Endemic diseases and outbreaks in Wisconsin

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Maps & Figures: CDC, USGS, WI DHS
Disease causing organisms

Helminth: Head (scolex) of Taenia solium

Virus: Herpes simplex
A single virus particle

Protozoan: Vorticella

Bacterium: E. coli

Fungus: Syncephalastrum

Fungus: Syncephalastrum

Bacterium: E. coli

Protozoan: Vorticella

Red blood cell

20 microns

Helminth is visible to the naked eye.

200 nm

Fungus: Syncephalastrum

Virus: Herpes simplex

A single virus particle

Bacterium: E. coli

Fungus: Syncephalastrum

Virus: Herpes simplex

A single virus particle

Bacterium: E. coli

Fungus: Syncephalastrum

Helminth is visible to the naked eye.
## Differences

<table>
<thead>
<tr>
<th>Eukaryotes</th>
<th>Prokaryotes</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Fungus, Protozoans, Worms</td>
<td>• Bacteria</td>
</tr>
<tr>
<td>• Have nucleus and organelles</td>
<td>• No nucleus or organelles</td>
</tr>
<tr>
<td>• Made of single and multiple cells</td>
<td>• Made of single cells</td>
</tr>
</tbody>
</table>

### Viruses

- Not cellular
- Not ‘alive’
- Made of protein and nucleic acid

Need to know physical differences to understand and treat infectious organisms
Size Comparison of Microbes

- **E. coli** (Bacterial cell) 2 μm long
- **Streptococcus** (Bacterial cell) 1 μm
- **Rickettsia** (Bacterial cell) 0.3 μm
- **Mimivirus** 450 nm
- **Herpes simplex virus** 150 nm
- **Rabies virus** 125 nm
- **HIV** 110 nm
- **Influenza virus** 100 nm
- **Adenovirus** 75 nm
- **T2 bacteriophage** 65 nm
- **Polio virus** 30 nm
- **Yellow fever virus** 22 nm
- **Hemoglobin molecule** (protein molecule) 15 nm

Yeast cell - 7 μm
What we are covering today

• Endemic diseases
  – Lyme disease-bacterial
  – West Nile virus-viral
  – Blastomycosis-fungal
  – MRSA-bacterial
  – CWD-prion
Borrelia burgdorferi

- Causes Lyme Disease
  - Named after towns in Connecticut: Lyme and Old Lyme (1975)
  - Some thought it was arthritis
  - High risk in Wisconsin!
  - Spread by ticks
Confirmed Cases of Lyme Disease (*B. burgdorferi*) per 100,000 Wisconsin Residents, 2018

Lyme disease cases occur in every Wisconsin county.

Number of Confirmed Cases per 100,000

- 0-24
- 25-49
- 50-100
- >100

Data Source: Wisconsin Department of Health Services
Lyme Disease (B. burgdorferi) Cases in Wisconsin

There were 3,105 Lyme disease cases reported in 2018.

Data Source: Wisconsin Department of Health Services
First Year

1. Newly hatched tick larvae become infected when they feed on small animals such as mice, which harbor the spirochete. The larvae continue development through this year.

Second Year

Eggs hatch

2. In the second year the larvae molt into the nymph, an aggressive feeding stage.

3. The nymph takes blood from a number of hosts, including deer and humans.

4. On deer, the nymphs mature into adult male and female ticks, which mate. The female lays eggs in plant litter, where they hatch and once again begin the cycle.
Stages of Lyme Disease

• A bull’s-eye rash begins at the site of the tick bite with fever, aches and pains and flu-like symptoms.
• If untreated it can spread to skin, heart, nervous system and joints.
• Late stage develops chronic arthritis and swelling in the joints.
• Treatable by antibiotics in early stages.

Two-Tiered Testing for Lyme Disease

First Test
- Enzyme Immunoassay (EIA)
  OR
- Immunofluorescence Assay (IFA)

Second Test
- IgM and IgG Western Blot
- IgG Western Blot ONLY

If patient with signs/symptoms consistent with Lyme disease for ≤ 30 days, consider obtaining a convalescent serum.
LYME DISEASE
Relative frequency of clinical features among confirmed cases - United States, 2008-2018

- Meningitis or Encephalitis: 2%
- Erythema Migrans (EM) Rash: 70%
- Radiculoneuropathy: 4%
- Facial Palsy: 9%
- Carditis: 1%
- Arthritis: 29%
Average Confirmed Lyme Disease (*B. burgdorferi*) Cases by Age Group (2014–2018)

Lyme disease cases are most common in Wisconsinites aged 5-14 years and 50-69 years.

Data Source: Wisconsin Department of Health Services
Other tickborne disease

- Anaplasmosis and Ehrlichiosis
- Powassan (POWV) Virus Infection
- Babesiosis
Acute Encephalitis

• **Encephalitis**: inflammation of the brain
  - always a serious condition; tissues of the brain are sensitive to damage by inflammatory processes

• **Acute encephalitis**
  - almost always caused by viruses borne by insects (arboviruses)
    - West Nile virus
    - herpesvirus
  - bacteria can cause encephalitis, but symptoms are more pronounced in the meninges
Arthropod-Borne Viruses (Arboviruses) (cont’d)

Signs and Symptoms

• Extremely variable and include coma, convulsions, paralysis, tremor, loss of coordination, memory deficits, changes in speech and personality, and heart disorders
  - in some cases, survivors experience some degree of permanent brain damage
  - young children and the elderly are most sensitive to injury by arboviral encephalitis
West Nile

• Many infected people remain asymptomatic, or are ill for a few days.
  – Rarely, the patient will develop encephalitis or meningitis.
  • This can result in permanent neurologic effects or death.

• There is no vaccine or specific treatment for West Nile fever.
Select Arboviruses

- West Nile fever is an emerging disease in the Western hemisphere.
  - It can infect birds, mosquitoes, humans, and some other mammals.
  - Humans generally contract it through mosquito bites.
EEE  Eastern equine encephalitis
LAC  Japanese encephalitis
SLE  St. Louis encephalitis
TBE  Tick-borne (Powassan) virus disease
WN   Western equine encephalitis
WEE  West Nile virus disease
VEE  Murray Valley encephalitis
MVE  Venezuelan equine encephalitis
Figure 1. Reported incidence of neuroinvasive West Nile virus disease by county, United States, 1999–2004. Reported to Centers for Disease Control and Prevention by states through April 21, 2005.
Average annual incidence of West Nile virus neuroinvasive disease reported to CDC by state, 1999-2019
West Nile Virus Cases in Wisconsin

Data Source: Wisconsin Department of Health Services
Average West Nile Virus Cases by Age Group (2014-2018)

Data Source: Wisconsin Department of Health Services
West Nile virus disease cases reported to CDC by week of illness onset, 1999-2015

Source: ArboNET, Arboviral Diseases Branch, Centers for Disease Control and Prevention
Other mosquito disease in Wisconsin
Mosquito Bite Prevention (United States)

Not all mosquitoes are the same. Different mosquitoes spread different viruses and bite at different times of the day.

<table>
<thead>
<tr>
<th>Type of Mosquito</th>
<th>Viruses spread</th>
<th>Biting habits</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Aedes aegypti</em>,</td>
<td>Chikungunya,</td>
<td>Primarily daytime, but can also</td>
</tr>
<tr>
<td><em>Aedes albopictus</em></td>
<td>Dengue, Zika</td>
<td>bite at night</td>
</tr>
<tr>
<td><em>Culex species</em></td>
<td>West Nile</td>
<td>Evening to morning</td>
</tr>
</tbody>
</table>

Protect yourself and your family from mosquito bites

Use insect repellent

Use an Environmental Protection Agency (EPA)-registered insect repellent with one of the following active ingredients. When used as directed, EPA-registered insect repellents are proven safe and effective, even for pregnant and breastfeeding women.

<table>
<thead>
<tr>
<th>Active ingredient</th>
<th>Higher percentages of active ingredient provide longer protection</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEET</td>
<td></td>
</tr>
<tr>
<td>Picaridin (known as KBR 3023 and icaridin outside the US)</td>
<td></td>
</tr>
<tr>
<td>IR3535</td>
<td></td>
</tr>
<tr>
<td>Oil of lemon eucalyptus (OLE) or para-menthane-diol (PMD)</td>
<td></td>
</tr>
<tr>
<td>2-undecanone</td>
<td></td>
</tr>
</tbody>
</table>

Find the insect repellent that's right for you by using EPA's search tool*

*The EPA's search tool is available at: www.epa.gov/insect-repellents/find-insect-repellent-right-you
Protect yourself and your family from mosquito bites (continued)

- Always follow the product label instructions.
- Reapply insect repellent every few hours, depending on which product and strength you choose.
  - Do not spray repellent on the skin under clothing.
  - If you are also using sunscreen, apply sunscreen first and insect repellent second.

Natural insect repellents (repellents not registered with EPA)
- The effectiveness of non-EPA registered insect repellents, including some natural repellents, is not known.
- To protect yourself against diseases like chikungunya, dengue, and Zika, CDC and EPA recommend using an EPA-registered insect repellent.
- When used as directed, EPA-registered insect repellents are proven safe and effective. For more information: www.2.epa.gov/insect-repellents

If you have a baby or child
- Always follow instructions when applying insect repellent to children.
- Do not use insect repellent on babies younger than 2 months of age.
- Dress your child in clothing that covers arms and legs, or
- Cover crib, stroller, and baby carrier with mosquito netting.
- Do not apply insect repellent onto a child’s hands, eyes, mouth, and cut or irritated skin.
  - Adults: Spray insect repellent onto your hands and then apply to a child’s face.
- Do not use products containing oil of lemon eucalyptus (OLE) or para-methane-diol (PMD) on children under 3 years of age.

Treat clothing and gear
- Treat items such as boots, pants, socks, and tents with permethrin or purchase permethrin-treated clothing and gear.
  - Permethrin-treated clothing will protect you after multiple washings.
  - See product information to find out how long the protection will last.
  - If treating items yourself, follow the product instructions.
  - Do not use permethrin products directly on skin.

Mosquito-proof your home
- Use screens on windows and doors. Repair holes in screens to keep mosquitoes outside.
- Use air conditioning when available.
- Keep mosquitoes from laying eggs in and near standing water.
  - Once a week, empty and scrub, turn over, cover, or throw out items that hold water, such as tires, buckets, planters, toys, pools, birdbaths, flowerpots, or trash containers. Check inside and outside your home.

www.cdc.gov/features/StopMosquitoes
Blastomycosis

- Blastomycosis usually is acquired via the respiratory route.
  - It is caused by *Blastomyces dermatitidis*.
  - It is associated with dusty soil and bird droppings.
    - Free-living species distributed in soil of a large section of the midwestern and southeastern U.S.
  - It can cause lung and skin infections.
  - Inhalation causes:
    - lung lesions.
    - persistent cough.
    - chest pains.
  - It can cause chronic pneumonia and may disseminate to other organs in AIDS patients.
Blastomycosis (or “Blasto”) is an infection caused by the fungus *Blastomyces dermatitidis.*

Illness can occur 2 – 15 weeks after breathing in the fungal spores.

Symptoms can include cough, fever, chills, muscle aches, joint pain, and chest pain.

Infection can spread to other parts of the body such as skin or bones.

Blasto is not spread from person to person.

The fungus lives in moist soil and decaying wood and leaves.

Blasto is treatable with antifungal medications.

People who smoke, have lung disease, or have weakened immune systems are more likely to become ill.

Ill individuals concerned about Blasto should visit their doctor.

Learn more at: http://www.cdc.gov/fungal/diseases/blastomycosis/
http://www.plosone.org/article/info:doi/10.1371/journal.pone.0002034
Figure 1. A. Blastomycosis cases reported to the Wisconsin Division of Health and Family Services by county from 2000–2006.

Recent outbreaks (2015-2018) Wolf river

http://www.plosone.org/article/info:doi/10.1371/journal.pone.0002034
Figure 4. Predicted potential geography of B. dermatitidis in Wisconsin based on maximum entropy modeling using all occurrence points.

http://www.plosone.org/article/info:doi/10.1371/journal.pone.0002034
Staphylococcus aureus

• Methicillin-resistant *Staphylococcus aureus* (MRSA):
  – Increasingly important cause of healthcare-associated infections since 1970s
  – In 1990s, emerged as cause of infection in the community
Factors that Facilitate Transmission

- Crowding
- Frequent Contact
- Antimicrobial Use
- Contaminated Surfaces and Shared Items
- Cleanliness
- Compromised Skin
Contact Diseases Caused by Exogenous Bacterial Species

- *Staphylococcus aureus* infections can create abscesses and/or produce exotoxins.
  - Folliculitis—base of hair follicle
  - Abscess—circumscribed pus filled lesion
  - Furuncle—a boil, warm abscess, can rupture
  - Carbuncle—connected deep abscesses
  - Impetigo—walled blisters, oozing yellow fluid
Impetigo: *Staphylococcus aureus* (cont’d)

**Culture and/or Diagnosis (cont’d)**

- **Coagulase test**
  - key technique that separates *S. aureus* from other species of *Staphylococcus*
  - any isolate that coagulates plasma is *S. aureus*; all others are coagulase negative
Most Invasive MRSA Infections Are Healthcare-Associated

Kleven et al JAMA 2007;298:1763-71
Reporting infections

Between 5 and 10 percent of all patients contract at least one healthcare-associated infection (HAI) during their stay at U.S. hospitals. States that require public reporting of HAI cases:

Where HAI strikes

Major sites of infection at hospitals

2002 data

**Annual cases**

Total: 1.7 million

- Other 386,090
- Surgical site 290,485
- Pneumonia 250,205
- Urinary tract 561,667
- Bloodstream 248,678

**Annual deaths**

Total: 98,987

- Other 11,062
- Surgical site 8,205
- Pneumonia 35,967
- Urinary tract 13,088
- Bloodstream 30,665

http://healthjournalism.org/blog/tag/health-care-associated-infections/
Prions

- Proteinaceous infectious particles
  - contain no genetic material

- Cause transmissible spongiform encephalopathies (TSEs)
  - neurodegenerative diseases with long incubation periods but rapid progressions
  - human TSEs: Creutzfeldt-Jakob disease (CJD) and Gerstmann-Strussler-Scheinker disease
  - animal TSEs: scrapie, transmissible mink encephalopathy, bovine spongiform encephalopathy (BSE, or “mad cow” disease)
TSEs and Prions

• Prions are infectious proteins.
  – Transmissible spongiform encephalopathies (TSEs) can occur in humans and other animals.
    • For example, mad cow disease
  – TSEs are neurologic degenerative diseases that can be transmitted within or between species.
  – Originally, scientists believed TSEs were caused by a virus.
  – Stanley Prusiner discovered the proteinaceous infectious particle (prion).
Prions: CJD

Signs and Symptoms
• Altered behavior, memory loss, impaired senses, delirium, premature senility
• Uncontrollable muscle contractions continue until death, usually within a year of diagnosis

Causative Agent
• Prion
  - causes transformation of a normal host protein (PrP) that functions in normal brain development
  - mutation causes a structural change in the protein, making PrP catalytic and able to convert other normal PrP proteins into the abnormal form
Other Noncellular Infectious Agents (cont’d)

• Bovine spongiform encephalopathy (BSE)
  - “mad cow disease”
  - recent crisis in Europe when researchers found that humans could contract the disease by consuming contaminated beef
  - infected individuals developed a variant of Creutzfeldt-Jacob disease
  - as of 2011, only three BSE-positive cows have been found in the US compared to over 184,000 cows in the UK
Classic CJD is *not* related to "mad cow" disease. Classic CJD also is distinct from "variant CJD", another prion disease that *is* related to BSE.

### Clinical and Pathologic Characteristics of Classic CJD

Classic CJD characteristics, as compared to variant CJD, are presented in the table below.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Classic CJD</th>
<th>Variant CJD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median age at death</td>
<td>68 years</td>
<td>28 years</td>
</tr>
<tr>
<td>Median duration of illness</td>
<td>4-5 months</td>
<td>13-14 months</td>
</tr>
<tr>
<td>Clinical signs and symptoms</td>
<td>Dementia; early neurologic signs</td>
<td>Prominent psychiatric/behavioral symptoms; painful dyesthesias; delayed neurologic signs</td>
</tr>
<tr>
<td>Periodic sharp waves on electroencephalogram</td>
<td>Often present</td>
<td>Often absent</td>
</tr>
<tr>
<td>&quot;Pulvinar sign&quot; on MRI*</td>
<td>Not reported</td>
<td>Present in &gt;75% of cases</td>
</tr>
<tr>
<td>Presence of &quot;florid plaques&quot; on neuropathology</td>
<td>Rare or absent</td>
<td>Present in large numbers</td>
</tr>
<tr>
<td>Immunohistochemical analysis of brain tissue</td>
<td>Variable accumulation</td>
<td>Marked accumulation of protease-resistance prion protein</td>
</tr>
<tr>
<td>Presence of agent in lymphoid tissue</td>
<td>Not readily detected</td>
<td>Readily detected</td>
</tr>
<tr>
<td>Increased glycoform ratio on immunoblot analysis of protease-resistance prion protein</td>
<td>Not reported</td>
<td>Marked accumulation of protease-resistance prion protein</td>
</tr>
</tbody>
</table>


*An abnormal signal in the posterior thalami on T2- and diffusion-weighted images and fluid-attenuated inversion recovery sequences on brain magnetic resonance imaging (MRI); in the appropriate clinical context, this signal is highly specific for vCJD.*
Excellent resource

• Vectorborne disease toolkit

• Wisconsin Climate and Health Adaptation Plan