• Epidemiology of Knowlesi Malaria in Malaysia
• Factors Contributing to Increase of Reported *P. Knowlesi* Infections
• Risk Factors of Knowlesi Malaria Infection
• Vectors of Knowlesi Malaria In Malaysia
• Prevention and Control
  • Vector Control
  • Personal protection
• Health Education
• Ongoing Research on Knowlesi Malaria in Malaysia
### Malaria [all] Cases & Malaria Death in Malaysia, 2000 – 2018

<table>
<thead>
<tr>
<th>Year</th>
<th>Imported Human Malaria</th>
<th>Introduced</th>
<th>Indigenous Human Malaria</th>
<th>Zoonotic malaria (Pk)</th>
<th>Malaria Death</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>3432</td>
<td>78</td>
<td>9273</td>
<td>0</td>
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<tr>
<td>2001</td>
<td>3972</td>
<td>95</td>
<td>8808</td>
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<tr>
<td>2002</td>
<td>3367</td>
<td>107</td>
<td>7652</td>
<td>0</td>
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<tr>
<td>2003</td>
<td>2074</td>
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<td>4264</td>
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<tr>
<td>2004</td>
<td>2165</td>
<td>33</td>
<td>3989</td>
<td>0</td>
<td>36</td>
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<tr>
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<td>2240</td>
<td>26</td>
<td>3329</td>
<td>0</td>
<td>30</td>
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<tr>
<td>2006</td>
<td>1377</td>
<td>7</td>
<td>3917</td>
<td>0</td>
<td>26</td>
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<tr>
<td>2007</td>
<td>1408</td>
<td>3</td>
<td>4048</td>
<td>0</td>
<td>18</td>
</tr>
<tr>
<td>2008</td>
<td>943</td>
<td>16</td>
<td>6071</td>
<td>376</td>
<td>30</td>
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<tr>
<td>2009</td>
<td>143</td>
<td>0</td>
<td>5955</td>
<td>912</td>
<td>26</td>
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<tr>
<td>2010</td>
<td>947</td>
<td>21</td>
<td>5194</td>
<td>509</td>
<td>33</td>
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<td>2011</td>
<td>288</td>
<td>0</td>
<td>4164</td>
<td>854</td>
<td>18</td>
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<tr>
<td>2012</td>
<td>862</td>
<td>21</td>
<td>2050</td>
<td>1813</td>
<td>16</td>
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<tr>
<td>2013</td>
<td>816</td>
<td>1092</td>
<td>1942</td>
<td>1942</td>
<td>14</td>
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<tr>
<td>2014</td>
<td>730</td>
<td>604</td>
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<td>2584</td>
<td>9</td>
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<tr>
<td>2015</td>
<td>428</td>
<td>242</td>
<td>1640</td>
<td>1640</td>
<td>8</td>
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<tr>
<td>2016</td>
<td>420</td>
<td>282</td>
<td>1600</td>
<td>1600</td>
<td>2</td>
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<tr>
<td>2017</td>
<td>415</td>
<td>85</td>
<td>3614</td>
<td>3614</td>
<td>12</td>
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<tr>
<td>2018</td>
<td>478</td>
<td>0</td>
<td>4131</td>
<td>4131</td>
<td>12</td>
</tr>
</tbody>
</table>

- **Number of Cases**: 14,000 to 0
- **Malaria Death**: 50 to 0

**2018, n=4,630**
Distribution of Malaria by Parasite Species in Sabah, Sarawak, and Peninsular Malaysia, 2018

Number of Cases

- P. falciparum
- P. vivax
- P. malariae
- P. ovale
- P. knowlesi
- Mixed Infection

n=4,630
Distribution of Malaria (all) by Species, Malaysia, 2018

- P. knowlesi; 4131; 89%
- P. falciparum; 182; 4%
- P. vivax; 284; 6%
- P. malariae; 13; 0%
- P. ovale; 14; 1%
- Mixed Infection; 6; 0%

Human Malaria: 499
- Import: 478
- Introduced: 21

n=4,630
Geospatial Distribution of Zoonotic Malaria, Malaysia, 2017
Factors Contributing to Increase of Reported *P. knowlesi* Infections

- Improved diagnostic capacity for Pk in 2009 – All Pk and Pm cases must be confirmed by PCR
- Reduction in human malaria cases and awareness of Pk
- Loss of relative immunity due to low rates of malaria
- Change in land use patterns creating increased opportunity for spill over of infections to humans – through closer associations with natural reservoir hosts or access to infected vectors

Source: Meeting report of Expert Consultation on *Plasmodium knowlesi* Malaria to Guide Malaria Elimination Strategies, WPRO 2017
## Risk Factors of Knowlesi Malaria Infection

<table>
<thead>
<tr>
<th>Factors</th>
<th>AOR</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age ≥15 years</td>
<td>4.16 (2.09 – 8.29)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Male Gender</td>
<td>4.20 (2.54 – 6.97)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Farmer (occupation)</td>
<td>1.89 (1.07 – 3.35)</td>
<td>0.028</td>
</tr>
<tr>
<td>Palm oil plantation work in past 4 weeks</td>
<td>3.50 (1.34 – 9.15)</td>
<td>0.011</td>
</tr>
<tr>
<td>Clearing vegetation in past 4 weeks</td>
<td>1.89 (1.11 – 3.22)</td>
<td>0.020</td>
</tr>
<tr>
<td>Slept outside walls of any house in past 4 weeks</td>
<td>3.61 (1.48 – 8.85)</td>
<td>0.0049</td>
</tr>
<tr>
<td>Travelled outside village (for &gt;4 days) in past 4 weeks</td>
<td>2.48 (1.45 – 4.23)</td>
<td>0.0010</td>
</tr>
<tr>
<td>Aware of monkeys in past 4 weeks</td>
<td>3.35 (1.91 – 5.88)</td>
<td>0.0048</td>
</tr>
<tr>
<td>Residual insecticide spraying of household walls (&lt;6 months)*</td>
<td>0.52 (0.31 – 0.87)</td>
<td>0.014</td>
</tr>
<tr>
<td>Open roof eaves or gaps in walls</td>
<td>2.18 (1.33 – 3.59)</td>
<td>0.0021</td>
</tr>
</tbody>
</table>

*IRS has an independent protective effect against knowlesi infection

Factors Contributing to Increase of Reported *P. knowlesi* Infections
Vectors of Knowlesi Malaria in Malaysia

- *P. knowlesi* vectors are members of the **An. leucosphyrus group**
  - found throughout the region
  - associated with dense jungle and forest fringe
  - rest and feed outdoors (exophagic) typically after dusk

- In **Sarawak**, the forest breeding **An. latens** was found to be the primary vector
  - **An. latens** has been found to harbor other simian malaria parasites: *P. inui*, *P. coatneyi*, and *P. fieldi*

- **An. balabacensis** implicated as vector in **Sabah** and it prefers to breed in ground pools formed in fruit orchard, rubber and palm oil plantations

- **An. cracens** is considered a major knowlesi malaria vector in **Peninsular Malaysia**
Spatial Distribution of Vector Species for Zoonotic Malaria, Malaysia, 2016

Source: MOH Malaysia
Prevention and Control of Knowlesi Malaria

- **Surveillance**

- **Vector Control**
  - Cluster*: IRS/ITN, larviciding (temephos)
  - ORS (ongoing study in Sabah & Sarawak)

- **Personal protection**
  - Clothing
  - Repellent
  - Mosquito coil

- **Health Education**
  - Leaflets, billboards

*Knowlesi cluster: two or more cases of *knowlesi* malaria cases reported in a locality within 14 days of their date of onset.
Outdoor Residual Spraying (ORS)

• Ongoing study in Sabah and Sarawak (IMR & MOH)
  • Combination of Outdoor Residual Spraying (ORS) and Perimeter Spraying (PS)
• Insecticide:
  • Insecticide used - the new formulation deltamethrin (PolyZone®)
  • PolyZone® features a proprietary polymer layer that protects the active ingredient from weather, irrigation and mechanical abrasion.
  • This controlled release formulation, which resists erosion, ensures residual spraying will continue to control malaria vectors outdoors.
  • two dosages were tested, 25 mg/m² and 30 mg/m²
• Preliminary Results
  • Deltamethrin Polyzone® at 25 mg/m2 was the most effective, giving rise to high mosquito adult mortality and effective knockdown
  • Outdoor residual spraying with this formulation is potentially an effective mean of controlling simian malaria vector.

• PolyZone® features a proprietary polymer layer that protects the active ingredient from weather, irrigation and mechanical abrasion.
• This controlled release formulation, which resists erosion, ensures residual spraying will continue to control malaria vectors outdoors.
Malaria Billboards
Malaria Health Volunteers
Ongoing Research on Knowlesi Malaria in Malaysia

• Effectiveness of Outdoor Residual Spraying (ORS) in control of Zoonotic Malaria
  • Institut of Medical Research (IMR), MOH, Sabah State Health Department, Sarawak State Health Department

• A multi-pronged approach in combating knowlesi malaria
  • Spearheaded by Universiti Malaya,
  • In collaboration with MOH, IIUM, UKM, UPM, Wildlife Department, Sarawak State Health Department.
  • Funded by Ministry of Higher Education (MOHE) under the Long Term research grant scheme (LRGS).

• Pilot Project Using Polyzone For Knowlesi Malaria Control
  • MOH

• Effectiveness of repellent in zoonotic malaria prevention
  • MOH
AGENCIES WORKING WITH US

- Government and private owned plantations
  - Forestry Department
  - Veterinary Department
  - Immigration department
  - Wildlife Department
  - Education Department
  - Labour Department
    - Sabah Parks
    - Special Task Force
  - Land Survey Department
- Sabah Foundation (Plantation Sector)
  - University: UMS
  - Institute of Medical Research
  - NGOs: 4x4 clubs