A Retrospective Look at Microbial Threats Through the Lens of One Health: Lessons for Tomorrow

Institute of Medicine
Forum on Microbial Threats
Washington, D.C.
December 10, 2012

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Emerging Infections

Growing concern of EID

Factors in emergence

Wake up call to counter complacency

Stimulus for many other studies and activities

Recognition of impact of threats to U.S. health

Recommendations: recognition & response
“It’s our Wits vs. Their Genes”

Dr. Joshua Lederberg – Science 2000
Risk

Number of catastrophes between 1970 & 2003

Source: Swiss Re, Sigma No. 1, 2004
Microbial Threats to Health

Call to action
Factors in emergence
Convergence model
Emphasis on global scope and scale
Concern with BT
Recognition of ecology of infectious diseases
Recommendations
Convergence Model

- Genetic and Biological Factors
- Physical and Environmental Factors
- Social, Political, and Economic Factors
- Ecological Factors
- Animals
- Humans
- Wildlife

E I D
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
Dynamics of One Health Domains

Newton’s 3rd Law of Motion: in essence, for every action, there is an equal and opposite reaction.
What is One Health?

Definition
Holistic, integrative and collaborative
New scientific niche for health
Emphasis on: multiple disciplines and professions; prevention and expansion of professional knowledge and experiences
Appreciation of the connectivity of domains of health
Targeted research portfolio
Peri-Urban Slum
The World’s Populations

1.3 billion cattle
1.0 billion pigs
2.0 billion small ruminants
50 billion poultry reared annually
500 million dogs and cats
Unknown populations of wildlife and exotics
7 billion people

(Need a 50% increase in protein from animal sources in the next 10 years)
Embracing complexity

Loss of biodiversity and pathogen filters

Counter to reductionism

All life is connected (#20) in Science’s Greatest Hits

Lyme disease is an example

Next critical component to One Health
“The response to a microbial threat – from detection to prevention to control – is a multidisciplinary effort involving all sectors of the public health, clinical medicine, and veterinary medicine communities.”
Global Trends in Emerging Infection Diseases (EID)

- 335 EID events: 1940-2004
- Steady increase with peak decade in 1980
- **20.9% drug-resistant microbes**
- **22.8% vector-borne (28.8% in the last decade)**

Global Trends in Emerging Infection Diseases

A: zoonotic pathogens from wildlife
B: zoonotic pathogens from non-wildlife
C: drug-resistant pathogens
D: vector-borne pathogens

Surveillance bias and wrong focus
21st Century Trojan Horses
Further One Health Issues

Pandemic and endemic divide

• 21St Century global mixing bowl; microbial swarms and a rapidly growing population of abundant hosts

• “Microbes awaiting disease”; travel, trade, habitats and novel exposures

Global food systems; substantial growth of both imports and exports; plant health – nutrition & famine

Vulnerable populations – a growing level of risk

Antimicrobial resistance; falling further behind
Further One Health Issues (cont)

Significant burden of disease for poor livestock and poultry keepers

Need to focus at the edge of existing endemic ranges and locales; e.g. Lyme disease

Divide between commerce/trade and health

Divide between animal and public health

Livestock 2020; the next revolution for agriculture

Shift of populations to peri-urban settings; new ag

Poor funding for wildlife agencies and organizations
Antibiotic Resistance: Need for One Health

Significant global threat
Adding huge costs to healthcare
Planetary environmental saturation with selective pressures
Horizontal transfer
Political, behavior and economic conflict
Tragedy of the Commons
The Causes and Impacts of Neglected Tropical and Zoonotic Diseases

Immense burden of illness: 2.5 billion cases with 2.7 million deaths
Under-reported/mis-DX
Double impact on poor L/S keepers (800 M)
Co-morbidity
Parasitic problems
Risk to people but control in animals
Greatest Burden of Zoonoses Falls on One Billion Poor Livestock Keepers

An ILRI study shows that zoonotic diseases are major obstacles in pathways out of poverty for one billion poor livestock keepers. The diseases mapped cause 2.3 billion human illnesses and 1.7 million human deaths a year. In poor countries, the diseases also infect more than one in seven livestock every year.

Map by ILRI, from original published in an ILRI report to DFID: Mapping of Poverty and Likely Zoonoses Hotspots, 2012.
Survey of Hospitalized Febrile Patients in Northern Tanzania

Bacterial zoonoses diagnosed greatly exceeded malaria cases (CID 2011:53 Aug. 15, Prabhu)

Q Fever (Coxiella burnetti) and Spotted Fever Group Rickettsiosis were the most common illnesses diagnosed; also found lepto and brucella

Because most undiagnosed febrile illnesses are assumed to be malaria (60%), many of these cases were treated incorrectly and others never diagnosed

Q Fever and SFGR (not typhus) are very likely endemic diseases; risk factors need to be studied

Co-infections were common
The Threat of Pandemic Influenza

Data and tissue sharing
Integrated surveillance
Improved diagnostics
Responding to crises one-at-a-time vs. systemically and LT
Control of zoonoses is an effective PH strategy
Trans-disciplinary and collaborative research on zoonotic risk
National Public Health and BioSurveillance

Strategy for Human Health

• Origin – HSPD-21

• Leverage national effort on electronic medical records

• Stressed need for animal, wildlife and plant disease surveillance

• Incorporate food and vector data

• Goal is national integration

80% of select agents are zoonotic

National Veterinary Diagnostic Laboratory System

Private lab data
Reported Human West Nile Virus Cases, by Date of Symptom Onset; and Date of First Positive Surveillance Event, Colorado, 2003

Source: John Pape, CO DOH
Learning from SARS

- Broad economic impact
- Speed of global spread
- Positive international collaboration
- Need for diagnostics and surveillance
- PH and risk communications
- Research agenda
- Transboundary ID event
Infectious Disease Movement in a Borderless World

- Migration and travel
- Trade and commerce
- Mobility
- Mobile animals and products
- Growth of peri-urbans
- IHR; animal heath std
- Capacity and PH and AH infrastructures
Improving Food Safety Through a One Health Approach

Intensive production systems
Globalization
H-A interface
Changing sources and risks
Livestock 2020 era
Environmental commons
Shifting upstream
Recommendations: Microbial Threats to Health

A One Health Scorecard

- Enhanced Global Response Capacity
- Improve Global ID Surveillance
- Rebuilding pH Capacity
- Improve Domestic Surveillance and Disease Reporting
- Developing and Using Diagnostics
- Educate and Train an ID Workforce
Recommendations: Microbial Threats to Health

A One Health Scorecard

- Vaccine Development and Production
- New Antimicrobial Drugs
- Reduce Inappropriate Use of Antibiotics
- Vector-borne and Zoonotic Disease Control
- Comprehensive ID Research Portfolio
- Interdisciplinary Centers
Current and Projected Importance of Factors Influencing Emergence

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Conclusions

Based on these precepts and the Score Card, we can conclude:

- Many of the key factors and drivers of convergence are intensifying and accelerating
- We have made progress on some of the 2002-03 recommendations but too little progress on others
- We will have surprises (mostly predictable) during the next decade with growing impact economically, politically, and on our health
Predictable Surprises

Problem is known but is not being addressed
Getting worse over time
Fix = costs with delayed benefits
Tendency toward status quo
Some benefits to inaction
Lack of imagination
A “black swan is an event, positive or negative, that is deemed improbable yet causes massive consequences. However, even exports are blind to them.

“Assuming more order than exists in chaotic nature.” - Francis Bacon (400 years ago)
Conclusions

• The One Health domains will become even more interconnected; thus, future interventions and strategies to address EID will also be more interconnected and complex

• Our human-animal interfaces will continue to collide and mix, facilitating microbial adaptation and spill over

• Environmental and ecological factors will expand and intensify and become more important drivers in disease emergence, re-emergence and dissemination.
Conclusions

• Our public health and animal health infrastructures and capacity have been limited or reduced based on the current global economic challenges. This has increased our vulnerability both regarding detection and response. Although recovery will eventually occur, the resources for public, animal and environmental health may not, thus creating an even greater vulnerability.

• Scientific and technological breakthroughs will continue and are the bright spots in addressing EID. However, the applications of these breakthroughs need to be realized more quickly.
Conclusions

• Anthropocentric thinking, planning and training doesn’t promote the interdisciplinarity and broad understanding of disease ecology and may promote defensive strategies rather than preventive and more cost effective interventions.

• AMR is rapidly becoming an extremely serious global health threat. Without resolution, resistant pathogens may be our greatest microbial threat over the next decade. The resolution is less about science and more about conflict resolution, changing incentives and human behavior.
Conclusions

• There will be greater elucidation on the role of microbes and microbial populations and diversity to determine health outcomes with the discovery of more links between acute ID and chronic diseases ushering in a new era of potential therapies and intervention

• The global food systems and the livestock revolution in agriculture will lead to more foodborne challenges especially in the developing world but also with food imports
Conclusions

• Neglected tropical diseases and neglected zoonotic diseases are not predictable surprises they are just neglected. An estimated 2.5 billion cases per year in our poorest 1 billion people (based on top 56 zoonoses); they don’t have constituencies or political will to effectively address them.

• Urbanization, immigration, refugee populations and the rapid growth in peri-urban centers worldwide may develop into the richest environment for future disease emergence and will truly become a major One Health challenge.
The Next Decade of Microbial Threats

Intensity and dynamics of 3 domains; the need for a One Health strategy
Predictions of outbreaks and threats
AMR a growing global threat
Foodborne and environmental/water challenges with L/S 2020
Neglected zoonoses still neglected
Urbanization and adjusting agriculture and even greater emergence issues
Disruptions and nonlinear events
Microbes seeking and finding disease
The Next Decade of Microbial Threats

More predictable and unpredictable surprises
Capacity and infrastructure problems
Greater globalization influences on health and infectious diseases
Improvements in diagnostics, innovative surveillance and integrated research
Growing need and demand for better communications in PH and science
More efforts to influence the political will
Climate and vectorborne issues variable
Lesson Learned and New Strategies

Integration of surveillance activities
Shift attention upstream closer to problems
Risk-based approaches to detection and response at H-A interfaces
Rapid, accurate and inexpensive diagnostics in real time and POC
Address AMR issue as a national conflict negotiation and building a common ground
Refocus strategies for poor L/S keepers to reduce zoonoses and improve economics
Lessons Learned and New Strategies

Invest in pandemics and high profile outbreaks into a LT strategy for all emerging and re-emerging disease especially zoonoses

Develop integrated ecological and One Health research teams and programs

Recognize that many AH and EC strategies are good PH interventions and plan accordingly

Value proposition and proof of concept; paradigm shift
One World - One Medicine - One Health