

Emerging Infectious Diseases and Bioterrorism Risk

Satellite Conference
Tuesday, July 20, 2004
12:00-1:30 p.m. (Central Time)

Produced by the Alabama Department of Public Health
Video Communications Division

Faculty

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Objectives

- Introduce the audience to lessons learned from deadly epidemics of the past two centuries, including respiratory, waterborne, parasitic, gastrointestinal, and foodborne disease epidemics.
- Review examples of recently identified infectious diseases related to man's manipulation of ecology.

Objectives

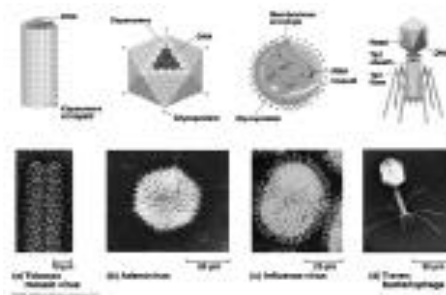
- Discuss short and long-term strategies to reduce the danger for future pandemics.
- Discuss specific emerging infectious diseases that should be considered potential bioterrorism agents.

The "End" of Infectious Diseases

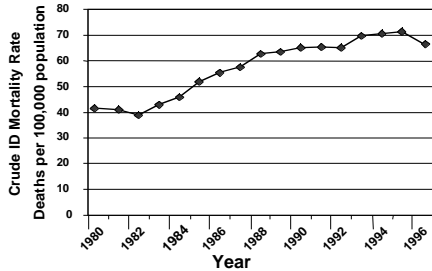
"...one can think of the middle of the twentieth century as the end of one of the most important social revolutions in history, the virtual elimination of the infectious disease as a significant factor in social life."

Macfarlane Burnet, 1962

Viruses



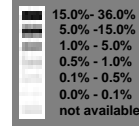
Infectious Disease Mortality in the United States, 1980-1996



Source: JAMA 1996;275:189-193 & unpublished CDC data

Global HIV Pandemic

Adult Prevalence



Global HIV infection rates Ref: UNAIDS, 2002



“Distinctions between domestic and international health problems are losing their usefulness and often are misleading.”

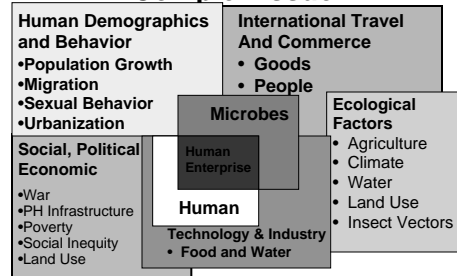
America's Vital Interest in Global Health.
IOM, 1997

IOM Definition of Emerging Infections

New, reemerging or drug-resistant infections whose incidence in humans has increased within the past two decades or whose incidence threatens to increase in the near future.

Institute of Medicine Report, 1992

How Do We Conceptualize This Complex Issue?



Adapted from Microbial Threats to Health Institute of Medicine, 2003

Recent Examples of Emerging Infectious Diseases Related to Man's Manipulation of Ecology, Travel - I

- **RESPIRATORY**
 - H5N1 avian influenza now circulating in Asian fowl and threatening as a new worldwide pandemic strain
 - SARS-associated coronavirus, zoonosis → nosocomial

Recent Examples of Emerging Infectious Diseases Related to Man's Manipulation of Ecology, Travel - I

- **SEXUALLY TRANSMITTED**
 - Global HIV pandemic, changing sexual mores
- **VECTOR-BORNE**
 - Expansion of malaria associated with global warming

Recent Examples of Emerging Infectious Diseases Related to Man's Manipulation of Ecology, Travel - I

- **GASTROINTESTINAL**
 - E. coli 0157:H7, undercooked fast food link
 - Cryptosporidiosis, water/food/immunosuppression links

Recent Examples of Emerging Infectious Diseases Related to Man's Manipulation of Ecology, Travel - II

- **PARENTERAL**
 - Hepatitis C via injection & transfusion
- **MIXED ETIOLOGY**
 - Legionnaire's Disease via aerosolized water in modern ventilation systems

Recent Examples of Emerging Infectious Diseases Related to Man's Manipulation of Ecology, Travel - II

- **ECOTOURISM**
 - Arboviruses
 - Leptospirosis and the Eco-Challenge

African Virus May Be Culprit In Mosquito-Borne Illnesses

By JENNIFER STEINHAEUER

The mosquito-borne illness that has killed three people in New York City may not be St. Louis encephalitis, as experts have thought, but rather a similar disease that has never been diagnosed in the Western Hemisphere, Government scientists said yesterday.

The disease, West Nile virus, was discovered this week in dozens of birds that died in and around the Bronx Zoo this summer. The virus is indigenous to Asia and northern and eastern Africa and occasionally makes its way to Europe, but has never been found in birds or people in this hemisphere, said Duane Gubler, the director of the division of vector-borne infectious disease at the Federal Centers for Disease Control and Prevention.

enough because that disease is rarely found outside the Southeastern United States.

Scores of tests will need to be completed before health officials will be able to say for sure whether the infections were caused by some type of West Nile virus or St. Louis encephalitis. Officials at the C.D.C. said they hope to have the tests completed sometime next week.

But the discovery of the West Nile strain in the birds has cast some doubt on the original diagnosis, officials said. "West Nile virus is closely related to St. Louis encephalitis, the virus we thought was causing the outbreak," Dr. Gubler said. The discovery of the dead birds, he said, "has caused some confusion as to whether that is true now."

NY Times, Sept. 25, 1999

From Whence Will Future Threats Emerge?

- Institute of Medicine cites key changes in the world and the way we live as responsible for these and other emerging IDs

From Whence Will Future Threats Emerge?

ZOONOSES

- SARS, with nosocomial transmission
- West Nile, with bird migration and insect control
- Hantavirus, with rural home infestation of rodents
- Monkeypox, with importation/promulgation of exotic pets

From Whence Will Future Threats Emerge?

UNANTICIPATED

- Ebola virus, unknown origin
- Marburg virus, unknown origin
- Bioterrorism, as with anthrax, October 2001, USA

How Do We Classify Emerging Infectious Diseases? (by Clinical Characteristic)

| Classification | Infection |
|------------------------------|---|
| Diarrheal Disease | Secretory; Invasive |
| Respiratory Disease | Upper or lower respiratory |
| Central Nervous System | Meningitis, bacterial or aseptic Encephalitis; Abscess |
| Cardiovascular | Endocarditis; Myocarditis; |
| Dermatologic, Ophthalmologic | Vasculitis |
| Bone and Joint | Skin; Systemic viral exanthems; Conjunctivitis |
| Genitourinary | Osteomyelitis, Septic arthritis Urine infections; STDs |
| Sepsis, Blood | Disseminated, "systemic" |

Classification By Reservoir

- Human
 - Person-to-person
- Animals
 - Zoonoses from vertebrate animals to man
- Environmental
 - Soil, Water, Fomites
- Vector-borne
 - Insects, Ectoparasites
- Mixed sources
 - Hospital-acquired (nosocomial)

Classification by Mode of Transmission

- Type of contact:
 - Direct
 - Indirect
- Food- or water-borne
- Airborne or respiratory
- Vector-borne
- Sexually transmitted

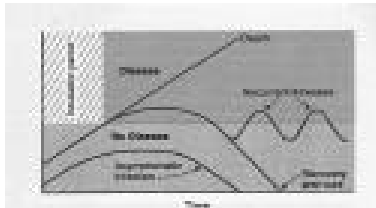
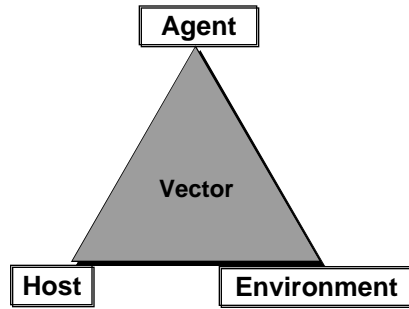
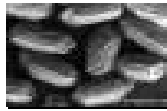


Figure 1.2. Microbial multiplication and clinical manifestations of disease. The number of microorganisms present in a patient must exceed a given threshold to cause disease. If the number is below this threshold, no signs and symptoms of disease will be apparent. In some cases, the numbers oscillate above and below the threshold, resulting in recurrent bouts of disease. Note that this drawing is idealized. In reality, the threshold of microorganisms is not fixed but varies with the physiological state of the host.



Factors Influencing Exposure and Infection: Agent Factors

- Sources, reservoirs, transport and environmental persistence
- Ability to enter a portal in the human or other host



Anthrax Spores



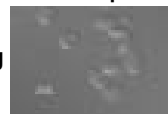
Giardia Cysts

Factors Influencing Exposure and Infection: Agent Factors

- Ability to reach and proliferate at site(s) of infection in the host
- Excretion of agent from host
 - Quantity (dosage) and quality (including virulence) of infectious organisms



Anthrax Spores



Giardia Cysts

Factors Influencing Exposure and Infection: Environmental Factors

- **Reservoirs:** where organisms live or persist outside of the host; can be an animal or the environment
- **Vehicles:** inanimate objects/materials by which organisms get from one host to another; includes water, food, objects (fomites) and biological products (e.g., blood)

Factors Influencing Exposure and Infection: Environmental Factors

- **Amplifiers:** Types of reservoirs where organisms proliferate, (e.g., airborne transmission organisms)

Environmental Factors Influencing Survival or Proliferation of Organisms

- **Physical:** temperature, relative humidity, sunlight, moisture content or water activity, climate and weather
- **Chemical and Nutritional:** Antimicrobial chemicals, nutrients for microbial proliferation
- **Biological:** Inhibiting or enhancing activity such as antimicrobial agents, parasitism, etc.; presence of a vector

Factors Influencing Exposure and Infection: Vectors

- **Vectors:** Creatures that transmit infectious organisms to host
 - **Mechanical vectors:** Microbes do not multiply in vector
 - e.g., *biting insects infected or colonized with the organism*
 - **Biological vectors:** Microbes must propagate in the vector before they can be transmitted to a host

Factors Influencing Exposure and Infection: Host Factors and Host Susceptibility

- **Opportunities for host exposure**
 - Transmission routes
 - Host availability

Factors Influencing Exposure and Infection: Host Factors and Host Susceptibility

- **Susceptibility factors**
 - Age of subject
 - Nutritional status
 - Immunocompetence and health status
 - Host genetics
 - Gastric acidity
 - Behavior (personal habits) of host

The Iceberg Concept: As Applied to Viral Infections



Infectious Dose

- Microbes differ in their infectious dose
- **Enteric/respiratory viruses** often infectious at low doses
 - As little as one cell culture infectious dose has a high probability of infecting an exposed human, but this may still require exposure to many virus particles
 - Cholera is infectious at 10^{13} organisms, only 10^9 if host is achlorhydric

Infectious Dose

- Most enteric bacteria are infectious at moderate (10s-100s of cells) to high (1,000 cells) doses
- Protozoan cysts may be infectious at low doses
 - A few as 1-10 cysts of *Giardia lamblia* or oocysts of *Cryptosporidium parvum*

Outcomes of Infection

- Microbes differ in their outcomes of infection
- Infection without illness
 - Long term, harmless = commensal

Outcomes of Infection

- Infection with illness
 - Acute or chronic
 - With or without long-term sequelae
- Lethal infection
 - Host immune response unsuccessful in containing the organism

Major Factors Contributing To The Emergence Of Infectious Diseases

1. Human demographics and behavior
2. Technology and industry
3. Economic development and land use
4. International travel and commerce
5. Microbial adaptation and change
6. Breakdown of public health measures

Institute of Medicine Report, 1992

Human Demographics, Behavior and Society

- High risk behavior
 - Sexual
 - Drug use
 - Tobacco
- Immune compromise/exposure
 - Under/over Nutrition
 - Modern health care

Human Demographics, Behavior and Society

- Travel/Migration
 - Long distance air travel
 - Humans and domestic animals encroaching natural habitats
 - Urbanization

Human Demographics, Behavior and Society

- Economic impoverishment
 - War
 - Urban decay, loss of PH
- Population growth
- Pets
- Outdoor recreation
- Child care facilities

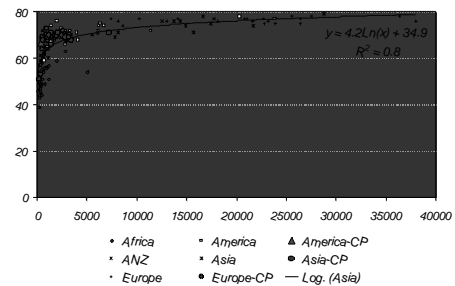
Disease Reservoir Imbalance

- Megacities
- Mixing of people, animals and microbes in an environment transformed by industry, technology, demands of population growth, chemicals, climate change or agriculture

Disease Reservoir Imbalance

- Exploration and clearing of new lands
- Settlement on margins of habitable lands
- Interventions introduced without understanding potential impacts

Life expectancy & GDP



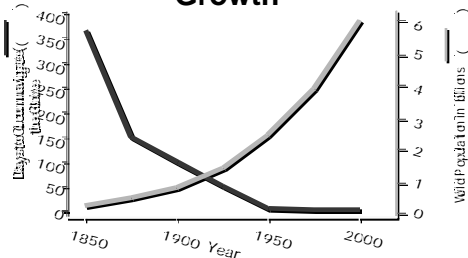
Migration and Travel

- Introduces infections to new populations
- Magnitude and speed unparalleled in history
- Much movement unplanned and unwanted
 - leads to settlements in areas or under conditions that lead to increased risk of disease

Migration and Travel

- Includes all biological life: humans, animals, plants, seeds and insects
 - Hastens spread of disease
 - Changes ecology and habitat of area, possibly extinguishing local species

Speed of Global Travel in Relation to World Population Growth



From: Murphy and Nathanson Sems. Viact. 5, 87, 1994

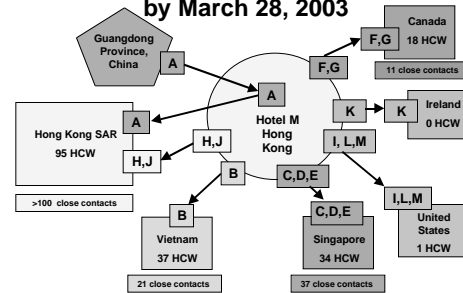
Technology and Industry

- Long-distance livestock transportations
- Irrigation
- Globalization of food supplies
- Changes in food processing

SARS

Severe Adult Respiratory Syndrome caused by a novel coronavirus → zoonotic origin likely

Spread from Hotel Metropol, HK by March 28, 2003



SARS Containment Strategies : *Detect, Isolate, Quarantine*



SARS Control

- Early detection is key
 - Heightened suspicion
 - Triage procedures
- Isolation of infected
 - Contact precautions (gloves, gown, hand hygiene)
 - Eye protection
 - Airborne precautions (N-95 respirator, negative pressure) and environmental cleaning

SARS Control

- Contact tracing and quarantine
 - Track the secondary cases from each case

Surveillance, Response and the International Health Regulations (IHR)

- Last revised 1973
 - Technical guidelines on shipping, aviation
 - Reporting requirements for 3 diseases
 - Yellow fever, plague, cholera
 - No enforcement or compliance powers
- Designed prior to rapid mass travel era

Environmental Factors: Economic Developing and Land Use

- Deforestation/reforestation
- Alterations in natural wetlands
- Flood/drought
- Global warming

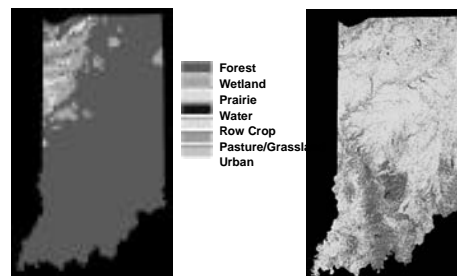
Global Changes That Can Increase Prevalence of Infectious Diseases

- Poverty
- Many children or elderly
- Movement of people, food products, goods
- Poor immunological status
- Increased land development

Global Changes That Can Increase Prevalence of Infectious Diseases

- Dearth of knowledge/access to technology
- Changing social norms
- Deteriorating security

Indiana from ~1820 to ~1990



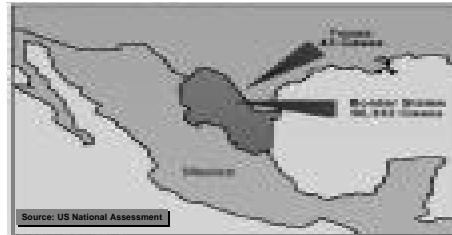
Source: CIPEC and Carnegie-Mellon U.

Vector-Borne Diseases And Global Warming

- Average global air temperature rose 0.45° C over the last century
- Mosquitoes multiply faster and bite more in warmer weather
- Heat speeds reproduction of pathogens
- Warmer temperatures will introduce mosquitoes to new regions
- Mosquitoes will live longer

Reported cases of Dengue 1980-96:

Does Climate Change Abruptly At The Border?



Microbial Adaptation and Change

(e.g., Health Care and Prevention)

- New medical devices
- Organ/tissue transplant
- Immunosuppressant drugs
- Widespread use of antibiotics
- Reductions in prevention programs

Microbial Adaptation and Change

(e.g., Health Care and Prevention)

- Inadequate communicable disease surveillance
- Lack of trained personnel
 - e.g., epidemiologists, laboratory scientists, vector and rodent control specialists

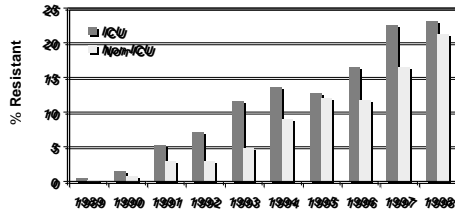
Host/Pathogen Factors

- A new agent could evolve and infect humans
- An agent could adapt from a non-human animal host to humans
- A new group of symptoms could arise from infection with an already established pathogenic agent
- A rare disease may become common
- A mild disease may become severe
- A pathogen may gain resistance to antimicrobial therapy

Antimicrobial Resistance

- Worldwide problem
- Dramatic increase in antimicrobial-resistant community-acquired and nosocomial pathogens
- Major risk factors:
 - Antimicrobial use (misuse)
 - Infection control practices (noncompliance)

Emerging Vancomycin-Resistant Enterococcal Infections*



* in U.S. NNIS Hospitals

Breakdown of Public Health Measures

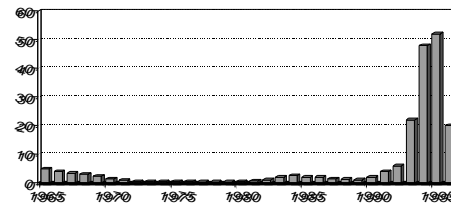
- Decreased emphasis on preventative measures
 - Water purification
 - Sanitation
 - Immunization
 - Vector control

Breakdown of Public Health Measures

- Inadequate disease surveillance and reporting
- Erosion of public health laboratory systems
- Reductions in the budget for infectious diseases, other than AIDS, in the late 20th century

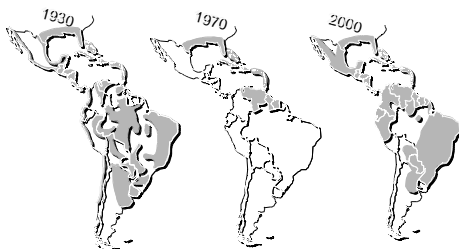
Disruption Of Health Services Can Be Disastrous, Though Recovery Is Feasible

Diphtheria Cases (x1000) in Soviet Union & FSU



Source: WHO and Carnegie-Mellon U.

Aedes aegypti Distribution In The Americas



Substantial dengue and YF risk in the Americas

Bioterrorism In The Context Of EIDs

- Deliberate release of agents is not complex
- Fear of use as instruments for war or terrorism by groups, not necessarily states
- It is certain that bioterrorism events will occur in the United States, but we do not know when, where, and how large



NY Times, October 16, 1999

Syndromes Potentially Resulting From Bioterrorism

- Encephalitis (many agents)
- Hemorrhagic mediastinitis (anthrax)
- Pneumonia with abnormal liver function tests (especially respiratory exposures)
- Papulopustular rash (smallpox)

<http://www.cdc.gov/ncidod/emergplan/slideset/22.htm>

Syndromes Potentially Resulting From Bioterrorism

- Hemorrhagic fever (many agents)
- Descending paralysis (botulism)
- Nausea, vomiting ± diarrhea (especially oral exposures)

<http://www.cdc.gov/ncidod/emergplan/slideset/22.htm>

Bioterrorism Response

- Development of local, regional and national response plans
- Disease surveillance that focuses on early detection and response
- Efficient and effective laboratory capabilities
- Requires coordination between healthcare providers, state and local health agencies and the CDC

Strategies To Reduce The Danger For Future Pandemics

- Surveillance:
Agressive, active, action-oriented
- Public health responses
Quarantine, isolation, universal precautions, vector control, case finding and treatment, vaccination, veterinary partnerships, improved public health infrastructures, environmental/business partnerships, food/water/sanitation safety

Adapted from Dr. J. Hughes, CDC

Strategies To Reduce The Danger For Future Pandemics

- Global political commitments
Governments, non-profit and private partnerships, corporate involvement, emergency response plans

Adapted from Dr. J. Hughes, CDC

Infrastructure and Training Needs

- 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

<http://www.cdc.gov/ncidod/emergplan/slideset/26.htm>

Immediate Challenges Of Priority

- HIV/AIDS, including STDs and TB expansion
- Antimicrobial resistance
- Arboviral diseases (like dengue) and Malaria

Immediate Challenges Of Priority

- Zoonotic diseases, including hantaviruses
 - Urban Yellow Fever in Latin America
 - Pandemic Influenza and other respiratory viruses like the SARS coronavirus

Immediate Challenges Of Priority

- International foodborne/waterborne outbreaks
- Role of microbial agents in chronic diseases
- Bioterrorism and as yet unknown threats

Upcoming Programs

2004 Infection Control and Lab Update
Wednesday, August 11, 2004
2:00-4:00 p.m. (Central Time)

Chemical Agents of Opportunity for Terrorism
Thursday, August 12, 2004
12:00-1:30 p.m. (Central Time)

Upcoming Programs

Radiological Terrorism
Thursday, August 19, 2004
12:00-1:30 p.m. (Central Time)

The Behavioral Health Response to Disasters
Tuesday, August 24, 2004
2:00-4:00 p.m. (Central Time)