Convergence of forces behind emerging and reemerging zoonoses, and future trends in zoonoses

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Workshop on Sustainable Global Capacity for Surveillance and Response to Emerging Zoonoses
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“It is “time to close the book” on the problem of infectious diseases.”

“The future of infectious diseases will be very dull.”
Macfarlane Burnet, 1960 Nobel Prize Winner In Medicine (1972)

There are “no new diseases to be discovered.”
Lewis Thomas, Dean Yale Medical School (1976)
Infectious Disease Mortality, United States, 1900-1996

Armstrong et al, JAMA 1999
Why Diseases Emerge

Genetic and biological factors
– Microbial adaptation and change
– Human susceptibility to Infection

Physical environmental factors
– Climate and weather
– Economic development and land use

Ecological factors
– Changing ecosystems
– Human demographics and behavior

Social, political, and economic factors
– International Travel and commerce
– Poverty and Social inequity
– War and Famine
– Lack of political will
– Intent to harm
Significant Global Epidemics Over the Last 15 Years

• 1993 – Hanta virus
• 1994 – Plague (India)
• Ebola virus (Zaire)
• 1996 – New Variant of CJD (UK)
• H$_5$N$_1$ influenza (Hong Kong)
• 1998 – Nipah virus (Malaysia)
• 1999 – West Nile
• 2000 – Rift Valley Fever
• 2001 – Anthrax
• 2002 – Noro-viruses
• 2003 – SARS
• 2004 – Marburg Virus
• 2005 – H$_5$N$_1$ Influenza
• 2006 – E. coli – spinach, lettuce
• 2007 – PIN
Number and type of emerging infectious disease events by decade, 1940-2000

EID event = the first temporal emergence of a pathogen in a human population which was related to the increase in distribution, increase in incidence or increase in virulence or other factor which led to that pathogen being classed as an emerging disease

Jones et al, Nature 21 Feb 2008
Relative risk EID from zoonotic pathogen from wildlife

Jones et al, Nature 21 Feb 2008
Relative risk EID from zoonotic pathogen from non-wildlife

Jones et al, Nature 21 Feb 2008
Large proportions of emerging, reemerging and persisting pathogens are heavily influenced by the interactions between 3 main “environments” or domains:

- Human
- Animal
- Environment
Human Domain
Human Health Issues
Behavior, Attitudes, Preferences, Culture
Lifestyle, Economics, Technology
Movement, Transport, Trade

Animal Domain
Non-human Animal Health Issues
Behavior
Geographic Range
Habitat and Feeding Preferences or Requirements

Environmental Domain
Long-term climatic change
Global Weather Influences (ENSO)
Local/Regional Weather Patterns
Altitude, Temperature, Humidity
Soil and Vegetation Type
Human Domain
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Human-Environment Interface:
“Built Environment”
Pollution (Air, Water, Noise, Light, Solid Waste)
Urban/ Periurban Development
Non-animal Farming Practices
(Crop Choice, Irrigation)

Human-Animal Interface:
Companion Animal Ownership
Animals as Food, Husbandry Practices
Wildlife Management Practices

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Animal-Environment Interface:
Expansion/ loss of range
Invasive Species
Effect of Environmental Conditions on Lifespan and Reproduction (especially vectors)
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- Human Health Issues
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  - Lifestyle, Economics, Technology
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- Non-human Animal Health Issues
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**Human-Animal Interface:**
- Companion Animal Ownership
- Animals as Food
- Husbandry Practices
- Wildlife Management Practices
- Habitat Encroachment

**Animal-Environment Interface:**
- Expansion/ loss of range
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- Effect of Environmental Conditions on Lifespan and Reproduction (especially vectors)

**Disease**
- Emergence
- Re-emergence
- Persistence
Commerce and Trade - A New Built Environment of Global Enterprises

- World of “collapsed space” – smaller, faster and progressively more interconnected
- Annual global trade (2006) - $12 trillion
- 6% annual growth projected
- 90% of global trade is between private corporations
- Of the top 100 global economies, over half are private international companies
- 6 million food shipments come into the U.S. each year with a small % inspected
Worldwide Ship Traffic

www.sailwx.info
Population Movement
Urbanization
Travel/Tourism

Estimated 1 billion people crossing international borders each year

25 crossings per second

“There is nowhere in the world from which we are remote and no one from whom we are disconnected”

*Nobel Laureate in Medicine, Joshua Lederberg*
World Population Growth, 1950 - 2100

Population size estimates (1950-1990) and projection (1990-2025), by regions show a drastic increase in Asia and Africa.

Source: Delehner, 1995
Trends in Global Population


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Source: US Bureau of the Census
Urbanization
60% of world’s population will live in cities by 2030

78% of urban dwellers in least developed countries live in slums (1 billion world wide in 2001)
Urbanization
60% of world’s population will live in cities by 2030

By 2015, it is anticipated that 22 mega-cities will exist, 17 of which will be located in developing countries
Livestock 2020 – The Next Food Revolution

- Global increase and demand for protein and food of animal origin
- Shift from poverty of 1-2 billion people to middle class
- “Westernization” of Asia and Latin America
- Increases in emerging zoonoses through the concentration of people and animals
World Meat Consumption, 1983 - 2020

Million Metric Tonnes

1983 1993 2020

Developing World
Developed World

Source: Newcomb, J., One World - One Health: An Economic Perspective, 2004
Projected Species Production, 1961 - 2025

Million Metric Tonnes

- Pork
- Poultry
- Beef and Veal
- Misc.
- Mutton and Lamb

Source: Newcomb, J., One World - One Health: An Economic Perspective, 2004
Concentrated Animal Feeding Operations (CAFOs)

Their Impact on Food Safety and Healthy Environments
Meeting the Need

Human-animal interface
Animals as food
High density production
Meeting the Need

Human-animal interface
Animals as food
High density production
“Backyard” flocks

800 million poor livestock keepers
Meeting the need

Animal Human Interface
Animals as food
High density production
“Backyard flocks”
Bush meat

• Nearly 12 tons per year of illegally smuggled meat (including bush meat) into UK

• Over a six month period at the beginning of 2006, US Customs officers confiscated 62 pounds of bush meat being smuggled through a single US airport from Africa

• Evidence of repeated emergence of new viruses similar to HIV arising from human infection with simian viruses, common among Central African bush meat hunters

Sources: Wooldridge, Hartnett et al. 2006; (US Customs and Border Protection 2006)
Animals, Waste, and the Risk of Disease Emergence
Animal Human Interface – an extreme

Human population density

Poultry population density

Source: FAO, WHO, Rimsa, Mexico City April 2005
Last year, over 21 billion food animals were produced to help feed a population of over 6 billion people resulting in trillions of pounds of products distributed worldwide. Projections toward 2020 indicate that the demand for animal protein will increase by 50%, especially in developing countries.
Climate change
Certain
Real phenomenon

2000-2006 Temperature anomaly

Source: Goddard Institute for Space Studies
Changing Environment

Environmental change
Deforestation
Desertification
Changing Environment

Environmental change
Built environment
Habitat encroachment
Calamity

Political and socio-cultural unrest
War
Complex Humanitarian Emergencies
Bioterrorism
Microbial View
No single agency has the mandate or the capacity to address zoonotic diseases.

Internationally, responsibility for zoonotic diseases is disparate:
  - World Health Organization
  - World Organization for Animal Health (OIE)
  - UN Food and Agriculture Organization (FAO)

In US, the responsibility for zoonotic diseases is spread across many government departments and programs – each with own focus and interests.
Zoonotic Disease Control in the United States

US Dept of Agriculture
- Animal Health orientation
  † Economic threat to US agriculture

US Dept Health and Human Services
- Human Health orientation
  † Minimization/ mitigation of public health threat of zoonoses

US Dept of Defense
- “Force Protection” orientation
  † General health threat to soldiers (or potential for being used as bioweapon against US soldiers)

US Dept Homeland Security
- Bioterrorism orientation
  † Preventing / controlling access to potential biothreats

US Agency for International Development / Dept of State
- International development orientation
  † Increasing involvement in improving capacity to detect and respond to zoonoses, primarily Avian Influenza
Zoonotic Disease Control in the United States

National Center for Zoonotic, Vector-borne, and Enteric Diseases

OIE Collaborating Center for Emerging and Re-emerging Zoonoses
National Center for Zoonotic, Vector-borne, and Enteric Diseases

Strategic Themes and Cross-Cutting Areas

Zoonotic Diseases
- 75% of all emerging diseases
- 60% of all human pathogens

Food-borne Illnesses
- 76 million illnesses caused by food-borne pathogens each year
- 325,000 hospitalizations and 5000 deaths in the U.S. each year

Global Microbial Threats
- Imported diseases
- Emerging/ re-emerging diseases
- Select Agents
National Center for Zoonotic, Vector-borne, and Enteric Diseases
Strategic Themes and Cross-Cutting Areas

• **Vector-Borne Diseases**
  - 1.5 million West Nile virus infections reported since 1999
  - 2.5 billion people in more than 100 endemic countries are at risk for dengue fever
  - 300-500 million cases of malaria and 1 million malaria deaths each year

• **Water-Borne Diseases**
  - > 1 billion people without access to safe water for drinking personal hygiene, and domestic use
WHAT'S NEXT!

NEW TREATMENTS FOR YOUR HEART
HOW THE INTERNET MAKES US ALL INVENTORS
THE NEXT TARGET VOTER: YOU
WHY MOVIES WILL NEVER BE THE SAME
PLUS: COOL, MUST-HAVE GADGETS
Cultivating a Public Health Revolution
Social Networking, Strategic Information, Sense Making, and Situation Awareness
- Hospital visits due to asthma
- US Winter weather reports
- Ambient air quality levels

- Data is organized by time and place
- Information on the spatial and temporal distribution of cases and air quality is distributed

- High risk places and times of year for asthma are identified
- Policy and plans for patient and hospital notification are established
MicrobeNet™

- Curated reference database
  - Phenotypic and genotypic information
  - 16S ribosomal gene sequences
  - Beginning with certain bacteria and fungi
  - Polyphasic identification of prokaryotic as well as eukaryotic pathogens
  - Will be available for known and novel pathogens
Figure 1. Overview of MicrobeNet and concept of reference data management. Data in CDC Working Libraries are protected and only accessible to authorized staff on a need-to-know basis. Release of selected data from Working Libraries to MicrobeNet Reference Database is voluntary and data transfer is controlled by laboratory sender. Reference data are devoid of patient-identifying information and scientific curation is performed by CDC and partnering subject matter experts. Data types in the Reference Database can be unique to a specific CDC laboratory (triangles, squares, diamonds) or shared between multiple CDC laboratories (stars, shaded according to origin).
Malaria – a “new” zoonotic disease?

• Recent reports of *Plasmodium knowlesi*, a primate species of malaria, occurring in humans in Southeast Asia
• Unknown at this time how transmission is occurring
  – mosquito transmission directly from a monkey
  – simian parasites are becoming established in human populations and being transmitted between humans via the mosquitoes.
• Likely been occurring for a long time and it has gone unrecognized because the diagnostic standard is smear microscopy
• Large studies in Malaysia suggest that ~14% of all of the malaria reported in Malaysia is caused by *P. knowlesi*. 
Convergence Challenges

• The role of governments, educational institutions, and society
• Animal and human health are a continuum of causality with the environment and need to be viewed as one and need integrated strategies
• Recognizing the moral and ethical imperative: health disparities
• Inclusion of diverse communities, thinking, and tools
• The need for new leaders and new ways of leading
Convergence Challenges

• Impact and influence beyond health – goods, services and economies
• A shift from problem solving to managing dilemmas
• A new global interdependence and connectivity
• Factors creating the microbial storm are well entrenched
• Reconciliation of great change with habitual and traditional thinking and ways of working
• Adopting a “One World – One Health” mindset and strategy
Acknowledgements

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• Ali Khan
• Peter Bloland
• Kate Glynn
The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the Centers for Disease Control and Prevention.