

The First Large-Scale Use of Synthetic Insecticide for Malaria Control in Tropical Africa: Lessons from Liberia, 1945–1962

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ABSTRACT. In 1945, a United States Public Health Service team in Monrovia, Liberia, began the use of synthetic insecticides for indoor residual spraying (IRS) and as a larvicide, with the goal of controlling malaria in the Liberian capital. In the early 1950s, the project was “scaled up” to reach the surrounding areas, and in 1953, the World Health Organization (WHO) launched an antimalaria program in the upcountry region of Central Province, Liberia. It was initially based solely upon IRS, as it was one of a series of pilot projects whose goal was to determine the feasibility of malaria eradication in tropical Africa. The malaria control project in Monrovia constituted the first large-scale use of synthetic insecticide to combat malaria in tropical Africa, and the WHO pilot project in Central Province was one of a first cluster of projects initiated to explore the efficacy of IRS in a variety of African ecological zones. These projects encountered a spate of difficulties that foreshadowed the general retreat from malaria eradication efforts across tropical Africa by the mid-1960s. **KEYWORDS:** malaria, DDT, Liberia, World Health Organization, United States Public Health Service, indoor residual spraying.

“Apparently no Administration of any African territory has, so far, shown the willingness of setting up a project of this kind. Certainly some campaigns have given good results, but as far as I am aware, no endeavor has been made to find out in rural west or East Africa, the method which is the most effective and the least expensive at the same time. If WHO can help to determine it, it will have rendered a

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great service to all Health Administrations of African countries and territories.— Dr. E. J. Pampana, 1952.”¹

“Prior to the widespread use of DDT and free distribution of anti-malarial drug, most of Liberia appeared to be under the false sense of hyperendemic malaria protection. The colossal slaughter of the young was not as carefully recognized as malaria death and the relative freedom from serious clinical attacks gave the impression of an immuned population. This was false security as analysis will show because economic inefficiency and retardation of mind and body is associated with high malaria incidences. Nevertheless, the introduction of DDT and free distribution of anti-malarial drugs have disturbed that immunity and whenever defects occur now in the effective use of these control measures, the clinical manifestations are more frequent and more severe in the adults. These manifestations assume epidemic proportion at times.—Hildrus A. Poindexter, 1952”²

IN the immediate aftermath of World War II, the prospects for the global control of malaria—and perhaps even global eradication—appeared promising.³ The older approaches to malaria control in tropical Africa, based upon environmental management techniques such as the drainage and larviciding of anopheline mosquito breeding grounds, had been used with success before the war in some urban areas and in some plantation and mining sites, and during the war in some of the important coastal ports, including Freetown and Accra.⁴

1. Dr. E. J. Pampana to General E Daubenton, 2 January 1952, Report on My Visit to Liberia, Liberia (WHO) 7.0022, JKT I. SJ 4, World Health Organization Archives, Geneva, Switzerland (hereafter WHO Archives).

2. Hildrus A. Poindexter, Chief, Public Health Staff, ICA to Acting Country Director, 5 August 1952, Annual Report Fiscal Year 1952, Biennial Reports Folder, Liberia Program Reports, Box 3, Liberia Subject Files, Record Group 469, Records of the U.S. Foreign Assistance Agencies, 1948–1961, National Archives and Records Administration, College Park, MD (hereafter RG 469, NARA).

3. For recent surveys of malaria history that discuss the global malaria eradication program, see James L. A. Webb, Jr., *Humanity's Burden: A Global History of Malaria* (New York: Cambridge University Press, 2009); and Randall M. Packard, *The Making of a Tropical Disease: A Short History of Malaria* (Baltimore, Maryland: Johns Hopkins University Press, 2007). On the history of biomedical research on malaria, see Leo B. Slater, *War and Disease: Biomedical Research on Malaria in the Twentieth Century* (New Brunswick, New Jersey: Rutgers University Press, 2009).

4. For the environmental management techniques in the Zambian copperbelt, see Jürg Utzinger, Yesim Tozan, Fadi Doumani, and Burton H. Singer, “The Economic Payoffs of Integrated Malaria Control in the Zambian Copperbelt between 1930 and 1950,” *Trop. Med. Int. Health*, 2002, 7, no. 8, 657–77.

These techniques, however, were relatively expensive and could not be “scaled up” to provide protection to most African communities. The wartime successes in vector-borne disease control using dichloro-diphenyl-trichloroethane (DDT) in southern Europe and within the United States, however, suggested another path to disease control that could be replicated in other malarious regions, including tropical Africa.⁵

In Monrovia, the capital of the Republic of Liberia, Americans launched the first initiative to bring powerful synthetic chemical insecticides to bear on the tropical African malaria problem. Several years later, the program expanded to the areas surrounding the capital, and in 1953, the WHO developed a pilot project in rural Central Province to explore the feasibility of malaria eradication. These projects uncovered a spate of difficulties that foreshadowed the general retreat from malaria eradication efforts in Africa.

PRELUDE TO THE AMERICAN INITIATIVES AT MOSQUITO CONTROL (1941–1944)

In March 1941, the government of the United States of America passed the Lend-Lease Act that facilitated the U.S. provision of essential war materiel to the UK and other Allied powers.⁶ In July 1941, the U.S. government requested that Pan American World

5. For wartime Europe, see Edmund Russell, *War and Nature* (New York: Cambridge University Press, 2001), 119–44; Darwin H. Stapleton, “The Short-Lived Miracle of DDT,” *Invent. Tech.*, 2000, 15, no. 3, 34–41; Frank M. Snowden, *The Conquest of Malaria: Italy, 1900–1962* (New Haven: Yale University Press, 2006), 198–212. In the United States, during the 1940s, DDT played a role in the decline of malarial infections in the southern states, and enthusiasm for vector control with the newly deployed synthetic insecticide was high. In the United States, the decline was measured in clinical cases of malaria. Retrospective analysis indicates that malarial infections were in marked decline before the use of DDT. This decline was principally owing to the widespread destruction of mosquito habitat brought about by the environmental transformations of the 1930s that included the drainage and impoundment programs of the Tennessee Valley Authority and the out-migration of the once-vulnerable populations to cities and towns. See Margaret Humphreys, “Kicking a Dying Dog: DDT and the Demise of Malaria in the American South, 1942–1950,” *Isis*, 1996, 87, 1–17; Margaret Humphreys, *Malaria: Poverty, Race, and Public Health in the United States* (Baltimore, Maryland: Johns Hopkins University Press, 2001). In Liberia, by contrast, there were virtually no baseline data. No malariological studies had been carried out beyond the Firestone plantations since 1936. Ludwik Anigstein, “Medical Exploration in Liberia,” *Bull. Health Org. League Nations*, 1937, 6, no. 1, 93–127.

6. The United States had previously extended naval assistance to the UK through the 1940 “Destroyers for Bases Agreement,” and before the Lend Lease Act of 1941, the UK had been obliged to pay in gold for other war materiel.

Airways build an airfield in Liberia. Pan American turned to the Firestone Tire and Rubber Company—which had established a rubber plantation in Liberia in 1926—to undertake the project, and for its part Pan American agreed to fly U.S.-made aircraft from the United States to Brazil, then across the South Atlantic to Liberia, and then on to British forces in the Mediterranean.⁷ A runway at the newly constructed Roberts Field airbase opened in Liberia in January 1942.⁸ The U.S. Army Air Force took over the airfield and extended it to accommodate giant B-29 Flying Fortress bombers. By late 1942, an estimated five thousand U.S. troops garrisoned the airbase in Liberia.⁹

The further development and protection of strategic wartime assets in Liberia appeared vital. In early 1942, the Japanese seizure of the British colonial rubber plantations in Malaya cut off the supply of the Allies' principal source of natural rubber, a critically important resource for the war effort. The Firestone rubber plantation in Liberia—by far the largest in the Atlantic basin—thus took on greater significance, even as a new technology of synthetic rubber production, legal restrictions on civilian use of rubber tires, and an active “reclaim” program for used tires allowed the United States to meet its essential wartime needs.¹⁰

President Franklin Delano Roosevelt, the first U.S. head of state to visit Africa, touched down at Roberts Field in January 1943, signalling a new era in U.S.–Liberian relations.¹¹ In conversations with the Liberian president Edwin J. Barclay, Roosevelt reached an

7. For the early history of Firestone in Liberia, see Arthur J. Knoll, “Firestone’s Labor Policy, 1924–1939,” *Liberian Stud. J.*, 1991, 16, no. 2, 49–75.

8. Alfred Lief, *The Firestone Story: A History of the Firestone Tire and Rubber Company* (New York: Whittlesey House, 1951), 321–23.

9. Harrison Akingbade, “U.S. Liberian Relations during World War II,” *Phylon*, 1985, 46, no. 1, 30. The U.S. troops suffered high rates of malarial infection, owing in part to fluctuating policies in the administration of antimalarial prophylaxis. See John W. H. Rehn, “Africa–Middle East Theater,” in Medical Department, U.S. Army, *Communicable Diseases: Malaria*, vol. 6 in the series *Preventive Medicine in World War II* (Washington, DC: Office of the Surgeon General, Department of the Army, 1963), 303–46.

10. Lief, *The Firestone Story*, 271–81; for general background on Firestone in Liberia, see Ibrahim Sundiata, *Brothers and Strangers: Black Zion, Black Slavery, 1914–1940* (Durham, North Carolina: Duke University Press, 2003), 107–26.

11. U.S.–Liberian relations had been seriously strained by the Government of Liberia’s involvement with forced labor practices that came under investigation by the League of Nations. On the labor abuses and the League of Nations investigation, see Sundiata, *Brothers and Strangers*, 79–139.

agreement for the United States to construct a deepwater port at Monrovia.¹² The U.S. strategic goal was to provide maritime protection for the Allies in the South Atlantic. Barclay took the decision, effective 31 December 1943, to adopt the U.S. dollar—instead of the pound sterling—as the sole legal tender in Liberia. The arrangements drew Liberia and the United States into a closer embrace.

William Tubman assumed the presidency of Liberia in January 1944, and within weeks of his accession, the government of Liberia had declared war on the Axis powers. Tubman then took steps to restructure the internal politics of Liberia. He announced a “Unification Policy” that, in principle, would diminish the cultural division between the Americo-Liberians, who were the descendants of U.S. freed slaves and who controlled the Liberian state along the Atlantic coast, and the “upcountry” native Africans. To further this aim, in 1944 a joint U.S. and Liberian force began the first continuous road into the Liberian interior, from Monrovia to Ganta, near the border with French Guinea, and on to Saniquellie to the northeast.¹³

In October 1944, the United States signed a Lend-Lease agreement with Liberia and arranged to send a Foreign Economic Administration mission to Liberia with a broad general portfolio.¹⁴ Tubman sought assistance from the United States in planning for improvements in the sanitation of Monrovia and other coastal towns. His request was folded into the military program in Liberia. The United States approved a United States Public Health Service (USPHS) mission to Liberia to provide additional military sanitation, in cooperation with the Government of Liberia, charged with the following objectives: to protect U.S. military personnel; to

12. As part of an agreement with the government of Liberia in 1926, the Firestone Tire and Rubber Company committed to building a harbor at Monrovia at a cost not to exceed \$300,000. The Liberian government was to repay the expense of construction to Firestone. Harvey J. Firestone, president of the Firestone Tire and Rubber Company, spent \$115,000 toward this end, before engineers determined that the project was impracticable; Firestone absorbed the financial loss (Lief, *The Firestone Story*, 164).

13. Wayne Chatfield Taylor, *The Firestone Operations in Liberia* (Washington, DC: National Planning Association, 1956), 14–15; Akingbade, “U.S. Liberian Relations during World War II,” 25–36; David McBride, *Missions for Science: US Technology and Medicine in America's African World* (New Brunswick, New Jersey: Rutgers University Press, 2002), 169.

14. J. H. Mower, “The Republic of Liberia,” *J. Negro Hist.*, 1947, 32, no. 3, 299.

render the environs of the airport free of mosquito species that would be dangerous if introduced to the United States; to assist the Government of Liberia in planning for the sanitation of coastal towns; and to render aid to the Government of Liberia in the event of a request to enlarge its public health program.¹⁵

MOSQUITO CONTROL ARRIVES IN LIBERIA (1945–1947)

In 1945, an “all-Negro” team of eleven U.S. physicians, engineers, entomologists, and nurses from the USPHS, headed by Dr. John B. West, arrived in Monrovia to create a five-year development plan in public health.¹⁶ One of their principal charges was to bring malaria under control, and in March 1945, they launched a malaria control program in the greater Monrovia area. The efforts were largely makeshift. DDT solution insecticides (10 percent DDT in kerosene) were used for indoor residual spraying (IRS); intensive larviciding (with 5 percent DDT in kerosene), as well as some drainage operations, were carried out over an area about twelve miles long and three miles wide.¹⁷

In the greater Monrovia area, much of the insecticide use was inefficient because of the construction methods used in housing. DDT worked most effectively when sprayed on impermeable walls where it could continue to kill insects landing there for more than 3 months. But more than 50 percent of the interior house walls in Monrovia were constructed of laterite bricks, a natural hard clay-like soil that is high in iron and aluminum. The DDT soaked through these walls, instead of staying on the surface, and thus was

15. Anon., Country Study on Liberia, 17 January 1951, 66, Misc. Unfiled Materials Folder, Liberia-Reports-Travels, Interdepartmental Advisory Council on Technical Cooperation, Box 4, UD504, Liberia Subject Files, RG 469, NARA. On the political culture of Liberia and the corruption of the Tubman era, see Tuan Wreh, *The Love of Liberty... The Rule of President William V. S. Tubman in Liberia, 1944–1971* (London: C. Hurst & Company, 1976).

16. “U.S. Will Help Liberia in 5-Year Health Work,” *New York Times*, 22 November 1944, 6; Lawrence A. Marinelli, *The New Liberia: A Historical and Political Survey* (New York: Frederick A. Praeger, 1964), 80. The surgeon Dr. John B. West was stationed in Liberia with the U.S. Army medical corps (McBride, *Missions for Science*, 178).

17. Roy F. Smits, “Historical Review of the Malaria Control Program in Liberia, 1944–1955,” 23 August 1955, 1, Liberia-Reports Folder 3/3, Liberia-Personnel 1951–1958, Box 2, UD 754, RG469, NARA. Pampana to Daubenton, 2 January 1952, SJ 4, JKT I, Liberia 1932–1951, WHO7.0022, WHO Archives; Charles E. Kohler, “A Five Year Malaria Eradication Plan for the Republic of Liberia,” 1–2 SJ 3, JKT II, Liberia 1953–1956, WHO7.0022, WHO Archives.

much less effective as a residual insecticide. At the time, there was no entomologist or chemist in Liberia who understood the issue, and work proceeded on an ad hoc basis. When the DDT seemed no longer to do the job—that is, to kill the mosquitoes inside the dwelling—the sprayers returned and sprayed again. The result was roughly a once-a-month spraying cycle with exceedingly high per capita costs.¹⁸

The larvicidal and drainage operations also faced daunting logistical problems. There were an estimated 90,000 acres of mangrove swamps in the greater Monrovia area in which mosquito breeding could not be controlled with routine ground methods of larviciding. Airplane spraying was costly, and it was estimated that only 5 percent of the mangrove swamps would produce mosquitoes at any one time. Moreover, the heavy rainfalls would dilute the larvicide and make it almost impossible to reduce anopheline vector populations to a level at which transmission of malaria would not occur.¹⁹

Even though the mosquito control program was very expensive, it produced positive health results, at least by one measure: malaria admissions to the public health hospital in Monrovia decreased by almost 95 percent from 383 in 1945 to 21 in 1947. This decline may have been in part a result of the local community's access to antimalarial drugs that reduced the severity of the malarial attacks, as well as a result of the vector control program.²⁰ The initial mosquito control efforts in Monrovia were well received by the local population, especially once they noticed the near disappearance of flies, bed bugs, and other insects, in addition to mosquitoes. Another benefit flowed from the drainage operations that dried out some swamp areas that were then planted in food crops.²¹ According to Dr. J. N. Togba, the sole western-trained Liberian physician—who in October 1950 became director of the newly

18. Kohler, "A Five Year Malaria Eradication Plan," 2.

19. Public Health Activity Joint Commission, Annual Report, 1953, 4–6, Liberia Subject Files, Box 2, Liberia-Health, UD504, RG469, NARA.

20. Interdepartmental Advisory Council on Technical Cooperation, Country Study on Liberia, 17 January 1951, 68–70, Liberia Subject Files, Unfiled Materials Folder, Box 4, Liberia-Reports-Travels, Misc. UD504, RG469, NARA; Hildrus A. Poindexter to Dr. Louis L. Williams, Jr., Chief, Division of International Health, USPHS, 20 July 1952, Subject Files-Liberia, 1947–1952, Box 16, RG469, NARA.

21. Dr. Estabrook to Mr. Eason, "Resume of Accomplishments in Public Health Mission to Liberia," 23 August 1951, 3, Liberian Branch-Subject Files, 1948–1955, Box 20, E-530, RG 469, NARA.

formed Bureau of Public Health and Sanitation and from October 1952, the director of the newly formed National Public Health Service (NPHS) of Liberia—interest in public health further intensified following a successful effort to counter an outbreak of smallpox in 1947 that involved the vaccination of roughly 95 percent of the total population. Requests for hospitals and clinics poured in from the counties and provinces.²²

RETRACTION (1948–1952)

By 1947, the malaria control program had thus achieved some positive results in reducing hospital admissions and in reducing nuisance insect and mosquito densities. But for the Americans, the expense of the program argued against its continuation. The U.S. mission withdrew the malaria control officer from Liberia and replaced him with a “sanitary engineer” who had no expertise in malaria control and who took on a wider scope of work. By 1948, the malaria control budget had declined by 80 percent. And from 1947, the population of Monrovia surged, nearly doubling in the next five years, as the government relaxed restrictions against the immigration of “upcountry” Africans. The immigrants were highly parasitized, and they lived in close proximity to Monrovia whose acquired immunity—maintained by recurrent inoculations by malaria-carrying mosquitoes—had deteriorated as a result of the vector control program and their access to antimalarial drugs. The result was a sharp increase in malarial infections and a surge of resentment against the U.S. mission.²³

From 1948 to 1950, the control efforts deteriorated as a result of inept direction and restricted resources. From an epidemiological point of view, the malaria control program had spiraled into ineffectiveness. Mosquito densities had declined markedly; but an analysis

22. J. N. Togba, “Official Report of the Bureau of Public Health and Sanitation. For Fiscal Year October 1, 1950–September 31, 1951,” 7–8, SJ 3, JKTI, Liberia 1932–1951, WHO7.0022, WHO Archives. Dr. J. N. Togba trained in the United States and received his medical degree in 1946. He returned to Liberia for one year, and then went to the United States for two years of public health training at Harvard University. (Memorandum from Haldore Hanson. “Notes on My Liberian Visit—February 23 to March 2, 1951,” 7, E-529, General Correspondence–Liberia, 1948–1955, Box 1, RG469, NARA.) For the broader West African context of western-trained African physicians, see Adell Patton, Jr., *Physicians, Colonial Racism, and Diaspora in West Africa* (Gainesville: University of Florida Press, 1996).

23. Poindexter to Williams, 20 July 1952.

of blood smears in 1950 indicated that the control program had no impact whatsoever on rates of infection.²⁴ The Americo-Liberians' view of the malaria control program, however, had gained traction. Americo-Liberians considered the program to be a powerful good, because it reduced the problem of nuisance mosquitoes and house vermin. They enthusiastically seized the opportunities to have their houses sprayed. As Prof. C. W. Kruse, a World Health Organization (WHO) consultant from the Johns Hopkins University noted in his 1950 report: "One gets the impression that almost everybody in the town is supervising the operation and issuing instructions. . . . This control program, inspected from the standpoint of apparent effectiveness, cost, and permanence does not appear favorable."²⁵ At the time of Prof. Kruse's survey, there were only about 4,000 buildings (including homes and huts) that were sprayed in the Monrovia region, and the average cost was \$2.25 per house per year. This made it one of the most expensive spraying operations in the world. The larvicidal program in principle followed a set routine: the control zone had been divided into five sectors and the crews went from one to another during the five days of the workweek. But the zone had been established without any reference to mosquito flight ranges. Some of the zones extended five miles to the east or five miles to the west of Monrovia, far beyond the flight ranges of the mosquitoes.²⁶

As the mosquito control efforts waned, mosquito densities increased, and vermin returned in large numbers. The reduced malaria control efforts soon appeared to be nearly futile, and Liberia's public health leader Dr. Togba, among others, added his voice to strident criticism of the U.S. program. Dr. Poindexter, the director of the USPHS mission in Monrovia, recommended to his superiors in Washington that the program be scrapped, arguing that a holding pattern would damage the prestige of the United States. Dr. Togba, put additional pressure on the United States by threatening to ask the WHO to send a malaria control team to Liberia, and in 1951, the medical officer in charge of the Division of

24. C. W. Kruse, Associate Professor of Sanitary Engineering, The Johns Hopkins University, School of Hygiene and Public Health, "Sanitary Survey of the Republic of Liberia" [1950], Liberia, 1932-1951. JKT I. SJ 2, WHO7.0022, WHO Archives.

25. *Ibid.*, 33-34.

26. *Ibid.*

International Health Relations of the USPHS visited Monrovia and promised a new U.S. team, composed of a malariologist, a sanitary engineer, and a sanitarian, to reinvigorate the malaria control efforts.

The WHO sent Dr. Ragnar Huss, a specialist in public health, to visit Liberia in 1951. His recommendation was for a scale-up of operations: the U.S. malaria control program should be extended “to cover the important malarial regions outside Monrovia.” He suggested that, if the USPHS was not prepared to extend the control program, Liberia should request assistance from the WHO. The fundamental rationale for the scale-up was the extent of the economic loss due to malaria that was imposed on the laboring population of the country.²⁷

The U.S. team arrived later in 1951. They recommended the establishment of a control zone of twenty-five square miles around Monrovia in which drainage and larvicidal operations would be carried out. The Liberian Institute of Tropical Medicine, in October 1951, countered with a recommendation that residual spraying with a DDT emulsion should take place at 4–5 week intervals in all the houses in the Monrovia area, in what was essentially a resumption of the earlier IRS program.²⁸ By November 1951, the program had stabilized to include limited larviciding in a main part of Monrovia; the abandonment of the project of large-scale drainage of the mangrove swamps; and a concentration on IRS using insecticides other than DDT, because of concerns over its effectiveness in coastal Liberia, and benzene hexachloride (BHC), because of its objectionable odor.²⁹

27. Ragnar Huss, “Public Health Medical Services in Liberia,” 10 April 1951, 22, WHO/PHA/5, SJ 3, JKT I, Liberia, WHO7.0022, WHO Archives.

28. The Liberian Institute of the American Foundation for Tropical Medicine, known as the Liberian Institute of Tropical Medicine, was endowed by a gift from Harvey J. Firestone, Jr., as a memorial to his late father, in 1947. Its research mission was to investigate both human and animal diseases. See [Anon.], “Liberia, Scene of New International Institute for Tropical Medicine,” *Am. J. Trop. Med.*, 1947, 5-1-27, 517–19. Its work was supported by the Liberian Foundation. For details on the Liberian Foundation, see Stanley J. Leland, “The Liberian Foundation: Aims and Methods,” *Milbank Mem Fund Q.*, 1950, 28, no. 1, 43–51. The Americans withdrew their support of the Institute in the late 1960s. In 1975, a Liberian Institute for Biomedical Research came into existence, “somewhat in succession to the Liberian Institute for Tropical Medicine.” See D. Elwood Dunn, Amos J. Beyan, and Carl Patrick Burrowes, *Historical Dictionary of Liberia* (Lanham, Maryland: Scarecrow Press, 2001), 209.

29. Kohler, “Malaria Control Terminal Report 1957,” 4.

In 1951, following on the scaling down of mosquito control efforts in the immediately preceding years, mosquito populations “exploded” in the Monrovia region. As a stopgap measure, the USPHS sent a “Fog Generator” to blanket the large breeding areas near the coastal settlements with insecticide. It caused quite a stir. Its first trial suggested smoke from a conflagration, and the local fire brigade mobilized to stamp it out.³⁰ The fog generator achieved limited success, owing to the difficulty of getting proper wind direction and movement and the need to release the fog before the sun’s heat became intense after 9 a.m.³¹ A technology that had worked reasonably well in the United States did not transfer well to coastal Liberia.

Toward the end of the same year, Dr. Togba submitted a malaria control proposal for inland areas to UNICEF. It was forwarded to T. A. Austen, the Public Health Officer to General F. Daubenton, the acting director of the WHO Regional Office for Africa, who considered the request to be unrealistic: The road system into the interior was rudimentary; there were no maps showing where villages were located; there was no rural medical network; and all supplies of insecticide would have to be carried by porters into the interior. In testy conversations with Togba, Austen was frustrated in his efforts to get the most basic information about the public health prospects for a Liberian malaria control program; he was unable even to confirm the number of administrative districts in Liberia.³²

Austen followed up by making inquiries about the prospects for collaboration between UNICEF and the WHO. Austen learned that UNICEF was already operating a small malaria control program about forty miles from Monrovia in a group of thirty villages with a population of about 1500. When he tried to learn more about the program, he waded into troubled political waters. The local head of UNICEF was unforthcoming and refused to

30. T. A. Austen to General F. Daubenton, Acting Director, Regional Office for Africa, dated 3 December 1951, from Monrovia, para 6, WHO7.0022 Liberia. JKT 1. SJ 3, WHO Archives.

31. Poindexter to Acting Country Director, 5 August 1952, Annual Report Fiscal Year 1952, 6-7, Biennial Reports Folder, Box 3, Liberia Program Reports, Liberia Subject Files, RG469, NARA.

32. Austen to Daubenton, 3 December 1951, para. 6.

confirm his own estimate of the population. The project workers were hesitant to count the villagers for fear that they would be accused of helping the government to seize the villagers' food and livestock and that they would lose the confidence of the villagers.³³

In Monrovia proper, the malaria control program was struggling to cope with an ongoing economic boom. By 1952, the population of the capital had grown to somewhere between 10,000 and 15,000, with a considerable fluctuation of migrants. With Monrovia burgeoning, government officials began to push for an extension of the malaria control program into the rest of the country. The motivation was straightforwardly economic: to attract foreign enterprise to Liberia and to be able to offer an environment for investment that was free from malaria. This was a variation on the theme "malaria blocks development" that had earlier focused on the biophysical burden borne by malaria sufferers. Healthy workers would now attract investments. In Liberia, the "antimalaria" program was at the vanguard of development ideology.³⁴

In 1952, Dr. E. J. Pampana, chief of the Malaria Section of the WHO, assessed the Liberian situation. In his view, a new IRS model of malaria control would be required:

Monrovia, in spite of seven years of control activities, does not teach us anything as regards the solution of the problem of Liberia. There is no doubt that malaria is hyper-endemic all over the country, that it causes a very severe death rate amongst children and is certainly responsible for some deterioration in the physique of young people and perhaps for the apathy of the indigenous population. On the other hand there is no reason why, once a simple, efficient and economical method of insecticide application is found, Liberia could not try to control malaria with its own personnel in the areas of greatest developmental importance.³⁵

33. *Ibid.*, para. 12. For an overview of Americo-Liberians' exploitation of the peoples of the interior, see M. B. Akpan, "Black Imperialism: Americo-Liberian Rule over the African Peoples of Liberia, 1841-1964," *Can. J. Afr. Stud.*, 1973, 7, 217-36. For economic evidence on the government "requisitioning" of crops and livestock without compensation and forced labor recruitment, see Robert W. Clower, George Dalton, Mitchell Harwitz, and A. A. Walters, *Growth without Development: An Economic Survey of Liberia* (Evanston, Illinois: Northwestern University Press, 1966), 17-20.

34. A. Avery-Jones, "General Summary of the Situation of Malaria Project Liberia-5" [1956], 1, SJ 3, JKT 2, Liberia, WHO7.0022, WHO Archives.

35. Pampana, "Report on My Visit to Liberia."

In 1952, the USPHS personnel in Monrovia made the decision to switch from DDT to dieldrin, known as DLD. (It was not appreciated at the time that DLD was a more toxic pesticide with potentially more serious effects on human health.) The major advantages seemed to be that the chemical was stable and remained toxic even in contact with iron and aluminum and that it appeared to have a longer residual effect. It thus promised the possibility of a once-per-year spraying regime that would drastically reduce the labor and materials costs of the malaria control program.

THE DIELDRIN CAMPAIGN IN MONROVIA (1953–1957)

The DLD campaign in the greater Monrovia area was launched in September 1953, and the initial results were highly positive. The United States International Cooperation Administration (ICA) malariologist noted that, after spraying the houses in Monrovia, Bushrod Island, and Sinkor, the anopheline mosquito populations dropped dramatically and that both the adult and the larval populations remained at low levels. Moreover, whenever adults and larvae were found, they were always associated with a significant number of unsprayed houses. Treating the unsprayed houses immediately brought about dramatic reductions in the breeding pools.³⁶

Progress was rapid. By August 1954, the spraying program had been so successful that the malaria control teams could find no vector larvae in Monrovia. Then DLD resistance began to emerge, and by 1955, the control program had shifted back to the use of DDT in Monrovia on a twice-yearly basis. The NPHS of Liberia began to take part in the operations, and the Americans drew down their staff, and by 1956, there was only one American participant.³⁷ And from March 1956 until 1957, the vector prevalence was regularly monitored. The teams appeared to have achieved the local eradication of the malaria vectors, a significant achievement. As the

36. Kohler, "A Five Year Malaria Eradication Plan," 2. The spraying program also covered Tchien in the Eastern Province and Harper in Maryland County. In 1954, 8,493 houses had been treated and 52,716 people had been "protected." The Cooperative Liberia–United States Public Health Program (1954), 5, Liberia Programs Reports, Liberia Subject Files, Box 3, UD504, RG469, NARA.

37. Fred L. Soper, Visit to Africa [23 November 1959], 32, Fred L. Soper Papers, 1919–1975, MS C 359, History of Medicine Division, National Library of Medicine, Bethesda, Maryland.

final report noted: “The main thing we have accomplished is to prove that malaria control can be effective in the hyperendemic tropics and have created an organization which can expand to cover the whole country as more people are available.”³⁸ The accomplishment was limited to Monrovia, but nonetheless the success was real. It had been achieved despite the loss of trained men who quit their jobs to go to the diamond fields and the time-consuming necessity of training the replacements.³⁹

BEYOND MONROVIA: MOSQUITO CONTROL IN KPAIN, CENTRAL PROVINCE (1953–1958)

In 1953, the WHO in collaboration with UNICEF, launched an antimalaria program in the upcountry of Central Province, as one of the first pilot projects to investigate the feasibility of malaria eradication in tropical Africa.⁴⁰ The extension of malaria control into the interior of Liberia posed new challenges. One was architectural. The upcountry houses were not like the houses in the greater Monrovia area. They were built from timber, rather than laterite clay, and the roofs were not close fitting. The weight of the house structure was borne by heavy-uprights and joists, rather than by mud walls. Mosquitoes flew unimpeded through the wide gaps at the eaves.⁴¹

A more intractable problem arose from the rhythms of the rural agricultural economy. In the towns of the interior—that were accessible by a motorable road and had one or more Lebanese trading stores—only a quarter to half of the houses were occupied during the daytime. Nighttime occupation rose to 80 or 90 percent. In the villages—that typically could only be approached on foot

38. “Malaria Control Activities, National Public Health Service—R.L. February 1957. Monthly Report,” 1, SJ 1, JKT III, Liberia, WHO7.0022, WHO Archives; Kohler, “Malaria Control Terminal Report 1957,” 9–10.

39. “Malaria Control Activities, National Public Health Service—R.L. March 1957. Monthly Report,” 2.

40. James L. A. Webb, Jr., “Malaria Control and Eradication Programs in Tropical Africa, 1945–1965,” in *The Challenge of Malaria: Lessons from the Past and Future Prospects*, ed. Rick Bucala and Frank Snowden (New York: World Scientific Publishing, in preparation); Matthieu Fintz, “Moustiques et gouvernement du paludisme en Afrique: De la conservation de la nature à l’organisation du marché des biens de lutte” (Thèse de doctorat en science politique, Université Robert Schuman—Strasbourg III, 2004).

41. R. Elliott, “Report on a Consultant Appointment to Project Liberia 16” (1958), 5. WHO AFR/MAL/17, WHO Archives.

and sometimes required up to twenty miles of rough walking from a motorable road—the daytime residents were mainly the sick, aged, or the disabled. Nighttime occupation in the villages, as in the towns, was around 80 or 90 percent. Spraying could only take place during the daytime hours and during the dry season, from November through April. During the wet season, many farmers stayed near their fields and slept in their open shelters.

During the dry season, most adults and children worked their fields and were gone during the daylight hours. In their fields, they built other structures—usually a “rice kitchen,” which was a sizeable structure with an open ground floor and a substantial ceiling with an upper-storey storage granary, and a “farm kitchen,” which had the same open architecture without the storage granary. The storage granaries were a common resting place for the vector mosquitoes (and hence offered logical surfaces for insecticide application), but they were kept locked, and thus were inaccessible to the spray teams who found their way into the fields. In practice, this happened infrequently, because the farmers refused to tell the spray teams where their rice kitchens were located because they sensed that sharing this information would leave them vulnerable to predation by Liberian government workers.⁴² As one observer noted bluntly: “No villagers will direct the spraying squads and they will never say where the rice kitchens are located.”⁴³ The farm kitchens were accessible only by discontinuous forest paths, and only the local people knew the traces.

By contrast, the enthusiasm for the extension of the antimalaria campaign into the upcountry on the part of the international community was great. It bubbled up from the success in Monrovia and from the support that was building for the idea of a WHO-led global malaria eradication campaign. Although Dr. Pampana of the WHO had stressed the need for experiments to determine the best means of control, within Liberia the antimalaria program went forward without much in the way of planning. For this reason, from its beginnings, the upcountry spraying campaign evolved as a cavalcade of errors. As in the greater Monrovia area, there was no

42. Elliott, “Report on a Consultant Appointment,” 6–7, 33.

43. Dr. P. C. Issaris, “Report on the Joint UNICEF/WHO Malaria Project, Kpain (Liberia) [25 March to 10 May 1957],” 7, SJ I, JKT III, Liberia 1957–1967, WHO7.0022, WHO Archives.

malariological survey before the IRS campaign began, and thus no baseline data of infection against which to measure progress. Nor was there an entomological survey. The project directors simply assumed that the same vector that was principally responsible for malaria transmission in Monrovia—*Anopheles gambiae*—had the same epidemiological significance in the upcountry. This, alas, was not the case.

In haste to protect the largest number of people in the shortest possible time, the campaign began along the northern terminus of the Monrovia–French Guinea road and its spurs. The approach was to spray along the ribbons of the road network. The logistics were daunting. The spraying could only take place during the dry season; materials had to be brought 180 miles by road from Monrovia to the project headquarters at Kpain; and soon a shortage of transport vehicles brought the project to a near standstill. Moreover, the spraying along the ribbons of roadway was uneven. At frequent intervals, strips of unsprayed areas were left as “check areas.” These would normally have been at considerable distance from a sprayed area, to prevent the easy infiltration of mosquitoes. On top of this confusion was layered a poorly considered effort to try out a variety of different insecticides at various dosages. Some areas were sprayed with DLD, others with BHC, and yet others with DDT. The result was that a practical evaluation of the differential effectiveness of the insecticides was impossible.⁴⁴

The logistics of the project were further complicated by the fact that during the wet season, the local roads were barely negotiable. The team leader, Dr. W. Müllhausen, paid visits to the local authorities in Voinjama and Kolahun in the nearby Western Province in May 1957. The distance between the two towns was twenty-six miles, but the trip took nine hours and involved crossing sixty-two “bad” bridges, “reconstructing” twenty bridges by adding planks, and frequent unloading of the heavily packed cars because the bridges would not bear their weight.⁴⁵

44. M. E. C. Giglioli, “Report of the Entomologist 1955–1957,” 4, WHO AFR/MAL/4, WHO Archives.

45. Dr. W. Müllhausen to the Regional Director, AFRO. Monthly Report, May 1957, 1, WHO/UNICEF Joint Malaria Project, Kpain, Liberia, SJ 1, JKT III, Liberia, WHO7.0022, WHO Archives.

During the rainy season, the inundations also caused damage to the walls of the upcountry houses and huts. Rural Liberians seasonally replastered their walls to repair the damage. When the malaria team members became aware of replastering, they realized that the newly applied wall surfaces would likely diminish the utility of the residual spray, and that the replastered buildings might have to be re-sprayed. This possibility challenged the pretension to full coverage, and there was no surveillance network to alert the sprayers to the instances of replastering.

In 1955, the enthusiasm generated by the formal commitment of the WHO to the global eradication of malaria raced through the malaria control projects. Yet by 1956, at least one prescient specialist had realized that the eradication project in Liberia could not meet its goal. The larger significance of the replastering problem was apparent to the consulting entomologist M. T. Gillies. He noted:

If... effective coverage with the insecticide of all inhabited shelters is not possible, then the only rational policy left open would be the abandonment of the attempt at country wide spraying and its replacement by an intensification of treatment centres. Such a suggestion, in the heady atmosphere of eradication schemes, may sound retrogressive and heretical. But to this outside observer at least, it appears that the problems of Liberia (which in some ways are unique) may ultimately force the international organization concerned to adopt this unpopular policy.⁴⁶

In 1956, the upcountry malaria control program opened a new portfolio, engaging the Gillies' suggestion that medical treatment had to be part of the assault on malaria. The WHO/UNICEF project received a supply of antimalarial drugs as a supplement to the IRS campaign.⁴⁷ The drugs were dispensed initially in a haphazard manner: the health propagandist at Kpain, on the orders of Dr. Müllhausen, the team leader, handed out the pills freely to children that he encountered in the villages, and Müllhausen himself reportedly gave to each child from whom he took blood a

46. M. T. Gillies, "Report on a Travelling Fellowship to Study Malaria Control Problems in West Africa (June-September 1956)," 3, SJ 2, WHO7.0200, WHO Archives.

47. General Progress Report of Executive Director: Programme Developments in Africa, 18 February 1956, para. 35, WHO. E/ICEF/309/add.2, WHO Archives.

Nivaquin pill.⁴⁸ Müllhausen was worried about the impact of the IRS program on the immunological status of the children. As he wrote to the WHO Regional Director: “If the houses are sprayed, they will not get infection during this time and they might lose [*sic*] some immunity, so that the children get probably worse attacks by re-infection while staying in the farms for the other months.”⁴⁹

How effective was the spraying? Had the rates of malarial infection declined as a result of the interventions? Here—as with the issue of the differential effectiveness of insecticides—it was necessary to have baseline data, and the best measure was the parasite rate in human blood samples. (The less expensive, but less telling diagnostic test was palpation of the spleen. The percentage of people found to have distended spleens was expressed as a “spleen rate.”) The rural townspeople, however, were uncooperative. The default was to examine schoolchildren; but because the students’ homes were often far away from the schools, their parasite rates did not reflect the local parasite rates in towns where the schools were located. Some medical officers secured the support of the local chiefs and District Commissioners and arrived with an escorting soldier and forced the townspeople to comply.⁵⁰

The project’s activities were concentrated on the inhabited areas along the main roads. Although the team claimed that they covered a depth of twenty miles on either side of the roads, large areas were never explored and uncounted hamlets and rice kitchens went unsprayed. Moreover, the work of the spraying squads was impossible to supervise fully. In principle, teams of six spray men went into villages with two supervisors, and in the best-case scenario, two of every six houses were checked for quality. Many supervisors, however, stayed in town taking care of private business rather than accompanying their teams into the bush.⁵¹

48. Dr. K. W. C. Sinclair-Loutit, WHO Medical Advisor, UNICEF-AERO, “Report on a Visit to West Africa [4–11 April 1957],” 3, SJ 1, JKT III, Liberia, WHO7.0022, WHO Archives.

49. Dr. W. Müllhausen, “The Activities of the Malaria Team for the Quarter January–March 1957 (Quarterly Report),” 2, SJ 1, JKT III, Liberia, WHO7.0022, WHO Archives.

50. “Reports on the Haematological Malaria Survey 1956. [2 May 1957],” 1, SJ 1, JKT III, Liberia, WHO7.0022, WHO Archives.

51. Dr. P. C. Issaris, “Brief Report on the Joint UNICEF/WHO Malaria Project. Kpain (Liberia),” 22 May 1957, 1–2, SJ 1, JKT III, Liberia, WHO7.0022, WHO Archives.

The WHO retrospective assessment held that even in the easily accessible villages the insecticide coverage was incomplete. Some houses were left unsprayed. The DLD spray cycle was on an annual basis, but no consideration was given to the importance of completing the spray cycle before the peak mosquito breeding season. Moreover, the rural villagers replastered their houses frequently and rebuilt houses and even entire villages in the course of the year. The result left “a great percentage” of houses unsprayed in most areas.⁵²

One consequence of the uneven rate of coverage was that the parasite rates of infants varied widely. One important variable was whether the infants slept inside or outside the sprayed houses. Yet even in the heavily sprayed areas, the infant parasite rate was never suppressed below 29 percent.⁵³ There was a series of other difficult issues. The team suffered interpersonal conflicts among the expatriate staff, and the lines of authority over the Liberian staff members were blurred. When Dr. M. E. C. Giglioli, the WHO entomologist, discovered that one of the chief insect collectors had been submitting false reports to him for three continuous months, he demanded that the collector be fired. The Liberian administrator intervened to save the man’s job.⁵⁴ Giglioli resigned in July 1957, amid charges from Müllausen that he, in turn, had not done his job.⁵⁵ By 1957, resistance to DLD was confirmed and cross-resistance to BHC was reported. In the WHO project area, *A. gambiae* had become highly resistant.⁵⁶ By the second half of 1957, resistance to DLD had become widespread, and spraying operations were suspended in February 1958.⁵⁷ The project had not

52. O. Mastbaum, “Report on the Joint UNICEF/WHO Malaria Project, Kpain (Liberia) [1957],” 3, AFR/Mal/8, WHO Archives; Guttuso, “Kpain (Liberia) Malaria Project,” 4.

53. Dr. P. C. Issaris, “Report on the Joint UNICEF/WHO Malaria Project, Kpain (Liberia) [25 March to 10 May 1957],” 5, SJ 1, JKT III, Liberia 1957-1967, WHO7.0022, WHO Archives.

54. Issaris, “Brief Report,” 3.

55. UNICEF ICA. Malaria Control Project 2.1.4. TA (LIR-16), Liberia-5, 1, SJ 1, JKT III, Liberia, WHO7.0022, WHO Archives. Giglioli got in the last word. As he observed in an official WHO report after he had been posted to Nigeria, “This debacle of the Project is an excellent example of the results of planning scientific work on a basis of political expediency” (Giglioli, “Report of the Entomologist 1955-1957,” 4).

56. C. D. Ramsdale, “Report on a Visit to Liberia for the Testing of Dieldrin-Susceptibility in *A. Gambiae* (18 October-4 December 1957),” 14, WHO/MAL/198, WHO Archives.

57. Dr. C. Guttuso, “The Kpain (Liberia) Malaria Project,” 30 May 1962, 1, WHO AFR/MAL/61/43, WHO Archives.

only failed; it had set the stage for a resurgence of malaria by decreasing acquired immunity among children by only temporarily interrupting malaria's prevalence.

Toward the end of the project, in 1957, Müllhausen reported that an epidemic of malaria was exacting an extraordinary toll in morbidity and mortality—on the order of 25 percent—from infants and children. The local malaria team launched an emergency treatment program with chloroquine, but a WHO report disparaged the effort on the grounds that it would have little effect on future malaria control. “Such a rather ill-planned and unmethodical drugging may have some propagandistic value and may be prompted by humanitarian consideration, but their [*sic*] value as an effective means of malaria control is more than doubtful, especially in view of the fact that according to inquiries made only a small proportion of sick children could be treated as at this time of year the majority of the people live in rather inaccessible shelters on their farms.”⁵⁸

The impact of the IRS program on the immunological status of the adult villagers was also marked. The initial use of DLD had been highly effective in interrupting malaria transmission, until the emergence of resistance. During this period of interrupted transmission, the acquired immunities of the adult villagers began to degrade. After the emergence of resistance to DLD and the re-establishment of transmission, a malaria epidemic surged through the adult villagers. The project staff measured spleen rates and had no doubts. As a quarterly project report concluded, “vector resistance to DLD [dieltrin] has been followed by a malaria epidemic of which the adult spleen rate obtained in the Project Area is ample proof.”⁵⁹

The WHO program that began in 1953 lasted for five years. The “protected” population was sizeable and increased over the life of the project (Table 1). Was the Kpain project worth following up? What lessons were to be drawn from it? The WHO position was that the Kpain program had been so poorly led and executed that it would have been highly improbable if it had achieved the

58. [n.a.], “Report on the Joint UNICEF/WHO Malaria Project, Kpain (Liberia),” 2, SJ 2, JKT III, Liberia, WHO7.0022, WHO Archives.

59. Republic of Liberia, UNICEF-WHO Malaria Project, Kpain (LIB 16). Second Quarterly Report (July–September 1959), 22, SJ 4, JKT III, Liberia, WHO7.0022, WHO Archives.

TABLE 1

Estimated Population Protected by the Kpain Malaria Project,
1953–1957^a

Year	Population
1953	54,000
1955	142,000
1956	200,000
1957	300,000

^aDr. C. Guttuso, “The Kpain (Liberia) Malaria Project,” 30 May 1962, 1, WHO AFR/MAL/61/43, WHO Archives.

interruption of malaria transmission. The WHO decided to fund a new project at Kpain, staffed by a malariologist, an entomologist, and a sanitarian. The expectation was that it could achieve the interruption of malaria transmission and thereby pave the way toward eradication.⁶⁰

THE ICA/UNICEF/LIBERIAN GOVERNMENT PILOT PROJECT IN
MONTSERRADO (1958–1962)

In 1958, the Government of Liberia (GOL) in collaboration with the International Cooperation Administration (ICA) of the U.S. State Department and UNICEF decided to open a new field of antimalaria operations immediately inland from the greater Monrovia area, to build upon the success of their earlier program. The insecticide of choice was DDT, and in 1958, the spray campaign in the Montserrado region began. As early as 1959, however, major difficulties loomed. Some 6 percent of rural Liberians refused to open their houses to the spray teams, and the buzzing nuisance culicine mosquitoes, rather than the silent anophelines, had become resistant to DDT.⁶¹ The two issues were directly linked—because one of the immediate benefits of the IRS program was that it eliminated nuisance mosquitoes, and when this benefit was lost, the percentage of “spraying refusals” would climb. The UNICEF/ICA

60. Report of Meeting of Regional Malaria Advisors from 29 July to 9 August 1959, 56, WHO. M2/87/13+ Annex, WHO Archives.

61. Soper, Visit to Africa, 32.

project assessment was blunt: “The general conclusion to be drawn from these and similar surveys in Liberia is that in rural areas residual house spraying is not sufficient for interruption of transmission. It is expected that more efficient control will be achieved by insecticides supplemented with mass-drug treatment.”⁶²

ROUND TWO: THE KPAIN PROJECT, 1958–1962

At the WHO Technical Meeting on Malaria convened in Brazzaville in December 1957, specialists agreed that the pilot projects to date throughout West Africa had failed to achieve the interruption of transmission, and that new projects should include large-scale experiments in mass drug administration. Because the cost of training special health teams to record the dispensation of drugs was very costly, mass drug administration typically meant that the spray teams would leave behind tablets with heads of family who, in principle, would hand them out to family members who were away in the fields or give the tablets to the village chiefs who would then hand them out to the villagers.⁶³ In theory, this would ensure a low-cost chain of supply that would extend to the hard-to-reach villagers. The issue of actual usage—who took the antimalarials, in what doses, and how this would be measured—was not broached.

The new Kpain project, far smaller in scale than the first, would thus attack both the vector *and* the reservoir of parasites within the human population—what was termed “the human factor.” It was planned for the upcountry towns of Bahn and Saniquellie, which were readily accessible from the Kpain headquarters and had a combined population of about 45,000–50,000. The initial malaria eradication operations had started in this region, and even after four continuous years of IRS, the malaria indices had stayed very high.

By design, half the population would be treated with IRS and mass drug treatment and the other half with only IRS. The Bahn sector (population 24,000) would receive IRS and drug treatment with chloroquine and pyrimethamine. To accomplish this, the Bahn

62. UNICEF ICA. Malaria Control Project, Liberia-5 (LIR-16), 3, SJ 1, JKT III, Liberia, WHO7.0022, WHO Archives.

63. M. A. C. Dowling, “The Use of Mass Drug Administration in Malaria Projects in the African Region [1960].” Technical Meeting on Chemotherapy of Malaria. Working Paper No. 44, 2, SJ 2, JKT VII, WHO7.0202, WHO Archives.

sector was to be divided into four sub-sectors as treating units, and a total of sixteen “treaters” would be employed. The Saniquellie sector would receive IRS alone.⁶⁴

The “human factor,” however, was a lot more complicated—and mobile—than the project designers appreciated. Residents of the Bahn sector, in particular, frequently traveled to French Guinea where malaria was also hyperendemic and residents of French Guinea frequented the Bahn sector. This regional epidemiological integration was not factored into the program, despite the fact that the problem had been laid out clearly by the Haematological Malaria Survey reports in earlier years: “The movement of the [Bahn] population is variable—many of them like to stay for a long time in the adjacent French colonies, where no spraying is carried out. On the other hand many visitors and traders from other African countries can be found here regularly, which results in a complete mixture of all West African strains of malaria (and other) parasites.”⁶⁵

In September 1958, the first DDT spraying cycle began. The entomological realities had shifted enormously. *Anopheles funestus* had been all but eliminated from the upcountry regions that had been sprayed, and into its ecological niche flitted the *A. gambiae*, formerly a minor upcountry vector. In this second round of the Kpain malaria project, the Liberian government took steps to neutralize the resistance of the villagers. It issued signed letters of authority to headmen, and pressured chiefs and local authorities to facilitate the work of the malaria teams. The “plan-ops” called for twice-yearly spraying with DDT, and the first two spray cycles met with grand success. IRS with DDT caused *A. gambiae* to disappear from the larger settlements. Emboldened by this achievement, the project managers took the next logical step. They shifted the focus of the spraying teams to the rice kitchens, farms, hamlets, and the small settlements.

Here the rate of progress of the teams was slower—and the field of operations was larger—than had been anticipated. The number of rice kitchens was found to equal or exceed the number of permanent houses. The spray teams fanned out into the remote countryside. This was extremely time-intensive work. Dr. Guttuso, the project director, insisted on thoroughness—the spraying of the

64. Issaris, “Report,” 9–10.

65. “Reports on the Haematological Malaria Survey 1956. [2 May 1957],” 2.

entire interior of all of the village houses and of all the isolated farm shelters.⁶⁶ The expanded field of work was beyond the means of the spray teams, and in their efforts to cover more ground, the insecticide spraying cycle lapsed from twice to once per year.

The shift to DDT also necessitated some logistical adjustments. DDT was packaged in unwieldy 200 lb drums. The initial plan was for “specially selected” porters who could handle heavy loads, organized in four-man teams, to carry the drums using a hammock. This proved impractical when winding down narrow trails in the bush and in fording streams. Because the rice kitchens were often at great distance from one another and each required only a small amount of insecticide, the porters transferred the DDT into the small DLD drums of 40 lbs each. And as the malaria work expanded, the labor arrangements also had to be revamped. The men who initially had been “selected” as unpaid insecticide porters had labored under compulsion from the village chiefs. During the following year (1959), the system of forced labor was reformed to one of compensated labor.⁶⁷

As the work advanced, the scientific surveys from a few fully sprayed areas turned up good news. The laboratories at Kpain reported that both the mosquito dissections and the human blood surveys were negative for parasites. Yet at the same time, diamonds were discovered in the project region, and migrants began to flood in. They built houses that went undiscovered and thus unsprayed. The parasite rates of infants who had been born in, and had remained in, the sprayed areas were nil. Yet there was still malaria in the project region. The positive cases had been introduced—in what was known as “malaria without anophelism”; the increase in mining activity had drawn in parasitized workers from afar.⁶⁸

66. Fred L. Soper, Memorandum on Trip to Africa and Geneva, October 31st to December 10, 1959, 2, Folder 3, Box 13, Fred L. Soper Papers 1919–1975, MS C 359, History of Medicine Division, National Library of Medicine, Bethesda, MD.

67. Dr. L. J. Bruce-Chwatt, “Report on a Visit to Ghana, Liberia, and Gambia (7–23 January 1959),” 12, SJ 4, JKT III, Liberia, WHO7.0022, WHO Archives. [Bruce-Chwatt was a leading malariologist who had worked extensively in Nigeria. He was one of the foremost advocates for experimenting with IRS spraying in tropical Africa to explore the prospects for malaria eradication.]

68. Afro Malaria Year Book No. 2. December 1960, 141, WHO. AFRO/MAL/7, WHO Archives.

Soon thereafter, *A. gambiae* built up its numbers in the unsprayed houses, and the transmission of malaria was reestablished.

By 1959, other serious problems were emerging. The old DLD and BHC zones had been re-sprayed with DDT, and there were reports of an increasing tolerance of *A. gambiae* to DDT, although laboratory tests did not corroborate the reports. At the project headquarters at Kpain, visitors in mid-1959 described critical lapses. Only one of the two zones had been sprayed; the laboratory technicians had no blood slides to analyze; and the distribution of antimalarial drugs had ground to a halt. A major constraint was transport. Only three vehicles were in working condition, and there was no mechanic who knew how to fix the vehicles that were out of repair.⁶⁹

Could the problems be addressed through economies of scale? One possibility was to fold the smaller ICA/UNICEF/GOL pilot project into the WHO project. The smaller project involved a program of spot spraying in Monrovia and the Montserrado region, just inland from Monrovia. Yet the execution of the ICA/UNICEF/GOL program was haphazard at best. The former Rockefeller Foundation malariologist, Fred L. Soper—who had led a successful species eradication campaign in Brazil and was now director of the Pan American Sanitary Bureau—was highly critical of the organization of the spraying campaign. As he noted in his diary, “There are no maps, the houses are not numbered, the only number in use is the numerical order of the house in the day’s work of a squad in a certain district of the city; there is no way in which the past work of individual squads can be evaluated; no-one knows how many houses nor in what districts the service is responsible for; men doing work get different pay scales according to the circumstances of their employment; range for spraymen from \$17.50 to \$35.00 monthly.” He judged the larvicidal operations to be no better.⁷⁰

69. Dr. R. Marti and Dr. R. Lavoipierre, “Visit to Liberia (18th–26th May 1959),” 7, SJ 4, JKT III, Liberia, WHO7.0022, WHO Archives.

70. Dr. Fred L. Soper, a physician and epidemiologist who became the director of the Pan-American Sanitary Bureau in 1947, was a leading authority on malaria control as a result of his successful work for the Rockefeller Foundation in Brazil in eradicating an introduced African anopheline species. See his *Visit to Africa* and other papers in the National Library of Medicine, cited above. By 1959, Dr. Togba had invested many of his energies in business opportunities: in a taxi business, trucking business, rubber plantation,

In addition to the deficient management, other sticking points made collaboration difficult. By U.S. law, the ICA could only hire Americans and Liberian nationals. And if there were to be institutional cooperation, on what basis would it take place? Soper pushed for an integration of the antimalaria programs and for the participation of all institutions on the same projects on a percentage basis.⁷¹ This was not to be. The WHO funding for the Kpain project ended in 1961.⁷² As the guiding hand of WHO sponsorship faded, the professional antimalaria project staff in Kpain arranged to be transferred back to Monrovia; the NPHS withdrew five UNICEF vehicles from Kpain and jettisoned administrative oversight procedures.⁷³ Malaria control quickly unravelled.

ASSESSMENTS

The malariological lessons were many, complex, and difficult to assimilate. On the technical side, the most striking lesson was that DDT's impact was both immediate and long lasting. In some areas that had been left unsprayed during the second cycle, the DDT residue was still active as long as twenty-six months after spraying, even though full coverage had not been achieved. On the conceptual side, the campaigns overturned the notion of a static rural malaria problem in tropical Africa. By the end of the project, the project staff recognized that the malaria problem was a dynamic one. The large number of migrants who flowed in and out of the "industrial" zones and the movement of people between the Liberian upcountry into Sierra Leone and French Guinea portended a complicated program that would have to extend across political borders. In the upcountry of Liberia, the boundaries of the tropical African state clearly did not constitute a workable unit of epidemiological intervention. Effective malaria control or

mining, and lumbering. Soper judged Togba to be in the millionaire class and to spend more time on his private businesses than on the Department (Soper, *Visit to Africa*, 33). In 1960, Togba was arrested and imprisoned on charges of embezzling \$209,000 in government funds (*Jet*, 17 March 1960, 50.).

71. Soper, *Visit to Africa*, 15.

72. Guttuso, "The Kpain (Liberia) Malaria Project," 5.

73. Dr. C. Guttuso, "Report on a Visit to Liberia. July 1962," 7, SJ 5, JKT III, Liberia 1957-1967, WHO7.0022, WHO Archives.

eradication in Liberia—and elsewhere in West Africa—would require close collaboration between neighboring states.

In financial terms, the costs of the WHO antimalaria project were higher than had been anticipated. The IRS program alone far exceeded estimates. This was principally a function of the average surface per capita that had to be sprayed. Originally estimated at forty-four square meters, in practice the figure was at least 100 square meters per capita. This was owing to the large number of crop huts and to the fact that the houses were frequently built over six meters in height, and *A. gambiae* could be found resting in the apices. This greater surface area, in addition to the time necessary to locate and travel to the rice kitchens and to spray the houses' high ceilings, drove the cost "through the roof."⁷⁴ The 1959 monthly program of mass drug administration also proved administratively complex and expensive, and it was abandoned. Mass drug administration had reached only six thousand recipients, a much smaller number than anticipated.⁷⁵

The DDT spraying operations by themselves proved remarkably effective in reducing mosquito density. *Anopheles funestus* had been the most important malaria vector in the Liberian countryside, and it had proved highly vulnerable to DDT. As *A. funestus* died off, however, *A. gambiae* had moved into its ecological niche. Some specialists suspected that the initial susceptibility of *A. gambiae* to DDT was the result of its imperfect adaptation to the new environment. The implication was that as its adaptation improved, *A. gambiae* would become less susceptible to spraying operations.⁷⁶

Faced with these divergent, complex, and incomplete results, the WHO crafted an interpretation of the Liberian antimalaria campaign as troubled but ultimately successful. They identified the main constraints as the high costs of the project and the lack of the administrative capacity to manage the project. The WHO characterized the participation of the Government of Liberia as "exemplary."⁷⁷ The WHO claimed that the interruption of malaria

74. Afro Malaria Year Book No. 2. [December 1960], 141, WHO. AFRO/MAL/7, WHO Archives.

75. Ibid.

76. Guttuso, "The Kpain (Liberia) Malaria Project," 5–9.

77. Afro Malaria Year Book No. 2. [December 1960], 142. In late 1959, President Tubman allocated \$100,000 for the suppression of annoyance mosquitoes in Monrovia

transmission had been achieved with IRS alone, although some specialists did not support this claim because it implied a *sustainable* interruption of transmission. The movement of parasitized in-migrants and the migrants' construction of new buildings in the project zone had facilitated the rapid re-establishment of transmission.⁷⁸

The WHO did not give any retrospective consideration to the medical consequences of re-infection in populations that had had their acquired immunities to malaria compromised by the antimalaria programs, even though those who were directly involved with the projects had observed the onset of epidemic malaria in the adult population. The WHO assessment was also silent on the issue of post-project epidemic malaria among children.

DÉNOUEMENT

By 1962, following on a series of early pilot projects across tropical Africa, WHO malaria specialists had come to the view that, while technically feasible, the logistical and financial problems of eradicating malaria in tropical Africa were insurmountable at the present time. The best approach was thought to be to encourage the establishment of a "pre-eradication" program in the newly emerging independent African states. In addition to the training of technical personnel, a key component of the "pre-eradication program" was to be the development of a rural health infrastructure that could serve as the basis for the program. In principle, this would allow for the efficient treatment and cure of severe malaria.

In July 1962, at Yaoundé, Cameroon, the WHO convened a conference on African malaria that included the WHO, NPHS of Liberia, and USAID. All were agreed on the need to establish a WHO pre-eradication program for Liberia. Definitive decisions, however, were being taken elsewhere. In Monrovia, USAID had

during his 1960 presidential inauguration. He went over the heads of his health officials to do so (Soper, *Visit to Africa*, 13).

78. In a pilot project in South Cameroon, the WHO did achieve the interruption of malaria transmission in the sprayed zone around Yaoundé; the WHO position was that the interruption of transmission had been "virtually obtained" in the western highlands of Uganda. ("The Malaria Eradication Programme in the African Region, January 1965, 1-2, WHO. AFR/MAL/67. WHO Archives.") For a general overview of the pilot projects, see Webb, "Malaria Control and Eradication Programs in Tropical Africa, 1945-1965."

signed a new program agreement with the Liberian government that lacked a rural health infrastructure component.⁷⁹ The program goal was simply to expand the residual spraying program into the interior, from Montserrado County into the Central Province, as quickly as possible. A new malaria control project began in Monrovia in 1962, aimed at protecting an urban population that had grown to 100,000. The WHO appointed a public health advisor who served for five years, from 1963 to 1968. The Liberian government never appointed a counterpart.⁸⁰ The Malaria Pre-Eradication Project was folded into the Department of Basic Health Services in January 1968, and the project headquarters shifted from Kpain to Monrovia.⁸¹ By 1970, when Dr. Arnaldo Gabaldón, chief of the Malaria Program at the WHO, visited Liberia, the antimalaria projects outside of Monrovia had collapsed. In Monrovia, the efforts were directed at nuisance, rather than vector, mosquito control. Gabaldón was unable to get any cooperation, data, or even an expression of interest about the malaria problem.⁸²

CONCLUSION

Before the antimalaria projects in Liberia, mosquito control efforts in West Africa had been concentrated in urban areas and on plantation or mining sites. Before World War II, drainage and larvicidal interventions had been effective in reducing the density of anopheline mosquitoes and the intensity of local malaria transmission. The projects had evolved on an ad hoc basis, taking account of local microenvironments. In the immediate postwar period, the Americans introduced malaria control with synthetic insecticides to Monrovia. The early successes of the mosquito control programs in

79. Guttuso, "Report on a Visit to Liberia. July 1962," 2.

80. [n.a.], Assignment Report, 20 September 1969, Liberia 0033 (ex-Liberia 20), AFR/MAL/96; AFR/PHA/44, SJ 1, JKT IV, Liberia 1968-1993, WHO7.0022, WHO Archives.

81. Dr. P. G. Lopez-Tello, "Assignment Report. Basic Health Services (Monrovia)," 1, SJ 2, JKT IV, Liberia, WHO7.0022, WHO Archives.

82. Small-scale malaria control projects in and around Monrovia flickered on and off for the next decade and a half. See Dr. Le Du and Mr. V. Ramakrishna, "Malaria Control in Liberia. Report of Missions Carried Out in 1974-1976 by a WHO Consultant Team," AFR/Mal/152, WHO Archives, and AFRO-memorandum from Dr. Wilfred S. Boayue To Dr. Comland A. A. Quenum, 29 April 1983, SJ 3, JKT IV, Liberia, WHO7.0022, WHO Archives.

the Liberian capital created a demand for “scaled-up” projects in the surrounding areas and in the “upcountry” of Central Province that dovetailed with the Government of Liberia’s political program of “unification.” A long list of difficulties troubled the early efforts at malaria eradication in upcountry Liberia and foreshadowed the sort of problems that would lead to the general retreat from malaria eradication efforts across tropical Africa by the mid-1960s.

The WHO assessment of the Liberian experience highlighted the institutional, logistical, and financial difficulties encountered by the pilot projects, and claimed that the goal of the interruption of malaria transmission through the use of IRS alone had been achieved. This underplayed some of the core challenges that the malaria eradication pilot project had encountered, and it did not address the issues of the medical consequences of the epidemic malarial re-infection of adults after the partial loss of acquired immunity or of the epidemic malarial infection of children.

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