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1. THE MALARIA ERADICATION PROGRAMME IN TRINIDAD AND TOBAGO

The following note has been obtained from the 1960 Annual Report of the Malaria Division of the Health Department of Trinidad and Tobago.

As will be seen from the table below, the incidence of malaria in the early 1940s in these islands, which then had a population of about half a million, was between 30 and 40/1000. Following the increased activities of the Malaria Division, which was formed in 1943, the rate in the second half of the decade gradually dropped to less than 10/1000. There it remained static until 1954, after which there was a sudden drop, due in all probability to the intensification of the spraying programme in both the A. aquasalis and A. bellator areas. From 1 January 1956, following the introduction of legislation which required that the diagnosis of reported cases of malaria be substantiated by a positive blood film, the reported incidence dropped to under 0.4/1000, but this was probably too low a figure.

Year	Population	Malaria		Year	Population	Malaria	
		No. of cases	No. of deaths			No. of cases	No. of deaths
1941	492 000	15 835	...	1951	649 000	5 641	136
1942	510 000	17 097	...	1952	663 000	5 931	80
1943	525 000	18 196	...	1953	678 000	5 050	74
1944	536 000	12 356	...	1954	698 000	5 515	63
1945	547 000	9 455	...	1955	721 000	1 540	44
1946	561 000	8 854	...	1956	743 000	274	20
1947	583 000	6 115	217	1957	765 000	640	6
1948	600 000	5 198	177	1958	789 000	376	3
1949	616 000	4 827	148	1959	817 000	96	0
1950	632 000	5 098	141	1960	826 000	11*	0

* Indigenous or relapse; plus 2 imported, i.e. 13

A tripartite plan of operations was drawn up between the Government of Trinidad and Tobago, PAHO/WHO and UNICEF, and the malaria eradication programme started at the beginning of 1959. Due to the prevalence in the island of two main vectors of completely different habits - A. aquasalis and A. bellator - it was necessary to carry out the following techniques:

- (a) The twice yearly spraying of all houses with DDT throughout those areas in which A. aquasalis was considered to be the vector;
- (b) Spraying of the bromeliad area with copper sulphate to eliminate this breeding place of A. bellator, but in view of the exophilic habits of A. bellator no residual spraying was carried out in these areas unless A. aquasalis co-existed;
- (c) Mass distribution of chloroquine and primaquine on a monthly basis to all inhabitants in the bromeliad areas.

In addition, routine surveillance procedures with active and passive case detection methods, distribution of antimalarial drugs to fever cases, and radical treatment of all proven cases, were undertaken.

Of the eleven indigenous cases in Trinidad (apart from two imported cases) occurring in 1960, nine were found in one county in an area where both vectors co-exist, and where a considerable proportion of the population work in forests and cocoa estates during the week, returning to their homes at the weekend. The other two cases occurred in two other counties, one probably being a relapse. The second case, a P. falciparum infection, occurred in a seven year old boy and no satisfactory clue to the origin of this infection was obtained.

In the island of Tobago, no indigenous cases of malaria have occurred since December 1953, but it was considered unwise to place the island under maintenance until the incidence of malaria in Trinidad had been reduced. Since the beginning of 1960 it is considered that malaria has been eradicated in Tobago.

2. ENTOMOLOGICAL WORK IN THE ATTACK PHASE

The following note on entomological work in the attack phase in areas under total coverage with residual insecticides is part of a working paper prepared by Dr R. C. Muirhead-Thomson, Regional Entomologist, South-East Asia Region, and presented by him at the Meeting of Senior WHO Entomologists held at Alexandria in May 1961.

It is now generally accepted that entomological evaluation of spraying operations in malaria eradication programmes can only be carried out to the greatest advantage if investigations follow a certain logical course. An essential preliminary to this course is at least one and preferably two years of pre-treatment survey in which basic data about the identity of vectors, their seasonal incidence and geographical distribution, the house haunting and man-biting habits, etc. can all be studied under natural conditions. On the basis of this information the entomologist is in a good position to select those index villages or representative catching stations which offer the best opportunity for subsequent evaluation in the attack phase, and to provide a solid base-line of data to which subsequent observations can be referred. In the course of this pre-eradication or preparatory survey he may also have the opportunity of carrying out carefully considered trials on the effect of different insecticide dosages on the reactions of vector mosquitos in treated houses.

In actual fact, however, it is only too rarely that this ideal sequence of events can take place. The entomologist is much more liable to find that his pre-treatment observations can only be carried out for a period of a few months before spraying operations overtake him, or he may find that spraying operations have already become established in the area to which he has been assigned and that the area is under total spray coverage. It is with this latter state of affairs that this note deals.

When the entomologist has to initiate entomological work in the attack phase in areas under total coverage with insecticide he may still find that previous records by other workers all combine to provide a general background about the identity, distribution and seasonal abundance of vectors. In such instances, despite the fact that he has not been able to carry out a pre-treatment survey himself, he may still have a very good idea about the most suitable type of index village, the most suitable

type of catching station, the most suitable period of the year for critical evaluation, and the most promising techniques to be used in following the fluctuations in vector density in accordance with the known habits of the vector.

In other cases, however, the entomologist initiating evaluation work under conditions of total coverage, has not even the assistance of this minimum background information and may even be assigned to areas where the vector situation has never been satisfactorily clarified.

A new critical approach to evaluation inevitably means limiting the objective according to the availability of trained and responsible staff, and makes it essential to select study areas or index villages not simply on the basis of uniform geographical distribution or coverage, but on the basis of clearly defined topography, endemicity, or spraying history.

Both in the selection of suitable index villages and catching stations, the choice of entomological sampling or catching methods is the first and foremost question to be dealt with. In the selection of the most suitable methods, the entomologist normally has three aims in mind:

- (a) to find out the most useful sampling technique for following general changes in vector density according to topography, season and spraying history;
- (b) to find the best index of changing density, behaviour, mortality and man-biting activity in sprayed houses, and
- (c) (a third objective which is closely bound up with the other two) is to find a suitable sampling method which will provide him with enough mosquito material for routine susceptibility tests, infection rates, age grouping, precipitin tests, etc.

In order to attain objective (a) the entomologist can carry out his investigations on the following general lines. The study of vector densities is carried out in habitations which have been left unsprayed accidentally - for example, new houses or "missed" houses or in trap houses deliberately left unsprayed, or specially constructed, to form catching stations. In such places hand catches followed by aerosol spraying is recommended. For those species which have developed a marked exophily in sprayed areas, artificial shelters for sampling outdoor resting mosquitos may be used for following vector density.

In areas under total coverage in the attack phase the aim should be to find out by trial and error the best single index of vector density in general. In one area or with one species the best and most easily available index may prove to be the density in unsprayed occupied habitations. In other areas or with other species it may prove to be the number of vectors collected from ten pit traps or some similar arbitrary standard. Under other conditions the numbers of mosquitoes attacking animal or human bait over a uniform period may prove the best sampling method for this purpose. When the best single method applicable to the sprayed area has been worked out it should be adopted as routine. As an example of widely different indices which can conveniently be used to compare vector densities at different stages of the attack phase, are the following:

Daytime catch in unsprayed mixed dwellings or cattle sheds (A. culicifacies, India);

Daytime catch in artificial pit shelters (A. fluviatilis, Nepal; A. funestus, Africa; exophilic A. gambiae, Southern Rhodesia);

Animal bait - donkey at sundown (A. albimanus, Jamaica)

The vector densities in sprayed houses are of very limited value in judging the actual vector abundance in sprayed areas. Over long periods this index may yield such a low figure as to give a false impression of vector scarcity and should accordingly be discontinued in this context.

It is assumed that the best single index of vector density selected will also be the most sensitive, i.e. the one best calculated to detect the presence of vectors at very low densities. However, there are limitations to the sensitivity of even the best sampling method, and it is doubtful if a single adult index can furnish proof by itself of actual vector eradication such as is claimed for A. minimus for example, in parts of Nepal and Thailand. Further proof of vector eradication in such areas may well have to depend on supporting evidence of persistent absence of vector larvae from known breeding places.

With regard to objective (b), i.e. the question of suitable indices to measure changes in vector behaviour, density, and mortality in treated houses, this point is adequately covered by the WHO tentative operational method (WHO/MAL/285; WHO/Insecticides/120 of 17 January 1961).

Success in objective (c) will be closely dependent on the efficiency of methods developed in dealing with objectives (a) and (b).

The entomologist, in the course of his preliminary work to establish the particular sampling methods best suited to the confirmed or suspect vectors, will almost certainly accumulate a great deal of valuable geographical and local information which will enable him to select the most suitable representative or index areas in which entomological studies will be concentrated. These index areas or index villages will be selected with a view to topography, to vector potential, to spraying history and to malaria endemicity, past and present. They should be strictly limited in number so as to allow the maximum supervision by qualified staff and they should be selected as far as possible with a careful eye to communications and all-weather accessibility. The entomologist can then use these various techniques described above to help to answer the following questions:

- (a) Do suspect anophelines rest inside treated houses? If so, where, and on exactly what kind of surfaces? Any indications of anophelines resting actually on DDT deposits should receive particular attention.
- (b) What is the susceptibility status of vectors in the sprayed area under total coverage? Is there any indication of resistance or of increasing tolerance?
- (c) Do anophelines enter freshly or recently sprayed houses and bite the occupants or human bait? If so, do such mosquitos appear to rest on the walls for a brief period either before or after feeding, or both?
- (d) Are vector anophelines (especially bloodfed and gravid) found in outdoor resting places in freshly sprayed villages? If so, is there any indication that they are still capable of transmission? (Precipitin tests, survival rates, etc.)
- (e) If no vector species can be found indoors or biting man outdoors, are they still present biting domestic animals? (Vector species may on occasions still continue in abundance in sprayed areas under total coverage, but they may no longer be able to play a significant part in transmission because DDT deters them from entering or from feeding in treated houses.)

(f) If the vector is still difficult to find by any or all of these catching methods in areas in which it was reported to be abundant before treatment, a check on larval collections from suitable breeding places should be carried out. All cases in which it is reported that the vector itself has been eradicated or driven out of an area as a result of DDT treatment should be investigated very critically. Many of these reports may reveal that the vector is still present, but in places or in numbers undetectable by routine catching methods.

It is visualized that in this preliminary evaluation the index villages will be selected mainly from the point of view of their entomological suitability. From an early stage, however, it is expected that the entomologist will familiarize himself with the malarial-epidemiological background of the area in which he is working. At a later stage, on the basis of experience gained in index areas and villages, he will be in a position to devote an increasing proportion of his work to difficult or problem areas, i.e. to those places where transmission is only being interrupted slowly or with difficulty due to entomological factors such as resistance of vectors, behaviour phenomenon in treated houses, exophily, etc. In all such difficult areas he will have to judge first and foremost how far the problem is due to inadequacy of spraying coverage or other spraying deficiencies (new houses, "missed" houses, refusals, etc. etc) and how much appears to be due to the purely entomological factors with which he is concerned.

These methods of evaluation will lead in the later stages of the attack phase to problems of surveillance and the investigation of local transmission.

In the interpretation of these changing conditions the entomologist is faced with the difficult task of collating a group of observations on different activities of the vector and trying to judge how far these combined indices reflect significant changes, resulting from total insecticide coverage, on survival rate of vectors or in their contact with man, indicative of interrupted transmission. In this synthesis of different entomological observations there must be a constant reappraisal of criteria according to the changing malarial conditions of the population protected. On the basis of these combined observations the entomologist should be in a good

position to detect at an early stage, any signs of reversal to the status quo in which the possibilities of transmission may once again be re-established. This reversal may be due to such causes as incomplete spraying or coverage, ageing or deterioration of insecticide deposits, increasing proportion of new or "missed" houses, or to increased tolerance of the vector concerned. A close liaison between the entomologist and the operational staff should ensure that these warning signs do not go unheeded.

When surveillance operations start in the final stages of the attack phase an even closer liaison between the entomologist and other members of the malaria eradication team will be necessary. At that stage the entomologist may well be confronted with a number of pockets of foci in which the repeated recording of positive human malaria cases suggests persistent local transmission. In that situation the entomologist will have the responsibility of judging how far the situation is due to a refractory or an exophilic vector and how much is due to deficiencies in spraying operations or in the supervision of surveillance. There is little advantage in initiating detailed entomological studies in a local situation of this kind where there is a good chance that the focus of infection can be obliterated by the more obvious mopping-up activities, i.e. drug treatment alone or in combination with intensified focal spraying. At this stage in the attack phase the entomologist will have to exercise a considerable degree of judgment in deciding to what extent these local problems are really entomological ones, worthy of careful examination, or whether they are in fact purely operational and time-limited, in which case a critical entomological investigation would be quite superfluous.

Finally the entomologist will have to appraise the practical significance of any increased tolerance or appearance of resistance on the part of the vector to DDT as revealed by the standard WHO test. Unless a very high degree of resistance has obviously developed, the increased or increasing tolerance to this insecticide does not necessarily mean that effective control by this insecticide is still not feasible, or that immediate change to another insecticide is indicated. The insecticide may well continue to interrupt transmission effectively for a long period after increased tolerance makes its appearance. It is during this "period of grace" that the closest attention to other entomological indices is required. Again, in his interpretation of the practical significance of these developments the entomologist will take into account

the particular stage of the attack phase which has been reached, so that his final judgement on the potential danger or otherwise of the situation can be guided by the knowledge about the potential reservoir of infection still remaining in the human population in the area under total coverage.

3. RESOLUTION OF THE REGIONAL COMMITTEE FOR EUROPE ON MALARIA ERADICATION

In the expectation that all previously malarious countries of Continental Europe will enter the consolidation phase of malaria eradication during 1962, the Regional Committee for Europe at its eleventh session in Luxembourg in September 1961 adopted resolution EUR/RC11/R9 reproduced below. This resolution draws the attention of governments to the necessity of strengthening the measures to be taken against the reintroduction of malaria from areas which have not yet reached this stage of eradication.

MALARIA ERADICATION

The Regional Committee for Europe,

Pursuant to resolution EUR/RC10/R1, adopted at its tenth session;

Having studied resolution WHA14.2, of the Fourteenth World Health Assembly with special reference to paragraph 2;

Having studied document EUR/RC11/7 "A Brief Evaluation of the Co-ordinated Plan Establishing Priority for the Eradication of Malaria in Continental Europe" submitted by the Regional Director;

Noting the progress made in implementing the malaria eradication programme in most countries of the Region referred to in the plan;

Believing that the time has come to consider strengthening the measures taken against the reintroduction of malaria in all formerly malarious countries that have achieved or are about to achieve eradication, so that their technical and financial effort shall not be jeopardized by a resurgence of malaria imported from other countries or regions,

1. INVITES all countries concerned to intensify their efforts to achieve by 1962 the targets set in the Co-ordinated Plan Establishing Priority for the Eradication of Malaria in Continental Europe, and more particularly to ensure that

surveillance be so organized as to enable them to obtain from a WHO evaluation team certification that eradication has been achieved so that they can be listed in the official register established by the Director-General of WHO in accordance with resolution WHA13.55;

2. SUGGESTS that countries in which importation of cases may give rise to a resumption of malaria transmission, consider making microscopical blood examinations in suspect fever cases and, if they have not yet done so, consider making compulsory the notification to the health authorities of suspected or confirmed malaria cases;

3. BELIEVES that the countries concerned should notify all the doctors, laboratories and health units responsible for detecting malaria cases once the maintenance phase of the eradication programme has been reached, of the danger of the reintroduction of malaria and that they should maintain a central specialized technical service competent to deal with any possible localized reintroduction of the disease, and

4. INVITES the countries referred to in paragraph 2 above to study measures consistent with the International Sanitary Regulations for examining persons from areas of endemic malaria and, if necessary, for treating them before they give rise to foci of transmission.

4. COSTING OF SPRAYING OPERATIONS IN BRAZIL

We are indebted to Engineer Oscar Larrea, PAHO Adviser to the Brazil 41 Project, for the following example of costing of spraying operations in the State of Sao Paulo (Brazil), where there is a malarious zone of about 108 000 km² containing 450 000 dwellings sprayed with DDT twice a year. The average sprayable surface is 200 m² per dwelling. For operational purposes, the malarious area is divided into eight work zones, each in charge of an engineer/malariologist. The zones are in turn divided into sectors, each in charge of an inspector (Chief of Sector) who has received training at an international or local malaria training centre. Finally, the sectors are split up into work areas, each with its team of spraymen.

ZONES	I	II	III	IV	V	VI	VII	VIII	Total
No. of sectors	3	1	3	3	3	3	2	2	20
No. of work areas	9	3	12	12	15	18	11	7	87

The calculations summarized at the end of the note have been made on the following basis:

- (1) Insecticides - DDT 75% w.d.p. is used
Average sprayable surface times dose - $200 \text{ m}^2 \times 2 \text{ g/m}^2$
- 400 g techn. DDT
- 0.534 kilos DDT 75%
Costing 154 Cruzeiros/kilo - 82.50 Cruzeiros/house

(2) Labour

Sprayman - the average output per sprayman is 10 houses a day and his daily wage 317 Cr.

Team auxiliary (driver) - one per five spraymen, i.e. output 50 houses a day.

Team chief - in charge of team of 5 spraymen and the team driver - daily output therefore related to that of the team - i.e. 50 houses per day.

Chief of Sector - the average sector is taken as five teams and the Chiefs of Sectors operate with these teams 5 days a week or 110 days per cycle, during which 22 500 houses are sprayed, hence the proportion is 1/205 of his salary per house.

Additional drivers - two drivers are costed at the same ratio as the Chief of Sector, i.e. 1/205 of their salary per house.

Zone Engineer - in the average zone 56 250 houses are sprayed per cycle of six months and the salary for this period is Cr 348 000.

Clerical staff - three such staff are employed per zone, one being a draughtsman, on 144 days employment per cycle for 56 250 dwellings, their ratio is 1/314 of their salary.

(3) Transport - to obtain the average cost per house, the average number of km covered per day were divided by the number of houses sprayed.

(4) Other allowances - calculated on the basis of the budgetary provision divided by the number of houses sprayed in the period.

Summary of Costs (per application)

Item	Cost per house Cr.	Cost per house [*] US\$
1. Material DDT - 75%	<u>82.50</u>	<u>0.37</u>
2. Labour		
Sprayman 0.1 man days/house at 317 Cr/day	31.70	
Team Auxiliary 0.02 man days/house at 340 Cr/day	6.80	
Team Chief 0.02 man days/house at 360 Cr/ day	7.20	
Chief of Sector 0.004 man days/house at 533 Cr/day	2.60	
Additional Drivers 0.004 man days/house at 380 Cr/day	3.70	
Zone Engineer 0.003 man days/house at 1934 Cr/day	6.20	
Clerical staff 0.009 man days/house at 359 Cr/day	<u>3.30</u>	
	<u>61.50</u>	<u>0.27</u>
3. Transport		
Spraying - average km/vehicle/day = 100; average cost/km = Cr 8		
Cost/house/day (i.e. one team output of 50 houses)	16.00	
Supervision	<u>4.00</u>	
	<u>20.00</u>	<u>0.09</u>
4. Other allowances	<u>10.50</u>	<u>0.05</u>
TOTAL COST	<u><u>174.50</u></u>	<u><u>0.78</u></u>

The percentage breakdown of these figures is:

1. Materials	47%
2. Labour	33%
3. Clerical staff	2%
4. Transport	11%
5. Allowances	6%

The following items were not included in this costing: Capital cost of vehicles, spare parts, sprayers, depreciation, uniforms, salaries of headquarters staff.

* Calculated on the basis of US\$ 1 = 220 Cruzeiros (June 1961).