Emerging Pathogens

Biosafety and Healthcare Preparedness Conference

Marty K. Soehnlen, PhD, MPH
• Overview of previous Emerging Infectious Diseases
• Causes of expansion or emergence of diseases
• Insights into predicting the next (re) emerging infectious disease
• Overview of items to help prevent spread of emerging pathogens
• Example of current emerging pathogen – Zika Virus
THE EBOLA FIGHTERS
Salome Karwah
As the virus raged on, she kept both her patients
and her husband and now
221 children safe.

SARS
What You Need to Know
The New Age of Epidemics

Beyond the Ebola Scare: What Else Is Out There?

WARNING:
WE ARE NOT READY FOR
THE NEXT PANDEMIC

MURDOCH & MGI: WHAT DOES RUPERT WANT?

Killer Virus

The Next
Killer Flu
Can we
stop it?

PLUS HAWAII’S OUTER KINGDOM 23
Africa’s Danakil Desert 32 Battle of Trafalgar 54 Missouri Stone Age Site 88
Street Elephants of Thailand 128 Zip USA: Triplet Boom 18
<table>
<thead>
<tr>
<th>Emerging / re-emerging disease</th>
<th>Date identified</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIV1</td>
<td>1983</td>
</tr>
<tr>
<td>HIV2</td>
<td>1985</td>
</tr>
<tr>
<td>Enterocytozoon bieneusi</td>
<td>1985</td>
</tr>
<tr>
<td>Human Herpesvirus 6 (HHV 6)</td>
<td>1986</td>
</tr>
<tr>
<td>Hepatitis C virus</td>
<td>1989</td>
</tr>
<tr>
<td>Hepatitis E virus</td>
<td>1990</td>
</tr>
<tr>
<td>Guanarito virus</td>
<td>1991</td>
</tr>
<tr>
<td>Barmah Forest Virus</td>
<td>1992</td>
</tr>
<tr>
<td>Bartonella henselae</td>
<td>1992</td>
</tr>
<tr>
<td>Sin Nombre Hantavirus</td>
<td>1993</td>
</tr>
<tr>
<td>Cyclospora cayatenensis</td>
<td>1994</td>
</tr>
<tr>
<td>Sabia virus</td>
<td>1994</td>
</tr>
<tr>
<td>Hendra virus</td>
<td>1994</td>
</tr>
<tr>
<td>Human herpesvirus 8</td>
<td>1994</td>
</tr>
<tr>
<td>Lyssavirus (in Australia)</td>
<td>1996</td>
</tr>
<tr>
<td>Nipah virus</td>
<td>1996</td>
</tr>
<tr>
<td>vCJD</td>
<td>1996</td>
</tr>
<tr>
<td>H5N1 Influenza</td>
<td>1997</td>
</tr>
<tr>
<td>West Nile Virus (In the United States)</td>
<td>1999</td>
</tr>
<tr>
<td>Emerging / re-emerging disease</td>
<td>Date identified</td>
</tr>
<tr>
<td>------------------------------------------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Bacillus anthracis - intentional</td>
<td>2001</td>
</tr>
<tr>
<td>Crimean Congo Hemorrhagic Fever Virus</td>
<td>2001</td>
</tr>
<tr>
<td>SARS CoV</td>
<td>2003</td>
</tr>
<tr>
<td>Monkeypox (in the US)</td>
<td>2003</td>
</tr>
<tr>
<td>Chikungunya Virus</td>
<td>2005</td>
</tr>
<tr>
<td>XDR-Tuberculosis</td>
<td>2006</td>
</tr>
<tr>
<td>H5N1 Influenza</td>
<td>2003</td>
</tr>
<tr>
<td>Pandemic H1N1 Influenza</td>
<td>2009</td>
</tr>
<tr>
<td>H7N9 and H5N6 Influenza</td>
<td>2012</td>
</tr>
<tr>
<td>MERS-CoV</td>
<td>2012</td>
</tr>
<tr>
<td>Enterovirus D68</td>
<td>2014</td>
</tr>
<tr>
<td>Dengue Fever Virus</td>
<td>2012-14</td>
</tr>
<tr>
<td>Ebola (largest outbreak)</td>
<td>2014</td>
</tr>
<tr>
<td>Zika Virus</td>
<td>2015</td>
</tr>
</tbody>
</table>

It is estimated that between 50-75% of EIDs have a zoonotic component – this emphasizes the importance of “One Health”
- Prevent Disease
- Promote Wellness
- Improve Quality of Life

SOURCE: Morens et al., 2004.
Factors of Emergence

• Microbial adaptation/Host susceptibility
• Human demographics and behavior
• Technology & industry (animal practices, food production)
• Economic development and land use
• International travel and commerce
• Breakdown of public health infrastructures
• War and Famine
• Poverty and social inequality
• Climate and weather
• Changing ecosystems
• Intent to harm
Microbial Adaptation and Change

• A number of microbes utilizing different genetic mechanisms
• Genome sequences show that lateral transfer is common
• High mutation rates in RNA viruses—rapid adaptation
• Quick reproduction resulting in rare mutations building up rapidly

- Efflux pumps
- Conjugation
- AIDS, Influenza
- Viruses, bacteria
• Increases in the human population

• Urbanization - more people concentrated in cities - often without adequate infrastructure

• Increases in the elderly populations

• Increases in children in daycare: working mothers with young children was 28% in 1970. 2013 census data placed this number at over 66%.
Technology and Industry

- Blood transfusions and organ transplants save lives but increase risk of infections
- Transportation technology - the ability to rapidly move people and goods
- Industrial changes - mass production of food
- Industrial pollution - increases incidence of TB
Economic Development and Land Use

- Consumption of natural resources, deforestation, and dam building

- Logging in the rain forest has exposed people to new viruses

- Standing water lead to mosquito breeding grounds

- Historic examples - emergence of Yellow Fever when humans entered the Central American jungle to build the Panama Canal; increase in Schistosomiasis when the Aswan Dam was built on the Nile River; increases in Lyme Disease in US reforested regions
International Travel and Commerce

• Less than 36 hours to circumnavigate the globe
  – 36 hours is faster than many disease incubation periods
• In 2016 the US State Dept. recorded over 72 million trips of citizens outside the US
• Increased incidence of both Tuberculosis and Influenza transmission on long flights
Breakdown of Public Health

• Late 1970’s - World Bank forced reductions in public sector investment, especially in Latin America and Africa
  – World Bank has shown that these countries are economically better off than that time period
  – Reduction in public health sector caused decreased immunization and nutrition levels, and a drop in medical supplies
• War refugees are over 1% of the global population

• War refuges are forced onto new areas where they are exposed to new microbes from vectors and people.

• War and famine are closely linked

• In 2001, tracking 16 countries with “food emergencies”, showed that 9 were because of civil unrest – this is prior to the numerous armed conflicts since that period

• Famine is also caused by social, economic, political forces, and weather
Mortality from infectious diseases correlates with income

Factors
- malnutrition, lack of clean water and sanitation, poor housing, ignorance of risky behaviors, lack of transportation, lack of funds for out-of-pocket healthcare expenses.
Elevated rainfall and increased overall temperatures lead to expanded or new breeding habitats for mosquitoes

- Spread of mosquito-borne illnesses (Zika, Malaria, Chikungunya, Dengue)
- Decreases salinity which can increase toxic bacteria
- Increases vegetation which increases rodents (Sin Nombre Hanta virus outbreak)
- Increases runoff into drinking reservoirs (Cryptosporidiosis outbreak)
- Higher ocean temps increase Vibrio parahaemolyticus (shellfish)
Changing Ecosystems

• Ecological changes can increase the risk of infection by altering human exposure or pathogen distribution.

• Rainforest destruction forests reduce while cropping increases humidity

• Urban development increases atmospheric particles and increases air temperatures
Intent to Harm

- **Bioterrorism**
  - Anthrax attacks in DC metro area
  - Salmonella in OR
  - Select Agents are high risk
  
  **Will discuss in later conference sessions**

- **Chemical terrorism** – may lead to reduce immune responses to protect from infectious agents
Preventing Emerging Infectious Diseases

- **Surveillance and Response**
  - Detect, investigate, and monitor emerging pathogens, the diseases they cause, and the factors influencing their emergence, and respond to problems as they are identified.

- **Applied Research**
  - Integrate laboratory science and epidemiology to increase the effectiveness of public health practice.

- **Prevention and Control**
  - Ensure prompt implementation of prevention strategies and enhance communication of public health information about emerging diseases.

- **Infrastructure and Training**
  - Strengthen public health infrastructures to support surveillance, response, and research and to implement prevention and control programs.
  - Provide the public health work force with the knowledge and tools it needs.
Predicting Emerging Diseases

• Federal, State, and Local Partners track diseases that arise in other countries
  – Respiratory usually travels from Asia to US

• Clinical laboratories and public health laboratories share information of increasing disease trends

• Impact on Clinical Labs: predictions allow for time to get Emergency Use Authorizations (EUA) from FDA on diagnostic assays
  – Public health labs can help offset delays in diagnostics

• Reduction of hospital outbreaks or in some cases nosocomial infections

• Appropriate treatment of patient through antimicrobials or other treatment regimens.
Example of a recent ongoing re-emerging disease - Zika Virus
Non pregnant patients must have at least one of the following symptoms to obtain approval for testing at MDHHS:

- Fever
- Rash
- Arthralgia
- Conjunctivitis
MDHHS Bureau of Laboratories began testing in May, 2016.

TESTS AVAILABLE

- Zika IgM
  - CDC’s MAC-ELISA
- Dengue and Chikungunya IgM
  - InBios
- Zika, Dengue and Chikungunya PCR
  - CDC’s Trioplex
- Zika and Dengue types 1 & 2 PRNT
  - CDC PRNT Assay
Specimen Type

- Serum (≥1 ml)
- Urine (≥1 ml)
  - CSF & Amniotic fluid (must be accompanied with serum)

- Ship frozen or refrigerated with frozen ice pack
  - Do not send at room temperature

*TAT: 1-2 weeks (results usually available within 1 week)

- Specimen DOC must be within 12 weeks of symptom onset/exposure/travel
  (Exposure may include unprotected sex with a partner who traveled)

- Travel must be to an area of localized transmission of Zika

- Patient must be either pregnant or symptomatic

- MDHHS BOL Test Requisition and Zika Supplemental Questionnaire must be completed
Algorithm for Testing Pregnant or Symptomatic Patients:
Serum and urine collected ≤ 14 days after symptom onset
(CSF or amniotic fluid for some tests)

Test all specimens by **Trioplex rRT-PCR**

**Note**: Urine and amniotic fluid testing are authorized only for ZIKV.

**Dengue virus (DENV)**
- **POS**: Serum positive, patient positive for dengue virus infection. Report all results. No further testing required.
- **NEG**: Serum negative, dengue virus RNA not detected. Serum should be analyzed by serological methods.

**Chikungunya (CHIKV)**
- **POS**: Serum positive, chikungunya virus RNA not detected. Report all results. No further testing required.
- **NEG**: Serum negative, chikungunya virus RNA not detected. Serum should be analyzed by serological methods.

**Zika virus (ZIKV)**
- **POS**: Any specimen positive, patient positive for Zika virus infection. Report all results. No further testing required.
- **NEG**: All specimens negative, Zika virus RNA not detected. Serum should be analyzed by serological methods (For pregnant women, request convalescent sample for repeat testing).
Algorithm for Testing Symptomatic Patients:

Serum and/or CSF collected \(<12\) weeks within symptom onset

**Serological testing**
Test serum specimen by:
- Zika MAC-ELISA
- dengue IgM assay (InBios)
- chikungunya IgM assay (InBios)

**POS**
Any test **presumptive positive, equivocal or inconclusive.**
- Report results.
- Forward for confirmation by PRNT

**NEG**
All tests **negative**, no evidence of recent virus infection.
- Report results.
- **No further testing of specimen required.**

Serum tested by PRNT
- POS=Evidence of Zika infection
- NEG=No evidence of Zika infection

- Report results.
- **Combine results with results of other diagnostic tests to determine overall interpretation.**
Algorithm for Testing Asymptomatic Pregnant Women:

Women residing in an active Zika transmission area or ≤12 weeks after travel to an active Zika virus transmission area or sexual contact with a person confirmed to have Zika virus infection.

Test serum specimen by the Zika MAC-ELISA

**POS**

Zika IgM presumptive positive, equivocal or inconclusive
Report results.

Forward specimen for confirmation by PCR/PRNT

If PCR is positive, specimen is confirmed positive
If PCR is negative, perform PRNT testing
If PRNT is positive, specimen is confirmed positive
If PRNT is negative, specimen is reported negative

Combine results with results of other diagnostic tests to determine overall interpretation.

**NEG**

Zika IgM negative, Report no evidence of recent Zika virus infection
(For pregnant women, request convalescent sample (if within 12 weeks post travel/exposure) for repeat testing)