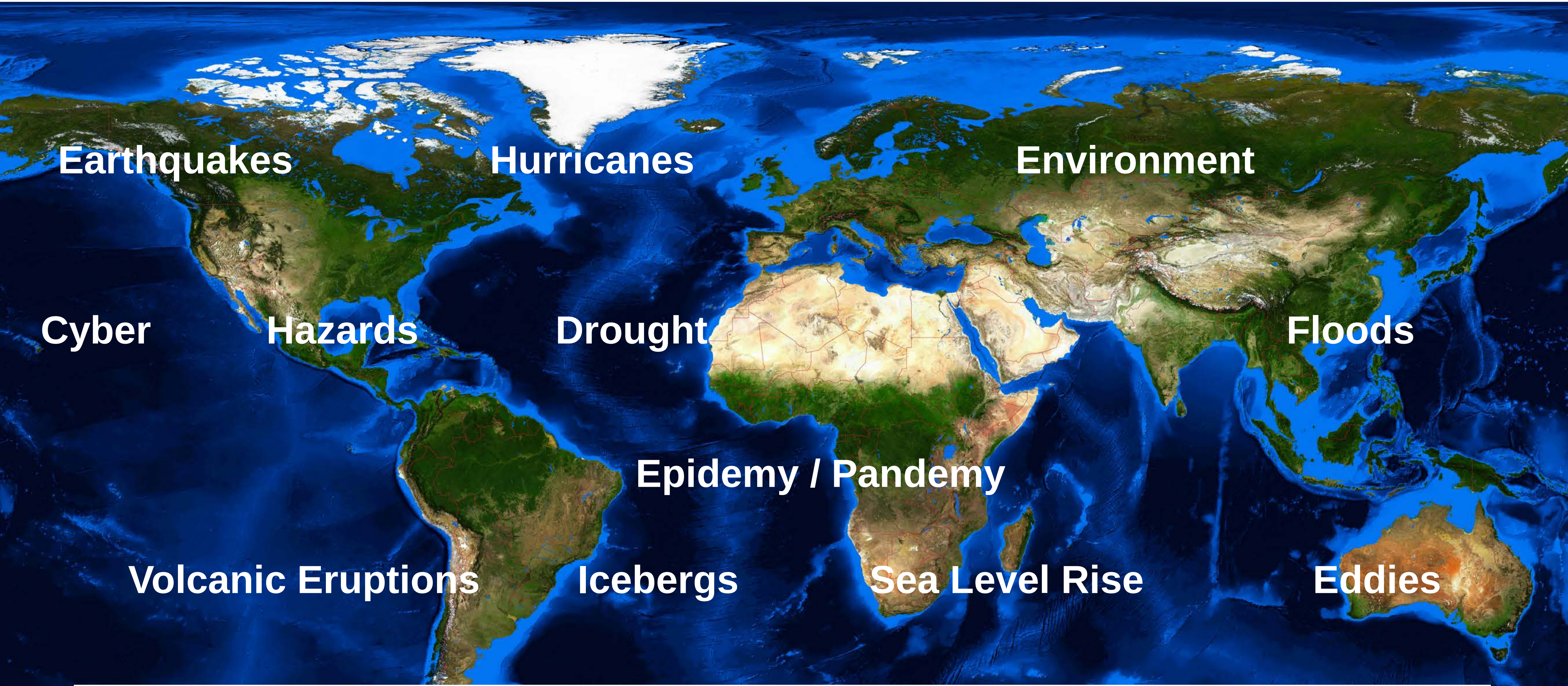
Risk Transfer

Various methods, beyond the control of insurance, by which a pure risk and its potential consequences are transferred to other parties



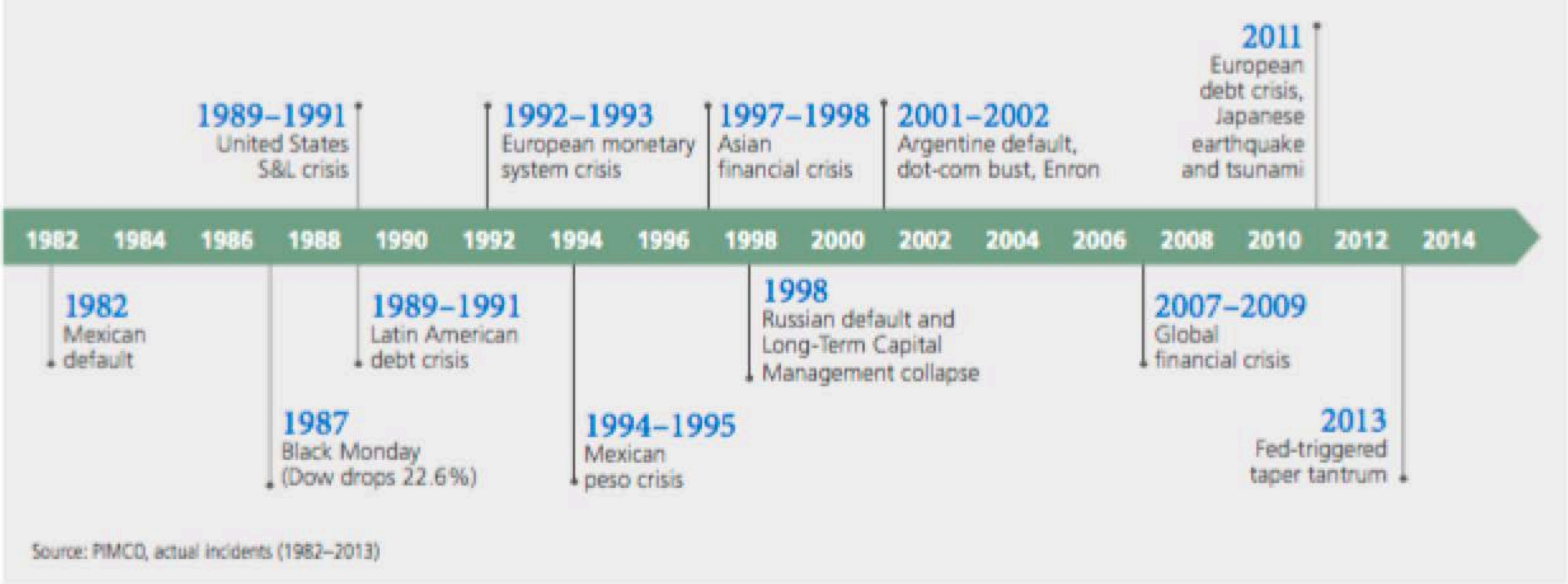


Types of Global Risks / Multinational Risks

Capital and Catastrophic Events

- Catastrophic events are by definition long-tail
- Insurers covering such infrequent events collect premiums that may be insufficient to cover and even, leading to insurer collapse
- Regulations must prevent this from occurring
- Insurers must hold reserves invested in safe (usually low return) asset classes
  - Use combination of accumulation management and reinsurance to carefully manage capital levels
- Reinsurance
  - “Insurance for insurance companies”
  - Trade underwriting risk for counterparty/financial risk
  - Lower capital requirements
  - Increase ability to write more business
  - Smooth earnings
  - Retrocession is reinsurance for reinsurance companies

Tail Events Are More Frequent Than Investors Realize



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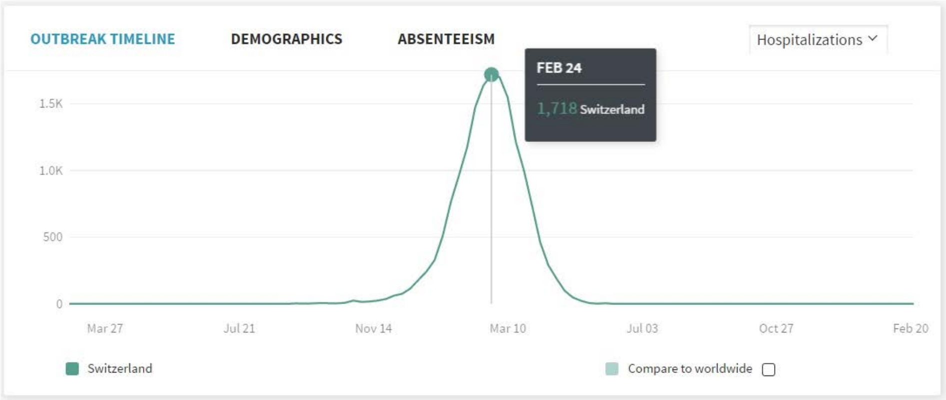
Tail Events

- Tail Events are rare, but when they occur, they usually are catastrophic in nature
- Tail events require multi-years solutions and repairs and rebuilding approaches
  - Period of reconstruction after a loss
  - Insurance coverage period is a multi-years period
- Geographical and time scopes of these risks may make any single insurers resources, or even national resources, insufficient
- Tail events, or even a related sequence of tail events, require a very different complex actuarial modeling, reserving, premium setting, etc.



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Insuring Tail Risks

- Tail Event is a loss outside the “expected range”, in the tail of the probability distribution
    - Long time between premium collection and payment of claims
    - Events with small probability of occurrence
- Long Tail Lines
    - Specific losses unknown for some period and can take long time to settle
    - Premiums can be invested and earn a return
    - Total claims often are higher than premiums collected
- Short Tail Lines
    - Losses usually known and paid shortly after loss occurs
    - Little opportunity for re-investment of premiums
    - Insurers must charge higher total premiums than claims paid

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BI Case Study: Point of sale Travel Insurance

- **Product:** Travel Insurance policy against cancellations due to Zika outbreak
- **Target Customers:** Travelers to Latin America and 2016 Olympic games visitors
- **Coverage:** Trip cancellation or re-booking to another destination if the Zika outbreak gets worse

Trigger Considerations

- The trigger should be very simple and easy to understand
  - Described in two lines next to a check-box on tour operator website
- "Zika related" should be defined generously: Zika, microcephaly etc.
- Threshold of X Zika related cases in the respective country / in Latin America
- General travel alert by the Country/s Ministry of Foreign Affairs for the respective country due to Zika
  - Is meant for everybody, not only for pregnant women

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BI Case Study: Public & Private Partnership

- September 20 – Saudi Arabia reports its first SARS case
- October 15 – Metabiota & Reinsurer partner on SARS risk assessment
- October 20 – Reinsurer completes risk analysis to take on tourism risk
- October 30 – Saudi Arabia government offers travel insurance cover

- **Event**: A SARS Outbreak in Saudi Arabia
- **Purpose:**
  - Stop the losses in air travel and tourism spending caused by trips cancellations
  - Confirm public confidence in Governmental outbreak response
- **Parties involved**: Saudi Arabia National Government, a global Reinsurer, Metabiota

Process and Outcome

- Metabiota's team of epidemiologists analyzes the development pattern of the disease and informs the reinsurer about expectations in terms of remaining duration of the outbreak
- Saudi Arabia issues a travel insurance policy covering the treatment cost for all tourists
- By partnering with the private sector, Saudi Arabia succeeds to limit the potential disruption to the economy

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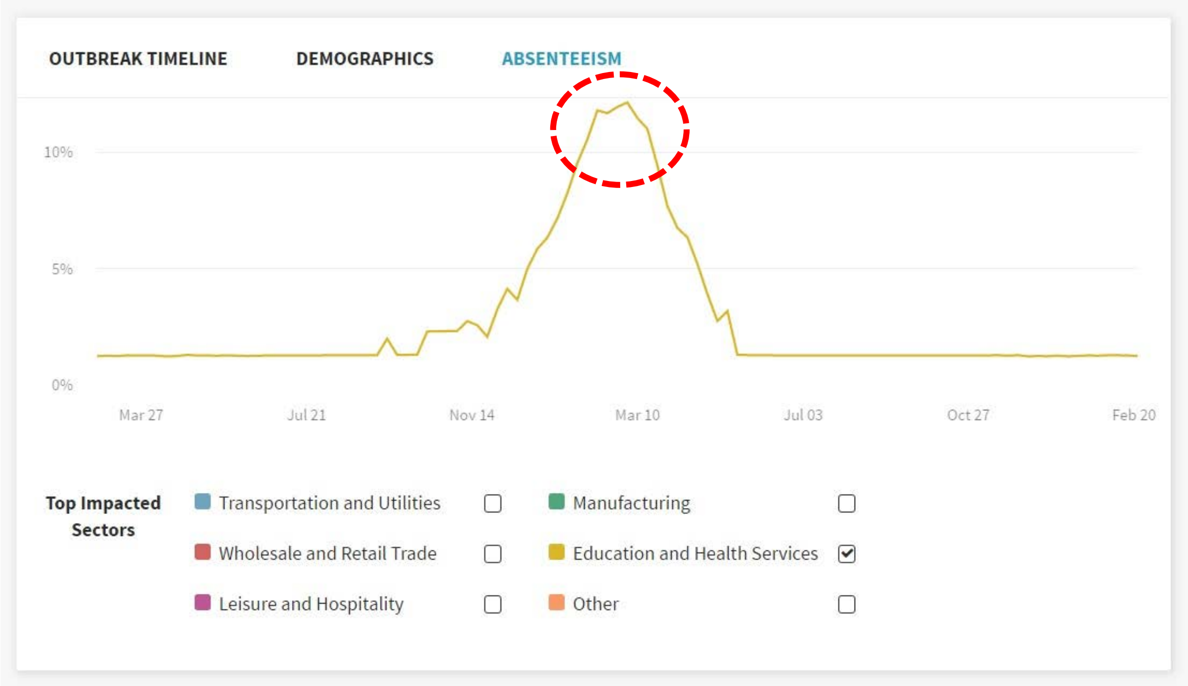
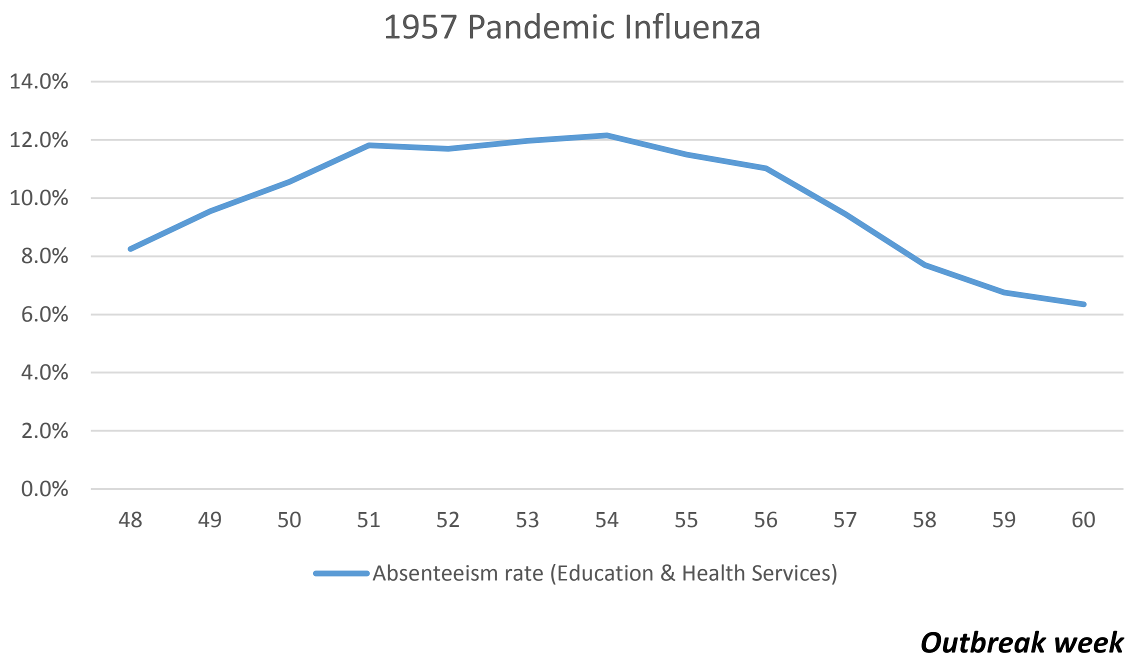
BI Case Study: Hospitals & Physicians Groups

1957 Pandemic Influenza, Peak ABSENTEEISM RATES (Switzerland)





- Enables creation of multi-part triggers for business interruption resulting from employees not being present at work during an outbreak or epidemic event
  - Absenteeism rate = (number of people missing work / total workforce)
  - Absenteeism rate granularity = weekly
  - 1957- like event can produce up to 12% absenteeism rate in the Education & Health Services
  - The specificity of 1957 event is that the peak is "sticky" – the max values are sustained for more than 3 weeks (week 51-54)

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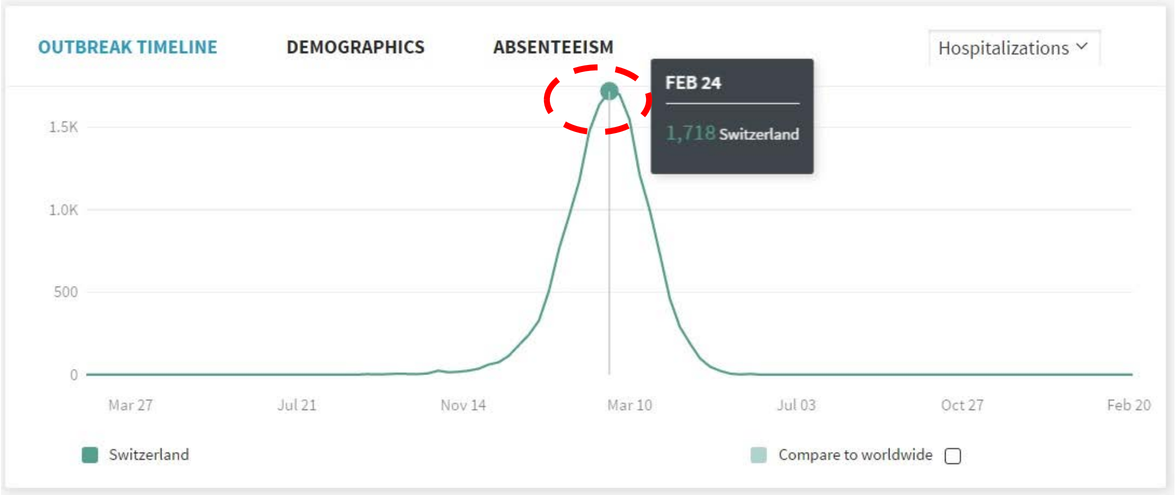
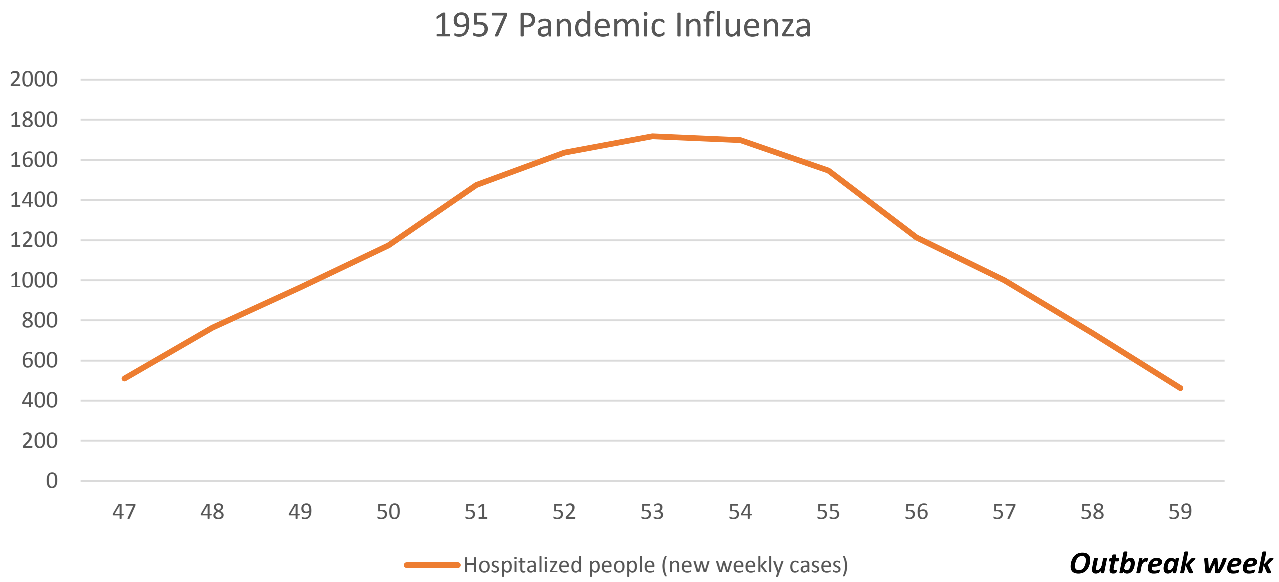
Source: Analytics Platform of Metabiota

BI Case Study: Hospitals & Physicians Groups

1957 Pandemic Influenza, Peak HOSPITALIZATION COUNTS (Switzerland)





- Hospitalization counts = weekly new number of sick people getting admitted in hospital
- Hospitalization rates are capped to account for the max hospital capacity by country
- A peak in hospitalization rates correlated with a peak in absenteeism rates can double the cost for a hospital -> new people need treatment, and while under pressure the medical personnel is also missing work

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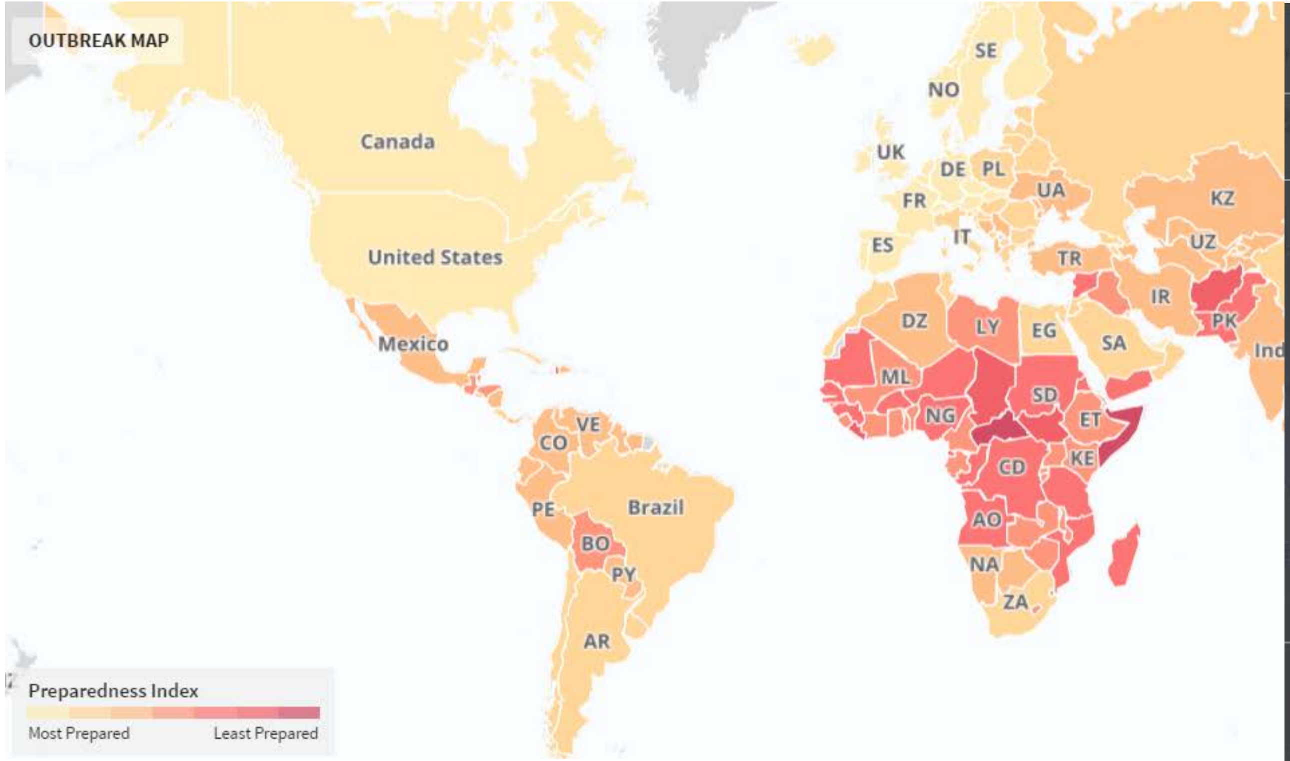
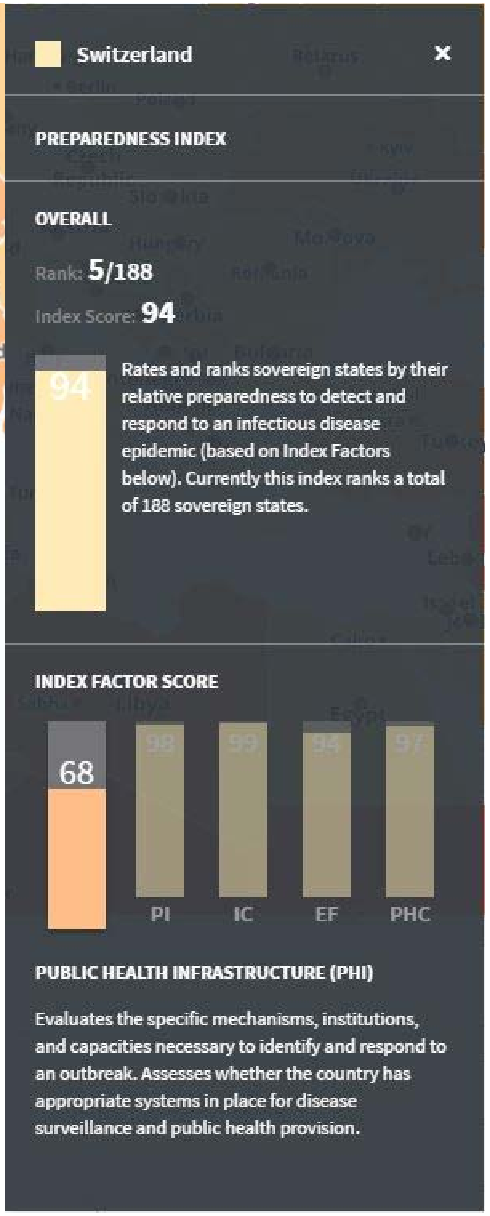
Source: Analytics Platform of Metabiota





Insurability & Risk Differentiation

Insurers need to understand: Preparedness of a country and its neighbor countries to handle outbreaks, frequency and severity of events, and likely absenteeism for an event with a 20-50 year return period.

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Allows insurers to view risks of a country/region with respect to other countries and regions

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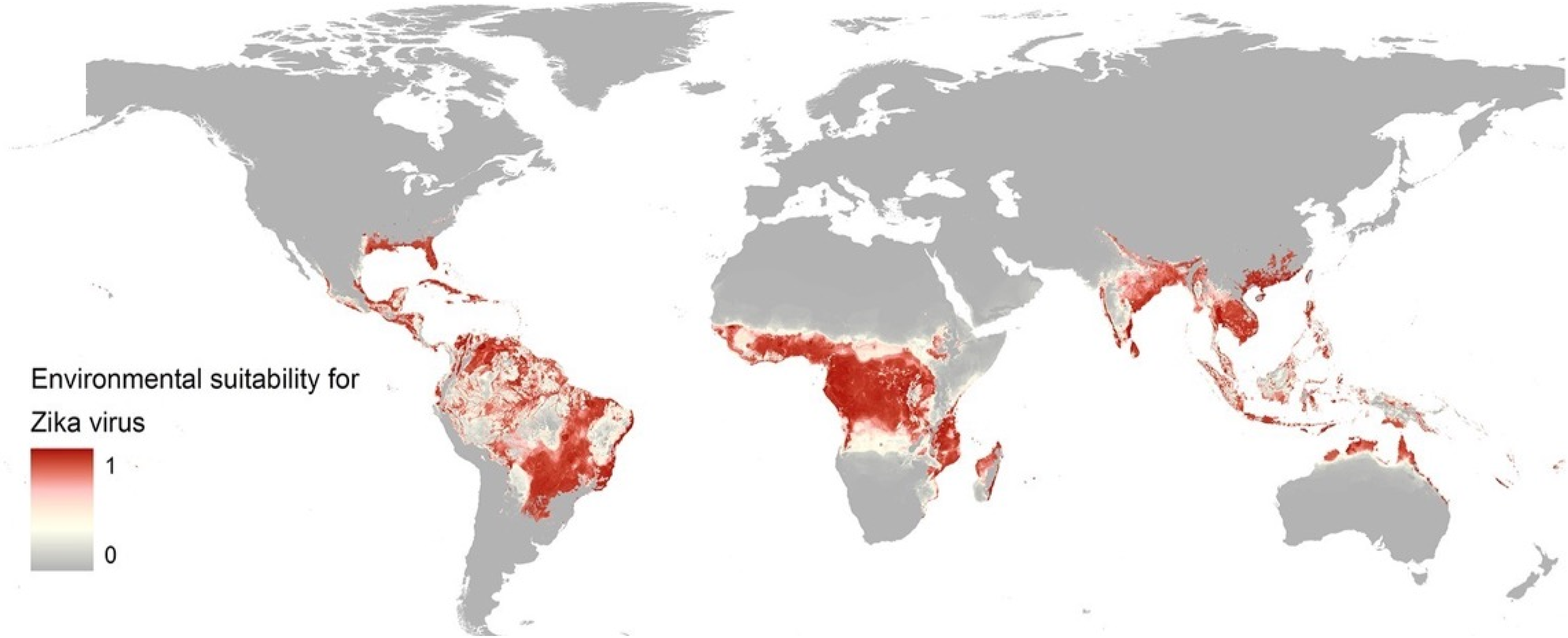
Why are Epidemics Risks Important to Understanding Future Risk



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Thank you

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Catastrophe Risk Modeling

Paul Nunn

AMERICAN ACADEMY *of* ACTUARIES

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Pandemic Risk Webcast
6th June 2017

Catastrophe Risk Modelling

Paul Nunn
Head of Catastrophe Risk Modelling

AGENDA

1 Quick intro to Catastrophe Risk Models

2 CAT models have improved our quantification of risk

3 But models struggle to represent real world complexity/ behavior
Vulnerability examples
Hazard examples

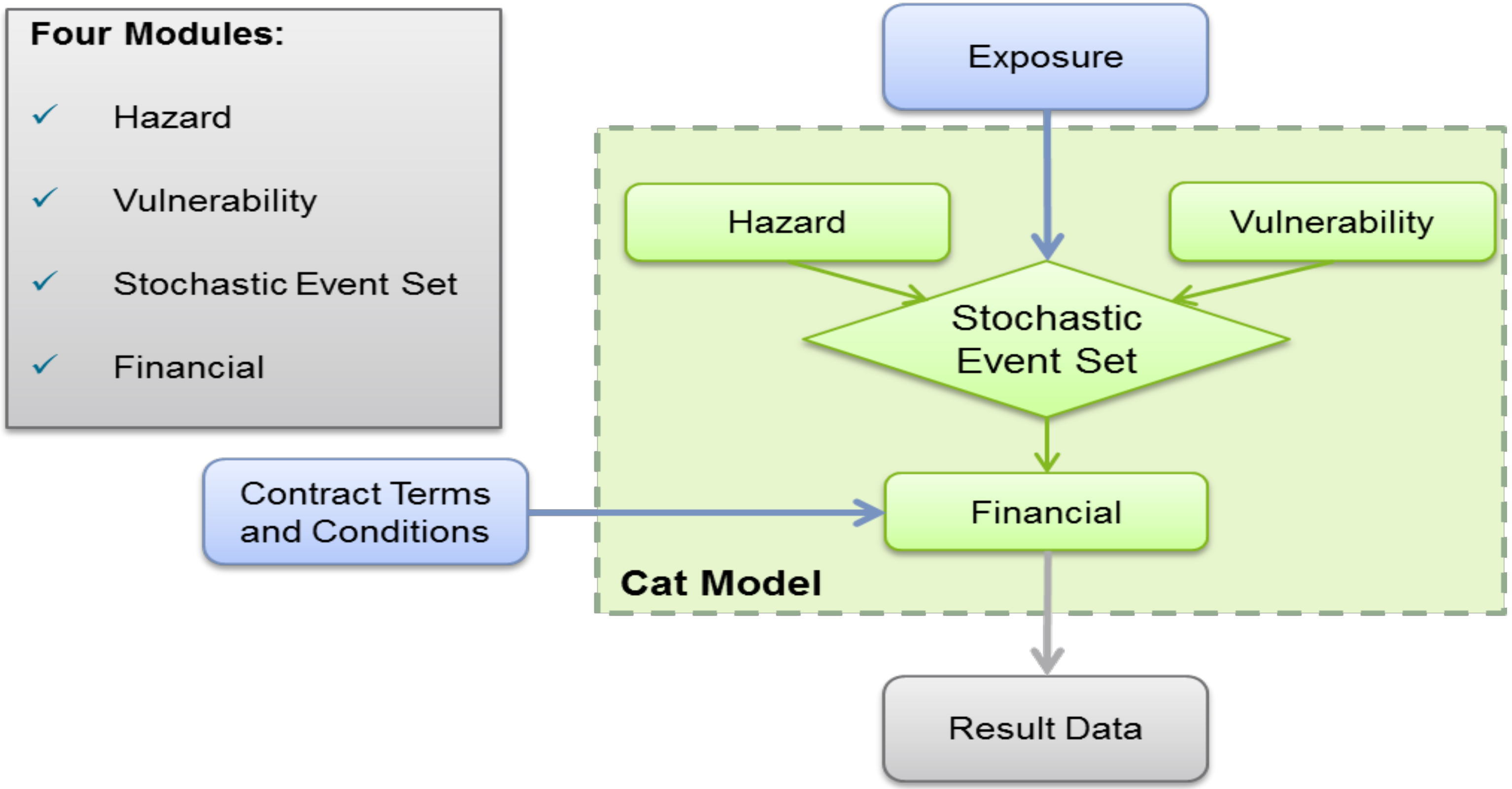
4 The Calibration Conundrum

5 Making sense of all this uncertainty
Ensemble of risk outcomes

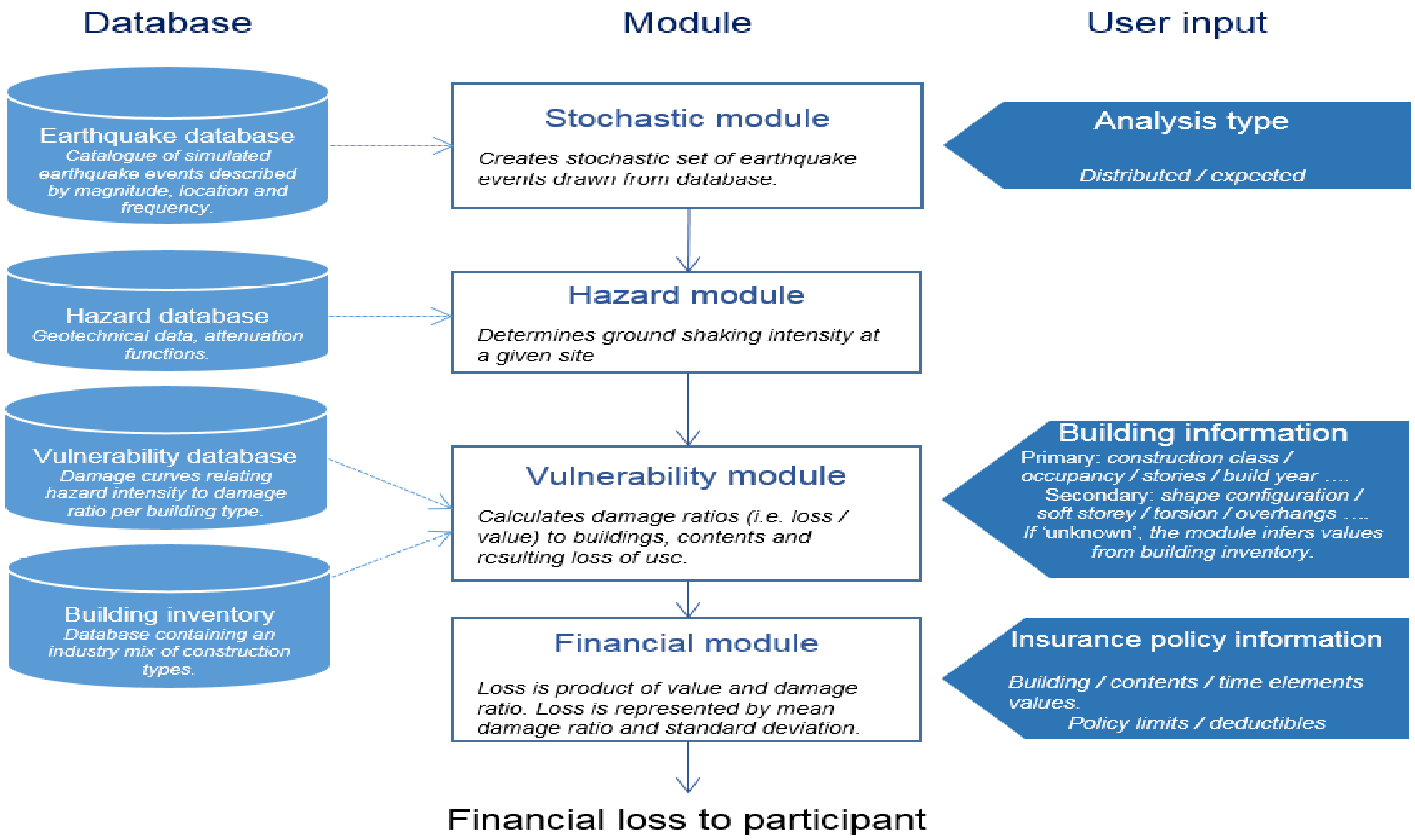
6 Modeling improvements expected & enabling technologies

7 Summary

Typical anatomy of Cat Risk Models



…requires significant amount of data to build, and to use

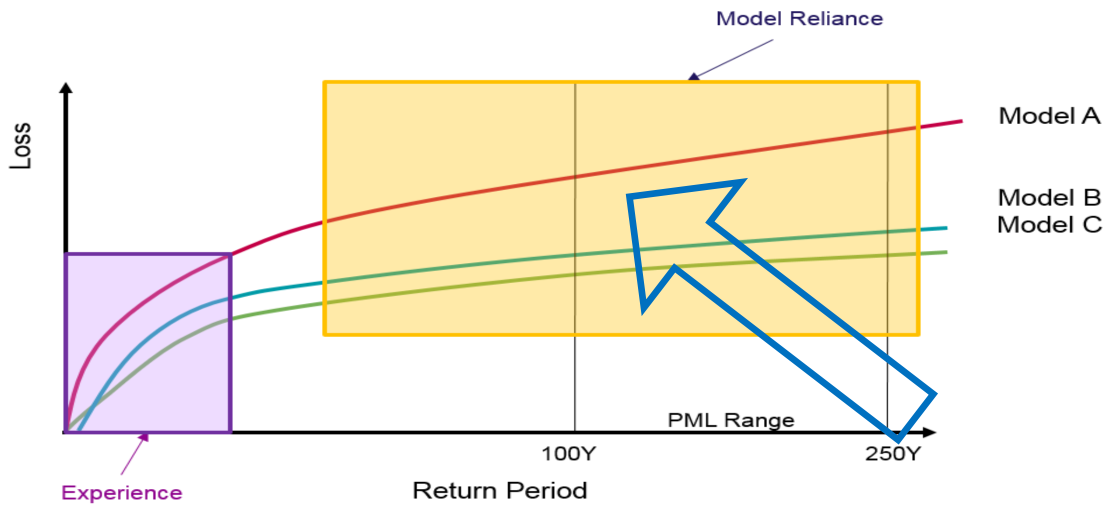


CAT models have improved our quantification of risk

Dramatically

Industry benefit of Cat models

- **Why do we need them at all?**
  - We have a natural bias to what we have seen and experienced – but we live only a century or less – and most underwriters have worked for only 20 years or less
  - But severe catastrophes usually occur on timescales longer than human experience
  - Extreme loss events usually fall outside of our experience / lifespan
  - **Cat models fill this gap by allowing us to estimate the impact on today's portfolio of extreme tail events of which we have no prior experience**



- **Key benefits of CAT models**
  - **Extend our risk horizon**
  - **Risk Transfer design**: Very few cedants now decide XL limit without supporting Cat model analysis
  - **Capital efficiency**: Cat modelled 'PML' is often lower than the benchmark it replaced – e.g. 3% nationwide PML vs. previous market standard of 25% of Zone A
  - Communication

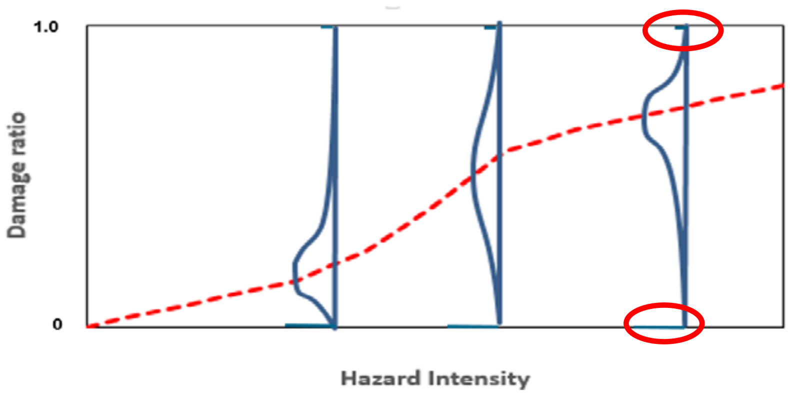
But models struggle to represent real world complexity/ behaviour

Vulnerability examples

Vulnerabilities aim to represent real world behavior

USGS, public domain

- Picture shows random (**aleatory**) variation in response between structures of similar construction
- Represented by severity distribution around the Mean Damage Ratio
- Chart below shows example Probability Density Functions (PDF) for severity distributions



- Note asymmetric “Cow Horns” at damage states [0] and [1] (red circles) representing probability of damage in these states
- Not all model vulnerabilities have Cow Horns

- Hurrricane Andrew 1992 - near-total destruction spanning seven blocks in Dade County, Florida

By Bob Epstein, FEMA News Photo (This image is from the FEMA Photo Library.) [Public domain], via Wikimedia Commons

- Wenchuan EQ 2009, China: 80% of buildings were flattened in Beichuan with complete collapse of buildings at Xuankou secondary school

Does it really matter?

- Site locations with Total Loss (TL) are aggregated with smaller losses from other locations – up to Event level

- A severity distribution with a low MDR will be appropriate where the TL risks are similar in value to the rest of the damaged stock – *where the event loss is not dominated by only a few risks*

- It is ***not appropriate where risks with TL dwarf the losses from remaining damaged stock*** - as can happen in unbalanced* portfolios

- In such cases, the Cat modeled portfolio OEP 1:250 or 1:500 may be only a small multiple of the maximum retention per risk (for Cat XL treaties) or the maximum treaty cession limit (for pro rata treaties)

- **This means that TL of just 1-2 risks may exhaust the reinsurance cover (Cat XL limit or pro rata event limit), with spillover falling back to the net account**

- **Cedant is therefore not buying sufficient reinsurance limit to allow for possibility of TL of peak risks**

- **Commonly observed** in industrially dominated portfolios:-
  - Developing world treaty business is dominated by industrial/ commercial risk
  - Onshore energy portfolios – covered by both treaty & fac
  - D&F industrial & large commercial portfolios

- TL requires high hazard intensity, so only likely with EQ, Major Hurricane, Wildfire, Severe flooding or a tornado outbreak

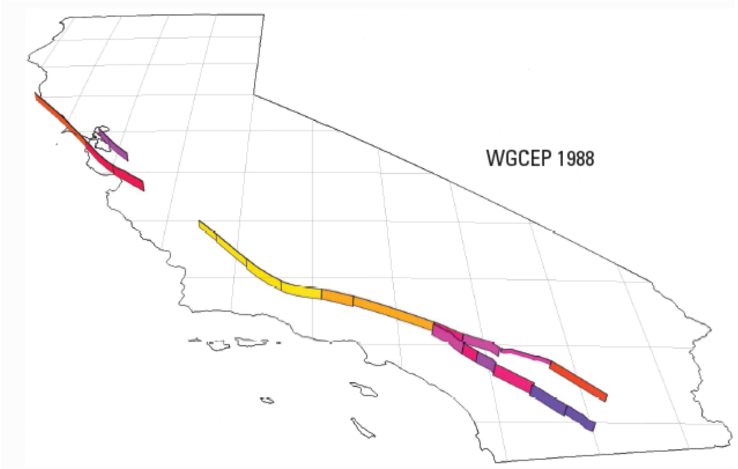
* Unbalanced in the sense that the net or ceded risk profile is highly heterogeneous, often comprising a wide raft of smaller risks and a few peak risks. This can be common in the above portfolios.

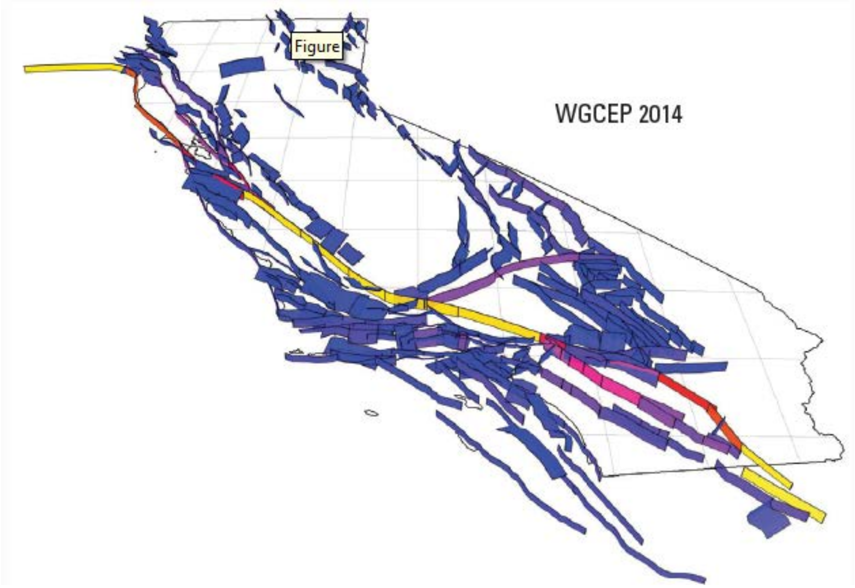
Models struggle to represent real world complexity

Hazard examples

Complex, incompletely known systems
California EQ

Changes with time of the inventory of faults used in California earthquake forecast models (WGCEP, Working Group on California Earthquake Probabilities)



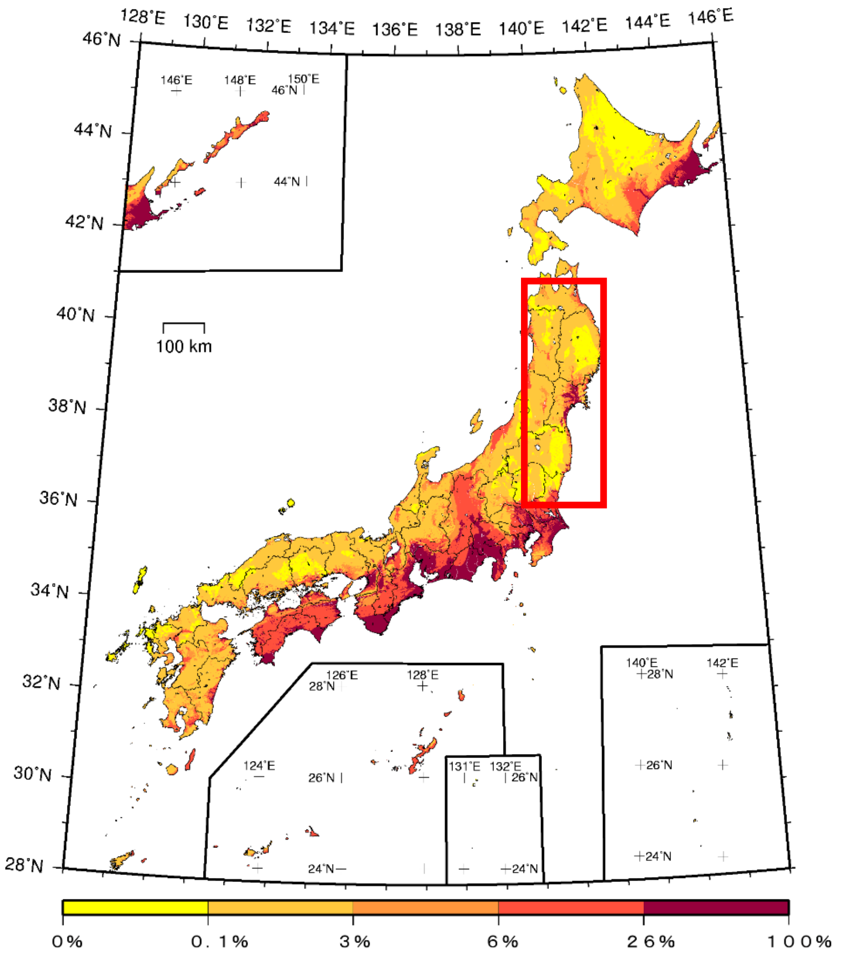


- Major advances have been made in representing linear seismic sources in California since 1988
- Particular emphasis placed on identifying *blind*, *active* faults – as caused Northridge in 1994
- Identification rate is not 100% however in all parts of the State
- Frequency-magnitude relations of all parts of major faults are also poorly constrained in many areas

- UCERF3 has recently changed CGS/USGS view on multi-fault/ multi-segment rupture probabilities
- **Lots of scope for "experts to get it wrong" – this is to be expected as a key part of scientific advancement**
- All major model vendors now updating the probabilistic seismic hazard models to reflect the 2014 update to USGS National Seismic Hazard Maps and UCERF3 (2015). Implementations vary widely between vendors

Complex, incompletely known systems
Japan EQ

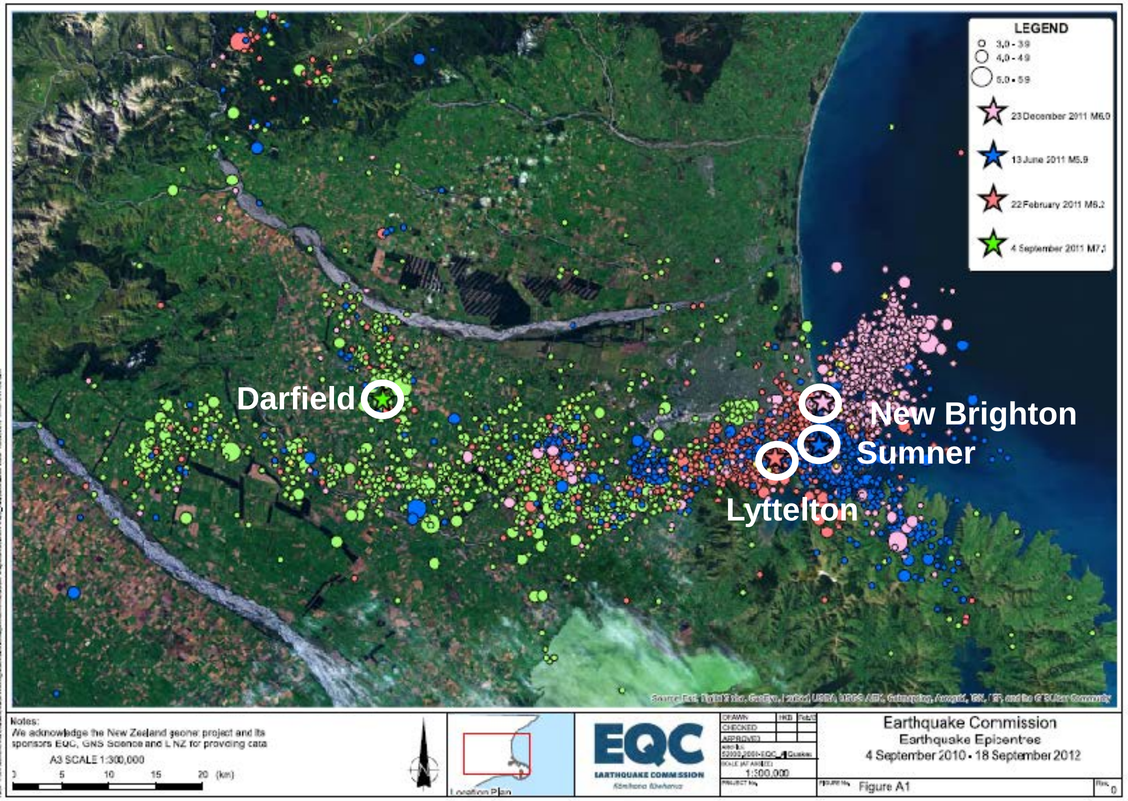
Exceedance probability of JMA 6 shaking in a 30-year period commencing Jan 2010



http://www.j-shis.bosai.go.jp/en/wp-content/uploads/2012/02/tme-total-y30-s55-sui-p0.png

- Map shows the Probability of JMA 6 intensity (‘**disastrous**’) shaking in 30 year period commencing Jan 2010, from National Seismic Hazard Map (NSHM, 2010)
- Deficiencies clearly highlighted in 2011
  - JMA 6 shaking was experienced across much of the area in the **red box**, from the 2011 Tohoku earthquake
  - Annual probability of JMA 6 shaking in the **red box** is mostly less than 1:1,000 (<3% in 30 years)
  - **Within less than 2 years of the map being published in 2010, such shaking was exceeded**
  - **The map was subsequently revised!**
- 2010 map reflected expert consensus that multi-segment rupture on the Japan trench in a M_w9.0 earthquake was not credible – now since revised
- Experts can and regularly do get it wrong, especially when the actual answer is not known and will only very slowly be revealed to us over time – and always in hindcast
- Model vendors calibrate their (different) seismic hazard models against the NSHM, and vary in how closely they track the guidance provided – part of the benefit of multi-modeling approaches to risk quantification

Complex, incompletely known systems
2010/11 New Zealand aftershocks/ triggered events



- **Aftershock** – an event that is completely contingent on the prior occurrence of a main shock
  - **Removed during de-clustering** of the historic event set to allow independent historic main shocks to be identified, which are then used as the basis for parameterizing the seismic source model
  - **Aftershock seismicity usually missing from CAT models**
- **Triggered event** - an event primed to occur anyway but occurs earlier because of a triggering main shock

- Lyttelton (USD 16.2 B) and Darfield (USD 7.5 B) are **two of the top 5 earthquakes worldwide by insured loss**
- Lyttelton likely triggered by Darfield – less than 6 month gap. **Important that CAT models consider triggered events**

- Common vendor response is that analogues for triggered events are already present in the stochastic event set
- But the enhanced occurrence rate of triggered events is not reflected in the model default Year Loss Table – how can it be, as there are thousands of alternative triggered events that could arise from each main shock trigger (combinatorial explosion of results data) – **hence triggered event simulation is also missing**

The Calibration Conundrum

The Calibration Conundrum

Calibration: *combining hazard, vulnerability and exposure in a modeling framework in a way that will produce loss results in line with expectation*

- **Expectation** however is strongly biased towards our experience – which is the risk horizon represented by the bottom part of the EP curve
  - CAT models should be calibrated to ensure a broad match with experience
  - This usually only impacts the bottom end (short return periods) of the EP curve

- **However, most extreme events in the tail of the loss distribution <u>have not yet occurred</u>**
  - Hence we usually cannot draw on experience*

- Dilemma therefore is
  - **Whether to calibrate the model in the tail?**
  - If so – what against? Market view? Competitor model? Own opinion? Mix of these?
  - Clearly a range of things that can be done
    - **Will also result in a wide range of possible outcomes**
    - Largest vendor model difference we have seen to date is x10 at OEP 1:200

- **Given so much uncertainty – vulnerability, hazard, calibration – we favor an ensemble of possible risk outcomes to ensure a comprehensive representation of the actual risk**

* Exceptions do exist, including the 2011 Tohoku earthquake and tsunami and the 2010-11 Canterbury earthquake sequence, both of which are considered tail loss events

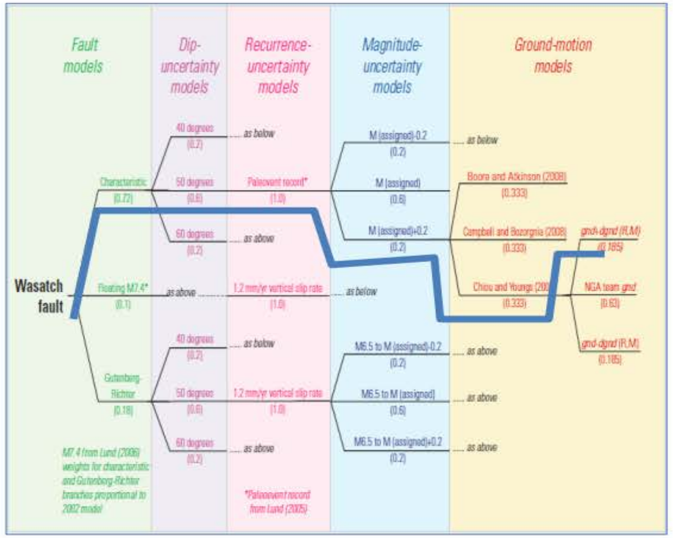
Making sense of all this uncertainty

The logical next step

Ensemble of risk outcomes

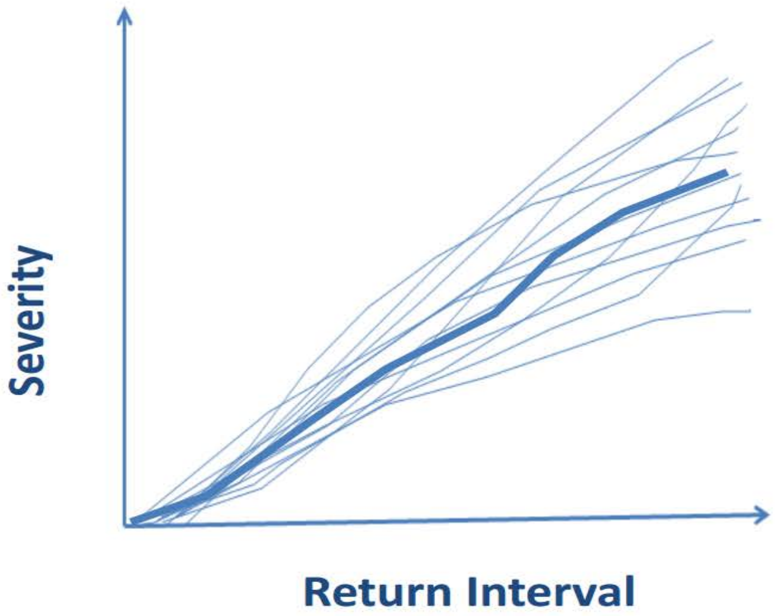
- CAT models currently reflect a single model parameterization (set of fixed core values for hazard, vulnerability, calibration)
  - **Usually termed the ‘best’ or ‘reference’ view of risk**
  - This often considers alternative outcomes that are combined together into a single averaged view in a probability-weighted manner, e.g. weighting of attenuation functions or tropical cyclone windfield models

- **Instead, taking every decision pathway as a separate view of risk will generate a set of possible alternate outcomes (an “ensemble of risk outcomes”)**



Each decision pathway is a separate probability-weighted view of risk

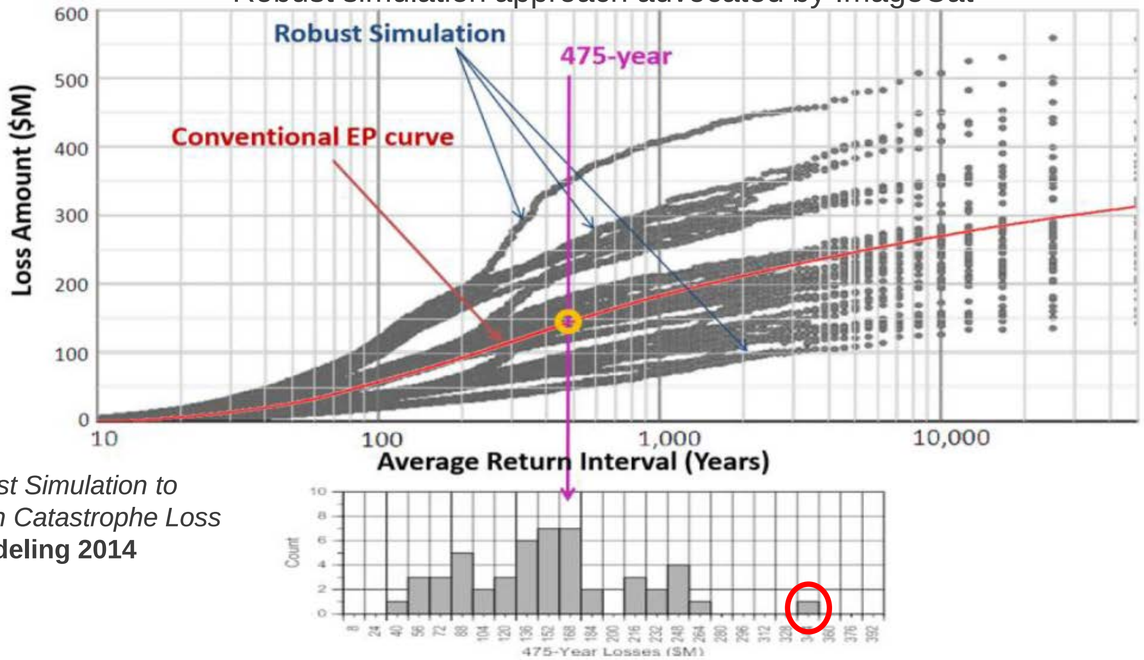
Cf. ImageCAT 2015*



* http://www.imagecatinc.com/wp-content/uploads/2015/09/RS-SCEC-Meeting-2015.pdf

Ensemble of risk outcomes

Robust simulation approach advocated by ImageCat



Lee et al (2014) *Using Robust Simulation to Characterize Uncertainties in Catastrophe Loss Assessments*. **RAA Cat Modeling 2014 February 11-13, 2014**

- A conventional EP curve (single view of risk) clearly does not do justice to the wide range of possible outcomes
- The example above
  - Was generated by following all pathways through the hazard modeling decision process
  - Is a more comprehensive representation of the risk faced than the single conventional EP curve
  - Also allows outlier views of risk to be identified - see red circle above – informs scenario testing

  - Could be expanded by adding multiple different vulnerability modules and severity distribution types
  - Could be expanded by using different end-result calibrations
  - **Could be summarized in probability-based ways to generate a single configurable view of risk**

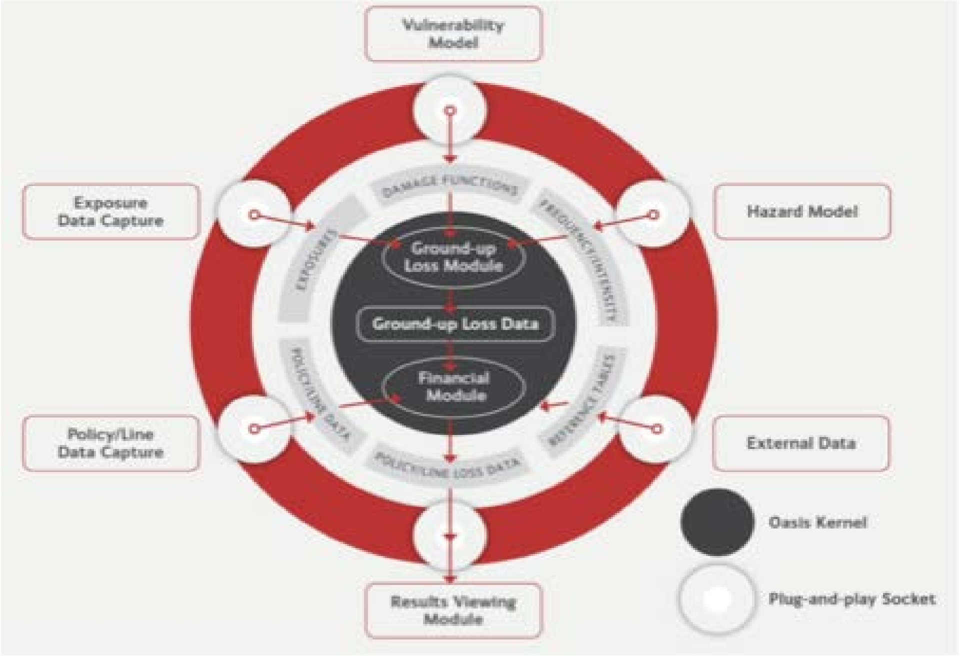
Modeling Improvements Expected
&
Enabling Technologies

Which of these can we expect to be resolved?

Current issue	Viewpoint
Lack of adequate total loss simulation	Models in future must be capable of simulating the volatility of loss that is possible with individual risks that will dominate the overall event-level portfolio loss if they are destroyed
Triggered EQ events	1. Must develop temporal links between main shock and triggered event(s) in the YLT. An interesting research project! 2. We will then able to more properly test the impact on Cat XL hours clauses and single peril annual aggregate Cat XL covers. 3. This will increase runtime so summary views of impact on pricing and accumulation will be needed for renewal modeling.
Ensemble of risk outcomes	1. Significantly more robust risk assessment, but requires cloud-based enabling technology to be in place (next slide). 2. Runtime performance needs to be addressed as a major issue. It is possible that the full ensemble would be run only for periodic portfolio rollups, not for individual contracts during renewal. 3. This will impact all modeled aspects of risk transfer (reinsurance limit guidance and reinsurer pricing, accumulation, capital setting) 4. Risk ensembles will require considerable CAT modeling re-education work in order to gain widespread industry acceptance – but will likely succeed in the longer term

Enabling Technologies

- Oasis Loss Modelling Framework is a new, open-source, catastrophe risk model
- Major interest in using open platforms for Public-Private risk financing initiatives (e.g. CCRIF, Africa Risk Capacity, PCRAFI)
- This platform is deployable onto a Cloud-hosted large-scale distributed computing solution, that will provide the necessary computing firepower and data storage lake for ensemble analysis
- Open-source framework allows actuaries to build in-house models
- Next generation models could leverage standardized design and interoperability to better reflect real-world complexity, e.g.
  - Supply chain risks (BI, CBI, NDBI)
  - coupled models, such as Pandemic following Flood



http://www.oasislmf.org/

Summary

- CAT models have dramatically improved our quantification of risk…
- …but models struggle to represent real world complexity/ behaviour
- Combining *hazard* with *vulnerability* and then *calibrating* can lead to a very wide range of possible loss outcomes
- We need a way to make sense of all this uncertainty – obvious way is to use ensembles of outcomes to better represent the uncertainty envelope
- Technology is starting to catch up. Oasis and Cloud computing are key parts of this recipe
- Next Generation models will better reflect complexity and systems effects

Question & Answers

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