Health on the Homefront:
Malaria Incidence in Relation to Country of Birth and Exposure Region among Navy and Marine Corps Active Duty Service Members

Disclaimer

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Outline

- Background of malaria
  - Transmission, diagnosis, treatment, prevention
  - History and current statistics
  - Travel risk
  - Military impact and policies
  - Navy and Marine Corps malaria surveillance

- Analysis of Navy and Marine Corps malaria cases
  - Case identification methods
  - Overall trends and demographics
  - Travel characteristics
  - Discussion of results

What is Malaria?

- Malaria is a serious disease caused by the *Plasmodium* parasite
  - Four species cause disease in humans: *P. falciparum*, *P. vivax*, *P. ovale*, *P. malariae*
  - *P. falciparum* infections most likely to cause severe disease

- Transmission via mosquito vector (*Anopheles*)
  - Incubation period after infective bite typically 7-30 days
Malaria Diagnosis

- Symptoms of malaria include:
  - Fever
  - Chills
  - Sweats
  - Headaches
  - Nausea & vomiting
  - Body aches
  - General malaise

- Symptoms may be attributed to influenza, a cold, or other infections in countries where malaria is infrequent
  - Important to consider recent travel
Malaria Diagnosis

- Malaria is diagnosed using blood smears, detection of antigens through rapid diagnostic tests (RDTs), or molecular diagnosis using polymerase chain reaction (PCR) tests.
  - Blood smears are gold standard for laboratory confirmation
  - All RDTs should be followed up with blood smears to confirm results
  - PCR useful for confirming species of malaria after establishing a positive diagnosis

Malaria Treatment

- Treatment depends on several factors:
  - Species of infecting parasite
  - Area where the infection was acquired and the drug resistance status of that area
  - Clinical status of the patient
  - Co-morbid conditions
  - Drug allergies or other medications taken

- Drugs used include chloroquine, mefloquine (Lariam), atovaquone-proguanil (Malarone), artemether-lumefantrine (Coartem), quinine, quinidine, doxycycline, clindamycin
Malaria Prevention

- Avoidance of mosquito bites through use of repellents or insecticide-treated bed nets

- Drugs for malaria prophylaxis:
  - Atovaquone-proguanil (Malarone)
  - Chloroquine
  - Doxycycline
  - Mefloquine (Lariam)
  - Primaquine

Malaria Statistics

- In 2012, there were approximately 207 million cases of malaria and 627,000 malaria deaths worldwide.
  - 80% of cases in sub-Saharan Africa
  - Most deaths in sub-Saharan Africa (90%) and in children under five years of age (77%)

- Between 2000 and 2012, malaria mortality rates have fallen more than 42% globally and by 49% in Africa

- Approximately half of countries with ongoing malaria transmission are on track to meet the World Health Assembly target of a 75% reduction in malaria cases by 2015 (compared to 2000)

Source: World Malaria Report 2013 (WHO)
Malaria Statistics

- In the US, approximately 1,500 cases of malaria are reported every year
  - Most cases are those returning from travel to a malaria-endemic country

- From 1957 to 2011, 63 outbreaks of locally transmitted mosquito-borne malaria have occurred in the US
  - Local mosquitoes become infected by biting persons carrying malaria parasites (acquired in endemic areas)
  - Infected local mosquitoes transmit malaria to local residents

- From 1963 to 2011, 97 cases of transfusion-transmitted malaria were reported in the US

Source: CDC

Travel Risk

- Risk from travel to countries where malaria is endemic
  - *P. falciparum* predominant in Africa
  - *P. vivax* predominant in the Middle East and Asia

- 104 endemic countries (as of 2012)
**VFR Travel**

- Increased risk from traveling for “Visiting Friends and Relatives” (VFR)
  - Persons who return to their country of origin to visit friends and relatives still living in that country

- In 2011, VFR travelers accounted for the majority of reported malaria cases among patients for whom reason for travel was known (70%)
  - 86% of US children with malaria were VFR travelers

Source: Malaria Surveillance – United States, 2011 (CDC)

**Malaria and the Military**

- Navy and Marine Corps active duty service members are at increased risk for malaria due to deployments to malaria-endemic regions
  - Stand-up of United States African Command (AFRICOM) in 2008 increased deployments to Africa, many to highly malarious countries
  - Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF) increased deployments to the Middle East

- Cases of malaria related to deployments have been well documented
  - Somalia 1993
  - Liberia 2003

- Impact of VFR travel in the military not well known
Military Malaria Policies

- Navy Bureau of Medicine and Surgery (BUMED) instruction for malaria prevention and control provides guidelines for assessing risk and preventing and treating malaria among active duty personnel, other beneficiaries, and civilian employees.

- The Navy and Marine Corps Public Health Center (NMCPHC) Pocket Guide to Malaria Prevention and Control is the primary source for malaria guidance.

Military Malaria Policies: Chemoprophylaxis

- Chemoprophylaxis required for travel to locations where potential malaria attack rates (without the use of antimalarials) are 0.2% per month or more
  - Chloroquine first choice (areas with no chloroquine-resistant malaria)
  - Atovaquone-proguanil (Malarone) or doxycycline acceptable for areas with chloroquine-resistant malaria
  - Mefloquine should be reserved for individuals with intolerance or contraindications to both first-line medications
Military Malaria Policies: Chemoprophylaxis

- Prophylactic regimens vary based on the specific drug
  - Chloroquine taken weekly starting one week before travel, Malarone and doxycycline taken daily starting one day before travel
  - Chloroquine and doxycycline continue for four weeks after returning, Malarone continues for one week

Military Malaria Policies: Mefloquine

- 2009 Department of Defense (DOD) directive promotes doxycycline use for prophylaxis instead of mefloquine

- Mefloquine should not be given to anyone with the following contraindications:
  - Active depression, or recent history of depression
  - Generalized anxiety disorder
  - Psychosis
  - Schizophrenia
  - Other major psychiatric disorders
  - History of convulsions
  - Recent history of traumatic brain injury (TBI) or symptomatic TBI
Military Malaria Policies: Other Preventive Measures

- Personal protective measures
  - Barrier methods

- Unit protective measures
  - Discipline and training
  - Treatment of clothing and equipment
  - Location of base camp
  - Vector control

Reporting Malaria in the Military

- Malaria is a reportable condition in the military (Armed Forces Reportable Event Guidelines)
  - Suspected or confirmed cases should be reported within 24 hours of diagnosis
  - Details of relevant travel and/or deployment history, chemoprophylaxis compliance, and all related laboratory tests should be included

- A medical event report (MER) is created for each case using the Disease Reporting System-internet (DRSi)
DRSi

- DRSi is a system through which preventive medicine technicians report information about certain medical events that occur at their facilities.

- BUMED instruction requires all reportable medical events (RMEs) to be entered into DRSi for all DOD beneficiaries receiving care at Navy MTFs.

- 86 medical events required to be reported (Armed Forces Reportable Event Guidelines)
  - Reportable events are those which represent a significant threat to public health and military readiness.
  - Infectious (chlamydia, Salmonella) and non-infectious (heat and cold injuries) conditions included.

Disease Surveillance at the EDC

- EpiData Center Department
  - Created in 2005, part of NMCPHC.
  - Provides epidemiologic services to Department of the Navy customers.

- Electronic data sources include:
  - Inpatient and outpatient medical care.
  - Deployment history.
  - Self-reported health histories (deployment, yearly physical readiness test).
  - Personnel files (alcohol and drug incidents, monthly personnel files, physical readiness testing).
  - Prescription drug information.
  - Pathology and chemistry testing information.
Malaria Surveillance at the EDC

- The EDC conducts daily surveillance for most reportable conditions, including malaria
  - Laboratory-based surveillance system
    - Queries for over 50 reportable diseases
    - “Live” algorithms that are continuously evaluated to ensure alignment with clinical/ordering practices at MTFs
  - Cases across all Department of Defense (DOD) military treatment facilities (MTFs) worldwide
Laboratory Data

- The EDC receives daily feeds of Health Level 7 (HL7)-formatted laboratory data from Defense Health Services System (DHSS)

- Records originate from each DOD MTF’s Composite Health Care System (CHCS) and are transmitted to DHSS upon certification

- Not available:
  - Shipboard or field operations
  - Procedures and tests performed outside the Military Health System (MHS)

Laboratory Data

- Chemistry: laboratory-certified results for antibody tests (IgG, IgM, IgE), PCR tests, blood/urine tests (e.g., cholesterol, diabetic testing)
  - Database timeframe: May 2004 – present

- Microbiology: laboratory-certified results for bacterial, viral, and fungal cultures
  - Database timeframe: May 2004 – present
Malaria Linelist

- Additional malaria surveillance on a monthly basis for Navy and Marine Corps service members
  - Malaria linelist of active duty Navy and Marine Corps cases (from 2005 forward)
  - Uses multiple data sources to identify and describe cases
    - DRSi
    - Laboratory data
    - Inpatient data
    - Personnel records

- Provides ongoing surveillance to assist with case ascertainment; policy and program support and evaluation

Malaria Linelist

- The use of multiple data sources in the linelist allows compilation of information regarding all aspects of a malaria case:
  - Demographic information
    - Country of birth
  - Species of malaria
  - Travel information
    - Location
    - Reason for travel
Objective

- Describe the incidence of malaria among active duty Navy and Marine Corps personnel in relation to country of birth and exposure region over a nine-year period

Methods

- Malaria cases from January 2005 to December 2013 identified using three data sources:
  - DRSi
  - Laboratory data
  - Inpatient data

- A person needed to have a malaria record in at least one database to be considered a case.
Methods: DRSi

- DRSi is used to report cases of reportable conditions as indicated in the Armed Forces Reportable Event Guidelines.

- Case definition: medical event report for malaria

- Guidelines for reporting a case of malaria: (Armed Forces Reportable Event Guidelines, March 2012)
  - Suspected: Positive rapid test
  - Confirmed: Detection and specific identification of malaria parasites by microscopy on blood smear
  - Required documentation of relevant travel/deployment history, prophylaxis regimen

Methods: Laboratory

- Chemistry and microbiology records originate from CHCS in fixed MTFs.

- Case definition: positive smears, positive rapid diagnostic tests, or positive PCRs for malaria
Methods: Inpatient

- The EDC receives records of inpatient healthcare services at fixed MTFs on a monthly basis
  - All DOD facilities worldwide
  - Hospitalization information, including admission/discharge dates and International Classification, Ninth Revision, Clinical Modification (ICD-9-CM) diagnosis codes

- Case definition: inpatient record with the ICD-9-CM code for malaria (084) in the primary diagnosis field

Methods: Travel Information

- Travel information was determined using the MER when available.
  - Country of exposure
  - Reason for travel

- Cases with missing travel information were further reviewed using the Armed Forces Health Longitudinal Technology Application (AHLTA).
  - Electronic medical records system used by DOD MTFs
  - Outpatient medical encounter information, including provider notes and laboratory records
Methods: Travel Information

- Countries of travel grouped into regions based on geographic location:
  - Africa, Middle East, Southeast Asia, Caribbean

- Three travel reason categories:
  - Duty: Deployed or assigned to the country of exposure
  - Personal: Travel on leave, not related to a deployment or assignment
  - Unknown: Reason for travel unable to be determined from MER or AHLTA

Methods: Additional Data Sources

- Country of birth determined using the Defense Manpower Data Center (DMDC) database
  - Personnel roster for Navy and Marine Corps service members

- Population counts for each year retrieved from the Defense Medical Epidemiology Database (DMED) maintained by the Armed Forces Health Surveillance Center (AFHSC)
  - Counts used for denominators to calculate yearly malaria incidence rates
## Demographics of Malaria Cases, 2005-2013 (n=112)

<table>
<thead>
<tr>
<th>Service</th>
<th>Gender</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Navy</td>
<td>Male</td>
<td>69</td>
<td>61.6%</td>
</tr>
<tr>
<td>Marine Corps</td>
<td>Female</td>
<td>43</td>
<td>38.4%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Age Category</th>
<th>Country of Birth</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;20</td>
<td>United States</td>
<td>2</td>
<td>1.8%</td>
</tr>
<tr>
<td>20-29</td>
<td>Foreign Born</td>
<td>70</td>
<td>62.5%</td>
</tr>
<tr>
<td>30-39</td>
<td>Africa</td>
<td>25</td>
<td>22.3%</td>
</tr>
<tr>
<td>40-49</td>
<td>Europe</td>
<td>12</td>
<td>10.7%</td>
</tr>
<tr>
<td>50+</td>
<td>Asia</td>
<td>2</td>
<td>1.8%</td>
</tr>
<tr>
<td>Unknown</td>
<td>Caribbean</td>
<td>1</td>
<td>0.9%</td>
</tr>
<tr>
<td>Unknown</td>
<td>Unknown</td>
<td>1</td>
<td>0.9%</td>
</tr>
</tbody>
</table>

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## Malaria Incidence Rates by Year and Service, 2005-2013

- **Stand-up of AFRICOM 1 Oct 2008**

<table>
<thead>
<tr>
<th>Year</th>
<th>Rate per 100,000 Service Members</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>Navy: 2.5, Marine Corps: 1.8</td>
</tr>
<tr>
<td>2006</td>
<td>Navy: 3.0, Marine Corps: 2.0</td>
</tr>
<tr>
<td>2007</td>
<td>Navy: 1.5, Marine Corps: 1.0</td>
</tr>
<tr>
<td>2008</td>
<td>Navy: 2.2, Marine Corps: 1.4</td>
</tr>
<tr>
<td>2009</td>
<td>Navy: 2.8, Marine Corps: 2.1</td>
</tr>
<tr>
<td>2010</td>
<td>Navy: 3.2, Marine Corps: 2.4</td>
</tr>
<tr>
<td>2011</td>
<td>Navy: 6.0, Marine Corps: 5.5</td>
</tr>
<tr>
<td>2012</td>
<td>Navy: 1.0, Marine Corps: 0.5</td>
</tr>
<tr>
<td>2013</td>
<td>Navy: 1.2, Marine Corps: 0.6</td>
</tr>
</tbody>
</table>
### Species of Malaria Infections*, 2005-2013

<table>
<thead>
<tr>
<th>Species</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>P. falciparum</em></td>
<td>56</td>
<td>50.0%</td>
</tr>
<tr>
<td><em>P. ovale</em></td>
<td>3</td>
<td>2.7%</td>
</tr>
<tr>
<td><em>P. vivax</em></td>
<td>21</td>
<td>18.8%</td>
</tr>
<tr>
<td>Unspecified</td>
<td>33</td>
<td>29.5%</td>
</tr>
</tbody>
</table>

* One dual falciparum/vivax case was counted once for each species.

### Travel Characteristics of Malaria Cases, 2005-2013

<table>
<thead>
<tr>
<th>Region of Exposure</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>66</td>
<td>58.9%</td>
</tr>
<tr>
<td>Middle East</td>
<td>26</td>
<td>23.2%</td>
</tr>
<tr>
<td>Caribbean</td>
<td>8</td>
<td>7.1%</td>
</tr>
<tr>
<td>Southeast Asia</td>
<td>8</td>
<td>7.1%</td>
</tr>
<tr>
<td>Unknown</td>
<td>4</td>
<td>3.6%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reason for Travel</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duty</td>
<td>68</td>
<td>60.7%</td>
</tr>
<tr>
<td>Personal</td>
<td>30</td>
<td>26.8%</td>
</tr>
<tr>
<td>Unknown</td>
<td>14</td>
<td>12.5%</td>
</tr>
</tbody>
</table>
### Reason for Travel by Country of Birth, 2005-2013

<table>
<thead>
<tr>
<th></th>
<th>Duty (N=68)</th>
<th>Personal (N=30)</th>
<th>Unknown (N=14)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>US Born</td>
<td>Foreign Born</td>
<td>Unknown</td>
</tr>
<tr>
<td>Duty</td>
<td>62 (92.2%)</td>
<td>4 (5.9%)</td>
<td>2 (2.9%)</td>
</tr>
<tr>
<td>Personal</td>
<td>5 (16.7%)</td>
<td>23 (76.7%)</td>
<td>2 (6.7%)</td>
</tr>
<tr>
<td>Unknown</td>
<td>8 (57.1%)</td>
<td>5 (35.7%)</td>
<td>1 (7.1%)</td>
</tr>
</tbody>
</table>

### Reason for Travel by Region of Exposure, 2005-2013

<table>
<thead>
<tr>
<th></th>
<th>Africa</th>
<th>Caribbean</th>
<th>Middle East</th>
<th>Southeast Asia</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duty</td>
<td>31 (45.6%)</td>
<td>5 (7.4%)</td>
<td>25 (36.8%)</td>
<td>7 (10.3%)</td>
<td>0 (0.0%)</td>
</tr>
<tr>
<td>Personal</td>
<td>28 (93.3%)</td>
<td>1 (3.3%)</td>
<td>1 (3.3%)</td>
<td>0 (0.0%)</td>
<td>0 (0.0%)</td>
</tr>
<tr>
<td>Unknown</td>
<td>7 (50.0%)</td>
<td>2 (14.3%)</td>
<td>0 (0.0%)</td>
<td>1 (7.1%)</td>
<td>4 (28.6%)</td>
</tr>
</tbody>
</table>
### Reason for Travel by Species of Malaria Infection*, 2005-2013

<table>
<thead>
<tr>
<th></th>
<th>P. falciparum</th>
<th>P. ovale</th>
<th>P. vivax</th>
<th>Unspecified</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duty (N=68)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25 (36.8%)</td>
<td>2 (2.9%)</td>
<td>17 (25.0%)</td>
<td>24 (35.3%)</td>
<td></td>
</tr>
<tr>
<td>Personal (N=30)</td>
<td>25 (83.3%)</td>
<td>1 (3.3%)</td>
<td>1 (3.3%)</td>
<td>4 (13.3%)</td>
</tr>
<tr>
<td>Unknown (N=14)</td>
<td>6 (42.9%)</td>
<td>0 (0.0%)</td>
<td>3 (21.4%)</td>
<td>5 (35.7%)</td>
</tr>
</tbody>
</table>

* One dual falciparum/vivax case (personal travel) was counted once for each species.

### Duty Travelers (N=68)

- Majority were US-born (91.2%)

- Travel to Africa (N=31, 45.6%) and Middle East (N=25, 36.8%) most common
  - Several different African countries; Ghana (N=8, 25.8%) most frequent
  - Middle East: Nearly all were Afghanistan (N=20, 80.0%) exposures; two were in Kyrgyzstan and three did not specify countries

- Only three Southeast Asia exposures (N=7, 10.3%) had specific countries identified (Vietnam, Malaysia, Philippines)

- Five duty exposures (7.4%) were in Haiti in spring 2010

- 72% of cases were *P. falciparum* or unspecified species
Personal Travelers (N=30)

- Majority were foreign-born (76.7%)
  - Most frequent countries of birth among foreign-born travelers: Ghana and Nigeria (both N=8, 25.0%)

- For foreign-born personal travelers, all regions of travel were the same as the region of birth
  - For those with specific countries of travel identified, all were the same as the country of birth

- For all personal travelers, all but two traveled to Africa
  - Most frequent countries: Nigeria (N=8, 26.7%) and Ghana (N=7, 23.3%)

- All but six (83.3%) were *P. falciparum* infections

Discussion

- 112 malaria cases among active duty Navy and Marine Corps personnel from 2005 to 2013
- No clear trends observed across this timeframe
- Peaks related to clusters of cases from a particular exposure
Discussion

- Ramp up of forces to support activities in AFRICOM over this time period
  - AFRICOM stand-up: 1 October 2008

- Majority of Navy cases related to African travel
  - Increase in Navy cases visible after 2008

- Marine Corps peak rate in 2011 (6.5 per 100,000) related to mission in Ghana in spring 2011

Discussion

- All but one case from the Caribbean were related to travel in Haiti
  - Five duty-related and two unknown travel reasons in spring 2010
  - Recovery efforts in response to the January earthquake

- Increased risk for malaria when responding to disaster recovery missions, particularly in countries where malaria is endemic
  - Large amount of time spent outside, flooding/pooling of water, fluid and disorganized environments
Discussion

- Results show that VFR travel may be a concern for active duty Navy and Marine Corps personnel
  - Over one-fourth of all cases were related to personal travel, and most were foreign-born service members
  - Travel to Africa and infection with *P. falciparum* most common
- Motivation for travel does not differ from civilians for VFR travel, however, there is the potential impact on mission readiness as well as prophylaxis requirements for active duty
- Studies in civilian VFR travelers show many do not fully realize or accept the risk for malaria in their native countries and may not be as compliant with prophylaxis

Focus areas for future malaria prevention and surveillance for NMCPHC and the Department of the Navy:
- Provide continuing education on malaria risks, prophylaxis, care
- Use social media to reach beneficiaries that may be doing personal travel (not duty related) to increase awareness
- Continue surveillance and inform leadership on changes in trends or increased infections
- Create focused training for units pre-deployment
- Create a culture of prevention
- Publish findings, start conversation
Limitations

- Databases used in this analysis do not include records from shipboard facilities, battalion aid stations, in-theater facilities, or care not within an MTF.
- Diagnoses in inpatient encounters depend on correct ICD-9-CM coding practices.
- Laboratory data contain many free-text test results, requiring extensive queries.

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