Vector Borne Infectious Diseases
Agents Transmitted By Vectors

Viruses
Rickettsia
Bacteria
Protozoa
helminths
Agents Transmitted By Vectors:

Viruses
More Than 600 Different Viruses Are Transmitted By Arthropods

Culex pipiens

West Nile Virus
Diseases Transmitted By Arthropods

Viruses

Yellow Fever
Dengue Fever
Rift Valley Fever
Encephalidides:

Japanese Encephalitis
Dengue Fever
West Nile Encephalitis
Eastern Equine Encephalitis
Western Equine Encephalitis
La Crosse Encephalitis
St. Louis Encephalitis
Worldwide Distribution of Major Arboviral Encephalitides

EEE: Eastern equine encephalitis
JE: Japanese encephalitis
LAC: LaCrosse encephalitis
MVE: Murray Valley encephalitis
POW: Powassan encephalitis
SLE: St. Louis encephalitis
TBE: Tick-borne encephalitis
WEE: Western equine encephalitis
WN: West Nile encephalitis
VEE: Venezuelan equine encephalitis
Agents Transmitted By Vectors:

*Rickettsia And Bacteria*
**Bacteria And Rickettsia***

- *Rickettsia akari*
- *Rickettsia mooseri*
- *Rickettsia prowazokii*
- *Rickettsia rickettsia*
- *Rickettsia typhi*
- *Rickettsia tsutsugamuchi*
- *Ehrlichia sp*
- *Yersinia pestis*
- *Borrelia burgdorferi*
- *Borrelia recurrentis*

*Many are zoonotic infections*
Agents Transmitted By Vectors:

Protozoa
Protozoans

*Babesia microti*
*Babesia divergens*
*Plasmodium falciparum*
*Plasmodium malariae*
*Plasmodium ovale*
*Plasmodium vivax*
*Leishmania braziliensis*
*Leishmania chagasi*
*Leishmania donovani*
*Leishmania infantum*
*Leishmania major*
*Leishmania mexicana* (many subspecies)
*Leishmania tropica*
*Trypanosoma cruzi*
*Trypanosoma brucei gambiense*
*Trypanosoma brucei rhodesiense*
Protozoans

Mosquitoes

- Babesia microti
- Babesia divergens
- Plasmodium falciparum
- Plasmodium malariae
- Plasmodium ovale
- Plasmodium vivax
- Leishmania braziliensis
- Leishmania chagasi
- Leishmania donovani
- Leishmania infantum
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- Leishmania mexicana (many subspecies)
- Leishmania tropica
- Trypanosoma cruzi
- Trypanosoma brucei gambiense
- Trypanosoma brucei rhodesiense

Kissing Bugs

- Rhodnius prolixus

Ticks

- Dermacentor andersoni

Sandflies

- Phlebotomus papatasi

Tsetse Flies

- Glossina palpalis
Protozoans

Babesia microti
Babesia divergens
Plasmodium falciparum
Plasmodium malariae
Plasmodium ovale
Plasmodium vivax
Leishmania braziliensis
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Leishmania tropica
Trypanosoma cruzi
Trypanosoma brucei gambiense
Trypanosoma brucei rhodesiense

Photo: CDC
Agents Transmitted By Vectors:

Helminths
Helminths

Wuchereria bancrofti
Brugia malayi
Mansonella ozzardi
Mansonella perstans
Mansonella streptocerca
Onchocerca volvulus
Loa loa
Helminths

- Wuchereria bancrofti
- Brugia malayi
- Mansonella ozzardi
- Mansonella perstans
- Mansonella streptocerca
- Onchocerca volvulus
- Loa loa
Helminths

- Wuchereria bancrofti
- Brugia malayi
- Mansonella ozzardi
- Onchocerca volvulus
- Mansonella perstans
- Mansonella streptocerca
- Loa loa

Mosquitoes

Biting Midges

Blackflies

Tabanid Flies
Agents Transmitted By Vectors:

Viruses
Dengue Fever
World Distribution of Dengue - 2000

Areas infested with *Aedes aegypti*
Areas with *Aedes aegypti* and dengue epidemic activity

CDC
Dengue Is On The Rise

Reported Cases of Dengue/DHF

South-East Asia Region*

*Countries included in this WHO region (SEARO)
Bangladesh, Bhutan, Democratic People's Republic of Korea, India, Indonesia, Maldives, Myanmar, Nepal, Sri Lanka, Thailand
Distribution Of Dengue Transmission In Dhaka

Aedes aegypti
Dengue Outbreak 2000 in Bangladesh Urban Areas

- Death: over 100 including doctors
- Affected: over 10,000
- Risk: those affected in 2000 are likely to be vulnerable to other 3 serotypes in 2001...
- Prevention: collective and not individual effort in each locality
- Clinical Guide: WHO Guidelines
Vector control

Environmental management

1. Environmental modification
2. Environmental manipulation
3. Changes to human habitation or behaviour
Environmental management

- Improvement water supply
- Solid waste management
- Modification man-made larvae habitats
- Chemical control
- Biological control
Protozoans

*Babesia microti*
*Babesia divergens*
*Plasmodium falciparum*
*Plasmodium malariae*
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*Trypanosoma brucei rhodesiense*
The Malarias

*Plasmodium falciparum*
*Plasmodium vivax*
*Plasmodium ovale*
*Plasmodium malariae*
Within The Last 100 years, As Many People Have Died Throughout The World From Malaria As Now Live Within The United States
Two out of three deaths among children and young adults in Africa and Southeast Asia are due to seven causes (ages 0 - 44)

- Other Causes: 43%
- AIDS: 13%
- Malaria: 6%
- TB: 4%
- Diarrhoeal diseases: 9%
- Measles: 5%
- Maternal & perinatal conditions: 11%
- ARI: 9%

Source: World Health Organization/CDS
LEADING INFECTIOUS KILLERS
Six high-burden diseases cause 90% of total disease deaths

- Acute respiratory infections
- AIDS*
- Diarrhoeal diseases
- TB
- Malaria
- Measles

*HIV-positive people who have died with TB have been included among AIDS deaths

Source: World Health Organization/CDS 1999
World Distribution Of Malaria
Distribution Of Malaria In Bangladesh
Dominant Mosquito Vector Species In Bangladesh

An. dirus
An. minimus
An. philipinensis
An. sundaicus
An. aconitus
An. anularis
An. vagus

Anopheles dirus
Distribution Of Malaria In Bhutan
Plasmodium falciparum

Sporozoites injected during second blood meal

Gametocytes ingested during first blood meal

Sporozoites enter bloodstream

Macrogametocyte Microgametocyte

EXOERYTHROCYTIC CYCLE

Infected liver cell ruptures, releases merozoites

"Signet" ring stage in peripheral blood

ERYTHROCYTIC CYCLE

Deep vascular schizogony

*Parasitic Diseases* 4th Ed. © Apple Trees Productions, LLC., Pub. P.O. Box 260, New York, NY 10032
Mosquito Cycle (Sporogony)

- Sporozoites are injected into human host when infected mosquito takes second blood meal.
- Gametocytes in peripheral blood.
- Gametocytes ingested with blood meal.
- Gamete formation occurs in stomach.
- Sporozoites migrate to salivary glands.
- Exflagellation and fertilization occur in stomach.
- Oocyst formation occurs in wall of stomach.
- Sporozoite formation and release occur in stomach.
Exflagellation of the microgametocyte of a malaria parasite
Portion of an infected mosquito stomach. Note numerous oocysts on outer wall.
The Sporozoite Stage Of Malaria
Entry Of Sporozoites Into Parenchymal Cells Of The Liver

From: Ute Frevert
NYU School of Medicine
Exoerythrocytic stages of malaria in liver parenchymal cell
Child infected with malaria, probably *P. malariae*. Note enlarged spleen.
Cerebral malaria: experimental infection in monkey

stain: tissue Giemsa
TEM of RBC infected with *Plasmodium falciparum*

“Knobs” of histidine-rich protein. Points of attachment to endothelial cell

N = Nucleus; F = food vacuole
Diagnosis
Diagnosis of *Plasmodium falciparum* by blood smear

Gametocyte stage

Signet Ring Stage
Diagnosis of *Plasmodium malariae* by blood smear

Note infected RBC is about the same diameter as non-infected cells
Diagnosis of *Plasmodium vivax*
by blood smear

Note infected RBC is larger in diameter than non-infected RBCs.
Treatment
Drugs Of Choice:

A. Parent Compound

Quinine

B. Older Derivative

Chloroquine

C. Newer Derivative

Mefloquine
Drug-resistant Malaria

From: CDC
Drug-resistant Malaria

Red - chloroquine resistant
Green - chloroquine sensitive
Black - chloroquine and mefloquine resistant
Artemisinin

In Vitro Interactions of Artemisinin with Atovaquone, Quinine, and Mefloquine against *Plasmodium falciparum*

S. Gupta,¹ M. M. Thapar,¹ W. H. Wernsdorfer,² and A. Björkman¹*
Leishmaniasis
Co-distribution Of Leishmaniasis and HIV/AIDS

Map: WHO
Leishmania donovani
Leishmania tropica
Leishmania major
Macrophage With Two Promastigotes

Photo: K. P. Chang
Leishmania donovani

Sandfly ingests blood, injects parasites

Promptigote

Intracellular amastigotes invade phagocytic cells

Reservoir hosts

Cycle in fly

Liver

Spleen

Bone marrow

PATHOLOGY

Sandfly ingests blood, acquires infection

Post Kala-azar dermal Leishmanoid reaction

Cell death
Leishmania tropica

Sandfly ingests blood, injects parasites

Promastigote

Intracellular amastigotes invade macrophages

Amastigotes

PATHOLOGY

Cutaneous lesion

Reservoir hosts

Cycle in fly

Sandfly ingests blood, acquires infection
Feeding Sandfly
Multiple Lesions Of Leishmania tropica
Single Resolving Lesion Of *Leishmania tropica*
Resolved Lesion Of *Leishmania tropica*
“Chichlero’s” Ulcer
Hepatosplenomegaly From Leishmania donovani

Photo: WHO
Macrophage With Two Promastigotes

Photo: K. P. Chang
Diagnosis
Biopsy
Bone Marrow Aspiration
Stained With Giemsa

Amastigote Stage
In Macrophage

Photo: CDC
Culture Promastigotes In Insect Culture Medium
Treatment
Drug Of Choice: Sodium Stibogluconate And Derivatives

Antimony meglumine
Post-Kala Azar Dermal Leishmanoid

Photo: F. Opperdos
Filariasis
## Morbidity and Mortality

<table>
<thead>
<tr>
<th>Parasitic Disease</th>
<th>Number of Infections (millions)</th>
<th>Morbidity (%)</th>
<th>Mortality (number) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ascariasis</strong></td>
<td>1,472</td>
<td>23</td>
<td>60,000 0.004</td>
</tr>
<tr>
<td><strong>Hookworm infections</strong></td>
<td>1,298</td>
<td>12</td>
<td>65,000 0.005</td>
</tr>
<tr>
<td><strong>Lymphatic filariasis</strong></td>
<td>120</td>
<td>37</td>
<td></td>
</tr>
<tr>
<td><strong>Onchocerciasis</strong></td>
<td>18</td>
<td>4.2</td>
<td>45,000 0.25</td>
</tr>
<tr>
<td><strong>Schistosomiasis</strong></td>
<td>200</td>
<td>10</td>
<td>20,000 0.01</td>
</tr>
<tr>
<td><strong>Trichuriasis</strong></td>
<td>1,049</td>
<td>21</td>
<td>10,000 0.001</td>
</tr>
</tbody>
</table>
Lymphatic Filariasis In South Asia
Pathogenesis*

*or so we thought!

Live Worms → 10 years → Dead Worms
Wolbachia sp. of bacteria cause the pathology associated with filariasis
Wolbachia are gram-negative bacteria that form intracellular inherited infections in many invertebrates. They are extremely common with 20-75% of all insects being infected. In addition, nematodes, mites, and spiders harbor this symbiotic infection.
Diagnosis
An analysis of the safety of the single dose, two drug regimens used in programmes to eliminate lymphatic filariasis


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17 Kenya Medical Research Institute (KEMRI), Nairobi, Kenya
18 Filariasis Research Laboratory, Faculty of Medicine, University of Ruhuna, Galle, Sri Lanka
FIG. 1. The multifactorial benefits and linkage potentials of the Global Programme to Eliminate Lymphatic Filariasis, which is based on mass drug administrations (with albendazole–ivermectin or albendazole–dihethylcarbamazine), use of salt fortified with diethylcarbamazine (DEC salt), and, in limited settings, vector control.
TABLE 2. The broad anti-parasite effectiveness of two of the drugs used to control lymphatic filariasis (Ottesen et al., 1999)

<table>
<thead>
<tr>
<th>Disease/parasite</th>
<th>Ivermectin</th>
<th>Albendazole*</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Ascaris</em></td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td><em>Strongyloides</em></td>
<td>95</td>
<td>45</td>
</tr>
<tr>
<td><em>Enterobius</em></td>
<td>85</td>
<td>85</td>
</tr>
<tr>
<td><em>Trichuris</em></td>
<td>10–50</td>
<td>40–60</td>
</tr>
<tr>
<td>Hookworm</td>
<td>0–20</td>
<td>95</td>
</tr>
<tr>
<td>Larva migrans</td>
<td>100</td>
<td>80</td>
</tr>
<tr>
<td>Onchocerciasis</td>
<td>95</td>
<td>0</td>
</tr>
<tr>
<td>Lice</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>Scabies</td>
<td>100</td>
<td>0</td>
</tr>
</tbody>
</table>

*Multiple doses of albendazole are also effective against cysticercosis, echinococcosis, giardiasis, trichomonads, Microsporidia and Cryptosporidium.
Drug of choice: Ivermectin

Mode of Action:
Blocks Cl\(^{-}\) ion channels, inhibits γ-aminobutyric acid receptor complex.
Vector Control
Vaccine Development