WORLD HEALTH ORGANIZATION

ORGANISATION MONDIALE DE LA SANTÉ

WHO/Mal/483.64
29 December 1964

ENGLISH ONLY

MALARIA EPIDEMIC IN HAITI FOLLOWING A HURRICANE

by

John Mason D.V.M, M.P.H.[1] and Philippe Cavalié M.D.[2]
National Malaria Eradication Service
Port-au-Prince, Haiti

Introduction

On the night of 3-4 October 1963 a hurricane (Flora) swept across the southern peninsula of Haiti with devastating effect. In addition to the immediate damage caused by the storm, the area affected suffered a severe malaria epidemic which started two to three months after the hurricane had passed. Since the epidemic occurred during the course of a malaria eradication programme, in which extensive surveillance activities were being carried out, an opportunity was provided to study its development closely. The following is a description of the outbreak, which is estimated to have caused some 75 000 cases of malaria.

Malaria in Haiti

Malaria in Haiti is mesoendemic and moderately unstable, with seasonal epidemic exacerbations showing a fairly close correlation with alterations in rainfall. Comparatively high blood slide positivity rates (31%) were seen in surveys of schoolchildren carried out in 1940-1942 by Paul & Bellerive (1947). At that time 88% of the infections were caused by Plasmodium falciparum, 10% by Plasmodium malariae and 2% by Plasmodium vivax.

---

[1] Chief Malaria Advisor, United States Agency for International Development/ Haiti.

[2] Chief Country Malaria Advisor, World Health Organization/Pan American Health Organization/Haiti.

The principal vector is Anopheles albimanus, which is the main vector in the Caribbean and central American region. A. albimanus is primarily a coastal mosquito, although it is readily found inland if conditions are suitable. It is largely non-domestic and zoophilic, but bites man and will enter houses. Reported sporozoite rates are low, below 0.6% according to Macdonald (1957). On the basis of epidemiological surveys, malaria transmission in Haiti is considered to be found mainly in areas under 500 metres altitude.

The rainy season in the area usually starts in late March or early April. The rainfall rises to a peak in May, with a secondary peak in August or September, and then begins to drop in October, November and December (Graph 5). Although there is considerable fluctuation in rainfall from month to month and from season to season, some mosquito breeding continues, even during the driest seasons.

A number of blood surveys carried out in 1960 and 1961 in the area later affected by the hurricane showed parasite rates ranging from 17% to 32%. Annual parasitological surveys were started in January 1962, when the malaria eradication spraying programme was initiated. Rates of 10% were seen in 1962 in index localities in the hurricane zone. By January 1963, the rate had dropped to 0.8% in the same area, but the rates in January 1964 had increased to 17%.

The Haiti malaria eradication programme

The malaria eradication programme in Haiti was started in March 1961. The preparatory phase activities were carried out from May to December 1961 and the first cycle of spraying of houses with DDT at a dosage of 2 g/m^2 technical grade was started in January 1962. Spraying was limited to localities under 500 metres altitude and was carried out in six-month cycles. About 50% of the fourth cycle had been completed when the hurricane struck.

The surveillance programme was started in June 1962, five months after initiation of the spraying operations. By 1 October 1963 some 100 voluntary collaborator posts were in operation in the area affected by the hurricane. These were being visited monthly by eight malaria service case finders, who also collected blood slides, primarily from fever cases, in localities along the route from one collaborator post to the next. Both collaborators and case finders in Haiti provide single doses of chloroquine to all fever cases from whom blood slides are obtained.

Area affected by the hurricane

The cyclone crossed the mid-section of the southern peninsula of Haiti, directly affecting an area of some 2200 square kilometres (Map 1). This area is made up of two coastal plains separated by a discontinuous chain of mountains in the interior, which reach an altitude of 1200 metres. The main resources of the region are coffee and sisal cultivation. Small scale farming of bananas, corn, millet, and red beans is carried on for family use. Some 550 000 persons live in the affected area. The region is densely populated, averaging some 250 persons per square kilometre. The highest densities are found on the coastal plains, where certain sections have more than 350 persons per square kilometre. The population is primarily rural. There are few urban centres and these contain only about 10% of the total population. Practically 100% of the population is of the negro race.

The houses in the rural areas are of the type of construction commonly found in Haiti: walls made up of a base of woven wooden strips covered with mud, and a thatch roof made of palm leaves or straw. The houses are quite small, approximately 9 feet by 19 feet (2.7 m by 5.8 m), with the sprayable wall surface averaging about 100 square metres. There is an average of 3.5 persons per house.

Description of the hurricane

The hurricane was reported for the first time off the coast of Venezuela on 30 September 1963. The storm touched the southern peninsula of Haiti about 17.00 hours on 3 October, and reached its maximum intensity in the interior about 20.00 hours, with winds up to 250 kilometres per hour. It had completely passed over the peninsula by midnight that same night.

Flown over at low altitude, the area presented a picture of total destruction and desolation. Almost all the houses were completely demolished. The first estimate of actual damage, which could never be completely verified, was that there had been some 4000-5000 deaths. Some 200 000 persons were without any shelter and crops not yet harvested had been destroyed.

In addition to the actual damage from the winds, considerable damage was caused by floods following the storm. There were actually two distinct periods of heavy rainfall, one immediately related to the passage of the cyclone on 3 and 4 October, and a second period on 8 October, occasioned by the passage of the hurricane to the north of Haiti.

The second period of rainfall was less intense than the first, but because of the highly saturated condition of the soil from the first heavy rains, this second period caused even heavier flooding. Many of the river courses had been blocked by fallen trees and impacted debris, mud and stones, causing diversion of the flood waters at many points. Although no observations were made on mosquito density by entomological personnel during October, it is assumed that the breeding subsequent to the hurricane must have reached an extremely high level. The temperature and humidity in the area for October and November were optimal for mosquito survival and reproduction (Table 6).

Development of the malaria epidemic

The first indication of an unusual increase in malaria incidence in the affected area was a report by a voluntary collaborator post in mid-December of a sudden rise in the number of fever cases. By the end of December it was obvious that a full-blown epidemic was developing. From a total slide positivity rate of about 2.0% for the area in September 1963 the incidence rose to 12.1% by the end of December, to 22.2% by the end of January and to 25.6% by the end of February (Table 1).

The sharp increase in malaria infections apparently occurred simultaneously in almost all parts of the area directly affected by the hurricane. Tabulation of the slide positivity rates by date of blood slide collection at voluntary collaborator posts indicated that the incidence already was rising sharply about six weeks after the hurricane, in the middle of November (Graphs 3 and 4). The epidemic curve continued to maintain a high plateau, fluctuating between 21% and 31% during December, January and February.

The slide positivity of slides from voluntary collaborator posts dropped by the end of March to 9%. The "Flora" zone was visited by entomological personnel at the end of November and in February, and it was reported that many of the possible breeding areas already were quite dry and very few A. albimanus larvae could be collected. This would seem to be consistant with the rainfall data for this period (Graph 5). However, the incidence rose again in April to 12%, continued rising to 17% in May and was up to 19% in June and 27% by July (Table 2).

The parasite density was determined for all positive slides collected in the "Flora" zone. The proportion of cases with "high" parasite density (more than 1000 parasites per cubic millimetre of blood) rose from 56% in October 1963 to 77% in November 1963, dropped to 64% in March 1964 and rose to 84% in June 1964.

The outbreak was caused by Plasmodium falciparum (Table 4). Males and females were equally affected. Although the highest slide positivity rates were seen in infants and young children, the older age-groups were also heavily affected, with rates in adults reaching 21% in January 1964 at the peak of the outbreak (Table 5).

The most intensely affected area was along the northern coastal plain of the peninsula. The coastal sections showed higher rates than those in the interior and localities under 300 metres higher rates than localities at higher altitudes. At the height of the outbreak, malaria cases were detected in about 80% of localities sampled. Slide positivity rates for slides collected by voluntary collaborators reached 40-50% in some localities.

About one half of the fourth spraying cycle had been completed in most of the zone when the hurricane struck. Spraying operations had to be completely suspended in part of the area, since there were few houses left to spray, and were not resumed until 6 January 1964, when the regular fifth spraying cycle was started in the rest of the country. In the intervening period, a quick reconnaissance to appraise the amount of house damage was carried out at the end of October, and a second more detailed geographic reconnaissance was accomplished in December. The first reconnaissance revealed that in the area affected by the hurricane about 68% of the houses had been destroyed, with the rest damaged to a greater or lesser degree. By the December reconnaissance some 80% of these houses had been rebuilt and repaired, and most of the rest were under construction. By the end of the fifth spraying cycle in April 1964, practically all the houses had been rebuilt or repaired.

The area of high slide positivity rates and rapidly increasing malaria incidence matches almost perfectly the area affected by the hurricane. However, it should be noted that some sections in the middle of the hurricane area, with a high percentage of house destruction, showed rather low parasite rates during the course of the epidemic. These are inland, mountainous sections, and are largely non-malarious areas.

The number of fever cases reporting to voluntary collaborator posts began to rise sharply in early December 1963, reaching a peak in January 1964 and early February. At the height of the outbreak, the collaborators were collecting about 1500 slides per week.

It is estimated that some 75 000 cases of malaria occurred in the hurricane zone between October 1963 and March 1964, based on an over-all 25% slide positivity rate for fever cases, with an estimated 50% of the population affected with fever during the course of the epidemic.

Even though the epidemic developed rapidly, and probably affected most of the susceptible persons at risk in the area, there were no reports of undue or exceptional suffering or illness from the population or the civil authorities. A number of reports were received from medical practitioners of an increase in malaria cases in the area, but there was nothing to indicate that the epidemic had produced any alarming increase in the number of deaths or even in the amount of disability in the population. Mortality reporting is practically non-existant in Haiti and no reliable information could be obtained from official sources.

Discussion

The rapid, simultaneous development of the malaria epidemic over practically all the area affected by the hurricane (Flora) can be attributed to the following factors:

1. Continuing malaria transmission in the area before the hurricane and the presence of a considerable reservoir of gametocyte carriers at the time of maximum mosquito activity after the hurricane.

2. The great majority of the population without shelter or living in temporary shelters, with maximum exposure to biting activity of the mosquito vector.

3. Almost complete removal of insecticide coverage in houses.

4. An explosive increase in mosquito breeding, brought about by the heavy rainfall and extensive flooding.

5. Increased population movement in search of food, construction material, medical care, etc.

There had been an increase in malaria incidence in the affected zone in June, July and August 1963, before the hurricane. Although there was an apparent drop in incidence in September, it is very likely that the number of fresh clinical cases was on the increase by October when the hurricane struck. With a considerable number of gametocyte carriers available after the rains and flooding had stopped, when mosquito density was reaching its peak, and with little or no protection from mosquitos available, the first sharp rise in incidence could be expected about 6-8 weeks after the hurricane (Graph 4). This rise was seen, in fact, in the middle of November.

It is unlikely that the epidemic could have developed as rapidly, and as simultaneously over such an extensive area if malaria transmission had been interrupted before the hurricane occurred, during 3-1/2 cycles of house spraying with DDT. The explosive nature of the outbreak can best be explained by assuming that all the factors necessary to produce a malaria epidemic were combined at a time when the malaria incidence was already increasing in the area.

As has been noted above, the great majority of the rural houses were destroyed by the storm. Most of those that remained standing were without roofs, and practically all the houses, with or without roofs, were thoroughly drenched by the heavy rains that followed the storm. It can be assumed that there was almost complete removal of any insecticidal coverage that had been present before the hurricane. No appreciable difference in malaria incidence was seen between localities sprayed during the first three months of the fourth cycle, before the hurricane, and those that had not yet been sprayed when the hurricane struck.

No direct correlation was seen in the different sections in the affected zone between the amount of house destruction and the level of total slide positivity parasite rates over the six-month period after the hurricane. It is assumed that the difference in rates is an expression of the differing "malariousness" of each area rather than a direct result of the amount of house destruction. Also, it was

noted that the percentage of house destruction was not necessarily a reliable index of insecticide coverage, since practically all of the houses left standing were damaged to some degree, and most of the insecticide was later removed by rains, repairs or replastering.

The fifth cycle of spraying in the affected zone, which started in January 1964, was accelerated so that the area could be covered in four months, by the end of April 1964 when the next transmission season was due to start. In addition, mop-up brigades covered the area again in April to spray any new or repaired houses missed by the regular brigades.

The rainfall in the area in April was particularly heavy, and totalled as much as was recorded during October 1963, when the hurricane had struck (Graph 5). The malaria incidence in the area had dropped during April and it was hoped that the fresh insecticide coverage would provide the protection needed to prevent any further increase. However, the rates began to rise in May and June and by July had reached a slide positivity of 21% for slides collected by voluntary collaborators (Table 3).

In addition to an increase in percentage of positivity for slides collected by both voluntary collaborators and case finders, the absolute number of cases also rose. The proportion of positive slides with high parasite density began to rise again in April 1964, after having dropped from a peak in December 1963. Also, the percentage of "positive" localities and the percentage of collaborator posts detecting malaria cases began to show an increase in July 1964. From all indications, there was a true increase in malaria in the area, evidently as a direct result of the heavy rains in April 1964.

It was assumed initially that one of the main factors in the development of the epidemic was the loss of insecticide coverage caused by the house damage and heavy rains during and after the hurricane. In view of the increase in malaria transmission after the spring rains, in spite of fairly adequate spray coverage, it would appear that this factor may have less importance than previously estimated.

Recent studies on the behaviour of A. albimanus in Haiti indicate that most of the biting activity takes place in the early evening, when the great majority of the rural population can be found outside of their houses. Only a small proportion of the mosquitos come inside of the houses to bite or rest.

Even though the vector is susceptible to DDT and bio-assays on sprayed wall surfaces indicate satisfactory mortality up to six months, it is likely that most of the malaria transmission in Haiti is extra-domiciliary and that DDT house spraying alone may not be sufficient to interrupt transmission in highly malarious areas. Additional studies are now being carried out to clarify these questions.

Summary

An epidemic of malaria following the passage of a hurricane over Haiti 3-4 October 1963 is described. The epidemic started about 6-8 weeks after the hurricane and is estimated to have produced some 75 000 cases of malaria in a 3-4 month period. It is assumed that the rapid, simultaneous development of the epidemic over practically the entire affected area was facilitated by the presence of a considerable reservoir of gametocyte carriers, and the massive increase in mosquito breeding brought about by the heavy rains and flooding. The effect of DDT insecticide spraying in houses on malaria transmission in Haiti is still under investigation.

Any gains made by two years of DDT spraying have been completely wiped out by the epidemic and the malaria eradication programme can be assumed to be starting over again in the affected area.

REFERENCES

Paul, J. H. & Bellerive, A. (1947) A Malaria Reconnaissance of the Republic of Haiti, J. nat. Malar. Soc., 6, 41

Macdonald, G. (1957) The Epidemiology and Control of Malaria, London, p. 68.

RESUME

Les auteurs décrivent l'épidémie de paludisme consécutive au passage du cyclone Flora sur le tiers moyen de la péninsule Sud de la République d'Haïti (Grandes-Antilles), le 3 octobre 1963.

Survenant au cours de la deuxième année de la phase d'attaque du programme national d'éradication du paludisme, qui bénéficiait déjà d'un important système de surveillance active et passive, l'épidémie a pu être suivie dans le détail de son déroulement.

Six à huit semaines après le passage dévastateur du cyclone, le paludisme a rapidement affecté l'ensemble des 550 000 personnes vivant au-dessous de 500 mètres d'altitude (limite supérieure de la transmission palustre localement). Des quelque 75 000 cas qui ont dû se produire de décembre 1963 à mars 1964, presque tous étaient dus à P. falciparum, quelques-uns seulement à P. malariae.

L'explosion épidémique sur l'ensemble de la zone dévastée a été favorisée par : l'existence d'un réservoir assez important de gamétocytes dans cette zone, l'augmentation massive et généralisée de la population anophélienne par l'augmentation considérable des gîtes larvaires, l'obligation dans laquelle s'est trouvée la population de vivre à l'extérieur pendant que les maisons étaient en cours de reconstruction.

Les bénéfices de deux années d'aspersion au DDT ont été anihilés et la campagne a dû recommencer à nouveau dans cette région.

TABLE 1.* MALARIA CASES DETECTED IN AREA AFFECTED BY HURRICANE
(By Month of Laboratory Examination of Blood Slides)

	Blood slides collected by:						Totals			
	Voluntary collaborators			Malaria service case finders						
	Blood slides collected	Positive slides	% Positive	Blood slides collected	Positive slides	% Positive	Blood slides collected	% Pop. exam.	Pos. slides	% Positive
1962										
June	361	12	3.3	1 010	24	2.4	1 371	0.3	36	2.6
July	365	6	1.6	1 075	38	3.5	1 440	0.3	44	3.1
August	589	18	3.1	558	33	5.9	1 147	0.2	51	4.4
September	742	11	1.5	716	26	3.6	1 458	0.3	37	2.5
October	850	6	0.7	1 384	13	0.9	2 234	0.4	19	0.9
November	681	19	2.8	890	11	1.2	1 571	0.3	30	1.9
December	35	0	-	189	0	0.	224	0.04	0	0.
1963										
January	257	6	2.3	1 894	16	0.9	2 151	0.4	22	1.0
February	1 008	9	0.9	2 911	52	1.8	3 919	0.8	61	1.6
March	486	2	0.4	4 838	14	0.3	5 324	1.0	16	0.3
April	898	2	0.2	4 020	20	0.5	4 918	0.9	22	0.4
May	519	1	0.2	2 266	7	0.3	2 785	0.5	8	0.3
June	644	4	0.6	3 466	6	0.2	4 110	0.8	10	0.2
July	1 012	24	2.4	4 885	55	1.1	5 897	1.1	79	1.3
August	1 024	51	5.0	4 176	67	1.6	5.200	1.0	118	2.3
September	1 310	47	3.6	3 883	55	11.4	5 193	1.0	102	2.0
October	724	16	2.2	1 840	28	11.5	2 564	0.5	44	1.7
November	896	54	6.0	2 844	62	2.2	3 740	0.7	116	3.1
December	1 524	301	19.8	2 338	166	7.1	3 862	0.7	467	12.1

* See Graphs 1 and 2.

TABLE 1. MALARIA CASES DETECTED IN AREA AFFECTED BY HURRICANE
(continued)

	Blood slides collected by:						Totals			
	Voluntary collaborators			Malaria service case finders						
	Blood slides collected	Positive slides	% Positive	Blood slides collected	Positive slides	% Positive	Blood slides collected	% Pop. exam.	Pos. slides	% Positive
1964										
January	3 276	853	26.0	3 692	693	18.8	6 968	1.3	1 546	22.2
February	3 805	1 443	37.8	5 699	986	17.3	9 504	1.8	2 429	25.6
March	3 829	781	20.4	5 659	870	15.4	9 488	1.8	1 641	17.3
April	4 487	668	14.9	7 851	423	5.4	12 338	2.4	1 091	8.8
May	1 993	241	12.1	8 564	246	2.9	10 557	2.0	487	4.6
June	1 100	130	11.8	6 991	411	5.9	8 091	1.6	541	6.7
July	1 875	259	13.8	7 510	715	9.5	9 385	1.8	974	10.4
August	1 731	300	17.3	3 192	180	5.6	4 923	1.0	480	9.8
September	5 978	428	10.8	1 254	62	4.9	5 232	1.0	490	9.4
October	3 835	773	20.2	2 447	188	7.9	6 282	1.2	961	15.3

TABLE 2. MALARIA CASES DETECTED BY VOLUNTARY COLLABORATORS - BY WEEK OF SLIDE COLLECTION

	Weeks	Total slides	Total positive	Percentage positive
1963				
September	1-7	19	1	5.3
	8-14	32	3	9.4
	15-21	91	5	5.5
	22-28	122	3	2.5
	29-5 Oct.	253	1	0.4
October	6-12	80	0	0.0
	13-19	183	1	0.6
	20-26	290	9	3.1
	27-2 Nov.	294	14	4.8
November	3-9	248	14	5.6
	10-16	307	11	3.6
	17-23	459	44	9.6
	24-30	341	50	14.2
December	1-7	550	144	26.2
	8-14	692	168	24.3
	15-21	657	146	22.2
	22-28	317	72	22.7
	29-4 Jan.	359	76	21.2
1964				
January	5-11	807	220	27.3
	12-18	1 560	397	25.4
	19-25	1 384	435	31.4
	26-1 Feb.	1 560	405	26.0
February	2-8	1 131	264	23.3
	9-15	942	214	22.7
	16-22	913	199	21.8
	23-29	1 046	286	27.3

TABLE 2. MALARIA CASES DETECTED BY VOLUNTARY COLLABORATORS (continued)

	Weeks	Total slides	Total positive	Percentage positive
March (1964)	1-7	1 310	309	23.6
	8-14	890	175	19.7
	15-21	831	137	16.5
	22-28	599	75	12.5
	29-4 April	463	40	8.6
April	3-11	374	36	9.6
	12-18	494	59	11.9
	19-25	497	53	10.7
	26-2 May	411	43	10.5
May	3-9	373	40	10.7
	10-16	411	68	16.5
	17-23	245	37	15.1
	24-30	318	36	11.3
	31-6 June	249	22	8.8
June	7-13	256	32	12.5
	14-20	278	52	18.7
	21-27	259	43	16.1
	28-4 July	428	60	14.0
July	5-11	373	52	13.9
	12-18	429	90	21.0
	19-25	352	96	27.2
	26-1 Aug.	332	101	30.4
August	2-8	640	82	12.8
	9-15	993	122	12.3
	16-22	817	117	14.3
	23-29	526	52	9.9
	30-5 Sept.	702	83	11.8

TABLE 2. MALARIA CASES DETECTED BY VOLUNTARY COLLABORATORS (continued)

	Weeks	Total slides	Total positive	Percentage positive
September (1964)	6-12	1 077	131	12.2
	13-19	994	152	15.3
	20-26	1 079	180	16.7
	27-3 Oct.	826	106	12.8
October	4-10	752	100	13.2
	11-17	542	80	14.8
	18-24	127*	17*	13.4

* Partial.

TABLE 3. MALARIA CASES DETECTED BY VOLUNTARY COLLABORATORS
(BY MONTH OF SLIDE COLLECTION)

	Slides collected	Positive slides	Percentage positive
1963			
September	264	12	4.6
October	1 363	25	1.8
November	1 355	119	8.8
December	2 222	530	23.8
1964			
January	5 670	1 533	27.1
February	4 032	963	23.8
March	3 630	696	19.2
April	2 239	231	10.3
May	1 347	181	13.4
June	1 042	149	14.3
July	1 914	399	20.8
August	2 976	373	12.5
September	3 852	546	14.1
October	2 247	303	13.5

TABLE 4. PARASITE SPECIES DISTRIBUTION
(Positive Blood Slides - October 1963 - May 1964)

	No.	%
Plasmodium falciparum	6 184	98.5
Plasmodium malariae	59	1.0
Plasmodium vivax	26	0.4
Mixed	7	0.1
Totals	6 276	100.0

TABLE 5. BLOOD SLIDES COLLECTED BY VOLUNTARY COLLABORATORS OCTOBER 1963 - MARCH 1964 (BY AGE-GROUP)

	Blood slides collected	Positive slides	Percentage positive
Under 1 year	204	72	35.3
1-4 years	955	326	34.1
5-9 years	1 297	391	30.1
10-20 years	3 031	841	27.7
21 years and over	6 247	1 094	17.5
Totals	11 734	2 724	23.2

TABLE 6. PORT-AU-PRINCE - HAITI

	Temperature (C)			Average relative humidity
	Average	Maximum	Minimum	
October 1963	27.6	31.8	25.4	73.9
November 1963	27.9	32.6	23.2	66.5
December 1963	27.8	32.5	23.1	65.4

The purpose of the WHO/Mal series of documents is threefold:

(a) to acquaint WHO staff, national institutes and individual research or public health workers with the changing trends of malaria research and the progress of malaria eradication by means of summaries of some relevant problems;

(b) to distribute to the groups mentioned above those field reports and other communications which are of particular interest but which would not normally be printed in any WHO publications;

(c) to make available to interested readers some papers which will eventually appear in print but which, on account of their immediate interest or importance, deserve to be known without undue delay.

It should be noted that the summaries of unpublished work often represent preliminary reports of investigations and therefore such findings are subject to possible revision at a later date.

The issue of a paper in this series does not therefore constitute formal publication and a paper so issued may, with the agreement of the author and WHO, be published in a WHO periodical or elsewhere.

Authors alone are responsible for views expressed in signed articles. The mention of manufacturing companies or of their proprietary products does not imply that they are recommended or endorsed by the World Health Organization.