Action Plan for Public Policies, Health Systems and Communication: Global Perspectives, Global Impacts

Frederick A. Murphy
Sir William Osler (1849-1919)

“One Medicine”
the term coined by Osler to encompass the relationship between human and veterinary medicine
The development of the concept of New, Emerging and Re-emerging Infectious Diseases, the basis for rebuilding infectious disease research.
The Convergence Model

At the center is a box representing the convergence of factors leading to the emergence of an infectious disease. The black center represents unknown factors, “the black box.”

From IOM Study: Microbial Threats to Health, Emergence, Detection and Response 2003
The Nature of the Threat of New, Emerging & Re-emerging Zoonoses and Bioterrorism

- **Microbial / viral determinants**
  (mutation, natural selection, evolution)

- **Determinants pertaining to the host**
  (natural resistance, innate & acquired immunity)

- **Natural determinants**
  (ecologic, environmental, zoonotic influences)

- **Determinants pertaining to human activity**
  (personal behavior, societal, commercial, and iatrogenic factors)

- **Accidental or malicious release**
Zoonoses are complex, seemingly fragile, but actually entrenched

Zoonoses must be dealt with at the interface between public health and veterinary public health/animal health

The research base involves the interface between: virology (biologic & molecular biologic), immunology, pathology, ecology, animal biology, wildlife biology, mammology, ornithology, entomology, meteorology, climatology, geography, sciences pertaining to societal and commercial risk factors, economics, government, biodefense, etc., and the medical sciences and veterinary sciences
New, Emerging and Re-emerging Diseases, 2010

A Global Perspective...

H1N1 Influenza
[e.g., A/California/07/2009 (H1N1)]

= Zoonotic
“Knowing is not enough; we must apply. Willing is not enough; we must do.”

— Goethe

Motto of the Institute of Medicine
National Academy of Sciences
Rabies, Still A Global Problem

- Rabies causes 40,000-70,000 human deaths each year; most in Asia and Africa; 30-50% in children (WHO)
- 10 million people receive post-exposure treatment each year
- Most cases are still caused by the bite of a rabid dog
- Most children who die from rabies have not received post-exposure treatment: vaccine and rabies immunoglobulin
- There is a notorious lack of surveillance data. Underestimating the importance of rabies leads decision-makers to perceive rabies as a rare disease, resulting from the bite of an economically unimportant animal (the dog)
- In many countries rabies falls in the crack between ministries of health and agriculture
A new understanding of the need for global health... global disease control...
<table>
<thead>
<tr>
<th>Year</th>
<th>Filovirus</th>
<th>Country</th>
<th>Cases</th>
<th>Death %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1967</td>
<td>Marburg</td>
<td>Germany &amp; Yugoslavia</td>
<td>32</td>
<td>21%</td>
</tr>
<tr>
<td>1975</td>
<td>Marburg</td>
<td>South Africa</td>
<td>3</td>
<td>33%</td>
</tr>
<tr>
<td>1976</td>
<td>Ebola-Zaire</td>
<td>Zaire</td>
<td>318</td>
<td>88%</td>
</tr>
<tr>
<td>1976</td>
<td>Ebola-Sudan</td>
<td>Sudan</td>
<td>284</td>
<td>53%</td>
</tr>
<tr>
<td>1976</td>
<td>Ebola-Sudan</td>
<td>England</td>
<td>1</td>
<td>0%</td>
</tr>
<tr>
<td>1977</td>
<td>Ebola-Zaire</td>
<td>Zaire</td>
<td>1</td>
<td>100%</td>
</tr>
<tr>
<td>1979</td>
<td>Ebola-Sudan</td>
<td>Sudan</td>
<td>34</td>
<td>65%</td>
</tr>
<tr>
<td>1980</td>
<td>Marburg</td>
<td>Kenya</td>
<td>2</td>
<td>50%</td>
</tr>
<tr>
<td>1987</td>
<td>Marburg</td>
<td>Kenya</td>
<td>1</td>
<td>100%</td>
</tr>
<tr>
<td>1989</td>
<td>Ebola-Reston</td>
<td>USA &amp; Philippines</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>1990</td>
<td>Ebola-Reston</td>
<td>USA &amp; Philippines</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>1992</td>
<td>Ebola-Reston</td>
<td>Italy &amp; Philippines</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>1994</td>
<td>Ebola-Zaire</td>
<td>Gabon</td>
<td>49</td>
<td>59%</td>
</tr>
<tr>
<td>1994</td>
<td>Ebola-Ivory Coast</td>
<td>Ivory Coast</td>
<td>1</td>
<td>0%</td>
</tr>
<tr>
<td>1995</td>
<td>Ebola-Zaire</td>
<td>Congo</td>
<td>315</td>
<td>81%</td>
</tr>
<tr>
<td>1996</td>
<td>Ebola-Zaire</td>
<td>Gabon</td>
<td>31</td>
<td>68%</td>
</tr>
<tr>
<td>1996</td>
<td>Ebola-Zaire</td>
<td>Gabon</td>
<td>60</td>
<td>75%</td>
</tr>
<tr>
<td>1996</td>
<td>Ebola-Zaire</td>
<td>South Africa</td>
<td>2</td>
<td>50%</td>
</tr>
<tr>
<td>1996</td>
<td>Ebola-Reston</td>
<td>USA</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>1996</td>
<td>Ebola-Reston</td>
<td>Philippines</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>1998</td>
<td>Marburg</td>
<td>Congo</td>
<td>128</td>
<td>64%</td>
</tr>
<tr>
<td>2000</td>
<td>Ebola-Sudan</td>
<td>Uganda</td>
<td>425</td>
<td>53%</td>
</tr>
<tr>
<td>2002</td>
<td>Ebola-Zaire</td>
<td>Gabon &amp; Congo</td>
<td>122</td>
<td>79%</td>
</tr>
<tr>
<td>2003</td>
<td>Ebola-Zaire</td>
<td>Congo</td>
<td>&gt;50</td>
<td>90%</td>
</tr>
<tr>
<td>2004</td>
<td>Ebola-Zaire</td>
<td>Sudan</td>
<td>17</td>
<td>41%</td>
</tr>
<tr>
<td>2005</td>
<td>Ebola-Zaire</td>
<td>Congo</td>
<td>12</td>
<td>75%</td>
</tr>
<tr>
<td>2005</td>
<td>Marburg</td>
<td>Angola</td>
<td>374</td>
<td>87%</td>
</tr>
<tr>
<td>2007</td>
<td>Marburg</td>
<td>Uganda</td>
<td>2</td>
<td>50%</td>
</tr>
<tr>
<td>2007</td>
<td>Ebola-Zaire</td>
<td>Congo</td>
<td>264</td>
<td>71%</td>
</tr>
<tr>
<td>2008</td>
<td>Ebola-Bundibugo</td>
<td>Uganda</td>
<td>149</td>
<td>25%</td>
</tr>
<tr>
<td>2009</td>
<td>Ebola-Reston</td>
<td>Philippines</td>
<td>6</td>
<td>0%</td>
</tr>
<tr>
<td>Family</td>
<td>Genus</td>
<td>Complete Virus List</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------------</td>
<td>--------------------------------------------</td>
<td>------------------------------------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rhabdoviridae</td>
<td>Lyssavirus</td>
<td>Rabies virus, Lagos bat virus, Mokola virus, Duvenhage virus, Australian bat lyssavirus, European bat lyssavirus 1, European bat lyssavirus 2, Aravan virus, Khujand virus, West Caucasian bat virus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rhabdoviridae</td>
<td>Unassigned</td>
<td>Gossas virus, Kern Canyon virus, Mount Elgon bat virus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paramyxoviridae</td>
<td>Henipavirus</td>
<td>Nipah virus, Hendra virus, Menangle virus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paramyxoviridae</td>
<td>Rubulavirus</td>
<td>Tioman virus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coronaviridae</td>
<td></td>
<td>SARS coronavirus, Bat coronavirus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Togaviridae</td>
<td>Alphavirus</td>
<td>Cabassou virus, chikungunya virus, eastern equine encephalitis virus, Highlands J virus, Sindbis virus, Venezuelan equine encephalitis virus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flaviviridae</td>
<td>Flavivirus</td>
<td>Bukalasa bat virus, Carey Island virus, Central European encephalitis virus, Dakar bat virus, Entebbe bat virus, Japanese encephalitis virus, Jugra virus, Kyasanur Forest disease virus, Montana Myotis leucoencephalitis virus, Phnom-Penh bat virus, Sokuluk virus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bunyaviridae</td>
<td>Orthobunyavirus</td>
<td>Catu virus, Guama virus, Nepuyo virus, Kaeng Khoi virus (genus unassigned)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reoviridae</td>
<td>Orbivirus</td>
<td>Ife virus, Japanaut virus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arenaviridae</td>
<td></td>
<td>Tacaribe virus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Herpesviridae</td>
<td></td>
<td>Agua Preta virus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unclassified</td>
<td></td>
<td>Issyk-kul virus, Keterah virus, Mapuera virus, Mojui dos Campos virus, Yogue virus</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Nearly all of the most dangerous pathogens (BSL4) are zoonotic.

Brian Bird, DVM/PhD
Then at School of Veterinary Medicine
UC Davis (right)

David White, DVM/PhD
Then at College of Veterinary Medicine
Colorado State (left)

Maximum Containment Lab
CDC, Atlanta, 2005
Modern Animal Agriculture and the Emergence of Infectious Diseases

- Bringing together of large numbers of animals at high density
- Asynchronous introduction of animals from diverse sources
- Care of animals by inadequately trained workers
- Elaborate housing systems with complex air/feed/waste systems
- Manipulation of natural biologic rhythms (artificial daylight, estrus synchronization, growth hormone, etc.)
- Global movement of food products, animals, semen, embryos, other animal products
- Major changes in food production, processing and distribution
- Rise of novel, trendy foods (e.g., ostrich, deer, elk, buffalo, etc.)
The Real Human Food Chain
1986: BSE identified in cattle in England
1987: Announcement that large numbers of cattle are infected
1988: Orders to slaughter all BSE-infected cattle
1989: Southwood Committee Report: “...it is most unlikely that BSE will have implications for human health...”
1990: 23 countries ban British beef as a public health measure

1990: UK agriculture minister John Gummer attempts to allay public fears about the safety of beef by feeding his daughter, Cordelia, a hamburger
By 1990, as the BSE epidemic escalated, questions were raised across the UK, "...does BSE pose a risk to human health?" Government officials responded "...there is nothing to worry about..." This of course led the public to become more skeptical. The editors of *NATURE* reacted:

"...Never say there is no danger {risk}. Instead, say that there is always a danger {risk}, and that the problem is to calculate what it is... Never say that the risk is negligible unless you are sure that your listeners share your own philosophy of life..."
The Original...
Saul Steinberg’s New Yorker Cover
“View of the World from Ninth Avenue” (1976)
A New Version of Saul Steinberg’s New Yorker Cover, “View of the World from Ninth Avenue” (1976)

"View of the United States from Inside The Beltway" (2010)
Historic Turf and Turf Battles

For particular zoonotic infectious agents, general oversight and control responsibility has largely been in the hands of people associated with different government and academic communities:

- **Animal health and agriculture** (e.g., *Mycobacterium bovis*; *Brucella abortus*; traditional bacteria of concern in preharvest food safety).
- **Public health and medicine** (e.g., rabies virus; arthropod-borne viruses, bacteria, and protozoa; rodent-borne viruses and bacteria; primate-borne viruses and bacteria).
- **“In between” – new turf issues?** (e.g., new influenza viruses; *Salmonella enteriditis*; *Listeria monocytogenes*, many protozoa and parasites, novel bacteria of concern in preharvest food safety).
Asian Development Bank (2005):

“If the disease remains primarily confined to poultry, the aggregate impact on the economies of the Asian region will be hardly perceptible...”
Economic Impact of an Avian Influenza Pandemic

However, if there is a human pandemic...
- U.S. (CDC, 1999 study): 100,000-200,000 deaths, >700,000 hospitalizations, 40M outpatient visits; 50M additional illnesses
- U.S. (CBO): cost $100-200B / year (1.5% drop in GDP)

If the pandemic is like the 1918 pandemic...
- U.S. (CBO): 2M deaths (2.5% of cases); 90M illnesses
- U.S. (CBO): Cost ~$500B (5% drop in GDP / year, more than in any postwar recession except that in 1982)
- Economic growth stops - 0.75% permanent workforce reduction
Economic Impact of an Avian Influenza Pandemic

However, if there is a human pandemic...

- **Worldwide (WHO):** 2-7M deaths; 28M hospitalizations; 1.2B cases [Other estimates are much higher, exceeding 100M deaths]
- **Worldwide (ADB, 2005):** cost $950B / year
- **Worldwide (World Bank, 2005):** cost >$800B / year (>2% of GDP)

Severe economic shock: tourism, transportation, retail sales, hotels and restaurants, workplace absenteeism, disruption of production processes and food supply
New & Emerging Zoonoses
What’s Next ?...
ANTHRAX

4TH GRADE
GREENDALE SCHOOL
FRANKLIN PARK NJ 08852

SENATOR DASCHLE
509 HART SENATE OFFICE BUILDING
WASHINGTON D.C. 20510

WASHINGTON D.C.
Letter delivered to Daschle’s office tested positive for anthrax bacteria.

BOCA RATON, FLA.
An employee at American Media died of inhalational anthrax and another became ill. Traces of anthrax were found in the building and at the local post office, although no packages were identified.

TRENTON, N.J.
Letters were sent from a post office near NBC and to the office of Senate Majority Leader Thomas A. Daschle.

NEW YORK CITY
An NBC employee developed skin anthrax from a contaminated letter. The child of an ABC employee developed skin anthrax. The source is unknown.

RENO, NEV.
Testing was being done to confirm the presence of anthrax bacteria on a letter received at a Microsoft office.
Agricultural bioterrorism?

- 9,677 farms involved
- 10 million animals killed (1-in-7 of all farm animals)
- Cost £6.3 billion (0.8% of GDP)
Aurora Organic Dairy, Boulder County, Colorado, a 6,000 head operation. It is owned by Horizon Organic, which is owned by Dallas-based Dean Foods, the nation's largest dairy distributor, with $10 billion in annual sales.
Findings and Conclusions

- The United States is vulnerable to bioterrorism directed against agriculture
- Intentional introduction of pathogens may differ substantially from unintentional introduction
- The nation has inadequate plans to deal with agricultural bioterrorism
- No publicly available, in-depth, interagency national plan has been formulated for defense against the intentional introduction of biological agents directed at agriculture
- There are important gaps in our knowledge of foreign-animal pathogens. These gaps reduce the reliability and timeliness of risk assessment and risk-management decisions
- Our ability to rapidly detect and identify most pathogens soon after introduction is inadequate. This allows them to spread, and makes it impossible to recover
- The adverse effects of bioterrorism agents on wildlife have not been considered
- The current inspection and exclusion program at the US borders is inadequate for countering the threat of agricultural bioterrorism
- A large-scale multi-focal attack on agriculture could not be responded to or controlled adequately or quickly and would overwhelm existing laboratory and field resources
- It is not feasible to be specifically prepared or have all the scientific tools for every contingency or threat to agriculture
- Although the nation’s fundamental science, research, and education infrastructure (academic, industrial, and government) is in place and functioning, preparing the nation for agricultural bioterrorism requires special efforts and support of the infrastructure
- There is a need to enhance the basic understanding of threat agents so as to develop new and exploit emerging technologies for rapid detection, identification, prophylaxis, control
New & Emerging Zoonoses

What’s Next ?...
Extra Complexities
When the Agent is Zoonotic

- Investigation strategies are diverse, varying from disease to disease
- Investigation requires highly specialized knowledge and experience
- Investigation requires many areas of expertise: medicine, veterinary medicine, virology, pathology, ecology, animal biology, wildlife biology, entomology, etc.
- Few people have broad knowledge and experience in zoonotic disease investigation
- Investigation requires understanding of unique biosafety principles & practices, in the lab and in the field
- Investigation requires understanding of the concept of CONVERGENCE
Predicting the next emerging infectious disease
Editorial
Who Will Be the World’s Epidemiologist?

The rare but terrifying Ebola virus has emerged from its hiding place in the African rain forests once again to kill scores of people in Zaire. The virus — one of a host of emerging viruses that have medical scientists worried — becomes an unbelievable nightmare on the infrequent occasions it invades the human body. It turns internal organs to mush, causes profuse bleeding from virtually every orifice, and typically kills 90 percent of those infected. There is no vaccine to prevent it, no drug to treat it, not even a clue as to what animal or insect serves as its normal reservoir until some luckless human comes into contact and is infected.

No wonder authors and film makers have seized upon Ebola or viruses like it as the ultimate horror. Were Ebola to mutate so as to become more highly transmissible, it could cause incredible death and other body fluids. Primitive hospitals, where contaminated needles and instruments may be used on scores of patients, often amplify an initial outbreak.

The World Health Organization and the Federal Centers for Disease Control and Prevention have rushed experts to the scene to help find and isolate victims, making it likely that this outbreak can be contained as were earlier ones. But it is not hard to imagine an outbreak that could threaten the globe. A modest genetic change might enable Ebola to spread rapidly through the air, and infected travelers could spread the virus widely before anyone realized they were sick. Alternatively, a wholly different lethal virus that was readily transmissible could emerge.

A grateful public once thought that vaccine...