further intravenous fluid therapy, especially saline, has to be employed with caution. The last patient (No. 19) died from a technical hazard not solved by the surgeon—the presence of an aberrant pancreatic duct opening into the back of the first part of the duodenum. This duct was not seen in the oedematous scar, and a pancreatic fistula resulted from which the patient ultimately died. The problem would have been avoided by not disturbing the ulcer base in the pancreas, and closing the duodenal orifice by an inturning method, as mentioned above.

It is no doubt impossible to achieve the ideal level of skill, but there are reasonable grounds for thinking that several of our fatalities need not have occurred if treatment had been more skilful. If that is so, the inherent mortality of our series would be a figure between 3 and 4%. If we could obtain this result in a comparable series of patients we would be satisfied that we had reached as near to the truly inevitable death rate as could be achieved in our present state of medical knowledge and methods.

One further observation is pertinent—whether patients with known chronic ulcers of the stomach or duodenum should be advised to continue on expectant medical treatment or be operated upon because of the risk of bleeding or of perforation. Of our 19 fatalities, 14 had deep chronic ulcers, some of enormous size. An ulcer which has extended through the muscle coats of the stomach or duodenum is no longer peptic in nature, but has become a callous ischaemic ulcer—ischaemic until it ulcerates into a neighbouring large blood vessel—and is not capable of natural sound healing. Against the continued ill-health which these ulcers represent, with the risk of perforation or bleeding, has to be set the risk and result of operation. The mortality of partial gastrectomy in a skilled organization is about 2%, and the prospect of a healthy digestion and social life following this operation is about 90%. Equivalent facts about medical treatment of chronic peptic ulcer to set against these figures are less certain, and are the subject of separate investigations now proceeding.

Summary

A policy in the treatment of massive bleeding from peptic ulcer has been defined and applied, particularly in regard to the relationship of medical and surgical treatment, and its results are assessed.

The policy was to treat such bleeding by medical measures in the first place, and by surgery as soon as it was plain that medical treatment was not succeeding.

The importance of early and adequate transfusion in medical treatment is stressed.

The decision for surgery was usually made within 24 hours of admission to hospital, if bleeding still continued; or at any time while the patient was in hospital if the bleeding, having stopped, started again.

In this way 358 consecutive patients were treated, of whom 30% were aged 60 or over: 10% of the patients came to operation. The overall mortality was 5.3%.

The fatalities are considered and improvements in methods discussed.

The results are held to justify the policy of treatment, readily applicable to the medical and surgical departments, in collaboration, of a general hospital.

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THE MALARIA ERADICATION SCHEME IN MAURITIUS

BY

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Until recent years the chief method of malaria control consisted in the destruction of the larval stage of the anopheles mosquito by means of surface oiling, usually combined with the clearing, canalizing, or draining of its breeding-places. This method has been employed in Cyprus, and the success of the campaign there is well known. Shortly after the end of the 1939–45 war a malaria-control scheme, based on anti-adult measures and employing the residual insecticide D.D.T., was undertaken in British Guiana under the direction of Dr. Giglioli. The universal spraying of indoor resting-places proved to be very successful against the chief local vector, *Anopheles darlingi*, which, being predominantly a domestic species, was reduced almost to the point of elimination in the course of the next few years. Unfortunately, however, the ever-present risk of anopheline extension from the neighbouring territories made necessary the continued application of the antimalarial measures. In 1948, following upon the success of the British Guiana experiment, the Government of Mauritius, in conjunction with the Colonial Insecticides Committee, decided to sponsor a similar scheme in an attempt at the total eradication of malaria from the island. It was considered that, eradication once obtained, it would be possible to prevent the reintroduction of anopheles at the port or airfield. The high recurrent annual expenditure on malaria would then no longer be necessary.

Mauritius is a small island of some 720 square miles (1,864 km.²) with a population of almost half a million. Malaria was introduced in the middle of the last century, and the year 1867 saw a severe epidemic of the disease affecting chiefly the capital town of Port Louis, which was probably the point of introduction. In this town, with a population of 47,000, there were more than 6,000 deaths in a single month. The disease rapidly encircled the island, transmitted by the African vectors, *Anopheles funestus* and *A. gambiae*. The former appears to have been the chief carrier, and, by breeding vigorously all the year round, maintained the infection at a high level on the coast during the winter months of June–December. It was possible to find as many as 1,200 adults of this species in a single room on the coast—an unusually high density. *A. gambiae* probably played an important part in the transmission of the disease during the epidemic summer months.

Residual Spraying

In the first instance an attempt was made to eradicate the two vectors by residual spraying. This primary method was to be supplemented or superseded by other measures if these were considered necessary in the light of experience. A small team, selected in the United Kingdom, arrived in Mauritius in November, 1948, to direct the experiment and, by setting up scientific controls, to interpret the results. For purposes of administration the island was divided into six districts, each with a locally chosen team of 50 to 70 men under the direct supervision of a field officer. A thorough house survey had been ably carried out before the arrival

of the research team in Mauritius, and this, together with detailed sketch maps of the countryside, made it possible for work to begin as soon as the preliminary training of spraying staff had been completed. Three distinct zones were chosen, and a different insecticide formulation was used in each. By contrasting the three preparations used—D.D.T. technical in kerosene, and the 50% wettable powders of D.D.T. and B.H.C. (gammexane)—it was hoped to use in the later stages the one which proved most effective and economical.

Spraying began in the middle of January, 1949, and was everywhere completed by May. A large residential area on the central plateau of the island was omitted, as it was well protected by efficient antimalarial works. Hand-sprayers of the knapsack pattern were used, but for large buildings petrol-driven power-sprayers were found to be invaluable. All possible domestic resting-places for the anopheles adults were treated, including barns, churches, temples, and factories as well as the native dwelling-houses, outhouses, and cattle-sheds. Technical D.D.T. was mixed in bulk with kerosene to make a 5% solution and distributed to districts from the central depot. The two wettable powders were mixed at field stores to make a 5% suspension in water. The aim was to apply a surface deposit of 100–150 mg. of D.D.T. or B.H.C., and this was checked by continual chemical analysis of test papers and rigid checking by the supervisory staff. The amounts used for the first spraying were higher and more variable than was desired, but the variability diminished considerably as the spray gangs became better trained. Table I shows

TABLE I.—Total Spraying Figures, 1949–50

Spraying	Houses Sprayed	Rooms Sprayed	Population Directly Protected
Jan.-May, 1949	75,829	376,998	324,181
Sept.-Dec., 1949	58,184	275,554	231,824
Sept.-Dec., 1950	48,090	220,697	193,640
Total	182,103	873,249	—

briefly the total number of buildings treated during 1949–50. In the light of the results obtained it was found possible to reduce considerably the areas sprayed after the first treatment. The second spraying included a re-treatment of the B.H.C. zone with D.D.T., as the former insecticide was abandoned at the beginning of 1950 on economic grounds. In 1951 the Shell product “supona D,” which is an oil-bound suspension of D.D.T. readily miscible with water, was introduced.

Difficulties Encountered

To make the work of the unit easier an ordinance was introduced in 1948 authorizing personnel to enter houses for the purpose of spraying or scientific control work. Certain difficulties were of course experienced, particularly in the early stages of the scheme. The custom of replastering the interior walls of houses immediately before the New Year, chiefly among the Indian community, presented a very serious obstacle, as the redecoration took place soon after spraying had been completed and at the beginning of the malaria epidemic season. A second difficulty was that house-spraying took place during the winter, and coincided with the gathering of the sugar crop. Many families made their way at dawn to the canefields, leaving their houses locked, to return at dusk after the day's work. These and many other minor obstacles were overcome, thanks to the assistance willingly given by Government officials, estate managers, and many private individuals who appreciated the value of the scheme to the health of the community. It has been the practice of spray gangs to cover all furniture and furnishings as thoroughly as possible to protect them from the spray. This procedure consumed a good deal of time, as the average house contained a formidable amount of bric-à-brac, but it was an important factor in maintaining the good will of the inhabitants.

So as to be able to interpret accurately the results of the residual spraying, a series of scientific controls were set up during the brief period between the arrival of the team and the beginning of the campaign. Laboratories were equipped and a staff of laboratory assistants and field mosquito boys were trained. Macgregor in 1924 had made a thorough survey of the mosquitoes of Mauritius (Macgregor, 1947), and Sippe and Twining in 1942–4 had prepared tables of spleen and parasite indices for towns and villages throughout the island at different seasons of the year (Sippe and Twining, 1946). Since that time, however, new and efficient anti-malarial work had been carried out under the supervision of the Director of Medical Services, Dr. A. Rankine, and the crowded residential plateau in the middle of the island, together with the business centre of Port Louis, had been virtually freed from malaria. Throughout the greater part of the coast the disease continued undiminished all the year round, as shown in the preliminary survey in 1948.

Examination of Children

Four spleen and parasite surveys were carried out, and the figures given in Table II represent a mean for the whole island (including the healthy central plateau). It can be

TABLE II

Survey	No. of Children Examined	Spleen Rate %	Parasite Rate %
Before spraying (1948) ..	3,585	34.8	9.5
After first spraying (1949) ..	12,105	15.3	2.4
After second spraying (1950) ..	14,577	2.8	0.4
After third spraying (1951) ..	17,208	2.5	0.1

seen that a considerable reduction has taken place since the initial survey in 1948. Thick drops were taken from each child, Giemsa-stained, and examined at the unit laboratory for the presence of parasites (which in Mauritius included the three species *Plasmodium falciparum*, *P. malariae*, and *P. vivax*).

In an attempt to estimate the degree of malaria transmission among the protected population, a continuous survey was instituted late in 1949. In this infant survey blood slides were taken from children born in the coastal zone since the first spraying in their locality, a positive being accepted as evidence that the child had contracted the disease in spite of the treatment of his dwelling with residual insecticide. In all, more than 31,000 children were examined between September, 1949, and the end of March, 1952, and only 34 positive cases discovered, representing a parasite rate of 0.11%. Out of some 4,500 children examined during the epidemic first five months of 1951, only one positive case was found, suggesting that transmission of the disease is now of a very low order. The corresponding age group, 0–2 years, in the first spleen and parasite survey of 1948 gave a parasite index of 10.0%.

Notifications

In 1948 regular notification of all fresh cases of malaria treated at dispensaries and hospitals was introduced in Mauritius. Before this date no differentiation was made, and patients returned for treatment were counted as additional notifications. Thus the year 1948, a normal year for the disease in the island, makes a useful comparison with the years that follow. Table III shows the numbers of cases notified during the epidemic first six months of the years 1948–51.

TABLE III.—Malaria Notifications During the First Six Months of the Years 1948–51

	1948	1949	1950	1951
Total cases notified	29,938	17,742	3,762	852
Reduction % on 1948 figure	—	40.8%	87.4%	97.2%

Among those cases notified as malaria by dispensaries and hospitals during this period of 1951, 428, or just over 50%, had had blood slides taken before treatment and sent to the unit laboratory for examination. Of these slides only 26 were found to be positive. This suggests that many notified cases were not in fact malaria, but represented other forms of fever which, in a tropical country, may easily be confused with the disease. The district of Flacq, an area of about 115 square miles (298 km.²) with a population of 50,000, was originally a very grave malarious district. Furthermore, no antimalarial works had been introduced before 1948, so that Flacq has made a good experimental area for research. The graph demonstrates clearly how remarkable has been the reduction in the disease so far as can be judged from notifications. The infant survey was

Malaria notifications in the district of Flacq, 1948-51. (1)=First residual spraying with D.D.T. (2)=Second residual spraying with D.D.T. (3)=Beginning of pilot larviciding scheme. The "epidemic season" refers to the five-months period, January to May.

carried out in this district during February and March, 1951. Altogether, some 2,400 children aged between 3 months and 2 years were examined, and not a single positive case was found.

Results Reflected in the Death Rates

The vital statistics for the island indicate the influence of so striking a reduction in malaria on the general health of the community (Table IV). When considering the death

TABLE IV.—Total Death Rates per 1,000 Mid-year Population, 1934-50

Range in death rates, 1934-48		36.1-20.1
Mean death rate, 1934-48		27.2±3.37
Death rate, 1949		16.6
.. .. 1950		13.9

rates for the whole colony it is more reliable to study those from all causes; the specific rates, such as the malaria mortality, do not represent an accurate index. The total rates also have the added advantage of reflecting both the direct and the indirect effects of the disease, and therefore demonstrate more closely the effects of its reduction.

The infant mortality rate has similarly undergone a significant reduction on the previous years, as can be seen in Table V. Improved health services, antenatal clinics, good

TABLE V.—Infant Mortality per 1,000 Live Births, 1934-50

Range in infant mortality, 1934-48		188.0-113.9
Mean infant mortality, 1934-48		150.0±19.2
Infant mortality, 1949		91.0
.. .. 1950		76.4

years for the sugar crop, and other factors have undoubtedly contributed considerably to these reductions in mortality, but the virtual suppression of malaria must have played an important part in the process.

House-spraying

Study of the effects of house-spraying on the anopheline vectors revealed a very interesting situation. After the arrival of the team in Mauritius in November, 1948, a careful check was maintained on the mosquito population, particularly in the adult stage. Some 5,500 houses, scattered evenly throughout the island, were selected at random to form catching stations. Flitted regularly once a month by trained mosquito boys, these stations provided some

evidence of the effect of the residual insecticide on the domestic vector species. Total figures for the catches of adult mosquitoes, by routine methods and also by regular "massed catching" by district staffs during the interspraying periods, are given in Table VI.

TABLE VI.—Adult Mosquito Catches. Total Figures, 1948-50

	No. of Houses Flitted	<i>A. gambiae</i>	<i>A. funestus</i>	Culicines	Vectors per House	Total Mosquitoes per House
Before spraying ..	7,817	2,486	31,496	113,235	4.35	18.8
After spraying:						
1949 ..	32,300	184	352	222,998	0.02	6.9
1950 ..	66,500	482	50	363,701	0.01	5.5

At the same time a continuous survey of anopheline breeding-places was carried out by whole-time skilled personnel. A review of the entomological data after the summer of 1950 revealed two facts of significance. First, *A. funestus* had been virtually eliminated, and, with the exception of two small sparsely populated areas on the coast, this previously very common mosquito could not be found either in adult or in larval form. In this connexion it is of interest to note that, during the whole of the period December, 1950, to March, 1952, no specimen of this species was discovered in spite of intensive searching. A similar effect has been observed on *Aedes aegypti*.

The second point of interest was that *A. gambiae*, although apparently considerably reduced in numbers by residual spraying (98% reduction in 1950, according to the catches of adult mosquitoes in houses), was actually to be found breeding in large numbers throughout the coastal region in March and April of that year. In the course of a number of observations carried out to investigate this problem it was shown that *A. gambiae* could be found without difficulty in new unsprayed houses and cowsheds (as many as 98 adults of this species in a house and 306 in a cowshed), while the adjoining sprayed houses remained negative both to day- and to night-catching. Unfortunately, owing to lack of skilled personnel, it was not found possible to carry out more detailed research into the exact behaviour of *A. gambiae* under the conditions prevailing. This question is being investigated by an experienced entomologist, and the results may throw new light on the situation.

The problem which faced the organization at the end of the summer of 1950 was therefore briefly as follows. Residual spraying with D.D.T. as a single measure was sufficient, under conditions in Mauritius, to reduce malaria and its chief vector, *A. funestus*, to a very low level. The second vector mosquito, however, *A. gambiae*, although not apparently transmitting malaria to any extent, had shown itself capable of evading the lethal effect of the insecticide. It was therefore decided that measures additional to house-spraying should be undertaken in an attempt at the eradication of *A. gambiae*, and accordingly the second phase of the scheme was entered upon in October, 1950.

Pilot Larvicide Scheme

In Mauritius the winter season is relatively dry, and from September until the middle of December the breeding of *A. gambiae* is almost entirely restricted to permanent breeding-places along the coast. The plan was to carry out the wholesale destruction of larvae with Shell "malariol high-spread," in the first instance indiscriminately; and to follow this up by constant and detailed weekly checking, combined with "spot oiling" where vector larvae were discovered. It was hoped by this means to train personnel during dry months and at the same time to reduce considerably the population of *A. gambiae* when most vulnerable, so that it would be possible for the organization to cope with the great increase in work brought about by the advent of the rains in January. The district of Flacq, previously mentioned as a good experimental area, especially in that it possessed good natural boundaries which would help to

prevent anophelines from infiltrating from untreated areas, was selected for a pilot larvicide scheme. If the results in this district proved to be satisfactory it was decided to extend the scheme to the whole island in the winter of 1951.

At the end of the epidemic first five months of 1951 it was possible to conclude from results in Flacq that the use of the larvicide scheme on a larger scale would be warranted. Not only was breeding of *A. gambiae* reduced by more than 97% (as compared with other untreated areas of previously similar breeding intensity), but this mosquito remained confined to a narrow coastal strip throughout the summer and did not penetrate inland, as was previously the case during the rains. Accordingly, practice areas were set up in all the other districts for the training of personnel in the new methods, and the island-wide campaign began during the dry month of September, 1951.

Conclusion

Future policy must, of course, depend largely upon the reaction of *A. gambiae* to this second form of attack. The house-spraying, using a D.D.T. preparation, was repeated during the winter months of 1951, in the hope that the combined effect of the two methods would prove to be a potent weapon against this evasive species. However successful the scheme may be, it would be rash to relax vigilance for many years to come; for a small missed breeding-pocket might gradually re-establish transmission of the disease.

During the three years that the scheme has been in progress the total annual cost (including capital expenditure, running costs, salaries of United Kingdom and local personnel, and the laboratories with their equipment) has been the equivalent of a little over 3s. per head of population in Mauritius. It has been encouraging to see how rapidly house-spraying with a residual insecticide on a large scale can reduce the transmission of malaria in a community even when the vectors are as efficient carriers of the disease as *A. gambiae* and *A. funestus*.

NOTE.—Further information about the scheme, covering the period since this article was written, appears in a letter from the author on page 339.

I would like to express my thanks to Dr. A. Rankine, until recently Director of Medical Services in Mauritius, and to his successor, Dr. R. Lavoipierre; to Dr. P. C. C. Garnham, chairman of the Malaria Subcommittee of the Colonial Insecticides Committee; and to Mr. C. B. Symes, officer in charge of research to the Committee, for all their advice and assistance given during the course of the past three years.

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Writing on the hospital services in *The Fortnightly* (July), Professor A. P. Thomson, dean of the faculty of medicine at Birmingham University, says: "We have in the Midlands some first-rate hospitals, but in 1948 the regional board took over from a county authority, and immediately closed, a hospital for chronic patients, of whom there were 16. There was no indoor sanitation, and the only water supply was from a stand-pipe in the yard. Ten of the patients were bedridden. That was the worst example, but there were several larger hospitals that were not much better. I was so astonished at what I saw that I got photographs of several of these places, and when I am reproached that hospital development is slow I get comfort from looking at the pictures, because we have nothing like them now."

THE SUPERIORITY OF "CAMOQUIN" OVER OTHER ANTIMALARIALS

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The rational objectives of antimalarial therapy have always been (1) to prevent deterioration in the patient's health by treating an attack vigorously and bringing it to a speedy end; (2) to prevent relapses; and (3) in the absence of world-wide mosquito control to reduce the patient's infectivity to the mosquito. Since the advent of chloroquine, proguanil ("paludrine"), and mepacrine ("quinacrine") the use of quinine has rapidly receded into the background. These three drugs have been very effective in eradicating M.T. malaria, although exceptions in the case of proguanil have been met with. None of them tried singly, however, cures B.T. malaria, but pentaquine and combinations of quinine and pamaquin, proguanil and pamaquin, and quinine and pentaquine have considerably lowered the relapse rate. In treating the acute attack mepacrine is often superior to proguanil, but both are inferior to chloroquine. In some respects "camoquin," which has been recently introduced, seems to be superior to chloroquine. We record here our observations on its use in comparison with some of the above drugs.

Clinical Trials

Only pure infections of M.T. and B.T. malaria were selected. The patients were a heterogeneous crowd of soldiers aged between 16 and 35. They had acquired recent infection after a variable stay in endemic and hyperendemic zones in various parts of India. None of them had been on suppressive treatment or had had any antimalarial drug before treatment was started. All of them were treated in hospital under identical conditions. They had the usual febrile forms of the disease, and criteria for relapse were an enlarged spleen, history of malaria within the previous two years, and the presence of gametocytes in the blood on the first day of the disease.

Antimalarial therapy was given only to those who showed almost persistent parasitaemia for 24 hours. Parasite counts were done, being expressed as the number of infected cells per 1,000 R.B.C.s. Haemoglobin estimation, red-cell counts, total and differential leucocyte counts, serum-bilirubin estimations, tests for serum methaemoglobin, and routine urine examinations were done, and blood pressure was recorded before starting treatment in every case. Temperature was recorded four-hourly. Therapy was always begun at the onset of a rigor, to ensure accuracy and uniformity. Blood smears were continued six-hourly for parasite counts till they became persistently negative for 72 hours. In order to record any evidence of immediate or delayed toxicity other blood and urine examinations, as stated above, were made after 48 hours and again 10 days later, after starting treatment. Blood pressure was recorded daily. In the case of mepacrine and proguanil these investigations were confined to recording the duration of pyrexia and the period of asexual parasitaemia. In the case of camoquin only, the patients were followed up for the last 14 months for evidence of relapse.