Report on a consultation for the Malaria Consortium (Liverpool School of Tropical Medicine) for UNICEF (Mozambique)

THE EVALUATION OF INDOOR RESIDUAL INSECTICIDE SPRAYING ACTIVITIES IN MOZAMBIQUE

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&
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1. EXECUTIVE SUMMARY

A two-week evaluation of the indoor residual spraying programme of the Ministry of Health for the control of malaria vectors was conducted between 27th November and 10th December 1999. This visit was supplemented with a second visit during the period following the severe flooding experienced in southern Mozambique in early 2000. Information sources were primarily discussions held during the mission with people listed in Annex 3, with householders from Inhambane Province and Maputo City and from documents held at the Ministry of Health. During the second visit, emergency residual spraying operations were observed in Gaza province.

The present policy with regard to indoor residual spraying is to spray the internal surfaces of houses from selected *bairros* within a 50km radius of the main urban centres once a year with lambdacyhalothrin, a synthetic pyrethroid. In addition to protecting the residents of these houses the policy is designed to reduce the spread of drug resistant parasites into the urban centres. The current policy was not designed to protect inhabitants of rural areas, where malaria transmission is more intense.

Management of the residual spraying programme is essentially vertical, although some devolution to districts has recently taken place. Evaluation of the impact of spraying on malaria incidence is not currently undertaken as part of routine programme activities, and the choice of areas to spray is based largely on historical precedent. Funding for the operational costs of the programme was in the past provided by UNICEF.

The main conclusions from the first consultancy are as follows:

- It is not possible, with the current reporting system, to determine the impact of indoor spraying with residual insecticides in reducing malaria transmission in Mozambique.
- It was not possible to accurately determine coverage rates from the data available
- In the previous two years spraying was not completed before the onset of the rains.
- Prospective spray rounds should be concluded before the end of the school year term in mid-December. If spraying cannot be started before the beginning of the rains resources should be transferred to curative services and that particular spray round should be skipped.
- A possible increasing refusal rate among householders is a cause for concern.
- In order to improve coverage and assessment all structures that are due to be sprayed should be numbered and maps showing their location produced. Mapping could be carried out in collaboration with the Spatial Development Initiative (SDI).
- In order to assist in supervision and assessment of the impact of spraying, a label, detailing date of spray, type and dosage of insecticide and name of spray person, should be attached to the upper inner wall of sprayed houses.
- Evaluation of malaria transmission intensities, and estimation of the population at risk, should be undertaken in representative sites throughout the nation.
- Reporting from the province to the central level was generally good and virtually complete. It may be helpful to introduce a standard residual spraying reporting form, to facilitate collation and analysis of data at central level.
- Bio-assays on various types of surface, and physiological resistance testing, should be routinely used. These will determine the half-life of the insecticide *in situ* and the possible development of resistance in the field.
- Experiments should be conducted to compare the impact of spraying walls and eaves (not ceilings), and eaves alone.
- Operational research on the use of focal indoor residual insecticides to control *Anopheles funestus* during the dry season should be encouraged.

- Estimated programme costs were US$ 0.40 per head for insecticide and US$ 0.15 per head for operational costs. Transportation and storage costs of the insecticide as well as the replacement costs of pumps are not included.
- Long term funding, perhaps by private-public partnership, should be secured as part of long term planning of control activities.
- ITNs sale and use should be encouraged, particularly in high-risk areas.
- The use of alternative insecticide types on nets and on walls should be considered.

Emergency Vector Control Activities

Extensive rainfall in southern Africa caused severe flooding in southern Mozambique during February 2000. By April 2000, approximately 250,000 people, including 50,000 under five years of age, were living in 68 Internally Displaced Person (IDP) camps or accommodation centres throughout the affected areas in Maputo, Gaza, Inhamabane and Sofala provinces.

UNICEF provided funds to the Ministry of Health to support emergency control of malaria vectors in IDP camps in three provinces; Maputo, Gaza and Inhambane. Indoor residual spraying with lambdacyhalothrin (ICON) was an important component of this response. Indoor residual spraying is an appropriate anti-epidemic control method in communities where there is public acceptance of spraying, availability of suitable equipment, adequately trained spray personnel, supervision and strong financial support.

- Coverage within the sprayed camps was high, ranging from 71% - 97%. Displaced persons interviewed by the consultant were pleased that malaria control efforts had been undertaken on their behalf.
- Some 19,332 structures were sprayed in IDP camps during the emergency, probably protecting over 100,000 people. These structures ranged from permanent buildings through to canvas tents and plastic sheeting shelters. At the same time, spraying was carried out in urban and peri-urban areas of Xai-Xai Town, where some 4,962 structures were sprayed.
- Prior to spraying the proportion of malaria cases was over 60% but once spraying had had time to take effect, the proportion had dropped to just over 40%. In addition, numbers of malaria vector mosquitoes found resting in tents was reduced to zero.
- Commencement of spraying of camps was timely, given logistical constraints and continuing bad weather.
- The spray team from Xai-Xai sprayed Inhacutse camp very efficiently and effectively. Residents reported an absence of mosquito nuisance after spraying for at least one month
- There was general agreement that spraying was more difficult in urban parts of the town due to a high refusal rate. The main reason given for refusal was generally 'irritation of the insecticide' although an increase in cockroaches was also cited.

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ABBREVIATIONS

INS	Instituto Naçional de Saúde
LATH	Liverpool Associates in Tropical Health
MoH	Ministry of Health
NGO	Non-governmental Organisation
SDI	Spatial Development Initiative
TAAM	Technical Addendum to Aide Memoire
ULV	Ultra Low Volume
WHO	World Health Organisation

2. BACKGROUND

The Ministry of Health in Mozambique operates a programme of indoor residual insecticide spraying of houses, complemented by limited outdoor spraying. Spraying activities are primarily focused on urban and peri-urban areas, whilst the rural areas, from where the majority of malaria cases originate, are not sprayed. Residual insecticide spraying is a well-established and successful method of malaria control, which requires detailed planning, rigorous implementation and careful monitoring and evaluation to be effective. In Mozambique, there is a strong perception that the spraying programme is effective, but there are limited objective data to support this assumption. Available malaria case data are consistent with annual variation caused by differences in climatic and other variables. UNICEF has provided a total of US$ 1,327,924 to the MoH for malaria control activities covering the period 1994-1998. The majority of these funds have been spent on residual insecticide spraying activities.

A joint evaluation of the spraying programme by MoH/WHO/UNICEF was planned for 1999-2000. The purpose of this evaluation was to review the operational aspects of implementation of the spraying programme in Mozambique to assess the effectiveness of the programme, make recommendations to improve the programme and to clearly define the role of residual spraying within an integrated malaria control programme in Mozambique.

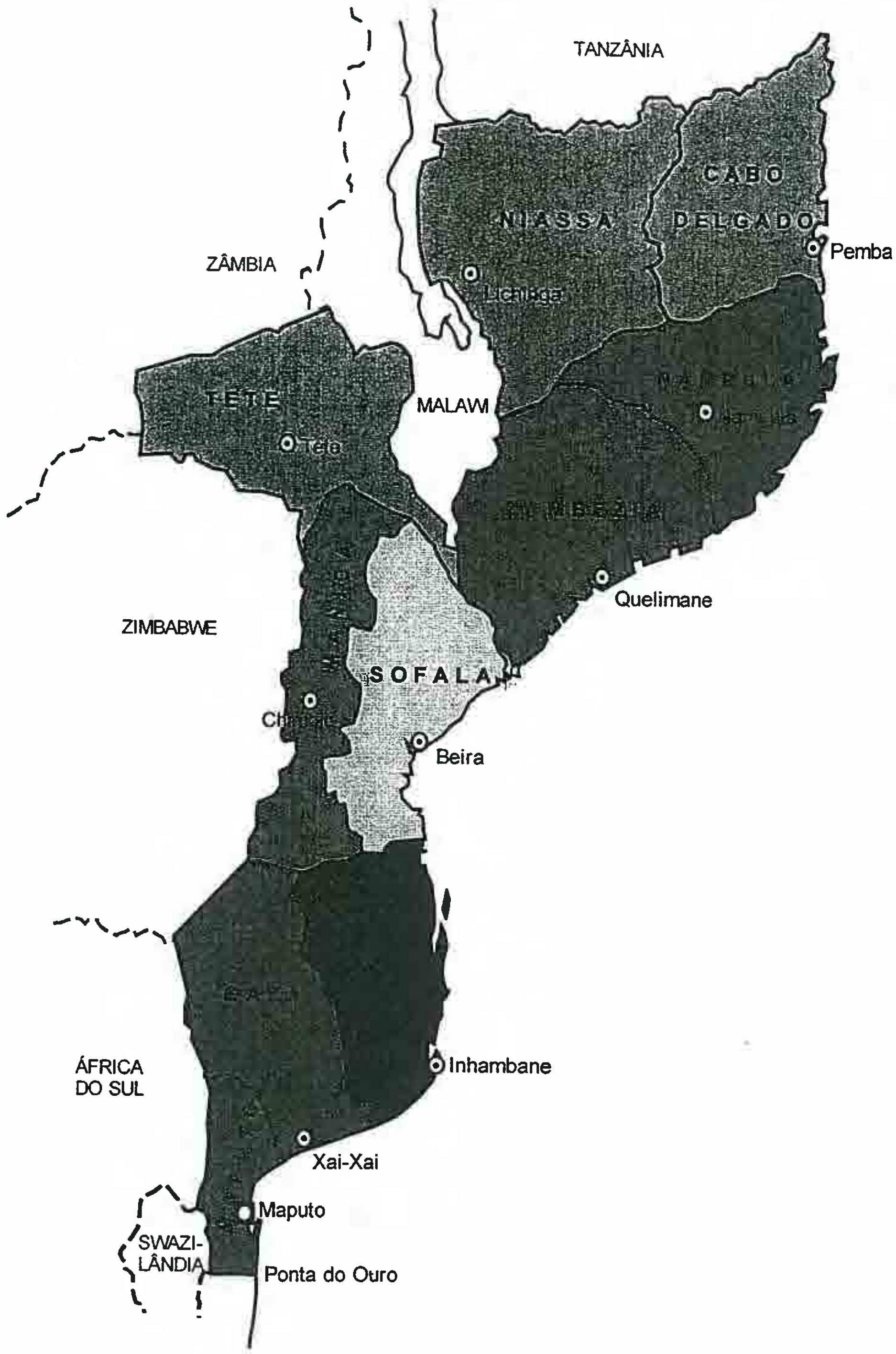
2.1 Malaria situation

Mozambique is a tropical country in southern Africa bordered to the north by Tanzania, the west by Zambia, Malawi, Zimbabwe and the south by South Africa and Swaziland. The climate is humid and tropical, mean annual temperatures range from 19° C in the highlands of the central and northern areas to 26° C in the south of the country. Relative humidity varies between 60 and 80% and the vegetation is a mixture of savannah and open woodland forest. The wet season extends from November/December to March/April. Average rainfall varies from 800mm in the southern part of the country to 1400mm in the central region. In other words the environment is eminently suitable for malaria transmission. Although transmission is perennial, peak transmission takes place between December and May.

2.2 Malaria vectors in Mozambique

It is considered that *Anopheles gambiae s.l* (mainly *An. arabiensis*) is the primary vector in coastal regions and *An. funestus* is the principal vector in areas where annual mean temperatures are below 21°C. It is likely that *An. funestus* is responsible for perennial transmission, particularly in rural areas, and that *An. arabiensis* is responsible for seasonal and epidemic transmission. *Anopheles funestus* breeds in large bodies of water with emergent vegetation, they have a limited flight range (generally less than half a kilometre) and are most common in houses close to such water bodies. It is a highly anthropophagic, endophilic mosquito and densities can sometimes reach several hundred per room. Peak densities are found at the end of the rainy season, particularly in rice growing areas. Although larvae of *An. arabiensis* can be found (especially in the dry season) at the edges of the water bodies favoured by *An. funestus*, it typically breeds in small sunlit pools. It has a larger flight range than *An. funestus*. It is also a less synanthropic mosquito than *An. funestus*, the degree of endophiliy and anthropophagy varying according to the availability of alternative hosts and alternative resting sites. This can affect the insects' ability to transmit disease. Nevertheless, in areas where alternative hosts are not available (such as is the case for many areas of Mozambique) it is likely to be as efficient a vector as *An. funestus*. Given the flight range and breeding site differences, the geographical distribution of the two species is likely to differ (especially in the wet season when breeding sites for *An. arabiensis* are widespread) even within very small areas.

Figure 1: Map of Mozambique



2.3 Health Information System

An overview of the malaria situation in Mozambique is provided in the draft document 'Technical Addendum to Aide Memoire' (TAAM) produced by a joint World Bank, World Health Organisation, UNICEF rapid assessment mission conducted between the 10-19 February 1999.

Data collection on outpatient attendance for malaria was only started nation-wide in 1998 and the health information network in peripheral areas is weak. Nevertheless, even in the absence of reliable, quality controlled data it is obvious that malaria is a most important disease in Mozambique. It is the leading cause of mortality and morbidity in the country. It is responsible for almost half (44%) of outpatient attendance as well as a high proportion of paediatric admissions (estimates vary between 57.6 and 70%) and one third of hospital deaths. Case fatality rates vary from 1.8% in Maputo to 9.6% in the central Province of Zambezia. Overall estimated infant mortality rates are 134 per 1000 births whilst children under 5 years of age have a mortality rate of 199 per 1000 births. Indeed it has been estimated that 394 children under 5 years of age die every day in Mozambique.

The 1997 population census recorded 16,543 million inhabitants (52.6% women and 47.3% men). Annual population growth rates are estimated to be 2.5% (which implies a population doubling time of 30 years). Children under the age of 18 (82% of whom live in rural areas) represent 55% of the population. Approximately 20% of children are of low birth weight. Chloroquine remains the first line treatment of the disease although resistance in urban and peri-urban areas has reached a point where 'a change in policy needs to be urgently considered' (TAAM).

Sixteen districts in seven Provinces (Maputo Province, Gaza, Inhambane, Sofala, Zambezia, Cabo Delgado and Manica) are considered to be epidemic prone. Although the last reported epidemic occurred in Maputo Province in early 1996 (when 12,795 cases, with 7,829 admissions and 107 deaths were recorded between February and April) the malaria situation in the district of Maxixe in Inhambane Province in early 1999 could perhaps also be considered an epidemic.

Plasmodium falciparum is the predominant species of malaria. It accounts for 90% of all infections. *Plasmodium malarie* and *P. ovale* account for 9.1% and 0.9% respectively of the other malaria infections.

3. MALARIA CONTROL

3.1 Malaria Control in Mozambique

A major challenge for malaria control is the limited access of much of the population, especially in rural areas, to adequate preventive interventions, diagnosis and treatment. Only 40% of the rural population is reached by health facilities and little has yet been done in community-based malaria control.

Spraying operations were first carried out when Mozambique was under the Portuguese colonial administration. At the time the insecticide used was DDT. This was done as part of a nation-wide malaria eradication project but was stopped in 1975. More recently spraying has been limited to a 50km radius around the major population centres in all but one province. The basic idea behind the control programme is to reduce the number of cases, and hence the use of chloroquine in these centres. It was hoped that this would reduce the spread of chloroquine resistance in the country as a whole. Whether it slowed down the spread of chloroquine resistance is uncertain. Nevertheless more than 40% of cases are now considered resistant and it is likely that, following WHO guidelines, the country will change the first line treatment in the future (an antimalarial drug policy meeting will be held in Mozambique in October 2000). Date of commencement of spraying differs according to province. For example, operations have been conducted in Sofala (Beira) since 1987, Zambezia since 1990, in Manica since 1994, in Inhambane since 1995, in Tete and Gaza since 1995 and in Cabo Delgado since 1998.

Chloroquine resistance is of major concern to the Mozambican health authorities. In the mid 1990s a strategy for reducing the development of resistance in the major towns was developed. This consisted of establishing a protected barrier zone, of 50 km depth, around each major town. The method employed was indoor spraying of houses with the residual insecticide lambdacyhalothrin (trade name ICON) a highly potent long lasting synthetic pyrethroid. The idea behind this strategy was to reduce the transfer of drug resistant parasites from the outskirts to the major towns. The rationale behind the strategy is no longer as valid as it was during the civil war because there is now a much greater flux of people between rural areas and towns.

3.2 Indoor Residual Spraying

Residual insecticide spraying is a well-established method of malaria control and is used extensively and successfully by control programmes throughout southern Africa. To be effective, it requires detailed planning, rigorous implementation and careful monitoring and evaluation. Important considerations for the technique of application of residual insecticides include the number, type, location and accessibility of the structures to be sprayed. This information should be obtained by a detailed geographical reconnaissance of the target areas. Adequate maps should be prepared showing roads, location of villages, water points and other important features. The number, type and size of dwellings should also be identified, mapped and recorded. Each house should ideally receive a reference number that is painted on the door or wall so that spray personnel can determine where they are and what they have to spray and so that squad leaders can easily supervise the work done. The average surface area of dwellings should be calculated (so that the total number of square metres of surface to be sprayed, and hence the amount of insecticide to be used, can be determined. For epidemiological evaluation information on the age and number of people living in each house should, where possible, be obtained. This enables information on the changes in prevalence, and perhaps incidence, of malaria to be determined, when linked with disease data.

The timing of spraying is also important and depends on the seasonality of vector populations and transmission cycles. As it stands the spray programme is designed to control seasonal transmission of malaria by *Anopheles arabiensis,* rather than perennial transmission by *An. funestus.* Given the dependence of *An. gambiae* mosquitoes on rainfall it is important that the spray round should be completed prior to the onset of the main rains. Spraying operations in Mozambique take place once a year and are designed to occur before December when the main rains start. Transport facilities for moving equipment, materials and personnel is an important consideration for a successful spraying operation. Given the difficulties of access of many areas during the rains spraying before the rains also makes the work of the spray teams easier. High coverage rates (houses sprayed compared to the total) are required for spraying to be an effective malaria control measure.

The area within each house that requires spraying can depend on the behaviour of the local vector. For example, if the mosquitoes rest on the ceilings of houses then it is mandatory that they are sprayed, if they do not then this requirement may be unnecessary. In Mozambique all indoor surfaces including ceilings and under eaves are sprayed. It may also not be mandatory to spray buildings that are unoccupied at night, such as schools. Given these considerations, the total amount of insecticide required for each spray round is determined by the target dosage (the amount of insecticide applied per sq. metre of wall surface) and the estimated total surface area to be sprayed (average surface area of buildings multiplied by the number of buildings to be sprayed).

It is important that a uniform coverage of insecticide be applied to sprayed surfaces. The factors which determine the amount are: The insecticide concentration in the liquid, the air pressure in the sprayer, the nozzle aperture, the distance from the nozzle tip to the surface to be sprayed and the speed of application. The uniformity of application of the correct dosage by individual spray people is usually determined during training sessions held prior to the actual operation in the field. Spraying is carried out in Mozambique by teams of four spray people each supervised by a squad leader responsible for supervision and evaluation. The squad leader reports to the Brigade Chief who reports to the Supervisor for the Province. This Programme Administrator is responsible for Vigilance and Epidemiology of Communicable Diseases in general including malaria, sexually transmitted diseases, AIDS and cholera. It is their responsibility to compile the weekly and monthly epidemiological reports that are sent to Maputo for integration into the nation-wide epidemiological reports. It is the job of the co-ordinator to assess the reports from the districts for epidemic forecasting (for all diseases) and to evaluate the feedback from the spray teams.

3.3 Role of UNICEF in malaria control in Mozambique

The operational costs of the spraying program were previously funded by UNICEF. Following the introduction of the new country programme, however, UNICEF malaria control interventions will focus on the capacity of communities to prevent, recognise and correctly treat malaria. It will be based upon community capacity development, strengthening the capacity of communities to organise themselves to take informed decisions on the prevention and home based management of malaria. The triple A approach of Assessment, Analysis, and Action will be used and community ownership and involvement will be developed.

The overall objective for 1999-2001 is to develop and support the taking to scale of effective community based malaria prevention and treatment strategies. The annual objective for 1999 is to develop and support community based strategies for promoting the use of Insecticide Treated Nets within an integrated national malaria control programme.

Given the change in policy it was decided to evaluate the effectiveness of past spraying campaigns, to suggest improvements and to determine what the role of indoor residual spraying may be in the future. The terms of reference for the mission are provided in Annex 1 and summary answers given in Annex 2.

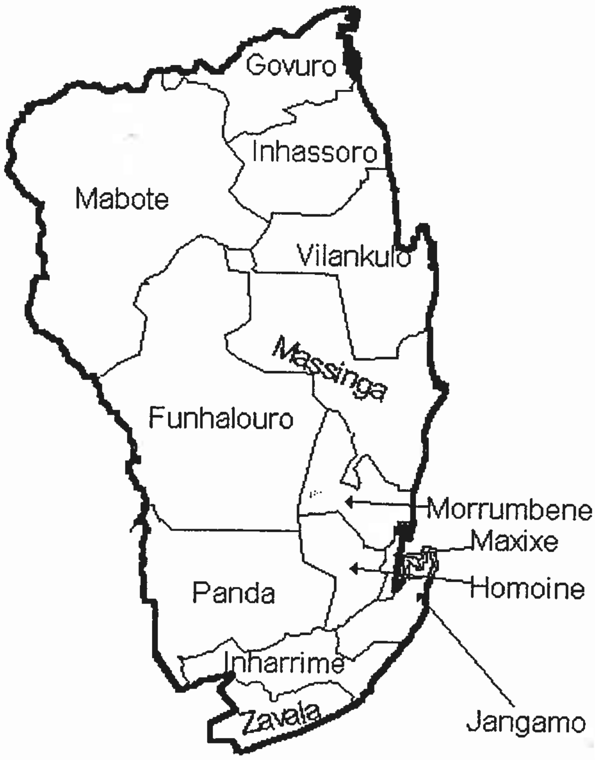
4. FINDINGS IN INHAMBANE PROVINCE

4.1 Epidemiology of malaria in Inhambane

The town of Inhambane lies some 600km north of Maputo (Fig 1 Map of Mozambique). According to data provided by the National Bureau of statistics there were 997,600 people living in the province in 1990. This was equivalent to 8% of the total population of the country. Recent estimates of population density around the town of Inhambane, provided by MARA, are 80-100 inhabitants per sq. km. During the present assessment 12 houses from Muele, a peri-urban bairro in Inhambane town, were measured and their owners questioned about malaria. Mean number of occupants per house was 3.5 (std dev 1.7) and the mean wall surface area was 29.1 sq. m (std dev 8.8), whilst the mean ceiling area was 12.8 sq. m (std dev 4.1). Hence the total mean interior surface area was 41.9 sq m (std dev 12.5).

There are 12 districts in Inhambane Province as well as the towns of Inhambane and Maxixe that provide information on malaria incidence to the provincial headquarters (Fig 2 Map of Inhambane Province). Table 1 provides information on estimated population sizes for each district and Table 2 mean weekly malaria incidence rates per 1000 people, by age group, averaged over 1998 and the first half of 1999. Incidence rates should be treated with caution since incomplete recordings will bias the results (upwards if rates were only reported during the peak transmission season, downwards if rates were reported only at other times). More importantly, the data is based on information supplied by health facilities and many cases may not reach such facilities. Nevertheless, the data indicates that people in Inhambane

Figure 2: Map of Inhambane Province



Province will on average have a clinical attack of malaria every two months. In some districts reported rates are as high as one attack every two and a half weeks. Estimated rates depend on the size of the denominator (population size). It is likely that the population estimates used are too low which means that they will overestimate the clinical attack rate of malaria. Nevertheless even if estimated rates are halved it still implies that people in some districts are ill with malaria every five weeks.

From 1989-1992 (i.e. prior to spraying operations) records of admissions and deaths due to malaria in the paediatric ward of Inhambane hospital were kept. These are shown in Fig 3. With the exception of a sharp peak in deaths in May of 1991 and a similar peak in June of 1992 in each of these years paediatric cases, and deaths, peaked in the first four months of the year.

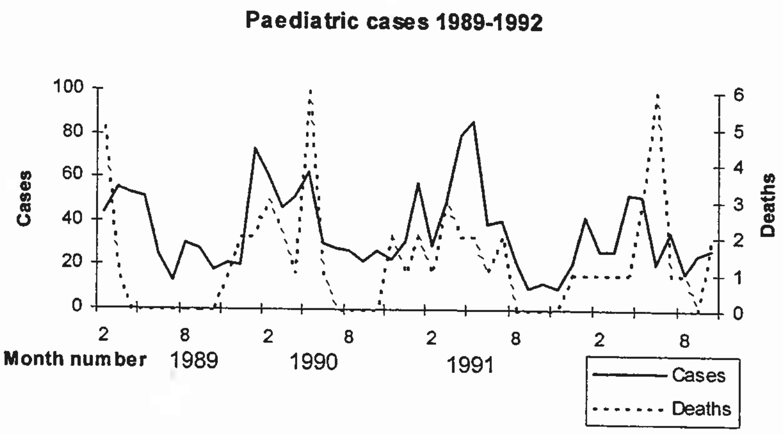


Figure 3. Admissions and deaths 1989-1992 from the paediatric ward Inhambane Hospital.

In 1995 age stratified data was obtained on malaria admissions to Inhambane hospital. Rainfall data for this year from the town was also provided. These are shown in Fig 4. For all age groups cases peaked in February.

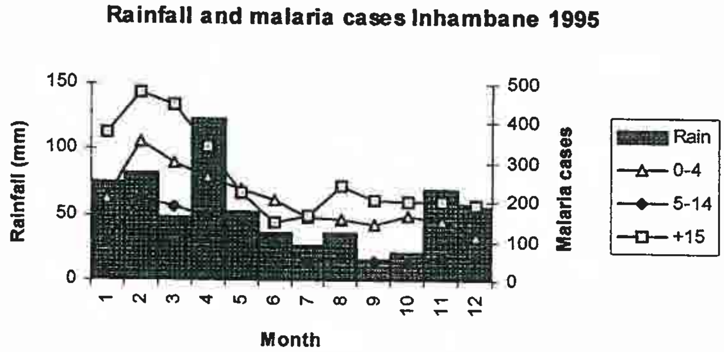


Figure 4. Rainfall and malaria admissions Inhambane hospital 1995.

The pattern of peak transmission occurring during the early months of the year continued in later years. In 1997 malaria becamé a notifiable disease and information from the district health centres started to be collected. In 1998 information on the age of patients attending the health centres and their treatment (either chloroquine, sulphadoxine-pyrimethamine - Fansidar; quinine or Halfan - the latter two classified as 'other') were collected on a weekly basis. Age groups were 0-4 yr., 5-14 yr. and 15 or over. In addition cases were identified as either being unconfirmed (when presumptive treatment was given), confirmed (by blood slide examination) or inpatients (Table 3). Information on death due to malaria was also obtained.

In line with the observed increase in chloroquine resistance nation-wide, the proportion of confirmed cases that required treatment with sulphadoxine -pyramethamine has increased over recent years (Fig 5).

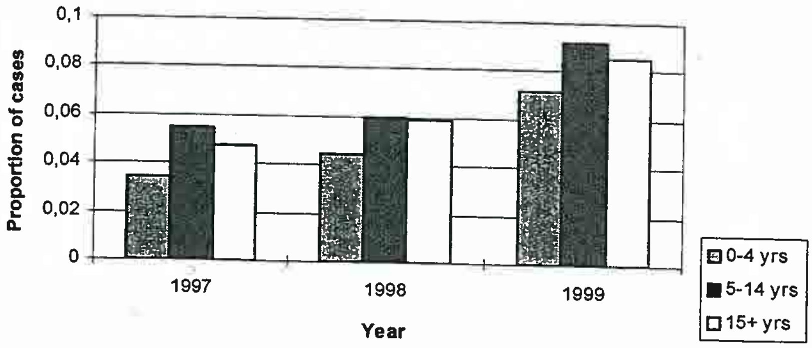


Figure 5. **Proportion of confirmed malaria cases Inhambane Province treated with Sulphadoxine-Pyrimethamine**

Total monthly estimated numbers of cases for the years 1997-1999 from Inhambane Province (both sprayed and unsprayed) by age group are shown in Figs 6-8. Incidence rates in 1999 were approximately twice those in the two previous years (Fig 6-8). Estimated case fatality rates were, however, not significantly different from other years (Table 4). Seasonality in inpatients and in non-confirmed cases is much more evident than it is for outpatients. There may be a number of reasons for this. For example, the number of confirmed cases may reflect the number of slides that can be read at the laboratory rather than the number of cases of malaria. The proportion of cases that are sent for confirmation of diagnosis may vary from one season to the next. In the dry season, when there are fewer cases, a higher proportion may be sent for confirmation of diagnosis, with the result that seasonal differences in confirmed cases disappears. It is also not known what proportion of confirmed cases are from those people who return for repeat diagnosis a week after initial treatment.

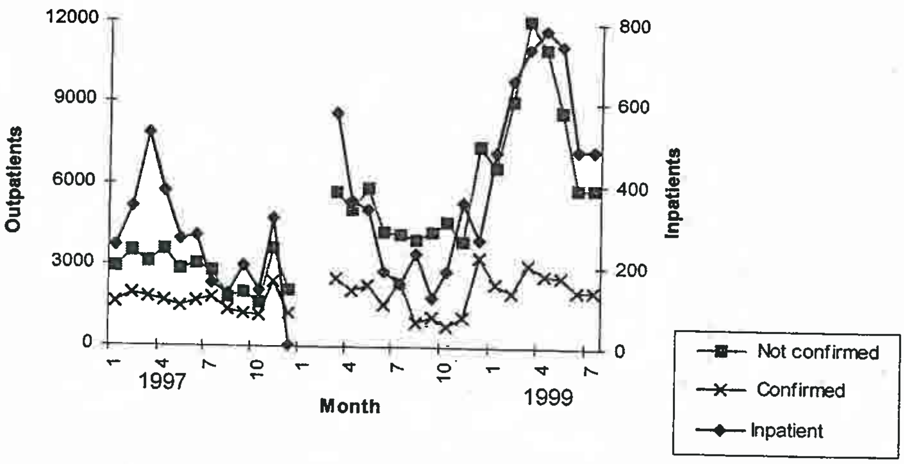


Figure 6. **Monthly malaria incidence rates Inhambane Province, 0-4 year old children 1997-1999.**

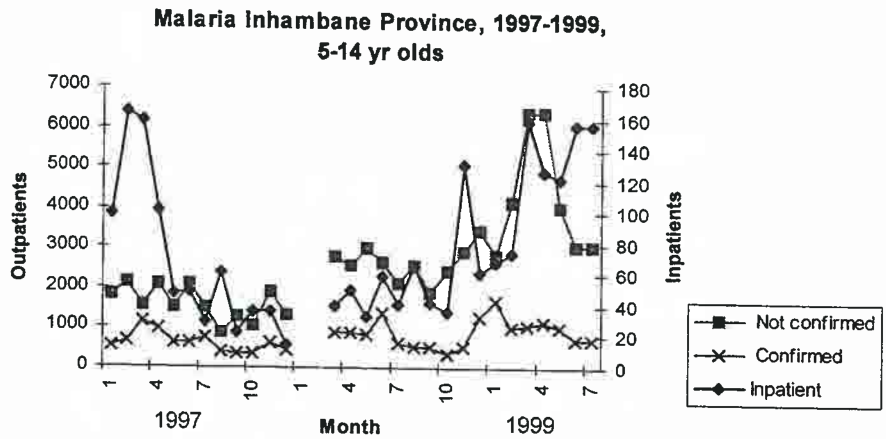


Figure 7. **Monthly malaria incidence rates Inhambane Province, 5-14 year old children 1997-1999.**

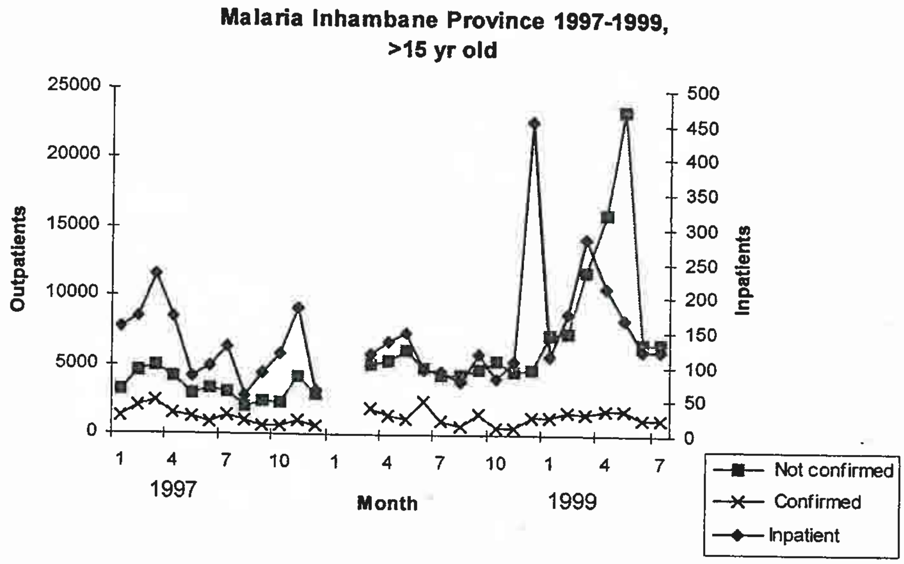


Figure 8. **Monthly malaria incidence rates Inhambane Province, 15 years and over, 1997-1999.**

The large number of cases in children 0-4yrs of age and the relative decline in cases in children below 15 yr. of age observed in all available data indicates that transmission is relatively intense. The very high incidence in adults, however, is anomalous. Where transmission is intense adults generally avoid becoming clinically ill with malaria because they are sufficiently immune to be able to control infections without medication. It is possible that adults taking young children suffering from malaria for treatment take the opportunity to obtain treatment for themselves even though they may not be ill. It is also possible that changes from one year to the next are due to a more rigorous reporting of cases. The confirmation of disease in adults would be useful.

Although the late spraying in 1999 (considered the spray round of 1998) which left more people unprotected may have contributed to an excess in the number of cases this is unlikely to be the main factor since most cases came from unsprayed districts. Unfortunately we do not know the time of spraying for the spray rounds of 1998 or 1997 for Inhambane. Elsewhere spraying in other provinces was also later than ideal in previous years.

1999 was an exceptionally wet year. The high incidence of malaria in 1999 was probably due to exceptional rains which caused widespread flooding and which probably produced favourable conditions for breeding for both vector species. Ten-day rainfall patterns, derived by extrapolation from satellite data are shown in Figure 9.

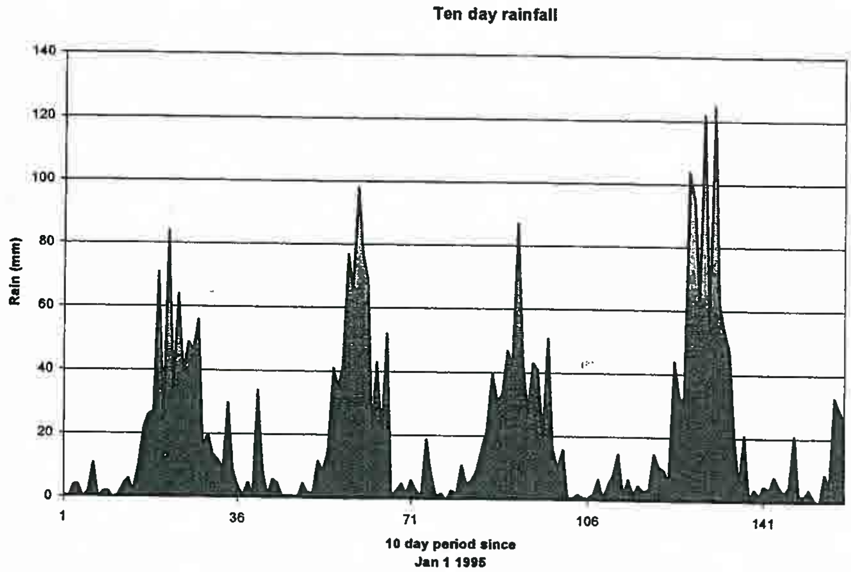


Figure 9. Ten day rainfall totals for Mozambique from 1 January 1995 to January 1999 courtesy of Malsat, Liverpool School of Tropical Medicine.

Cases of malaria, from 12 districts, are now reported on a weekly basis to the Provincial Headquarters. The mean number (and standard deviation) of cases per 1000 inhabitants is shown in Figure 10. Such a figure allows exceptional reports to be identified at the Provincial level. An ability to identify trends is particularly important for epidemic prediction (see below).

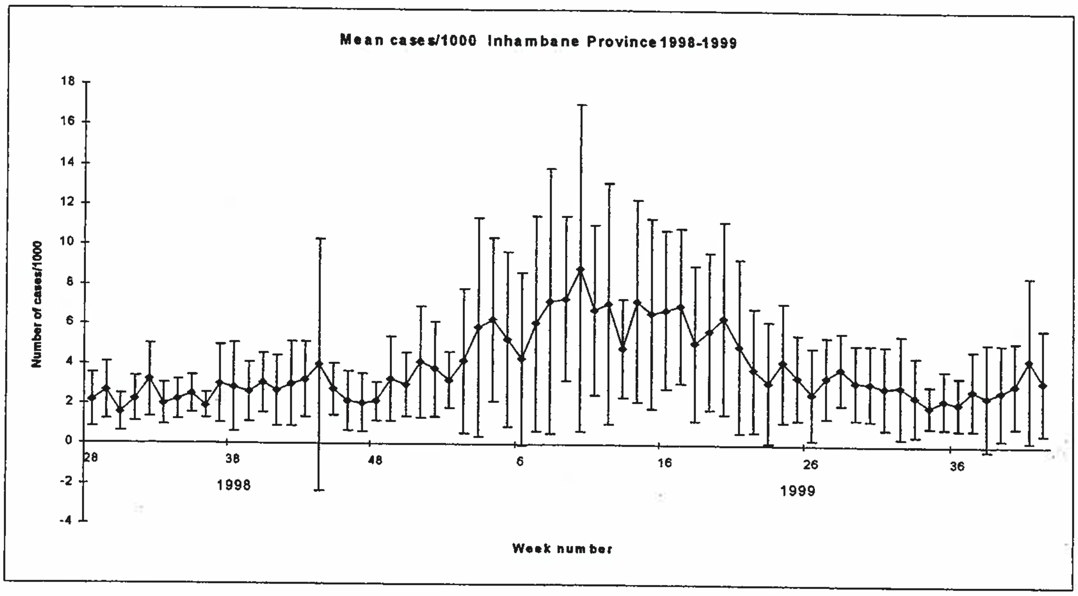


Figure 10. Weekly mean and standard deviation of malaria incidence, all ages, Inhambane Province.

Thus, there is now relatively complete data collection although some extra information would be useful in assessing how useful the data really are. For example, data on the number of negative blood slides by age group would enable, by extrapolation, an assessment of presumptively treated cases (particularly in adults) that are unlikely to be malaria. There is little analysis of the data at the local level. This means that exceptional data are ignored and are not checked at the Provincial level. An example of this would be that in the district of Massinga in the 39th week of 1998 there were 87 cases and 39 deaths were recorded. This was because data had 'jumped' across columns in the information sheet. Once recorded, however, the error continued so that overall mortality registered from the districts for last six months of the year was 53 instead of 14. The weekly reports are useful in that they can provide information on trends in cases. Inconsistent reporting, however, can also give rise to exceptional trends. In this case two weeks data may be combined and given as the number of cases for just the one week. The errors that can arise if such a situation is not checked are obvious.

4.2 Residual Spraying in Inhambane

Control operations around Inhambane town have been undertaken for the last 4 years, operations around the town of Maxixe commenced in 1998. Eight peri-urban bairros (Liberdade 1,2, & 3; Mulele 1, Balane 3, Chalambe 1 & 2 and Marrambone) around Inhambane town centre were sprayed. Population estimates were available for all of these bairros, with the exception of Chalambe 1 & 2, for 1995. Assuming that these had numbers of residents equivalent to the mean of the other bairros then the total population in 1995 was 33,796.

In 1999 spraying took place from 11-Jan to 4-March 1999. Compared to the previous year there was a decline of 11% in the proportion of houses covered (it was 94% in 1998). 7,330 houses, with 21,009 inhabitants of an expected number of 8,821 were sprayed, giving a coverage rate of 83% using a total of 5,753 fills of the pumps. This was due in part to an increasing number of householders who refused to have their houses sprayed and in part to the rain which made access difficult and which meant that household goods could not be removed from the house for the spraying operation.

The person responsible for Malaria Control Operations for the Province saw the increasing refusal rate as a matter of concern. The main reason given for refusing was the perceived lack of an effect on the mosquito nuisance inside houses. According to a Ministry of Health follow up on this complaint (in June 1999) the nuisance insects are likely to be culicines (probably *C. quinquefasciatus*) which are tolerant of pyrethroid insecticides. This could be a major problem in the future since the perceived impression that the spraying makes little difference, albeit a possibly incorrect one, is likely to increase despite possible health education efforts by the Ministry of Health. Such a problem has occurred elsewhere (for example in the Dar es Salaam area of Tanzania). Under such circumstances the incorporation of an anti-culicine component (using expanded polystyrene beads to control larvae breeding in pit latrines, etc.) into the control programme was the only viable way in which the project could continue.

Although extra-domiciliary spraying (by Ultra Low Volume, ULV, fogging) was used in the past, this method has little or no impact on indoor resting mosquitoes that are active at night (such is the case for both *An. gambiae sl* and *C. quinquefasciatus*). The use of fogging may be a useful Public Relations exercise but that is all. It might also be counter-productive if the biting nuisance does not noticeably drop for more than a few days. The technique might be useful against swarming males. For this the site of swarming needs to be known. At present there is no information available from continental Africa on this aspect of anopheline behaviour.

Plans for the control of larvae by fortnightly application of pirimiphos-methyl (trade name Actellic) to large shallow lakes around the town of Inhambane are also being contemplated. There are no plans to evaluate the effects of this technique.

4.3 Maxixe.

Six bairros of Maxixe were sprayed in 1999. Due to the unavailability of insecticide spraying only started on the 26-April. Spraying was completed by the 9-June. This meant that the mosquito population densities were low (so that the effects were not seen by the local population) and that water for the pumps was in some areas difficult to obtain. People, who had to walk a long distance to obtain their water, or even to buy it, were understandably reluctant to give it to the spraypeople. Thus, coverage was low 10,014 houses (with 23,969 inhabitants) were sprayed and 5,946 of the target area were not sprayed (a coverage rate of 63%). 12,378 fills of the pumps were used during this operation. Spraying was interrupted (but only for two days) due to unavailability of insecticide.

The operational budget (in thousands of Meticais and dollars -using a conversion rate of 11,925 meticais per dollar, the rate for January 1999) for the spraying operation in Inhambane and Maxixe for the 1999 spray round -due to start early in 2000, is given in Table 5.

5. RESIDUAL SPRAYING NATIONALLY

It was difficult to ascertain how the spraypeople are recruited. Some respondents said that they were the same people from previous years whereas others indicated that it was better to train a new cadre each year. Some indicated that they belonged to the communities that were sprayed and others that they were not chosen because they lived in the spray zone. Similarly some respondents indicated that there is a relative constancy in spraypeople whilst others said that there was a large turnover of spraypeople from one year to the next. As such they are not considered to be good recruits for subsequent campaigns. When spraying operations are not underway Brigade leaders are assigned to other tasks.

The organisational structure for spraying in the other provinces and for Maputo City is similar. Teams of four spraypeople with a squad leader are trained for a week. During spraying operations each sprayperson is given eight packets of ICON a day. One packet contains sufficient insecticide, in a soluble gelatine sachet, for one pump refill. Each pump refill is sufficient for two to three houses. Thus each sprayperson is expected to spray 16 to 24 houses a day. Work takes place between 05:30 to circa 13:00h. At the end of each day the spraypeople return the empty packets for stocktaking. It is the squad leader's responsibility to check the work of the spraypeople and to provide a report of the day's activities to the Brigade Leader who reports to the Supervisor for Malaria for the Province. The means of notification that houses have been sprayed varies from area to area. In the past a paper ticket was given to the householder giving the name of the sprayperson, date of spray etc. In Maputo City a wall or door of the house is marked with a 'P' (for *pulverizado*) when it has been sprayed. In many areas, however, notification is by word of mouth only.

An important aspect of any control programme is that adequate records be kept. At the end of each spray round each Province provides a report to the MoH giving information on the timing of spraying activities, the number of houses sprayed, refusals, the population protected and the amount of insecticide used. They also provide information on the operational costs. A summary of the available data for the spray rounds of 1996, 1997 and 1998 (which took place in early 1999) for each province is given in Table 6-8. Although spraying started later and coverage rates were lower in 1998 compared to previous years in both 1996 and 1997 spraying was generally not completed until well into the main transmission season.

In addition reports provide a summary of the difficulties encountered and suggestions for future operations. Records were relatively complete. It would help if there were a standard form, which the people in the provinces could send to the MoH. As it is they require some interpretation before they are entered on the summary sheet at the Ministry. The reports written from the Provinces also indicate that at the provincial level the problems associated with each campaign were recognised. Recognition of a problem is the first step to solving it. For example, under-dosage in Tete was a problem recognised by the person responsible for the spraying operation (but over dosage in Cabo Delgado was not). The late timing of spraying was also recognised as a major problem in many provinces as was the increasing refusal rates among householders. The reasons given for refusal may not necessarily have been the real reasons why householders did not want their houses sprayed. For example, in Maputo City many of the householders in the spray zone are street vendors. They do not want people to see their stocks and so refuse entry but might cite lack of effect. Elsewhere people cited an increase in the number of fleas and allergic reactions for refusing entry.

'*Chefes dos quaterões*' are local community leaders. They should accompany spraymen and should introduce them and their work to householders. As such they play a pivotal role in ensuring adequate community participation. Whilst some *Chefes dos quaterões* are interested in the campaign and actively participate others, apparently, will only do so for remuneration. *Chefes dos quaterões* are an obvious target for health education. Wherever possible they should be involved in decision making. This will enhance their status within the community and will therefore be likely to ensure their active co-operation. Where they lead others will follow.

5.1 Costs

It was not possible to obtain details of all costs of the programme because data from all provinces were not available. Nevertheless, from Tables 6-8 the total number of pump refills could be estimated. Each drum of insecticide contains 148 packets and costs 8,084,339 meticais (US$ 673) hence, the cost per house sprayed is approximately 2.3 or 1.5 dollars (at rates of two or three houses sprayed per refill). The national cost of insecticide per spray round would be therefore be at least US$ 600,000. (The MINSAUD has more exact figures for insecticide purchased). The past five year operational costs (borne by UNICEF) have been in the order of 250,000 dollars a year. Districts sprayed by province in 1998 and estimated operational costs for 1999 are shown in Table 9.

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Insecticide costs plus operational costs divided by the number of people 'protected' provides an estimate of costs of the programme per head. In 1998 170,982 people were considered to have been protected. Estimated cost of the insecticide would then be US$ 0.40 per head and estimates of the operational costs US$ 0.15 per head. It should be emphasised that this is the minimum estimated cost per head. It ignores transportation and storage costs of the insecticide as well as the replacement costs of pumps.

A better way of estimating costs is to assess the number of episodes of malaria and possible deaths prevented. Spraying in an area of low endemicity, whilst it may protect a large population, may prevent relatively few episodes of malaria compared to protecting a smaller population in a highly endemic area. Unfortunately, given the fact that cases from sprayed and non-sprayed areas cannot be distinguished it was not possible to estimate this using the present system. Such estimates are necessary in order that resources can be used to target the appropriate population. At the present time mosquito nets are expensive in Mozambique. If they were procured more cheaply they would almost certainly, be the most cost effective method of control, particularly amongst the scattered rural population.

5.2 Epidemic response

Epidemics occur when exceptionally favourable conditions arise for the transmission of a disease within a non-immune population. They are usually notable for the high number of deaths that occur. In the absence of any control measure they tend to be self-limiting. The last reported epidemic in Mozambique occurred in Maputo Province in early 1996 (when 12, 795 cases, with 7,829 admissions and 107 deaths were recorded between February and April). Measures, and management structures used to prevent epidemics differ from those ordinarily used to control malaria. During an epidemic measures can include mass drug treatment of susceptible individuals as well as widespread vector control by indoor residual spraying of houses. Depending on the duration of the epidemic, spraying may often be a useful intervention. It is easy to introduce into affected areas and the area covered depends mainly on the number of spray teams involved.

During an epidemic it is important that affected areas are treated as rapidly as possible. A significant degree of protection might be provided even if only the outside eaves of houses were sprayed. This would only take a fraction of the time that a complete spray would take and sprayteams would be able to cover much larger areas in a short time. An experiment to determine the effect of such a procedure on house entry by the local vectors would be worthwhile. The relative effect that not spraying ceilings might have on the degree of protection could also be investigated. Since the criteria for evaluation in both cases would be entomological, rather than epidemiological, a relatively small number of dwellings could be used to determine these effects.

Conditions, such as higher than usual rainfall, may foster epidemics. Epidemic forecasting can be achieved through the application of remote sensing technology to the study of the epidemiology of malaria. One major group involved in this work is based in South Africa. They may, in the future, be able to advise the MoH of the likelihood of an epidemic some time before it occurs so that preventive measures could be inaugurated.

In the absence of a reliable forecasting system should an epidemic occur it has to be recognised, early on, for what it is. In other words the degree of abnormality in the excess number of cases needs to be identified. This should, in the first instance, be done at the provincial level. Not every excess in reported cases represents an epidemic. Sometimes due to non-reporting in the previous week(s) cases are lumped together for a single week. Sometimes data may not be entered correctly and typographical errors lead to excess numbers of reported cases or deaths. By looking at the data (especially graphically) those responsible in the provinces should be able to sort out these problems. They should be able also to determine if they are at the early stages of an epidemic.

Most, if not all, provincial centres have computers. Data could and should be entered on these computers and simple analysis undertaken. The people responsible for collating and examining the data at provincial level may not be computer literate. Tuition on a one-to one basis on site, perhaps by the person responsible in Maputo for the more sophisticated nation-wide analysis, is desirable.

As a rule of thumb an epidemic is occurring if cases exceed an epidemic threshold - the mean plus two times the standard deviation of expected cases for a given time period. Once a sufficient amount of 'baseline' data has been collected (in which hopefully an epidemic is not occurring!) then means and standard deviations can be determined and the threshold level derived. Such has been done with the weekly data from Inhambane Province (Figure 11). A fourth order polynomial has been added in order to produce a smoothed line against which actual cases (per thousand head of population) can be compared.

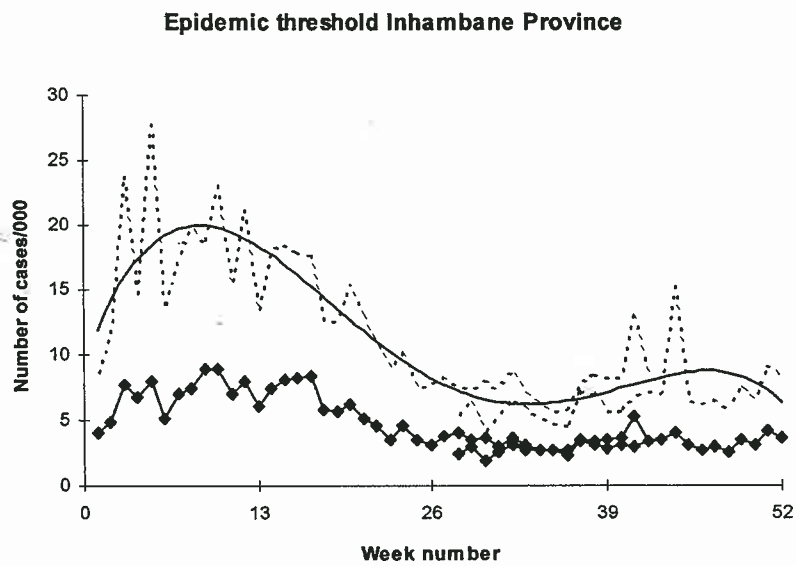


Figure 11 Epidemic threshold for Inhambane Province.

The dotted line is equivalent to the mean plus two times the standard deviation of the number of cases of malaria reported from 15 districts of the Province. The solid line is the data for the last months of 1998 and 1999. The smoothed line is a fourth order polynomial applied to the data. Since only limited data were used to generate this figure the estimate should be regarded with caution.

As data collection continues noise is reduced and more accurate thresholds using simpler estimates (such as moving averages, which are easier to prepare and understand) can be produced. Thresholds at the provincial level are, however, of limited value. When sufficient data has been collected from the different districts within a province more localised thresholds can be produced. It is these that will eventually be most useful for the recognition of epidemics. For this to work an adequate reporting system is needed. For areas served by health centres a weekly reporting system is already in place. Examination and analysis of the weekly data at the Provincial level is then required.

Should an epidemic occur, maps would assist all relief organisations not just those involved in vector control. Time spent in reconnaissance is never wasted. Detailed maps of the districts in Maputo Province, Gaza, Inhambane, Sofala, Zambezia, Cabo Delgado and Manica, that are considered to be epidemic prone should be prepared.

An organisational structure to rapidly deal with the problems created by an epidemic is also needed. Active intersectoral preparedness for a rapid epidemic response is to be encouraged. Emergency funds for relief should be available; a stock of appropriate drugs for treatment and, if it is not too late, insecticide and pumps for residual spraying of houses should be available. The logistics of moving the supplies and equipment to affected areas should also be prepared beforehand. For vector control a directory of local people previously trained in the technique of spraying should be maintained so that they can be recruited and put into action with the minimum of refresher training. A full time spray team working as part of a public-private partnership in and around Maputo City, not dependent on external funds, may enable a rapid response capability to be established. The size of this sprayteam would depend on demand from the public.

An analysis of the epidemic in 1975 and the measures used to contain it would help in identifying factors responsible for the outbreak and the weak spots (if any) in the techniques used (if any) to control it. For example, routine indoor residual spraying was already the main malaria control strategy in the province at the time. It failed to prevent the epidemic (which ended with the end of the main transmission season) but may have contained it. An examination of all of the contributing factors, and the response of the MoH to the problem would be apposite.

6. OTHER VECTOR CONTROL MEASURES

6.1 Larval control

Control of mosquito populations by environmental management, which reduces the number of potential, breeding sites available, is a goal of many anti-vector programmes. Management can be the filling in of puddles by schoolchildren to the draining of swamps. A possible short-term alternative is to control breeding by the application of insecticides to water. Thus the application of Paris Green to puddles helped eliminate *An. gambiae* from Brazil in the 1940's. The potential practicality and effectiveness of these approaches would depend on factors such as the range of breeding sites. They tend to be less used than in the past as some require more public sector authority than usually exists. In rural areas the numbers of small breeding sites often makes the task difficult.

The control of mosquitoes breeding in large shallow lakes around Inhambane by the application of insecticide (pirimiphos-methyl, trade name 'Actellic') is apparently to be undertaken when funds are available. Repeat applications are expected every two weeks. It was not clear what the rationale for this was. The lakes are very large, stable water bodies that presumably are the source of *An. funestus*. The role of predators in population regulation under such circumstances is unknown. They are likely to have a significant impact. Insecticide application will reduce predators as well as mosquito larvae. It is highly likely that mosquito populations will recover much more rapidly than predator populations. Freed from the constraints of predators mosquito populations may increase. Thus insecticide application may even enhance malaria risk. No evaluation of the larvicide is planned.

6.2 Fogging

Another possible way to control mosquitoes is by the application of ultra low volume (ULV) fogs outside in the late afternoon - early evening. These fogs do not have a residual effect. They are generally used against diurnal vectors of disease, such as *Aedes aegypti* in epidemic situations. It is generally recognised, however, that they do not have much impact on the mosquito population as a whole and so do not have a significant impact on the transmission of disease. They do, however, have a considerable impact on people's perceptions of the work done by mosquito control agencies. They are good for public relations. They are, however, expensive. For example the operational budget for a limited amount of fogging in Matola province was 94,944,795 Meticais, more than a quarter of the total operational budget for all spraying activities in Matola. (The operational budget for intra domestic spraying was 254,626,000 Meticais, 84,700,000 Meticais for personnel and 169,926,000 Meticais for equipment).

7. Emergency Malaria Control

Extensive rainfall in southern Africa caused severe flooding in southern Mozambique during February 2000. By April 2000, approximately 250,000 people, including 50,000 under five years of age, were living in 68 Internally Displaced Person (IDP) camps or accommodation centres throughout the affected areas in Maputo, Gaza, Inhamabane and Sofala provinces.

Extensive rainfall and flooding have the potential to increase malaria transmission, as a result of a proliferation of mosquito breeding sites, coupled with a reduction in immunity levels in displaced populations, caused by inadequate nutrition and increased stress. To prevent a significant increase in the number of malaria cases, support was rapidly mobilised for intensified malaria control activities, including emergency indoor residual spraying, space spraying, health education and procurement of ITNs for distribution to affected communities.

7.1 Indoor Residual Spraying

7.1.1 Appropriateness of technique for Emergency Control

UNICEF provided funds to the Ministry of Health to support emergency control of malaria vectors in IDP camps. These funds were provided centrally to the National Malaria Control programme to support activities in three provinces; Maputo, Gaza and Inhambane. This report concentrates on activities in Gaza Province. Residual spraying is probably the most easily applicable large-scale malaria transmission control measure, and is perhaps the most suitable method for malaria vector control in emergencies, especially where people are living in temporary shelters. Indoor residual spraying with lambdacyhalothrin (ICON) was an important component of this response. Indoor residual spraying is an appropriate anti-epidemic control method in communities where there is public acceptance of spraying, availability of suitable equipment, adequately trained spray personnel, supervision and strong financial support.

7.1.2 Coverage Achieved

The camps sprayed by the Xai-Xai, Chibutu and Chockwe district teams, the number of structures sprayed per camp, the dates of the interventions and the amount of insecticide used are shown in Table 10. It is difficult to ascertain whether all the camps where spraying was planned were reached because no formalised plan of activities was ever drawn up. However, coverage within the sprayed camps was high, ranging from 71% - 97%. Populations in the camps were not really offered the option to refuse spraying and so coverage in sprayed camps was high. However, it is considered unlikely that the refusal rate would have been high. Indeed, all the displaced people that I spoke to were very pleased that some efforts at malaria control had been undertaken on their behalf. It is also good and important that anti-vector measures were undertaken by the Ministry of Health rather than by outside agencies.

Some 19,332 structures were sprayed in IDP camps during the emergency, probably protecting over 100,000 people. These structures ranged from permanent buildings through to canvas tents and plastic sheeting shelters (including blankets hanging in entrances). At the same time, spraying was carried out in urban and peri-urban areas of Xai-Xai Town (Table 11), where some 4,962 structures were sprayed.

In an emergency, a rapid response is necessary. For example, the team in Chibutu, under the direction of Ernesto Sitoe Mondlane, sprayed the camps within a couple of weeks of their installation (dates not recorded), and then returned to spray new structures as the camp grew. Return visits to spray newly installed accommodation should be undertaken. If a similar situation arises again, it is recommended that in order to facilitate identification of previously sprayed tents identification labels with date of spraying, insecticide used and name of spray-person could be stuck onto the outside of the tent. Regular visits by a smaller team than that used in the original spraying would then ensure that coverage is maintained. Health activistas can easily advise people to remove their belongings before the arrival of the spray-team.

Spraying began in most camps around the end of March, some 7 weeks after the first cyclone, and approximately 5 weeks after the second cyclone. Although this may seem an untimely response to some, generally, malaria epidemics do not occur immediately after a natural disaster such as extensive flooding, because heavy rainfall inundates mosquito breeding sites, washing away malaria mosquitoes. It is only later that the mosquito population recovers, taking advantage of the large number of suitable mosquito breeding sites created by the receding flood waters. Malaria epidemics tend to occur 8 weeks after a flooding emergency.

Commencement of spraying was delayed on several occasions because of heavy rainfall. Similarly there were considerable logistic problems in transporting insecticide and spray pumps around, with most roads cut, and a heavy reliance on air transport. The spray teams in Xai-Xai concentrated first on completing the routine spraying in Xai-Xai town urban and peri-urban areas in order to prevent high levels of malaria transmission in the city.

7.1.3 Standard of Spraying

Spraying requires a relatively well-disciplined and focussed effort on the part of all concerned. It requires good leadership and motivation to do what is a demanding job, properly. It is a pleasure to report that the teams that I met in Xai-Xai and Chokwe as well as those that I met in Maputo Province all appeared to have a good team spirit. The team from Xai-Xai sprayed Inhacutse camp very efficiently and effectively. Residents reported an absence of mosquito nuisance after spraying for at least a month, when reporting was effectively stopped. Previously sprayed tent material (often plastic sheet) may be donated to the population for their return home. This is likely to be used as temporary roofing material. It is possible that the plastic sheets will continue to provide some protection to the returning populations, if they are carefully folded during transport to prevent the insecticide rubbing off.

7.1.4 Routine spraying programme - Xai-Xai Town and environs.

Table 11 gives the results from the routine spraying by the DDS in Xai Xai town and environs. There was a high refusal rate from many Bairros, which compromises the effectiveness of the campaign. Refusal rates were higher in the more urban bairros.

A meeting was held with Sr. Armando Dgedge and the spray teams for Xai-Xai town on 21 April in which an assessment of this year's routine spraying was given. There was general agreement that spraying was more difficult in urban parts of the town due to a high refusal rate. The reason given for refusal was generally 'irritation of the insecticide' although an increase in cockroaches was also a reason. Once refusals start there is a tendency for them to increase and indeed in some areas of town less than half of the expected number of structures were sprayed. Spraying of interior walls kills mosquitoes after they have fed, as opposed to insecticide impregnated nets, which kill mosquitoes as they attempt to feed. Thus, unlike nets an individual sprayed house does not provide personal protection and a high coverage rate is required for the technique to be effective. With the low coverage rates obtained, despite the best efforts of the spray-people, adequate protection even for people in sprayed houses is not provided.

An additional difficulty was the late arrival of funds and insecticide for the spraying campaign. The insecticide lasts for approximately six to nine months on sprayed surfaces (other than mud where the residual life is much shorter). Malaria transmission is largely seasonal in Gaza with peak transmission taking place in January-April.

The introduction of ITNs as a malaria control strategy was discussed and comments from those responsible for malaria control in the Province and in the town were favourable.

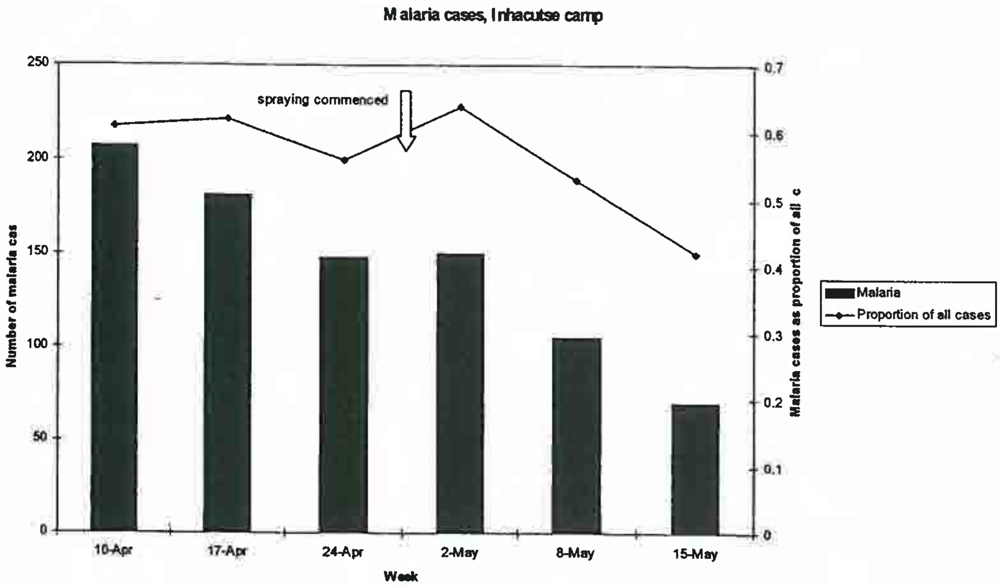
7.1.5 *Spraying Inhacutse camp*

Inhacutse is an IDP camp for people displaced from areas on the southern bank of the Limpopo river. Many people originally stayed with relatives but moved to the camp to obtain relief assistance. The population of the camp peaked at more than 5,000, but has since stabilised at around 1,800. The number of reported cases of malaria is shown in Figure 12.

Following an advisory visit on the Monday Inhacutse camp spraying was undertaken on Tuesday 25 April 2000. Prior to the spray resting collections were undertaken in 13 tents. There was an average of 2 *Anopheles arabiensis* (the main malaria vector) in each tent. All belongings were removed from the tents (largely plastic 'home made' ones) prior to spraying. All tents were sprayed within a two-hour period. The spray-people used protective clothing. The pressure gauges on all of the pumps were broken, therefore pressure was determined by counting the number of strokes to charge the pump. Unfortunately due to delays in procurement, the Hudson pumps procured by UNICEF did not arrive in time to be used by the spray people in Xai-Xai. The message to avoid contact with the sprayed surfaces for at least the first night after spraying was given but needed reinforcing. For example the general information given was not to re-enter the tents for two hours after spraying without the cautioning to avoid contact with the sprayed walls for at least one night. The message was eventually given more forcefully with the result that no side effects were reported when I stayed in the camp over the next few days indicating that the spraying had worked. No mosquitoes were seen inside tents in the days following spraying, indicating the relative success of the programme (though this is by no means a thorough scientific investigation). Numerous specimens (up to 30 *An. arabiensis* per house) were collected in houses leading down to the river. These houses had not been sprayed.

Monitoring of malaria cases was continued until the end of the month of May by which time an effect of the spraying on malaria cases should have been apparent. The population size of the camp had not changed during the period of the evaluation. Cases continued to drop during May, but this may have been due to a natural change in transmission due to a drop in mean daily temperatures. However, it is clear that prior to spraying the proportion of malaria cases was over 60% but that once spraying had time to take effect, had dropped to just over 40%. It should be noted that in the village surrounding the camp, *Anopheles arabiensis* were still present in these houses, particularly in those closest to the Limpopo (a mean of 12 per room were collected from three houses by the river, and 5 per room from 3 houses closer to the camp). Mosquitoes may still have bitten people in the camp despite the fact that no mosquitoes were seen from the 6 tents examined.

Figure 12: Malaria cases in Inhacutse Camp



8. CONCLUSIONS/RECOMMENDATIONS

The malaria control programme of the MoH has been operating for a number of years. When it started the country was suffering from a catastrophic civil war and there was considerable immigration into the main towns fleeing the fighting. Under those circumstances residual spraying of houses in transmission areas around urban centres was probably the best solution to contain the disease. People are, apparently, now gradually returning to their homes in the rural areas. Urban areas are developing and houses are improving making access by mosquitoes more difficult. Malaria is, therefore, now largely a disease of the rural areas. Risk of malaria transmission is likely to be higher amongst inhabitants of rural areas, and these people are not currently protected by the residual spraying programme.

The programme management structure has recently developed from a vertical centralised spraying programme into a less centralised one, with decisions increasingly being made at the provincial level. Nevertheless, given the way that the program is organised, it cannot easily 'grow' to meet needs outside of predetermined areas. Areas to be sprayed are historically determined and little is done to assess present needs and, given the reporting system, assessment of the impact on malaria cannot be made.

Although spraying activities were not observed during the first consultancy, a subsequent visit following the severe flooding of early 2000, revealed that coverage within sprayed camps was high, ranging from 71% - 97%, with very low refusal rates. Residents of camps interviewed were very pleased that some efforts at malaria control had been undertaken on their behalf. In addition, residents reported an absence of mosquito nuisance for at least a month after spraying. The spraying teams in Xai-Xai, Chokwe and Maputo Province all appeared to have a good team spirit, whilst the team from Xai-Xai sprayed Inhacutse camp very efficiently and effectively.

It is now recognised that integrated control using a variety of available methods to reduce transmission is the best way of containing the disease. Recently the Ministry of Health developed a new vision for the next three years for its malaria control programme. The focus is on the capacity of the family to prevent, recognise, and when necessary, correctly treat malaria or refer to a health facility. The target groups of this strategy are children under five years of age and pregnant women. Given the acknowledged increased risk of malaria transmission in rural areas and the difficulties of covering such a population by residual spraying the use of mosquito nets should be encouraged

The role of residual spraying within an integrated malaria control strategy should be considered carefully. It may be more effective to redirect activities towards reducing perennial transmission of malaria by *An. funestus* (rather than seasonal transmission by *An. gambiae*).

Given the ecology of the vectors it is likely that within provinces, districts and even villages, particularly in areas to the north of Maputo, there is a mosaic of transmission intensities. People living close to permanent water will almost certainly suffer much higher transmission rates (by *An. funestus*) than people elsewhere. Targeting control to these houses, during the dry season, when breeding is restricted, may have a considerable impact on transmission particularly in rural areas. The timing of spraying would be less critical than it is at present. An operational research project, investigating the efficacy of such a strategy, would be worthwhile.

The introduction of weekly reporting of malaria cases, by age group, treatment and diagnosis (confirmed or unconfirmed) has enabled a more fine-grained analysis of the epidemiology of malaria from the districts of each province to be obtained. This is obviously a very positive step. With a number of caveats it should allow a rapid response to epidemic situations to be developed. Unfortunately for the purposes of the present evaluation available data was not adequate to determine the effectiveness of residual spraying, as it has been performed in Mozambique over the last few years. This was largely because reporting areas contained sprayed and unsprayed districts. (The inclusion of the response to the question 'Has your house been sprayed?' in the register might alleviate this problem). One way of ensuring regularity of data input is to provide feedback of the analysis to all levels of the reporting system. The national monthly Epidemiological Bulletin from the Ministry to the Provinces is a first step towards this. Feedback should, however, also be given from province to District and from District to health centre and eventually from health centre to village. In this way people at the periphery realise the importance of their work. In order for this to take place some analysis of the data should be encouraged at provincial and district level. The ongoing production of simple graphs detailing the number of cases per week would be a first step.

It would be useful to record the number of negative blood slides taken. Second 'control' slides made after treatment should also be distinguished from initial infections. This will enable a more reliable estimate of treatment failures to be made and will highlight the possible development of drug resistant malaria. It will also help in determining if there are specific groups who are most likely to have malaria and will enable assessment of the number of non-malarial fevers among unconfirmed cases.

Should residual spraying continue as it is presently organised then there are a number of points that should be considered :

8.1 When to spray.

The half life of insecticides used for residual spraying depends on the type of surface onto which they are sprayed. Lambdacyhalothrin has a shorter residual effect on mud and brick than on wood or reed. In general it is expected to be effective for six months. The main transmission season lasts for three or four months (from January to April). For maximum effect, therefore, spraying should be completed before the end of December. It is suggested that spraying be completed before the start of the Christmas school holidays. This date makes sense from an epidemiological point of view and also means that children and infants will be less exposed to the irritant effects of the insecticide because they will be at school at the time of spraying. Given the long half life of the insecticide on the surfaces in most houses, spraying could be completed well before this. Indeed, in areas where, during the dry season, water is scarce, spraying could be started as soon as access after the previous rains is no longer a problem.

- Due to logistical difficulties, the spray round almost everywhere in 1998 was late. Even in 1997 spraying was not completed until well into the transmission season. It is unlikely that the operation in either of these years will have had that much effect on reducing transmission. Many of the reports from the Provinces cite the increasing refusal rate as a cause for concern.
- During the rains people are less inclined to move their possessions outside of their houses, they are also less likely to stay outside of their houses for the prescribed two hours post spray. Rain also makes access for vehicles and spray teams more difficult and the work becomes considerably harder to perform satisfactorily. This is likely to lead to uneven and incorrect dosages of insecticide on the walls Low dosages give rise to inadequate protection. Villagers notice that the spraying is not working for a long period and are therefore reluctant to let spraying take place in the future. Unfortunately once started lack of compliance tends only to increase. This has probably contributed to the drop in coverage rates. Reduced, late coverage means that many fewer people are protected. Low coverage will also enable the mosquito population to recover more rapidly. Rapid recovery of the population in general will not only enhance the risk of transmission but will add to the perception that 'spraying does not work'. An enhanced perception that 'spraying does not work' will in turn lead to an increasing refusal rate. An increasing refusal rate will lead to lower coverage rates and so the circle will continue.

8.2 Where to spray

The lack of maps was a major problem. It meant that coverage rates could not really be accurately determined, Maps would also enable an assessment of which areas require spraying. Sketch maps showing all buildings and permanent breeding sites should be prepared. Houses should be numbered (both on the maps and on site). High-risk areas should be defined (using all available information, including parasite prevalence, vector densities and community perceptions) to the highest possible scale (for example within villages). In an environment of financial constraint this would enable more cost effective, focused control to be attempted. For example, vector control by residual spraying might be limited to houses closest to permanent breeding sites. Mapping and house numbering will also raise the profile of the malaria control team, which will result in greater community involvement.

A major objective of the three nation Spatial Development Initiative (SDI) is the control of malaria in Swaziland, South Africa and southern Mozambique by residual spraying of buildings using Lambdacyhalothrin. Village spraypeople will be used and complete geographical reconnaissance will be undertaken. The integration of MoH spraying activities in Maputo Province and the environs of Maputo City is recommended.

8.3 What to spray.

In many areas there is a mixture of cement and reed walled buildings. People who own cement walled buildings are generally more affluent than their neighbours. They have more heavy furniture and so the job of moving it out of the house is more difficult. They may be more likely to refuse to have their houses sprayed. The insecticide is also less effective on cement than it is on wood or reed. In addition mosquitoes do not enter cement walled houses to the same extent as they do the more open, reed walled houses. In an environment of financial constraint spraying only the reed walled buildings could be considered.The general rule to spray round the outside eaves of houses as well as ceilings and walls is a good one. Experiments to determine the effect of only spraying the outside eaves, or of spraying the interior walls but not the ceiling would also be worthwhile.

8.4 Who sprays?

Wherever possible spraypeople should come from the local community. Greater community involvement facilitates the actual spraying operation. It sensitises the local population to the need for malaria control, heightens community awareness and allows initial misgivings to be discussed and tackled.

8.5 Who pays?

The continuation of the spray campaign in its present form requires that adequate funds for insecticide purchase and for operational costs are available by mid year, every year. Should spraying be continued then adequate funding- perhaps from the World Bank- must be ensured well before the start of spraying activity is anticipated. It is possible that another donor can be persuaded to fund the operational costs of the programme. It should be re-emphasised that for spraying to have an effect in reducing wet season transmission it should be completed before the end of December. An alternative way of funding the programme, at least in the city of Maputo, might be to encourage the private sector to undertake spraying operations. Ironically, a greater coverage might be obtained if people have to pay for the service. Given the long residual efficacy of the insecticide a smaller team of full time spray people could be maintained. Such a development would reduce the cost to the government and would result in the availability of a cadre of trained people able to respond to epidemics. A smaller group of fully employed, well supervised, people may be more effective than a large group of temporary workers.

8.6 Improve supervision.

Lack of adequate supervision was seen as a major factor limiting the effectiveness of the spraying campaign. Supervision would be easier if houses were numbered and if a sticker (giving details of date, name of sprayperson, name of house owner and insecticide used) was placed on an inside wall of the house once the operation had been completed. Such stickers can now easily be produced from a PC at low cost. It is important that the Brigade Chiefs check up on the work of the Team Leaders (who themselves are only temporary workers). The team leaders are obviously the key to maintaining a high standard of work and to maintaining a high morale in spraypeople who have to do a demanding and difficult job for little reward.

8.7 Epidemic preparedness.

One of the most appropriate uses of residual spraying is during epidemics. The ability to predict, recognise and respond to epidemics should be elaborated. Regular prediction of the likelihood of epidemic conditions should be developed, perhaps in collaboration with MARA or MALSAT.

8.8 Insecticides.

Lambdacyhalothrin has been effective when used as a residual insecticide in other projects. The data from the Provinces indicates that the coverage rates differed between them. When inadequate doses had been applied the need to improve on coverage (so that optimum coverage rates could be achieved) was recognised by the people responsible for the respective malaria Programmes. It is not known, however, if the Brigade Chiefs recognised the problem on the ground. Recognising the problem of inadequate coverage (over or under dosage) at the end of the spray round is equivalent to 'shutting the stable door after the horse has bolted'. If synthetic pyrethroids are used on a wide scale to treat bednets then alternative insecticides for residual spraying could be considered. Just as combination therapy may slow down the development of malaria parasites resistant to available drugs exposure of the vector to two insecticides is likely to reduce the development of resistance either one.

of resistance in the target mosquitoes and should be used throughout the country.

8.8.1 Equipment.

The Hudson spray pumps used by the MoH are the most widely used pumps for indoor residual spraying. Records indicated that, with few exceptions, the equipment is well maintained.

9. ACKNOWLEGEMENTS

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12. ANNEX 3 - Tables

Table 1. Population estimates, number of families and urban rural ratios, by district, for Inhambane Province

	Urban				Total	Rural				Total	Total	Proportion	Mean weekly
Area	Houses	Families	Male	Female	urban	Houses	Families	Male	Female	rural	Population	Rural	Incidence/000 malaria
Zavala	1298	1306	2625	3309	5934	25140	25717	53351	67462	120813	126747	0.95	2.61
Inharrime	883	899	1735	2201	3936	15326	15601	31079	40545	71624	75560	0.95	3.55
Panda						11354	11202	19891	26392	46283	46283	1.00	7.98
Homoine	957	962	1671	2000	3671	22017	21937	37689	49427	87116	90787	0.96	2.39
Jangamo						18830	19152	35043	45349	80392	80392	1.00	3.37
Maxixe town	2826	23707	41648	51849	93497								
Inhambane Town	13564	12795	24490	27794	52284								
Morrumbene	3408	3347	5801	7476	13277	24037	23944	43000	55063	98063	111340	0.88	4.70
Massinga	4456	4335	7773	10790	18563	38433	38440	69578	94251	163829	182392	0.90	1.50
Funalouro						6879	6367	12740	17399	30139	30139	1.00	4.29
Mabote						7930	8239	15681	23845	39526	39526	1.00	5.93
Vilanculos	4470	4238	8915	10894	19809	22127	22232	40738	52544	93282	113091	0.82	4.49
Inhassoro						9934	9754	18388	23645	42033	42033	1.00	2.58
Govuro						6342	6104	11950	15415	27365	27365	1.00	2.78
TOTAL	31862	15087	65022	102808	144833	354130	208689	389128	511337	900465	965655		2.97

Population estimates for Inhambane Province. Note the high proportion of the population living in rural areas.

Table 2. Relative incidence rates per 1,000 population of unconfirmed, confirmed and interned malaria cases by district Inhambane Province 1998.

		not-confirmed Age group			Confirmed Age group			Hospitalised Age group		
District	Reported cases	0-4	5-14	15+	0-4	5-14	15+	0-4	5-14	15+
Inharrime	16981	0.86	0.88	0.91	0.13	0.11	0.08	0.01	0.00	0.01
Zandamila	4890	0.81	0.93	0.89	0.19	0.07	0.11	0.00	0.00	0.00
Quissico	12694	0.70	0.87	0.92	0.23	0.10	0.08	0.07	0.04	0.01
Panda	5527	0.56	0.60	0.63	0.38	0.37	0.32	0.06	0.03	0.05
Inhassune	5802	0.86	0.92	0.91	0.09	0.07	0.07	0.05	0.01	0.03
Homoine	6235	0.79	0.79	0.76	0.18	0.20	0.22	0.03	0.01	0.02
Jancamo	16160	0.84	0.95	0.94	0.15	0.05	0.06	0.01	0.00	0.00
C. S. Maxixe	14395	0.73	0.73	0.83	0.27	0.27	0.17	0.00	0.00	0.00
Morrumbene	4988	0.83	0.81	0.81	0.15	0.18	0.16	0.03	0.01	0.03
Massinga	21863	0.87	0.86	0.84	0.09	0.14	0.13	0.03	0.00	0.02
Mabote	8061	0.65	0.82	0.87	0.29	0.16	0.12	0.05	0.01	0.01
Vilankulo	26308	0.71	0.87	0.90	0.19	0.09	0.08	0.10	0.03	0.02
Inhassoro	9378	0.73	0.64	0.85	0.21	0.31	0.12	0.06	0.05	0.03
Hosp Provincal	8850	0.20	0.30	0.44	0.59	0.59	0.51	0.20	0.10	0.04
Total/mean	162643	0.74	0.80	0.84	0.20	0.18	0.14	0.05	0.02	0.02

Note these rates have been estimated using the total population only, not the population per age group. Information on the number of people by age category was not available

Note reporting rates varied by District, hence total cases do not represent all cases from each district.

Table 3. Non-confirmed, confirmed and hospitalised cases of malaria 1997-1998 and Jan-Jul 1999, Inhambane Province, by age and treatment.

		not-confirmed			Confirmed			Interned		
Year	Treatment	0-4	5-14	15+	0-4	5-14	15+	0-4	5-14	15+
1997	Chloroquine	32824	18965	39906	18796	6910	13808	0	0	0
	Fansidar	82	50	96	668	409	699	0	0	0
	Other	67	41	55	115	152	221	2967	820	1542
1998	Chloroquine	48877	26327	48963	17098	7283	11494	0	0	0
	Fansidar	99	149	249	810	469	733	0	0	0
	Other	47	6	39	199	108	145	2769	561	1420
1999	Chloroquine	59140	29814	78981	15160	6547	9262	0	0	0
	Fansidar	71	40	101	1193	679	880	0	0	0
	Other	41	9	9	395	176	197	4364	861	1193

Table 4. Estimated case fatality rates from malaria, Inhambane Province 1989-1998.

	Inpatients Age group			All cases Age group		
Year	0-4	5-14	+15	0-4	5-14	+15
1989	0.0252					
1990	0.0373					
1991	0.0306					
1992	0.0518					
1997	0.0394	0.0268	0.0447	0.0021	0.0008	0.0012
1998	0.0368	0.0303	0.0514	0.0015	0.0005	0.0012
1999	0.0273	0.0221	0.0478	0.0015	0.0005	0.0006

Table 5. Operational budget for the indoor residual spray campaign by item, Inhambane town 1998 (i.e. the spray round conducted in 1999).

Item	Cost (x000.00 Metecais)	US Dollars
Social Awareness	4085	342.56
Masks	5000	419.29
Caps	1050	88.05
Soap	2100	176.10
Cloths	625	52.41
Pens	105	8.81
Pencils	48	4.03
Rubbers	48	4.03
Paper	360	30.19
Co-ordinator allowance	1750	146.75
Supervisor allowance	3500	293.50
Brigade chief	3500	293.50
Team chief	6300	528.30
Storekeeper	875	73.38
Driver	875	73.38
Spraypeople	21000	1761.01
Fuel	4310,25	361.45
Total (Inhambane)	55531,25	4656.71
Global total (Inhambane & Maxixe)	121.080	10153.48

Exchange rate Metecais 11,9254 = US$ 1

Table 6. Time of spraying activities, number of houses sprayed, coverage rates, population protected and insecticide used, 1996 spray round

Locality	Date start	Date end	Houses Sprayed	Houses Not sprayed	Coverage	Pump fills	Population	Persons/hse	Fills/hse	Est mg/m²
Maputo-City	11/11/96	22/01/97	44847	7079	86		224235	5.0		
Maputo-Prov			10941	1940	85	4944	54765	5.0	0.45	0.56
Gaza-Xaixai			26340	2860	90		131799	5.0		
Gaza-Chokwe	18/11/96	18/12/96	8039	178	98		40195	5.0		
Gaza-Chibuto	15/01/97	20/02/97	13515	639	95	4276	67575	5.0	0.32	0.40
Inhambane			23482	950	96		117418	5.0		
Sofala-Beira	02/01/97	21/03/97	48295	1820	96	12815	259770	5.4	0.27	0.33
Manica-Chimulo	21/12/96	24/02/97	28258	1510	95	10437	141506	5.0	0.37	0.46
Tete-Moatize	17/12/96	08/03/97	18233	1891	91	9229	91265	5.0	0.51	0.63
Zambezia	03/12/96	05/02/97	33628	1250	96	11739	169140	5.0	0.35	0.44
Nampula-Sede	15/10/96	21/01/97	71087	1825	97	21907	365435	5.1	0.31	0.39
Nampula-Nacala	08/03/97	03/06/97	21826	2248	91	7004	109130	5.0	0.32	0.40
Nampula-Angoche	15/03/97	19/05/97	20351	129	99	7480	101755	5.0	0.37	0.46
TOTAL 1996			368842	24319		89831	1873988			

Estimated surface area of houses 50 sq.m; target dose of insecticide 30 mg a.i./ sq. m.

Table 7 Time of spraying activities, number of houses sprayed, coverage rates, population protected and insecticide used, 1997 spray round

Locality	Start	End	Houses Sprayed	Not sprayed	Coverage (%)	Pump fills	Population	Persons/hse	Fills/hse	Est mg/m^2
Maputo City	27/10/97	05/03/98	49620	562	99		291025	5.9		
Inhaca	26/03/98	04/04/98	1235	152	89		4014	3.3		
Catembe	24/03/98	18/04/98	2453	255	91		9540	3.9		
Mavalane	27/10/97	09/02/98	25929	2515	91	13654	129645	5.0	0.53	0.66
Maputo Province	27/10/97	09/03/98	19061	1800	91	8496	131872	6.9	0.45	0.56
Sofala	27/10/97	12/02/98	60120	7214	89	20048	307452	5.1	0.33	0.42
Manica	03/11/97	24/01/98	21866	2625	89	14262	229927	10.5	0.65	0.82
Tete	03/11/97	21/01/98	20898	3174	87	11931	101096	4.8	0.57	0.71
Nampula	05/11/97	09/02/98	38264	625	98		191320	5.0		
Nampula-Namialo	14/02/98	04/03/98	3515			3245	9566	2.7	0.92	1.15
Nampula-Angoche	06/04/98	29/03/98	22193			8080	54540	2.5	0.36	0.46
Nampula-Nacala	20/12/97	19/02/98	19516	2632	88	12782	115122	5.9	0.65	0.82
Nampula-Inguri	06/04/98	25/04/98	17660	1690	91	8080	88330	5.0	0.46	0.57
TOTAL 1997			302330	23244		100578	1663449			

Table 8. Time of spraying activities, number of houses sprayed, coverage rates, population protected and insecticide used, 1998 spray round

Locality	Start	End	Houses Sprayed	Not-sprayed	Coverage (%)	Pump fills	Population	Persons/hse	Fills/hse	Est mg/m^2
Maputo-City	16/11/98	22/03/99	38589			12876	223246	5.8	0.33	0.42
Maputo-Prov	01/12/98	19/02/99	19362	2144	90	9076	97520	5.0	0.47	0.59
Gaza-Xaixai	14/12/98	01/03/99	13129	2599	83		46292	3.5		
Gaza-Chokwe	14/12/98	01/03/99	34800			8216	50732	1.5	0.24	0.30
Gaza-Chibuto	15/12/98	25/02/99	31592	1226	96	8251	65836	2.1	0.26	0.33
Inhambane	11/01/99	04/03/99	7330	1491	83		21009	2.9		
Inhambane-Maxixe	26/04/99	09/06/99	10014	5946	63	12378	23969	2.4	0.71	0.89
Sofala-Beira/Mafambisse	01/12/98	09/03/99	67236			22273	297310	4.4	0.33	0.41
Manica-Chimulo	07/12/98	22/03/99	18106			15929	108863	6.0	0.88	1.10
Tete-Moatize	30/12/98	17/04/99	3691							
Tete-Songo	30/12/98	17/04/99	99098	8935	92	12839	108033	1.1	0.13	0.16
Zambezia-Quelimane	05/01/99	27/03/99	30460			14631	152300	5.0	0.48	0.60
Morrumbula	19/01/99	24/05/99	14957			7967	74785	5.0	0.53	0.67
Nampula-Sede			41255	6789	86	1961	206275	5.0	0.05	0.06
Nampula-Nacala			19109			1063	95545	5.0	0.50	0.63
Nampula-Angoche		02/07/99	17253			9566	86265	5.0		
Cabo Delgado	08/04/99	28/05/99	8795	6007	59	7678	51902	5.9	0.87	1.09
TOTAL 1998			474776			144704	1709882		0.30	

Table 9. Projected operational costs by Province and district for the proposed sprayround of 1999.

Province	Locality	Projected operational cost 1999 (Metecais)
Maputo City	Maputo City	Not available
	Inhaca Island	Not available
	Catembe	Not available
Maputo Province	Matola	254 626 000
Gaza	Xai-xai	80 000 000
	Chibuto	73 000 000
	Chokwe	73 000 000
Inhambane	Inhambane	53 780 375
	Maxixe	56 503 000
Sofala	Mafambisse	356 680 000
	Beira	20 400 000
Manica	Manica	216 000 000
Tete	Moatize	96 945 000
	Songo	145 940 000
Zambezia	Quelimane	186 240 000
	Morrumbala	117 360 000
Nampula	Nampula – sede	153 200 000
	Nacla Porto	86 800 000
	Angoche	57 200 000
	Ilha de Mozambique	12 900 000
Cabo Delgado	Cabo Delgado	103 000 000

Exchange rate Metecais 11,925 = US$ 1

Table 10 Emergency Residual Spraying, Gaza Province, 2000

Area	Type	Start	End	Work days	Spray	Not spray	% coverage	Population	Pump fills	Man_days	Protected
Xai Xai											
Inhacutse	camp	25-Apr	25-Apr	1	147			995	35	17	995
Centro F P Primario	camp	27-Apr	27-Apr	1	32			434	38	12	434
Hospital Provincial	Hospital	29-Apr	29-Apr	1					34		
Centro2000	camp	2-May	2-May	1	113			541	41	15	565
Fidel Castro	suburban	3-May	11-May	4	1122	141	88	3507	467	34	5610
Bairro 8	suburban	15-May	17-May	2	333	113	74.6	767	151	35	1665
Marien Ngoabi (OMM)	camp	17-Mar	17-Mar	1	76			933	44	2	933
Chibutu											
Guemulene	camp	Sprayed twice			27	-					
Alto-Chambane	village	4-May	4-May	1	347	10	97	106	870	94	
Eduardo Mondlane 1	village	5-May	6-May	2	688	63	92	174	1607	249	
Eduardo Mondlane 2	village	8-May	8-May	1	597	71	89	174	1542	329	
Eduardo Mondlane 3	village	9-May	9-May	1	430	175	71	139	1662	243	
Eduardo Mondlane 4	village	10-May	10-May	1	478	105	82	157	1165	149	
Eduardo Mondlane 5	camp				8	-					
Nglehire	village	11-May	12-May	2	1191	93	93	403	3009	512	
Samora Machel	camp	Sprayed twice			25	-					
Wenela	camp	Sprayed twice			52	-					
Chokwe											
Chaqualane	camp	27-Mar	8-Apr	8	4867	-			679	20	
Hospital	Hospital	30-Mar	30-Mar		128	-			48	3	
Mapapal	camp	7-Apr	7-Apr	1	480	-			140	20	
Magul	camp	11-Apr	11-Apr	1	1296	-			143	20	
Aldeia	village	13-Apr	13-Apr		28	-			13	3	
Hokwe	camp	13-Apr	20-Apr	7	4385	-			870	20	
Manjague	camp	22-Apr	24-Apr	2	1625	-			289	20	
Total					**19,332**				**12847**	**1797**	

Table 11: Xai-Xai post-emergency spraying, urban areas

Area	Type	Start	End	Work_days	Spray	Not_spray	% coverage	Population	Cargas
Marien Ngoabi 4	suburban	20-Mar	23-Mar	3	636	244	72	2421	324
Inhamissa 1	suburban	30-Mar	3-Apr	2	432	222	66	1482	237
Inhamissa 2	suburban	4-Apr	4-Apr	1	261	148	64	934	134
Inhamissa 3	suburban	11-Apr	12-Apr	2	526	240	69	1721	260
Inhamissa 4	suburban	13-Apr	13-Apr	1	205	142	59	654	108
Koka Missava 7	urban	14-Apr	14-Apr	1	263	108	71	993	138
Koka Missava 6	urban	17-Apr	17-Apr	1	265	120	69	1059	155
Koka Missava 5	urban	18-Apr	19-Apr	2	422	340	55	1602	260
Marien Ngoabi 3	suburban	2-Mar	3-Mar	2	481	223	68	1627	279
Marien Ngoabi 2	suburban	6-Mar	8-Mar	3	705	176	80	2560	371
Marien Ngoabi 5	suburban	13-Mar	13-Mar	1	182	81	69	680	93
Marien Ngoabi 1	suburban	14-Mar	16-Mar	3	586	151	80	1919	284
Total				22	4964	2195		17652	2643