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REVIEW OF THE SWAZILAND MALARIA CONTROL PROGRAM CONDUCTED BETWEEN MARCH 30 - APRIL 25, 1987

by

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I. EXECUTIVE SUMMARY

At the request of U.S. Agency for International Development (USAID) and the Government of Swaziland, the Swaziland Malaria Control Program was reviewed in order to (1) assess the health impact of the Government of Swaziland's current vector control practices and policies, particularly spraying with DDT 75% wettable dispersible powder combined with bedbug spray; (2) examine probable alternative vector control measures for use in Swaziland; (3) assess overall efficacy and cost effectiveness of current vector control practices; and (4) determine cost implications of alternative measures and provide the Government of Swaziland with a full assessment report including recommendations.

In order to address these specific charges, information and data had to be collected, collated, and interpreted on the nature of the malaria problem, the background and status of the program, and past and present performance of the organization. Inquiries were made regarding the administration and management of the program. These questions covered the qualifications and experience of employees, the availability and condition of supplies and equipment, the adequacy of facilities and transport, and the technical standards and output of operational, entomological, and parasitological services.

Based on the information and data obtained in the Review of the Swaziland Malaria Control Program, the Findings and Recommendations are listed below:

FINDINGS

1. The principal malaria vector mosquito in Swaziland is *Anopheles arabiensis*. The principal malaria parasite responsible for an estimated 95% of malaria cases, including cerebral malaria, is *Plasmodium falciparum*.

2. A clear cause-and-effect relationship exists between the increase in malaria rates and the cancellation of the annual DDT spray cycle scheduled for 1985-86, and a 50% underspraying of DDT spray rounds in 1982-83. Also, the malaria parasite is showing increasing resistance to chloroquine treatment.

3. A cost-effective malaria prevention method is residual DDT spraying. The average cost of treating a homestead in Swaziland is E1.37 or $0.68 per year and the unit cost of protecting one individual is E0.196 or $0.10 per year.

4. Spraying operations are presently severely handicapped because the geographical reconnaissance documentation of the Swaziland lowveld malarious area is inadequate.

5. Although there is no proof, An. arabiensis probably accounts for a low level of persistent transmission that is not being controlled by residual spraying.

6. Active and passive malaria case detection in the field are not being carried out efficiently and many defects exist in the system.

7. The malaria control unit suffers from administrative problems that impedes efficient control operations and encourages employee laxness. In addition, the unit does not have a functional entomological activity capable of conducting essential tests and studies to evaluate the impact of control methods.

RECOMMENDATIONS

1. Seven metric tons of DDT wettable dispersible powder, sufficient to treat 50,000 homesteads and other housing structures in the lowveld malarious area, should be ordered.

2. DDT spray applications should be revised to accomplish the following:

   - reduce the dosage rate from $2g/m^2$ to $1g/m^2$

   - increase the spray rounds from one to two per year

   - round one should be applied between September and November at $1g/m^2$ on the basis of total coverage throughout the lowveld territory; and

   - round two should be applied from February to March (inclusive) at $1g/m^2$ to focal areas of transmission.

3. The geographical reconnaissance of the malaria transmission area in the lowveld should be conducted again and its documentation revised.

4. If it can be shown, through entomological studies, that An. arabiensis is responsible for outdoor transmission, the residual spray method could be augmented with

larval control measures using Bacillus thuringiensis, var. israeliensis (serotype H-14), Bacillus sphaericus, or insect growth regulators. Applications of these materials should first be subjected to small field trials to evaluate control efficacy.

5. Immediate steps should be taken to improve the discipline of active and passive case detectors. Active case detectors should be retrained in their duties and responsibilities, including: geographical reconnaissance, routine entomological surveillance, and case searches and treatment.

6. Program administration needs to institute management practices that will help coordinate and integrate the work of the organization.

7. Improve management and administration at the malaria control unit headquarters, and in the field. With few exceptions, employee duties and responsibilities are not well defined, and supervision is lax. These factors are reflected in substandard performance, low output of the work force, absenteeism, and disregard for normal work rules.

8. Entomological work of high priority should include the following:

   - Retrain entomological personnel in the various techniques, methods of evaluation, and study of entomology related problems.

   - Provide in-service training to selected personnel in laboratory and field techniques, in procedures of entomological assessment of malaria control operations, and in evaluation of entomological factors associated with malaria transmission.

   - Continue to monitor the susceptibility of An. arabiensis to DDT. Susceptibility testing should be routinely conducted to assess the level of mosquito resistance to DDT, and bioassays should be performed to determine the loss of insecticidal activity of old DDT residual deposits in previously sprayed houses.

   - Conduct a study addressing the outdoor resting and biting activity of malaria vectors in the vicinity of the homesteads, including the outdoor activity

of people after sundown in relation to mosquito biting behavior.

- Conduct a study to determine why malaria cases are proportionately lower among infants and children when compared to adults. This type of study could be accomplished in cooperation with parasitology.

9. Appoint a malaria advisory board or committee consisting of five to seven members with representatives from the Ministry of Health, USAID (CCCD Program), World Health Organization (WHO), the medical clinics in the lowveld, and the Medical Directors of Ubombo Sugar Estate/Ranches, and other estates in the lowveld. The committee could meet two or three times a year to hear a progress report (achievements, problems, difficulties) from the manager of the malaria control unit. Committee members could advise and assist the manager, either directly or indirectly, on appropriate corrective measures.

10. Postpone the introduction of new innovative control measures until the malaria control unit reestablishes its administration and management on a sound basis. At the present time, it would be premature to attempt something new and untried until traditional measures are restored to their earlier level of satisfactory performance.

Using the Findings and Recommendations as a guideline, the review indicates that the Swaziland Malaria Control Program has the potential of achieving a high level of malaria control (90%), which is equal to or better than the low malaria rates generally maintained before 1985. A reduction in malaria cases could lead to a leveling off and eventual disappearance of the growing parasite resistance to chloroquine and other antimalarial drugs.

II. OVERVIEW: SWAZILAND AND THE MALARIA CONTROL PROGRAM

A. Historical Perspective

In 1946, the Swaziland Malaria Control Program was organized to control malaria vector mosquitoes and to prevent malaria transmission. It was one of the earliest programs in Africa to adopt the indoor house spraying control strategy using insecticides with long residual mosquitocidal activity. The Program's control operation involved residual spraying of houses indoors using DDT or other long-lasting insecticides applied to surfaces where mosquitoes rest (mainly walls and ceilings). The Program augmented this method by controlling the larval stages of malaria mosquitoes in breeding places near houses and rural villages. The Malaria Control Program was well organized, directed, and evaluated, and control efforts were carried out with adherence to an operational plan wherever feasible. Until recently, the Program's success was evident with low malaria rates achieved shortly after the start of the Program and maintained for almost 40 years. However, since 1982, Swaziland has experienced a sharp increase in malaria rates for reasons not clearly defined due to a lack of malariometric assessments. This recent increase in malaria rates has caused serious concern about the Program's capability to cope with current and future problems.

In 1947, a malaria control unit was organized in Swaziland, and DDT residual spraying was initiated in a few small areas of transmission in the lowveld. In 1950, spraying of all malarious areas was accomplished and continued once a year. A few years later, DDT was replaced by benzene hexachloride (BHC) which does not have the long residual activity of DDT (six months or more). The records do not clearly indicate why the switch from DDT was made, but it is probable that BHC was not as costly as DDT.

By 1955, all known areas of malaria transmission in the lowveld were sprayed twice a year with BHC. During this time, malaria rates in children (under 12 years of age) fell dramatically from 65% to 2% in the sprayed areas. In addition to house spraying, control of Anopheles mosquito larvae was carried out in the proximity of homesteads. Unfortunately, the impact of this supplementary larval control measure on mosquitoes and malaria was never assessed malariometrically, but it is possible that this control method had an impact on reducing outdoor transmission.

The impact of residual spraying in reducing malaria rates was so reassuring that it was withdrawn from areas where no malaria cases had been reported for two years. By 1958, spraying

was limited to a 15 mile protective barrier along Swaziland's eastern border with Mozambique. In 1959, spraying was discontinued altogether, but quickly resumed in 1960 when An. gambiae reappeared in houses, and indigenous malaria cases were detected.

Throughout the 1960's, the control operations continued to sustain a low malaria incidence, ranging from 0.7% to 1.3% of the average blood examination rate (ABER).

In the 1970's, malaria rates were maintained at low levels until 1977 and 1978. In 1977, 902 cases (ABER 2.9%) of malaria were detected and in 1978, 1,476 cases (ABER 5.1%) were detected. The reasons for this increase are unknown. In 1984, 1985, and 1986, cases numbered 3,373, 1,778, and 1,732, respectively. These higher rates are a serious cause for concern possibly indicating a control breakdown. The 1987 data are incomplete, but reports from the field in April indicate flare-ups and outbreaks of malaria in various locations in the lowveld.

Additional information concerning the annual parasite incidence in Swaziland from the Program's initiation to 1986 is presented in Annex I by number of slides examined, number positive, and percent positive, correlated with annual rainfall. These data were derived from the records of the malaria control unit, which tabulated the percent of blood slides positive out of those collected and examined by microscopy for each year from the inception of the Malaria Control Program. This information provides an excellent comparative record of the rise and fall of malaria rates from 1946 to 1986, and gives an overall perspective of the malaria situation in time and space, from the past up to the present.

B. Description of the Country

Swaziland is a small country of 6,700 square miles (17,363 km^2) approximately the size of New Jersey, USA (Annex II, Map). Its estimated population in 1987 was 770,000 people. The country measures 120 miles north to south and 90 miles east to west. It is bordered by South Africa on the north-west and south, and by Mozambique on the east. The country's latitude of 26° south places it well within a subtropical climate. Along Swaziland's western border with Transvaal, South Africa, mountains rise up to 6,000 feet above sea level. This area, referred to as the high-veld, slopes eastward through rolling grassy midlands, called the middleveld, which range between 2,000 and 4,000 feet in elevation. The land levels off, further east, to a low plain, referred to as the lowveld, which is approximately 500 and 2,000 feet in elevation.

The temperatures and rainfall in Swaziland vary with altitude. For example, the average temperature in the highveld averages a cool 60°F (16°C), and rainfall varies from 30 to 45 inches (76 to 114 centimeters) annually. The average temperature in the middleveld is a comfortable 66°F (19°C), and rainfall ranges from 30 to 45 inches (76 to 114 centimeters) annually. Finally, the climate in the lowveld is much drier and warmer; the average temperature is 72°F (22°C), and rainfall in this area averages 20 inches (51 centimeters) annually.*

Swaziland's lowveld is agriculturally rich. It is supplied with water from several large rivers which are used for irrigation of sugar cane, cotton, and other commercial crops for export. The lowveld's agricultural operations are company owned and managed, employing thousands of workers, many of whom live in company houses with their families. The country's lowveld area is interspersed with homesteads and small settlements of Swaziland farmers, most of whom graze cattle and grow just enough food for their families, but some farmers have started to raise cash crops.

The country's lowveld is the heartland of malaria. In fact, approximately 90% of malaria cases originate in this area, and the estimated population of 250,000 people are at risk to malaria. In the past, the lowveld's malaria control operations have lead to relatively low risk to malaria. However, this area has demonstrated the potential for resurgence when control measures are not effectively maintained.

C. Occurrence of Malaria

Malaria transmission in the lowveld, together with a few pockets of malaria transmission in the middleveld, is characterized as unstable and seasonal, occurring from November through April (summer season). The malarial instability is mainly a reflection of the variability of rainfall in Swaziland where a positive correlation exists between higher and lower than average rainfall, and higher and lower than average malaria mosquito population densities. In addition, high temperatures increase the rate of development of the mosquito larval stage and the sexual stages of the parasite in the mosquito. Consequently, forecasting the severity of the malaria problem in any given year is about as predictable as forecasting rainfall and temperature.

*Annex III presents additional information on the average rainfall in the three ecological zones of Swaziland.

The only predictability in this biological event is the generalization that malaria mosquitoes and malaria increase during the warm, wet season. Therefore, it is important that planning and preparations for malaria prevention and control be made well in advance of the expected event.*

D. Malaria Vectors and Malaria Parasites

Three efficient malaria vector species were originally present in Swaziland. Two of the three vector species, *Anopheles gambiae* s.s. and *An. funestus*, have a preference for resting (endophilic) and feeding (endophagic) indoors and prefer humans (anthropophilic) over domestic animals. The third species, *An. arabiensis*, feeds on both man and domestic animals and will rest and take a blood meal indoors and outdoors. In addition, a fourth species, *An. quadriannultatus*, is present in Swaziland but prefers cattle (zoophilic) over man, and apparently plays no role in malaria transmission.

Under the insecticidal pressure of DDT house spraying, two malaria vector species, *An. gambiae* and *An. funestus*, have virtually disappeared. Conversely, the vector species, *An. arabiensis*, which has a much lower DDT exposure, has maintained populations of sufficient density to continue low-level malaria transmission.

The dominant malaria parasite in Swaziland is *P. falciparum* (malignant tertian malaria). This parasite is responsible for 90% to 95% of the malaria cases in Swaziland. In addition, two parasites, *Plasmodium malariae* (quartan malaria) and *Plasmodium ovale*, are present, but they are not often detected.

In Swaziland, the *P. falciparum* parasite produces severe illness among children and adults alike, and the fatality rate may exceed 10% of all cases. In recent years, the parasite has developed resistance to chloroquine, the most effective antimalarial drug. This resistance is reported to be widespread throughout much of tropical Africa, and increasing in intensity as a result of the continuing heavy use of the drug for preventive and presumptive treatment.

E. Malaria Control Measures

The primary malaria control measure in Swaziland is indoor residual spraying of houses. This method of malaria vector control emerged with the discovery of DDT at the end of World War

*See Section C-Parasitology, page 13 for observations on the occurrence of malaria by age and sex groupings.

II. It was based on the concept that malaria vector mosquitoes

II. It was based on the concept that malaria vector mosquitoes entered houses at night to take a blood meal from the occupants then rested on ceilings, walls, and other indoor surfaces while digesting their blood meal. Therefore, if the mosquito resting surfaces were sprayed with DDT or other residual-type insecticides, mosquitoes contacting the treated surfaces would die and malaria transmission would be greatly reduced or interrupted completely after a period of one or two years. The method has been generally successful throughout the malarious areas of the world where the malaria vectors rest and feed indoors, and where people are indoors after sundown. In many areas of the world, however, malaria vectors and people do not conform to this indoor pattern of behavior, and malaria transmission may occur outdoors but usually at a much lower level of intensity. This seems to be the case in Swaziland.

In recent years, control programs have been relying on the use of antimalarial drugs with increasing frequency. This control method is in response to the rising level of malaria outbreaks associated with the reduction of control measures like residual spraying.

F. Organization of the Malaria Program

The malaria control program consists of four principal divisions: Operations, Entomology, Parasitology, and Administration. Operations is responsible for planning and implementing control measures directed at the mosquito vectors of malaria. Entomology determines when, where, and how mosquito control measures should be applied to obtain maximum cost-effective results. In addition, it assesses the efficacy of control measures needed to achieve a large reduction in the adult vector mosquito population, preferably above 95%, in and around human habitations. Finally, the Entomology Division investigates the causes of control failures and recommends solutions. Parasitology routinely monitors the population at risk to malaria, and assesses the impact of control operations on malaria rates. The monitoring of the population at risk to malaria is carried out by active case detectors, and clinics and hospitals collaborate with the Program's malaria control unit by providing blood slides for passive case detection. Administration provides the men, materials, equipment and transport for the malaria program. Its purpose is to facilitate the work of these essential components of the organization to ensure smooth functioning of the malaria program.

III. PRESENT STATUS OF THE PROGRAM

A. Rising Malaria Rates

The recent increase in observed malaria rates in Swaziland could be attributed to several factors. For example, resistance of the malaria parasite to chloroquine treatment is a growing problem in Swaziland. In addition, higher than average rainfall in 1984* may have contributed to an increase in the malaria vector population, but the malaria control unit has no supporting entomological data to confirm this. Inadequate or incomplete spraying in 1983-84 could also be a factor, but again, since the spray records are lost, and the geographical reconnaissance information is missing, there is no back-up data to support this assumption. However, WHO malariologist, L. T. Almeida Franco, who reviewed the program in 1984, noted that the malarious area in the lowveld was undersprayed in 1982-83 and 1983-84 to the extent that a 50% insecticide surplus existed. He noted further that malaria cases increased from a baseline of 155 cases in 1981-82 to 743 in 1982-83, and to 3,373 in 1983-84.

Malaria has not only increased, but the virulence of the parasite seems to have intensified. More cases of cerebral malaria are being reported, and the death rate has risen. Between January 1 and April 28, 1986, 15 malaria deaths were reported in the lowveld. A disturbing highlight of these malaria deaths was that not one of the cases had been seen or treated by the malaria control unit health assistants assigned to active case detection before the patients were admitted to the hospital. Moreover, there was no follow-up by the malaria control unit to determine the address of the patients, or the specific locations where malaria was contracted. Finally, the malaria parasites were chloroquine resistant.**

In view of the rising incidence of malaria, and the spreading chloroquine resistance, it is all the more urgent that the malaria control unit strengthen vector control operations together with entomological and parasitological surveillance. Problems in need of immediate resolution are noted below:

B. Breakdown in Spray Operations

The annual spray round scheduled for September through November 1986-87 was cancelled because DDT was not purchased as requested by the malaria control unit. The order was placed in

*Cyclone Domoina struck Swaziland January 29-30, 1984.
**Report by David L. Heymann, CCCD Project Mbabane, Swaziland.

time, but no follow-up action was taken by the Government of Swaziland purchasing authorities.

Without DDT, not only was the malaria control unit unable to carry out its principal operational responsibility for protecting the population at risk to malaria in 1986-87, but many of the employees were unable to perform the work they were trained and hired to do. Unfortunately, meaningful alternatives for productive activity for these employees were unavailable to the manager of the malaria control unit.

1. Cost of Spray Operations

The estimated cost of spray operations for total coverage round is given in Annex IV. Although imperfections exist, the residual spray method has proved to be, under most conditions, the most cost-effective malaria prevention method yet devised. This can be seen from the estimated cost breakdown of one total coverage spray cycle of the lowveld area. As the data show, the average cost of treating a homestead is E1.37/annum ($0.68), and the unit cost of protecting one individual is E0.196/annum ($0.10). This compares with the estimated cost of active case detection of E.800/person ($0.40). However, the comparison is flawed. While residual spraying protects people from malaria, active case detection only detects on the presumption of malaria and at great expense, and since it is basically a clinical measure, it has little impact on malaria transmission.

2. Handicapped Spray Operations

Spraying operations are presently severely handicapped due to the loss of the geographical reconnaissance documentation of the lowveld malarious area. The geographical reconnaissance is the most important planning document of the malaria control unit, and of vital importance to spray operations, active case detection, and entomology. It is essentially a census of the malaria transmission area of the country showing the number and location of houses and the physical features of the environment plotted on sketch maps drawn to scale. It was completed in the mid-1970's, but the document is missing and the only recourse is to redo the work.

3. Example of a Good Spray Operation

It is important to note that the ability of the malaria control unit employees to conduct residual spraying, according to WHO specification and procedures, was demonstrated during this consultancy at a prison near the Big Bend area. Sufficient leftover DDT from the 1984-85 spray round was available to treat

the prison compounds where prisoners had recently contracted malaria.

Based on observations of this spraying operation, the work was well done, and the men were versed in the techniques and methods of application, including the preparation and mixing of spray to achieve the proper dosage rate. Also, under the supervision of the malaria control unit spraymen, the prisoners were trained to perform the spraying. It was encouraging to see a fine demonstration of such a precision activity, and confirms that the operational personnel of the malaria control unit are capable of excellent performance when given essential materials and equipment.

C. Parasitology

Parasitology activity is accomplished by active and passive malaria case detection in the field, and blood slide examination by the two microscopists in the malaria control unit laboratory at Manzini. Passive case detection is provided by clinics in the malarious areas located mainly in the lowveld, and also by hospitals, which are reported to be less cooperative than the clinics. Blood slides from suspected malaria cases are collected weekly by the malaria control unit for laboratory examination, but there is a lag of about two weeks between submission of slides and receipt of results. The workload of blood slide examination and the recording and analysis of results is more than enough to fully occupy two microscopists which accounts for the reporting lag.

Passive and active case detection of malaria rates, and blood slide examinations are compared and presented in Annex V. Active case detection is a direct responsibility of the malaria control unit. Sixteen case detectors at the health assistant level monitor the population at risk to malaria in the lowveld. Each detector is assigned to an area or locality in which he is responsible for checking, on a monthly schedule, all of the houses in his area, and for interviewing the inhabitants for signs and symptoms of malaria. Individuals having positive signs are given a presumptive dose of chloroquine and a blood slide is taken once a week for parasite confirmation. This blood sample is sent to the unit laboratory in Manzini.

Based on observations and interviews, the detectors in the field are not performing their work efficiently and many defects exist in the system. For example, the detectors were not aware of the number of houses and people in their assigned areas, and they were uncertain about malaria symptoms. In addition, some of the detectors were taking blood slides from patients waiting in line at clinics and reporting them as active case blood slides.

Moreover, the detectors did not present a business-like appearance on the job, wearing shabby casual street clothing. A uniform would be more appropriate for public service employees engaged in medical activities involving daily contact with the public. Finally, there was evidence of absenteeism among the detectors. Due to these and other deficiencies, the active case detection program lacks credibility.

Based on 1987 activity, the annual estimated cost of active case detection is given in Annex VI. The active case detection program is higher in cost by E26,047/annum ($13,024) than the cost of spraying one spray round of DDT as shown in Annex III. The cost effectiveness of the active case detection program leaves much to be desired.

In Swaziland, malaria can accurately be characterized as a disease of the adult population. Its distribution by age consistently shows a lower proportion of cases occurring in infants and young children (five years of age and younger) when compared to the occurrence of adult cases, roughly 85:15 adults to children. In addition, malaria cases in adult males significantly exceeds malaria cases in females.

In order to understand the significant occurrence of malaria in adult males, a comparison should be made between the outdoor feeding and resting behavior of the principal vector mosquito, An. arabiensis, in relation to the behavior and customs of the rural Swazi people after sundown. It appears that adult males habitually gather outside the house in the early evenings, after the day's work, to socialize with other adult males. At the same time, the cattle have been corralled (Kraal) for the night. The women, on the other hand, stay inside to tend to household duties. The young children, particularly the infants, are indoors with their mothers during this time. Therefore, the main vector contact is largely with the adult males who are socializing outdoors after sundown, while infants, children, and adult females stay indoors after sundown under the protection of the residual spray.

D. Entomology

At present, the malaria control unit does not have a functional entomological activity capable of conducting essential tests and studies to evaluate the impact of control measures. For example, it is crucial to determine if the DDT spray applied in September-December 1985 is still exerting some effect, and to what degree it is effective. It was not possible to determine the residual effect of the DDT because the malaria control unit lacked the necessary equipment to conduct the appropriate tests; although the equipment was available in previous years. In

addition, it was not possible to determine the vector susceptibility to DDT because of missing items in the WHO test kit (all but one hand-sprayer for spray-sheet collections indoors were missing). Some employees in the malaria control unit have had training and experience in entomological techniques, but evidently these employees are not qualified to plan and supervise an entomological program.

An opportunity to observe the entomology aides in the conduct of space spray collection indoors and night-biting collection indicated a satisfactory degree of proficiency. The techniques and methods were demonstrated at the refugee camp managed by the World Confederation of Lutheran Churches near Big Bend, in the lowveld. The aides should be currently engaged in entomological evaluation work on a systematic sampling basis in order to assess the entomological effects of the cancelled 1985-86 spray cycle, and to determine if there is any insecticidal activity remaining from the previous 1984-85 spray cycle.

E. Administration

A roster of the malaria control unit employees by name, age, position title, salary, and qualifications is given in Annex VII.

Thirty-two employees are assigned to the lowveld malaria area. Sixteen of these employees are assigned as active case detectors. The remaining employees are stationed at headquarters including one store-keeper, two microscopists, a driver, one assistant manager, and one manager. A miscellaneous group of employees (i.e., entomological aides, malaria control aides), who have no special assignments, are on call to conduct services when needed.

The employees range in age from 27 years old to 65 years of age; the average age of the employees is 54 years old. Quite a few employees have attended WHO malaria control training schools during the late 1960's and early 1970's. These employees are experienced in many of the basic field techniques and methods, but they have had little opportunity to perform in the past few years due to insufficient insecticide, equipment, and entomological supplies.

The malaria control unit suffers from administrative problems that impedes production and encourages employee laxness. In addition, employees appear to lack interest in the essential duties and responsibilities of the program. Evidence indicates that there are no clear lines of authority, responsibility, or delegation of duties by the manager. For example, the malaria control unit has no short- or long-term plan of work as a guideline to follow. In addition, daily and weekly work schedules are

not laid out to assist in the coordination of activities. Also, an inventory document, listing the supplies and equipment on hand, and the items transferred to unit personnel at Manzini, and in the field, does not exist. Finally, the files and records of past work in Operations, Entomology, and Parasitology were not accessible.

IV. SUGAR ESTATE MALARIA PROGRAM IN THE LOWVELD

The malaria problem at two of the five sugar estates in the lowveld (Ubombo Sugar Estate/Ranches, Mhlume Sugar Estate and the Swaziland Irrigation Scheme) were reviewed in discussions with the medical officers in charge of these operations.

Dr. La Roux, Medical Director of the Ubombo Sugar Estate/ Ranches, provides medical services to 3,500 workers and 8,000 family members living in company housing. He expressed deep concern about the malaria problem and described it as the most important disease problem during the transmission season. His company supports a malaria prevention and treatment program consisting of one annual DDT residual spraying of all company housing before the wet season. In addition, provision is made for weekly chloroquine prophylaxis of the estate population, but compliance is not 100% because workers are reluctant to take pills when there is no illness. The problem of chloroquine-resistant parasites is complicating matters and officials are unsure as to how this problem can be managed apart from increasing dosage rates or changing antimalarial drugs. The yearly expenditures for malaria control are more than E40,000 ($20,000).

Dr. Fouche, Medical Director of the health program at both Mhlume Sugar Estate and the Swaziland Irrigation Scheme, outlined the malaria control program at both these facilities. Dr. Fouche reported that malaria has been on the increase in the past few years in areas outside the estate, and numerous malaria cases are being detected and treated without charge to the patient. In fact, Dr. Fouche reported that in April 1987, more cases of malaria were logged in the company than ever before.

The company noted the probability of outdoor transmission and have extended the spraying area to the eaves and parts of the outside walls where resting mosquitoes have been observed.

Within the company, malaria areas are being contained through a malaria program consisting of DDT residual spraying twice a year of all estate housing, plus antilarval spraying around estate housing. In addition, the program provides weekly antimalarial prophylaxis (Nivaquine) to all estate workers and family members.

The estate purchases its own DDT and equipment, trains the workmen, and evaluates the results. The estate receives no assistance from the government program. The cost of the malaria program was not available, but the control program was estimated to be close to the cost of the Ubombo Sugar Estate/Ranches

program. Dr. Fouche commented that malaria control is a more complex technical and administrative operation than he had originally perceived it to be.

As a final comment, Dr. Fouche added that he had not seen any evidence of spraying activity by the malaria control unit in two years and suggested that coordination and cooperation between the private sector operations and the Government of Swaziland could be mutually beneficial.

V. CONSULTANT'S COMMENTS ON CHARGES OF THE REVIEW

Below are comments on each of the four specific charges requested by USAID/Swaziland:

A. Assess health impact of the current Government of Swaziland vector control practices and policies, particularly the spraying of DDT 75% wettable dispersible powder combined with bedbug spray.

Based on the documentation of malaria rates from 1946-1986, DDT spraying clearly maintained malaria rates at low manageable levels safely, and at an affordable cost to the Government of Swaziland. In fact, DDT spraying was so successful in the 1960's that malaria rates fell dramatically, prompting a termination of DDT spraying on two occasions (spraying was quickly resumed when indigenous cases reappeared). Its safety record is excellent and evidence of mammalian toxicity has never been observed, nor have serious objections to spraying of houses been noted. Annex VIII discusses the safety of DDT as applied in residual household spraying.

Following DDT spraying, bedbug infestations have been reported. This increase in bedbug populations is considered to be the result of irritation by the DDT, which drives the bugs from crypts and crannies out into the open. In fact, many bugs are killed by the DDT, and after a few days bedbug activity is normalized.

DDT's value and effectiveness is supported by previous consultants from the World Health Organization, who have reviewed the program in the past, and by Dr. C. F. Hansford, Director of the Tropical Disease Institute at Tzaneen, South Africa. Dr. Hansford directs the malaria program of Natal and Transvaal where the malaria problem is similar to the problem in Swaziland. In his program, one million houses are sprayed annually exclusively with DDT, and with good results. However, outdoor transmission may be occurring when people are gathered outdoors in the homesteads in the early evening. The source of this transmission is probably the malaria vector An. arabiensis, which bites and rests indoors and outdoors. Until outdoor transmission can be confirmed by entomological and parasitological evidence, this transmission remains an assumption to be proved. If An. arabiensis proves to be responsible for this transmission, then controls can be devised to cope with the problem.

On the question of a Swaziland malaria control policy, the Government of Swaziland endorses residual spraying on an annual basis, stated as follows:

- "Residual spraying of all human habitations with insecticides" (specific insecticides not indicated) "at least 3 to 4 months prior to the peak transmission season."

- "The filling and draining of all stagnant water bodies and use of other basic sanitary measures, i.e., larvicides, where vector mosquitoes can breed."

The policy is a very general statement, leaving much latitude to the program director to exercise discretion and judgment based on knowledge and experience.

B. Examine possible alternative vector control measures.

There are no measures for Swaziland on the horizon that would serve as alternatives to DDT, as long as there is no evidence of mosquito resistance to the insecticide. However, there are some materials that might supplement or replace residual spraying in situations where DDT is infeasible or undesirable.

The use of bednets treated with a nontoxic insecticide has been suggested. This suggestion is based on a recent experiment in Tanzania where treated bednets were reported to have greatly reduced mosquito biting rates indoors. However, there was no measurable impact on the malaria rates. In an interview with members of the malaria control unit, those interviewed were very skeptical about the use of bednets in Swaziland. They thought the method would not be practical in the malaria zone because the people sleep on floor mats. There is virtually no use made of nets in the country. One important reason cited is the high cost of a net, estimated at E50 ($25) to E100 ($50) each, depending on the size and the quality of material used. Since the nets would need to be reimpregnated with insecticide every few months, supervision and coordination would be needed, particularly if thousands of nets are involved in the operation. Moreover, with six or seven occupants per house several or more nets would be needed per family unit. The cost would be affordable to only the middle and high income Swazi family.

Another augmentation possibility is larval control in the vicinity of homesteads in focal areas of malaria transmission. There are many examples of effective malaria control achieved through larval control alone, when the control measures are carefully planned and executed. This method may be worth investigating on a small pilot project scale to work out methods and systems, and to assess control impacts and cost.

Biological control of mosquito larvae using environmentally safe products selective to mosquitoes, such as B. thuringiensis (H-14), B. sphaericus, or insect growth regulators, could be useful in a larval control program where the work is carried out in the proximity of homesteads. Discovered in 1976, B. thuringiensis (H-14) is now used widely and successfully in the United States and Europe for mosquito control. However, these materials should be subjected to small-scale field trials to evaluate control efficacy before they are considered for the Swaziland program. Additional information concerning larval control strategies is presented in Section VI.

In view of the seasonal periodicity of malaria transmission from November to April and the focal distribution of the disease, together with the tendency of transmission to intensify during the latter half of the typical malaria season, the spray application should be revised:

- reduce the dosage rate from $2g/m^2$ to $1g/m^2$
- increase the spray rounds from one to two per year
- round one at $1g/m^2$ would be applied between September and November on the basis of total coverage throughout the lowveld
- round two at $1g/m^2$; and
- application would be made to focal areas of transmission, as determined by parasitological and entomological evidence, instead of total coverage.

This spraying strategy would have the effect of ensuring higher insecticidal activity from fresh deposits of DDT applied at the midpoint and the latter half of the malaria season, and spraying would be limited to specific, sensitive transmission sites. These sites would probably represent less than half of the homesteads sprayed in the total coverage first round. As a result, less insecticide would be used and the insecticidal effect would be improved. The disadvantage of the revision would be the cost of additional labor and transportation required for spraying. However, the unit has staff that could be spared for this work, and the estimated savings in insecticide should be sufficient to defray other miscellaneous expenses. The success of this method would depend on sound entomological and parasitological evidence that limit the areas of the focal transmission.

C. Assess the overall efficiency and cost effectiveness of the current vector control effort in Swaziland.

The present effort consists of one spray round annually of DDT at $2g/m^2$ surface area. The cost breakdown of this work, including the cost of casual labor, supervision of spraymen, and transport is given in Annex III. The total cost is E55.048 ($27,524) to treat 40,000 houses. The cost to evaluate the results is estimated at 10% of the total cost. On this basis, the unit cost of spraying one house is E1.37 ($0.68) and the unit cost of protecting one person is E0.196 ($0.10).

D. Determine cost implication of alternative measures.

At this time, no cost-effective alternatives to residual spraying in Swaziland exist. In fact, only supplementary measures directed at reducing outdoor transmission have any cost-effective possibilities.

Before useful alternatives and supplements are adopted, the potential of alternative methods should first be investigated for Swaziland field conditions.

VI. LARVAL CONTROL STRATEGIES

Since the discovery of the role of anopheline mosquitoes in the transmission of malaria at the turn of the century, control of the larval stage of the mosquito was adopted as the principal antimalarial strategy worldwide. Three basic methods were used: (1) application of larvicidal materials to mosquito breeding sites (oils, Paris green, etc.); (2) water management (drainage, filling, diking, etc.); and (3) biological control (planting, mosquito fish, predators, and habitat modifications).

Tremendous advancements were made in malaria control by means of these larval control methods in tropical and temperate malarious zones in all parts of the world. However, larval control has important limitations. For example, its effective execution requires highly trained technical supervision such as entomologists and engineers, assisted by experienced field personnel, to plan, direct, execute, and evaluate the results. Moreover, in developing countries, larval control was necessarily limited to selective uses and not as a basic control measure, largely because of economic constraints and technical complexities.

These constraints were negated by the discovery of the insecticidal residual properties of DDT in World War II, and the development of the DDT house residual spraying method. Malaria control in the developing countries was suddenly and dramatically revolutionized.

The new control method was simply based on the observation that malaria vector mosquitoes, in general, tended to enter human habitations in the evening to feed on the inhabitants and to rest on the walls and other indoor surfaces. Consequently, the principal site of malaria transmission occurred indoors. Therefore, by treating malaria mosquito resting surfaces with DDT, mosquitoes contacting the surface would die, and the transmission cycle of malaria would be terminated. There was evidence from pilot projects that malaria eradication was a reasonable possibility in a relatively short period of time, if the DDT residual coverage was maintained at a sufficiently lethal concentration against resting mosquitoes. In fact, residual spraying was so effective and economical that larval control was greatly reduced and eliminated altogether from most malaria control programs.

However, in Swaziland and in quite a few other developing countries, there were and are today malaria vector species that rest and bite outdoors, and these species are responsible for transmitting malaria by the extra-domiciliary route. The

Swaziland vector is An. arabiensis. Although there is no proof, this vector probably accounts for a low level of persistent transmission that is not being controlled by residual spraying.

If it can be shown that An. arabiensis is, indeed, responsible for outdoor transmission, it would be useful to identify the areas involved, and then consider the feasibility of selective larval control activity to complement the residual spraying. Potential larval control sites include sugar estates where large numbers of workers and families are housed, and malaria mosquito breeding sites that are identifiable in and around cities and towns. It would be cheaper to control the larvae than to spray scores of houses.

Larval control is currently the main mosquito control measure throughout the USA, Canada, Australia, Europe, and most developed countries. In recent years, the trend has moved toward biological control and a gradual decrease in the use of synthetic chemical compounds. Pyrethroids (synthetic pyrethrins) are receiving increasing attention because of their effectiveness at extremely low dosage rates. However, these synthetic controls are deadly to fish, aquatic predators, and to the parasites of mosquitoes. Also, the mosquito quickly acquires resistance to these substances. New environmentally safe biological larvicides, such as B. thuringiensis (H-14) and B. sphericus are enjoying a rapid increase in popularity. Generally, however, they are too costly for malaria control purposes in developing countries.

As previously noted, the use of larvicides are visualized as a supplement to residual spraying for use in areas where outdoor transmission can be clearly delineated. When larvicides are selectively applied, they have demonstrated the ability to produce a significant reduction in malaria rates. Pilot field projects should be carried out under professional supervision, and the results evaluated before adopting the measure in the regular control program.

VII. RECOMMENDATIONS AND AN ADDITIONAL OBSERVATION BY THE CONSULTANT

This year (1987) is a crucial period for the malaria program. A turn around in the steep climb in malaria rates recorded in the past three years must be engineered. The increase in malaria cases, and the rising number of cerebral cases and malaria deaths reported in 1985-86 and 1987 are preventable. Immediate high-priority action should be instituted to overcome an apparent deteriorating situation. Recommendations are outlined below:

1. A purchase order should be placed for 7 metric tons of DDT wettable dispersible powder sufficient to treat 50,000 homesteads and other housing structures in the lowveld territory. The spraying should be initiated in September for completion in November before the heavy transmission season. In addition, necessary spare parts should be ordered to ensure that all spray pumps are in good working order.

2. The geographical reconnaissance of the malaria transmission area in the lowveld should be conducted again. This should be undertaken now in order to update the population census, record the number of dwellings to be residual-sprayed, and to collect other physical and environmental data necessary to plan and carry out an efficient spray operation. As a start, assign the active case detectors to begin a house and population census of each of their 16 localities as a routine integrated activity. The work could be readily accomplished within the existing time frame of the active case detection activity without the need of additional personnel and work hours.

3. The Peace Corps should be asked to provide the short-term assistance of a volunteer with experience in field surveys and mapping to help the malaria control unit staff to carry out geographical reconnaissance in the lowveld. Since the volunteer would be needed immediately, the candidate should be someone already connected with the Peace Corps, who would be willing to extend his present tour of duty for the few months required to complete the geographical reconnaissance activity.

4. Entomological work of high priority should include determination of the susceptibility of vector mosquitoes to DDT. A new WHO test kit should be

ordered. If necessary, assistance may be requested from WHO, USAID, or Dr. Frank Hansford, to conduct the testing assisted by the malaria control unit personnel. Concurrently, a number of bioassay tests should be run to determine the residual insecticidal activity of DDT sprayed in 1985. It would be useful to have a reading of the DDT activity 18 months after the last application to answer the questions: "Will DDT still kill mosquitoes and at what level of mortality?"

5. An intriguing entomological question of great practical and operational significance is the outdoor resting and biting activity of malaria vectors in the vicinity of homesteads and the extent to which it contributes to malaria transmission outside the protective umbrella of sprayed houses (extra-domiciliary transmission). A study of this kind should address the outdoor activity of people after sundown in relation to mosquito biting behavior.

6. Parasitology, in cooperation with entomology, should determine the reason for the very low proportion of malaria cases among infants and children compared to adults, since the opposite occurs in the holoendemic malaria areas of equatorial Africa, such as Kenya, Uganda, and Tanzania. Is outdoor transmission the reason for the low malaria rates among infants and young children because they are indoors after sundown under the protection of residual spraying?

7. Immediate steps should be taken to improve the discipline of the active case detectors. At present, their duties are insufficient to keep them occupied throughout the workday. In the past, the active case detectors were responsible for random sampling of mosquito populations using the spray-sheet collection method during house visits. This work provided valuable information on the effectiveness of DDT house spraying and a check on the completeness of the spraying. This is no longer done and should be resumed. One active case detection health assistant said he would like to do the sampling work, but he needed pyrethrum spray to begin the work of knocking down the resting mosquitoes.

8. Program administration needs to institute management practices that will help coordinate and integrate the work of the organization. In addition, practices should be incorporated to improve worker discipline, performance, and efficiency.

The following suggestions are made in an effort to improve management:

The manager should:

- Prepare an annual program plan and work schedule that outlines priority activities to be carried out by Operations, Entomology, Parasitology, and Administration, including a schedule for starting and completing work.

- Prepare job descriptions for each of the malaria control unit employees, outlining their duties and responsibilities, and give each employee a copy for reference.

- Establish production norms and targets for active case detectors, redefine and delineate the purposes of their work, the procedures and methods they should follow, and their expected weekly output. Evaluate employee performance on the job and advise in writing the deficiencies observed and corrective action to be taken.

- Delegate greater responsibility to subordinates to deal with administrative details in the office, and to running errands, in the field. These duties are presently occupying too much of the manager's time. The manager needs to allow time for program planning, reporting, analysis of operational and technical data, and other substantive matters of importance to program management.

- Institute brief weekly staff meetings to review problems, accomplishments and progress, develop work plans, and schedule assignments for the following week.

- Prepare a monthly progress report for the Assistant Director of Health, USAID, WHO, clinical directors, and others concerned with the malaria problems. This monthly report should outline program progress, problems, actions taken, and recommendations.

- Establish contact with the sugar estate companies and the medical directors regarding their malaria problems and control activities. Determine possibilities for coordination of efforts and mutual assistance.

9. Training of entomological personnel should be given high priority.

The need is urgent to revive the entomology program and to retrain personnel in the various techniques and methods of evaluation and study of entomology related problems. The entomological tests and studies previously noted cannot be carried out properly without retraining and professional supervision. The most feasible and potentially rewarding approach would be to conduct a comprehensive training course or courses in the context of performing meaningful tests, studies, and investigations under practical field conditions. Hands-on training and demonstration are needed, not lectures, except for purposes of preliminary orientation. It is suggested that training assistance be requested from USAID/Vector Biology & Control Project.

10. It is proposed that the residual spray rounds be revised as outlined under the section dealing with alternative control measures.

AN ADDITIONAL OBSERVATION BY THE CONSULTANT

In conclusion, I would propose that the Swaziland Malaria Program serve as a center for development and training on integrated malaria control in the South East African area. Although the country is small, it has a similar spectrum of malaria problems (i.e., the same vector species, the same malaria parasites, a varied ecology) as a number of other African countries, all contained in a relatively small area. All parts of the country are reachable through a network of good roads in less than a half day's drive from the malaria control unit headquarters in Manzini.

As visualized, the integrated program would have residual spraying as the primary control method, augmented by selective larval control using traditional methods. Entomological evaluation of these vector control operations would be routinely carried out to include bioassays, susceptibility tests, house spray-sheet collections, man-vector biting collections (indoors and outdoors), and other tests as necessary to establish the effectiveness and efficacy of the vector control work.

Parasitological evaluation would be accomplished primarily by examination of blood slides collected from clinics and hospitals (passive case detection). A voluntary collaborator's network system, which has proven successful in Latin America, is recommended to augment the clinic-hospital passive case detection. The active case detection activity would be greatly

reduced as presently constituted because of high cost and questionable efficacy.

In the context of this standard program, the center would include a vector biology and control, and developmental section fully equipped and staffed to conduct laboratory and field studies on special problems. Some high priority problems in need of investigation would include the causes and control of outdoor and persistent transmission, the disappearance of malaria vectors in sprayed areas, testing and evaluation of novel vector control materials and methods and field trials of those found most promising for adoption in the control program. In conjunction with the investigations, the section would run a training course in malaria vector control for the South East African region. Training would emphasize practical "hands-on" field demonstrations (learn-by-doing).

The establishment of this proposed center would be contingent upon the cooperation and assistance of international and bilateral health agencies.

ANNEXES

ANNEX I

ANNUAL PARASITE INCIDENCE IN SWAZILAND

BY YEAR FROM 1946 TO 1986[1]

Year	Slides Examined	Number Positive	Percent Positive	Rainfall[3] mm
46	8562	6850	80.0	332
47	6030	2400	39.8	442
48	7347	3200	43.3	413
49	5685	2060	36.23	606
50[2]	5652	1300	23.0	584
51	2741	500	17.0	574
52	3030	200	6.6	384
53	6666	800	12.0	481
54	3333	100	3.0	540
55	6666	120	1.8	700
56	4111	74	1.8	652
57	7600	38	0.5	597
58	6666	12	0.18	464
59	12090	13	0.11	621
60	14750	118	0.8	605
61	8333	5	.06	519
62	18235	62	0.34	356
63	23571	33	0.14	589
64	24705	84	0.34	414
65	26666	120	0.45	544
66	26829	110	0.41	621
67	27000	432	1.6	617
68	30000	84	.028	498
69	9000	27	.30	513

[1]Blood slides collected by active and passive case detection since 1946. The blood samples originate from hospitals and clinics located in various areas of the country, as well as the active case detection system of the malaria control unit.

[2]Year of total spray coverage plus larval control in vicinity of homesteads, BHC and DDT used.

[3]Data are expressed according to hydrological year which runs from October 1 to September 30.

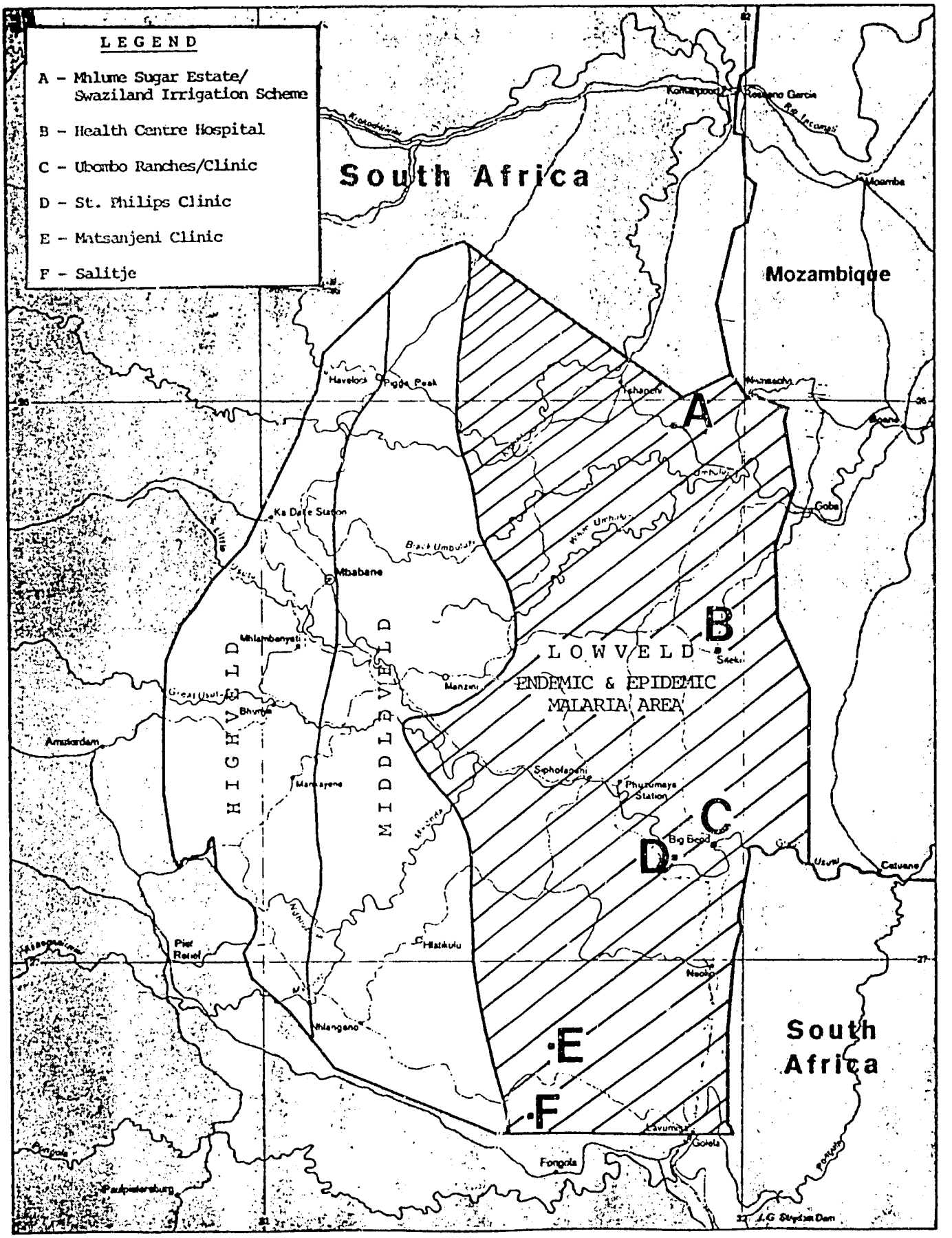
ANNEX I cont.

Year	Slides Examined	Number Positive	Percent Positive	Rainfall[3] mm
70	40015	4	.01	504
71	N/A	N/A	--	577
72	N/A	N/A	--	1071
73	27727	61	0.22	604
74	35925	70	0.27	781
75	37555	169	0.45	1019
76	25542	212	0.83	477
77	31103	902	2.9	714
78	28841	1476	5.1	512
79	25250	303	1.2	650
80	19161	594	3.1	398
81	33700	337	1.0	682
82	12424	155	1.24	413
83	26535	743	2.8	509
84	21621	3373	15.6	949[4]
85	19410	1778	9.16	499
86	24358	1732	7.2	390

[4]Cyclone Domoina struck Swaziland January 29-30, 1984. Heavy rainfall caused flooding which probably created more mosquito breeding places that reflected later in an increase in malaria transmission.

ANNEX II

MAP OF SWAZILAND



ANNEX III

AVERAGE RAINFALL IN THREE ECOLOGICAL ZONES OF SWAZILAND

Highveld (3000-6000 elevation)
Middleveld (2000-3000 elevation)
Lowveld (500-2000 elevation)

MONTH	1985 OCT	NOV	1985/1986 DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP	TOTAL
Mbabane (High)	126	178	213	250	213	174	79	35	19	22	28	62	1400
Big Bend (Low)	49	78	86	94	75	61	30	21	12	10	10	30	563
Matsapha (Middle)	100	132	116	157	124	105	62	31	1	10	15	62	914

ANNEX IV

COST OF SPRAY OPERATIONS COMPLETE COVERAGE (lowveld)

Estimated number of houses in Malaria Transmission Area to be sprayed	40,000
Average sprayable surface per house (ceiling, walls eaves)	$56m^2$
No. of grams DDT 100% per house	112g
No. of grams DDT 75% per house	148g
No. of kilograms per spray round (148g x 40,000 houses)	5,920 kilos
Cost per kilo	E4.40
Total cost of DDT	E26,048
Cost of DDT per habitation	E0.65
<u>Labor Cost</u>	
No. of casual labor employed	30
No. of days employed	90
No. of work days	2700
Wages per day	E8.00
Total labor cost per sprayround	E21,600
<u>Supervisory Cost</u>	
Health Assistant - (each one supervises three casual laborers)	10
Salary (E250 per month x 3 months) x 10 men	E 7,500

ANNEX IV cont.

Note: Since Health Assistants carry out normal duties of active case detection, taking blood slides as they proceed with the spraying round, one-third of cost is charged to spraying operations

Supervision: 1/3 x E7500	E 2,500
Transport Cost	
4000km per month @ E0.40/km x 3 months	E 4,800
GRAND TOTAL	E55,048
Unit cost per house	E1.37
Unit cost of protecting 1 person at an average of 7/house	E0.196

Population = 280,000 (estimated)

ANNEX V

A COMPARISON OF PASSIVE AND ACTIVE CASE DETECTION

MALARIA RATES FROM JULY 1986 TO MARCH 1987

	Passive Case Detection			Active Case Detection		
Medical Clinic:	St. Philips			Sr. Simelane		
Month	Number Slides Examined	Number Slides Positive	% Positive	Number Slides Examined	Number Slides Positive	% Positive
July	28	5	17.8	172	5	2.9
Aug	-	-	-	467	2	0.4
Sept	8	0	0.0	151	2	1.3
Nov	38	4	14.3	22	-	0
Dec	21	12	57.7	31	1	3.2
Jan	23	8	34.7	62	4	6.4
Feb	30	11	37	178	35	19.6
Mar	229	105	46	272	54	19.8
Total	416	145	35	1444	104	7.2

	Passive Case Detection			Active Case Detection		
Medical Clinic:	VIP			M. Khumalo		
Jul	-	-	-	-	-	-
Aug	-	-	-	45	-	-
Sept	-	-	-	30	-	-
Oct	-	-	-	178	-	-
Nov	9	0	0	85	-	-

ANNEX V cont.

	Passive Case Detection			Active Case Detection		
Month	Number Slides Examined	Number Slides Positive	% Positive	Number Slides Examined	Number Slides Positive	% Positive
Dec	2	0	0	90	-	-
Jan	15	2	13	70	-	-
Feb	21	7	33	111	1	.9
Mar	43	28	65	59	9	15
Total	90	37	41	668	10	1.5

ANNEX VI

ESTIMATED COST OF ACTIVE CASE DETECTION
(Based on 1987 activity)

No. of case detectors		16
Salary per month		E 371.25
Salary per year		E 4,455.00
Total salary 16 men		E71,280.00
No. blood slides collected/year		18,336.00
No. positive blood slides		392.00
Percent positive		2.13%
Cost of Slide Examination		
No. microscopist		2
Wages/month Microscopist No. 1		E 406.22
Microscopist No. 2		E 371.00
Total per month		E 777.22
Total per year		E 9,226.64
Unit cost blood slide exam		E 0.51
Cost cloroquine tablets/1,000		E 53.90
No. used/year	25,000	E 1,347.00
RECAP		
Total wages (ACD)		E71,280.00
Total wages microscopist		E 9,324.00
Cost of antimalarial tablets		E 1,347.00
	TOTAL	E81,095.00
Unit cost/positive blood slide		E 168.70

E = Emalageni local currency, exchange rate 2E = 1 US $

ANNEX VII

ROSTER OF MALARIA CONTROL UNIT

NAME	DESIGNATION OR TITLE	ANNUAL SALARY OR WAGE	UNIT SERVICE IN YEARS	AGE	DUTIES AND QUALIFICATIONS
C.T. Mamba	Public Health Inspector	E530.00	4	31	Diploma PH Inspection, Chief Malaria Control Unit WHO Training 1983, training RSA 1986
Q.T. Dlamini	Public Health Inspector	N/A	5 months	25	Diploma PH Inspection
W.M. Twala	Senior Health Assistant	E43[illegible].00	29	52	SHA by promotion, WHO Training 1972; house spraying; mosquito surveys; GR and ACD
I.H. Matsabela	Senior Microscopist	E406.22	20	49	Senior Microscopist, WHO Training 1973, 1974 Tanzania
R.M. Motsa	Health Assistant	E371.37	29	60	H/A by promotion, WHO Training 1972; house spraying; GR; larval control; mosquito survey; ACD; driver's license
S.F. Magagula	Health Assistant	E371.00	14	34	Trained H/A supervises field H/A; house spraying; GR; ACD; larval control; mosquito survey; driver's license
E.M. Dlamini	H/A - Microscopy	E371.00	17	38	Trained H/A house spraying; GR; ACD; mosquito survey; larval control; microscopy
M. Mkhatshwa	Health Assistant	E371.25	16	50	H/A by promotion; house spraying; mosquito surveys; larval control
S. Dlamini	Health Assistant	E371.25	33	65	H/A by promotion; house spraying; larval control; GR; ACD; mosquito control
J.B. Gamedze	Health Assistant	E371.25	18	48	H/A by promotion; house spraying; larval control; GR; ACD; mosquito survey
J.N. Mkhatshwa	Health Assistant	E371.25	31	53	H/A by promotion; house spraying; larval control; GR; ACD; mosquito survey
S. Magagula	Driver	E250.00	13	39	Driver collects blood slides from ACD, clinics, hospitals for Malaria Control Unit
I.N. Mathaba	Accounts Officer	E241.50	2		Accounts
E. Mthembu	Switchboard Operator	E202.50			
E.V. Dlamini	Storeman		1		

SHA - Senior Health Assistant; GR - Geographical Recon.; ACD - Active Case Detection; H/A - Health Assistant

ANNEX VII cont.

NAME	DESIGNATION OR TITLE	ANNUAL SALARY OR WAGE	UNIT SERVICE IN YEARS	AGE	DUTIES AND QUALIFICATIONS
Field Staff:					
N. Mthethwa	H/A ACD	E371.25	17	45	Malaria surveillance, annual inservice training
A. Mavuso	H/A ACD	E371.25	27	60	Malaria surveillance, annual inservice training
J. Dlamini	H/A ACD	E371.25	26	55	Malaria surveillance, annual inservice training
B. Tsabedze	H/A ACD	E371.25	13	39	Malaria surveillance, WHO malaria training
A. Nxumalo	H/A ACD	E371.25	27	60	Malaria surveillance, WHO malaria training
M. Sukati	H/A ACD	E371.25	25	56	Malaria surveillance, annual inservice training
S. Zubuko	H/A ACD	E371.25	23	52	Malaria surveillance, annual inservice training
S. Simelane	H/A ACD	E371.25	24	51	Malaria surveillance, annual inservice training
D. Khumalo	H/A ACD	E371.25	19	39	Malaria surveillance, annual inservice training
B. Magongo	H/A ACD	E371.25	23	39	Malaria surveillance, annual inservice training
N. Dlakubi	H/A ACD	E371.25	27	59	Malaria surveillance, annual inservice training
S. Mbhamali	H/A ACD	E371.25	28	60	Malaria surveillance, annual inservice training
M. Khumalo	H/A ACD	E371.25	28	60	Malaria surveillance, annual inservice training
S.M. Simelane	H/A ACD	E371.25	18	39	Malaria surveillance, annual inservice training
E. Mhlanga	H/A ACD	E371.25	15	40	Malaria surveillance, annual inservice training
Z. Sihlongonyane	H/A ACD	E371.25	29	66	Malaria surveillance, annual inservice training
S. Thwala	H/A ACD	E371.25	28	63	Malaria surveillance, annual inservice training

= Annual Inservice Training

32 employees

SHA - Senior Health Assistant; GR - Geographical Recon.; ACD - Active Case Detection; H/A - Health Assistant

ANNEX VIII

USE OF DDT IN MALARIA CONTROL PROGRAMS

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A.I.D. has concurred with the use of DDT in numerous anti-malaria programs, and, where the target vectors are susceptible, DDT is considered to be the pesticide of choice based on its record of human safety and cost.

The following statement is taken from the Initial Environmental Evaluation section of the A.I.D. Project Paper for the Malaria Control Program in Ecuador (1985) and is an accurate assessment of the environmental implications of its use:

BEGIN QUOTE

> The effectiveness of DDT as an insecticide was discovered in 1939 but it was first synthesized in 1874. Initially it was used to protect military areas and personnel against vector borne disease such as malaria and typhus. In 1945, DDT was released for commercial use. That year, 15,079 tons were produced in the United States. Use in the U.S. increased until 1959 and then declined gradually. Concern developed in the late 1960's that DDT might have adverse environmental effects not previously expected. However, in developing countries of the world where malaria was a serious problem, the continued use of DDT was necessary.
>
> In January of 1971 a statement entitled "The Place of DDT in operations against malaria and other vector-borne diseases" was presented at the forty-seventh session of the executive board of the World Health Organization. The statement points out that DDT is being replaced for control of many vector-borne diseases by other insecticides and the use of DDT is declining. However, for the present, no economic alternative to DDT is available and the epidemiological, operational, and financial consequences of the withdrawal of DDT would be very grave. The statement reviews the effects of DDT on man and wildlife and discusses environmental contamination from its use in anti-malarial campaigns. It concludes that:

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1. "Indoor spraying of DDT in routine anti-malarial operations does not involve a significant risk to man or to wildlife. The withdrawal of DDT from the malaria programmes would be fraught with great danger and is unjustifiable in the light of present knowledge. The Organization should do everything in its power to ensure that DDT remain available for this purpose.

2. Outdoor use of DDT should be avoided as far as possible.

3. Further research is needed on substitute insecticides..."

The use of DDT in the Ecuador anti-malaria program is confined to spraying the inside of houses and other buildings at the rate of 2 gm per sq. meter. In this situation it appears that only insignificant amounts will get into the environment utilizing wildlife and the relevant consideration must be the possible effects on humans.

The environmental impact of using DDT in malaria control programas has been thoroughly considered by AID, PAHO and the U.S. Public Health Service as well as by the GOE. These agencies are all in agreement that DDT is the safest and most effective insecticide for use in malaria control and does not threaten the environment when it is applied by the standardized methods recommended by PAHO and AID.

1. The DDT is sprayed only on surfaces where it will not wash away, i.e. on the inside of walls of houses and on sheltered areas of adjacent buildings. Thus, it is unlikely that any appreciable amounts of DDT can escape into the soil and subsequently into groundwater or streams.

2. DDT is characterized by low volatility and none of it escapes into the atmosphere.

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3. PAHO advisors are provided to ensure proper spraying and storing of the DDT.

PAHO and the U.S. Public Health Service both have responsibilities in the broad field of human health and have available to them the world's leading experts in the field of pesticide use, toxicology of pesticides and the safe handling and proper use of pesticides. Both organizations are on record to the effect that DDT is the cheapest, most effective and the safest insecticide available for use as a residual wall spray to control malaria mosquitoes.

Dr. Steinfield, Surgeon-General of the United States Public Health Service, in testifying before the EPA hearings on DDT stated, "the safety record for the use of DDT in the malaria eradication program is nothing short of phenomenal. Although billions of pounds have been used in anti-malaria programs during the past quarter of a century, there is no record of illness attributable to DDT resulting directly from the normal spraying operations among either the hundreds of thousands of sprayment of the hundreds of millions of occupants of DDT treated homes."

In a WHO publication entitled, "The place of DDT in Operations Against Malaria and Other Vector-Borne Diseases," an assessment of environmental contamination from the use of DDT in antimalarial operations is given as follows:

"Whereas damage to wildlife has sometimes followed the application of DDT in agricultural and forestry practice, the same risks do not now accompany the use of DDT in antimalarial operations. Since the vast majority of the DDT used in the control of malaria is applied as a residual spray indoors, only a small fraction of the insecticide is likely to involve any direct contamination of the environment. This, however, may take place during the process of spraying the houses with DDT, when a certain amount of contamination of the floor and immediately surrounding soil outside does take place. Some measurements have indicated that about 6% of the spray is deposited on the floor inside and some 2% on the outside soil around the houses. The deposit outside the houses, if

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calculated for rural areas with an average of 100 inhabitants per square km, as in parts of tropical Africa, would amount to a DDT input of 10 g per hectare: it will be seen that this is 200 times less than a standard DDT application of 2 kg. per hectare as employed on cotton crops. Moreover, whereas only one or two applications are made to houses per year, multiple applications are made to cotton during its growing season. The DDT sprayed on the inside walls and falling to the floor is held by those surfaces. Hence, provided the insecticide is used indoors as in the case of antimalarial operations, it would appear that there is little possibility of the insecticide contaminating the surrounding local vegetation and water sources that would endanger wildlife."

Since the use of DDT in malaria eradication of control programs is exclusively as a residual on the inside of buildings and it is not used as a larvicide, the amount getting into the outside environment are minimal. Nevertheless, since DDT has aroused considerable controvercy and emotion, a brief review of some environmental effects is presented. DDT tends to persist in the environment for relatively long periods of time and does accumulate in the tissues of animals and concentrations tend to magnify in some organisms over a period of time. DDT in soil has an average half life of three years (Edwards 1973). In Maryland occasionally cropped soil had 40% of the DDT applied after 17 years (Nash and Woolson 1967).

At the present time a vast literature exists on the effects of DDT on the environment. A review of the total literature is not practical here but the following presents the essential elements of it. There is widespread disagreement over the use of DDT and it has been banned in a number of developed countries even though some scientists favor continuation of its essential uses. In the United States DDT is banned but it allowed when necessary to protect human health. It was used in California in 1976 for control of plague (R.F. Peters, Pers. Com.).

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Because of the overriding necessity for DDT in malaria eradication and control it is still used for that purpose in many areas of the world. However, because of reported serious adverse effects on some forms of wildlife, notably fish and some birds, the use of DDT in malaria control is restricted to indoor residual spraying where the risk of exposing wild-life is extremely limited.

END QUOTE

Note: Alternative classes of insecticidal compounds (organophosphates or carbamates) are more costly; in addition, the active ingredients are more toxic than DDT, producing intoxication through depression of blood cholinesterase levels resulting in impaired nerve functions. Although used safely in many programs for over 30 years, and with excellent safety records when used properly, the use of organophosphate and carbamate compounds require a higher level of precaution (and/or protective clothing) by the applicators. This implies additional training especially if the spraymen are accustomed to using DDT which does not produce acute intoxication.

Given the above considerations, the fact that the main vector, *Anopheles arabiensis* is still susceptible to DDT in Swaziland, and that DDT is cheaper than alternative compounds, its continued use in Swaziland is considered appropriate.