Supplementary Information

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Figure S1. Yearly domestic *P. vivax* malaria cases in 2009-2018.
Figure S2. Weekly *P. vivax* malaria cases in 2014-2018 based on the data and model prediction with the estimated parameters. The total number of cases is the sum of short, long, and relapse cases.
Model equations

The model is described by delay differential equations (DDEs). Delays are added to the exposed state ($E_h$) for the implementation of different latency periods. There are three latency periods: short, long, and relapse.

\[
\frac{dS_h(t)}{dt} = \mu_h N_h(t) - \lambda_h(t) S_h(t) - (1 - q) p_h T_h(t) - \delta_h S_h(t)
\]

\[
\frac{dE_h(t)}{dt} = \lambda_h(t) S_h(t) - \mu_h E_h(t) - p \lambda_h(t - \tau_s) S_h(t - \tau_s) e^{-\delta_h \tau_s} - (1 - p) \lambda_h(t - \tau_s) S_h(t - \tau_s) e^{-\delta_h \tau_s} + q p_h T_h(t - \tau_s) e^{-\delta_h \tau_s} - \delta_h E_h(t)
\]

\[
\frac{dI_h(t)}{dt} = p \lambda_h(t - \tau_s) S_h(t - \tau_s) e^{-\delta_h \tau_s} + (1 - p) \lambda_h(t - \tau_s) S_h(t - \tau_s) e^{-\delta_h \tau_s} + q \rho_h T_h(t - \tau_s) e^{-\delta_h \tau_s} - \gamma_h I_h(t) - \delta_h I_h(t)
\]

\[
\frac{dT_h(t)}{dt} = \gamma_h I_h(t) - \rho_h T_h(t) - \delta_h T_h(t)
\]

\[
\frac{dA(t)}{dt} = \mu_a(t) (1 - \frac{A(t)}{k_A}) N_v(t) - \mu_v(t) A(t) - \delta_a(t) A(t)
\]

\[
\frac{dS_v(t)}{dt} = \mu_v(t) A(t) - \lambda_v(t) S_v(t) - \delta_v(t) S_v(t)
\]

\[
\frac{dE_v(t)}{dt} = \lambda_v(t) S_v(t) - \nu_v E_v(t) - \delta_v(t) E_v(t)
\]

\[
\frac{dI_v(t)}{dt} = \nu_v E_v(t) - \delta_v(t) I_v(t)
\]

where the force of infections are $\lambda_h(t) = b(t) \beta_{hv} \frac{I_v}{N_h}$ for humans, $\lambda_v(t) = b(t) \beta_{vh} \frac{I_h}{N_v}$ for mosquitoes, and the total number of humans $N_h(t) = S_h(t) + E_h(t) + I_h(t) + T_h(t)$, and the total number of adult mosquitoes $N_v(t) = S_v(t) + E_v(t) + I_v(t)$.
Table S1. Descriptions, values, and references for the model parameters. * temperature-dependent parameters.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Value</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\mu_h$</td>
<td>Birth rate of humans</td>
<td>0.00</td>
<td>[1]</td>
</tr>
<tr>
<td>$\delta_h$</td>
<td>Death rate of humans</td>
<td>0.00</td>
<td>[1]</td>
</tr>
<tr>
<td>$p$</td>
<td>Probability of having short latency period</td>
<td>0.42</td>
<td>Estimated</td>
</tr>
<tr>
<td>$\tau_s$</td>
<td>Average short latency period</td>
<td>14 days</td>
<td>[2]</td>
</tr>
<tr>
<td>$\tau_l$</td>
<td>Average long latency period</td>
<td>314 days</td>
<td>[2]</td>
</tr>
<tr>
<td>$\tau_r$</td>
<td>Average latency period for relapse</td>
<td>207 days</td>
<td>[2]</td>
</tr>
<tr>
<td>$\gamma_h$</td>
<td>Treatment starting rate = 1/Average infectious period</td>
<td>1/41/day</td>
<td>[2]</td>
</tr>
<tr>
<td>$\rho_h$</td>
<td>Recovery rate = 1/Average duration of drug action</td>
<td>1/351/day</td>
<td>[3]</td>
</tr>
<tr>
<td>$q$</td>
<td>Probability of relapse</td>
<td>0.04</td>
<td>[2, 4]</td>
</tr>
</tbody>
</table>

**Mosquito**

| $k_a$   | Vector carrying capacity                                        | $165 \times N_h$ | [5, 6]   |
| $\mu_a^*$ | Egg deposition rate per adult mosquito                         | $\max\{-0.153T^2 + 8.61T - 97.7, 0\}$ | [5-7]   |
| $\delta_a^*$ | Death rate of immature mosquitoes                           | $\min\left\{ 0.002 \exp\left( \frac{(T - 23)^2}{6.05} \right), 1 \right\}$ | [5, 6, 8] |
| $\mu_v^*$ | Maturation rate                                                 | $\frac{e(T)p_E(R)p_L(T,R)p_F(R)}{\tau_{EA}(T)}$ for $16.5 \leq T \leq 35.6$ | [5, 6, 9] |
|         |                                                                  | $e(T) = \frac{T}{\delta(E)}$ with $\delta(E)$ being lifetime number of eggs laid by adult mosquitoes. |         |
\[ f(T) = -0.153T^2 + 8.61T - 97.7 \]: Total number of eggs laid per day.

\[ 1/\delta_v(T) \]: Average adult mosquito lifespan.

\[ p_E(R) = \frac{3.6(R_L-R)}{R_L^2} \]: Daily survival probability of eggs. \( R \) and \( R_L \) denote rainfall (mm) and rainfall threshold (mm), and fixed to 3mm and 76mm, respectively.

\[ p_L(T,R) = e^{-0.00554T + 0.06737} R^2 \]: Daily survival probability of larvae.

\[ p_P(R) = \frac{3R(R_L-R)}{R_L^2} \]: Daily survival probability of pupae.

\[ \tau_{EA}(T) = \frac{-0.00094T^2 + 0.049T - 0.552}{-0.00094T^2 + 0.049T - 0.552} \]: Total development time from egg to adult mosquito.

\[ \delta_v^* \]: Death rate of adult mosquitoes

\[
\begin{align*}
\delta_v^* &= 1 & T \leq -4 \\
&= \frac{29}{570} T + \frac{227}{259} & -4 < T \leq 15 \\
&= \frac{1}{30} & 15 < T \leq 32 \\
&= \frac{29}{570} T - \frac{303}{190} & 32 < T
\end{align*}
\]

\[ \nu_v \]: Progression rate of mosquitoes to the infectious state = 1/Average latency period of mosquitoes

\[ \nu_v = \frac{1}{10 \text{ days}} \]

Transmission

\[ \lambda_h^* \]: Force of infection from mosquitoes to humans

\[ \lambda_h(T) = b_h(T) \beta_h^* \frac{I_v}{N_v} = b(T) \beta_h^* \frac{I_v}{N_h} \]

\[ \lambda_v^* \]: Force of infection from humans to mosquitoes

\[ \lambda_v(T) = b_v(T) \beta_v^* \frac{I_h}{N_h} = b(T) \beta_v^* \frac{I_h}{N_h} \]

\[ b_h^* \]: Biting rate for humans is defined as the number of mosquito bites per human per unit time

\[
\begin{cases}
0.000203T(T-11.7)\sqrt{42.3 - T} \times \frac{N_v}{N_h} & T \geq 0 \\
0 & T < 0
\end{cases}
\]

\[ b_v^* \]: Biting rate for mosquitoes refers to the number of human bites for one mosquito per unit time

\[
\begin{cases}
0.000203T(T-11.7)\sqrt{42.3 - T} & T \geq 0 \\
0 & T < 0
\end{cases}
\]

\[ \beta_{hv} \]: Probability of transmission of infection from an infectious mosquito to a susceptible human

\[ 0.09 \]

\[ \beta_{vh} \]: Probability of transmission of infection from an infectious human to

\[ 0.03 \]
| a susceptible mosquito | 55 ed |
Results obtained from HIRA data

We also explored the monetary influences of RDT introduction on medical costs estimated from the HIRA data as a nationally representative database. As the cost extraction structure in the HIRA is not completely consistent with that in the NHIIH, the estimated average medical costs were smaller than those of the NHIIH, while the difference between the two medical costs increased, leading to a smaller benefit for RDTs as shown in Table S2. Therefore, the resulting IBCR value is the repetition of the sensitivity analysis in the main text, but we can verify how this value is derived.

<table>
<thead>
<tr>
<th>Medical costs ($)</th>
<th>Microscopy only</th>
<th>Microscopy + RDT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benefits ($)</td>
<td>0</td>
<td>12.98</td>
</tr>
<tr>
<td>Costs ($)</td>
<td>11.72</td>
<td>35.63</td>
</tr>
</tbody>
</table>

Table S2. Average expenditure (USD) of medical use, benefits, and costs for one patient in 2019 estimated from HIRA data.

Despite the lower benefit, total medical costs were saved for 10 consecutive years as shown in Table S3 because of the reduced malaria incidence in the microscopy + RDT scenario. In Figure S3, the trend of IBCRs is the same as the results described in the main text; however, in this case, beneficial results can be seen from the ninth year. Hence, the lower the benefit, the more the years of continuous RDT implementation required.

<table>
<thead>
<tr>
<th>Year</th>
<th>Yearly costs ($)</th>
<th>Yearly cumulative costs ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Microscopy only</td>
<td>Microscopy + RDT Saved</td>
</tr>
<tr>
<td></td>
<td>Microscopy + RDT Saved</td>
<td>Microscopy only Microscopy + RDT Saved</td>
</tr>
<tr>
<td>2019</td>
<td>107,435</td>
<td>101,751 5,684 5.3%</td>
</tr>
<tr>
<td>2020</td>
<td>105,920</td>
<td>83,541   22,379 21.1%</td>
</tr>
<tr>
<td>2021</td>
<td>102,495</td>
<td>66,007   36,488 35.6%</td>
</tr>
<tr>
<td>2022</td>
<td>100,026</td>
<td>52,546   47,480 47.5%</td>
</tr>
<tr>
<td>2023</td>
<td>97,384</td>
<td>41,745   55,639 57.1%</td>
</tr>
<tr>
<td>2024</td>
<td>94,428</td>
<td>32,948   61,480 65.1%</td>
</tr>
<tr>
<td>2025</td>
<td>91,209</td>
<td>25,865   65,344 71.6%</td>
</tr>
<tr>
<td>2026</td>
<td>87,660</td>
<td>20,222   67,438 76.9%</td>
</tr>
<tr>
<td>2027</td>
<td>83,871</td>
<td>15,750   68,121 81.2%</td>
</tr>
<tr>
<td>2028</td>
<td>79,893</td>
<td>12,227   67,666 84.7%</td>
</tr>
</tbody>
</table>

Table S3. Yearly total medical costs and cumulative costs over 10 years.
Figure S3. Yearly cumulative incremental benefits and costs and IBCRs, 2019-2028.

Figure S4. Scatter plot of incremental costs and incremental benefits in 2028. Solid line indicates IBCR = 1.
References


