Technical note:

Malaria risk and malaria control in Asian countries affected by the tsunami disaster

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This document is a work in progress. A first version by Dr Allan Schapira was posted on 5 January 2005. Updates will be posted when new information becomes available. Corrections and suggestions are welcome and should be sent by email to Dr Charles Delacollette, RBM Department, WHO HQ, delacollettec@who.int or rietvelda@who.int
1. General malaria situation in coastal areas in South and South-east Asia

1.1 Vectors

Mosquitoes of the genus Anopheles are the only and exclusive vectors of malaria. They bite between sunset and sunrise. Anopheles mosquitoes generally breed in clean, freshwater pools that may be stagnant or slow-flowing. Yet, in coastal areas of Aceh (Indonesia), Andaman and Nicobar islands (India), and South-western coastal areas of Myanmar, the primary vector of malaria is Anopheles sundaicus, which breeds in brackish water. The original distribution of this vector starts in eastern India (but not as far south as Tamil Nadu) then along the coasts of Bangladesh, Myanmar, Thailand, Malaysia, Indonesia and Viet Nam. An.subpictus is considered as the secondary vector in coastal areas, including in Tamil Nadu (India).

These coastal vectors are not very efficient. In coastal areas, the intensity of transmission does not reach the levels of Southeast Asian forests or African savannahs. Parasite prevalence is rarely higher than 10% at most. Transmission is generally focal and concentrated in areas with suitable breeding sites. Focal outbreaks have been reported. In Viet Nam, the optimal salinity of water-bodies breeding An.sundaicus corresponds to between 3 and 50% of the salinity of sea-water. The larvae tend to hide in vegetation. According to some entomologists, the mosquito larvae are less sensitive to water salinity than to the preferred salinity of the vegetation for which they have an affinity. Breeding-sites are very often man-made; for example, related to aquaculture. The vectors have some exophilic and exophagic tendencies (i.e., they bite and rest outdoors as well as indoors), but are usually well controlled by indoor residual spraying (IRS) and community-wide use of insecticide-treated nets (ITN). However, they are sometimes insecticide-resistant because of nearby agricultural use of insecticides, so it is important to select insecticides for vector control according to local data on resistance. Targeted larviciding can be effective, where the breeding sites are accessible and limited in number and size. Environmental management to reduce the number of suitable brackish water breeding sites near human habitation should be considered, where feasible, as a long-term measure.

The tsunami has, at least in some areas, led to environmental disturbance of the kind that would typically be associated with increased An.sundaicus breeding. Pools of salt water that do not support this mosquito by themselves, could be diluted by rains, underground water or fresh-water streams. In some, probably rare, cases, fresh-water bodies could have become brackish through contamination by sea-water. Salt-water puddles that are not diluted will of course become more and more salty and not constitute a problem. Sustained heavy rains will reduce again the number of suitable An.sundaicus breeding sites.

In lowland areas that are in the vicinity of coastal areas but are not subject to salt-water intrusion, several vectors are found, such as An.culicifacies and An.aconitus, which typically breed in rice-fields and An.maculatus, which typically breeds in small streams. An.stephensi has several sub-species. Some are rice-field breeders; others have adapted to breeding in urban areas. The tsunami is not likely to have affected them directly. However, there may be increased exposure if displaced people live without proper shelter. Drinking water storage around temporary dwellings can become a breeding place for some malaria vectors, especially An.stephensi.
1.2 Parasites

Both *P. falciparum* and *P. vivax* occur in all malaria-endemic areas affected by the tsunami. The proportion of cases due to *P. falciparum* is typically around 40-60%, although the percentage is only 15-20% in Sri Lanka and 75-90% in Myanmar.
2. Malaria situation in affected areas by country

2.1 Indonesia

Malaria of varying endemicity occurs in coastal areas of Aceh, the main vector is \textit{An.sundaicus}. \textit{P.falciparum} and \textit{P.vivax} resistance to chloroquine has been reported. Recently adopted national policy for treatment of falciparum malaria: artesunate + amodiaquine.

The invasion of inland areas by sea waters and later diluted by rain and fresh water will likely add to the breeding of \textit{An.sundaicus}. With about 600,000 displaced people, there is concern that local malaria epidemics could occur over the coming weeks near \textit{An.sundaicus} breeding sites.

Reported malaria cases in Aceh province (source: WHO/Jakarta)
2003: 20 440 clinically diagnosed cases 1 843 confirmed malaria
2004 (Jan-Sep): 8 990 clinically diagnosed cases 993 confirmed malaria

![Number of reported clinically diagnosed malaria cases 2002, Banda Aceh Province](image-url)
2. 2 Sri Lanka

Endemic sporadic malaria close to tsunami-affected areas is transmitted by *An. culicifacies*, which sometimes breeds in stagnant rock pools in river beds. It has been considered DDT-resistant for many years. It is still sensitive to organophosphates such as malathion, and pyrethroids.

The national policy for treatment of falciparum malaria is officially chloroquine + primaquine, but it is generally considered that sulfadoxine-pyrimethamine (+ primaquine) is more efficacious.

There will be some risk of malaria epidemics over the coming weeks, mainly related to the rains that have led to increased *An. culicifacies* breeding. *An. sundaicus* does not occur.

*Distribution of confirmed cases, Sri Lanka, 2002 and 2003*
2. 3 Myanmar

Malaria transmission occurs along the coast, transmitted mainly by *An.sundaicus*. In Myanmar, *P.falciparum* resistant to chloroquine and sulfadoxine–pyrimethamine has been reported. Mefloquine resistance has been reported in Kayin state and the eastern part of Shan state. *P. vivax* with reduced sensitivity to chloroquine has been reported. The national policy for treatment was recently changed to artemether + lumefantrine, but it has been difficult to obtain necessary supplies. The high tides have created conditions favorable for mosquito breeding along a long stretch of coast line.

2. 4 Bangladesh

*An.sundaicus* was eradicated from most of Bangladesh because of DDT spraying in the 1960s and 1970s. Coastal areas in the east probably harbour this vector, and have a risk profile similar to that of Myanmar. It is so far assumed that malaria epidemics as a result of the tsunami are unlikely, but watchfulness is warranted.

2. 5 India

The areas affected by the tsunami are endemic for chloroquine-resistant falciparum malaria. Malaria epidemics are possible, and extreme watchfulness is warranted. Increasing trend of *P.falciparum* has been observed in recent years. Andaman and Nicobar islands and Tamil Nadu (South India) are still predominantly *P.vivax* areas. The locations of greatest concern are the Andaman and Nicobar Islands, which have areas with *An.sundaicus* and endemic malaria. On the mainland there is very little malaria along the coast in southern tsunami-affected areas. In Tamil Nadu malaria is virtually restricted to urban centres and transmitted by *An.stephensi* in urban centres. Further north, the situation may give rise to more concern. It is not clear to what extent the salt water intrusions in Andhra Pradesh overlap with the
distribution of *An. sundaicus*. Epidemics caused by *An. sundaicus* transmitted malaria may occur, and the distribution of these mosquitoes may also spread south along the coast.

<table>
<thead>
<tr>
<th>STATE</th>
<th>DISTRICT</th>
<th>POP. in 1000s</th>
<th>B.S.E.</th>
<th>Pf cases</th>
<th>Total Positive</th>
<th>A.P.I.</th>
<th>S.P.R.</th>
<th>DEATHS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andaman and Nicobar</td>
<td>Andaman district</td>
<td>355</td>
<td>80992</td>
<td>34</td>
<td>227</td>
<td>0.64</td>
<td>0.28</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Nicobar district</td>
<td>42</td>
<td>45164</td>
<td>65</td>
<td>336</td>
<td>8.00</td>
<td>0.74</td>
<td>0</td>
</tr>
<tr>
<td><strong>State Total</strong></td>
<td></td>
<td><strong>397</strong></td>
<td><strong>126156</strong></td>
<td><strong>99</strong></td>
<td><strong>563</strong></td>
<td><strong>1.42</strong></td>
<td><strong>0.45</strong></td>
<td><strong>0</strong></td>
</tr>
</tbody>
</table>

**Distribution of chloroquine-resistant *P. falciparum* in India (2000)**

2.6 Thailand and Malaysia

Malaria has been under control in tsunami-affected areas for many years. Any small epidemic can probably be handled by national authorities.

2.7 Maldives

The country has not reported any malaria cases for at least 15 years. No report of the presence of vectors in these islands during the last five years. Therefore there is no likelihood of any threat from malaria on these islands.
3. Malaria prevention and control in the tsunami-affected areas

3.1 Surveillance and diagnosis

It is important to track weekly case numbers. Cases should be recorded separately as suspected (= not laboratory-tested) or confirmed. Reliable diagnosis by microscopy or rapid diagnostic test (RDT) should be obtained in the greatest possible number of cases. When using an RDT that can only detect falciparum malaria, give treatment for vivax malaria in the presence of clinical indicators and a negative test. Differential diagnoses in tsunami-affected areas include dengue fever, dengue haemorrhagic fever and salmonellosis.

In areas where *An. sundaicus* is a potential threat, entomological surveillance will be necessary. Water collections near habitations should be checked for the occurrence of anophelines. If *An. sundaicus* larvae are found in water of suitable salinity, it should be considered a vector breeding site. Entomological surveillance requires specialized entomological guidance.

3.2 Malaria prevention

Guiding principles: decisions have to be based on local epidemiological situation and resources. For rapid control, the emphasis is on chemicals. Use trained personnel, plus monitoring and evaluation. Insecticides and equipment should be conform approved specifications, and already registered for use in-country.

3.1 Criteria

Malaria prevention by vector control should be applied selectively in areas where:

1. malaria was endemic before the tsunami,
2. there is historically a risk of malaria epidemics,
3. entomological or epidemiological surveillance indicates that there may be a risk of an epidemic, or
4. meteorological or environmental information suggests a high risk of an epidemic.

3.2 Adulticiding (measures against adult mosquitoes)

If the epidemiological data indicates ongoing transmission (criteria must be established locally, but could be more than 1 confirmed malaria case in a week in a community), then adulticiding must be used. Where feasible, indoor residual spraying or community-wide use of insecticide-treated nets should be the preferred method(s) for reducing malaria transmission. Refer to the WHO manual 'Malaria vector control. Decision-making criteria and procedures for judicious use of insecticides' for selection of methods and insecticides. 

WHO specifications for quality control of pesticides are available at www.who.int/whopes/quality.

In areas where people are accustomed to using mosquito nets, and where it is possible to mount the nets (outside buildings, it may be possible to use sticks), these are the method of choice. Insecticide-treated nets (ITN) are preferable and still offer some protection when holed or torn. ITN offer personal protection; high coverage will also give community protection. ITN are also useful as protection against nocturnal nuisance species. Ordinary

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nets can be replaced by long-lasting insecticidal nets or, if need be, treated with insecticides. Long-lasting nets are ideal, but there are currently supply shortages of these products, so it may be necessary to resort to treated nets or treatment of nets. People in Asia generally prefer rectangular, large "family size" nets, e.g. W 190 cm x L180 cm x H150 cm. Note that factory pre-treated nets must be white, as coloured pre-treated nets have in some cases had insufficient insecticidal activity because of a technical problem. In the *Instructions for treatment and use of Insecticide-treated Mosquito nets* (see references below), please note the summary on pages 42-43 of the document.

Where people are unaccustomed to using nets and/or large numbers of displaced people live in shelters with sprayable walls, indoor residual spraying of shelters - including tents and tarpaulins with residual insecticide can be applied. IRS is effective if done well, which is highly dependent on operational factors. It requires timely delivery of commodities, presence of on-site expertise and capacity, trained staff, good organization, planning, manpower, supervision. IRS is a community control measure, not personal protection; high coverage is essential for success. Impact assessment (vector density, parasite prevalence) is desirable with IRS since it is not always done well even when applied in a timely manner.

**Insecticide-treated plastic sheeting** is still an experimental tool for malaria control. There is evidence for effectiveness against vector mosquitoes in certain, limited situations. Results are promising, but not WHO-confirmed. Safety and efficacy data from large-scale trials in Africa are currently being analysed. Where insecticide-treated plastic sheeting is being used, their impact (efficacy and safety) should be closely monitored.

**Space spraying** (fogging) needs to be repeated frequently, at times coinciding with target flight activity of the local target species, and under suitable meteorological conditions. For malaria vectors, it would usually have to be applied at night. While space spraying can be useful for nuisance biting species and flies, there is no evidence to support its use in malaria epidemic prevention and control. Nevertheless, space spraying may sometimes be used as an initial measure, when (a) transmission is already ongoing, (b) populations are congregated, as in a refugee camp. The WHO document on space spray application of insecticides should be consulted.\(^2\)

### 3.3 Larviciding (measures against mosquito larvae)

Larviciding may be useful in areas where breeding sites are accessible, are limited in number and size and are within 1-1.5 km of human settlements. Granular formulations should be considered in situations where the larvicide has to penetrate vegetation. If and only if there is no transmission, larviciding may be considered as the sole method of vector control. In all other circumstances, it should be combined with adulticiding. The most widely used product is temephos.

### 3.4 Selection of insecticide

The susceptibility of the target species to insecticides is the chief consideration. Products that have previously been used in the country for the same application are preferred. In selecting application equipment, the previous operational experience and expertise with specific machines has to be taken into consideration. The effectiveness of vector control interventions should be carefully monitored to ensure efficient and effective use of resources.

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3. Treatment

Advice on the selection of treatment is found in the report on malaria epidemics (below). In emergencies, drug resistance problems may be worse than before, and access to health services more difficult. It is therefore important to use highly effective treatment, but the medication must be authorized by the country's health authorities (see Table 1 on page 12), and health workers must be trained in its use.

For treatment of severe malaria, quinine iv or artemether im are the medicines of choice. Details are available in Management of Severe Malaria - A practical handbook, available on the WHO/RBM website at [http://mosquito.who.int/docs/hbsm_toc.htm](http://mosquito.who.int/docs/hbsm_toc.htm), and in inserted guidelines.

Reference texts

Malaria epidemics: forecasting, prevention, early detection and control. From Policy to Practice: [http://mosquito.who.int/docs/Leysinreport.pdf](http://mosquito.who.int/docs/Leysinreport.pdf)

Field guide for malaria epidemic assessment and reporting: [http://mosquito.who.int/cmc_upload/0/000/016/569/FTest.pdf](http://mosquito.who.int/cmc_upload/0/000/016/569/FTest.pdf)


Instructions for treatment and use of Insecticide-treated Mosquito nets: [http://mosquito.who.int/cmc_upload/0/000/016/007/InstructionsITNen1.pdf](http://mosquito.who.int/cmc_upload/0/000/016/007/InstructionsITNen1.pdf)

Sources and Prices of Selected Products for the Prevention, Diagnosis and Treatment of Malaria. WHO/RBM, 2004. [http://rbm.who.int/mmss](http://rbm.who.int/mmss)

Recent review publication on *Anopheles sundaicus*

Table 1. DRUG REGIMEN SEA REGION, selected countries 2004 (dosage for adults)

<table>
<thead>
<tr>
<th>Country / area</th>
<th>Treatment</th>
<th>Severe malaria</th>
<th>Prevention</th>
<th>Pregnancy</th>
<th>Chloroquine</th>
<th>Treatment</th>
<th>Primaquine</th>
<th>Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bangladesh</td>
<td>CQ or AQ</td>
<td>ATM + LUM</td>
<td>Q7</td>
<td>Q7</td>
<td>CQ or Q</td>
<td>CQ 25 mg/kg</td>
<td>Q3 + SP</td>
<td>PQ for 5 days</td>
</tr>
<tr>
<td>India</td>
<td>CQ 10 mg/kg</td>
<td>CQ 25 mg/kg</td>
<td>SP+PQ 45 mg</td>
<td>Inj. Q 10 mg/kg, 7d</td>
<td>CQ 10 mg/kg</td>
<td>CQ 10 mg/kg</td>
<td>CQ 25 mg/kg</td>
<td>PQ 5 days</td>
</tr>
<tr>
<td></td>
<td>+ PQ 45 mg (Stat)</td>
<td>or inj. ATM derivatives</td>
<td>+ PQ 0.25 mg</td>
<td>for 5 days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indonesia</td>
<td>CQ + PQ</td>
<td>ASU3 + AQ</td>
<td>SP or Q</td>
<td>Q7</td>
<td>CQ</td>
<td>CQ 25 mg/kg</td>
<td>Q7</td>
<td>PQ 14 days</td>
</tr>
<tr>
<td>Maldives</td>
<td>CQ</td>
<td>CQ 25 mg/kg</td>
<td>M.SP</td>
<td>-</td>
<td>-</td>
<td>CQ 25 mg/kg</td>
<td>M.SP</td>
<td>PQ 14 days</td>
</tr>
<tr>
<td>Myanmar</td>
<td>ASU + MEF</td>
<td>ATM + LUM or</td>
<td>ASU + DOXY7 / T7</td>
<td>Q7 + CLIN7</td>
<td>CQ 25 mg/kg</td>
<td></td>
<td>PQ 14 days</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ASU + MEF</td>
<td>or + DOXY7 / T7 /CLIN7</td>
<td>1st trimester</td>
<td>but routinely</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>ASU + MEF</td>
<td>or + CLIN7</td>
<td>Q7</td>
<td>not recom-</td>
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<tr>
<td></td>
<td></td>
<td>+CLIN7</td>
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<td>mended</td>
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<td></td>
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<td></td>
<td>2-3 trimester</td>
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</tr>
<tr>
<td>Sri Lanka</td>
<td>CQ + PQ</td>
<td>CQ + PQ (stat)</td>
<td>SP 1500 mg</td>
<td>Inj. Q 10 mg/kg,</td>
<td>CQ or Q</td>
<td>CQ 25 mg/kg</td>
<td>-</td>
<td>PQ 5 days</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>+ PQ 45 mg (stat)</td>
<td>I.V. infusion 8 hrly</td>
<td>if CQ switch to oral Q</td>
<td></td>
<td>or 75 mg</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>when appropriate</td>
<td>prophylixas</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thailand</td>
<td>-</td>
<td>MEF + ASU (2d)</td>
<td>Q7 T7</td>
<td>Q</td>
<td>-</td>
<td>CQ 1500mg</td>
<td>-</td>
<td>PQ 14 days</td>
</tr>
<tr>
<td></td>
<td></td>
<td>or ASU</td>
<td></td>
<td>Q7</td>
<td></td>
<td>base over 3</td>
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<td></td>
<td></td>
<td></td>
<td>days</td>
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</tr>
</tbody>
</table>

M=Mefloquin e  
CQ=chloroquin e  
PQ=primaquine T=Tetracycline  
ASU=Artesunate  
ATM=Artemether  
ATE=Arteether

(25 mg/kg over 3 days)  
(45 mg, single dose)  
(T7=Tetracycline 7 days)  
SP=Sulfadoxine + pyrimethamine  
(or 15 mg/day)

M=Mefloquin e  
CQ=chloroquin e  
PQ=primaquine T=Tetracycline  
ASU=Artesunate  
ATM=Artemether  
ATE=Arteether

(25 mg/kg over 3 days)  
(45 mg, single dose)  
(T7=Tetracycline 7 days)  
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(or 15 mg/day)