Factors affecting the emergence of zoonoses

Janusz T. Paweska
Head Center for Emerging and Zoonotic Disease
NICD-NHLS

6th FIDSSA Congress
South Africa, 05 – 08 October 2015
Emerging zoonotic diseases

• An unprecedented era of EZD which can occur anywhere in the world.

• The interdependence of people and animals and the many different factors controlling this relationship are converging to create environment that is conducive to the emergence of zoonotic pathogens.

• EZD highlight the dangers of the ability of pathogens to constantly adapt to survive and to infect populations of animals and people.

• The recent epidemics of SARS, West Nile virus, avian influenza, MERS, EVD demonstrate the global importance of emerging disease and the important role of public health and veterinary services in prevention, detection, diagnosis, surveillance, response and research activities.

• EZD are an important reminder of our roles and responsibilities as health professions and our obligations to ensure the improvement of the health and well-being of the public.

• Emerging and re-emerging zoonoses of public health concern are also a sobering reminder of the tremendous socio-economic and trade damage that this group of diseases can cause.
Emerging zoonotic diseases

- Recent years have witnessed an increasing number of novel infectious diseases originating from a zoonotic pool – an important source of emerging diseases
- Over the last several decades, there has been an average of almost one new emerging disease each year, and approximately 75% of these diseases have been zoonotic.
- Of 1415 known pathogens of humans 62% have an animal origin
Examples of recent emerging zoonoses and their means of spread

- **Ebola virus** – linked to consumption of contaminated bush meet, a growing trend in many regions of Africa as a result of political and economic forces. Recent geographic expansion.

- **Bovine spongiform encephalopathy** (“Trojan cow”) – spread through shipments of contaminated meat and bone meal.

- **Nipah virus** – in 1999 NV destroyed the swine industry in Malaysia while creating massive public panic – spread from coughing animals to humans.

- **Lujo haemorrhagic fever** – air importation to SA from Zambia via sick patient likely exposed to excreta of infected rodents.

- **Haemolytic Uraemic Syndrome** – certain *E. coli* strains contaminating meat and other food products.

- **Alveolar echinococcosis** – highly fatal parasitic infection – moved from its historic home in Arctic to southerly climates via translocation of Arctic carnivores.

- **Monkeypox** – made headlines in 2003 when occurred in North America. Spread from African rodents to North American prairie dogs, all grouped together as a part of the exotic pocket pet trade. Human cases in 4 different states after exposure to sick or dying prairie dogs.
Are we prepared?

• Did we shaped our thinking, responses, and understanding of microbes evolutionary biology and the ecology

• Do we have in place Global Emerging Infections Surveillance and Response System

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

—Goethe
With the acceleration and expansion of global trade, human movement and travel and the escalating population of both people and animals, the microbes have an even greater opportunity to adapt, change, and be transported to new hosts and ecosystems, often with catastrophic results.
“The future of humanity and microbes likely will unfold as episodes of a suspense thriller that could be titled Our Wits Versus Their Genes”

Joshua Lederberg, “Infectious History” (2000)
Emerging zoonoses of public health concern

- Severe Acute Respiratory Syndrome (SARS)
- Human Immunodeficiency Virus (HIV/AIDS)
- Avian Influenza
- Middle East Respiratory Syndrome (MERS)
- Ebola Virus Disease
Emerging zoonotic diseases

• In a recent publication by the US Institute of Medicine entitled “Microbial Threats to Health, Emergence, Detection and Response”, the authors suggested that a group of factors are swirling and converging to create a perfect microbial storm.

• This metaphor helps describe the conditions and dynamics that have produced a new era of emerging diseases. From the centre, or eye, of the perfect storm, a group of zoonotic pathogens of significant public health concern are emerging.
The interior of the central box is a gradient flowing from white to black; the white outer edges represent what is known about the factors in emergence, and the black center represents the unknown.

Interlocking with the center box are the two focal players in a microbial threat to health—the human and the microbe.

The microbe-host interaction is influenced by the interlocking domains of the determinants of the emergence of infection: genetic and biological factors; physical environmental factors; ecological factors; and social, political, and economic factors.
The host-pathogen ecological continuum – EID of wildlife constitute threats to human health

Canine distemper: domestic animals to wildlife
Lyme disease: wildlife to humans
Ebola virus: wildlife to wildlife, wildlife to humans
Cat scratch fever: domestic animals to humans
Rabies: wildlife and domestic animals to humans

Adapted from SCIENCE Vol 287 21 Jan 2000, P. Daszak et al.
<table>
<thead>
<tr>
<th>Year</th>
<th>Factors of Emergence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1992</td>
<td>Microbial adaptation and change</td>
</tr>
<tr>
<td></td>
<td>Economic development and land use</td>
</tr>
<tr>
<td></td>
<td>Human demographics and behavior</td>
</tr>
<tr>
<td></td>
<td>International travel and commerce</td>
</tr>
<tr>
<td></td>
<td>Technology and industry</td>
</tr>
<tr>
<td></td>
<td>Breakdown of public health measures</td>
</tr>
<tr>
<td>2003</td>
<td>Microbial adaptation and change</td>
</tr>
<tr>
<td></td>
<td>Economic development and land use</td>
</tr>
<tr>
<td></td>
<td>Human demographics and behavior</td>
</tr>
<tr>
<td></td>
<td>Technology and industry</td>
</tr>
<tr>
<td></td>
<td>Breakdown of public health measures</td>
</tr>
<tr>
<td></td>
<td>International travel and commerce</td>
</tr>
<tr>
<td></td>
<td>Human susceptibility to infection</td>
</tr>
<tr>
<td></td>
<td>Climate and weather</td>
</tr>
<tr>
<td></td>
<td>Changing ecosystems</td>
</tr>
<tr>
<td></td>
<td>Poverty and social inequality</td>
</tr>
<tr>
<td></td>
<td>War and famine</td>
</tr>
<tr>
<td></td>
<td>Lack of political will</td>
</tr>
<tr>
<td></td>
<td>Intent to harm (bioterrorism)</td>
</tr>
</tbody>
</table>

Source: IOM
## Factors in disease emergence

<table>
<thead>
<tr>
<th>Factor</th>
<th>Specific Factor</th>
<th>Disease Emergence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ecological changes (incl. those due economic development and land use)</td>
<td>Agriculture, dams, changes in water ecosystems, deforestation/re-forestation, flood/drought, famine, climate change</td>
<td>RVF (dams, irrigation), Argentine and Hantaan HV (agriculture), Hantavirus pulmonary syndrome (weather anomalies)</td>
</tr>
<tr>
<td>Human demographics, behaviour</td>
<td>Migration (movement from rural areas to cities), war or civil conflict, economic impoverishment, urban decay, human behaviour e.g. commercial sex trade, intravenous drug use, outdoor recreation, high density settings</td>
<td>HIV/AIDS, dengue (urbanization), Ebola (hunting wildlife, (consumption of bush meat), cholera outbreaks (refugee camps)</td>
</tr>
<tr>
<td>International travel and commerce</td>
<td>Worldwide movement of goods and people, air travel</td>
<td>Dissemination of mosquito vectors, rat borne hantaviruses, SARS, influenza, MERS</td>
</tr>
<tr>
<td>Technology and industry</td>
<td>Globalization of food supplies, production and processing</td>
<td>Food production processes: haemolytic uraemic syndrome, BSE, Nipah virus, avian influenza</td>
</tr>
<tr>
<td>Microbial adaptation and change</td>
<td>Microbial evolution</td>
<td>Antibiotic resistance, antigenic drift in influenza virus</td>
</tr>
<tr>
<td>Breakdown in public health measures</td>
<td>Reduction in prevention programmes, inadequate sanitation and vector control measures</td>
<td>Resurgence of TB, cholera, measles, diphtheria, rabies</td>
</tr>
</tbody>
</table>
Bush meat highly prized by humans in Central equatorial Africa

<table>
<thead>
<tr>
<th>Animal group</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primates</td>
<td><em>Ceropithecus</em> (monkeys)</td>
</tr>
<tr>
<td></td>
<td><em>Pan troglodytes</em> (chimpanzee)</td>
</tr>
<tr>
<td></td>
<td><em>Gorilla gorilla</em></td>
</tr>
<tr>
<td>Artiodactyls</td>
<td><em>Potamochoerus</em> (bush pig)</td>
</tr>
<tr>
<td></td>
<td><em>Cephalophus</em> species (duiker)</td>
</tr>
<tr>
<td></td>
<td><em>Hyemoschus aquaticus</em> (chevrotain)</td>
</tr>
<tr>
<td>Pholidota</td>
<td><em>Manis</em> species (pangolin)</td>
</tr>
<tr>
<td>Rodentia</td>
<td><em>Atherurus africanus</em> (porcupine)</td>
</tr>
<tr>
<td></td>
<td><em>Viverra and Nandinia</em> species</td>
</tr>
<tr>
<td>Carnivora</td>
<td>(civets)</td>
</tr>
</tbody>
</table>

In Central Africa alone 1 million to 3.4 million tonnes are consumed annually.

25 tonnes of turtles are exported from Indonesia every week.

28 000 primates are hunted annually in Peru.
Monkey (bushmeat) for sale at roadside
Challenges for BATS ON AFRICAN MARKETS
Challenges, lessons and ways forward

- African continent suffers from one of the highest burdens of infectious disease of humans and animals in the world but has the least capacity for their detection, identification, and monitoring.
- Studies on the risk of spread of EIDs point to Africa and Asia as likely to harbour the endemic settings for both conventional and emerging epidemic diseases, especially in the human-livestock-wildlife interface areas.
- Lessons learned from recent epidemics in Africa and elsewhere clearly indicate the need for:
  - Coordinated research
  - Interdisciplinary centres
  - Response systems and infrastructure
  - Integrated surveillance systems and workforce development strategies
  - More and stronger partnerships across national and international sectors (human health, animal health, environment) and disciplines (natural and social sciences) involving public, academic and private organizations and institutions
In order to strengthen the efficiency of early warning systems, monitoring trends and disease prediction, and timely outbreak intervention, it is essential that each nation improves its own capacity in disease recognition and laboratory competence.

Is this goal possible?
Who will pay?
Integrated research approach to zoonotic pathogens biology, ecology, epidemiology
One Health Focus on Infectious Diseases

- Bio-sciences
- Social Sciences

Collaborative Effort between

- Human
- Animal
- Environment

To advance understanding of Interactions between

- Public/Animal Health

To improve
Core Values of One Health

• **Jointly managed (owned)** by veterinary and medical academic and research institutions, sharing resources and expertise to achieve .....  
  • **Scientific Excellence through theme-based research programme**

• Collaboration across human and animal health sectors, addressing the important zoonosis.

• **Community of Practice** approach to enhance quality of supervision, mentorship and research collaboration across institutions, sectors, borders,
Global Health Security

Biorisk Spectrum and Biorisk Reduction Measures

Source WHO
Global Health Security

Biorisk Management Framework for Responsible Life Science Research

Vision:
excellent, responsible, safe and secure life sciences research activities promoting public health

Biorisk management for responsible life sciences research

Research excellence

Ethics

Biosafety and laboratory biosecurity

Communication, education and training, capacity development, interaction with stakeholders, development of norms and standards

WHO Guidance Document, 2010
图示了“ONE HEALTH”概念。它包括三个要素：

- Agent (致病因子)
- Hosts (宿主)
- Vectors (媒介)

这三个要素共同构成了“Environment (环境)”、“Disease (疾病)”、“Outbreak (疫情)”的多个层叠关系。理解这一概念有助于全球卫生安全的研究和实施。
Emerging zoonotic diseases - a new kaleidoscopic lens through which we view the world.