A One Health Discipline: the case for integrating science, medicine & public health

Gary L. Simpson, M.D., Ph.D., M.P.H.
Challenges

- Pressing need for enhanced, global, integrated, species-neutral, infectious disease surveillance for outbreak detection, diagnosis and response.
- Notable lack of pathogen genomics infrastructure, including forensic molecular epidemiology resources.
- Slow response to the reality that the vast majority of emerging infectious diseases are of zoonotic origins.
- Investments in preparedness, frequently, have been without routine intrinsic, medical and public health value.
- Major traditional and structural barriers that limit the potential for integrating science, medicine and public health.
Spectrum of Biosecurity Risk

Probability of Outbreak

0%

100%

Vaccine Preventable

Emerging Infectious Diseases

Intentional Release
Major Factors Contributing to Emerging Infections: 1992

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
More Factors Contributing to Emerging Infections: 2003

7. Human vulnerability
8. Climate and weather
9. Changing ecosystems
10. Poverty and social inequality
11. War and famine
12. Lack of political will
13. Intent to harm

Institute of Medicine Report, 2003
Zoonotic Infectious Diseases

- Zoonosis—“Disease or infections which are naturally transmitted between vertebrate animals and humans.” (W.H.O.)
- 60% of the est. 1,451 known infectious diseases of humans can infect both humans and animals.
- 75% of all emerging infectious diseases of the past two decades are zoonotic.
Hantavirus Pulmonary Syndrome
NEW MEXICO

Land of the Flea
Home of the Plague
Index Cluster

May

28 29 30 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28

21 y/o F

19 y/o M

5 mo/o F

27 y/o M

11 mo/o M

25 y/o F

= Admission

= Death
Timeline - Unexplained deaths, 1993

OMI calls. | IHS reports 5 deaths. | CDC, ID, Toxicology Experts consulted | Families interviewed. CO, AZ, UT called. | Physician information letter sent.
---|---|---|---|---
May 14 | May 17 | May 18 | May 19 | May 24

Notification sent to all states. | Family and community contacts interviewed. | CDC Requested; Placitas meeting | CDC team arrives. Clinical conference. | CDC: Hantavirus antibody found in 3 patients
---|---|---|---|---
May 25 | May 26 | May 27 | May 29 | June 4
# Disease Conditions in the Differential Diagnosis

<table>
<thead>
<tr>
<th>Bacterial</th>
<th>Viral</th>
<th>Environmental</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plague</td>
<td>Influenza</td>
<td>Paraquat</td>
</tr>
<tr>
<td>Tularemia</td>
<td>Adenovirus</td>
<td>Phosphene</td>
</tr>
<tr>
<td>Anthrax</td>
<td>Parvovirus</td>
<td>Phosgene</td>
</tr>
<tr>
<td>Legionella</td>
<td>Coxsackie</td>
<td>DNP</td>
</tr>
<tr>
<td>Leptospirosis</td>
<td>RSV</td>
<td>Metal fume fever</td>
</tr>
<tr>
<td>Chlamydia</td>
<td>Hemorrhagic Fevers</td>
<td>Toxic Oil Synd.</td>
</tr>
<tr>
<td>Mycoplasma</td>
<td></td>
<td>Polymer fume fever</td>
</tr>
<tr>
<td>Brucella</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ehrlichiosis</td>
<td>Fungal</td>
<td>New Agent</td>
</tr>
<tr>
<td>Q fever</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rickettsia</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Molecular Epidemiologic Linkages
PCR analysis demonstrated:

- Infecting agent was a hantavirus.
- Infecting agent was newly recognized.
- RNA sequences from tissues from different patients were homologous.
- RNA sequences from deer mouse tissues were homologous to those found in patients.
<table>
<thead>
<tr>
<th>Case</th>
<th>Rodent</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 A</td>
<td>Snowflake</td>
<td>AZ</td>
</tr>
<tr>
<td>2</td>
<td>1(A)</td>
<td>Hesperus</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>Grand Junction</td>
</tr>
<tr>
<td>4 B</td>
<td>Cortez</td>
<td></td>
</tr>
<tr>
<td>5 C</td>
<td>3</td>
<td>Grand Junction</td>
</tr>
<tr>
<td>6</td>
<td>Sedan</td>
<td></td>
</tr>
<tr>
<td>7 D</td>
<td>Farmington</td>
<td></td>
</tr>
<tr>
<td>8 E</td>
<td>Pinehill</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>4(H)</td>
<td>Springerville</td>
</tr>
<tr>
<td>10</td>
<td>5</td>
<td>Springerville</td>
</tr>
<tr>
<td>11</td>
<td>6</td>
<td>Alpine Ranchero</td>
</tr>
<tr>
<td>12 F</td>
<td>7</td>
<td>Black Mesa</td>
</tr>
<tr>
<td>13</td>
<td>Pinehill</td>
<td></td>
</tr>
<tr>
<td>14 G</td>
<td>8(G)</td>
<td>Pinehill</td>
</tr>
<tr>
<td>15</td>
<td>9(G)</td>
<td>Pinehill</td>
</tr>
<tr>
<td>16</td>
<td>10(G)</td>
<td>Pinehill</td>
</tr>
<tr>
<td>17</td>
<td>Pinehill</td>
<td></td>
</tr>
<tr>
<td>18 H</td>
<td>11(H)</td>
<td>Pinehill</td>
</tr>
<tr>
<td>19</td>
<td>12(H)</td>
<td>Pinehill</td>
</tr>
<tr>
<td>20</td>
<td>13(G)</td>
<td>Pinehill</td>
</tr>
<tr>
<td>21</td>
<td>Black Mesa</td>
<td></td>
</tr>
<tr>
<td>22 I</td>
<td>14</td>
<td>Casamero Lake</td>
</tr>
<tr>
<td>23 J</td>
<td></td>
<td>Black Mesa</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
“I hope we never lose sight of one fact, that this was all started by a mouse.”

Walt Disney
New World Hantaviruses

Sin Nombre
Peromyscus maniculatus

Muleshoe
Sigmodon hispidus

Isla Vista
Microtus californicus

El Moro Canyon
Reithrodontomys megalotis

Calabazo
Zygodontomys brevicauda

Choclo
Oligoryzomys fulvescens

Caño Delgadito
Sigmodon alstoni

Rio Mamore
Oligoryzomys microtis

Orán
Oligoryzomys longicaudatus

Bermejo
Oligoryzomys chacoensis

Andes
Oligoryzomys longicaudatus

New York
Peromyscus leucopus

Prospect Hill
Microtus pennsylvanicus

Bloodland Lake
Microtus ochrogaster

Bayou
Oryzomys palustris

Black Creek Canal
Sigmodon hispidus

Rio Segundo
Reithrodontomys mexicanus

Juquitiba
Unknown Host

Laguna Negra
Calomys laucha

Maciel
Necromys benefactus

Hu39694
Unknown Host

Lechiguanas
Oligoryzomys flavescens

Pergamino
Akodon azarae
New Mexico State Reschedules Navajo Programs

Concert postponed

Desert Mystery

Doctors Almost Cancel Convention

‘Damage Control’ Quashes Illness Rumors

CDC: ‘Not Navajo disease’

School visit canceled over fears of mystery illness

Navajos call for investigation of discrimination
Secret CIA files reveal...

GERM WARFARE TEST ACCIDENT KILLED NAVAJO INDIANS

THE MYSTERY disease ravaging Indians in the Southwest was triggered by a vicious germ warfare virus captured from Iraq during the Gulf War — and unleashed by the CIA!

An EXAMINER probe has exposed shocking evidence that the Central Intelligence Agency secretly spread the virus through Indian reservations to test its potency and set the stage for the development of a vaccine against it.

In a world-exclusive interview, a CIA source reveals: “The never-divulged
EDITORIAL

By Charles L. Ortleb

Dr. Gary Simpson: Successful Medical Sleuth, or Incompetent Pompous Ass?
Enhanced Surveillance
Surveillance

...the ongoing, systematic collection, analysis, interpretation, and dissemination of data regarding a health-related event for use in public health action to reduce morbidity and mortality and to improve health.

*MMWR 50(RR-13), July 27, 2001*
Surveillance

- Passive suspect case report system
- Enhanced passive reporting
- Active case finding
- Laboratory reports
- Data mining
- Syndromic surveillance
Sentinel Surveillance

Monitoring of key health events through sentinel:

- Sites
- Events
- Providers
- Vectors & animals
New Mexico
Office of the Medical Investigator

- Comprehensive autopsy report & computerized database
- Retrospective analyses/prospective coding for epidemiology & research
- Organization: statewide population-based surveillance
- UNM tie: consultation/collaboration, enhanced diagnostic accuracy, research
New Mexico
Office of the Medical Investigator

- Investigates 4800 of 12400 deaths/year
- 1850 autopsies/year (>95% of NM autopsies)
- Sentinel groups*:
  - Children less than 2 years (7%)
  - Alcoholics (>7%)
  - IVDA’S (>5%)
  - AIDS patients (1.3%)

Medical Examiner
Infectious Disease Deaths

- Infections 25% of natural disease autopsies*
- Pneumonia, meningitis, upper airway, encephalitis, myocarditis, necrotizing fasciitis, endocarditis, pyelonephritis, AIDS, sepsis

*Nolte KB, et. al., Arch Pathol Lab Med 1996;1120:125-128
Infectious Disease
Death Review Team

- Monthly examine autopsies with demonstrated or suspected infections
- Members: ID, forensic & clinical pathology, microbiology, epidemiology, public health
- Identify notable pathogens, unusual clinical or pathologic syndromes, epidemiologic settings
- Monitor sentinel populations
“Severe Fever and Thrombocytopenia Syndrome”
The most valuable surveillance tool will always be the astute clinician.
Acute Undifferentiated Febrile Illness
(“Flu-like” illness or nonspecific viral syndrome)

- Characterized by sudden onset of fever and headache, and

- Associated with generalized constitutional symptoms of:
  - myalgia
  - malaise
  - weakness
  - lethargy
  - anorexia
I TOLD YOU I WAS SICK
B. P. ROBERTS
MAY 17, 1929
JUNE 18, 1979
## Differential diagnosis of fever and thrombocytopenia in the Southwest

- Hantavirus pulmonary syndrome
- Bacterial sepsis
- Borreliosis (relapsing fever)
- Strep./Staph. toxic shock syndromes

- Acute/chronic alcoholism
- Drug reaction
- ITP
- TTP/HUS

- Plague
- Tularemia
- Spotted fever-like illness
- Parvovirus B19
- Primary HIV infection
- Acute bacterial endocarditis
- Colorado tick fever

- DIC
- Pancreatitis
- Rheumatic fever
- Lupus
- Hematologic malignancy
Diagnoses of 180 cases of **Undifferentiated Febrile Illness** & thrombocytopenia over a 6 year period: Diagnosis made 1 day to 3 weeks after referral.

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hantavirus pulmonary syndrome</td>
<td>17</td>
</tr>
<tr>
<td>Bacterial sepsis</td>
<td>10</td>
</tr>
<tr>
<td>Acute HIV-1 infection</td>
<td>3</td>
</tr>
<tr>
<td>Q fever</td>
<td>2</td>
</tr>
<tr>
<td>Plague</td>
<td>3</td>
</tr>
<tr>
<td>Tularemia</td>
<td>2</td>
</tr>
<tr>
<td>Acute rheumatic fever</td>
<td>2</td>
</tr>
<tr>
<td>Colorado tick fever</td>
<td>1</td>
</tr>
<tr>
<td>Borreliosis</td>
<td>5</td>
</tr>
<tr>
<td>Bartonella species</td>
<td>5</td>
</tr>
<tr>
<td>Parvovirus B19</td>
<td>5</td>
</tr>
<tr>
<td>Novel arenavirus</td>
<td>5</td>
</tr>
<tr>
<td>Typhus-like fever (RMSF serol.)</td>
<td>5</td>
</tr>
<tr>
<td>Undiagnosed = cryptic UFI</td>
<td>115</td>
</tr>
</tbody>
</table>

Undiagnosed = cryptic UFI (115)
Public Health Applications of Genomics

Microbial genomics will become routine

- Pathogen toolkit and pathogenesis
- Origin
- Fingerprinting and tracking spread
- Molecular diagnosis
- Rationally designed vaccines and drugs
- Targeted public health interventions
Specimen Archiving and Infectious Disease Modeling
Integrated Archives
MSB

PREVENTION

PREDICTION

TRAINING

COLLECTIONS
- Traditional Specimens
- Frozen Tissues
- Information

ECOLOGY
- Ecosystem Dynamics
- Community Processes
- Host-Pathogen Behavior

SYSTEMATICS
- Phylogeny, Taxonomy
- Genealogical & Genetic Diversity
- Ecological Diversity
- Biogeography, Phylogeography
- Prediction

Biodiversity
- BASELINES
  - Survey, Inventory, Monitoring
  - Voucher Specimens
  - Historical Information

IDENTIFICATION
- Morphology
- Molecular Markers
- Genomics

INFORMATICS
- Genomics
- GIS
- MetaData

PUBLIC HEALTH
- CONTROL & MANAGEMENT
  - Identification
  - Prevention & Exclusion
  - BioControl & Interactive Processes
Reservoir studies \rightarrow Predictive model

Remote Sensors \leftarrow Weather

Vegetation

Rodent Populations

Human Disease

Surveillance and Prediction of Microparasites
NINO3.4 SST Anomalies
Jan 1950 to Apr 2009
Why? Significant questions are centered on our ability to assess change.

- Climate change
- Habitat conversion
- Pollutants
- Emerging pathogens & diseases
- Introduction of exotics
- Loss of biotic diversity
Zuni Hantavirus Study Site
Peromyscus maniculatus
One World, One Health, One Medicine

“To win the diseases battles of the 21st Century while ensuring the biological integrity of the Earth for future generations require interdisciplinary and cross-sectional approaches to disease prevention, surveillance, monitoring, control and mitigation, as well as to environmental conservation more broadly”
Key Points

• The current global milieu (population size, density, mobility, location, vulnerability) favors the emergence of infectious disease.

• Wildlife, domestic animals and humans are dynamic, and their environments are complex and global.

• The implications of emerging infectious diseases are unprecedented and unpredictable.

• Our (the world’s) response must be coordinated, integrated, interdisciplinary, multiorganizational, which in turn, requires pre-existing collaborative, productive, trusting relationships.

• If you live, work or play on the planet, you have a stake in this issue.
Curricular Implications

- Worldview
- Skill sets
  - leadership
  - team dynamics & facilitation
  - systems thinking
  - change/advocacy
  - creativity and innovation
Curricular Implications (cont’d)

• Self-awareness
  VUCAD
  complexity science
  non-linear systems
  leadership in emergent, self-organization
Final Thoughts
“I wake up every morning determined to both change the world and have one hell of a good time. Sometimes this makes planning the day a little difficult.”

E.B. White
One World – One Health – One Medicine
One World – One Health – One Medicine

One Love
Acknowledgments:

• Mary Wilson, M.D., Harvard Medical School
• Lonnie King D.V.M., Centers for Disease Control
• Sandra Cointreau, The World Bank
• Duc Vulgia, M.D., California Dept. of Health Services
• Robert Burnham, M.D., BCCDC
• Laura Kahn, M.D., Princeton

Links:

www.cdc.gov
www.oneworldonehealth.org
www.who.int
www.wcs.org
www.onehealthinitiative.com