Lesson 10: Vector Control

Zoonotic Diseases

February 3, 2005

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Lesson Overview

- Definitions
- The Problem
- Causal Factors
- Control Measures

Definitions

- Pest: Serious or fatal disease (archaic)
- Pestilence: Any, usually fatal, epidemic disease
- Zoonotic Disease: Diseases transmitted from vertebrate animals to humans through various routes
  - Pets
  - Livestock
  - Wildlife
Definitions Continued

- **Vector:**
  - An arthropod which carries a pathogen to a new host
  - Any organism which helps a pathogen reach a new host
  - An animate vehicle
- **Vectorborne Disease:** Diseases transmitted by a vector

Emerging Diseases

Zoonotic Disease Transmission

- **Direct Contact**
- **Transmission by Vectors**
Zoonotic Diseases

Table 3.2 Number of Diseases that Human Populations Share with Domesticated Animals

<table>
<thead>
<tr>
<th>Animal</th>
<th>Diseases Shared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poultry</td>
<td>26</td>
</tr>
<tr>
<td>Rodents</td>
<td>32</td>
</tr>
<tr>
<td>Horse</td>
<td>35</td>
</tr>
<tr>
<td>Pig</td>
<td>42</td>
</tr>
<tr>
<td>Sheep/Goats</td>
<td>46</td>
</tr>
<tr>
<td>Cattle</td>
<td>50</td>
</tr>
<tr>
<td>Dog</td>
<td>65</td>
</tr>
</tbody>
</table>

Source: McNeil WH. *Plagues and People*, 1977

Direct Animal Contact

- Disease agent found in saliva, blood, other body tissues
- Bites, scratches
- Contact with animal tissues or fluids (open cuts or on mucous membranes)
  - livestock - veterinarians, farmers
  - wildlife - handling dead or ill animals, field specimen collections

Direct Animal Contact

- Anthrax - Handling sheep, other animals
- Plague - trappers skinning animals, blood or tissue contact, also flea bites
- Brucellosis - livestock tissue contact
- Ringworm - fungal infection (young kittens, puppies)
- Rabies - bites, scratches (virus found in saliva, salivary glands, nerve tissue only)
- Rat bite fever - (Streptococcal bacterial infection)
- Tularemia - rabbits, hares, rodents (also transmitted via other routes)
Lesson 10: Zoonotic Diseases

For Example

- 900 Salmonella cases reported annually in Washington
  - Difficult to identify source of exposure for every case
    - Most probably are foodborne
    - Unknown percentage due to animal contact
    - Some waterborne, some person-to person
    - Need good thorough investigations
  - Consider animal exposure

Salmonella Sources

- High percentage of reptiles (snakes, lizards, turtles) naturally carry Salmonella without signs of illness
- Serious cases in infants, immunocompromised, elderly
- Any animal food product may harbor Salmonella
- Outbreaks: Denver Zoo, Oregon infant cases, petting zoos

Transmission by Vectors

- Ticks, mosquitoes, fleas, flies acquire disease agent from animal reservoir and transmit it to another host
- Natural host is not affected by the agent
- Accidental host may be severely ill or die
- Washington - low incidence of reported vector-borne diseases
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The Vector Problem

- Nuisance
- Property damage
  - Crops
  - Structures
  - Goods
- Human disease

Each year . . .
- American consumers spend $600,000,000 on pest control
- 60% is spent in the residential market
- $2.9 Billion is spent on professional pest control

Economic Impact

Each year . . .
- 1/3 of the world’s crops are destroyed during growth, harvesting and storage
- 25% of home gardener’s crops destroyed
- $20 Billion in crop loss/damage
- Residential damage = ???
Important Zoonotic & Vectorborne Diseases

- Arboviral Encephalitides
- Dengue
- Hantavirus
- Lyme Disease
- Malaria
- Plague
- Rabies
- RMSF
- Tularemia
- Typhus (Epidemic)
- Typhus (Murine)
- Yellow Fever

On the web...

Vectorborne Disease

United States, 1983 - 1987

- Arboviral Encephalitis
- Colorado Tick Fever
- Fleaborne Diseases
- Lyme Disease
- Rocky Mt. Spotted Fever
- Tularemia
Generalized Vector Cycle

Vectorborne Disease Ecology

- The agent becomes established in an animal population
- The animal population comes into contact with man
  - (one or the other, or both, move)
- The vector must be able to transmit the agent to humans

Disease Ecology Continued

- Epizootic conditions prevail
  - Sufficient numbers of infective vectors
- Appropriate climatic conditions exist
  - Temperature range
  - Humidity
  - Rainfall
- Confluence of all of these factors is necessary
Important Vectors

- Arthropods
  - Mosquitoes
  - Other flies
  - Fleas
  - Ticks
  - Lice
  - Mites

- Other Animals
  - Rats
  - Mice
  - Bats
  - Birds

Transmission

- Mechanical
- Biological

Tickborne Diseases

- Lyme disease
- Relapsing fever
- Tularemia
- Ehrlichiosis
- Babesiosis
- Rocky Mountain Spotted fever
- Tick paralysis (intoxication)
Rocky Mountain Spotted Fever

Mosquitoborne Diseases

- Western equine encephalitis virus
- St. Louis encephalitis virus
- Both have occurred in Washington but no reported cases since early 1980's
- West Nile virus
  - detected in 1999 in New York City
  - human and horse deaths, dead birds
  - progressing to other states in 2000
  - Planned surveillance effort in Washington

Malaria
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Malaria

FIGURE 1. Number of endemic cases, by state in which the disease was diagnosed — United States, 2001

Malaria Incidence in Washington

Diseases Transmitted by Flies

- Tularemia - deer fly bites
- Mechanical transmission of enteric bacteria (Salmonella, Shigella, Campylobacter)
Fleaborne Diseases

- Bartonellosis - formerly cat scratch fever
- Tapeworms
- Plague - (1984) one human case in Washington

Plague

- Early 1330s: an outbreak of bubonic plague occurred in China
- Spread to western Asia and Europe
- Sicily, October of 1347

- 1348: spread as far north as England
- 25 million people died in 5 years
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Plague

- Estimated population of Europe from 1000 to 1352:
  - 1000 ~ 38 million
  - 1100 ~ 48 million
  - 1200 ~ 59 million
  - 1300 ~ 70 million
  - 1347 ~ 75 million
  - 1352 ~ 50 million

London, 1665-1666

- Disappeared after 1352
- Until the mid-17th century

Plague in the U.S.
So What?

Historically interesting
But things are different today, right?

Plague: Distribution

Countries reporting plague: 1970 - 1995
Probable foci

Plague in the U.S.

Reported human plague cases by county
Plague: Incidence

Number of Human Plague Cases
United States, 1970 - 1995

No. of Cases

Plague Incidence

Plague

- **Agent:** *Yersinina pestis* (bacterium)
- **Vector:** *Xenopsylla cheopis*
  (Oriental Rat Flea)
- **Reservoir:** *Rattus Norvegicus* and *Rattus rattus*
  (Norway and Roof Rats)
- **Onset:** 2 - 6 days after being bitten
- **Disease:** Bubonic, Pneumonic & Septicemic
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Bubonic Plague
- High Fever
- Toxemia
- Petechiae
- Shock
- Buboes

Plague: Agent

Plague: Transmission
Plague: Vectors

Oriental Rat Flea

Male Kissing Bug
(oriental rat flea) engorged with blood.

Plague: Vectors - Continued

Flea engorged with blood on human arm.

Plague: Vectors - Continued

Life cycle of the flea
Reservoir

Urban

Rural

Protecting the Public’s Health

- Surveillance
- Personal Protection and Education
- Vector Control

Causal Factors

- A “good” vector must:
  - Be able to harbor the agent
  - Be able to spread the agent
  - Be mobile
  - Survive long enough to:
    - Reproduce
    - Disseminate the agent
  - Have wide zonal tolerances
Zoonotic Disease Program

- Education/technical assistance prevention information
- Case investigation (human and animal)
- Surveillance
  - Human and animal cases
  - Animal reservoir, arthropod vectors

Personal Protection

- Wear long sleeves & pants in mosquito-infested areas
- Use repellent containing DEET (N,N-diethyl-3-methylbenzamide) and follow directions carefully
- Limit outdoor activities at dawn and early evening
- Repair holes in door & window screens

Control

- Usually involves controlling the vector
  - Habitat reduction / modification
  - Sanitation
  - Larvaciding
  - Adulticiding
  - Integrated Pest Management (IPM)
To Control Vectors

- Deny them:
  - Water
  - Food
  - Harborage
  - Warmth

Surveillance

- What does it mean?
  - Human and animal cases
    - who, when, where, how
  - Prevalence studies
    - reservoir animals
    - arthropods (ticks, mosquitoes)
  - Population monitoring
  - Species distribution

For Example

- WNV Surveillance:
  - Dead birds
    - Especially crows, jays, magpies
  - Mosquitoes
  - Captive sentinels (e.g. chickens)
  - Veterinary surveillance
  - Human surveillance
**Estimated Sensitivity of WNV Surveillance Methods**

- Human cases
- Veterinary cases
- Mosquitoes
- Dead birds
- Sentinel hosts
- Estimated Sensitivity of WNV Surveillance Methods

**EVS Mosquito Traps**

- Packed with dry ice in preparation for trapping.

**EVS Mosquito Traps**

- Setting the trap in proper location.
### EVS Mosquito Traps

In operation.

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### WNV Mosquitoes in Washington

<table>
<thead>
<tr>
<th>Mosquito species</th>
<th>Counties (39)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aedes cinereus</td>
<td>29</td>
</tr>
<tr>
<td>Aedes vexans</td>
<td>27</td>
</tr>
<tr>
<td>Culex pipiens</td>
<td>28</td>
</tr>
<tr>
<td>Culex restuans</td>
<td>1</td>
</tr>
<tr>
<td>Culex tarsalis</td>
<td>35</td>
</tr>
<tr>
<td>Anopheles punctipennis</td>
<td>26</td>
</tr>
<tr>
<td>Coquilletidia perturbans</td>
<td>10</td>
</tr>
<tr>
<td>Ochlerotatus canadensis</td>
<td>5</td>
</tr>
<tr>
<td>Ochlerotatus japonicus</td>
<td>1</td>
</tr>
</tbody>
</table>

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### Tick Surveillance

Tick dragging for ticks.
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Rodent Surveillance

Control Measures

- Appropriate for pest
- Acceptable to community
- IPM approach
- Good records

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Control Measures Continued

- **Arthropods**
  - Sanitation
  - Environmental modifications
  - Pesticides
    - Larvicides
    - Adulticides
  - Repellants

Control Measures Continued

- **Rodents**
  - Sanitation
  - Environmental modifications
    - Rodent proofing
  - Trapping
  - Rodenticides

Integrated Pest Management (IPM)

- Physical Control
- Mechanical Control
- Biological Control
- Chemical Control
**IPM**

- **Physical Control**
  - Sanitation
  - Environmental modification
- **Mechanical Control**
  - Trapping

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**Habitat Reduction**

- Eliminate standing water (flower pots; tires; wheelbarrows; wading pools)
- Change the water in birdbaths at least weekly
- Aerate and chlorinate swimming pools and hot tubs; cover if possible
- Consider mosquito-eating fish for your pond
- Keep gutters clean to prevent standing water
- Spread the word: educate your friends and neighbors

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**IPM Continued**

- **Biological Control**
  - Use resistant species
  - Natural enemies
  - Sterile males
  - Biological insecticides
    - Insect pheromone
    - Bacteria
IPM Continued

- Chemical Control
  - By Application
    - Larvacides
    - Adulticides
  - By Mode of Action
    - Stomach poisons
    - Contact poisons

IPM Continued

- Chemical Control Continued
  - By Chemistry
    - Inorganics
    - Organochlorine compounds
    - Organophosphate compounds
    - Carbamate compounds
    - Pyrethrins & Pyrethroids

Cooperation / Coordination

- Federal
- State
- Local
- Private sector (PCOs)
Questions

Summary

- Historically vectorborne diseases have been a major threat
- Well controlled in industrialized world since WW/II
- Remains a problem in developing world
- Emerging problem for the entire world

Resources

- Web Resources:
  - [http://www.cdc.gov/ncidod/dvbid/index.htm](http://www.cdc.gov/ncidod/dvbid/index.htm)
  - Dengue Fever
  - Lyme Disease
  - Plagues
  - Arboviral Encephalitides
  - West Nile Virus
  - Japanese Encephalitis
  - Yellow Fever
  - Tularemia
  - [www.doh.wa.gov/WNV](http://www.doh.wa.gov/WNV)
WNV Background

- First isolated from the West Nile District of Uganda, 1937
- Recognized as a cause of inflammation of the spinal cord and brain with outbreak in elderly patients, Israel, 1957
- Equine disease noted in Egypt and France in the early 1960s
- 1999 “Old World” virus arrives in the “New World”
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WNV Outbreaks

- France - 1962, 2000
- South Africa - 1974
- Romania - 1996
- Italy 1997
- Russia - 1999
- United States - 1999-2003

Timeline

- Uganda 1937
- Israel 1951-54
- France 1962
- South Africa 1974
- Romania 1996
- Italy 1997
- Russia 1999
- US 1999-2003
- Israel 2000-2002
- France 2000

Transmission Cycle

- Mosquito vector
- Bird reservoir hosts
- Incidental infections
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Related Viruses

- The Japanese Encephalitis Serocomplex of the Family Flaviviridae, 1999

WNV in the U.S.

- Some Speculated Pathways of Introduction
  - Human-transported bird
    - Illegal (Black market “exotics”)
    - Legal (zoos & legitimate breeders)
  - Human-transported mosquitoes
  - Storm-transported bird
  - Intentional introduction (terrorist event)
    - not likely
  - Infected human traveler
    - not likely

The Disease

- Symptoms:
  - High Fever
  - Headache and body aches
  - Skin rash
  - Swollen lymph glands
  - Neck stiffness
  - Disorientation
  - Convulsions

- Incubation period:
  - Generally 3-14 days
    (following a bite from an infected female mosquito)
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ENV H 311: Intro. to Environmental Health

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Cumulative Distribution of WNV in the United States

Before 1999

States with WNV (0)

Cumulative Distribution of WNV in the United States

November 1999

States with WNV (4)

Cumulative Distribution of WNV in the United States

November 2000

States with WNV (12) + DC
2003 WNV Activity

As of October 17, 2003

<table>
<thead>
<tr>
<th>Year</th>
<th>Humans (deaths)</th>
<th>Horses (deaths)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003*</td>
<td>7,021 (152)</td>
<td>2,912</td>
</tr>
<tr>
<td>2002</td>
<td>4,156 (284)</td>
<td>14,717 (~5,150)</td>
</tr>
<tr>
<td>2001</td>
<td>66 (9)</td>
<td>733 (156/470)</td>
</tr>
<tr>
<td>2000</td>
<td>21 (2)</td>
<td>60 (23)</td>
</tr>
<tr>
<td>1999</td>
<td>62 (7)</td>
<td>25 (8)</td>
</tr>
</tbody>
</table>

* As of October 17, 2003

Case Summary

Demographics & Mortality
United States, 1999-2002

<table>
<thead>
<tr>
<th></th>
<th>1999-2000</th>
<th>2001</th>
<th>2002</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Cases</td>
<td>83</td>
<td>66</td>
<td>2,661</td>
</tr>
<tr>
<td>Median Age</td>
<td>65</td>
<td>68</td>
<td>55</td>
</tr>
<tr>
<td>Age Range (in years)</td>
<td>5 - 90</td>
<td>19 - 90</td>
<td>1 mo. - 99</td>
</tr>
<tr>
<td>Males</td>
<td>54%</td>
<td>65%</td>
<td>54%</td>
</tr>
<tr>
<td>Fatality Rate</td>
<td>11%</td>
<td>14%</td>
<td>9%</td>
</tr>
<tr>
<td>Mean Fatality Age</td>
<td>78 (24-99)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Date of Symptom Onset
West Nile Virus — United States, 1999-2001

Number of cases

Week ending

Number of cases: 2001, 2000, 1999

Week ending:

- September 2002

Mosquito-borne Disease Response Plan
Washington State

- Instruction, training, and education to prevent disease
- Public education
- Monitoring and surveillance

Washington’s Response

- Statewide mosquito-borne disease response plan
  - Guidance for state/local agencies and organizations
  - Response protocols for disease-related events
  - Tiered response based on severity
  - Recommendations on public information and education, surveillance and control
- Re-establish, develop new partnerships
- Conduce ongoing training

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