Review of IRS related planning, implementation, supervision and monitoring in Madagascar.

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5-16 February 2006

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II List of Acronyms

ACT	artemisinin-based combination therapy
AFRO	Africa Regional Office (WHO)
ANC	ante natal care
CDC	Centers for Disease Control
DDT	diethyl-dichloro toluamide
ELISA	enzyme linked immunosorbant assay
GFATM	Global Fund for AIDS, TB and Malaria.
IPM	Pasteur Institute in Madagascar
IPT	intermittent presumptive therapy
IRD	Institute of Research for Development
IRS	indoor residual spraying
ITN	insecticide treated bednets
KDR	knock down resistance
LLIN	long lasting insecticide treated bednet
MoH	Ministry of Health
NMCP	National Malaria Control Program
PCR	polymerase chain reaction
PMI	Presidential Malaria Initiative
RDT	rapid diagnostic test
RTI	Research Triangle Institute
USAID	US Agency for International Development
WHO	World Health Organization
WHOPES	WHO pesticide evaluation scheme

1.0 Introduction

1.1 Background

Madagascar is one of eight new countries that will benefit from the third-round of the Presidential Malaria Initiative (PMI). This US$ 1.2 billion program led by USAID aims to cut malaria deaths by 50% in 15 countries in Africa by reaching 85% of those most vulnerable to the disease[1] with life-saving services, supplies and medicines. Key interventions supported by PMI include indoor residual spraying (IRS) with insecticide, insecticide treated bednets (ITNs), curative drugs and intermittent preventive treatment for pregnant women.

As a precursor to the release of PMI funds, CDC and USAID plan to conduct a comprehensive review of the National Malaria Control Program (NMCP) in the first quarter of 2007. This review should coincide with and benefit from a needs assessment being commissioned by the Ministry of Health (MoH) which is due to be conducted by two independent malaria control experts starting in March 2007 and lasting for one month. The MoH commissioned needs assessment and the PMI review should both inform the development of the GFATM round 7 applications and contribute to the revision of the National Strategic Plan for Malaria Control.

1.2 Purpose of this mission

The purpose of this mission was to assess the quality of the IRS campaign (which will end on 18 February before the CDC/USAID comprehensive NMCP review team is scheduled to arrive in country) and to identify any measures necessary for strengthening capacity to deliver IRS in line with PMI requirements.

In addition to assessing implementation of IRS in the field (logistics, spraying and supervision) a review of operational and technical issues was carried out covering a broad range of subjects including: choice of insecticide; targeting of spray operations; timing of spray operations; and, evaluation of operational impact.

In addition, a review of underlying epidemiological and entomological issues was conducted and meetings were held with existing and potential partners to discuss options for collaboration and capacity strengthening.

2.0 Malaria and its control in Madagascar

Malaria is endemic in 90 percent of Madagascar (population ~17 million) but the whole country is considered vulnerable to the disease. Malaria is ranked as the leading cause of under-five mortality and according to UNICEF it kills approximately 20,000 Malagasy children every year. The epidemiology of the disease differs distinctly according to location and so, for malaria control purposes, the country has been stratified into four

[1] Pregnant women, children under five and people living with AIDS.

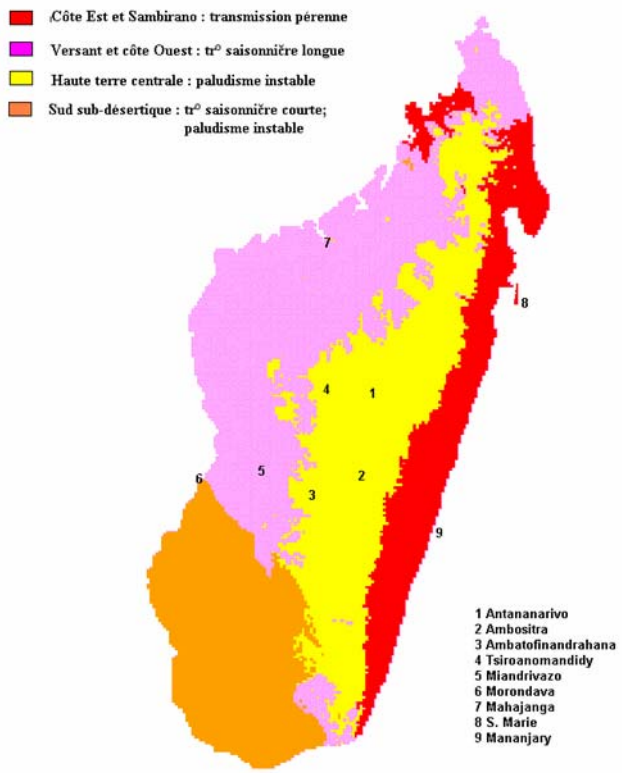


Figure 1. Malariametric stratification of Madagascar: Red, lowland perennial transmission; Pink, lowland long transmission season; Yellow, highland unstable seasonal transmission (epidemic prone); Orange, semi-desert unstable seasonal transmission (epidemic prone).

distinct zones (Fig. 1): West, Central, East and South. The key epidemiological factors in each are highlighted in table 1. In the West and in the East transmission is stable and perennial (although in the West transmission does fall somewhat in July and August). In both regions immunity amongst adults is reported to be high and morbidity and mortality is mainly amongst children under five and pregnant women. In the highlands of the Central Region transmission is seasonal and moderately unstable (see figures 2 and 3). In the semi-desert of the South transmission is also seasonal but very unstable and in many years transmission is almost absent. In both the Central Highlands and in the South, immunity is limited and the whole population is vulnerable to periodic epidemics. These are often associated with high levels of mortality in all age groups. The most recent large scale epidemic in the late 1980s killed an estimated 30,000 people. Almost one third of the central highlands lie above 1,500 meters where malaria transmission tends not to occur.

All four species of human plasmodia are endemic. While *P.falciparum* predominates in all areas, other species appear to be most abundant in the highlands.

Long-lasting insecticide treated bednets (LLINs).

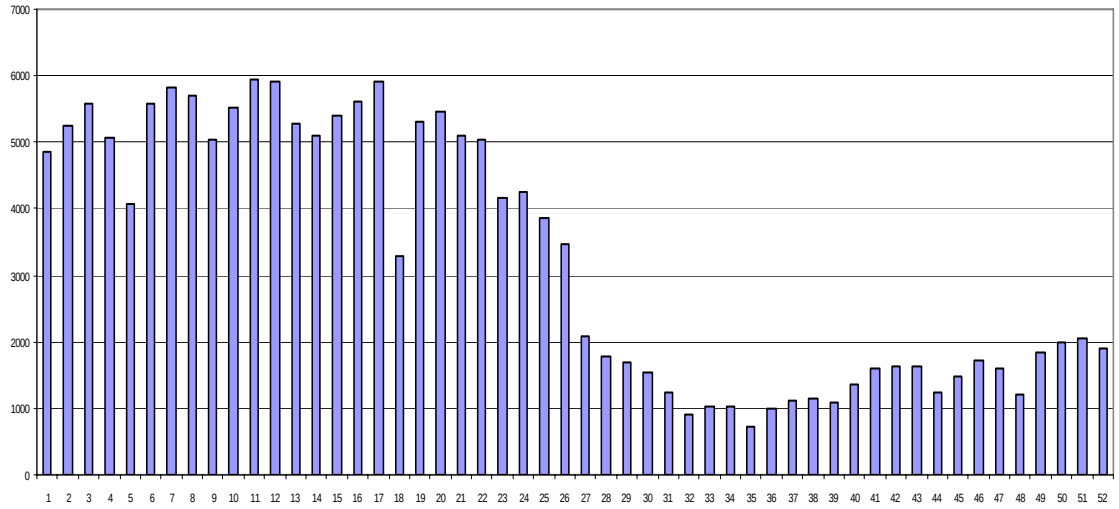
Malaria prevention in the East and West is based on the provision of LLINs for pregnant women and children under five. The nets are being distributed through ante-natal care (ANC) facilities and through mass distribution during vaccination campaigns. 600,000 LLINs were distributed to children during the 2006 measles campaign. In 2007, a further 1.5 million nets will be given to children (60% funded by the Global Fund and 40% by the International Red Cross with strong technical assistance for planning provided by WHO/International Red Cross) and a further 300,000 will be given to pregnant women attending ANC facilities. This is expected to result in near total coverage of high risk groups living in areas of stable transmission.

Table 1. Key malaria related characteristics by epidemiological zone.

	West	**Central**	**East**	**South**
Ecology	Tropical lowlands	Highlands	Tropical lowlands	Lowland semi-desert
1^{o} Vector	*An. gambiae s.s.*	*An. funestus*	*An. gambiae s.s.*	*An. funestus*
Endophily	+	+++	+	+++
Anthropophily	+++	++	+++	++
2^{o} Vectors	*An. arabiensis*, *An. funestus*	*An. arabiensis*	*An. arabiensis*	*An. arabiensis* *An. gambiae s.s.*
Ratio of *P. falciparum* to other plasmodia (N)[2]	90:10 (48)	85:15 (26)	100:0 (4)	95:5 (48)
Transmission	almost perennial	Seasonal	perennial	seasonal
Peak season	September-June	Jan-Feb & Apr-May	-	?
Low season	July-August	Jun-Sept	-	?
Endemicity	high	Low	medium	very low
Epidemic prone	no	Yes	no	yes
NMCP surveillance	no	Yes	no	yes
Prevention	LLIN & IPT	IRS (routine and responsive)	LLIN & IPT	IRS (responsive only)
Diagnosis	RDT (except for children <5 who are treated presumptively)			
Treatment	ACT (irrespective of Plasmodium species), no treatment for children <1 and no community based emergency treatment for patients unable to swallow (artesunate rectocaps).			
Proportion of clinical cases RDT positive[3].	1-26%	45-48%	1-2%	24-31%

[2] N= number of *P. falciparum* cases in sample on which estimate is based.
[3] Study conducted by Pasteur Institute in 2006.

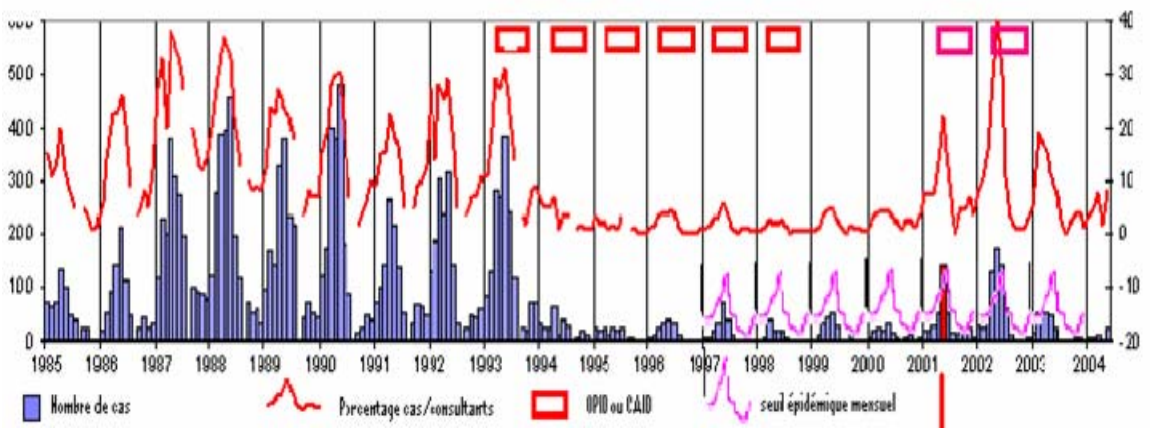
Figure 2. Weekly fluctuations in the number of clinical malaria cases reported by public sector health facilities in the central highlands in 2005.



Indoor residual spraying (IRS).

In the Central Highlands, malaria prevention is based on IRS. Selected communes[4] are usually sprayed in November immediately before the start of the transmission season. In 2007, 1.2 million of the 6.9 million inhabitants of the highlands were expected to be

Figure 3. Chart illustrating the impact of IRS on the number of cases of malaria reported in Analaroa Province between 1985 and 2004. Histograms represent number of cases (left axis), the red line represents malaria cases as a percentage of consultations (right axis), the boxes denote years in which IRS campaigns were conducted (red, total coverage; pink, partial coverage), and the pink line indicates the epidemic threshold (double the monthly mean number of cases for the three preceding years).



[4] The commune selection process is discussed in section 5.1.2.

protected by IRS. The chart in figure 3 dramatically demonstrates the effect that high coverage IRS had on transmission during the mid to late nineties and shows also the lesser effect achieved with partial spray in more recent years.

In addition to this routine preventive IRS the NMCP is also responsible for implementing an emergency response whereby, in the event of a confirmed malaria outbreak[5] in which *An.funestus* is implicated as a vector, focal IRS may be carried out later-on during the transmission season.

In the South there are no routine malaria prevention activities. There is however a network of sentinel sites for monitoring the epidemiological situation (similar to that in the Central Highlands) in 9 epidemic prone districts (out of 22 districts in total) and in the event of a confirmed outbreak, focal IRS is carried out.

In addition, periodic information campaigns (usually linked to IRS and LLIN distribution) promote best practice for malaria prevention and control. There are no other organized vector control measures in Madagascar at present.

Diagnosis and treatment.
Falciparum specific and pan-specific rapid diagnostic tests (RDTs) for malaria are currently being rolled out in all areas, together with artemisinin-based combination therapy (ACT). Diagnostic tests and drugs are expected to be available at all public health facilities by the end of 2007. In addition, RDTs and ACT are being introduced at community level however roll-out is expected to take some years.

The first-line treatment for malaria (irrespective of species) is artesunate-ammodiaquine, the second-line is artemether-lumefantrine and the third-line is quinine. The ACTs are packaged for three age-groups: 1-6 years; 7-13 years; and 14 years and over. There is currently no ACT available for children under 1 year. Furthermore, there is currently no emergency treatment for severe malaria at community level.

Sulphadoxine-pyrimethamine is available for intermittent preventive treatment (IPT) for malaria for pregnant women attending ANC facilities.

3.0 Key players involved in indoor residual spraying and related activities.

Although MoH staff take direct responsibility for planning, implementing and monitoring the annual IRS campaign (as well as for any follow-on focal applications), there are a number of other players who are involved either directly or indirectly in some aspect of IRS or related activities. The roles of the key groups are summarized below:

[5] The outbreak detection process is discussed in section 5.2.1.

3.1 Ministry of Health and Family Planning (MoH)

National Malaria Control Program (NMCP)

The NMCP has two senior staff that are directly involved in IRS related activities: the Head of the Epidemiology and Entomology Department (a medical doctor) and an entomologist (with a BSc in biology). Both have completed a two year-long training course in epidemiology and medical entomology at university in the Ivory Coast (MSc level).

The departmental head and the entomologist work with staff from provincial level to plan and supervise IRS campaigns. In addition they are responsible for the design and oversight of epidemiological and entomological monitoring. Entomological field work is carried out by three NMCP entomology technicians; and two NMCP entomology assistants. Additional staff (insect collectors and facilitators) are hired to assist with field-work on an *ad hoc* basis.

Peripheral MoH

During the planning phase of the IRS campaign the NMCP collaborates closely with a number of MoH staff at provincial[6] level and below. These staff include: Provincial Vector Control Directors (2 in the Central Highlands) and Sentinel Site Doctors (6 in the Central Highlands). All have received some formal training in epidemiology and malaria control.

At operational level there is a well defined management structure for IRS comprising of Zone Leaders, Area Leaders and Spray Team leaders. Spraymen are hired locally as and when necessary. In most cases spray team staff remain the same from year to year.

3.2 Pasteur Institute in Madagascar (IPM)

The Pasteur Institute has a large long established facility in Antananarivo. It has a strong staff of research scientists with easy access to high level academic TA from Pasteur Institutes worldwide. It is well equipped but reagents such as primers for PCR analysis are in short supply and current funding for malaria related work is limited.

IPM has collaborated with NMCP on numerous occasions over the years. It has provided some training and currently runs an annual training session on malaria. However the institute currently plays no role in developing high level capacity within NMCP.

IPM has collaborated with NMCP on a broad range of research projects as well as on monitoring drug and insecticide resistance. However, at present the only links between NMCP and IPM are informal and any collaborative studies are organized on an impromptu basis. There are no strategic plans for collaborative research or programmatic monitoring of drug or insecticide resistance. In 2006 the epidemiology department was

[6] There are six provinces in Madagascar, two of which are in the Central Highlands.

involved in monitoring resistance to antimalarials *in vivo* (for ACT) and *in vitro* (for a broad range of drugs) at eleven sites. However there are no clear plans for continued monitoring at regular intervals.

Coordination between IPM and NMCP appears to be rather weak and as a result, some opportunities for productive collaboration are lost. For example, IPM is currently conducting a study of arboviruses at 11 sites across the country. All participants in this study will be screened for the presence of malaria parasites with RDTs and so this study should yield useful information relating to malaria, but as yet there has been no discussion with NMCP regarding possible collaboration.

Senior staff at IPM complained that recruitment of national staff can be difficult due to the shortage of well trained epidemiologists and entomologists educated to master's degree level. They pointed out that it is difficult to find bright young motivated candidates for training. They attribute this to the fact that there is little work beyond that at MoH (except with IPM) and so potential candidates feel that long-term prospects are limited; hence do not enrol on training. Staff at IPM felt that USAID support for overseas training would certainly be useful but cautioned that it is particularly hard to find English speaking candidates.

The government of Reunion Island recently funded two candidates to study entomology at the Institute of Research for Development (IRD - formerly ORSTOM) in Burkina Faso and Benin.

The entomology department at IPM has a well equipped laboratory with 7 technicians. The facility can conduct ELISA and PCR studies and biochemical and KDR testing is available for insecticide resistance monitoring.

In 2005-6 NMCP staff collected vector mosquitoes from 11 sites. These were tested for insecticide resistance using standard WHO bioassays and then passed on to IPM for biochemical and PCR analysis. Test results for KDR have so far proved negative but analysis is still underway. IPM was not involved in the development of the mosquito collection protocol. Closer collaboration during the planning phase would likely result in a more productive partnership with study participants having a stronger sense of ownership and with options for spin-off studies more fully considered. The concept of establishing formal collaborations between MoH and IPM was well received by both parties. Any such collaboration would however be dependent on regular funding.

At present the senior staff member responsible for entomological work at IPM (Dr Jocelyn Ratovonjato) dedicates approximately 30 per cent of his time to malaria related issues. He felt that increased emphasis on malaria work, comprising increased allocation of personal time (up to 50 per cent) plus recruitment of new national staff, would be quite feasible if additional funds became available.

3.3 University of Antananarivo, Faculty of Sciences, Entomology Department

The Entomology Department at Antananarivo has a dedicated academic staff of five comprising one professor of entomology, two doctoral level agricultural entomologists

and two doctoral level medical entomologists. All of the staff appear to be well versed in many aspects of medical entomology relating specifically to malaria (vector taxonomics, sporozoite dissections/ELISA, parity rate determination, age grading by counting follicular relics etc.). In addition they have experience in more generally applicable techniques such as PCR, polytene chromosome analysis, insecticide bioassays etc. The unit has an insectary room but does not have any mosquito colonies at present.

Staff have been involved in a number of high quality malaria related studies in the past (often in collaboration with the Institute of Parasitology at the University of Rome) resulting in a number of publications in the late 1980s and early 1990s.

A key focus of the department's current research program relates to the development of fungal biocides for the control of agricultural pests. Equipment for this work has been provided by USAID.

Although the department has three large laboratories which are structurally adequate, it is severely under resourced. Much of the equipment is outdated and often non functional (out of more than 20 dissecting microscopes only 1 was in working order). Although the staff members are skilled in PCR techniques, the department does not have the necessary equipment to enable it to undertake PCR analysis.

3.4 University of Antananarivo, Medical School, National Institute of Public and Community Health (INSPC).

The National Institute of Public and Community Health in Antananarivo teaches general epidemiology to Master's degree level through its well attended course in Public and Community Health. The School has a strong staff, is well equipped and adequately funded. It would be well placed to provide a short malaria-specific course on epidemiology for sentinel site doctors. Short-term technical assistance would however be required to assist in the development of a high quality, locally appropriate and malaria specific curriculum.

3.5 World Health Organization (WHO)

WHO Madagascar provides technical guidance to the NMCP on malaria control policy including that relating to IRS. WHO Madagascar has a full time International Advisor plus a National Project Officer dedicated to malaria control. In addition, periodically it calls on specialist expertise from AFRO or WHO HQ. A large number of technical reports have been produced by WHO over the years, including some specifically relating to IRS including one produced in 2006 by Prof. Guillet (annex 4). This report supports a move towards blanket spraying of communities below 1500m in the Central Highlands Province, alternating between pyrethroid, organochlorine (DDT) and carbamate over a three year period.

3.6 Interactions between players

Relations between the various partners appear to be very positive and in recent months there has apparently been a marked improvement in the coordination of malaria control efforts, with RBM partners now meeting on a regular basis.

In order to further streamline malaria control efforts the MoH is planning to soon appoint an Executive Officer for Malaria.

4.0 IRS

4.1 Operational issues

Operational aspects of the spray program appear to be managed very efficiently. There is a well defined management structure and communication between the various levels both during planning and during implementation appears to be both efficient and constructive.

The sites visited during this appraisal were selected by staff at the NMCP rather than by RTI. Ideally sites would have been selected by RTI in order to avoid any bias, but given the time constraints relating to the RTI schedule and the fact that the IRS campaign was drawing to a close (and had already finished in many areas), there was no option but to accept the NMCP selection. The NMCP provided assurances that the sites were selected according to accessibility rather than according to the quality of implementation.

Similar assessments conducted by PROCHIMAD at independently selected sites produced similar findings to those of RTI, thus corroborating NMCP claims that the selection of assessment sites was unbiased.

4.1.1 Choice of insecticide;

In 2004 the NMCP started using alpha-cypermethrin rather than DDT for IRS. The move away from DDT was made partly in an effort to slow the development of insecticide resistance in vector mosquitoes and partly in response to international pressure following the Stockholm Convention on persistent organic pollutants.

After brief and limited use of deltamethrin, alpha-cypermethrin was selected to replace DDT on the basis of a number of criteria including safety profile (WHOPES approved for indoor residual use), efficacy, residual life (6 months) and cost.

4.1.2 Targeting of indoor residual spray operations

In recent years the NMCP's routine IRS policy has moved away from blanket coverage with DDT, in favour of selective spraying with synthetic pyrethroids (table 2). The basis for this change was apparently partly locally acquired evidence that IRS has a long-lasting impact on *An.funestus* populations, but also spray coverage has been limited on several occasions as a result of funding constraints. During 2000 and 2001 there was no IRS campaign at all. Reported incidence of malaria in the Central Highlands has been

considerably higher since this stock-out and since the subsequent introduction of reduced coverage IRS (figure 3). In future, stock-outs must be avoided and the policy of selective spraying should be reviewed by a team of high level of experts (see recommendations).

The unit for IRS targeting is the commune. Communes generally vary in population size from 4,000-10,000 but some may be as large as 40,000. All dwellings and adjacent buildings in target communes are sprayed irrespective of their distance from population centres. There are three main criteria for the selection of target communes: altitude between 900 and 1,500 metres[7]; not subject to IRS during the previous two campaigns; and, reported caseload exceeding 'epidemic threshold' during previous transmission season.

The last of these criteria, when used in epidemiologic isolation, is problematic and should be reviewed (see section 5.2.1).

Table 2. Overview of insecticide usage (tonnes) and population protected by IRS since 1994.

Year	DDT	Deltamenthrin	Alpha-cypermethrin	population protected
1994	198	-	-	2.3
1995	198	-	-	2.3
1996	198	-	-	2.3
1997	198	-	-	2.3
1998	198	-	-	2.3
1999	100	1.1	-	1.3
2000	-	-	-	?
2001	-	-	-	?
2002	60	1.2	-	0.87
2003	40	0.06	0.3	0.5
2004	-	-	8.5	0.51
2005	-	-	17	1.25

4.1.3 Timing of spray operations

The spray campaign is generally carried out in November and December immediately before the start of the usual seasonal increase in transmission and six months before transmission would normally be expected to reach its peak in May (figure 3). Given the apparent six month residual life of alpha-cypermethrin on interior walls in Madagascar, this timing seems appropriate.

This year the IRS campaign was delayed until January/February as a result of slow release of funds from donor agencies. This could result in increased transmission and so those involved in malaria surveillance should be particularly vigilant this year.

Every effort should be made to ensure that future spray campaigns are initiated on schedule. Strenuous efforts should be made by the RBM partnership to raise awareness

[7] Below 900 metres malaria transmission tends to be perennial and these areas are targeted with LLINs. Transmission does not generally occur above 1,500 metres.

regarding the importance of timing of IRS amongst those responsible for bottlenecks in the 2006 procurement of insecticides.

4.1.4 Logistics

Customs clearance for insecticides and equipment and transport to a central depot is contracted out by MoH to a private company called PROCHIMAD. PROCHIMAD represents AVIMA, Bayer and BASF in Madagascar. [AVIMA supplies Hudson Xpert spray pumps and is also able to supply DDT and Propoxur. Bayer is able to supply Carbaryl. BASF supplies alpha-cypermethrin. AVIMA has strong links with BASF.]

In the case of medicines and RDTs, after customs clearance supplies are sent to a central depot run by a private pharmaceutical supply firm called CRESAN, but at present CRESAN does not have suitable premises for the storage of insecticides and so a district level warehouse in Antananarivo province is currently used as the central warehouse for the IRS program. Insecticides are kept at this warehouse only briefly (one or two weeks) before dispatch to district level warehouses in IRS target areas.

Customs clearance and delivery to the central store appears to be run very efficiently. However, the central depot is not suitable for the storage of insecticides and alternative arrangements should be made: a suitable space should either be rented [PROCHIMAD could apparently provide suitable premises on request or CRESAN could adapt a space within its central pharmaceutical depot], or a new facility should be built. An adequate emergency supply of insecticide should be kept at this central store. Current stock control at central level appears to be adequate both within NMCP and at the facilities of private sector partners. These levels of control would need to be maintained and regular audits would be required.

It was not possible to conduct a first hand review of transportation of supplies from central level to the periphery, but according to NMCP accounts this appears to be efficient and well managed. Associated paper work was reviewed and appeared to be in good order.

A number of peripheral depots for insecticide and equipment were visited and in general these were in need of some modifications or refurbishment. An in-depth appraisal of insecticide storage facilities is provided in the annexed report by Dr Samba Yade (RTI consultant).

4.1.5 Implementation of spray operations

The implementation of spray operations appeared to be efficient and well managed. Spray men kept detailed records of their work. All sachets were collected and counted and then passed up through the chain of command to district level for audit and safe disposal.

The quality of the spray provided by the spray men was generally good (appropriate width of swath, degree of overlap and speed of application). The spray nozzles were calibrated on a weekly basis and replaced when necessary.

Soap and water was available with each of the teams visited.

Activated charcoal was available in each of the health facilities visited but not all of the health workers questioned were aware of the treatment for pyrethroid poisoning (although all knew that DDT had been replaced with an alternative insecticide).

With the exception of footwear, the protective clothing worn by the spray teams and their supervisors was generally adequate. Spray men are currently equipped with perforated plastic sandals. These offer no protection against insecticides and should be replaced with fully enclosed rubber boots (socks should also be provided to improve the wearability of the boots in warm weather and thus maximize spray men's compliance with their use).

Only one pair of overalls was provided to each spray man and so overalls were being washed just once a week. NMCP should provide each team member with 2 pairs of overalls to allow for daily washing. A free compulsory daily washing service should be provided by the programme to ensure compliance with daily washing requirements.

In a number the sites visited, home-owners re-entered their homes during or immediately after spraying. Teams need to ensure that residents are adequately briefed regarding the importance of remaining outside during this period.

Spray pumps were correctly cleaned at the end of each day and rinse water was disposed of properly.

4.1.6 Supervision of spray operations

The supervision of spray operations appears to be strong. The team leader: sprayman ratio is high (1:5) and there is a well defined management structure (zone leader, area leader, team leader). Each level of management has clearly defined roles and responsibilities and existing checklists and reporting forms are used effectively (recommendations for improved checklists and reporting formats are presented in the annexed report by Dr Samba Yade – RTI consultant).

4.1.7 Evaluation of spray campaign

Periodic external evaluations of the IRS campaign are carried out by PROCHIMAD in association with AVIMA.

Although PROCHIMAD is only contracted to deal with customs formalities and to deliver products to the central stores, it also conducts independent assessments of the IRS campaign. Since alpha-cypermethrin was adopted for IRS in 2005, PROCHIMAD has conducted an annual monitoring mission with experts from AVIMA. The PROCHIMAD/AVIMA assessment team selects inspection sites and conducts field visits completely independently of MoH.

In 2005 and in 2006 the team found that the campaign was well managed and that the technical skills of the IRS staff were good. Recommendations included: replace old or damaged pumps, improve pump maintenance, strengthen briefing for householders and ensure that insecticide stores at peripheral level are not prone to flooding. A report from

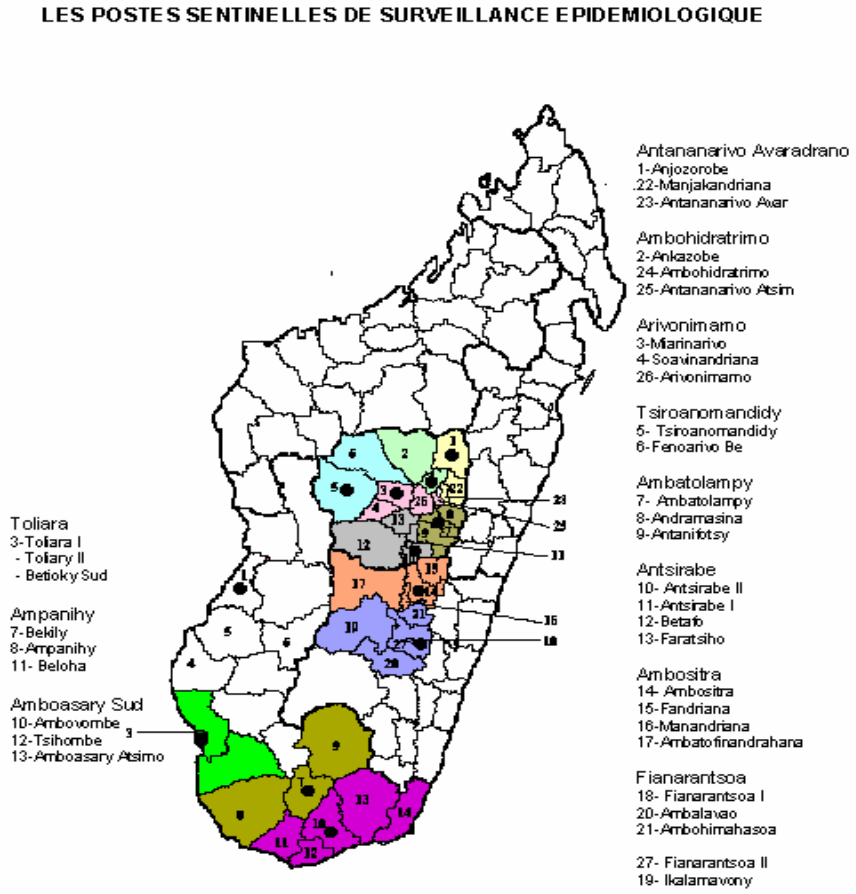
the 2006 mission is expected in the next week and if available will be annexed to this report.

4.1.8 IRS in response to outbreak

In addition to routine IRS the NMCP provides focal IRS in the event of any *An.funestus* mediated outbreaks later-on during the transmission season. The NMCP has its own malaria specific reporting system covering all epidemic prone districts (the whole of the Central Highlands and 9 of the 22 districts in the South – figure 4). Every health facility in an epidemic prone area is provided with a wall chart which shows its own weekly epidemic thresholds. Each week staff plot their facility's malaria case load on the chart and if levels exceed the epidemic threshold[8] for two consecutive weeks then they inform their district supervisors. The district then informs the sentinel site doctor and the sentinel site doctor investigates. If an outbreak is confirmed then a district team is despatched to work with the facility team to provide mass treatment and IEC. At the same time a team of entomologists is sent by the NMCP to collect vector mosquitoes. If *An. funestus* is detected then focal IRS is carried out.

[8] The epidemic threshold is defined as twice the mean number of malaria cases for any given week. The weekly mean is estimated from monthly cases reported during the previous three years (cases are clinically diagnosed).

Figure 4. Map showing location of sentinel sites for malaria epidemic monitoring.



4.2 Technical issues

4.2.1 Epidemiological surveillance

Reliance on clinical data

There is a profound lack of reliable up-to-date epidemiological data relating to malaria in Madagascar. Planning in recent years has relied almost entirely upon clinical data and studies conducted by the Pasteur Institute in 2006 revealed that between 48 and 99 per cent of malaria cases diagnosed clinically at level 2 health facilities[9] were RDT negative. Surprisingly, the lowest RDT positivities were found in the North and in the East of the country: areas traditionally considered to be hyper- or holoendemic for malaria. Outbreaks of dengue and chikungunya fever may have contributed to the low RDT positivity but even taking this possibility into consideration the findings were surprising and certainly warrant further investigation.

Anecdotal evidence also suggests that the malaria burden in the East may be much lower than commonly cited. There is no doubt that the east of Madagascar was once hyper-or holoendemic. It may be that transmission has fallen generally or it may be that malaria in

[9] Basic health unit with a physician.

the region is now quite focal as a result of changes in extrinsic factors such as land use and socio-economics. An epidemiological assessment is clearly warranted.

There do not appear to have been any systematic cross-sectional prevalence surveys conducted during the last many years.

The MoH is in the process of rolling out falciparum specific and pan-specific rapid diagnostic tests for malaria (with financial support from the Global Fund). Data related to number and positivity of RDTs should provide a much more reliable overview of malaria burden and seasonality. It is essential that a system be developed to collect and analyse at least some of the RDT data generated as this could provide robust epidemiological information for programmatic planning purposes. It is also important that the information generated is used to provide useful feedback to end-users. RDT positivity rates for example reflect clinical skills: if they are too low, RDTs are wasted and so the user may need to take more care to ensure subjects have at least some sign or symptom of malaria before testing; if they are too high, cases are missed and so the user may need to test more freely.

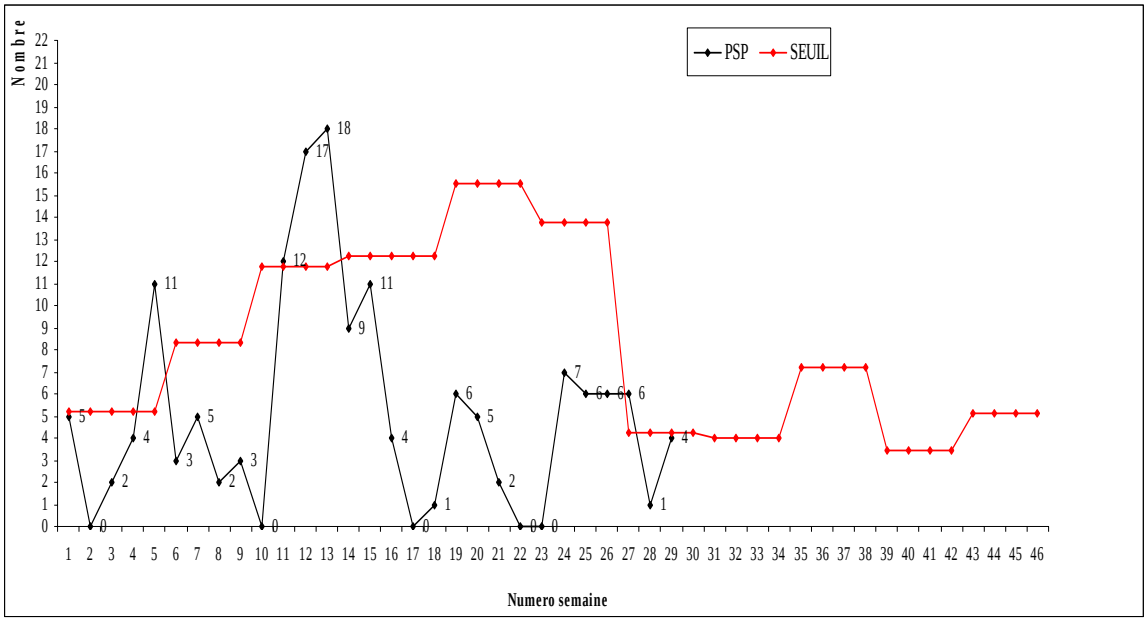
Data generated by RDT use may eventually provide all of the epidemiological data necessary for programme management. However, effective reporting mechanisms may well take time to establish and so during the interim period a more in-depth assessment of the epidemiological situation, involving cross-sectional prevalence surveys and sentinel site surveillance[10], may be more appropriate. Ideally a combination of both approaches would be adopted to provide the robust epidemiological data required for effective programmatic targeting and impact evaluation.

Guidelines regarding epidemic detection using the threshold method (number of cases exceed 2 x the mean of the previous 3 years for 2 consecutive weeks) need clarification to ensure that clinic staff continue to use *suspected cases* for their calculations. A switch to using RDT positive cases and thresholds should only take place once sufficient RDT data becomes available for the calculation of new thresholds based on *confirmed cases*.

One of the three criteria used for the selection of target communes for routine IRS is: reported caseload exceeding ‘epidemic threshold’ during previous transmission season (see section 5.1.2). This criterion is problematic when it is the only epidemiological criterion used (as is the case at present). If for example a commune in the highlands had a consistently high burden of malaria it would also have a high epidemic threshold and so would not be targeted for routine IRS. It would be sensible therefore to introduce an additional criterion designed to tackle malaria in communes with a routinely high malaria burden. An annual incidence in excess of X percent could for example be used to trigger routine IRS. Over reporting of malaria is a major problem in Madagascar. This over reporting phenomenon is likely to be both focal and consistent as it depends on the clinical skills of individual health workers. As a result, using annual reported incidence of *clinical* cases as a criterion for applying IRS would likely result in a higher degree of unnecessary spraying than the existing ‘epidemic threshold criterion’. It will therefore be important to link this new criterion to the *confirmed* case data that should be generated following the widespread introduction of RDTs.

[10] Sentinel site surveillance is currently restricted to epidemic prone areas.

Figure 5. Example of epidemic prediction chart showing threshold level (red line) and clinical cases (black line). Charts such as this are present in every health facility in an epidemic prone area.



The four to five weekly 'stepped' nature of the threshold line (figure 5) is an artefact which results from the use of monthly data to set weekly thresholds. This stepping could result in outbreaks being missed. The threshold for week 26 in figure 5 above for example is artificially high when compared with that for week 27. As a result an unusual increase in reported cases in week 26 could well be missed and this could result in a delay of at least one week in the detection of an outbreak. Some smoothing of the threshold line should be considered to avoid this risk. Dropping the high point at the edge of each step halfway down to the adjacent low point would be a simple way of increasing the chance of early epidemic detection. Use of weekly data for setting future epidemic thresholds based on confirmed cases should be introduced as soon as possible.

The Central Highlands has a malaria monitoring network with six doctors, trained in epidemiology, each responsible for monitoring reported incidence of malaria in three districts. Interviews with two of these sentinel site doctors revealed that they had limited technical capacity. Although both sentinel sites displayed a colourful variety of charts and maps, including some which displayed information from the malaria GIS, in many cases the colours used were counterintuitive and parameters described were inappropriate. For example, numbers of clinical cases were used where, from a planning point of view, reported incidence would have been much more useful. Sentinel site doctors were not able to account for anomalies in data sets and they appeared to be relying blindly on thresholds rather than thinking critically about the data they had compiled. For example, in one commune a very high proportion of outpatients were suspected of having malaria. This may be indicative of either an outbreak or of over-diagnosis and certainly warrants investigation, but no action had been taken.

At present there is no epidemic prediction mechanism in place. Options for epidemic prediction in Madagascar should be considered.

4.2.2 Entomological monitoring:

Monitoring of insecticide resistance. Numerous studies on the insecticide resistance status of vector mosquitoes in Madagascar have been carried out by entomologists at the National Malaria Control Program using the standard WHO bioassay technique. These studies have generally been confined to areas that have been subjected to IRS for malaria control. For the most part these studies have been conducted as add-ons to the NMCP work-plan and as a result they have been rather *ad hoc* as they have been dependent on small discrete blocks of funding from a number of different donors. As a result it is not possible to retrospectively track the development of resistance over time or to link the development of resistance to a particular factor. It is however clear that DDT resistance is widespread in *An.arabiensis* in the Central Highlands and low level resistance to pyrethroids may also be present in *An.funestus* at some sites. Recently systematic monitoring has been introduced at 4 sentinel sites in the Central Highlands (2 sites are checked each year on a rotational basis) and in 2006 resistant specimens from bioassay tests at NMCP were sent to IPM for further analysis (molecular and biochemical testing). No kdr resistance has been detected yet from these samples but further tests are still underway.

Sentinel site surveillance for *An. funestus* is problematic as once an area has been sprayed specimens tend to be hard to find (and substantial numbers are needed for bioassays). Testing F1 generation specimens[11] can result in adequate numbers for bioassay testing but this approach results in reduced genetic diversity of the sample so that it may no longer be representative of the population as a whole. The monitoring system should therefore be augmented by routine insecticide resistance testing of specimens collected from outbreak areas (outbreaks may well provide the first indication of operationally significant insecticide resistance). Furthermore, the current monitoring network needs to be expanded to cover areas where LLINs form the mainstay of malaria prevention efforts. This is especially important in light of the results of a recent study in Mali which demonstrated for the first time a profound reduction in efficacy of both IRS and LLINs in an area with kdr resistance.

Use of insecticides for agriculture and their likely impact on resistance in vector mosquitoes. Large scale deployments of insecticides for the control of agricultural pests are restricted to cotton protection (primarily in the southwest but also to a lesser extent in the northwest) and occasional locust control operations also focused primarily in the southwest.

Cotton companies use organophosphates, cypermethrin and chlorpyriphos for pest control. Normally they apply insecticides six times a year (in an effort to slow the development of resistance, a different insecticide group is used on each occasion). It may be that cotton growing areas and malaria endemic areas tend not to overlap to any great

[11] Captured blood fed or gravid mosquitoes are allowed to lay eggs which are hatched and reared through to adulthood for testing.

extent and if this is the case then the insecticides used for cotton should have little impact on the development of resistance in malaria vectors. This should be investigated.

The Ministry of Agriculture uses deltamethrin and fenitrothion for locust control in response to swarms. The last major locust control campaign mounted was in 1997. The infrequent use of insecticides for locust control should minimize any pressure for the selection insecticide resistance in vector mosquitoes.

Other than this, a broad range of registered insecticides are used by individual farmers. Apparently the use of insecticides to protect rice in Madagascar is limited and so again insecticide resistance selection pressure should be low.

Vector bionomics
Vector mosquitoes may avoid exposure to insecticide through the development of behavioural changes. Reduced endophily for example could lessen the impact of IRS on vectors such as *An.funestus* and this could result in increased malaria transmission. NMCP does conduct periodic assessments of vector behaviour. These assessments should be carried out on a regular basis and at a representative selection of sites.

4.2.3 Cost effectiveness of IRS versus ITNs

A study conducted in the highlands of Kenya in 2000 (Guyatt *et al*., 2002) suggested that per case prevented, conventional ITNs cost more than three times as much as IRS. The epidemiological situation in the highlands of Kenya is rather similar to that in the central highlands of Madagascar and so one might assume that, from a cost-effectiveness point of view, IRS is the obvious choice for malaria control in this region. However dwellings in central Madagascar are unusually large. Many have two or even three floors and on average buildings of this size have six rooms. A study conducted by MoH/WHO in the late 1980's indicated an average sprayable surface in a multi-storey dwelling of 240 m^2 (Lietaert, 1988). In addition, the average number of people living in a dwelling in central Madagascar is low, at 5.5. These factors combine to suggest that the cost per infection prevented by IRS in Madagascar is likely to be considerably higher than in Kenya. Furthermore, the Kenyan study was based on conventional ITNs. Despite high initial purchase price, LLINs do not require retreating and so are considerably more cost effective than conventional bednets (especially when the notorious inefficiency of ITN re-treatment is taken in to account). It would therefore be useful to conduct a study to assess the relative cost of IRS and LLINs in the central highlands of Madagascar.

Cost effectiveness is however just one of a number of factors that should be considered when developing malaria control strategies. Another crucial factor that must be taken in to consideration when weighing the relative advantages and disadvantages of LLINs and IRS is acceptability. People in central Madagascar are used to IRS and it is popular not only for its impact on malaria but also for its effect on insect pests. In all probability LLINs would also be popular as rice is the predominant crop and so nuisance mosquito densities are high. However, bednets are not well known in the area and so any planned introduction would need to be preceded by a well organized pilot study.

5.0 Key recommendations

The following key recommendations relate either directly or indirectly to IRS:

5.1 Assess the feasibility of malaria elimination in Madagascar

The President of Madagascar has proposed an ambitious National Development Plan which includes as an objective 'malaria elimination by 2012'. NMCP goals should be ambitious but achievable. USAID should consider supporting a team of senior consultants including an epidemiologist, an entomologist and a health economist to work together with an in-country technical working group to asses the feasibility of malaria elimination in Madagascar and to set realistic targets for the NMCP.

5.2 Develop a clearly defined medium term plan for IRS

In order to plan effectively, policies need to be clearly defined. Prof. Guillet has proposed a number of fundamental changes to the current IRS strategy but there appears to be a lack of ownership for these approaches within MoH at present. USAID should therefore consider supporting a consensus building workshop in order to precipitate a clearly defined evidence based medium term strategy for IRS. This workshop should be attended both by members of the national TWG on IRS and by a multilateral team of high level experts

5.3 Minimize risk of insecticide stock-outs

Efforts should be made to ensure that IRS policy is not subject to the vagaries of donor funding. In order to avoid epidemics on the scale of those that occurred in the highlands of Madagascar in the 1980s, it is essential that an adequate emergency supply of insecticide is kept in stock, that routine IRS insecticide requirements are carefully calculated well in advance (preferably several years in advance), and that donor/government commitment is secured in good time. This should be possible through effective lobbying during high level malaria coordination meetings. Support for high level meetings will raise and maintain the political profile of malaria once per year.

5.4 Strengthen epidemiological monitoring

There is a profound lack of reliable up-to-date epidemiological data relating to malaria in Madagascar at present. Hence, targeting of interventions is unreliable and assessing impact is a challenge. Support is needed for the development of a robust mechanism for epidemiological monitoring based on confirmed rather than clinical cases.

This support should be supplemented by building the capacity of sentinel site doctors through the development of a short course on the epidemiology and control of malaria at the Institute of Public and Community Health. External technical assistance would be needed for curriculum development. As a part of the course development, standardized reporting formats should be designed for various levels of health facility to allow easy interpretation and comparison of data between facilities.

Microscopy services are critically weak in many hospitals at present. Nevertheless, in skilled hands microscopy continues to offer a number of benefits over RDTs and it will continue to be used in preference to RDTs at this level. Support is needed for the

development of a robust mechanism for the supervision of microscopy and for needs based training and refresher training of microscopists.

Developing an epidemic prediction capability should be considered.

5.5 Strengthen entomological monitoring

There is a need to develop a systematic, long-term program for monitoring insecticide resistance and vector bionomics in IRS and LLIN target areas. IPM could be a key partner for NMCP in this venture.

Expansion of the entomological monitoring network will require the recruitment of additional trained staff. Strengthening capacity in medical entomology either through overseas training or through support for training at the University of Antananarivo is recommended.

6.0 Other recommendations

6.1 Review policy regarding the use of RDTs

According to current policy, RDT tests will not be used for children under 5. As a result, the real cause of illness for those children in this group who do not have malaria will be left untreated and so many avoidable deaths may occur. NMCP should seriously consider adopting RDTs for all suspected malaria cases irrespective of age.

According to current policy, RDT tests will not be used at all by community based treatment providers. Use of RDTs by community based treatment providers has been extremely successful in many settings. NMCP should therefore seriously consider introducing RDTs and ACT at community level.

6.2 Address the over prescription of ACT

With the introduction of ACT the over prescription of antimalarials has serious cost implications. Furthermore, the real cause of illness for those that do not have malaria is left untreated and so the case fatality rate amongst this group is likely to be high. A means of addressing this issue will need to be developed. Given the general reluctance of medical practitioners to rely on laboratory diagnosis (whether it be microscopy or RDT based), the solution will need to go beyond “simply” developing a quality diagnostic network. The approach will probably need to be based on a combination of training and supportive supervision for clinical staff and on the development of realistic treatment algorithms which allow for treatment of “possible malaria cases” (slide/RDT negative) with a cheaper anti-malarial such as chloroquine.

6.3 Introduction of artesunate rectocaps

Current treatment guidelines do not make any provision for patients at community level who are too sick to swallow tablets. The MoH should consider introducing artesunate suppositories as an emergency treatment for severe cases at community level. Initial treatment with suppositories should always be followed up with the full course of ACT once patients are well enough to take tablets. It is important to ensure that suppositories

are heat stable. The ‘rectocap’ formulation produced by Mepha is ideal. This approach is currently supported by GFATM in most of the remote and inaccessible malaria hotspots in Southeast Asia and is becoming increasingly popular in Africa.

6.4 Translation and compilation of reports

A great many valuable reports and papers relating to malaria in Madagascar have been written. Most of these are in French. USAID should consider supporting an intern to translate, compile, index and summarize these documents in order to maximize their future usefulness.

III References

Guyatt, H.L., Corlet, S.K., Robinson, T.P., Ochola, S.A. and Snow, R.W. 2002. Malaria prevention in highland Kenya: indoor residual house-spraying vs. insecticide treated bednets. *Tropical Medicine and International Health*, **7 (4)**, 298-303.

Lietaert, P., 1988. Rapport Preliminaire de Mission Effectuee en Republique Democratique de Madagascar, WHO Mission Report.

N’Guessan, R., Corbel, V., Akogbeto, M. and Rowland, M. 2007. Reduced efficacy of insecticide-treated nets and indoor residual spraying for malaria control in pyrethroid resistance area, Benin. *Emerging Infectious Diseases*, **13**, 199-206.

IV Annexes

1. Scope of Work

Technical Support for Environmental Compliance Monitoring for Indoor Residual Spraying Programs

Dr. Sean Hewitt
February 5 – February 16, 2007
Under RTI Project No. 0208954.001.110.001

Background
The U.S. Agency for International Development (USAID) offers technical and financial support for malaria vector control activities to Ministries of Health and National Malaria Control Programs. Under the Integrated Vector Management Task Order, RTI International, Inc. (RTI) has prepared Environmental Assessments (EAs) and Pesticide Evaluation Reports and Safer Use Action Plans (PERSUAPs) to satisfy USAID environmental review requirements (22 CFR Part 216) for Indoor Residual Spraying (IRS) activities in several countries (Eritrea, Angola, Uganda, Tanzania/Zanzibar) and has provided technical support for environmental compliance. USAID has asked that RTI conduct similar assessments and compliance activities for its support of IRS in other countries, including Ethiopia, Zambia and Madagascar.

USAID is supporting the IRS component of Madagascar's national malaria control program and may expand this support under the President's Malaria Initiative (PMI). In November 2006, USAID approved the PERSUAP for IRS using Alpha-cypermetherin for Madagascar's Central and Highlands, which establishes requirements for preventing or mitigating potential harm to human health and the environment that could result from the use of residual pesticides.

Purpose
- Under this consultant assignment, Dr. Sean Hewitt will perform the following activities:
- Visit Madagascar to observe IRS activities in progress and determine how IRS is being used in conjunction with vector control and malaria control interventions.
- Identify needs for strengthening the use of IRS in Madagascar and provide recommendations for IRS technical support for IRS spraying operations and procedures; training and monitoring.
- Assess current targets for IRS operations and provide recommendations for additional technical assistance needed to meet FY 2008 targets for IRS activities.
- Determine status of entomological monitoring in Madagascar and the status of insecticide resistance.
- Determine the capacity for entomological surveillance and institution (s) from which technical assistance may be available.

- Determine the status of information on malaria stratification and seasonality in Madagascar
- Work with RTI consultant Samba Yade to facilitate a 3 day workshop on environmental compliance and meeting conditions set forth in the PERSUAP for Madagascar.

Dr. Hewitt will report his findings to Ms. Anna Thompson.

Work plan & Duties
Madagascar (10 days)

Week 1: Dr. Hewitt and Dr. Samba will travel to Antananarivo to conduct field visits to observe IRS operations in progress and determine and document whether they are in full compliance with USAID requirements as included in the approved PERSUAP. In addition, Drs. Yade and Hewitt will lead a 3-day workshop on environmental compliance for IRS Programs and meeting conditions set for the PERSUAP for IRS using Alpha-cypermetherin for Madagascar's Central and Highlands.

During the first week, Drs. Yade and Hewitt will conduct an initial IRS environmental compliance visit with Senior Officials at the Ministry of Health/National Malaria Control Program and Ministry of the Environment to observe IRS Operations. The RTI Team upon return will meet with USAID, Ministry of Health and Ministry of the Environment to discuss initial findings from the site visit, the inspection protocol and to finalize planning for the 3-day workshop. The RTI Team will then facilitate the 3-day workshop which will include 2 site visits.

Week 2: Dr. Yade will conduct additional site visits with the National Malaria Control Program to observe field operations underway and determine whether they are fully in compliance with the environmental mitigation requirements listed in the approved PERSUAP. If gaps in compliance are identified, the consultant will document such gaps and meet with MOH representatives, district health authorities, and the Mission Environmental Officer to reach agreement on additional steps that will be taken to ensure full compliance with the Environmental Assessment. The consultant present will his observations, conclusions and agreed upon actions with USAID/Madagascar the Ministry of Health/National Malaria Control Program before departing from Madagascar on or about February 16, 2007.

During the 2nd week Dr. Hewitt will also meet with MOH representatives to identify needs for strengthening the use of IRS in Madagascar and assess current targets for IRS operations and provide recommendations for additional technical assistance. In addition, he will determine status of entomological monitoring, insecticide resistance and information on malaria stratification and seasonality.

Deliverables

Trip Report: An Assessment of IRS Operations and integration with vector and malaria control interventions in Madagascar (Dr. Sean Hewitt)- March 5, 2007

Deliverables	Date of Delivery
Madagascar Trip Report (draft)	February 28, 2007
Final Madagascar Trip Report	March 5, 2007

2. Itinerary

Calendrier de visite des Consultants

Drs Samba Yade & Sean Hewitt / RTI

from Feb. 6 to 16, 2007

Date	Time	Activities	Mtgs Venue
Sund. 4 Feb.	**22:50**	Sean Hewitt's arrival - lodged @ Hilton - Tel 22 260 60	
Mond. 5 Feb.	**22:50**	Samba Yade's arrival - lodged @ Hilton	
Mon. 5 Feb.	**8:00**	Joint briefing (RTI, MSH/RPM Plus and JHPIEGO) at USAID with Wendy Benazerga and Noé Rakotondrajaona to discuss the purpose of the assignment & concerns *(mtg confirmed* - USAID will provide a car at **7:30 a.m**. to pick Dr. Sean up from Hilton to AID)	USAID
	11:30	All Malaria TDYers briefing at MOH/SLP with Dr. Raveloson and SLP team *(mtg confirmed)*	MOH/IHS
Tue. 6 Feb.	**8:00 a.m.**	Sean Hewitt to meet with Dr. Raveloson/SLP - *mtg confirmed*	USAID
	10:00 a.m.	Meeting with Dr. Rakotoson Désiré, MOH/SLP - Tel 033 11 742 08 *(mtg confirmed)*	MOH/IHS
	14:00 p.m.	Meeting with Dr. Jocelyn/IPM(Tel 032 04 869 29) - Service Enthomologie & Dr. Atalarmin, IPM Director - *mtg confirmed*	IPM 22 401 64
	15:30 p.m.	Meeting with Mr. Dama, Directeur de la Protection de l'Environnement -at Min. Env. Ampandrianomby - *mtg confirmed*	Mr. Dama 032 04 150 69
Wed. 7 Feb.	**a.m.**	Field visit in Avaradrano (USAID car provided)	Avaradrano
	15:00 p.m.	Meeting with Mr. Fidimalala/PROCHIMAD (Imprimerie NIAG Antanimena on 1st Floor, near cookies shop Antanimena) - (*mtg confirmed)*	Prochimad Tel 22 216 33
Thurs. 8 Feb.	**a.m.**	Field visit in Ankazobe (USAID car provided)	Ankazobe
	15:30 p.m.	Meeting with Dr. Jocelyn/IPM(Tel 032 04 869 29) - Service Enthomologie - *mtg confirmed*	**IPM 22 401 64**
Frid. 9 Feb.		**Field visit in Fianarantsoa**	Fianarantsoa
Sat. 10 Feb.			

Sund. 11 Feb.		Trip back to Tana (8 hours drive)	
Date	**Time**	**Activities**	**Mtgs Venue**
Mon. 12 Feb.	**a.m.** **3:30 p.m.**	Team building workshop preparatory at MOH/IHS Meeting at USAID with the Mission Director, the Embassy, RPM Plus team, Institut Pasteur and PSI - Presentation given by MSH/RPM Plus, RTI, JHPIEGO and PSI - It includes: IPT, IRS, Bednets, ACT, RDT - What are the approaches? what the status is and what the next steps are? (planning, location,...) - *mtg confirmed*	IHS USAID
Tue. 13 Feb.	**8:30 a.m.**	Dr. Sean Hewitt to meet with the Faculté des Sciences staff, including Mrs. Raveloson Lala Tel 033 12 476 07 - *mtg confirmed*	Salle de Conseils - Faculté des Sciences - Département Enthomologie
	10:30 or 11:00	Meeting with Dr. Vincent Richard, Epidemiologist, Institut Pasteur, *mtg confirmed* Dr Samba to conduct CAID workshop at Relais de la Haute ville (Feb. 13 to Feb. 15)	Tel 22 401 65
Wed. 14 Feb.	**a.m.**	Meeting with Dr. Luciano Tuseo /WHO **-** *date/time TBD*	WHO: 23 313 64
Thurs. 15 Feb.		Meeting with Mr. Fidimalala/PROCHIMAD (Imprimerie NIAG Antanimena on 1st Floor, near cookies shop Antanimena) - (*mtg still TBD with Dr. Sean) - Tel 22 216 33*	
Frid. 16 Feb.	**9:00 am**	Debriefing with RBM partners *(still to be confirmed)*	TBD
	11.00 am	Meeting with Prof Jean de Dieu, Faculty of Medicine, School of Public Health	
	12.30 am	Meeting with Exxon Mobil	
	1.30 pm	Debriefing with USAID	
	Evening	Departure	

3. List of People Met

USAID
Wendy Benazerga, HPN Team Leader, Office of Health Population and Nutrition, USAID, Antananarivo. (wbenazerga@usaid.gov).

Dr Noe Racotondrajaona, Malaria Manager, Office of Health Population and Nutrition, USAID, Antananarivo. (nracotondrajaona@usaid.gov).

MSH
Dr Grace Adeya, Senior Programme Associate, Centre for Pharmaceutical Management, MSH, Washington DC. (gadeya@msh.org).

Kathleen Webb, Programme Associate, Centre for Pharmaceutical Management, MSH, Washington DC. (kwebb@msh.org).

NMCP
Dr Andrianirina Raveloson, Head of Malaria Control Service, Ministry of Health, Antananarivo, Madagascar. (a_raveloson@hotmail.com).

Dr Jean Desire, Head of Epidemiology and Entomology.

Dr Emmanuel, Entomologist

Provincial and District level staff involved in IRS

Pasteur Institute
Dr Antoine Talarmin, Director, Pasteur Institute. (atalarmin@pasteur.org).

Dr Vincent Richard, Head of Epidemiology Unit, Pasteur Institute. (vrichard@pasteur.org).

Dr Didier Menard, Malaria Research Unit, Pasteur Institute. (dmenard@pasteur.org).

Dr Jocelyn Ratovonjato, Medical Entomology Unit, Pasteur Institute. (ratov@pasteur.org).

SALAMA
Dr Tahina Andrianjafy, Director General, Salama, Central Store for Essential Drugs and Medical Materials for Madagascar, Antananarivo, Madagascar. (salama@salama.mg).

University of Antananarivo, Faculty of Sciences, Entomology Department
Prof. Olga Ralisoa, Head of Entomology Department, Faculty of Sciences, University of Antananarivo, Madagascar.

Dr Raveloson Lala, Agricultural Entomologist, Entomology Department, Faculty of Sciences, University of Antananarivo, Madagascar. (Tel. 033 1247607)

Dr Razafindratiana, Agricultural Entomologist, Entomology Department, Faculty of Sciences, University of Antananarivo, Madagascar.

Dr Randianarisoa, Medical Entomologist, Entomology Department, Faculty of Sciences, University of Antananarivo, Madagascar.

Dr Rafarasoa, Medical Entomologist, Entomology Department, Faculty of Sciences, University of Antananarivo, Madagascar.

WHO
Mr Arthur Rakotonjanabelo Lamina, Malaria Control Adviser, WHO, Antananarivo, Madagascar. (rakotonl@mg.afro.who.int).

Dr Luciano Tuseo, Roll Back Malaria, WHO, Bureau pour Madagascar et La Réunion, BP 362 Enceinte Galaxi Plaza Andraharo, Antananarivo Madagascar, Tel. 00261-20.23.313.64/71, Tuseol@mg.afro.who.int. Secrétaire: Mme Zana Razainandrasana razaiz@mg.afro.who.int.

PROCHIMAD
Mr Fidimalala Andriatsihoarana, Department Director, Public Health, PROCHIMAD, Madagascar Society of Chemical Products, Antananarivo, Madagascar.

University of Antananarivo, Faculty of Medicine, Public Health Department
Prof Jean de Dieu, Faculty of Medicine, School of Public Health, University of Antananarivo, Madagascar.

Exxon Mobil
Drew Goodbread, Director General, ExxonMobil Exploration and Production, Madagascar. drew.r.goodbread@exxonmobil.com.

4. Report by Prof. Guillet, WHO Geneva. **-** Attached as a separate document.