One Health for the 21st Century

3 December 2018
W.B. Karesh

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• Extensive global experience through expert networks and conducting investigations on emerging and endemic/enzootic diseases, economic analyses and modeling of disease emergence, spread, intervention options, and foodborne illness.

• >65 national and international partnerships working across disciplines at local and regional scales.

• Numerous global subject matter expert (SME) networks with direct and indirect access to thousands of subject matter and region-specific experts.
"Human or livestock or wildlife health can't be discussed in isolation anymore," Karesh said. "There is just one health. And the solutions require everyone working together..."
Ebola outbreak in Mbomo and Kéllé districts, December 2002 to April 2003, Congo (143 cases, 128 deaths).
Influenza Virus collected in Mute Swan in Mongolia shared with USDA, CDC, & WHO and selected for human vaccine construct.
The GAINS team is excited to release prototype maps like the one above using Google technology. We are in the process of developing more advanced mapping components that will be released at the start of 2007. If you have any feedback or suggestions about how you would like to see the maps improved, please let us know.
Emerging Pandemic Threats Program 2 (EPT-2)

Geographic Focus

Asia
- Bangladesh
- Cambodia
- China
- Lao PDR
- India
- Indonesia
- Nepal
- Malaysia
- Mongolia
- Myanmar
- Philippines
- Thailand
- Vietnam

Africa
- Cameroon
- Cote d’Ivoire
- DR Congo
- Ethiopia
- Gabon
- Ghana
- Guinea
- Kenya
- Liberia

Africa
- Republic of Congo
- Rwanda
- Senegal
- Sierra Leone
- Tanzania
- Uganda
- M.E.
- Jordan
- Egypt
High-risk Hosts for Zoonotic Viruses

as of June 2018
Viral Detection Success

Overall 984 known and new viruses:

- **812 novel and 147 known in animals**
- **3 novel and 31 known in humans**

<table>
<thead>
<tr>
<th></th>
<th>Bats</th>
<th>Nonhuman Primates</th>
<th>Rodents and Shrews</th>
<th>Humans</th>
<th>Other taxa**</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Novel</td>
<td>431</td>
<td>234</td>
<td>143</td>
<td>3</td>
<td>9</td>
<td>820</td>
</tr>
<tr>
<td>Known</td>
<td>80</td>
<td>55</td>
<td>15</td>
<td>31</td>
<td>1</td>
<td>182</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1002*</td>
</tr>
</tbody>
</table>
Emerging Pandemic Threats Program 2 (EPT-2)

With Governments: Making Data Available

A new Adenovirus, PREDICT_AdV-8, was found in 1 Indian flying fox (Pteropus giganteus). The samples were collected in Feb 2008.

There is no evidence at this time to suggest this virus poses a threat to human health.

Click here to access this virus in GenBank

Map Layers
- PREDICT Countries
- Hotspot Layer

Data Layer
*Actual location of sampling may be scaled to the District level, for conservation and privacy reasons.
- PREDICT Animal Sampling Data
- PREDICT Preliminary Test Results
- HealthMap Alerts for PREDICT regions
Living Safely with Bats
Temporal patterns in EID events

- EID events have increased over time, correcting for reporter bias (GLM_{P,JID} F = 86.4, p < 0.001, d.f.=57)

- ~5 new EIDs each year

- ~3 new Zoonoses each year

- Zoonotic EIDs from wildlife reach highest proportion in recent decade

Jones et al. 2008
Spatial patterns in EID events

Jones et al. Nature 2008
Global hotspots and correlates of emerging zoonotic diseases

Toph Allen¹, Kris A. Murray²,³, Carlos Zambrana-Torrello ³, Stephen S. Morse⁴, Carlo Rondinini⁵, Moreno Di Marco⁶,⁷, Nathan Breit¹, Kevin J. Olival¹ & Peter Daszak¹
Disease don’t have to arise, they can arrive.

- Calculating index
  - $E_i = \text{Jones et al. hotspots}$
  - $C_{ij} = \text{Est. Number of passengers}$
  - $H_i = \text{Healthcare spending per capita}$
    - $i = \text{source of risk}$
    - $j = \text{destination of risk}$

$$\phi_j = \sum_{all \ i} \frac{C_{ij} \cdot E_i}{H_i}$$

- We then interpolate risk out from airport locations globally
- Using Inverse Distance Weighted interpolation
EID risk per airport
African Swine Fever in Europe
Future Climate Change Scenario for the distribution of Nipah virus. Year 2050, optimistic scenario (B2). Red areas show new potential areas for virus spread.
Increased risk of Rift Valley Fever outbreaks

Starving marine mammals and birds, floods and landslides

Increased risk of Cholera, Dengue Fever

Increased risk of West Nile Virus, Hantavirus, Plague

Increased Risk of Mosquito-borne diseases

Risk of fisheries collapse

Drier than normal, decreased crop yields

Forest fires from dry conditions, haze and smoke, increased respiratory disease


Background map of average rainfall anomalies from Dr. Assaf Anyamba, et al., PLOS Neglected Pathogens, 2012.

Shades of yellow to red indicate below normal rainfall and blue to green indicate above normal.
One Health Economics

1) Single-sector analyses may miss:
   • Full costs associated with outbreak
   • Possible cumulative multi-sectoral benefits
   • Potential trade-offs (e.g. impact on environment from certain control measures)

   Can inform relevant stakeholders and partners for risk mitigation
   • Especially useful at **country level**

Example of animal health impacts:
Bangladesh, AI outbreak, 2007
   ➢ Poultry value chain:
     • US$1,971/broiler farm (US $0.82/bird)
     • US$1,2304 per layer farm (US $3.05/bird)
     • 8-13% drop in price of chicken

Impacts to **non-health sectors** often far exceed cost for health sector response
One Health Economics

**Affected sectors (examples)**

- Medical and public health sector costs
- Market shutdowns and response
- Travel and tourism losses
- Public space/event avoidance (e.g., malls, concerts, restaurants)
- Exports/trade and productivity losses

**Impacts (examples)**

- SARS China, Hong Kong, Singapore, Canada $30-50bn
- ~800 deaths
- Unpaid leave (e.g., airlines) and est. 3 million jobs lost in tourism sector
- Cancelled flights
- Reduced local trade
- Civet culling at markets and breeding farms (10,000 animals)
- Beijing: 25% fewer arriving airline passengers
- ~1.5 million fewer foreign visitors
- 13% decline in bus usage
- Beijing: Declines in leisure activities (government order closed all movie theaters, internet cafes and other entertainment venues on 28 April)
- Schools and universities closed (1 month)
- Guangzhou: 12% attendance at Trade Fair compared to prior year
Context Matters:
Both relevance and benefits may differ by sectors; need to consider multiple sectors to fully evaluate benefits.

Example of a human Ebola virus outbreak, where containing human-human spread is of immediate relevance. Animal and environmental factors and impacts may still be relevant for long-term or emerging risk (new spillover events).

In settings where livestock is the primary source of human RVF infections, control in animals is emphasized. Vaccination may be prioritized to effectively prevent or break the transmission chain and confer herd immunity. Environmental variables determine vector distribution and control.
Leptospirosis: Risk Mapping for the US

- Leptospirosis is a widespread zoonotic disease – possibly the most common zoonotic disease in the world.
  - Can infect a wide variety of domestic animals and wildlife, as well as humans

- Caused by *Leptospira*, an anaerobic spirochete
Spatial Clusters: Positive Tests per Estimated County Dog Population

Clusters of Positive PCR Results:
Positive Tests per Estimated Dogs

Clusters of Positive MAT Results:
Positive Tests per Estimated Dogs
Partial Dependence Plots: Antibody Results

deciduous_forest_2011 (10.5%) precip_coldest_quarter_average (8.6%) shrub_scrub_2011 (6.1%) developed_low_intensity_2011 (5.1%)

pasture_hay_2011 (4.9%) temp_average (4.8%) bio1B_precip_warmest_quarter_average (4.6%) dy_wetlands_2011 (4.1%)

precip_average (3.8%) bio16_precip_wettest_quarter_average (3.4%) median_income (3.2%) mixed_forest_2011 (3.1%)
## Boosted Regression Tree Results

### PCR Model: Top 5 Predictors

<table>
<thead>
<tr>
<th>Variable</th>
<th>Relative Influence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evergreen Forest Cover</td>
<td>12.24919776</td>
</tr>
<tr>
<td>Shrub/Scrub Cover</td>
<td>9.887439268</td>
</tr>
<tr>
<td>Grassland/Herbaceous Cover</td>
<td>7.161191081</td>
</tr>
<tr>
<td>Developed Open Space Cover</td>
<td>6.195173737</td>
</tr>
<tr>
<td>Median Income</td>
<td>5.81007611</td>
</tr>
</tbody>
</table>

### MAT Model: Top 5 Predictors

<table>
<thead>
<tr>
<th>Variable</th>
<th>Relative Influence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deciduous Forest Cover</td>
<td>10.6624204</td>
</tr>
<tr>
<td>Average Precipitation in Coldest Quarter</td>
<td>8.622065784</td>
</tr>
<tr>
<td>Shrub/Scrub Cover</td>
<td>6.067515302</td>
</tr>
<tr>
<td>Developed Low Intensity Cover</td>
<td>5.785643682</td>
</tr>
<tr>
<td>Pasture/Hay Cover</td>
<td>4.897024777</td>
</tr>
</tbody>
</table>
Summary of Final Results:

Relative Risk Prediction by County:

Clusters of Positive MAT Tests Relative to the Estimated County Dog Population
Understanding Rift Valley Fever

The project depicted is sponsored by the U.S. Department of Defense, Defense Threat Reduction Agency. The content of the information does not necessarily reflect the position or the policy of the federal government, and no official endorsement should be inferred.
RFV Project Site
Rift Valley Fever
First Long-term “One Health” RVFV Study in RSA

- Domestic ruminants
- Wild antelope
  - Game ranches
  - Free-ranging
- Mosquitoes
- People
- Vegetation Ecology
- Soil Science
- Climate
- Capacity Building
Costs and Benefits: Example for Rift Valley Fever Vaccination in Livestock

<table>
<thead>
<tr>
<th>Benefit</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private (Farm)</td>
<td>Benefits to vaccinated animals</td>
</tr>
<tr>
<td>Externality 1</td>
<td>Herd immunity in animals</td>
</tr>
<tr>
<td>Externality 2</td>
<td>Cost of illness savings to public health system from prevented/reduced RVF cases</td>
</tr>
<tr>
<td>Externality 3</td>
<td>Protection of international trade status</td>
</tr>
<tr>
<td>Externality 4</td>
<td>Protection of domestic market confidence</td>
</tr>
<tr>
<td>Externality 5</td>
<td>Cost of illness/mortality savings to agricultural systems for loss compensation</td>
</tr>
</tbody>
</table>

Net benefits = (Public benefits + private benefits) – (Total costs)

*Which sector(s) benefit, and which should pay?*
Africa Sustainable Livestock 2050

Scenario development

Africa human population in 2050 for:
• SSP2: Medium pop, medium urbanization and medium uneven economy
• RCP 4.5: medium-low mitigation, medium air pollution
Global hotspots and correlates of emerging zoonotic diseases

Toph Allen¹, Kris A. Murray²,³, Carlos Zambrana-Torrelío ¹, Stephen S. Morse⁴, Carlo Rondinini⁵, Moreno Di Marco⁶,⁷, Nathan Breit¹, Kevin J. Olival¹ & Peter Daszak¹

Based on our recent work Allen et al. 2017
Downscaled the EID hotspots (Allen et al. 2017, left) to a better resolution for ASL2050.
Hotspots and correlates of emerging zoonotic diseases

- 20 predictors in 4 categories: human presence/activity, animals-hosts, the environment, and reporting effort
  - Environmental predictors included climatic and land cover variables

- Livestock data included: cattle, pigs, sheep, buffalo, goats and poultry
Africa Sustainable Livestock 2050

Outputs: Relative Risk
One Health in International Policy:

a look at international organizations and their policy making processes
The UN promotes international cooperation, especially on issues of security and human rights

Like national governments, each part of the UN and other intergovernmental organizations has its role and functions.

- You don't have to become an expert on the entire system to effect change.
- Try to target the most relevant parts of the system for the issue you are addressing and focus your efforts there.
Intergovernmental policy making

United Nations Headquarters, New York

CBD COP13, Cancun, Mexico

CBD SBSTTA21, Montreal, Canada
UN Framework for Disaster Risk Reduction

• Shifting the paradigm from response to health emergencies to risk mitigation

• ‘PreventionWeb’ Blog posts with UN and World Bank partners:
http://www.preventionweb.net/experts/oped/list
# One Health Operational Guidance

This document provides an operational framework for strengthening human, animal, and environmental public health systems at their interface. It is a collaborative effort between various agencies, including The World Bank and the EcoHealth Alliance.

## One Health

**Operational Framework for Strengthening Human, Animal, and Environmental Public Health Systems at Their Interface**

**World Bank Group**

> 4,500 downloads

## Table: One Health Operational Guidance

<table>
<thead>
<tr>
<th>STAGE</th>
<th>DOMAIN</th>
<th>PREVENT</th>
<th>DETECT</th>
<th>RESPOND</th>
<th>RECOVER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>III. Communication and Information</td>
<td>Access to information for risk assessment and mitigation: List of pathogens in country; list of known disease hosts and reservoirs in country; prior finding of exposure in country (e.g., antibodies to pathogen); risk forecasting e.g., weather data for climate-sensitive diseases</td>
<td>Chain of command for information reporting and verification</td>
<td>Chain of command for information reporting and action</td>
<td>Multisectoral resilience planning and prioritization</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Contacts established between ministries</td>
<td>Regional risk profile</td>
<td>Pre-identification of risk factors likely to facilitate spread; multisectoral awareness of relevant risk and response protocols</td>
<td>After-action review and refinement of communication/information dissemination strategies</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Chain of command for information reporting</td>
<td>Population-specific and sensitive messaging (e.g., gender or cultural)</td>
<td>Ongoing coordination among authorities and between relevant ministries, affected sectors, logistical players (e.g., medical supply chain, treatment centers, vaccine producers, security), the media, and the public</td>
<td>Population-specific and sensitive messaging (e.g., gender or cultural)</td>
</tr>
<tr>
<td></td>
<td>IV. Technical Infrastructure</td>
<td>National, regional, or international access to laboratory diagnostics (known and novel)</td>
<td>National access to laboratory diagnostics (known pathogens and toxicology); confirmatory analysis at reference laboratory, if needed</td>
<td>Risk management for disease control, including via contact tracing, awareness campaigns, etc.</td>
<td>Health systems strengthening (general)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sentinel surveillance in animals (wild or domestic) or vectors and investigation</td>
<td>Disease prioritization</td>
<td>Medical treatment, where relevant</td>
<td>Risk mitigation measures, e.g., universal vaccination campaigns</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hazard identification and other relevant stages of risk analysis</td>
<td>Detection at point of entry</td>
<td>Control at point of entry</td>
<td>Climate-smart and other resilient health care infrastructure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Risk mitigation (e.g., at points of entry)</td>
<td>Identification of vulnerable populations (heightened risk and/or disease prioritization)</td>
<td>Containment to reduce potential for cross-border spread</td>
<td>Risk assessment refinement (e.g., with new epidemiological analysis)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Identification of vulnerable populations</td>
<td>Identification of vulnerable populations</td>
<td>Identification of vulnerable populations</td>
<td>Continued medical treatment provision, where relevant</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Identification of vulnerable populations</td>
<td>Identification of vulnerable populations</td>
<td>Identification of vulnerable populations</td>
<td>Biosafety (facility and personnel)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Identification of vulnerable populations</td>
</tr>
</tbody>
</table>
Where does One Health Fit In?

Primary Domain
- Human Health
- Animal Health/Agriculture
- Environment
- Multi-sector

Capacity Assessments
- Joint External Evaluation for the HQR Monitoring and Evaluation Framework
- OIE Performance of Veterinary Services
- DRM capacity assessment tools
- National capacity audits
- Expert networks may assist in capacity assessments and/or setting capacity benchmarks
- Capacity assessments inform country planning

Planning Tools
- National Action Plans for Health Security
- One Health Zoonotic Disease Prioritization
- Health Security Financing Assessment Tool
- Performance of Veterinary Services Gap Analysis
- National Biodiversity Strategies and Action Plans
- National Adaptation Plans
- National Action Plans on AMR
- DRR National Action Plans

Country plans implemented through projects and financial resources

Expert Networks
- IHR Committees and Roster of Experts (WHO)
- OFELI (OIE and FAO)
- Working Groups, Commissions (OIE and FAO networks)
- IUCN Commissions (Species Survival and Ecosystem Management)
- Expert networks may utilize, contribute to and inform reporting

Implementation Resources
- Projects: e.g. REDISSE
- Global Financing Facility
- World Animal Health Fund
- Global Environment Facility
- Nationally Determined Contributions
- Bilateral aid agreements

Implementation can enable/strengthen capacity for information sharing and reporting

Information Sharing and Reporting
- WAHIS (OIE)
- GLEWS (FAO-OIE-WHO)
- Desinventar (UNISDR)
- Sendai Monitor (UNISDR)
- ProMID-Mail (ISID)

Reporting standards inform capacity requirements

Regulatory Frameworks
- International Health Regulations (WHO)
- Terrestrial and Aquatic Animal Health Codes (OIE)
- Convention on Biological Diversity
- Framework Convention on Climate Change
- Convention on International Trade in Endangered Species of Wild Fauna and Flora
- Codex Alimentarius (FAO and WHO)
- Sendai Framework for Disaster Risk Reduction
- National DRR laws and regulations
- Other national policies

Information (as well as lack of reporting) and expert networks may inform risk assessment and subsequent risk management and regulations

- Wild animal cases
- Domestic animal cases
- Human cases

Key Points:
- Forecasting readiness
- Early detection
- Rapid response
- Control benefits to animals
- Control benefits to people

Graph shows the timeline and number of cases for different categories over time.
The security community uses the term “left of boom” to describe the entry point at which it is optimal to intercede with respect to major security breaches like bombings. We do this on the intentional side of biothreats as well—but prevention of spillover is not yet the prevailing paradigm in managing outbreaks that originate from animal and environmental exposures.
BUILDING RESILIENCE TO BIOTERRORISTS
An assessment of unmet core global health security needs

November 2018
EcoHealth Alliance
Prevent: Determine, assess, avoid, mitigate, and reduce threats and risks by reducing vulnerability and exposure.

Detect: Gather and analyze information, provide early warning, and inform strategies.

Respond: Control or mitigate the impact of disease and save lives.

Recover: Restore and strengthen normal operations.
One Health for the 21st Century

3 December 2018
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