Vectors and Disease

Why Does the Vector Matter?

- Mosquitoes
- Ticks
- Sand flies
- Fleas
- Chigger Mites
- Lice
- Tsetses

COL Jennifer Caci
US Army Special Operations Command
Why does the vector matter?

It's not just about disease...
• **Threats**
  - What does “vector-borne” mean?
  - Understanding vector-borne disease epidemiology
  - Area specific, risk assessment

• **Resources**
  - Where can you get information?

• **Identifying Important Vectors**

• **Prevention**
  - What can you do to minimize risk?
What is a vector?

- An arthropod that becomes infected with a pathogen and is able to transmit it to another host
- Although an arthropod is able to maintain a parasite alive within its body, transmission depends upon its competence as a vector
What are the priority threats?

It always depends but, in general according to “the experts”...

MEMORANDUM FOR RECORD

SUBJECT: Infectious Disease Threats to the US Military Prioritization Panel Results

1. A panel was hosted by the Directorate of Combat and Doctrine Development (DCDD) and the Military Infectious Diseases Research Program (MIDRP), US Army Medical Research and Materiel Command (MRMC), under the umbrella of the Medical Force Protection Integrated Capabilities Development Team (ICDT) Charter to prioritize the current infectious disease threats to the US Military (Appendix A).

2. Panel objectives were to identify and operationally prioritize the infectious disease threats to US Forces to assist in the determination of capability requirements.

Appendix A
Prioritization of Infectious Disease Threats to the US Military

1. Malaria
2. Dengue
3. Diarrhea, bacterial
4. Multidrug-resistant (MDR) wound pathogens
5. Leishmaniasis
6. Q fever (Coxiella burnetii)
7. Norovirus and other viral diarrhea
8. Influenza
9. Adenovirus
10. Leptospirosis

11. Diarrhea, protozoal
12. Tuberculosis (TB)
13. Crimean-Congo hemorrhagic fever
14. Human immunodeficiency virus (HIV/AIDS)
15. Hemorrhagic fever with renal syndrome (HFRS)
16. Chikungunya
17. Meningococcal meningitis
18. Plague
19. Rickettsioses
20. Viral encephalitides

21. Hepatitis E
22. Lassa fever and other arenaviruses
23. Tick-borne encephalitis
24. Rift Valley fever
25. Hepatitis C
26. Brucellosis
27. Other arboviral illnesses
28. Typhoid fever
29. Cholera
30. Schistosomiasis

31. Tularemia
32. Trypanosomiasis
33. Ebola/Marburg hemorrhagic fever
34. Chagas’ disease
35. Yellow fever
36. Lyme
37. Bartonellosis (Oroya fever)
38. Soil-transmitted helminths
## Vectorborne Disease Threats

### TABLE 1. Past and present impact of vector-borne diseases of military importance among deployed troops

<table>
<thead>
<tr>
<th>Past threats</th>
<th>Present threats</th>
<th>Other diseases of less importance</th>
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<tbody>
<tr>
<td>Sandfly-borne diseases</td>
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<tr>
<td>Sandfly fever</td>
<td>Star✨ Sandfly fever</td>
<td>Oroya fever</td>
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<tr>
<td>Old World cutaneous leishmaniasis</td>
<td>Star✨ Old World cutaneous leishmaniasis</td>
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<tr>
<td>New World mucocutaneous leishmaniasis</td>
<td>Star✨ New World mucocutaneous leishmaniasis</td>
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<tr>
<td>Visceral leishmanias</td>
<td>Star✨ Visceral leishmanias</td>
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<tr>
<td>Mosquito-borne diseases</td>
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<tr>
<td>Malaria</td>
<td>Star✨ Malaria</td>
<td>O'nyong nyong virus, Semliki Forest virus, Sindbi virus, and other mosquito-borne viruses</td>
</tr>
<tr>
<td>Lymphatic filariasis</td>
<td>Star✨ Dengue fever</td>
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<tr>
<td>Yellow fever</td>
<td>Star✨ Chikungunya disease</td>
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<tr>
<td>Japanese B encephalitis</td>
<td>Star✨ Rift Valley fever</td>
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<tr>
<td>Dengue fever</td>
<td>Star✨ West Nile virus</td>
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<tr>
<td>Chikungunya disease</td>
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<td>Flea-borne diseases</td>
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<tr>
<td>Plague</td>
<td>Star✨ Plague?</td>
<td>Flea-borne spotted fever</td>
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<td>Murine typhus</td>
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<td>Louse-borne diseases</td>
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<td>Typhus</td>
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<td>Trench fever</td>
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<td></td>
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<tr>
<td>Louse-borne relapsing fever</td>
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<tr>
<td>Tick-borne diseases</td>
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<tr>
<td>Rocky mountain spotted fever</td>
<td>Star✨ Rocky mountain spotted fever</td>
<td>New pathogenic rickettsiae (Rickettsia slovaca, Rickettsia helvetica, and Rickettsia sibirica mongolitimonae)</td>
</tr>
<tr>
<td>Mediterranean spotted fever</td>
<td>Star✨ Mediterranean spotted fever</td>
<td>‘Rickettsia of unknown pathogenicity’</td>
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<td>African tick bite fever</td>
<td>Star✨ African tick bite fever</td>
<td>Colorado tick fever</td>
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<td>Other common tick-borne spotted fevers</td>
<td>Star✨ Other common tick-borne spotted fevers</td>
<td>Kemerovo tick fever</td>
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<td>Ehrlichiosis</td>
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<td>Other tick-borne fevers (Dugbe or Banha virus)</td>
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<td>Q-fever*</td>
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<td>Omsk hemorrhagic fever</td>
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<td>Tularemia*</td>
<td>Star✨ Tularemia*</td>
<td>Kyasianur Forest disease</td>
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<td>Crimean–Congo hemorrhagic fever</td>
<td>Star✨ Crimean–Congo hemorrhagic fever</td>
<td>Alkhurma virus hemorrhagic fever</td>
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<tr>
<td>Tick-borne encephalitis</td>
<td></td>
<td>Human babesiosis</td>
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<tr>
<td>Mite-borne diseases</td>
<td></td>
<td></td>
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<tr>
<td>Scrub typhus</td>
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<tr>
<td>Tsetse fly-borne diseases</td>
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<tr>
<td>Sleeping sickness</td>
<td></td>
<td></td>
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<tr>
<td>Kissing bug-borne diseases</td>
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<td></td>
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<tr>
<td>Chagas disease</td>
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</tbody>
</table>

*Star✨ indicates a current threat among deployed troops.
What are the threats in my AO?

Depends on **where** you are and **when** you are there.
Components of Transmission

- **Pathogen**
  - Imported genotypes, mutations, replication rate
- **Vector**
  - Feeding behavior, host preference, habitat, vector competence, density, life span
- **Host and reservoir populations**
  - Susceptibility, immunity, density, living conditions, movement
- **Landscape**
  - Climate, rainfall, temp, humidity, elevation, habitat

Where can you break the cycle?
1. What pathogens and strains/species are present?

*P. falciparum* is far more serious than *P. vivax*

2. Will the mission put personnel into close contact with vectors?

- **VECTOR BEHAVIOR**
  - *Anopheles* mosquitoes are nighttime biters.
  - *Aedes* mosquitoes are daytime biters.
  - Sandflies typically fly close to the ground.
- **VECTOR HABITAT**…Will personnel operate in areas with vectors?
- **BILLETING**…in buildings with doors and screened windows?

3. Will conditions support disease transmission?

- **SEASONALITY**
- **RECENT WEATHER** (rain and mosquitoes, wind and sand flies)
- **DENSITY OF VECTOR**
- **INFECTION RATE**

4. What is the Incubation Period?

- **IMMEDIATE VS. DELAYED IMPACT**
Air Force Tent City

Army Tent City

No AC

Or, NO tent city...

Examples of varied risk levels in austere environments
Ecological Influence - Iraq Example

Water (rainfall, marshes etc)

1973
Malaria

Leish
2000

Land cover and Temperature

(Reisen, 2010)

Iraq 2003-04
<table>
<thead>
<tr>
<th>Location</th>
<th>collected</th>
<th>tested</th>
<th>infected</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. AF–407th AEG TOC</td>
<td>510</td>
<td>131</td>
<td>0.0%</td>
</tr>
<tr>
<td>2. Control Site 3</td>
<td>2,803</td>
<td>612</td>
<td>0.65%</td>
</tr>
<tr>
<td>3. 1/293rd INF, HHD</td>
<td>30</td>
<td>21</td>
<td>4.76%</td>
</tr>
<tr>
<td>4. AF – Post Office</td>
<td>351</td>
<td>74</td>
<td>4.05%</td>
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<tr>
<td>5. Control Site 4</td>
<td>5,104</td>
<td>803</td>
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<td>6. 171st ASG</td>
<td>1,180</td>
<td>251</td>
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<td>7. 607th MP Bn</td>
<td>149</td>
<td>80</td>
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<tr>
<td>8. 221 MI Bn</td>
<td>2,275</td>
<td>1,174</td>
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<tr>
<td>9. 933rd MP Co</td>
<td>923</td>
<td>329</td>
<td>1.22%</td>
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<tr>
<td>10. Mosque</td>
<td>131</td>
<td>89</td>
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<td>11. 2220th Trans</td>
<td>4,088</td>
<td>2,064</td>
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<td>12. 1208th QM Co</td>
<td>16,280</td>
<td>3,128</td>
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<tr>
<td>13. Army Finance</td>
<td>3,217</td>
<td>478</td>
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<tr>
<td>14. 933rd MP Co HQ</td>
<td>749</td>
<td>115</td>
<td>1.74%</td>
</tr>
<tr>
<td>15. 63rd Sig Bde</td>
<td>14</td>
<td>11</td>
<td>0.00%</td>
</tr>
<tr>
<td>16. 86th CSH</td>
<td>10</td>
<td>5</td>
<td>0.00%</td>
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<tr>
<td>17. AF – A10 Ops</td>
<td>595</td>
<td>102</td>
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<tr>
<td>18. AF – 407th ELRS</td>
<td>1,978</td>
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<td>19. 486th CA Bn</td>
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<td>52</td>
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<tr>
<td>20. V Corps IG</td>
<td>55</td>
<td>44</td>
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<tr>
<td>21. Airbase Entrance</td>
<td>53</td>
<td>28</td>
<td>0.00%</td>
</tr>
<tr>
<td>22. Laundry/Bath</td>
<td>20</td>
<td>18</td>
<td>0.00%</td>
</tr>
<tr>
<td>23. 3rd Sig Bde</td>
<td>14</td>
<td>11</td>
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</tr>
<tr>
<td>24. 86th CSH</td>
<td>10</td>
<td>5</td>
<td>0.00%</td>
</tr>
<tr>
<td>25. 707th Ord</td>
<td>9</td>
<td>6</td>
<td>0.00%</td>
</tr>
<tr>
<td>26. AF-Fire Dept</td>
<td>8</td>
<td>5</td>
<td>0.00%</td>
</tr>
<tr>
<td>27. AF Flight Ops</td>
<td>5</td>
<td>5</td>
<td>0.00%</td>
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<tr>
<td>28. Army Tent City</td>
<td>3,691</td>
<td>303</td>
<td>1.98%</td>
</tr>
<tr>
<td>29. Control Site 1</td>
<td>1,087</td>
<td>33</td>
<td>0.00%</td>
</tr>
<tr>
<td>30. AF – Tent City</td>
<td>2,353</td>
<td>845</td>
<td>2.37%</td>
</tr>
<tr>
<td>31. AF – 407th Maint</td>
<td>612</td>
<td>32</td>
<td>0.00%</td>
</tr>
<tr>
<td>32. S of 221st MI Bn</td>
<td>454</td>
<td>27</td>
<td>0.00%</td>
</tr>
<tr>
<td>33. Control Site 2</td>
<td>318</td>
<td>13</td>
<td>0.00%</td>
</tr>
<tr>
<td>34. AF–Security Force</td>
<td>268</td>
<td>15</td>
<td>0.00%</td>
</tr>
<tr>
<td>35. Convoy Center</td>
<td>230</td>
<td>9</td>
<td>0.00%</td>
</tr>
<tr>
<td>36. NW Control Site</td>
<td>150</td>
<td>9</td>
<td>0.00%</td>
</tr>
</tbody>
</table>

Red indicates positive sandflies
Blue indicates negative sandflies
Green indicates sandflies present but not tested
• Model of *P. falciparum*
• No transmission in areas surrounded by high transmission
• Why?
• No vectors; the cycle was broken with appropriate pesticide use

Kisumu, Kenya
Is there effective control or is no one looking?
HELP IN IDENTIFYING PRIORITY THREATS

- Infectious Disease Risk Assessment (IDRA)
  - AFMIC now NCMI
  - Web-based and CD (MEDIC)
  - Classified and unclassified medical intelligence/information

- Entomological Operational Risk Assessments (EORA)
  - Provide risk estimates for vector-borne and zoonotic diseases in the country of concern.
  - These estimates, prepared by USAPHC.
  - EORAs available for >30 countries.

- Disease Vector Ecology Profiles (DVEP)
  http://www.afpmb.org/content/disease-vector-ecology-profiles

- Geosentinel
- ProMed
Where can you find answers?

- Regional Public Health Command (PHC), Ento Div
- AFPMB
  http://www.afpmb.org
- NCMI (MEDIC CD)
- WRAIR Ento Div
- Walter Reed Biosystematics Unit (WRBU)
  http://wrbu.si.edu and
  http://mosquitomap.nhm.ku.edu/vectormap/
- Command PM assets
DVEPS

- Provide risk estimates for vector-borne and zoonotic diseases in the regions of concern.

- Prepared by AFPMB.
The Walter Reed Biosystematics Unit (WRBU) is a unique national resource. Its mission is to conduct systematics research on medically important arthropods and to maintain the U.S. mosquito collection. The WRBU is just one part of the U.S. Government's entomological research system, which includes the U.S. Department of Agriculture (USDA) and the Smithsonian Institution (SI). Historically, mosquito identification was managed by USDA and the SI, but in 1972 this responsibility was transferred from USDA to the U.S. Army for research on medically important arthropods. Located at the Museum Support Center of the Smithsonian Institution in Suitland, Maryland, the WRBU's physical space is provided by the Smithsonian Institution in return for curation of the collection and specimen identification... (more)

What's New?
Mosquito Classification 2010
Discussion Forum
New mosquito identification keys
See new WRBU staff publications

Vector Identification Resources
to medically important arthropods and WRBU's Vector Identification Service

Mosquito Resources
Mosquito Genera
Mosquito Literature
Mosquito Species Identification Keys

Culicidae Catalog
www.mosquitocatalog.org

Other Vectors
Sand Flies
Ticks
Scorpions
Fleas

http://wrbu.si.edu/
Comprised of MosquitoMap, SandflyMap and TickMap

Geospatially referenced clearinghouses for arthropod disease vector species collection records and distribution models.

Users can pan and zoom to anywhere in the world to view the locations of:

- past vector collections and
- the results of modeling that predicts the geographic extent of individual species.

http://mosquitomap.nhm.ku.edu/vectormap/

VectorMap is new and still in the test phase.
Requires you to download Silver Light freeware from Microsoft.
Hypoendemic, Mesoendemic and Hyper-holoendemic

Several sources of information on malaria risk (notably international travel health guidelines on malaria chemoprophylaxis, altitude limits for dominant vectors, climate limits for malaria transmission and human population density thresholds) have been combined in a GIS to generate this map. See Guerra et al. (2006) Advances in Parasitology 62: 157 – 179 and Guerra et al. (2006) Trends in Parasitology 22: 353 – 358 for details.

The method for defining the endemic levels within these limits can be found in Snow et al. (2005) Nature 434: 214 – 217.

Anopheles collection records show up as red dots
Emerging and Neglected Vectorborne Disease Threats

- Malaria
- Dengue
- Chikungunya
- Zika
- Filariasis
- Leishmaniasis
- Rickettsioses (e.g. CCHF, African tick bite fever)
- African Trypanosomiasis
- Onchocerciasis

Mosquito
Sand Fly
Tick
TseTse Fly
Black Fly
What is a vector?

• An arthropod that becomes infected with a pathogen and is able to transmit it to another host.

• Although an arthropod is able to maintain a parasite alive within its body, transmission depends upon its competence as a vector.

• Requires a blood meal to reproduce; spreads disease incidentally.
Vector Potential

• Mosquito species vary in their vector potential because of environmental conditions and factors affecting their abundance, blood-feeding behavior, survival, and ability to support parasite development (this all influences competence)

• Sporogony is the complex life cycle of the malaria parasite in female mosquitoes; completed life cycle is necessary for disease transmission.

• Most individual mosquitoes that ingest gametocytes from the reservoir or host do not support development to the sporozoite stage.
Blood required for egg development
Malaria - Anopheles mosquitoes

~100 cases per year in US forces in AFG; likely under reported
Malaria - Anopheles mosquitoes

- Risk varies geographically
  - Different species of *Anopheles* mosquitoes (varying competence)
- Entomological inoculation rate (EIR).
  - An estimate of exposure to infective mosquitoes,
  - EIRs can exceed 1 infective bite per person per night.
Barriers to Pathogen Transmission

1. Agent enters midgut in a bloodmeal
2. Agent enters epithelial cells and replicates
3. Agent escapes across basal lamina and spreads via hemolymph
4. Agent infects salivary glands
5. Agent crosses basal lamina of salivary glands and is released into saliva
Global distribution (Robinson projection) of dominant or potentially important malaria vectors. From Kiszewksi et al., 2004. American Journal of Tropical Medicine and Hygiene 70(5):486-498.
Anopheles gambiae complex

- Anopheles arabiensis
- Anopheles bwambae
- Anopheles merus
- Anopheles melas
- Anopheles quadriannulatus
- Anopheles gambiae sensu stricto

*An. gambiae s. str.*: very anthropophilic, night biter; Africa’s primary malaria vector
Eggs

- Eggs are laid individually on the water surface and are kept afloat by air chambers (floats).
- Females lay batches of 75 to 150 eggs.
- The eggs hatch after two or three days at temperatures of 25-30°C.
- At lower temperatures, this period can be longer, and the eggs can resist total or partial desiccation in moist soil for many days (up to years).
- Oviposition (egg laying) sites vary by species.
Biology of *Anopheles* spp.

**Larvae**

- Characteristic resting position, lying parallel to the water surface.
- Larval development takes around 5 to 7 days depending on temperature.
- Larval habitat varies with species.

**Pupae**

- Pupae do not eat.
- Metamorphosis of the larva into an adult.
- It lasts from two to three days.
Biology of *Anopheles* spp.

- Larvae lack a siphon
- Larvae rest parallel to water surface
- Breathe through spiracle on 8\(^{\text{th}}\) body segment
- Adults hold body at an angle of 30° degrees or more with the surface.
Biology of *Anopheles spp.*

**Adult:**

- Live from 3 to 4 weeks although some can overwinter.
- Feeding occurs at night (dusk to dawn).
- Host preference varies by species.
- **Indoor vs. outdoor feeding.**
- Complicated sexual stage of parasite life cycle occurs in mosquito
**P. falciparum** Transmission Cycle

Cycle in Mosquito (Sexual)
- Mosquito bites human
- Sporozoites
- Mosquito Salivary Gland
- Ruptured Oocyst

Cycle in Man (Asexual)
- Primary Tissue Schizont
- Secondary Tissue Schizont (does not occur in *P. falciparum* malaria)
- Mature Female
- Mature Male
- Gametocyte
- Fertilization & Zygote Formation
- Maturing Oocyst
- Ruptured Oocyst
- Early Trophozoite
- Late Trophozoite
- Mature Schizont
- Immature Schizont
- Red Blood Cell
- Early Trophozoite
- Late Trophozoite

**Figure 1** The malaria cycle.
Life cycle - Sexual stage

Oocyst (20% of sporozoites to salivary glands)

Gut wall
**Dengue- Aedes mosquitoes**

In the last 50 years, incidence of DF/DHF has increased 30-fold.

- Endemicity has increased from 9 countries to over 100 countries since the 1970s.
- The dengue transmission cycle occurs in the US.
- No vaccine; treatment basically limited to supportive care.

**As of fall 2013:**
- The Americas- 876,859 cases; 406 DHF/serious cases.
- Vietnam- 13,903 cases.
- Laos- 14,000 cases, 50 dead.
- Malaysia- 11,485 cases.
Epidemic dengue:

**Ae. aegypti** distribution:

**Ae. albopictus** native range:

**Ae. albopictus** introduction since Dec 07:

- First case of secondary transmission in Miami in 50 years in Nov 10; 2 cases in 2011; first case of secondary transmission in Tampa diagnosed in Oct 2011; 4 cases in 2012; 28 cases in 2013 Martin County outbreak

“Dengue virus returns to Florida after more than 50 years, UF researchers say” UF News, 23 Nov 09

- 27 locally transmitted cases confirmed in 09, 66 in 2010 (Key West)
Dengue in Africa

“Risk present, level unknown”
“From 2006 to 2010, 106 laboratory-confirmed or probable cases of chikungunya were detected among travelers returning to the United States. This compares with only three cases reported from 1995 to 2005. Since 2004, chikungunya virus has caused massive and sustained outbreaks in Asia and Africa, infecting more than 2 million people, with attack rates as high as 68% in some areas. With the movement of travelers, local transmission has taken place in areas where the virus was not previously found, including northern Italy and southern France.” -PAHO/WHO

Chikungunya Fever - Aedes mosquitoes

- Mosquito-borne virus
- Like dengue, traditional vector is *Ae. aegypti* but *Ae. albopictus* is competent vector; equivalent eradication challenges
- Symptomology also comparable to dengue
- Continuous outbreaks since 2005 in Europe, Asia & Africa, to include areas not previously endemic; over 200 cases in Italy in 2007
- Jun 11- Based on genomic studies from an outbreak of 480 cases in DRoC, *Ae. albopictus* is being considered as a more critical vector
- Caribbean outbreak 2014- over 230,000 cases as of Jul
- Jul 2014- US imported CHIK-V cases reaches 138; 30 states affected
- Malaysia: Over 1,100 cases Jan - April 2009
- Philippines: Over 500 cases thus far in 2013
Zika Virus - Aedes mosquitoes

- The French Polynesia Department of Health has confirmed an outbreak of Zika fever in the islands of French Polynesia. As of January 13, 2014, 361 laboratory confirmed cases and 7,156 suspected cases have been reported.
- Related to dengue, Yellow Fever, West Nile and JE
- Hosts are monkeys and humans
- ~10 day mosquito development stage
- Similar symptoms to dengue, CHIK-V

Approximate distribution 1947-2007

Ae. aegypti
Filariasis - Mosquitoes

Vector depends on the geographic area
- Africa: Anopheles
- Americas: Culex quinquefasciatus
- Pacific and Asia: Aedes and Mansonii

Biting behaviors matter!
Aedes Vectors

Ae. albopictus

Ae. aegypti
Feeding Habits – *Ae. albopictus*

- *Aedes albopictus* prefers to feed and rest outdoors.
- Feeds during daytime (diurnal)
- Feeds on any vertebrate host but prefers humans
**Aedes comparison**

- **Ae. aegypti**
  - Environment: Urban
  - Breed/feed: Indoors (< 200m)
  - Container type: Artificial
  - Biting peak: Daytime
  - Host: Human
  - Flight Range: < 200m

- **Ae. albopictus**
  - Environment: Sylvatic*
  - Breed/feed: Outdoors
  - Container type: Natural and artificial
  - Biting peak: Dusk
  - Host: Human/Vertebrates
  - Flight Range: < 600m

*Not necessarily true*
Mosquito Vector Comparison

- **Anopheles**
  - Length of palps compared to proboscis
  - Pointed abdomen

- **Aedes**
  - Resting and feeding behavior

- **Culex/Aedes**

- **Anopheles**
Behavior & Habitat Comparison

Anophelines: typically cleaner, slowly flowing; in some places temp pools ok as long as not stagnant

Aedes, Culex: stagnant, dirty, temp pools, opportunistic

Aedes, Culex: body hangs down from the surface; uses breathing tube

Anopheles: parallel to surface; spiracular plates on 8th abdominal segment
Sand Flies- Leishmaniasis
Global distribution of the leishmaniases (but not the global distribution of sand flies)
Sand Fly Bites

Biting Behavior
Mucocutaneous leish from French Guyana
The Epidemiological Triangle

Enzootic Cycle

Sand fly vector

Mammalian Reservoir (home to the pathogen)

Incidental Host

Man and his Activities
Psammomys obesus

Chenopods

*L. major* enzootic cycle
Characteristics

- Small (2-3 mm)
- Brown (but appear white when illuminated)
- Wings held in erect V-shape (even dead)
- Nocturnal
- Do not hover
- Silent
- Painful bite for some
Leishmaniasis - Sand Flies

Damp habitats, plumose antennae, larger, broader wings, more hair; sand fly always holds its wings up and away from its body, not flat like a drain fly.

Phlebotomus (Old World) and Lutzomyia (New World) spp.
Life cycle and developmental stages

- Eggs
- Fourth instar larvae
- Adult male
- Adult female
Sand flies – vital requirements

• Larvae breed in soil (not aquatic)
• Only females take blood, from a variety of vertebrate species
• Rest during the day in dark, humid microhabitats
• Both sexes require sugar as an energy source
Sand flies resting on wall of a chicken house
Variable Habitats:
rain forest, desert, mountains, cities
African Tick Bite Fever - Ticks

African tick-bite fever (ATBF)

- an emerging infectious disease endemic in sub-Saharan Africa
- the most commonly encountered rickettsiosis in travel medicine.

- Rickettsia africae
- Amblyomma, Dermacentor, Rhipicephalus

Crimean Congo Hemorrhagic Fever - Ticks

- Sep 09: First US Soldier death from CCHF since WWII; acquired in AFG (Arghandab Valley)
- Tick-borne virus (*Hyalomma*); 30% mortality rate
- Can also be transmitted by exposure to fresh infected blood (human or animal)
- Endemic in many countries in Africa, Europe, Asia and the Mediterranean; since 2001 cases or outbreaks have been recorded in Kosovo, Albania, Iran, Pakistan, and South Africa
- Most widely distributed HF in the world
- Austere conditions increase the likelihood of transmission; fewer “tick checks”, formal or informal
- Intensive monitoring of blood volume and component required
**Crimean-Congo Hemorrhagic Fever (CCHF) Virus Ecology**

**Enzootic Cycle**
- Ixodid (hard) ticks are both a reservoir and vector for the CCHF virus.
- The virus is maintained in nature transovarially and transstadially.

**Epizootic-Epidemic Cycle**
- CCHF cases occur more during the warmer parts of the year, mostly the spring and summer. There are no cases during the winter.
- Humans become infected through tick bites and direct contact with infected animal blood or tissue.
- Transmission can occur while slaughtering infected animals, during veterinary procedures, and in hospital settings where proper protective equipment and appropriate disinfection procedures are lacking.

The ticks feed on numerous wild and domestic animals, such as cattle, goats, sheep and hares. These animals serve as both food sources for ticks and amplifying hosts for the virus.
**Tick Removal**

**REMOVE TICKS PROMPTLY**

- If a tick is found attached to the body (Figure 1), seek assistance from medical authorities for proper removal, or follow these guidelines:
  1. Grasp the tick's mouthparts against the skin, using pointed tweezers (Figure 2).
  2. Pull back slowly and steadily with firm force.
     - Pull in the reverse of the direction in which the mouthparts are inserted, as you would for a splinter (Figure 2).
     - **BE PATIENT** — The long, central mouthpart (called the hypostome) is inserted in the skin. It is covered with sharp barbs, sometimes making removal difficult and time-consuming (Figure 3, inset).
   - Most ticks secrete a cement-like substance during feeding. This material helps secure their mouthparts firmly in the flesh, further adding to the difficulty of removal.
   - It is important to continue to pull steadily until the tick can be eased out of the skin (Figure 3).
   - **DO NOT** pull back sharply, as this may tear the mouthparts from the body of the tick, leaving them embedded in the skin. If this happens, do not panic. Embedded mouthparts are comparable to having a splinter in your skin. Mouthparts alone cannot transmit disease because the infective body of the tick is no longer attached. However, to prevent the chance of secondary infection, it is best to remove them. Seek medical assistance if necessary.
   - **DO NOT** squeeze or crush the body of the tick because this may force infective body fluids through the mouthparts and into the wound site.
   - **DO NOT** apply substances such as petroleum jelly, liquid soap-polish, nail polish remover, repellents, pesticides, or a lit match to the tick while it is attached. These materials are either ineffective, or worse, might agitate the tick and cause it to force more infective fluid into the wound site.
- Following removal of the tick, wash the wound site (and your hands) with soap and water and apply an antiseptic.
- **Save the tick** for future identification should you later develop disease symptoms. Preserve it by placing it in a clean, dry jar, vial, small Ziploc plastic bag, or other sealed container and keeping it in the freezer. Identification of the tick will help the physician's diagnosis and treatment, since many tick-borne diseases are transmitted only by certain species.

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Entomological Sciences Program, Aberdeen Proving Ground, Maryland 21010-5403
October 2003
Over 50% of the landcover in Africa is considered “highly suitable” to the tsetse fly; both sexes take blood meals.
African Trypanosomiasis - Tsetse Fly

Larvae are soil dwelling so control measures target adults.

Distinct features: long proboscis, calyptarate antennae, ptilinal suture, the wings overlap completely when held over the abdomen, the discal medial (i.e. the middle) cell of the wing has a characteristic hatchet shape; and it has more bulk than the Muscidae flies.
Onchocerciasis - Black Flies

- *Simulium complex* breed in fast-flowing streams and rivers hence the commonly known name of “river blindness”
- Large flight range
- Larval stage is targeted by control programs
- Painful daytime bite; “pool feeders”, ideal for transmission of microfilarial into skin
- Thousands of eggs can be laid at one time, outbreaks can be ecologically linked
Prevention
WHAT CAN YOU DO TO MINIMIZE RISK?

- Find out what the priority risks are in your area before you deploy.
- Understand the vectors so you can avoid them.
- Modify behaviors to minimize contact
  - Use repellents
  - Sleep under insecticide treated netting
  - Wear permethrin treated uniforms
- Take malaria chemo (if warranted)
- Call for help:
  - AFPMB (CLO) : afpmb-webmaster@osd.mil: subject CLO question
  - PHC, Ento Division
33% Controlled-Release DEET Lotion: NSN 6840-01-284-3982

Highest rated skin repellent available (Consumer Reports, May 2003; reconfirmed 2013-14)
CDC recommended repellents

- Of the active ingredients registered with the EPA, products containing these active ingredients typically provide longer-lasting protection than others:
  - DEET, Picaridin and IR3535

- The non-DEET compounds work as well as or nearly as well as DEET when they are used at higher concentrations (~10-20%).

http://www.cdc.gov/ncidod/dvbid/westnile/repellentupdates.htm
http://www.epa.gov/pesticides/health/mosquitoes/ai_insectrp.htm
http://www.entomology.wisc.edu/mosquitosite/topicalrepel.html
Picaridin

- Picaridin is a colorless, nearly odorless liquid active ingredient that is recommended by the CDC as an alternative to DEET.
- Lab and field studies of products containing picaridin (10-20%) indicate good protection.
- 7.5% products are not as effective.

- Natrapel, 20%, 3.5-oz. Pump Spray
- Cutter Advanced, 7%, 6-oz. Pump Spray
- Off Skintastic, 5%, 6-oz. Pump Spray
IR3535

- IR3535 is recommended by the CDC as an alternative to DEET.
- IR3535 is a synthetic insect repellent structurally similar to a natural amino acid, beta-alanine and is classified as a biopesticide by the EPA.
- This compound has been used as a mosquito repellent in Europe and Asia for 10-20 years.
- Approved by the U.S. EPA in 1999.
- IR3535 is currently available in the Avon Skin-so-soft Bug Guard 7.5%
A new training briefing on permethrin-treated Flame-Resistant Army Combat Uniforms (FR ACUs) is available – CAC REQUIRED

- https://peosoldier.army.mil/newpeo/ContactUs/faq/docs/fracu.asp
Bed Nets

Enhanced BedNet System 3740-01-546-4354
Improved Bed Net System 3740-01-543-5652
Bed net, Pop-up, self-supporting
Coyote Brown 3740-01-518-7310
OD Green (Camo) 3740-01-516-4415

NSN 3740-01-518-7310- CL 0X item, must be ordered through CL IX SARSS

The pop-up bed net is factory-treated with permethrin and has much finer mesh than the standard military bed net.
Myth Busters

• No evidence that eating garlic or taking vitamin B tablets reduces mosquito bites

• Dark clothing is usually more attractive than light colored clothing

• Drinking alcohol may increase your attractiveness to mosquitoes
Some mosquito control devices use repellents to protect a small outdoor area like a patio.

No products approved by the EPA for indoors.

Effective devices which use allethrin or other pyrethroids to repel mosquitoes include:

- Mosquito coils
- ThermaCell (™) Mosquito Repellent System
Myth Busters

Mosquito magnet can be very effective for area coverage
Myth Busters

• Citronella candles are weak
• Geraniol candles can provide 1 meter of protection
Myth Busters

- Sonic and electronic devices do not work
Final Thoughts

- Vaccine preventable diseases
  - Yellow Fever

**Socioeconomic Instability**

- Displaced persons/refugees
- Disaster response

2nd & 3rd Order Effects
• WRAIR 1367 Project 002. USASOC Dengue Seroprevalence Protocol. 10 Sep 09.
• http://www.promedmail.org/
• www.gideononline.com
More Resources (2 of 2)

- http://www.cdc.gov/eid/content/14/5/pdfs/814.pdf for *P. knowlesi* article.