

MEMORANDUM

Monrovia, Liberia
July 27, 1955

TO : Dr. J. N. Togba, Director General
Liberian National Health Service

THROUGH: Dr. J. S. Moorhead, Public Health Advisor, ICA

FROM : Roy R. Fritz, Malariaologist Consultant, ICA

SUBJECT: Evaluation of the Malaria Control Program Sponsored by the
Governments of Liberia and the United States

AUTHORITY: Request for malaria control consultation from the Acting
Director, USOM/Liberia and Travel Order No. 3.1404, 6/13/55.

A review of the malaria control problem in Liberia was prepared during late 1954 following one year's operation of the present residual spraying operation (Kohler, December 1954). Parasitological data did not clearly indicate the degree of reduction in the incidence of malaria generally achieved following a year of residual spray operations, although entomological data indicated a very considerable reduction in anopheline densities. In view of these facts, a more complete epidemiological evaluation of the program was considered desirable. The results of this evaluation form the body of this report and takes into consideration the various parasitological, entomological, operational population aspects of the problem.

Malaria control in many parts of the world has indicated that following a year of residual spray operations, no malaria is found in infants under one year of age and Plasmodium falciparum infections in older children have been reduced to relatively few, completely disappearing in about 18 months. These epidemiological observations are supported by the findings of Eyles and Young (1951) and Jeffery and Eyles (1954) who

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found that falciparum infections generally survived in human host less than a year but that a few were able to survive for as long as 17 months. Although infections due to P. vivax and P. malariae are able to survive longer in the human host, many of them survive only about one year, some survive two years and a few survive three, provided re-infections are prevented. Late relapses of malariae have been reported but these follow long periods of latency.

Malaria control operations have been carried on in Monrovia since 1945, but the writer is not competent to judge the scope, thoroughness or continuity of these measures prior to the present program which began late in 1953. The present program of diildren residual application was begun in Monrovia and has now been extended to villages within an approximate 30 mile radius of the Capital. Attempts have also been made to initiate programs in other coastal cities.

PARASITIOLOGICAL ASPECTS

Due to the absence of reliable morbidity and mortality statistics, malarionetric surveys must be relied upon to determine the prevalence of the disease. Parasitological examinations of blood smears, from children nine years of age, have been made prior to initiation of control and at intervals following initiation, insofar as possible. Table I shows a comparison of such data from the Bushrod Island section which lies adjacent to Monrovia on the north.

The percentage of infected individuals found by Young and Johnson (1949) seems abnormally low when compared to that found in subsequent surveys. However, an examination of the data will show that a considerable number of children over the age of nine and of adults, in which

Table I. Malaria Infection Rates
Bushrod Island, Liberia

Date and Area	No. Slides	Per Cent Infected			Reference
		Falciparum All Ages	All Species		
			Infants ^{1/}	All Ages ^{3/}	
9/48 Claratown	201			31.3	Young, et al 1949
9/53 All Towns	962	62.9	53.8	66.0	Burton, Oct. 1954 ^{2/}
9/54 All Towns	1144	40.6	31.4	50.8	Burton, Oct. 1954
May) '55 3 Towns June)	262	24.8	20.5	42.0	Kohler, (May) (June) 1955

- ^{1/} Includes youngsters through one year of age but not two years.
^{2/} Monthly reports, Malaria Control activities, National Public Health Service, Republic of Liberia
^{3/} Includes children up to nine years of age except for 1948 survey which included older individuals.

infection rates are generally lower are included. The basic figures are not available to determine infection rates for children under nine years in Claratown. However, for the entire survey in Liberia, the infection rates in children under nine years of age was 52.3 as compared to the overall infection rate of 30.65. It would appear that in the younger age group this survey is comparable to later ones.

The malarionetric survey during 1953 has been considered essentially as base-line (pre-spray) data by the present control personnel on the basis of statements in the FY 1952 Annual Report of the Chief, Public Health Staff, TCA, which calls attention to an apparent ineffectiveness of the malaria control due to the reported development of resistance to DDT on the part of Anopheles and for other reasons. The survey during 1954, although a year following the previous survey, was started only five months following the completion of spraying operations on the Island. The reduction in infection rates are not significant. However, if one considers only the children who

were born since spraying began, the infection rate was only 2.4 per cent (one, five month old child infected, of 41 infants examined) compared to 45.8 for the same age group in the previous survey (Kohler, 1954).

The surveys that have been accomplished to date during 1955 indicate a further reduction in infection rates even though they are not as low as might be expected after a year and a half of control when observations in other parts of the world are considered. That infection of the population measured is still being accomplished is evident by the fact that three (14.3 per cent) of the 21 children under one year of age who were examined were infected and by the maintenance of 24.5 per cent of falciparum infections.

A different situation is found when one analyzes malarimetric data for two other control areas (Tables II and III).

Table II. Malaria Infection Rates
Liberian Mining Co., Bomi Hills, Liberia

Dates	No. Slides	Per Cent Infected			Reference
		Falciparum	A. J. Species		
		All Ages	Infants ^{1/}	All Ages ^{3/}	
1/55 Prespray	126	56.5	50.0	72.2	Kohler, Jan. 1955 ^{2/}
4/55 3½ Months Post-spray	98	30.6	25.0	45.9	Kohler, Apr. 1955
7/55 5 Months Post-spray	74	12.0	0.0	29.7	Kohler, July 1955

^{1/} All children under one year of age.

^{2/} Monthly reports, Malaria Control Activities, National Public Health Service, Republic of Liberia.

^{3/} Children through nine years of age.

Excellent control of malaria appears to have been accomplished within five months among the children of workers of the Liberia Mining Company at Bomi Hills, approximately 45 miles from Monrovia. The absence of infections among infants and the greatly reduced rates among older children and of

Table III. Malaria Infection Rates,
Paynesville, Liberia

Dates	No. Slides	Per Cent. Infected			Reference
		<i>Falciparum</i> All Ages	Infants ^{1/}	All Species All Ages	
2/55 7 Months Post Spray	63	15.9	25.0	60.9	Kohler, Feb. '55 ^{2/}
7/55 12 Months Post Spray	21	4.8	0.0 ^{3/}	38.0	Kohler, July '55

1/ . children under one year of age.

2/ Monthly Reports, *ibid.*, page 3 and 4.

3/ Only two infants in sample.

falciparum indicate an absence of malaria transmission. It might be expected that one or more infants between the ages of five and eleven months would have been found to be infected. The relatively small sample (19) may account for none being found. Four one year old children were examined, two of which were found harboring malaria parasites.

Although no pre-spray survey was made at Paynesville, approximately seven miles from Monrovia, satisfactory reductions in malaria rates appear to have been accomplished. However, the samples are too small for positive interpretation.

Malaria infection rates for two areas, Johnsonville and Du Port, which recently have been included in the sprayed area, are relatively satisfactory considering the period of protection (Table IV). Du Port is across the Du River from unsprayed territory, which accounts for the overall higher rate.

The possible transfer of malaria parasites from a few heavily parasitized slides to negative blood films, as shown by Donaldson and Brooke (1948) during mass staining, was considered as a possible cause of continued positives being found among the infants of Bushrod Island. An examination of stained blood films did not reveal evidence of such transfers. However, an experiment

was undertaken to determine if such transfer might be occurring. Twenty-five blood smears taken from the writer soon after arrival in Liberia were interspersed with 76 survey slides from Bear Hills. Although some of the known negative smears were adjacent to slides with relatively heavy densities of parasites, no transfer of organisms was observed.

Table IV. Malaria Rates, Sprayed Areas, Liberia. No Pre-spraying Survey

Date and Area	No. Slides	Per Cent Infected			Reference
		Falciparum	All Species		
		All Ages	Infants ^{1/}	All Ages	
2/55 Johnsonville ^{2/}	76	28.9	14.3	43.4	Kohler, 2/55
7/55 Du Port ^{3/}	20	25.0	0.0	65.0	Kohler, 7/55

^{1/} Ibid, pp. 3, 4, 5.

^{2/} Sprayed six months prior to survey.

^{3/} Sprayed 12 months prior to survey. Adjacent to unsprayed territory.

Several malarionetric surveys have been made in various areas where no spray operations have been carried out. These can be considered roughly as "checks" for the sprayed areas. It is indicated in Table V that the infection rates in these areas are consistently high.

Table V. Malaria Infection Rates, Unsprayed Areas, Liberia

Date and Area	No. Slides	Per Cent Infected			Reference
		Falciparum	All Species		
		All Ages	Infants ^{1/}	All Ages	
9/53 Sinkor	258	55.4	32.4 ^{2/}	57.4	Kohler, Nov. 1953
9/53 Gbarnga	240	82.5	100.0 ^{a/}	88.3	Kohler, Dec. 1954
2/54 Tchien	148	57.4	77.8	70.9	Kohler, Dec. 1954
12/54 Careysburg	105	83.8	50.0 ^{b/}	94.2	Kohler, Dec. 1954
1/55 David Town	66	72.7	70.6	83.0	Kohler, Jan. 1955

^{1/} All children under one year of age except as noted by ^{2/}.

^{2/} Includes children through one year of age but not two years.

^{a/} Only seven infants in sample.

^{b/} Only four infants in sample.

Entomological Aspects

A tabulation of mosquito inspections prepared by Kohler indicates that anopheline larvae were readily found in the Monrovia area from early August 1953 through the first week in March 1954. Since the latter date no more than five individual breeding places have been found with anophelines in any one week and in no instance have the numbers exceeded five per dip. Since July 1954, only an occasional anopheline larva has been found. In one day's intensive dipping on Bushrod Island the writer and the Chief Inspector were able to find only three A. gambiae.

A tabulation of adult collections for the period July 1954 through June 1955 shows that only 68 specimens of Anopheles gambiae-melas were found by inspecting or flitting 2,596 houses in the Monrovia-Bushrod-Sinkor area. During the same period, 59 light trap collections yielded 25 specimens and three were caught during 19 night-time biting collections. Eighty-five adults were captured at the base of a cotton tree in 19 inspections. Comparison of these figures with those of a comparable period of earlier years is not possible. However, during August and September of 1953, 101 anophelines were found in 21 houses inspected and 117 were taken at the base of cotton trees. No anophelines were found during two days of house inspecting by the writer and the house inspection crew. The only anophelines found were two males resting at the base of a cotton tree.

The above results may be interpreted as indicating near eradication of Anopheles gambiae and A. melas from the protected area. However, some caution must be exercised in evaluating these data. Several scientists who have studied the biology and malaria transmitting capabilities of these species have noted a marked exophilic tendency on the part of gambiae and especially of melas. Muirhead Thomson (1951), by means of window traps,

demonstrated that 35 to 45 per cent of the melas and a lesser percentage of gambiae which entered a hut during the night left it by dawn. He believed that DDT residual applications intensified this exophilism. Gelfand (in press) working in Marshall Territory, Liberia, collected mosquitoes from window traps on an experimental, inhabited hut every two hours during the night. He showed that approximately 23 per cent of freshly engorged melas left the hut between 7:00 p.m. and 5:00 a.m. and another 62 per cent left between 5:00 a.m. and 7:00 a.m. (dawn). Only about 14 per cent remained in the hut and escaped at dusk the next day. The numbers of gambiae captured in this experiment were low but the data indicated that approximately 40 per cent were leaving the hut the same night as they fed. (Writer's interpretation of Gelfand's manuscript data.)

It is possible that this tendency for exophilism may be complicating the mosquito control efficiency in the Monrovia area, allowing some transmission which would account for the slow reduction in parasite rates observed in the Bushrod population. However, the lack of anopheline larvae in suitable and previously productive pools, the scarcity of adults in outdoor resting places examined and the lack of adults captured in night biting and light trap collections leads one to believe that the anophelines are being controlled. The performance of a series of window-trap experiments and a more thorough search for adults resting out-of-doors would give substantial information on this point.

Population Aspects

In evaluating a malaria control project it is essential that the composition and motility of the protected population be considered. The population of Monrovia is comprised of Americo-Liberians, foreign nationals, and people from the various tribes of West Africa. The latter group tends to live on

the periphery of the City or in tribal villages somewhat removed. From personal observations, it is evident that these people do a considerable amount of moving about. This probably is largely local in nature since much of it is on foot. However, inquiries of house boys and others indicate that they or members of their families may make one or more visits to their home village during the year. Some of such villages are in the unsprayed area not yet reached by the ICA and the WHO sponsored programs. Also, it is evident from the rapid growth of the City of Monrovia during recent years that considerable immigration is constantly occurring. It is believed that these newcomers may be more attracted to the Bushrod area rather than to the City proper because of lower rents and other advantages. As one gets farther away from the City, the writer believes that the village populations may be more stable. In the Bomi Hills camps, it is believed that the worker population is more stable because of the steady work and the provision of standard habitations built by the company. It was called to the writer's attention that near pay day relatives visit these camps. It is believed that the malariometric surveys have been made of the more permanent population.

Such reasoning as this would account for the achievement of adequate malaria control in some of the villages and for the slowness by which parasite rates are being reduced in the Bushrod area. Admittedly, these observations are without statistical support since no data are available concerning the immigration from or visits to unsprayed areas by these people. However, there seems to be no other simple explanation for the data concerning malaria, granted that the anophelines are under control in this area.

Operational Aspects

Malaria control operations in Liberia are not easy. A great many difficulties are encountered with personnel, transportation, equipment and procurement of supplies.

An analysis of malaria control personnel shows that 60 per cent have had no schooling and only 19 per cent have reached the eighth grade or attended high school. One aspect of this problem appears to be the salary scale which is not high enough to compete with government and business for the better educated men. Although in some of the operational jobs, education is not as important as native ability, in the entomological, parasitological and operational supervisory positions both are essential.

Absenteeism appears to be a major operational problem. During June the project time book shows that 91 man days of absence occurred in a crew of 32 men. During July 128 full man days were lost due to rain (partial lost days were not counted); 45 were lost due to illness and personal reasons and 11 man days were lost due to payment of salaries. This represents more than 26 per cent of operation time lost during the month.

The maintenance of vehicles in Liberia is a major problem both from the standpoint of rapid deterioration and of difficulty in locating and in vouchering for repair parts. A battery was stolen from one of the vehicles being used by malaria control during the last week in June, soon after the writer's arrival. This vehicle is still inoperative as of July 26 because the purchase of a battery has not yet been accomplished. Another vehicle can only be used locally because tires ordered months ago have not been secured. Vehicle repair facilities are limited and vehicles sometimes have to be deadlined for considerable periods before proper repairs can be made. One of the writer's contemplated field trips had to be delayed about three days while the jeep was being given minor repairs. A trip to the WHO malaria control project at Kpain had to be postponed indefinitely because of motor troubles. It was considered that none of the malaria control vehicles were

capable of making this trip so a new jeep was borrowed from the Educational Advisor. The start of the trip was delayed three hours while this vehicle was being repaired. A few miles from Monrovia it was evident that the generator was not charging and we had to return to the City.

Liberia does not yet have a network of roads connecting the Cities and villages. To reach the village not on the main roads it is necessary to travel along foot paths. To reach other coastal population centers it is necessary to use water or air transportation.

Maintenance of spray equipment is a continuing but not an acute problem. Apparently spray-bounce is not a problem here so that constant pressure valves give no particular advantage. The last order for spray cans specified that such valves be eliminated. Through an error, the valves were included and the cans will not be used until they are removed since they rapidly clog under conditions of use here.

The procurement of supplies is a major problem. Dieldren first requested March 1954 has not yet been placed on order. An emergency supply of emulsion requested two months ago is in the same status. Water-wettable dieldren is still in supply here but the emulsion is needed for treating the better class of houses in Monrovia.

Although the general population probably does not understand the reasons why the houses must be sprayed, the refusal rate has been at a minimum. However, with control of certain household pests achieved, there is a greater tendency for refusal of the spray now than formerly. The need for more public health education efforts is evident.

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SUMMARY AND CONCLUSION

Malaria data for the control program in Liberia indicate that satisfactory prevention of malaria is being accomplished. Although the data for the Bushrod area must be questioned on the basis that falciparum and total infection rates are not being reduced as rapidly as would be expected, the infant rates are at a very low level. Entomological data indicate that Anopheles gambiae and A. melas are at such a low density that the possibility of transmission seems negligible. However, because of the observed exophilic tendency of these species in other areas of West Africa, additional observations on outside resting of mosquitoes and their tendency to leave habitations after feeding are desirable. In the writer's opinion, the most probable explanation for the slow decrease in rates in the Bushrod Island area seems to be that there is considerable immigration from or visits to unsprayed areas by these people. A cardinal principle of a satisfactory malaria control program is to include sufficient area under control to reduce to an absolute minimum the introduction of infected populations or mosquitoes from unsprayed areas.

RECOMMENDATIONS

- It is respectfully recommended that consideration be given to:
 1. Increasing the comprehensive malarial and entomological evaluations of the control operations. This would involve:
 - a. An increase in the number of blood smears examined for any one area such as Bushrod, Sinkor, or Monrovia to 600 or 1,000 per year with at least 100 infants under one year of age, if possible. Such numbers would provide more accurate statistics for interpretation. Surveys from villages in the same general area will have to be combined to attain this number in many instances.

- b. A more intensive study of the exophilic and day time resting habits of A. melas and A. gambiae in the Monrovia area. This can be accomplished by increasing the search for mosquitoes resting at the base of cotton trees, termite mounds, in crab holes, etc., and by the occasional or regular operation of window traps on native or simulated native huts. Filling the entomologist vacancy on the project is essential to this phase of the work.
2. Expanding the Liberia-ICA malaria control problem as rapidly as possible to extend it to the area to be under control of the Liberia-WHO program and to the other populated coastal centers as originally planned. By this means, it is believed that a large enough area will be under control to minimize the effect of immigration and migration in maintaining infections in the Monrovia area. To accomplish this, additional personnel, equipment and materials will be necessary. It is the writer's opinion that:
 - a. An additional professional person, sanitarian or entomologist, with malaria control training is needed to carry the control program to the bush areas. This person should not be adverse to spending a week or more at a time living in the sparsely inhabited areas and in travelling by foot as necessary.
 - b. Local personnel will need to be trained to carry on the control program in the coastal communities with a minimum of supervision.
 - c. Some means of transportation must be provided for materials, equipment and supervisory personnel to reach those outlying areas which do not have connecting roads.

3. Securing and training a few individuals for high potential capabilities for carrying on top level administrative functions. Individuals capable of being counterparts for the malariologist, entomologist, and engineer would be desirable. However, if personnel with the prerequisite education and training are unavailable, individuals capable of being trained as assistants to the professional personnel would suffice. One means of training these individuals would be through the establishment of a few competitive training positions with a salary that will attract capable men. As these trainees become able to become counterparts or assistants for the professional personnel, they should be given permanent positions. Those individuals who do not meet the performance requirements should be released to provide a vacancy for another trainee. Such a program would greatly facilitate the expansion of the malaria control program eventually to the whole of Liberia.
4. Arranging for the malariologist and such other personnel as deemed feasible, to visit the malaria control programs in other parts of West Africa. It is believed that such a visit with Dr. L. J. Bruce-Chwatt, Outstanding Malariologist now in Lagos, Nigeria, would assist materially in confirming observations being made in Liberia and might well assist in the speedy expansion of the program here.

The interpretations and opinions expressed in this report are the writer's own and the recommendations are made in the spirit of suggesting possible means of securing the maximum effectiveness for the Liberia-ICA malaria control program.

Respectfully submitted,

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