Insect Precautions
Why worry? What works?

Anne E McCarthy, MD, FRCP, DTM&H, FASTMH, FISTM
Director Tropical Medicine and International Health Clinic Ottawa Hospital
Professor of Medicine, University of Ottawa
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Objective
- Review of vector prevention:
  - Repellents, permethrin, netting
- Provide and overview of vectors (describe vectors and transmission)

Choose the appropriate vector and disease association:
A. *Aedes* mosquitoes and malaria
B. *Phlebotomus* sandflies and leishmaniasis
C. *Triatoma* bugs and African trypanosomiasis
D. *Anopheles* mosquitoes and yellow fever

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PRESENTER DISCLOSURE

Relationships with commercial interests:
- Advisor: Shandand Inc.

BIG THANK YOU TO LIN CHEN

Vector types and diseases
- Mosquito
  - Dengue
  - Chikungunya
  - Encephalitis, Japanese
  - Filaria, bancroftian
  - Malaria
  - Rift Valley fever
  - West Nile virus
  - Yellow fever
  - Zika
- Fly
  - Loa loa
  - Onchocerciasis
  - Leishmaniasis
  - African trypanosomiasis
- Tick
  - Encephalitis, tick-borne
  - Lyme, Anaplasma, Babesia
  - Rickettsiosis (also fleas, lice, mites for some species)
  - Crimean Congo hemorrhagic fever
  - Kyasanur Forest dis, Omsk hemorrhagic fever
- Bug
  - American trypanosomiasis
- Flea (rodent)
  - Plague
What is needed for transmission of vector-borne diseases (VBDs)?

- Pathogen presence and amplification
- Vector presence and survival
- Presence of suitable hosts (reservoirs)
- Opportunities for human exposure

- **Vector competence:** can this mosquito transmit this particular virus?
- **Vector capacity:** how important is this mosquito in transmitting this particular virus?

Diseases and mosquito species

<table>
<thead>
<tr>
<th>Disease</th>
<th>Mosquito</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malaria</td>
<td>Anopheles</td>
</tr>
<tr>
<td>Dengue</td>
<td>Aedes</td>
</tr>
<tr>
<td>Chikungunya</td>
<td>(YF - also Haemagogus, Sabethes)</td>
</tr>
<tr>
<td>Yellow fever</td>
<td></td>
</tr>
<tr>
<td>Zika</td>
<td></td>
</tr>
<tr>
<td>Rift Valley fever</td>
<td>RVF (animal blood); Aedes, Culex</td>
</tr>
<tr>
<td>Encephalitis, Japanese</td>
<td></td>
</tr>
<tr>
<td>West Nile</td>
<td></td>
</tr>
<tr>
<td>Filarisis, lymphatic</td>
<td>various mosquito vectors</td>
</tr>
</tbody>
</table>

Major mosquito species of interest for travelers

- *Anopheles gambiae*
- *Aedes aegypti* (YF mosquito)
- *Aedes albopictus* (Asian tiger mosquito)
- *Culex*

Anopheles ecology: habitats, feeding

- Preferred: clean, unpolluted water.

- Larvae of *Anopheles gambiae*, the major malaria vector in Africa, can breed in diverse habitats. 3 habitats shown: tire tracks, rice fields, irrigation water.
- Feeding patterns: most are crepuscular (dusk/dawn) or nocturnal (night).

Global map of dominant malaria vectors

Sinka ME et al. Parasit Vectors 2012
When is the use of repellent most effective to prevent mosquito bites that transmit malaria?

A. Mid-day and early afternoon
B. Early morning and late afternoon
C. From dusk to dawn
D. From dawn to dusk

Aedes aegypti are container breeding, adults are indoor dwelling
Peak biting - daytime

Aedes mosquitoes: dengue, chikungunya, YF, Zika

Aedes aegypti
Aedes albopictus

Culex mosquitoes: JE and West Nile virus

www.cdc.gov/Dengue/entomologyEcology/m_habitats.html
**Culex mosquitoes: vector of Japanese encephalitis**

- Mosquitoes are infected by feeding on domestic pigs and wild birds, in whom the virus is amplified
- Biting behavior: dusk to dawn
- Often outdoors, but sometimes indoors
- Increased risk:
  - Rural areas, outdoors
  - Long-term travel

**A traveler plans to volunteer in a village in Cambodia. Which vector-disease pair is a significant risk?**

A. *Ixodes* ticks and tick-borne encephalitis
B. *Aedes* mosquitoes and Lyme disease
C. *Culex* mosquitoes and Japanese encephalitis
D. *Rhipicephalus* ticks and chikungunya

**Ticks**

*Ixodes scapularis*: Lyme, Babesia, Anaplasma

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**Ticks**

- Life: egg → 6-leg larva → 8-leg nymph → adult

- Diseases:
  - Encephalitis, tick-borne
  - Lyme, anaplasmosis, babesiosis
  - Rickettsiosis (esp. ATBF; some can be transmitted by fleas, lice, mites)
  - Crimean Congo hemorrhagic fever
  - Kyasanur Forest disease, Omsk hemorrhagic fever
Bug: American trypanosomiasis

- Protozoan: Trypanosoma cruzi
- Vector: Triatoma (reduvid bugs, kissing bugs)
- Other transmission modes: transfusion, vertical transmission

Sandflies: leishmaniasis

- Protozoan: Leishmania species
- Vector: sand flies, Phlebotomus and Lutzomyia

Summary: vectors and travel

- Mosquitoes
  - Anopheles
  - Aedes
  - Culex
- Sand flies
  - Lutzomyia
  - Phlebotomus
- Black flies
  - Simulium
- Horse flies/deer flies
  - Chrysops
- Tsetse flies
  - Glossina
- Kissing bugs
  - Triatoma
- Ticks
  - Ixodes
  - Amblyomma
  - Rhizophalus
- Others:
  - Flies
  - Lice
  - Mites

Mosquito proofing is effective

<table>
<thead>
<tr>
<th>Location</th>
<th>Date</th>
<th>Intervention</th>
<th>Risk ratio after intervention (baseline=1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lahore, India</td>
<td>1935-37</td>
<td>British infantry barracks: wire netting, double doors</td>
<td>0.08</td>
</tr>
<tr>
<td>Honduras</td>
<td>1926</td>
<td>Local houses: mosquito proofing</td>
<td>0.25</td>
</tr>
<tr>
<td>Mining communities, northern Zambia</td>
<td>1930-39</td>
<td>Drainage of flooded areas, modification of river boundaries, vegetation management</td>
<td>0.35</td>
</tr>
</tbody>
</table>
Evidence to support methods

- Improve housing design reduced malaria:
  - Modern houses had 47% lower odds of malaria infection/ 45-65% lower odds of clinical malaria
- Insecticide-treated nets/curtains/screen: 77% protective efficacy vs. cutaneous leishmaniasis
  - High protective efficacy of:
    - o IRS vs. dengue
    - o ITNs vs. Japanese encephalitis
- Larval source management reduced malaria incidence by %:
  - 2 cluster-RCTs (Sr Lanka): larviciding abandoned mines, streams, irrigation ditches, rice paddies.
  - 1 trial (India): removal of domestic water containers = weekly larviciding of canals/stagnant pools.

Tusting et al. Malaria J 2015; Wilson et al. PNTD 2014; Tusting et al. Cochrane 2013

Insecticide: permethrin, deltamethrin, cypermethrin

Repellents: EPA approved

<table>
<thead>
<tr>
<th>Active ingredient</th>
<th>Chemical name</th>
<th>Brands</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEET</td>
<td>N,N-diethyl-m-toluamide or N,N-diethyl-3-methylbenzamide</td>
<td>OFF! Cutter Sawyer Ultrathon</td>
</tr>
<tr>
<td>Picaridin</td>
<td>3-(2-hydroxyethyl)-1-piperidinecarboxylic acid 1-methylpropyl ester; XIR 3023, Bayrepel, caradin</td>
<td>Cutter Advanced Skin So Soft Bug Guard Plus Autan</td>
</tr>
<tr>
<td>Oil of lemon eucalyptus*</td>
<td>1-mentha-3,8-dien-3-ol</td>
<td>Repel</td>
</tr>
<tr>
<td>IR3535*</td>
<td>3-[N-buty-N-oxycarbonyl]-aminopropionic acid, ethyl ester</td>
<td>Skin So Soft Bug Guard Plus Expedition</td>
</tr>
<tr>
<td>2-undecanone</td>
<td>methyl nonyl ketone</td>
<td>BioUD</td>
</tr>
</tbody>
</table>

*Nonpesticides

Frequently asked questions

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is DEET safe in children?</td>
<td>Yes; 2 months and older; adults to apply</td>
<td>CDC, AAP</td>
</tr>
<tr>
<td>Is DEET safe in pregnancy?</td>
<td>Yes; trimesters 2-3 use on Thai-Myanmar border found no adverse effects on survival, growth, development at birth and 1 year</td>
<td>McGready et al. AJTMH 2001.</td>
</tr>
<tr>
<td>In what order should one apply DEET and sun screen?</td>
<td>Sun screen 1st, then DEET. Limited data suggest reduction of DEET mean protection time when sun screen applied on top</td>
<td>Webb et al. Aust N Z J Public Health 2009.</td>
</tr>
<tr>
<td>Is permethrin safe to use during pregnancy?</td>
<td>Very limited data; no significant, consistent association identified</td>
<td></td>
</tr>
</tbody>
</table>
### Repellents and children

<table>
<thead>
<tr>
<th></th>
<th>DEET</th>
<th>Picaridin (KBR 3023)</th>
<th>p-Methane diol (PMD= oil of lemon eucalyptus)</th>
<th>IR3535</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CDC</strong></td>
<td>&gt;2 mo, up to 50%</td>
<td>&gt;2 mo 7%, 15%</td>
<td>&gt;3 yrs (EPA)</td>
<td>&gt;2 mo</td>
</tr>
<tr>
<td><strong>AAP</strong></td>
<td>&gt;2 mo, up to 30%</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

### What does not work?

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Garlic</td>
<td>Rajan et al. Med Vet Entomol 2005</td>
</tr>
<tr>
<td>Vitamin B</td>
<td>Ives et al. J Am Mosq Control Assoc 2005</td>
</tr>
<tr>
<td>Ultrasound</td>
<td>Sylla et al. Wien Klin Wochenschr 2000</td>
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</table>

### The following is a safe and effective measure to prevent malaria:

A. Taking garlic extract  
B. Applying picaridin repellent to skin  
C. Spraying skin with permethrin  
D. Consuming 1 liter of tonic water every 15 minutes

### Ineffective: repellent-bracelet ...or...tape

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### A traveler is going to Dominican Republic x 1 week, stay in a hotel. The key preventive measure against chikungunya virus infection is:

A. Sleeping under insecticide-treated nets  
B. Administering the newly licensed vaccine  
C. Wearing long sleeves and pants impregnated with p-methane-diol  
D. Applying effective mosquito repellent to exposed skin
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Online resources

- CDC. www.cdc.gov/DiseasesConditions/
- CDC Travelers’ Health. www.cdc.gov/travel
- WHO. www.who.int
- CDC Division of Vector-Borne Diseases www.cdc.gov/ncidod/dvbid/westnile/RepellentUpdates.htm
- EPA. http://epa.gov/pesticides/insect/safe.htm
- PAHO. www.paho.org

New developments

- Coating Bed Nets With Antimalarial Drugs To Zap Parasites In Mosquitoes
- GMO mosquitoes

References


Summary: vector avoidance

• What works:
  • Timing of activities
  • Long sleeves, long pants
  • Mosquito proofing
  • Insecticide-treated nets
  • Insecticide-impregnated clothing
  • Repellents
Anopheles gambiae.

From CDC image library

Aedes albopictus

Aedes aegypti

Culex

THANKS

QUESTIONS???

THANKS AGAIN LIN FOR YOUR GENEROUS SHARING OF YOUR SLIDES....

from CDC image library