PANAMERICAN HEALTH ORGANIZATION

WORLD HEALTH ORGANIZATION

XVIII PAN AMERICAN SANITARY CONFERENCE

XXII REGIONAL COMMITTEE MEETING

WASHINGTON, D.C., U.S.A.
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AEDES AEGYPTI

At its 64th Meeting, held in Washington, D. C., in June-July 1970, the Executive Committee examined the report on the topic "Status of Aedes aegypti Eradication in the Americas".

In Resolution VII, the 64th Meeting approved the steps taken by the Director and requested him to submit to the XVIII Pan American Sanitary Conference a report on the present status of the problem of Aedes aegypti-borne diseases in the Continent and a preliminary study on the cost-benefit relationship in programs for the prevention of those diseases.

In compliance with the Executive Committee's recommendation, the following documents are submitted to the Pan American Sanitary Conference:

Status of Aedes aegypti Eradication in the Americas, together with the following annexes:

1) Report of the Meeting of the Study Group on the Prevention of Aedes aegypti-borne Diseases

2) Annexes to the PAHO document "Policy Guide in Aedes aegypti Eradication, Revised August 1968"

3) Status of the Aedes aegypti Eradication Campaign in the Americas, December 1969

The firm selected to carry out the cost-benefit study has begun its work and has visited a number of countries along with a specialist consultant to ascertain and analyze the situation on the spot.

As soon as the study and conclusions are in the hands of the Pan American Health Organization, the relevant report will be submitted to the Governments.

By way of additional information, document PAHO/ACMR 9/16, Surveillance of Dengue in the Americas, is likewise attached as being closely related to the problem of Aedes aegypti.

Annexes

executive committee of the directing council

PAN AMERICAN HEALTH ORGANIZATION

working party of the regional committee

WORLD HEALTH ORGANIZATION

64th Meeting
Washington, D. C.
June-July 1970

Provisional Agenda Item 7

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28 May 1970
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STATUS OF AEDES AEGYPTI ERADICATION IN THE AMERICAS

The Directing Council of the Pan American Health Organization, at its first meeting held in Buenos Aires in 1947, called upon the Pan American Sanitary Bureau to solve the problem of urban yellow fever in the Western Hemisphere through the eradication of Aedes aegypti.

At the time the Pan American Sanitary Bureau received those instructions, Aedes aegypti had already been eradicated from Bolivia and from a large part of the territory of Brazil. With the exception of Canada, however, all the other countries and territories in the Americas were infested by the mosquito to a greater or lesser extent.

So far, the mosquito has been eradicated in the following countries and territories which at present are considered to be free of it: Argentina, British Honduras, Bermuda, Bolivia, Chile, Costa Rica, Ecuador, Guatemala, Nicaragua, Paraguay, Peru, Uruguay, and the Panama Canal Zone. Five countries, which had also completed eradication, were reinfested recently. They are Brazil, El Salvador, Honduras, Mexico, and Panama.

Besides these reinfestations, the problem of Aedes aegypti persists in the extreme northern part of South America, in the United States of America, and in the Caribbean area.

The presence of Aedes aegypti in those areas, in addition to the risk of diseases transmitted by the vector to which the infested countries and territories are exposed, has been the cause of the frequent reinfestations that have been occurring in the Hemisphere and is endangering the very success of the continental eradication program.

Seriously concerned by that situation, the Governing Bodies of the Organization, in successive resolutions, have called upon the countries and territories that are infested to complete the eradication of Aedes aegypti as soon as possible, since the success of the continental program can only be safeguarded if the present sources of reinfestation in the Americas are rapidly eliminated.

The XVII Pan American Sanitary Conference, held in 1966, approved Resolution XIX, which instructed the Director of the Bureau to take all necessary measures to intensify and accelerate the continent-wide campaign, and to study and put into practice appropriate systems for ensuring that Aedes aegypti eradication was carried out, simultaneously and in a coordinated manner, in all the infested areas.

In implementation of the resolutions of the Governing Bodies, the Pan American Sanitary Bureau, in the last three years, has undertaken a number of activities for the coordination, stimulation, and acceleration of eradication, including the following:

(a) Conference on Aedes aegypti in the Americas. Held in Washington, D. C., from 3 to 5 April 1967; attended by representatives of almost all the countries in the Americas, who made a complete review of the continental eradication program.

(b) Study Group on Aedes aegypti Eradication. Met in Washington, D. C., from 6 to 12 April 1967, and made an in-depth study of the obstacles to the advance of the campaign, discussed measures to be taken to overcome those difficulties, and plans for simultaneous and coordinated campaigns in infested countries and territories, and formulated a set of recommendations on the organization and maintenance of proper surveillance services in areas already free of the mosquito.

(c) Study Group on Laboratory Colonies of Aedes aegypti. Met in Washington, D. C., from 17 to 19 July 1967, attended by recognized authorities in that field, who recommended ways and means of eliminating colonies as well as the basic criteria for the maintenance of colonies considered to be essential.

(d) Advisory services to countries and territories, including assistance with the planning, organization or reorganization of their campaigns. Assistance in training personnel and evaluating programs.

(e) Limited supplies of equipment, insecticides, vehicles, and materials as an incentive to certain infested or reinfested countries and territories.

(f) Study Group on the Prevention of Aedes aegypti-borne Diseases. Met in Washington, D. C., from 9 to 14 February 1970, and thoroughly reviewed the strategy for the prevention of Aedes aegypti-borne diseases, methods used and available for their control or eradication, and also defined the fundamental aspects to be taken into consideration in a cost/benefit study of different situations. The report of this meeting is contained in Addendum I of this document.

Encouraging developments that occurred in 1969 and in early 1970 were the initiation of the program in Guadeloupe, French Guiana, Martinique, and the Cayman Islands; the reorganization of the campaigns in Barbados,

Guyana, St. Lucia, and Surinam; completion of preparations for the attack phase to begin in Antigua, Netherlands Antilles, Grenada, and Montserrat; and the organization of a campaign to be undertaken in Dominica, Jamaica, and St. Vincent.

Although these developments indicate progress, much remains to be done before the continent-wide Aedes aegypti eradication program is completed. It is therefore necessary for the countries to ensure that the administrative and financial conditions of the programs must be such as to ensure the proper development of the whole process leading to the eradication of Aedes aegypti, as defined by the Study Group in 1967. Basically, these conditions are as follows:

(a) A firm decision on the part of the Government to eradicate the mosquito, and to assume the responsibility that eradication involves.

(b) Sufficient funds to cope uninterruptedly with the personnel, supply, and equipment requirements of the campaign, until such time as the eradication of the vector is achieved.

(c) Appropriate organization, on a national scale, to enable the campaign to perform its activities in a uniform and coordinated manner throughout the country.

(d) Administrative independence and flexibility, whereby the campaign can handle its budget without bureaucratic interference; establish conditions of employment of its staff; fix salary scales and per diem allowances; engage, transfer, discipline, or dismiss its personnel without delay or difficulty.

(e) Legal provisions giving the campaign authority to quickly enforce its decisions, and to adopt without delay the necessary measures to eradicate the mosquito.

The efforts, both of the governments and of the Bureau, are described in the following pages, which contain a summary of the status of the campaign in each of the countries and territories in which the Aedes aegypti eradication problem still exists.

Barbados - The results achieved up to 1967 were limited by various obstacles, the chief ones being insufficient funds, which made it impossible for the campaign to recruit sufficient personnel to cover the infested areas of the country adequately; the large number of houses that were neither inspected nor treated, or were only partially inspected and treated; and the incomplete or inadequate treatment of many potential breeding grounds.

In 1968, after a complete review of the program, the government decided to increase the funds allotted to the campaign, and to adopt the other necessary measures to ensure the complete eradication of the vector in Barbados over a period of three years.

During the first half of 1969, the reorganization and expansion of the campaign was completed, and at present activities are being carried out in accordance with the plan of operations. However, there is a very serious problem of closed houses which, in some cycles, amount to 10% of the houses scheduled for treatment. With the technical assistance of the Bureau, the Government is attempting to solve this problem.

Brazil - Brazil completed its eradication campaign in 1955, and was declared free of the vector in 1958; however, in 1967 it was discovered that the city of Belem, capital of the state of Para, at the mouth of the Amazon, was reinfested, as were other localities in the neighborhood.

As a result of this reinfestation, the Government took the necessary measures to delimit the affected part, so as to prevent the vector from being carried to other parts of the country; to reinforce surveillance services in the most exposed localities; and to eliminate the mosquito from the reinfested areas.

To investigate the extent of the problem, inspections were carried out in 1967 and 1968, in 111 localities in the state of Para, all of them situated in the sphere of influence of Belem, as well as in the city itself. Of these 111 localities, 35 were found to be infested, although in most of them the infestation level was still very low.

The eradication campaign has been resumed and, as a result of the strong support and adequate financing given to it by the Government, the mosquito has already been eliminated in 16 of the above-mentioned 35 localities, but the city of Belem itself and the other 19 localities continue to be positive.

In August 1969, four localities in the state of Maranhao - the town of Sao Luis, Anil, Ribamar, and Tiririca1 - were found to be reinfested. That area is also situated in the north-eastern part of the country, and is rather close to the focus of reinfestation in Para. The campaign was promptly resumed to eliminate that new focus.

In addition to the two areas mentioned above, the surveillance service in Brazil, which has substantially increased its activities since the discovery of the Para reinfestation, has not yet discovered Aedes aegypti in any other part of the country.

Colombia - Cucuta in the area bordering on Venezuela, and five other localities in the north-eastern region, continue to be infested. The reinfestations in Riohacha, Carraipia, Papayal, El Molino, and Distraccion were eliminated.

In the second half of 1969, the ports of Barranquilla and Cartagena were found to be reinfested. These reinfestations are now being dealt with.

Cuba - The results obtained by the campaign up to 1967 were limited, mainly because of reinfestations in the work areas caused by the reintroduction of the vector from provinces not covered by the program.

To meet this situation, the Government decided to incorporate the activities of the eradication campaign into those of the general health services, and to expand the campaign, so that eradication activities would be undertaken simultaneously in all the infested areas of the country.

This expansion of the campaign meant increasing the field personnel strength to approximately 4200 persons, and the Government, after studying the matter, reached the conclusion that it would be impossible to take on personnel for the campaign on such a scale owing to the demand for labor for other activities regarded as vital to the development of the country. The Ministry of Health therefore decided to try to find new ways of solving the problem, essentially by employing volunteers supplied by workers' organizations, for the application of insecticide and by using specialized campaign staff and health service personnel for the training and supervision of volunteers and the evaluation of treatments.

In view of the novelty of this program and the difficulties likely to be encountered by a mosquito eradication campaign based on such procedures, the Ministry decided to try out the program in one of the provinces of Cuba, before extending it to the entire country. For this experimental plan, it selected the province of Havana, the population of which is slightly more than 2 million and in which there are approximately 630,000 dwellings.

The experiment was begun early in 1968, and by July of that year a complete evaluation had been made. As a result, the Government decided to continue the experiment until December 1969, before extending the program to the rest of the country. This work is still going on at the present time.

In 1969, it was found that the strain of Aedes aegypti found in the province of Havana, primarily in the City of Havana, was resistant to chlorinated insecticides. Beginning in 1970, phosphorous insecticides will be used in that province.

El Salvador - The eradication campaign was completed in 1957, and in 1960 the country was declared free of Aedes aegypti. But in June 1965, an area of the city of San Salvador was found to be infested. Later investigations disclosed that the reinfestation covered the entire city and its surroundings and that many other areas in the country had already been reinfested.

Eradication operations were resumed in July 1965; but, owing to a shortage of funds for the campaign, its activities have so far been limited to the city of San Salvador and the airport of Ilopango, and the results achieved in these two localities have not been satisfactory.

United States of America - The campaign begun in 1964 has from the outset only partially covered the area infested by Aedes aegypti, which includes all or part of the territory of the 10 states in the south-eastern part of the country, as well as Puerto Rico and the Virgin Islands. Up to 1968, the results obtained by the campaign in those areas were very limited because of inadequate coverage.

The Government therefore asked the Pan American Sanitary Bureau to appoint a group of experts to make an evaluation of the program and to suggest ways and means of improving it.

This evaluation was completed in May 1968, and in August the report of the group of experts, recommending the measures they felt should be adopted to make the program a success, was submitted to the Government.

In spite of this, the budget for the program during the fiscal year 1968-1969 was drastically cut, so that, at the end of 1968, campaign activities had to be reduced still further. Later on, the Government decided to terminate the program, and, since July 1969, eradication operations in the country itself, and in Puerto Rico and the Virgin Islands, have stopped completely.

Guyana - Guyana was found to be extensively reinfested in 1962. The Government reactivated the eradication campaign in 1965, but, because of lack of funds, activities were restricted to Georgetown.

The results obtained in the campaign up to 1968 were not satisfactory. Despite the treatments carried out in Georgetown, the infestation index remained high, the reason being serious administrative difficulties and the resistance of the mosquito to the insecticide used.

In view of the situation the Government decided early in 1969 to completely reorganize the campaign. During the first six months of last year, the Government substantially increased the budget of the campaign, decided to change the insecticide, and undertook the training of sufficient personnel to satisfy the needs of the program.

At the present time, the campaign is being satisfactorily conducted, and the initial data received by the Bureau are very promising.

Honduras - Honduras completed the Aedes aegypti eradication campaign in 1959, and in that same year, after a special inspection carried out with the assistance of PASB, the country was declared free of the vector at the XI Meeting of the Directing Council of the Pan American Health Organization. Since then a surveillance service has been set up in the country and has been regularly inspecting the localities most exposed to reinfestation.

Up to February 1968, the mosquito had not been found in the course of any of these inspections. But towards the end of March and early in April, the localities of San Pedro Sula and Puerto Cortes, situated on the northern coast of the country, were found to be reinfested, probably by Aedes aegypti carried by road from El Salvador or by boat, in the form of eggs, from the United States of America. Following this discovery,

surveillance operations were increased in other localities exposed to reinfestation, and investigations carried out showed that further reinfestation had occurred in six localities close to San Pedro Sula and Nueva Ocotepeque, in the south-west region of the country, close to the El Salvador frontier.

In view of these reinfestations, the Government immediately resumed the eradication campaign in the country, but, because of a shortage of budgetary funds, work has begun only in the town of San Pedro Sula and the results obtained so far are limited. The Pan American Sanitary Bureau is providing assistance in the form of insecticides and spray pumps.

Haiti - The campaign was suspended in 1958 and has not yet been resumed.

Jamaica - Eradication activities were suspended in 1961, and since then the Aedes aegypti campaign of the country has been limited to control measures in international ports and airports.

The Government is in the process of organizing a nation-wide campaign and has already prepared a preliminary draft of a plan of operations, and has made the necessary budgetary provision. To obtain the additional funds needed, the Government is preparing an application for submission to the United Nations Development Programme.

There is a good possibility that the program will begin in the second half of 1970.

Mexico - The country completed its eradication campaign in 1961 and was declared free of the mosquito in 1963, at which date a surveillance service was organized and has been regularly inspecting the localities most exposed to reinfestations. Since then, the problem of Aedes aegypti in Mexico has been limited to the reinfestations which have occurred in the area bordering the United States of America.

Between 1965 and July of 1969, the following reinfestations were discovered at the dates given:

State	Locality	Date
Tamaulipas	Nuevo Laredo	June 1965
Tamaulipas	Nuevo Laredo	February 1967
Coahuila	Allende	June 1967
Tamaulipas	Nuevo Laredo	June 1968
Coahuila	Piedras Negras	September 1968
Coahuila	Sabinas	October 1968
Coahuila	Agujita	May 1969
Coahuila	Nueva Rosita	July 1969

With the exception of that in Nueva Rosita, all these reinfestations were small and localized and were quickly eliminated. In October 1969, another locality in the state of Tamaulipas, Matamoros, was found to be reinfested.

According to the information available, the reinfestations on the Mexican side of the border were due to Aedes aegypti introduced from the United States of America. The results of inspections made in other parts of Mexico have so far been negative.

Panama - Aedes aegypti eradication was completed in 1955, and in 1958 the country was declared free of the vector. For financial reasons, the Government has not established a regular surveillance service in the country; nevertheless, from time to time a small sample of localities exposed to reinfestation has been inspected.

Up to March 1969, these inspections proved negative, but in the course of that month, while investigating a sample in the city of Colon, on the Caribbean coast, inspectors from the general health services, working in conjunction with a PASB inspector, found a number of foci of Aedes aegypti in one of the suburbs of the town.

The suburb, Pueblo Nuevo, is situated at the extreme eastern end of Colon, where there is a wharf and a dock where small craft coming from various Caribbean ports frequently tie up. These craft have probably been responsible for introducting the mosquito into the suburb.

Because of this reinfestation, the Government, with the assistance of the Bureau and of the health authorities of the Canal Zone, resumed the eradication campaign in the country, on the basis of a plan of operations providing for the elimination of the mosquito in Colón, investigation of all the other Panamanian localities exposed to reinfestation, and intensification of surveillance operations against a further introduction of the vector.

The Government is making strenuous efforts to eliminate the focus and to implement the entire action plan.

Dominican Republic - The eradication campaign in the Dominican Republic was suspended in 1962 and has not yet been resumed.

Trinidad and Tobago - The island of Trinidad is presumed to be free of the vector, except for Port-of-Spain, where it is still found in the port area and in small craft coming from other Caribbean ports that are still infested. The reinfestations discovered in the city in the past 6 years are attributed to these sources.

Efforts have been made throughout this period to prevent such craft from transporting Aedes aegypti, but it has not so far been possible to solve the problem.

The island of Tobago continues to be regarded as free of the mosquito.

Venezuela - Activities are still concentrated in the western region, primarily in the area bordering Colombia. The Government has not yet decided to expand the campaign to provide complete coverage of the infested area.

FRANCE

Guadeloupe - The campaign was suspended in 1962, but was reactivated at the end of 1969.

French Guiana - This department was declared free of Aedes aegypti in 1958, but in 1963 the capital, Cayenne, was found to be reinfested. A survey made by the Government in 1964 showed that the reinfestation had spread throughout the city and its surroundings and that various localities in the interior were also positive.

The Government reactivated the campaign in 1969, but the results obtained so far are limited.

Martinique - Up to 1968, the Aedes aegypti campaign was limited to control measures. In 1969, the Government initiated an eradication campaign, but so far the results have been limited.

St. Martin - The French part of the island continues to be regarded as free of Aedes aegypti, but no recent information on the situation is available.

THE NETHERLANDS

Aruba, Bonaire, Curaçao, Saba, St. Eustatius, and St. Martin.

Aedes aegypti was eliminated and reintroduced several times in Aruba and Bonaire. Up to 1968, control activities were conducted in Curaçao.

The whole of the Netherlands Antilles is in the final stage of the preparatory phase of the campaign.

Surinam - Up to mid-1969, the results obtained by the campaign were limited. However, in the second half of the year, the campaign was reorganized, its budget increased, and a well-qualified medical director appointed. Effective disciplinary measures with respect to field personnel were also adopted. It is expected that better results will be obtained in 1970.

UNITED KINGDOM

The campaign is in the final stage of the preparatory phase in Antigua, Grenada, and Montserrat. In St. Lucia, the campaign is being reorganized.

Surveys made on Gran Cayman, in 1966 and 1968, showed that the island was negative. However, the mosquito was found on the island of Cayman Brac. The Government initiated a campaign on that island at the beginning of 1970.

Dominica and St. Vincent are endeavoring to organize campaigns. The Bahamas are continuing with limited control activities.

The Virgin Islands, Turks and Caicos Islands, St. Kitts, Nevis, and Anguilla are all infested, and no campaigns are in operation.

executive committee of the directing council

PAN AMERICAN HEALTH ORGANIZATION

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WORLD HEALTH ORGANIZATION

64th Meeting
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Provisional Agenda Item 7

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ADDENDUM I
27 May 1970
ORIGINAL: SPANISH

REPORT OF THE MEETING OF THE STUDY GROUP ON THE PREVENTION OF AEDES AEGYPTI-BORNE DISEASES

At its seventeenth plenary session, on 9 October 1969, the XIX Meeting of the Directing Council of the Pan American Health Organization approved Resolution XXIII, dealing with Aedes aegypti eradication in the Americas, which read as follows:

AEDES AEGYPTI

"THE DIRECTING COUNCIL,

Recognizing that the prevention or control of urban yellow fever, dengue, and other diseases transmitted by Aedes aegypti are of serious concern to all Members of the Organization;

Noting the successes in some of the Member Countries in the programs to eradicate Aedes aegypti, but fully cognizant of the continuing problem of reinfestation in areas that had been cleared;

Considering that the hemispheric campaign to eradicate Aedes aegypti has in the last few years encountered serious obstacles; and

Recognizing that control of diseases transmitted by Aedes aegypti must be a hemisphere-wide coordinated program,

RESOLVES:

1. To request the Director to sponsor a complete in-depth study of the strategy and methods of preventing the diseases transmitted by Aedes aegypti, and to this end:

a. Name, as quickly as possible, while continuing assistance to ongoing programs, a multidisciplinary group to review the present strategy for the prevention and control of diseases transmitted by Aedes aegypti in the Americas, and as necessary define the objectives and guidelines of a study that would examine all possible alternative systems, including the public health and economic consequences of the different systems.

b. Engage an independent agency to carry out as necessary the study defined by the multidisciplinary group and provide that agency with all assistance needed to obtain the facts, and professional technical advice required, presenting an assessment of the various alternatives - the relevancy of which should be based upon a cost/benefit analysis.

c. Present the results of these studies to the XVIII Pan American Sanitary Conference with interim progress report to the 64th Meeting of the Executive Committee.

2. To request the Director to seek through voluntary contributions the funds to cover the costs of this study.

3. To recommend to Governments that, independently of the results of this study, they continue to give all possible support to programs of Aedes aegypti eradication and to take appropriate measures to safeguard the gains already obtained."

After careful consideration of the provisions of Resolution XXIII, the Director of the Bureau convened a study group composed of highly qualified experts in epidemiology, virology, public health administration, entomology, environmental sanitation, anthropology, and economics. The purpose of the meeting was to examine and discuss the prevention of Aedes aegypti-borne diseases from a multidisciplinary standpoint.

The study group met at the Headquarters of the Bureau, in Washington, D. C., from 9 to 14 February 1970, together with seven consultants with wide experience in the epidemiology of communicable diseases, virology, Aedes aegypti eradication, and public health administration. The technical staff of the Pan American Sanitary Bureau and the World Health Organization that served as the Secretariat was also multidisciplinary and included specialists in the epidemiology of communicable diseases, communications sciences, virology, biology and vector control, sanitary engineering, public health administration, and Aedes aegypti eradication.

Unfortunately, one member of the study group, the economist, was unable to attend the meeting.

The terms of reference of the meeting, which were sent to each member or participant beforehand, were these:

TERMS OF REFERENCE FOR THE STUDY GROUP ON THE PREVENTION OF AEDES AEGYPTI-BORNE DISEASES

I. The Group should:

(a) Study the extent and distribution of jungle yellow fever in the Americas as well as the immediate and long-term consequences of the spread of the disease.

(b) Study the extent and distribution of dengue in the Americas, the types of the disease prevalent in the Americas and other types identified in other parts of the world.

(c) Consider the likelihood of the occurrence of hemorrhagic dengue fever, bearing in mind the need for surveys for this purpose if that disease were to occur in the Americas.

II. The Group should examine the present strategy for the prevention and control of diseases transmitted by Aedes aegypti in the Americas, giving special consideration to methods for control or eradication of the vector, vaccination, epidemiological surveillance and other measures.

III. The Group should:

(a) Review the present strategy for Aedes aegypti eradication in the Americas and determine how practical it is in countries or territories where the vector is present, bearing in mind the customs of the population, their attitude toward the multiplication of Aedes aegypti foci and the availability of devices in everyday use in technologically advanced countries.

(b) Study the possible consequences of the reinfestation of countries in the Americas by the vector.

(c) Analyze the feasibility of using other methods for eradicating the mosquito including biological, chemical, and genetic methods.

IV. The Group should produce a detailed plan that can be used by an independent agency as the basis for an in-depth cost/benefit analysis of procedures considered by the Group to be most suitable for the prevention and control of the diseases transmitted by Aedes aegypti.

V. The Group should include experts in the epidemiology and prevention of communicable diseases, health administration, virology, entomology, and economics.

The Report of the Study Group on the Prevention of Aedes aegypti-borne Diseases, together with its conclusions and recommendations, appears in the Annex.

Annex

PAN AMERICAN HEALTH ORGANIZATION
Pan American Sanitary Bureau, Regional Office of the
WORLD HEALTH ORGANIZATION

525 TWENTY-THIRD STREET, N.W., WASHINGTON, D.C. 20037, U.S.A. CABLE ADDRESS: OFSANPAN

IN REPLY REFER TO: TELEPHONE 223-4700

REPORT OF THE PAHO STUDY GROUP ON THE PREVENTION OF AEDES AEGYPTI-BORNE DISEASES

Washington, D. C.
9-14 February 1970

LIST OF PARTICIPANTS

I. Members

Dr. George Foster
Professor of Anthropology
University of California
Berkeley, California

Dr. William Hammon
Professor of Epidemiology
and Microbiology
Graduate School of Public Health
University of Pittsburgh
Pittsburgh, Pennsylvania

Dr. William W. Macdonald (Rapporteur)
Head, Subdepartment of Entomology
School of Tropical Medicine
Liverpool, England

Dr. Daniel Orellana
Chief, Office of the International
Health
Ministry of Health and Welfare
Caracas, Venezuela

Dr. William C. Reeves (Chairman)
Dean and Professor of Epidemiology
School of Public Health
University of California
Berkeley, California

Dr. Antonio M. Vilches (Rapporteur)
Director, National Institute of
Microbiology
Buenos Aires, Argentina

Dr. Abel Wolman
Emeritus Professor of Sanitary
Engineering and Water Resources
The Johns Hopkins University
Baltimore, Maryland

List of Participants (continued)

II. Advisers

Dr. Solôn de Camargo
National Department of
Rural Endemics
Rio de Janeiro, GB, Brasil

Dr. Wilbur G. Downs, Director
Yale Arbovirus Unit
Yale University
New Haven, Connecticut

Dr. Scott B. Halstead
School of Medicine
University of Hawaii
Honolulu, Hawaii

Dr. Philip K. Russell
Department of Virus Diseases
Walter Reed Army Institute of Research
Washington, D. C.

Dr. James V. Smith
Special Assistant to the Director
National Communicable Disease Center
Atlanta, Georgia

Dr. Fred L. Soper
Emeritus Director
Pan American Health Organization
Washington, D. C.

Dr. Adrián Torres Muñoz
Chief of the National Antimosquito Campaign
Division of Epidemiology and Sanitary Campaigns
Mexico, D. F.

List of Participants (continued)

III. Secretariat

Dr. Steven W. Bennet
Division of Research in Epidemiology
and Communications Science
World Health Organization
Geneva, Switzerland

Dr. Anthony W. A. Brown
Vector Biology and Control Unit
World Health Organization
Geneva, Switzerland

Dr. Alexander Rossi-Espagnet
Chief, Epidemiology of Communicable
Diseases
World Health Organization
Geneva, Switzerland

Dr. Arturo C. Saenz
Virus Diseases Unit
World Health Organization
Geneva, Switzerland

Mr. Donald J. Schliessmann
Department of Malaria Eradication
Pan American Health Organization
Washington, D. C.

Dr. Bichat A. Rodrigues
Acting Chief, Department of
Communicable Diseases
Pan American Health Organization
Washington, D. C.

Dr. Lelio B. Calheiros
Regional Adviser on *Aedes aegypti* Eradication
Department of Communicable Diseases
Pan American Health Organization
Washington, D. C.

CONTENTS

I. INTRODUCTION

Aedes aegypti and disease agents that are transmitted by this mosquito continue to prevail in the Americas in 1970. The Pan American Health Organization and all its Members recognize that advances in the Twentieth Century have provided an adequate scientific knowledge to allow the hemispheric eradication of Aedes aegypti. The primary purpose of such action would be to prevent the continual occurrence or threat of epidemic yellow fever and dengue fever in urban populations. The delay in accomplishment of what appeared to be an attainable goal, namely, eradication of Aedes aegypti and the diseases it transmits, led the Directing Council of the Pan American Health Organization at its XIX Meeting, September-October 1969, to request the Director to review the current problems that are associated with this hemispheric program (Figure 1).

As the first step to meet the above request, the Director convened this Study Group to undertake a review of the problem and to report on the following specific aspects:

1. The extent and distribution of disease agents that may be transmitted by Aedes aegypti in the Americas.

2. The immediate and long-term consequences of the spread of such diseases.

3. The present strategy and scope of methods that are being or would be used to prevent and control Aedes aegypti-borne diseases.

4. The factors that may have limited the success of present programs and the promise offered by alternative approaches to the problem.

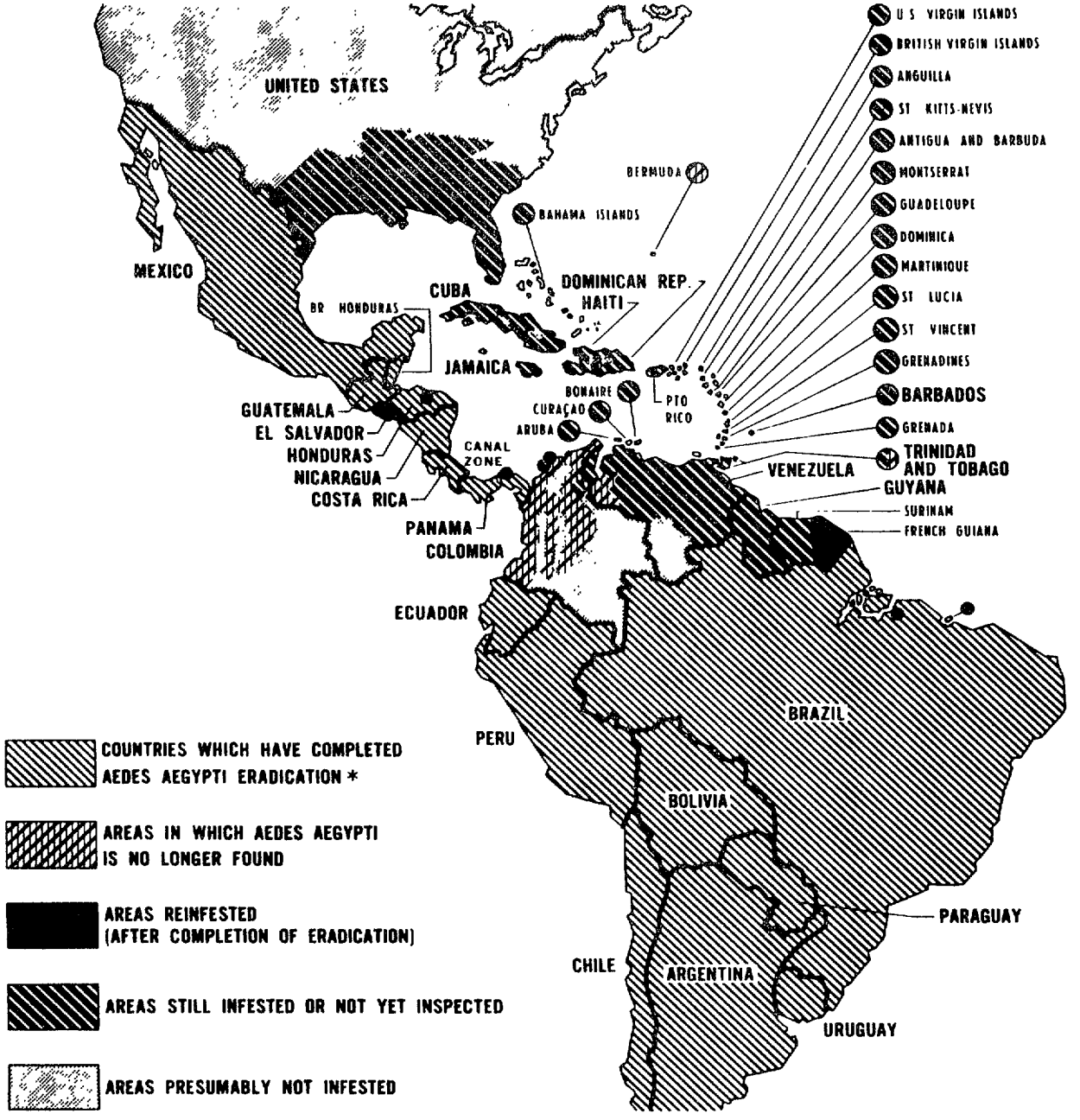
5. The identification of the procedures that are essential to or are alternative approaches in a program for the prevention and control of diseases transmitted by Aedes aegypti.

6. A plan for further in-depth study as to the costs and the benefits to be derived from alternative approaches to control, if they were utilized.

The following report summarizes the findings of the Study Group and its unusually competent panel of consultants and secretariat.

FIGURE 1

STATUS OF THE AEDES AEGYPTI ERADICATION CAMPAIGN IN THE AMERICAS, DECEMBER 1969



* ERADICATION CARRIED OUT ACCORDING TO THE STANDARDS ESTABLISHED BY THE PAN AMERICAN HEALTH ORGANIZATION

II. DISTRIBUTION OF AEDES AEGYPTI-BORNE DISEASES IN THE AMERICAS

A. Jungle yellow fever

The first recognition that there was a cycle of yellow fever maintenance and transmission other than the accepted cycle between Aedes aegypti and man came in the 1930's. In the following several decades, Haemagogus mosquitoes and monkeys were demonstrated to sustain a "jungle cycle." Aedes leucocelaenus and Sabethini mosquitoes were implicated as secondary vectors. It was also demonstrated in laboratory studies, although not by isolation of virus from wild animals, that marsupials might participate in the vertebrate reservoir system.

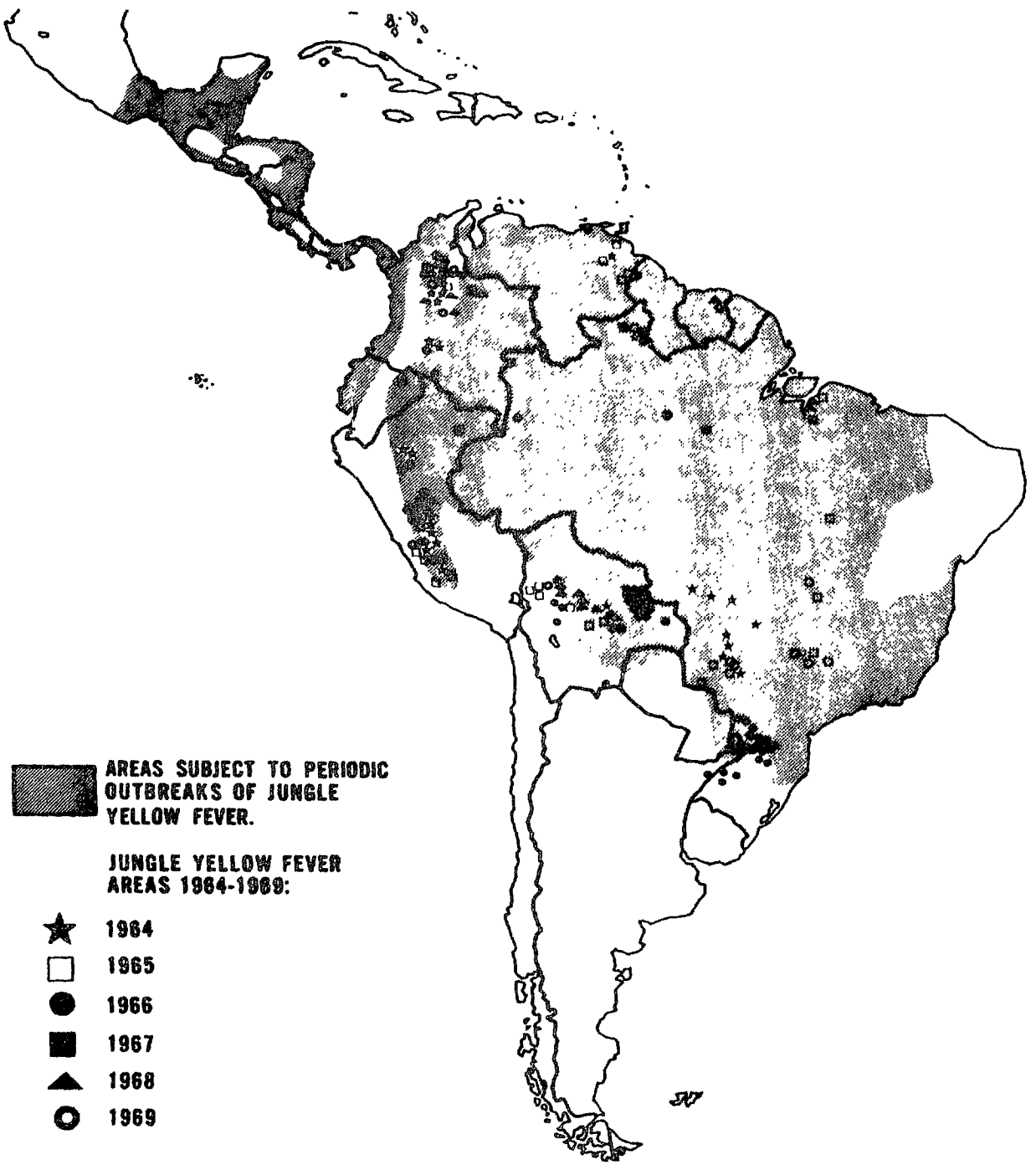
With the introduction of more adequate surveillance in jungle areas, helped by the use of the viscerotome in Bolivia, Brazil, Colombia, Ecuador, Peru, and Venezuela, a picture evolved of the total area involved in endemic transmission of yellow fever in the Western Hemisphere (Figure 2). The area is enormous, as it encompasses literally the entire Amazon drainage system (including the eastern parts of Colombia, Ecuador, and Peru, the Amazonian lowlands of Bolivia, and a part of Matto Grosso in Brazil) a small focus in the Ilheus region of Brazil, the Middle Magdalena Valley in Colombia, and the gallery forest areas of the Orinoco tributaries in Venezuela. The Darien lowlands of Panama, the hinterlands of French Guiana, Surinam and Guyana may also be suspected of harboring jungle yellow fever.

There have been repeated occasions in the past four decades when the virus moved out of suspected or known endemic foci to reinvade regions not known to be involved for considerable periods (Figure 2). Such movement of virus explains the epidemic which progressed from Panama to Mexico in the 1950's, the periodic epidemics which have swept through the more southern states of Brazil and into Paraguay and northern Argentina, and also those which have periodically involved northern Venezuela and Trinidad. The last known instance when a population center lay in the course of such movement and resulted in an Aedes aegypti-human cycle of transmission was in 1954 at Port of Spain, Trinidad.

There is evidence that epidemic movements have depended on the availability of susceptible monkey populations. The resident monkey population, particularly Alouatta, may be reduced to very low levels during these epidemic sweeps. Other monkey species are involved, and Cebus populations may suffer a low mortality. Periodic serological samplings of monkeys in a region provide data that allow an assessment of a given region's involvement in yellow fever virus activity. In addition, the information is of value to determine if the region is one of endemic persistence of virus, or will be subject to periodic epidemic invasion. In

FIGURE 2

JUNGLE YELLOW FEVER IN THE AMERICAS



regions where vaccination has not been done, serological surveys of the human population can furnish similar information. In reality, such sampling, either of monkeys or of humans, has been very sporadic, and insufficient to provide the detailed data needed for a thorough assessment of the distribution of yellow fever.

There has been a very marked decline in the use of the viscerotome in recent years, and it is obvious that there is much less effective monitoring of jungle yellow fever occurrence than existed thirty years ago. The laboratories that are currently available for diagnostic studies (serology and viral isolations) in Argentina, Brazil, Colombia, Panama, Trinidad, and Venezuela have been responsible for the more recent yellow fever virus isolations, but these laboratories routinely receive specimens from only a fraction of the total territory involved. Human infections in most of the region are inefficiently monitored.

The diagnosis of yellow fever presents peculiar difficulties. Often cases do not exhibit the classical symptomatology, and even classical sporadic cases may not be recognized. Most cases go undiagnosed as they have a mild fever, no jaundice, and no distinctive signal features. Missed diagnosis can even occur during the course of an epidemic when the index of suspicion is high. Consequently, the existing figures on occurrence of yellow fever in humans represent a picture of gross underdetection.

If it is desired to develop and maintain an adequate assessment of the distribution of jungle yellow fever, a monitoring system would have to be established that is more extensive and precise than the current haphazard system. At the same time we know the areas where yellow fever was active in the period 1932-1958 and the distribution of proved human cases in the past six years (Figure 2). All findings would indicate that an extensive area of enzootic yellow fever persists today in South America and that, although it recedes and expands, it will continue to be an endemic area.

B. Dengue fever

The current status of the epidemiology of dengue fever in the Americas has been fully described in the report of 16 January 1970 from the Scientific Advisory Committee on Dengue entitled "Surveillance of Dengue in the Americas." In summary, epidemic dengue fever has occurred in the Greater and Lesser Antilles in 1968-1969. Dengue virus types 2 and 3 were present during 1968. Dengue type 2 was responsible for the intensive epidemic in Puerto Rico in 1969. An unidentified type or types of virus were active in Venezuela. There is evidence that dengue is endemic or is becoming endemic in Jamaica, Haiti, and Venezuela. The geographical patterns of occurrence in the several epidemics in the period 1963-1969 are presented in Figures 3-5.

Figure 3

OCCURRENCE OF DENGUE IN THE CARIBBEAN, 1963-1965

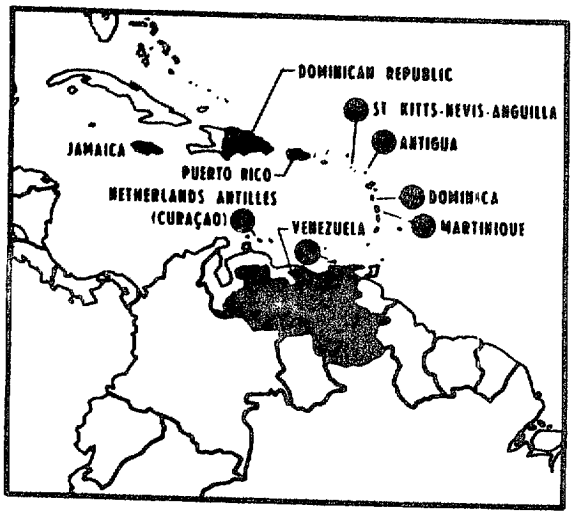


Figure 4

OCCURRENCE OF DENGUE IN THE CARIBBEAN, 1966-1967

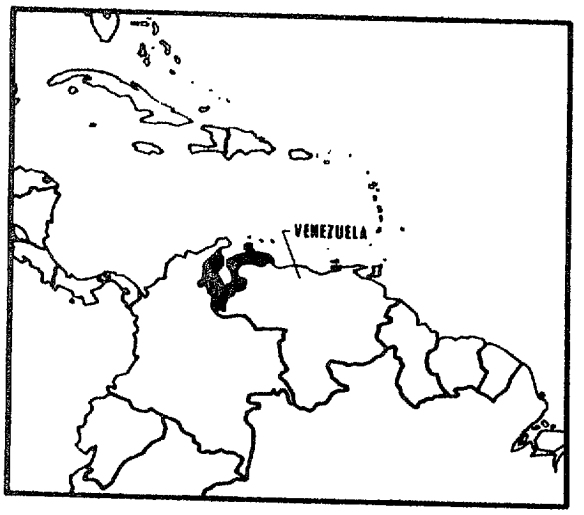
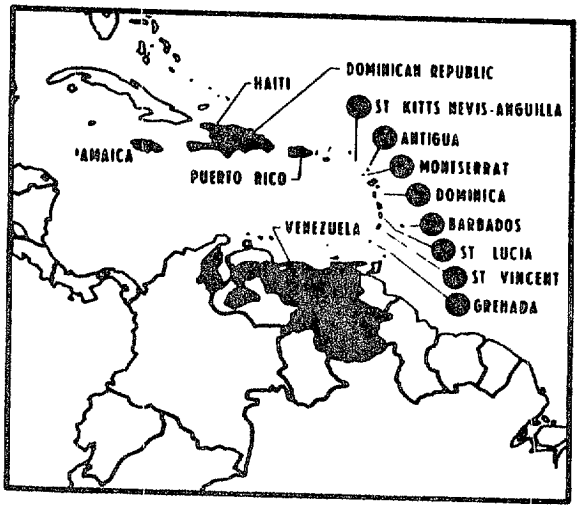


Figure 5

OCCURRENCE OF DENGUE IN THE CARIBBEAN, 1968-1969



In recent outbreaks in Asia, the spectrum of disease due to dengue has varied from undifferentiated mild febrile illness to the classical dengue fever syndrome. No cases of dengue hemorrhagic fever with or without shock syndrome have been reported from the Americas in spite of active surveillance in some areas.

Epidemic dengue and dengue-like disease occurred at irregular intervals in the pre-Aedes aegypti control era in an area that included much of the southeastern and Gulf coastal area of the United States of America, Mexico, Central America, and the northern part of South America. Eight major outbreaks have been recorded in this century. Serological surveys have revealed that dengue fever was active in earlier years in the Belem area of Brazil, and there are clinical reports of dengue-like illness in earlier years in more southern regions.

The continued presence of the vector in the Americas and the presence in the world of at least six viruses (dengue types 1, 2, 3, 4, yellow fever, and chikungunya) known to be transmitted by Aedes aegypti and to have major epidemic potential lead to the conclusion that the Americas remain at considerable risk.

Dengue fever, like yellow fever, has no reservoir in the temperate areas and must be reintroduced during the summer from a locality where transmission is active. Evidence recently obtained in Malaya may indicate there is a jungle dengue reservoir in monkeys.

C. Likelihood of occurrence of dengue hemorrhagic fever in the Americas

All available data from studies in Asia suggest that dengue hemorrhagic fever (with or without shock syndrome) occurs when two or more types of dengue viruses are continuously or simultaneously endemic. This situation now exists in the Caribbean, as dengue type 2 and 3 viruses were transmitted to man in the same area in 1968. We do not have sufficient information about the exact conditions of host and virus interaction to predict the occurrence of hemorrhagic fever. Based upon studies in Asia, it is clear that the syndrome may occur in both children and adults, although it has occurred predominantly in children. The intermittent disease experience in the Americas would suggest that, if dengue hemorrhagic fever develops, it may involve a broader age range than was observed in areas of Asia where dengue was highly endemic.

Dengue hemorrhagic fever may occur as sharp outbreaks accompanied by significant mortality. The short and fulminating course of this disease strongly resembles that of yellow fever. Epidemics in Southeast Asia have produced near panic. Should this disease occur in the

Americas, a serious fear reaction can be expected. The occurrence in the Caribbean of a mysterious and fatal disease could produce a dampening effect on tourism and economic development that could last for years.

A serologic survey and case-finding technique that employs sentinel institutions was recommended to the Director of the Pan American Sanitary Bureau by the Scientific Advisory Committee on Dengue, and this could form the basis for a sound program of surveillance for dengue hemorrhagic fever. Such activities would serve the same purpose for yellow fever surveillance. The need for laboratory-supported epidemiological studies on a permanent basis cannot be over emphasized. The areas where hemorrhagic fever is most likely to occur and which therefore require first and constant attention are those where dengue fever is either endemic or repeatedly epidemic.

III. STRATEGY FOR THE PREVENTION AND CONTROL OF AEDES AEGYPTI-BORNE DISEASES

A. The present situation and its implications

The strategy and operation of campaigns for elimination of Aedes aegypti-borne diseases from the Western Hemisphere for the past quarter century were based on eradication of the mosquito from all infested areas and territories. The concept was first endorsed by the XI Pan American Sanitary Conference in Rio de Janeiro in 1942. In 1947, the Directing Council of the Pan American Health Organization entrusted the Pan American Sanitary Bureau with the solution of the urban yellow fever problem through the eradication of Aedes aegypti. This action was endorsed repeatedly by Member countries of the Organization in subsequent annual resolutions of the Council. The present strategy for Aedes aegypti eradication is presented in summarized form in the attached excerpts from the "Present Policy Guide for Aedes aegypti Eradication" (Appendix A).

Eradication of Aedes aegypti infestations was proven feasible and practical when eighteen countries and territories of the Americas achieved this goal. This attainment is a tribute to the interest, commitment, and economic sacrifice of the countries and reflects creditably on the advisory services of and assistance by the Pan American Health Organization. Thirteen of these countries are presently free of the mosquito, but five have been reinfested (Table 1).

On the other hand, Aedes aegypti has not been eradicated from 26 countries and territories, and, in some cases, there has not even been a significant reduction in the area of infestation and density of the mosquito population.

TABLE 1

COUNTRIES IN WHICH *AEDES AEGYPTI* HAS BEEN ERADICATED AND THOSE WITH RECENT REINFESTATIONS

Country	Eradication Confirmed	Reinfested
Bermuda	September 1953	-
Bolivia	September 1958	-
Brazil	September 1958	July 1967
British Honduras	September 1958	-
Ecuador	September 1958	-
Nicaragua	September 1958	-
Panama	September 1958	March 1969
Paraguay	September 1958	-
Peru	September 1958	-
Uruguay	September 1958	-
Canal Zone	September 1958	-
Guatemala	September 1959	-
Honduras	September 1959	March 1968
El Salvador	September 1960	June 1965
Chile	October 1961	-
Costa Rica	October 1961	-
Mexico	September 1963	Nine reinfestations since 1965, latest in October 1969
Argentina	October 1965	-

Eradication of the vector and the diseases it transmits is a multinational problem due mainly to the danger of reintroduction. Those countries that have eliminated Aedes aegypti, at considerable cost, have a vested interest in the remainder of the Region that is still infested. The present review indicates that despite the demonstrated feasibility of eradication of Aedes aegypti from the Hemisphere, this objective will not be achieved within a reasonable time unless every country can obtain the resources and ensure the administrative support that a successful program requires.

Eradication requires an effective administration and techniques that all too often are not available to many national health services. The investments already made by the nations of the Americas in the solution of the problem warrant the adoption by the Pan American Health Organization of whatever measures may be deemed necessary to support the permanent prevention of Aedes aegypti-transmitted diseases.

The main factors that have prevented the completion of national eradication programs appear to be financial restrictions, administrative rigidity, unsatisfactory labor relationships, sociocultural factors, insecticide resistance in the vector, and reinfestations.

Attention in the last few years has been focused on the failures and difficulties in accomplishing Aedes aegypti eradication from the Hemisphere rather than on the successful achievements. This attitude has stemmed from a number of factors, including 1) the reinfestation of countries that had achieved eradication and the difficulties of rapidly identifying and solving the problem; 2) limited progress in eradication in infested countries of the Continent (Guyana, Surinam, United States of America, and Venezuela) and in the numerous Caribbean Islands (Figure 1); 3) outbreaks of dengue in many of the above areas in 1963-64 and again in 1968-69; 4) the wide distribution of jungle yellow fever and the threat of reestablishing urban transmission which spreads readily from country to country; and 5) increased concern that dengue hemorrhagic fever may appear in dengue endemic areas of the Hemisphere.

The above problems have been recognized by the Governing Bodies of the Pan American Health Organization since 1958 and are reflected in their annual resolutions that have called for initiation, intensification, or acceleration of action by infested countries. Various working groups convened by the Organization have reviewed all aspects of these problems.

The duration of the threat is dependent upon future action by infested countries, and its potential magnitude will reflect the ability of reinfested countries to eradicate the mosquito. Therefore, until

such time as eradication may be achieved in the Hemisphere, it is essential that consideration be given to other procedures for control and prevention of Aedes aegypti-borne diseases.

Prior to initiation of the eradication program, it was assumed that urban outbreaks of yellow fever would not occur where the Aedes aegypti index was less than five per cent. The threshold index for prevention of dengue is not known, but it is postulated from data in Southeast Asia that an index below five per cent could sustain endemic urban dengue fever. Methodology is available to achieve vector densities below such levels. Such methods have rested primarily on the use of insecticides and secondarily on health education and source (breeding-place) reduction. Where the procedures are applied routinely in infested areas and infestation indices remain low, the threat of Aedes aegypti-borne diseases will remain low.

A major threat of disease transmission arises in those areas where reinfestations are not recognized and in infested regions where there is little or no control and a high index prevails. Implementation of current surveillance procedures to detect Aedes aegypti has been shown to be inadequate in some countries. The early detection of cases of disease spread by Aedes aegypti is generally by clinical and pathological recognition supported by serological methods and viral isolations. The use of viscerotomy is very limited today. Even assuming an adequacy of detection of introduced infections, an epidemic probably will develop because of delay between the time when diagnosis is established and initiation of anti-mosquito measures. An epidemic might be interrupted by the control program.

Surveillance would be more effective if primary emphasis were placed upon the detection and rapid eradication of Aedes aegypti. If one waits upon the detection of frank disease cases, with all of the limitations of diagnosis, there inevitably will be a delay in the control of disease transmission.

The continuity and efficiency of inspection of transport facilities and goods, via air, water, and land, leave much to be desired. There is reason to believe that the supervision of these activities, which present opportunities for mosquito invasion, is not too successful. To improve the program it is necessary to give special attention to inspection and control procedures. This should include the potential use of dichlorvos for disinsection of aircraft.

Possible consequences of the reinfestation of countries by the vector include the potential urbanization of yellow fever and the extension of dengue fever to areas that are not now affected. Other consequences are the serious effects of such events on the health, economy, and public reaction within the country. The possible appearance of hemorrhagic

dengue in this part of the world cannot be disregarded, and Aedes aegypti reinfestations should be considered in the light of this additional potential danger. Provided that an effective surveillance program is maintained in the countries which have eliminated Aedes aegypti, history demonstrates that reinfestations can be quickly controlled although there will be additional costs for the program.

B. Feasibility of various methods for eradication or control of Aedes aegypti

There has been considerable basic laboratory research to develop biological and genetical approaches to mosquito control. However, field evaluation of the findings have been very limited or nonexistent, particularly in the case of Aedes aegypti. There are insufficient data and experience to allow us to decide whether biologic or genetic approaches to control should be seriously considered as practical for either eradication or control of Aedes aegypti in the Americas in the next five to ten years. A WHO panel has recently summarized the knowledge and current potential of these approaches for the control of a number of mosquito species (WHO, Informal Consultations on Alternative Methods of Vector Control, Geneva, 1969). The present situation with reference to Aedes aegypti can be summarized as follows:

1. Biological control

A range of infectious agents, parasites and predators have been identified that can reduce the numbers of Aedes aegypti. These include: a) predators, notably Toxorynchites mosquitoes, that show promise of achieving control with continuous inundative releases; larvivorous fish are not well adapted for use against a mosquito that breeds in small and/or temporary containers; b) parasites, notably the mermithid nematodes and particularly Romanomermis; and c) infectious agents, including fungi, bacteria, viruses, and microsporidia.

While agents have been identified that are pathogens of Aedes aegypti in the laboratory, there is little evidence that natural populations of Aedes aegypti are suppressed by such agents in Africa, Asia, or the Americas. However, the search for such evidence has been very limited. A procedure is established for the identification and laboratory evaluation of candidate agents at the WHO International Reference Center at Ohio State University. No single agent looks unusually promising for Aedes aegypti control or eradication, but it would be desirable for the Pan American Health Organization to support limited field trials in selected and limited areas of the Americas.

2. Genetical control

Certain genetical approaches have promised as adjuncts to our capacity to control or eradicate Aedes aegypti. None of them have been

evaluated in the field, and it is suspected that if they have any promise it will be to accelerate the final steps of an eradication campaign. They may be divided into the following three categories:

a) Chromosomal translocations

Workers at the Institute of Biology, University of Notre Dame, have a strain of Aedes aegypti with a chromosomal translocation which causes 80 per cent sterility and which is transmitted to surviving generations.

b) Sex ratio distorters

Strains of Aedes aegypti have been produced in the laboratory in which a meiotic drive mechanism ensures that 80 per cent or more of the progeny are males. Successful introduction of such a strain into a field population should cause a population decrease due to the scarcity of females.

c) Sterile male releases

Field trials with irradiated males have been limited and unpromising. Chemical sterilization still offers promise. Cytoplasmic incompatibility and hybrid sterility do not hold promise as a mechanism for Aedes aegypti control.

To summarize, the alternative or supplementary approaches to Aedes aegypti control or eradication by biological or genetical mechanisms continue to hold promise. However, developments have been slow, and there has been a lack of significant field evaluation. We will not know the feasibility or contribution of these approaches until well-organized field studies have been performed.

3. Chemical control

Resistance to insecticides by Aedes aegypti has become a serious problem. Strains that are both DDT-resistant and dieldrin-resistant are now widespread in the infested areas and are frequently responsible for reinfestations. It is important to know the exact levels of DDT-resistance as determined by standard tests in each infested area. It is also essential to know to what degree this resistance is interfering with the attainment of complete control in areas where DDT is still employed.

The continued use of DDT in the infested areas has led to two undesirable results, namely:

a) It aggravates the problem by leaving surviving populations that are increasingly difficult to control; and,

b) its use in three-month cycles, as compared to the one-week cycle employed in the successful eradication operations with larvicidal oil, makes it easier for foci to escape undetected and untreated.

Moreover, there are now increased objections on the part of the public and some Governments to its continued application to the environment.

A number of organophosphorus (OP) insecticides are now available for larval and adult control. Of these, the most important are malathion, fenthion, dursban, and abate. One of their advantages is that little or no resistance has developed to them, so that their application will give complete control in every focus treated. Although laboratory studies indicate that Aedes aegypti develops only a mild tolerance to them, and that, only slowly, the possibility of the development of OP-resistance in the field remains unless the control operations are carried out thoroughly, extensively, and rapidly.

Malathion and abate are suitable for application indoors, but abate is at present too expensive for large-scale outdoor application. Fenthion and dursban are highly effective, but not as safe as the other two compounds. In assessing the increased costs involved in using these OP compounds, it is necessary to know the costs of the formulations and the timing of cycles that each compound requires.

None of the OP compounds mentioned have the great residual effect that DDT had before the onset of resistance. For this reason, certain nonchlorinated analogs of DDT recently developed at the CSIRO, Australia, are of great interest, because they are residual, safe and effective against DDT-resistant strains. Since they are biodegradable and promise to be inexpensive, their development is awaited with considerable interest.

4. Vector surveillance

The Group felt that it would be desirable if the methods of reporting the presence of surviving populations of Aedes aegypti could be amplified in order to provide the information necessary to define precisely the relative status of Aedes aegypti in the Americas. The presence or absence of Aedes aegypti within countries, districts, and cities has usually been established, but fuller information is required. The data envisaged would include, for example, a quantitative and qualitative analysis of the main categories of larval habitats, their location (broadly speaking, whether indoors or outdoors), an estimate of the contribution each category makes to the adult Aedes aegypti population, and an estimate of the biting population.

Such data are considered necessary for a cost-benefit analysis of different methods of control, for a decision on the most suitable insecticide, and for evaluation of the progress of the control method which is chosen. The data would be essential for a balanced judgment on the potential value of control methods other than insecticides, such as the use of biological agents or genetical control methods.

The methods employed could well be reexamined, taking into account the experience of workers both in the Americas and elsewhere, and these methods should be applicable whether the objective is control, eradication, or surveillance of the mosquito.

C. Vaccination of human populations

Active immunization against the two Aedes aegypti-borne diseases presents a remarkable contrast.

1. Yellow fever

17D yellow fever vaccine is one of the most efficient and safe vaccines known. It produces serological conversions in nearly 100 per cent of the vaccinated persons and results in a long-lasting immunity. The precise duration of immunity is unknown but may extend for life. No case of yellow fever is known to have occurred in a properly vaccinated person more than seven days after vaccination. In recent years, serious reactions have been rare except in infants, and only one laboratory confirmed fatal postvaccinal encephalitis has been reported (in a three-year-old child). The use of jet-injector guns for vaccination greatly facilitates the use of 17D vaccine in mass campaigns. The vaccine is relatively thermolabile and should be maintained at -20°C, and under refrigeration (+4°C) when transported. Once diluted, it should be used within a period not longer than one hour.

Three laboratories are producing 17D vaccine in the Americas. They are located in Rio de Janeiro (Brazil), Bogotá (Colombia), and Philadelphia (USA). The laboratory in Rio de Janeiro produces between 3 and 5 million doses yearly, the laboratory in Bogotá between 1.5 and 2 million doses, and the laboratory in the United States between 150,000 and 200,000 doses.

Countries in South America, especially Brazil, Colombia, and Venezuela, with populations who live in forested areas where the virus circulates periodically, have instituted vaccination programs covering much of the population at risk. No definite figures are available of the number of persons vaccinated in each country. It has been estimated, however, that a large proportion of the population at risk (as high as 80-90 per cent) has been immunized in each of the three countries mentioned above.

In view of the fact that Aedes aegypti has been eradicated from all cities and towns in South America with the exception of the northeastern part of the Continent and Colombia, the urban populations are not regularly vaccinated.

Under the threat of epidemics, the vaccine is used in urban populations. No information is available regarding the proportion of an urban population that would need to be vaccinated to prevent an introduced virus from becoming established. The proportion of immunes required to bar virus spread would obviously depend on the presence, density, and distribution of the Aedes aegypti population.

2. Dengue fever

Vaccination cannot be counted on to play a significant role in current programs for the primary prevention of epidemics of dengue fever. It may play a modest role as a means of blunting the effect of a recognized or incipient epidemic in a nonendemic area in the Americas.

Four distinct dengue virus types are currently recognized, and they fail to cross-immunize for more than one to three months. Other variants may exist that are not protected against by these four types. Inactivated virus vaccine has little prospect of being effective, a situation similar to that found many years ago for inactivated yellow fever vaccines. Attenuated strains of two types of dengue fever have been tested experimentally, but only singly and not as a combined vaccine. One of these (type 1) appeared to give a detectable degree of short term protection when administered during a type 3 epidemic in Puerto Rico. This vaccine is still an experimental product made of infected suckling mouse brain. It has not been licensed for commercial production.

A similar vaccine, type 2, somewhat less attenuated, has also had some experimental trials in man, but it produced significant fever and rash in some persons.

Development of attenuated strains of the other two types has not been attempted.

If the sensitization hypothesis for the etiology of Southeast Asian dengue hemorrhagic fever is correct, it would have to be assumed that there would be an associated risk with use of any dengue vaccine in an area where any other type of dengue virus is or has been active in the recent past, or might be introduced in the near future. However, the degree of this risk, if any, is unknown, since it is postulated on hypothesis rather than experience. Expert opinions remain divided regarding the risk of using vaccine in such areas.

Studies have been made on purified fractions of dengue viruses as potential immunizing agents, but possible application of the findings will require further evaluation.

For these and other reasons that are not enumerated, effective control of dengue fever in the Americas by vaccination is not considered practical at the present time, nor to have great promise in the near future. Continued research, it is hoped, may improve the prospects.

D. Sociocultural factors

Several sociocultural factors bear on the problem of control or eradication of Aedes aegypti:

1. Weak motivation on the part of the general population and of the authorities to support Aedes aegypti eradication efforts may have been due in some cases, to the fact that the expression "eradication of Aedes aegypti" does not convey the proper priority to the program, since it does not place sufficient emphasis on the main objective, which is the prevention of urban yellow fever and dengue.

2. Resistance has developed to invasion of privacy during some spraying and vaccination programs. In addition to personal inconvenience, this may produce unforeseen and undesirable effects. A combination of education as to the need for spraying and vaccination, coupled with courtesy and consideration on the part of spray teams and vaccinators, overcomes much resistance.

3. Litter, the product of an affluent society, produces new and sometimes unexpected breeding places (e.g., discarded automobile tires). The litter problem is a part of a wider concern with environmental deterioration, and its solution will in major part depend on decisions made with respect to this larger problem. Individual and community motivation is badly needed to support community efforts at source reduction.

4. The population of some countries is increasingly concerned with and opposed to the use of insecticides.

5. Administrative-bureaucratic factors, such as overlapping jurisdictions, inter- and intra-agency competition and conflict, prestige, hierarchies within bureaucracies, and the like, may complicate the design and carrying out of the technologically most appropriate programs. It is increasingly apparent that one of the major barriers to

changing health behavior is rooted in the structural and value characteristics of administrative and professional systems. Medical systems urgently need behavioral science analysis comparable to that already done on target populations receiving new health services. Such research, of course, would normally not be restricted to Aedes aegypti programs.

IV. PLAN FOR THE ANALYSIS OF PROCEDURES FOR THE PREVENTION AND CONTROL OF AEDES AEGYPTI-BORNE DISEASES

The Group recognized during the course of this study that cost and benefit data were not available for many program activities. Such data are needed for proper evaluation of the feasibility and potential of alternative approaches to control.

A consideration of cost-benefit analyses of procedures for the prevention and control of diseases spread by Aedes aegypti must be related to the status of the vector control or eradication programs in the individual countries of the Americas. For example, preventive measures, and therefore cost requirements, will vary according to whether the countries a) have achieved eradication and/or have become reinfested; b) have programs in which the prospects of eradication in the immediate future are quite remote; or c) lack programs or have minimum programs in which little progress toward eradication has been made.

With reference to those countries that have achieved Aedes aegypti eradication, an estimate must be established of the costs of an effective surveillance system (vector inspection and control of foci), including emergency funds to combat extensive reinfestations. This implies that estimates will be made of the costs for an effective epidemiological surveillance if current services are not available within the countries.

For those countries still infested (b and c above), an objective evaluation of the programs should be made to determine if current procedures are adequate to prevent epidemics. If they are adequate, what are the projected costs and time required to achieve Aedes aegypti eradication under prevailing conditions? If current procedures are not adequate, realistic estimates should be made of the costs to reduce the vector population below the level at which an epidemic could occur and of the costs to achieve eradication within 4 to 6 years. In both cases the cost should be estimated for an adequate surveillance system to be maintained until the danger of reinfestations no longer exists.

Comparative data that will be required include annual costs of programs since their inception. In addition, estimates of the cost of combating epidemics of diseases and the economic impact that such epidemics would have in terms of medical care, quarantine embargoes, and tourism. Since the economic impact of an epidemic of yellow fever will differ significantly from that of a dengue epidemic, separate cost analyses should be made for the two infections.

Suggestions for elements that should be considered in making cost estimates, taking account of such factors as are mentioned above, are listed below as a guide and are not to be considered all-inclusive. While they are included as separate items, it is emphasized that the measures to prevent epidemics are not mutually exclusive. For example, the cost of preventing Aedes aegypti-borne yellow fever or dengue fever cannot be considered to be independent of the cost of maintaining an effective surveillance system, since both kinds of measures may be required.

It is appreciated that cost analysis studies must encompass a range of countries with different economies and monetary systems and this will be difficult. Some studies would best be done in selected situations that are representative of different ecological situations; other studies would best encompass evaluation of each country concerned with the problem of control of Aedes aegypti-borne diseases. Some recent estimates of the costs of programs are available (Appendices C - F), but the basis of these estimates and whether they are comparable cannot be stated.

The present Study Group did not include persons with expert knowledge of the technical approaches to a study of cost-benefit analysis. This is a highly specialized field, and the development of a detailed plan of cost-benefit analysis would require the collaboration of such persons with counterpart experts in the scientific fields concerned with the epidemiology of Aedes aegypti-borne diseases and control of the vector. However, the Group, based on its competencies in the last two fields, believes the following cost items deserve study and that comparative cost and benefit figures should be established.

The Group formed the opinion that many of the types of figures required should be part of the routine data collected by the Pan American Health Organization, and that this agency might consider developing its own staff to maintain an ongoing program of cost-benefit analysis in the countries of the Americas.

1. The control of epidemics

A cost analysis is required of the relative merits of establishing an international group of experts, supported by the Pan American Health Organization, who would be prepared to undertake control measures in any epidemic situation in the Americas versus leaving each country at risk to make its own arrangements. Studies are required in several different countries of the efficacy and cost of the following items:

a) Ultra-low volume spraying: these should take into account the various insecticides, dosage rates, and frequency of application required in regions with different physical attributes.

b) Aircraft: taking into account the availability of aircraft suitable for ULV application.

c) Ground application of insecticides: taking into account misting and fogging techniques, larval control, and the availability of equipment.

d) Insecticide stock-piles: taking into account both the quantities and types of compounds which might be held in stock.

e) Vaccine: taking into account the quantity of 17D vaccine that should be held in stock and the duration of its potency on storage.

Taking into account all the measures required, estimates should be made of the costs of an emergency program in selected areas believed to be high-risk areas.

2. Preventive programs

There are several possible means of preventing Aedes aegypti-borne infections; their relative merits can be debated, but their relative costs have not been established. In a cost-benefit analysis, special attention might be drawn to the level of control that might be achieved by different techniques. In particular, the level of Aedes aegypti control may range from negligible control to complete eradication, and all levels less than eradication will involve permanent recurring control costs.

Alternative, but not mutually exclusive approaches, are as follows:

a) Environmental control: taking account of such measures as campaigns for the manual elimination

of Aedes aegypti breeding sources and the elimination of household water tanks by the provision of an acceptable and potable piped water supply.

b) Chemical control: taking account of the merits of alternative compounds, methods of application and of staff requirements.

c) Supplementary or alternative methods: although genetical and biological control methods are still in the experimental stage, estimates of their relative costs and efficacy may be necessary at a future date.

d) Vaccination: taking account of distribution and storage problems in different areas.

Account should be taken of the costs of monitoring the results of control using different methods.

3. Surveillance after Aedes aegypti eradication

A cost analysis is required of the measures necessary to prevent reintroduction of Aedes aegypti into areas that are free of the mosquito. The procedures requiring analysis are:

a) The detection of reinfestations and elimination of the foci that are found.

b) The prevention of reintroductions by the inspection and treatment of vehicles and goods that enter the free areas.

c) The verification of a continued absence of Aedes aegypti by routine checks.

4. The advantages of preventing Aedes aegypti-borne diseases and the penalties of inaction

A comparative study should be made of the advantages to a country of preventing Aedes aegypti-borne diseases and of the penalties which might be suffered by not carrying out preventive measures. Such a study might be made by selecting specific countries with contrasting programs. Account should be taken both of epidemic and of endemic situations.

In addition to gathering data on mortality and morbidity, an analysis should include the effects of quarantine restrictions on the economy of the countries and take into account such sources of income as tourism and the import-export market.

5. The establishment and maintenance of a research program over the next ten years

Since there is a continued threat of Aedes aegypti-borne diseases in the Americas, there are many data which must be collected if we are to understand the dynamics of the infections and of their vector. In addition, there are some research projects which should be undertaken because of their direct relevance to the prevention and control of the infections. An analysis is therefore required of the cost of maintaining a research unit which would be responsible for such investigations.

The cost analysis could be based on the experience of the Pan American Health Organization and on that of existing research units in areas where Aedes aegypti occurs.

V. RECOMMENDATIONS

During the discussions of the Group, a number of suggestions and recommendations were made by the participants. Although the members were not asked for recommendations, they believed that certain items should be brought to the attention of the Organization.

1. The Pan American Health Organization should continue to stimulate and assist those countries that currently are not carrying out an eradication program to establish an adequate Aedes aegypti service.

Special attention should be given to the administration of such services.

The national services should be encouraged to develop and intensify community programs of source reduction including the extension of piped and potable water into individual dwellings.

2. The systems of surveillance in those countries which have already achieved eradication should be strengthened to prevent reintroduction of Aedes aegypti.

3. An appeal should be made to those countries that are still infested, and which are therefore likely to export Aedes aegypti, to have all routes of exit, such as maritime, fluvial and air ports, border towns, and other areas of contact, free of Aedes aegypti. Where there is extensive small boat traffic there should be insistence that all water containers are mosquito proofed.

Coordination of programs in neighboring countries, especially within the Caribbean Area, is considered absolutely necessary and may call for special regional agreements. The Pan American Health Organization should be prepared to offer immediate technical and financial assistance to manage emergency situations before spread to adjacent areas occurs. To meet such situations, the establishment of an Aedes aegypti Insurance Fund might be considered, along the lines of the pest control compact Document MS-36, The Council of State Governments, Chicago, Illinois, USA.

4. A permanent stock of at least 3 million doses of 17D vaccine should be kept at the disposal of the Pan American Health Organization for the control of possible urban outbreaks of yellow fever or emergency jungle yellow fever situations. A study should be done to evaluate whether potency will be retained on storage at -70°C.

5. A research program should be developed which will include a coordinated study of problems related to the control and eradication of Aedes aegypti-borne diseases. Advantage should be taken of the accumulated experience of the Pan American Health Organization with its Jamaica Insecticide Test Unit, INCAP, CEPANZO, and the Foot-and-Mouth Disease Center.

The following types of activities should be considered, among others:

a) Evaluation of promising new insecticides and of alternative genetical and biological methods for controlling the vector by their early assessment in the field. This will require the Pan American Health Organization to develop close relationships with the research laboratories and assist in the arrangement for the field tests. The Caribbean Islands will be well suited for such studies.

b) Intensified evaluation of the insecticides in use by means of frequent periodic testing of insecticide susceptibility by the standardized WHO method and assessment of the results achieved in the field. Continued support and expansion of the Jamaica Insecticide Test Unit could cover this point, taking account of the need for spot-checks on the effectiveness of insecticide treatment to be made twenty-four hours after the application.

c) Monitoring of the changing distribution and abundance of Aedes aegypti.

d) Continuing surveillance of jungle yellow fever in primate hosts and vectors, and of dengue in urban and rural communities.

e) Analysis of conditions which might predispose communities in different areas to endemic and epidemic disease.

f) Development of dengue virus vaccines and field evaluation of their efficacy.

g) Improvement of the stability of yellow fever vaccine and development of simplified methods for its administration under varied field conditions.

h) Evaluation of environmental sanitation activities (source reduction) on both house infestation indices and adult mosquito densities.

i) Field studies to determine the efficacy of ULV dispersal of insecticides by aircraft as a means of reducing adult mosquito populations and of preventing or aborting an epidemic.

j) Activities directed towards the epidemiological and ecological analysis of specific difficult situations.

6. Analysis of the sociocultural factors involved in vector control and in other activities related to this problem should be undertaken with the participation of behavioral scientists, who should be assigned, where appropriate, to Aedes aegypti field studies. Research is also needed on means of improving communications within the campaign services, and between control operators, the scientific workers, and the administrators at high levels of government.

7. The cost-benefit study, for which an outline is presented in Section IV of this report, is considered of great importance for rational decisions on the future strategy for the control of Aedes aegypti-borne diseases, and every effort should be made to carry it out.

APPENDIX A

Excerpts from PAHO Document
"Policy Guide Aedes Aegypti Eradication,
Revised August 1968"

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13. Operation of the campaign

13.1 Strategy

The most advisable strategy for an Aedes aegypti eradication campaign is that which provides for the simultaneous coverage of all the infested areas of the country. Such a strategy eliminates the possibility of autochthonous reinfestations, and normally makes it possible to eradicate the mosquito within a period of three to four years.

Only when the simultaneous coverage is not possible for financial reasons, because the infested area is too extensive, should any consideration be given to the use of a strategy based on the division of the infested area into two, or at most three parts, each of which would be covered separately. This strategy obviously increases the time needed to complete the eradication of the mosquito and makes it necessary to adopt strict internal vigilance measures to prevent the reinfestation of the localities being freed of the mosquito until eradication is completed in the country.

It is clearly very difficult to apply this strategy successfully if conditions do not permit establishing a strict system of vigilance capable of preventing or reducing to a minimum the transportation of the mosquito from one part of the country to the other.

In any event, before any decision is made to apply this strategy in any country, the whole question must be carefully considered, and all the drawbacks and the risks involved in it must be carefully weighed against the reduced cost which such a strategy may imply for the campaign, as opposed to the strategy of a simultaneous coverage of the entire infested area.

13.2 Stages of the campaign

Whichever of the two strategies is adopted, an Aedes aegypti eradication campaign comprises four basic stages: preparatory, attack, consolidation, and maintenance. If the strategy adopted by the program is that of coverage by parts, the order of succession of the four stages will naturally be the same in all parts. However, the parts into which the infested area is divided will not be all in the same stage at the same time, since eradication operations are begun in each of them at different times.

13.2.1 Preparatory

The following activities are carried out in this stage, although not necessarily in this order: preparation of the plan of operations; setting up of offices and establishment of the administrative system; recruitment and training of personnel; purchase of supplies and equipment; geographical reconnaissance of the area to be covered, including preparation of maps, numbering of blocks, and, if necessary, the numbering of houses; and the preparation of work itineraries.

A start will also be made on activities designed to inform and motivate the population about the program and to enlist the cooperation of the community in eradicating the mosquito.

The duration of the preparatory stage will, of course, vary, depending on the extent of the infested area and the scope of the program. Generally speaking, this stage should be completed in three to five months, but in some instances a longer period will be necessary. In any event, this period should not exceed one year.

13.2.2 Attack

Once the preparatory stage is completed, eradication operations proper will be begun throughout the area it is planned to cover. These operations should be carried out along the lines set forth in the manual of technical and administrative standards for Aedes aegypti eradication campaigns prepared by PAHO.

Aedes aegypti eradication by means of residual-action insecticides comprises basically the following operations:

a) Initial survey to ascertain the presence and the exact distribution of the mosquito in each locality;

b) Treatment of the localities found to be positive;

c) Verification (post-treatment inspection) of treated localities to evaluate the results of treatment; each verification will be followed by a new treatment of the areas found to be still infested, until eradication of the mosquito is achieved.

It is recommended that the methods laid down in the above-mentioned manual be applied in these operations.

Essential factors in the attack stage are correct coverage of each locality, strict compliance with work itineraries, punctual maintenance of

treatment and verification cycles, and efficient field operations. This can only be achieved as a result of the appropriate orientation, coordination, and supervision of the activities of all personnel.

To facilitate the attainment of this aim, the field personnel should be organized into teams composed of five workers, or six as a maximum, with a team leader. For every five team leaders there will be a supervisor who will be responsible for the general supervision of the work of the five teams. At a third level of supervision, every 25 teams will have an inspector who will be responsible for the orientation, coordination, and general supervision of the work of the teams.

The treatment-verification cycles adopted will depend on the duration of the residual action of the insecticide used by the program.

It is considered that, in normal conditions, a cycle of three months for DDT or dieldrin and two months for some organophosphorous insecticides will be adequate. Nevertheless, it should be borne in mind that only a careful evaluation of the results obtained in the early months of work, supported by laboratory observations on the duration of the residual action of the insecticide, can tell whether the cycle adopted by the campaign is adequate or whether it needs to be adjusted to special conditions existing in the area.

Furthermore, the results obtained with insecticide applications must be continuously and carefully evaluated in order to promptly discover any defect interfering with the eradication of the mosquito.

It is strongly recommended that if the infestation index in a locality is not drastically reduced through the application of insecticide, as is to be expected, a careful and complete investigation should be made, before normal operations are continued, to determine and eliminate the causes of the failure of the treatment. If this is not done, the campaign may suffer severe setbacks and financial losses which would have been avoided.

The duration of the attack stage coincides in practice with the duration of the eradication of the mosquito, since this stage is to be considered completed only when all the localities in the area covered have had at least one negative verification, and the Aedes aegypti problem in that area is reduced to the sporadic occurrence of small isolated foci of the mosquito.

Regarding time, the duration of the attack stage varies considerably, since it obviously depends on a whole cluster of factors. However, in normal circumstances, this stage should be completed in from one to three years, according to the size of the area covered, and its degree of infestation.

13.2.3 Consolidation

In this stage the foci of Aedes aegypti that have survived the attack operations will be eliminated.

In order to find these foci, the verification cycle employed in the attack stage will be continued in all the initially positive localities considered negative. These inspections will serve a dual purpose: to confirm the absence of the mosquito in those localities and to prevent reinfestations.

It is recommended that, in addition to the search for larvae, the presence of adults of Aedes aegypti should be investigated in the course of the verification of certain localities in which the conditions make for the existence of hidden breeding places, in order to discover any possible hidden foci of the mosquito.

The consolidation stage is to be considered completed when all localities in the initially positive area are negative by the last verification.

13.2.4 Maintenance

In this stage the inspection will be continued in the initially positive area until it can all be declared free of the mosquito, in accordance with the criteria for eradication established by PAHO.

During this stage a specific vigilance service will have to be organized.

14. Insecticides for the eradication of the mosquito

In some areas of the Americas, Aedes aegypti is still susceptible to DDT or to dieldrin, and the eradication of the vector in these areas should be based on the use of those insecticides. However, these products can no longer be used in most of the areas still infested in the Hemisphere owing to resistance of the mosquito.

For such areas some new insecticides are available, which have been used for several years now, with good results, against strains of Aedes aegypti resistant to the chlorinated insecticides. Among those new products, special mention must be made of the organophosphorous compounds Abate, fenthion and malathion.

Abate is a highly effective, persistent, and safe insecticide. Its application in drinking water in slow release formulations has been approved by the WHO Expert Committee on the Safe Use of Pesticides in Public Health (WHO Technical Report Series No. 356, 1966). Fenthion and malathion have been shown to be effective and safe products for "perifocal" use and for application to nonpotable water.

Fenthion, when employed in association with Abate by the "perifocal" method, is effective in work cycles of up to two months. Malathion with Abate used in the same way is equally effective, but in this case the treatment-verification cycle should not exceed one month, because the residual action of malathion in the containers does not last longer than that. The recommendation at present is that the eradication of the vector in areas where DDT and dieldrin resistance has been confirmed be based on the use of the above-mentioned organophosphorous insecticides, preferably the association of Abate with fenthion.

It is, however, obvious that only insecticides to which the local Aedes aegypti is susceptible should be used by the campaign. Thus, before initiating operations in any area, it will be advisable to test the susceptibility of the Aedes aegypti strains in the area in order to select the appropriate insecticides. Furthermore, once eradication work is begun, the campaign should continue to test the susceptibility of those strains regularly so that the insecticides being used can be promptly replaced, if it should become necessary.

In this regard it should be mentioned that WHO has undertaken a long-term program whose main purpose is to obtain new insecticides to solve the problems of resistance. More than 40 manufacturing companies provide this program, which was begun in 1960, with recently developed compounds; so far, approximately 1,500 compounds have been examined and new chemicals are being received at the rate of 200 per annum. All these compounds are systematically evaluated by a group of ten laboratories and four WHO field test units, where the new products are subjected to the necessary tests to determine their insecticide properties, toxicological characteristics, and suitability for practical use. Among the compounds currently under study, are some (in addition to the phosphorous compounds already mentioned) which appear to be suitable for Aedes aegypti eradication.

Therefore, it is believed that the resistance of the vector to insecticides will not prevent the success of the eradication campaigns provided they are appropriately carried out and the eradication of the mosquito is completed in a reasonable period of time.

15. Methods for combating the vector

Aedes aegypti eradication is based essentially on the use of insecticides, supplemented by the destruction, removal, or protection of containers of the kind preferred by the mosquito.

The elimination of the largest number possible of such potential breeding places should begin in the preparatory stage, and continue throughout the campaign to the vigilance stage. Through its health education program and other promotional activities, the campaign should

make sure that, in addition to its own personnel, personnel of the public health services and other official agencies, as well as the community in general, participate in this effort.

There is no need to emphasize the importance of eliminating potential breeding places. Suffice it to consider the time and money the campaign will save by the removal and adequate disposal of all the useless containers capable of breeding Aedes aegypti that are usually found in large numbers in courtyards and gardens, in vacant lots, and in certain commercial and industrial establishments.

However, experience to date has shown that the campaign must consider health education and environmental sanitation only as complementary measures. These measures make the field operations easier, and help to shorten the duration of the campaign, but the eradication of the mosquito must still be based chiefly on the adequate use of insecticides.

The method first used in Aedes aegypti eradication consisted basically in the application of a mixture of oil as larvicide in all containers found breeding the mosquito. Aedes aegypti was eradicated from Bolivia and from most of the territory of Brazil by that process, known at present as the traditional (or classical) method. Although very effective when correctly applied, the process is costly because the use of a larvicide without residual action requires a weekly cycle of work to detect the foci of the mosquito and eliminate them before the adults emerge. This method may still be indicated in special circumstances, but it is not recommended as routine for the eradication of the vector.

Since residual-action insecticides began to be employed against Aedes aegypti, the campaigns for the eradication of the mosquito have used the following methods:

a) Intradomiciliary method - It consists essentially in the spraying of the inside walls of the houses, supplemented by the treatment of the most important containers found in the premises. The spraying is basically the same as the one used in the malaria eradication campaigns. The treatment of the containers is done following the same technique used in the perifocal method (which will be described below). The insecticide concentration in the pump, and the length of the treatment-verification cycle will vary with the efficiency of the insecticide used, and the duration of its residual action.

b) Perifocal method - This method consists basically in the treatment of all containers of the type preferred by

Aedes aegypti, whether they have water or not. Such treatment comprises the spraying of the walls of the container both externally and internally so that they are completely covered with a thin film of insecticide. In addition, the spraying should extend to cover with the same film of insecticide the surface of the water, if there is any in the container, as well as any wall close by the container up to two feet on each side and above it. In this method also, the concentration of the insecticide in the sprayer, and the working cycle to be adopted, will depend upon the product used by the campaign.

c) Focal method - This process is based on the use of the insecticide, solely as larvicide. The product is put in all containers capable of breeding Aedes aegypti, whether or not they have water. The amount of insecticide to be poured into each container and the working cycle will depend on the size of the container and the efficacy and the duration of the residual action of the product. This method was employed in some areas in the early days with DDT. But, since it takes only limited advantage of the residual action of the insecticide, it was soon abandoned. Its use at present is not recommended for the same reason, except in special circumstances, such as in the event the campaign is forced to use a product with only larvicidal action.

Of the three methods, the intradomiciliary obviously gives the insecticide more chance to act against the mosquito, whether it is in the larval stage in the containers or as an imago either in the containers or on the walls. When correctly applied in the areas where Aedes aegypti normally rests inside the houses, the method is highly effective. However, it is too expensive and usually very difficult to apply in commercial and residential areas. Consequently, although its use may be indicated in special circumstances it is not recommended as a routine method for eradicating the vector. The method recommended for that purpose is the perifocal. In spite of using less insecticide in more limited areas, this method gets almost as much yield from the product as the intradomiciliary method. This is because the perifocal method applies the insecticide at precisely the points where the mosquito, by biological demand, is forced to enter in contact with the product, that is to say, in the breeding places and their surroundings. For this reason, the perifocal method, specially when the eradication campaign is combined with a program of environmental sanitation, is easier to apply and much more economical than the intradomiciliary, yet there is no great difference between the efficacy of the two methods.

16. Criteria of eradication

On the basis of the experience gained by the countries of the Americas in the struggle against Aedes aegypti, the Pan American Sanitary Bureau has

established the requirements to be met before the Governing Bodies of the Organization can accept the declaration of eradication of the vector in a country.

These requirements which may be found in the Guide for the Reports of the Aedes aegypti Eradication Campaign in the Americas (PAHO Miscellaneous Publication No. 49, 1960) are briefly as follows:

a) All areas of the country with ecological conditions favorable to Aedes aegypti must be inspected, and all localities that are found infested with Aedes aegypti in this inspection should be worked until the eradication of the vector is completed.

b) Generally, eradication of the mosquito will be considered achieved in a locality when, in a period of one year after the last application of insecticide, three consecutive verifications have negative results. In special cases two additional negative verifications within the period of a year will be necessary, the first upon eighteen months and the second upon twenty-four months after the last treatment.

c) In small rural localities, generally the mosquito will be considered eradicated upon one negative verification six months after the last treatment. In special circumstances a second negative verification will be required within at least eighteen months after the first negative verification.

d) Through periodic reports, the Government should supply to the Bureau the data necessary to the evaluation of the field work. These reports also constitute the basis for the Bureau's report on the continental program. Data on this program are published monthly in the Bulletin and are included in the Annual Report of the Director and in the documents concerning the program presented to the Governing Bodies of the Organization.

e) The final verification to prove eradication of the vector should be made with the collaboration of technical personnel of the Bureau.

In addition to the criteria mentioned above, in order for a country to be considered free of Aedes aegypti by the Governing Bodies of the Organization it must also satisfy certain requirements regarding colonies of

the mosquito. These requirements, established by the XVII Pan American Sanitary Conference (Washington, D. C., 1966) in its Resolution XX are in brief the following:

a) To eliminate all colonies of Aedes aegypti that exist in areas in its territory in which the ecological conditions are favorable to the vector;

b) Not to permit the existence of any colony of the mosquito except in recognized scientific centers situated in areas that are ecologically unfavorable to the vector;

c) To ensure that colonies of the vector existing in those unfavorable areas are permanently maintained in such a way as not to allow the country to be reinfested by Aedes aegypti from those colonies.

17. Vigilance service

Vigilance to prevent reinfestation should be initiated as soon as Aedes aegypti eradication is completed, and should be continued without interruption for as long as there are infested areas in the Americas.

It is unnecessary to emphasize the risk of reinfestation being run by countries which are not maintaining adequate vigilance services in their territories, especially those which, because of their geographical situation and ease of communications, are more exposed to the sources of reinfestation in the Hemisphere. Nor is there any need to insist on the advisability of all areas free of the mosquito in the Americas maintaining an efficient vigilance service.

This service should be aimed at preventing the importation of the mosquito and at discovering and promptly eliminating any reinfestation which it has not been possible to prevent.

For the achievement of these objectives the following measures are recommended:

17.1 Preventive measures

These measures should include:

a) Control of air traffic, to ensure compliance by the airlines with the provisions of the international sanitary regulations dealing with disinsection of aircrafts;

b) Control of sea and river transport. To ensure that small craft coming from abroad keep their water containers mosquito-proof. To inspect large vessels coming from infested areas, particular attention being paid to those parts of the vessels where Aedes aegypti may breed;

c) Control of land transport. It is essential to control railroads and other forms of land transport coming from infested countries. Where necessary, they must be disinsected and all containers capable of transporting eggs of the mosquito must be treated. Special attention should be paid to used tires regardless of their mode of entry, and those arriving from infested areas shall be appropriately treated.

17.2 Measures for discovering reinfestations

These shall vary from country to country depending on whether the country free of Aedes aegypti is adjacent to countries also negative or adjoin countries still infested.

In the first instance, the following is recommended:

a) Vigilance at all international ports and airports, and all frontier posts served by international communication systems;

b) Make this vigilance at a six-monthly cycle, inspecting at least ten per cent of the houses existing in the above-mentioned localities.

In the second instance the following is recommended:

a) To survey periodically the localities in which the ecological conditions are favorable to the vector, inspecting at least ten per cent of the existing houses;

b) To inspect at a six-monthly cycle ten per cent of the existing houses in the localities most exposed to reinfestation that are not an international port or airport, or a frontier post on the border with an infested country;

c) To inspect at a three-monthly cycle at least 33 per cent of the houses in the international ports and airports as well as in the frontier posts situated on the border with an infested country.

APPENDIX B

STATUS OF AEDES AEGYPTI ERADICATION BY COUNTRY AND
OTHER POLITICAL UNITS IN THE AMERICAS
DECEMBER, 1969

COUNTRY OR OTHER POLITICAL UNIT	AREA (IN KMS 2)			PRESENT STATUS	ACTIVITY IN PROGRESS
	TOTAL	AREA ASSUMED INITIALLY INFESTED	PERCENTAGE OF TOTAL		
Argentina	4,024,458	1,000,000	24.8	Eradication completed	Surveillance
Barbados	430	171	39.8	Infested	Program in operation
Bolivia	1,098,581	100,000	9.1	Eradication completed	Surveillance
Brazil	8,511,965	5,358,822	63.0	Reinfested	Program in operation
Colombia	1,138,338	280,000	24.6	Infested	Program in operation
Costa Rica	50,700	20,000	39.4	Eradication completed	Surveillance
Cuba	114,524	100,000	87.3	Infested	Program in operation
Chile	756,945	100,000	13.2	Eradication completed	Surveillance
Ecuador	283,561	69,454	24.5	Eradication completed	Surveillance
El Salvador	21,393	18,675	87.3	Reinfested	Limited program
United States of America	9,359,781	1,536,819	16.4	Infested	Program suspended
Guatemala	108,889	36,423	33.4	Eradication completed	Surveillance
Guyana	214,969	4,662	2.2	Infested	Program in operation
Haiti	27,750	27,750	100.0	Infested	Program suspended
Honduras	112,088	69,929	62.4	Reinfested	Limited program
Jamaica	11,424	11,424	100.0	Infested	Program in organizational phase
Mexico	1,972,546	1,000,000	50.7	Reinfested	Program in operation
Nicaragua	130,000	65,263	50.2	Eradication completed	Surveillance
Panama	75,650	56,246	74.3	Reinfested	Program in operation
Paraguay	406,752	200,000	49.2	Eradication complete	Surveillance
Peru	1,285,215	638,000	49.6	Eradication complete	Surveillance
Dominican Republic	48,734	42,020	86.2	Infested	Program suspended
Trinidad & Tobago	5,128	3,108	60.6	Infested	Program in operation
Uruguay	186,926	186,926	100.0	Eradication completed	Surveillance
Venezuela	912,050	710,000	77.8	Infested	Limited program

Cont.

STATUS OF AEDES AEGYPTI ERADICATION BY COUNTRY AND OTHER POLITICAL UNITS IN THE AMERICAS DECEMBER, 1969 (Continued)

COUNTRY OR OTHER POLITICAL UNIT	AREA (IN KMS 2)			PRESENT STATUS	ACTIVITY IN PROGRESS
	TOTAL	AREA ASSUMED INITIALLY INFESTED	PERCENTAGE OF TOTAL		
Antigua (Barbuda y Redonda)	442	442	100.0	Infested	Program in preliminaries of operation
Aruba	190	174	91.6	Infested	Program in preliminaries of operation
Bahamas	11,405	11,405	100.0	Infested	Limited program
Bermuda	53	53	100.0	Eradication completed	No information
Bonaire	281	246	87.5	Infested	Program in preliminaries of operation
British Honduras	22,965	22,965	100.0	Eradication completed	Surveillance
Canal Zone	1,432	1,432	100.0	Eradication completed	Surveillance
Cayman Islands	259	259	100.0	Infested	Program in operation at Cayman Brac
Curaçao	472	448	94.9	Infested	Program in preliminaries of operation
Dominica	789	789	100.0	Infested	No activities
French Guiana	91,000	91,000	100.0	Infested	Program in operation
Grenada- Grenadines (Carriacou, Little Martinique,& Union)	344	344	100.0	Infested	Program in preliminaries of operation
Guadeloupe (part of St. Maarten)	1,779	1,619	91.0	Infested	Program in operation
Martinique	1,102	1,000	90.7	Infested	Program in operation
Montserrat	98	83	84.7	Infested	Program in preliminaries of operation
Puerto Rico	8,897	8,897	100.0	Infested	Program suspended
Saba, St. Eustatius (part of St. Maarten)	67	67	100.0	Infested	Program in preliminaries of operation
St. Kitts-Nevis & Anguillas	357	357	100.0	Infested	No activities
St. Lucia	616	259	42.0	Infested	Program in operation
St. Vincent	388	332	85.6	Infested	Program in organizational phase
Surinam	142,822	48,000	33.6	Infested	Program in operation
Turks & Caicos Islands	430	430	100.0	Infested	No activities
Virgin Islands (UK)	153	153	100.0	Infested	No activities
Virgin Islands (US)	344	344	100.0	Infested	Program suspended

APPENDIX C

DATA ON THE COST OF THE VIGILANCE ACTIVITIES FOR *AEDES AEGYPTI* IN SOME COUNTRIES FREE OF THE VECTOR IN THE AMERICAS[1]

Country	Year	National Currency	Cost	Equivalent US$
Argentina	1964 - 1966	Argentinian Peso	18,185,579	90,027
Bolivia	1 year	Bolivian Peso	38,000	3,193
Brazil	1959 - 1965	New Cruzeiro	365,390	167,918
Mexico	1964 - 1966	Mexican Peso	2,962,000	236,960
Nicaragua	1969	Cordoba	72,247	10,321
Paraguay	1958 - 1966	Guarani	1,104,000	8,761
Peru	1954 - 1964	Sol	1,000,000	37,313
Uruguay	1969	Uruguayan Peso	6,325,000	25,500

[1] Source: Data presented by each country at the Conference on *Aedes aegypti* Eradication in the Americas, 1967, or received by cable in February 1970.

APPENDIX D

DATA BASED ON THE TOTAL COST OF THE *AEDES AEGYPTI* ERADICATION IN SOME COUNTRIES OF THE AMERICAS[1]

Country	Year	Currency	Cost
Argentina	1955 - 1963	Argentinian Peso	55,886,576
Colombia	1950 - 1966	Colombian Peso	5,437,538
Chile	1960 - 1961	Escudo	25,000
Mexico	1958 - 1963	Mexican Peso	44,207,000
Peru	1940 - 1954	Sol	5,250,000
Uruguay	1948 - 1958	Uruguayan Peso	430,000

[1] Source: Data presented by each country at the Conference on *Aedes aegypti* Eradication in the Americas, 1967.

APPENDIX E

DATA BASED ON THE AMOUNT EXPENDED BY THE *AEDES AEGYPTI* ERADICATION CAMPAIGN IN 1969 AND FIGURES FOR THE 1970 BUDGET OF SOME COUNTRIES AND TERRITORIES IN THE AMERICAS[1]

Country	Expended in 1969	Budget for 1970
Brazil	345,000	644,000
Colombia	53,521	72,394
El Salvador	61,291	62,160
Grenada	1,000	30,000
Guyana	100,000	120,000
Honduras	54,291	83,080
Martinica	3,000	261,000
Mexico	179,813	72,000
Panama	65,133	100,602
Santa Lucia	36,000	47,000
Surinam	202,503	236,096
Trinidad	119,000	123,000
Venezuela	765,618	742,824
Total	1,986,170	2,594,156

[1] Source: Data received by cable from each country or territory.

APPENDIX F

ESTIMATED COST OF THE *AEDES AEGYPTI* ERADICATION CAMPAIGN IN THE COUNTRIES AND TERRITORIES STILL INFESTED OR REINFESTED IN THE AMERICAS (FEBRUARY 1970)[1]

Country or Territory	Estimated number of houses	Probable duration of the campaign	Cost in US$ estimated by *Aedes aegypti* Working Group in 1967	Updated estimate in 1970, in US$
Antigua	14,000	3 years	176,000	176,000
Netherlands Antilles	52,000	3 "	542,000	542,000
Bahamas	29,000	3 "	358,000	358,000
Barbados	52,000	3 "	499,000	499,000
Brazil	180,000	2 "	-	2,500,000
Colombia	41,000	2 "	39,000	200,000
Cuba	2,330,000	4 "	27,400,000	27,400,000
Dominica	14,000	3 "	176,000	176,000
El Salvador	220,000	4 "	2,100,000	2,100,000
United States of America (2)	14,496,100	5 "	-	250,000,000
Grenada	27,000	3 "	290,000	290,000
Guadalupe	66,000	3 "	764,000	764,000
French Guiana	8,000	3 "	117,000	117,000
Guyana	135,000	4 "	1,220,000	1,220,000
Haiti	689,000	4 "	1,682,000	6,000,000
Honduras	60,000	2 "	-	600,000
Cayman Islands	500	2 "	-	10,000
British Virgin Islands	3,000	3 "	46,000	46,000
Jamaica	512,000	4 "	3,849,000	4,800,000
Martinique	67,000	3 "	764,000	764,000
Mexico	(3)	2 "	-	500,000
Montserrat	3,000	3 "	46,000	46,000
Panama	16,000	2 "	-	600,000
Dominican Republic	740,000	4 "	5,886,000	8,000,000
St. Kitts, Nieves and Anguilla	13,000	3 "	176,000	176,000
St. Vincent	19,000	3 "	261,000	261,000
St. Lucia	21,000	3 "	285,000	285,000
Surinam	70,000	3 "	859,000	859,000
Trinidad	50,000	2 "	161,000	400,000
Turks and Caicos	3,000	3 "	46,000	46,000
Venezuela	1,768,000	6 "	31,496,000	17,000,000 (4)
		TOTAL:	79,218,000	326,735,000

Observations:

1. Total cost, including cost of equipment, vehicles, materials, insecticides, etcetera. Not including PASB/WHO budgetary allocations, amounting to US$491,637 in 1970 for this Hemisphere.
2. Including Puerto Rico and US Virgin Islands.
3. Not possible to estimate.
4. Information received from one of the Study Group Members.

Pan American Health Organization

PAHO/ACMR 9/16

NINTH MEETING OF THE
ADVISORY COMMITTEE ON MEDICAL RESEARCH

Washington, D.C. 15-19 June 1970

SURVEILLANCE OF DENGUE IN THE AMERICAS

(Item 14.5 of the Agenda)

PAN AMERICAN HEALTH ORGANIZATION

SCIENTIFIC ADVISORY COMMITTEE ON DENGUE

FIRST MEETING
15-16 JANUARY 1970
WASHINGTON, D.C.

SURVEILLANCE OF DENGUE IN THE AMERICAS: A REPORT TO THE DIRECTOR

Ref: RD 49/10-2
16 January 1970

PAN AMERICAN HEALTH ORGANIZATION
Pan American Sanitary Bureau, Regional Office of the
WORLD HEALTH ORGANIZATION

Washington, D.C.

SCIENTIFIC ADVISORY COMMITTEE ON DENGUE

Dr. Pierre Ardoin
Director, Trinidad Regional Virus Laboratory
Port-of-Spain, Trinidad

Dr. N. Joel Ehrenkranz
Acting Chairman, Department of Epidemiology and Public Health
University of Miami School of Medicine
Miami, Florida, USA

Dr. Henri Fossaert
Chief, Virus Department
Instituto Nacional de Higiene
Caracas, Venezuela

Dr. Louis S. Grant
Head, Department of Microbiology
University of the West Indies
Kingston, Jamaica

Dr. Hernando Groot
Jefe, Sección de Investigación
Instituto Nacional para Programas Especiales de Salud
Bogotá, Colombia

Dr. Brian E. Henderson
Chief, Arbovirology Unit
Virology Section
National Communicable Disease Center
Atlanta, Georgia, USA

Dr. Karl M. Johnson
Director, Middle America Research Unit
Balboa Heights, Canal Zone

Colonel Philip K. Russell
Chief, Department of Virus Diseases
Walter Reed Army Institute of Research
Washington, D.C., USA

Dr. William F. Scherer (Chairman)
Chairman, Department of Microbiology
Cornell University Medical College
New York, New York, USA

Dr. M. Martins da Silva (Secretary)
Chief, Department of Research Development and Coordination
Pan American Health Organization
Washington, D.C., USA

OTHER PARTICIPANTS AND GUESTS

Dr. Lelio B. Calheiros
Regional Adviser on Aëdes aegypti Eradication
Pan American Health Organization
Washington, D.C., USA

Dr. Wilbur G. Downs (Temporary Adviser)*
Director, Yale Arbovirus Unit
Yale University
New Haven, Connecticut, USA

Dr. Leslie P. Spence (Temporary Adviser)
Department of Microbiology
McGill University
Montreal, Canada

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*Unable to attend

CONTENTS

INTRODUCTION

The meeting was opened by Dr. Arreaza Guzmán, Assistant Director of PAHO, who expressed the Director's regret at not being able to be present and reviewed the reasons why the Committee had been convened.

Concern over the increasing frequency and intensity of outbreaks of dengue in the Americas, he stated, had led PAHO to recognize the need, as a first step, to create a small, central working body to coordinate the exchange of information on this disease and to recommend courses of action to the Organization. This group, composed of representatives from the principal institutions actively engaged in studies of dengue, has been charged with the responsibility of maintaining under review the current status of information in this field, suggesting new areas of study in need of attention, and laying the groundwork for a basic approach to the epidemiologic investigation of dengue. In particular, the Committee's first assignment, as set forth in the agenda of the meeting, is to develop a plan for surveillance involving the participation of all the institutions in question.

Under the chairmanship of Dr. William Scherer, the Committee then addressed itself to its task. The first day was devoted to epidemiological reports from the laboratories that have been directly concerned with the dengue problem in the Americas and to a detailed, up-to-date summary of Aëdes aegypti eradication programs in the Western Hemisphere. The morning of the second day was given over to the formulation of statements on the public health importance of the disease, on existing sources of information and mechanisms for exchange, and on priorities to be established for future work in this field. Following this, there was general discussion of a design for surveillance, and a draft program, including specific recommendations, was developed and approved.

SURVEILLANCE OF DENGUE IN THE AMERICAS

1. Importance of the Disease

Dengue and dengue-like diseases have recurred in epidemic fashion at frequent intervals in the Western Hemisphere. In this century, major outbreaks took place in 1904, 1915, 1922, 1934, 1941, 1949-50, 1963-64, and 1968-69. Attack rates were high, sometimes exceeding 70 or 80 per cent. Type 2 dengue virus was isolated in 1953, and dengue type 3 was responsible for the 1963-64 epidemic. Both types 2 and 3 caused epidemic disease in the Americas during 1968, and type 2 predominated in 1969. Infection with one type does not confer protection against subsequent infection with another, and, indeed, under certain circumstances, it may even produce a hypersensitivity that is postulated to lead to the dengue shock syndrome.

Even though mortality and permanent residua are not significant features of classical dengue, the high attack rate and the associated morbidity, which includes long periods of convalescence, lead to absenteeism and impaired efficiency at work. Moreover, outbreaks of the disease place a burden on health facilities, thus diverting them from the care of persons who are more seriously ill. Finally, there may be subtle effects that have not yet been fully explored, such as the possible induction of congenital abnormalities, abortion, and recrudescence of underlying diseases.

The toll of an outbreak includes, in addition to the direct cost of treatment of the disease, indirect losses from expensive emergency vector control measures, lowered manpower productivity, and, in some areas, decreased revenue from tourist trade. In addition to these economic losses, the costs of initial and follow-up programs to control Aëdes aegypti are a heavy burden to communities at risk. Despite large recent expenditures in several countries for the control and eradication of this vector, dengue outbreaks continue to recur.

Some 30 to 35 million persons, not including an undertermined number of tourists, reside in areas at risk to dengue outbreaks. These areas currently include the Caribbean islands, the countries of the northern coast of South America, and the southeastern part of the United States. The geographical extent of the disease may increase as reinfestation of formerly Aëdes aegypti-free areas continues. There is evidence that 11.8 million km^2, or

29 per cent of the land in the Western Hemisphere, is capable of supporting Aëdes aegypti, and that, as of December 1969, 3.4 million km^2 were infested.

The rapidity with which outbreaks of dengue spread from one area to another makes the disease an important international problem. Moreover, as long as ecologic factors permit outbreaks to occur frequently, the conditions exist for introduction and dissemination of other more virulent viruses, such as yellow fever, that have a similar transmission cycle. Importation of other dengue types from Asia is also an ever-present danger. In addition, the apparently accelerating frequency of epidemics (Figures 1, 2, and 3), plus the increase in population size and density, may lead to a hyperendemic situation in the Western Hemisphere similar to that now present in Southeast Asia and, consequently, to the possible occurrence of the dengue shock syndrome, with its associated mortality.

2. Current Status of Surveillance

In the Americas, recognition of infectious diseases, including dengue, has classically been, and remains, in the hands of private and government physicians working in private offices, clinics, and hospitals. In those countries where dengue has a history of recurrent epidemic behavior, major clinical signs and symptoms of this virus infection in adults are generally well appreciated by a majority of the general practitioners and internists in the communities when epidemics are occurring. It is probable, however, that in interepidemic periods sporadic cases in adults are readily overlooked or misdiagnosed. Dengue in children is less readily recognized because of its mild and unremarkable manifestations.

Resources for the specific diagnosis of dengue, as well as for certain investigative programs on the disease, exist in various laboratories in the countries and territories where dengue has been active in the last two decades. Another group of institutions, laboratories, and university microbiology departments in the United States maintains a current interest in various aspects of the problem. Within the Caribbean area, these laboratories include the Department of Microbiology at the University of the West Indies in Jamaica; the Trinidad Regional Virus Laboratory; the National Institute of Hygiene in Venezuela; the National Institute of Health in Colombia; the Department of Microbiology at the University of Valle in Cali, Colombia; the Gorgas Memorial

Laboratory; and the Middle America Research Unit (NIH) in Panama. Dengue-interested, and dengue-capable, organizations in the continental United States include the National Communicable Disease Center, the Walter Reed Army Institute of Research, the NIAID Pacific Research Section, the Gulf South Research Institute, the Yale Arbovirus Research Unit, and the departments of microbiology, epidemiology, and/or medicine at the following universities: Hooper Foundation/University of California (at San Francisco), Cornell, Hawaii, Johns Hopkins, Maryland, Miami, Pittsburgh, and Rutgers.

Systems for the collection and dissemination of information regarding dengue vary. In most instances, ministries or departments of health have an epidemiologist responsible for reporting such diseases to the Chief Medical Officer or his equivalent in the governmental health structure. With respect to the Caribbean area, such epidemiologists exist in Puerto Rico, Haiti, the Dominican Republic, Jamaica, Guyana, and Trinidad. In addition, epidemiologists reporting infectious diseases have long been established in Venezuela, Colombia, Panama, and all the countries of Central America.

The Pan American Health Organization has considered dengue a reportable infectious disease since 1965. Statistical notification of cases of dengue is therefore received at PAHO Headquarters through the regular channels of disease reporting maintained between the Organization and the various country and territory governments. Typical time between the completion of this reporting by the government agency and appearance of the data in the Weekly Epidemiological Report is between three and six weeks. A breakdown of the reporting systems used in the various countries is presented in Table 1. Table 2 shows the statistics on dengue compiled by PAHO in the last decade on the basis of regular reports, supplemented by answers received in an annual questionnaire.

Other sources of information concerning dengue fever in the Americas include Morbidity and Mortality, the weekly report of the National Communicable Disease Center; the Arbovirus Information Exchange, which is maintained as an informal service for groups actively working in the field of arbovirology; and, of course, the scientific literature. The Arbovirus Information Exchange

appears two or three times yearly in English. Although it is of considerable use to participating laboratories, it is not intended to provide standardized information to larger communities of public health workers and scientists. With respect to the scientific literature, a problem exists in the time lapse between the occurrence of significant events and the publication of findings. Another difficulty is that the literature on dengue may appear in either Spanish or English, and English-speaking workers may fail to be aware of studies and reports published in Spanish by journals of small circulation.

The present system for the surveillance and diagnosis of dengue has significant shortcomings, however. Laboratory tests are not uniformly available or widely used to confirm clinically diagnosed dengue virus disease. As a concomitant, there is widespread failure to diagnose the disease in children. Also, the incidence of the disease is grossly underestimated. The system for collection and handling of information is deficient in several regards: certain regions are not covered at all; acquisition and dissemination of data is slow; and long-term clinical records that might reveal new, unrecognized manifestations have not been kept.

3. Need for Improved Surveillance

The epidemiologic mechanisms that result in periodic dengue outbreaks in the Hemisphere are poorly understood. Areas of endemicity during interepidemic years have not been defined, nor are the reasons for the appearance of an outbreak fully known. The interpretation and understanding of epidemiologic events in any single country or territory depends on knowledge of the situation in the entire area in which the potential for transmission of dengue viruses is present. It is in these areas, detected only by effective surveillance, that major investigative efforts should be made.

The persistence of large Aëdes aegypti populations and the expanding size of the human population in the Americas, and in particular in the Caribbean region (Figure 4), will be associated with the continuous or periodic presence of dengue. Ultimate control of this and other Aëdes aegypti-borne diseases such as yellow fever obviously depends on reduction or elimination of the primary vector. However, the present eradication program has been faced with difficulties in

several countries and territories. In the absence of adequate universal vector control, active surveillance is necessary for progress in the prevention or control of dengue. This surveillance should attempt to supply the epidemiological and virological information necessary to identify potentially dangerous developments and hopefully to provide direction for vector control programs. Any surveillance network established for the evaluation of dengue will, of course, be equally applicable to the problem of urban yellow fever.

4. Proposed Program

A coordinated, well-planned program for the surveillance of dengue in the Americas is considered essential. Such a program should be directed toward accomplishment of the following objectives:

- To discover dengue epidemics in the early stages and thus permit prompt institution of emergency control measures and pertinent research investigations
- To detect dengue shock syndrome/hemorrhagic fever or other currently unrecognized manifestations caused by dengue viruses so that prompt and proper patient management may be applied
- To monitor continuously the magnitude of dengue as a public health and economic problem
- To provide knowledge on the natural history of dengue viruses by facilitating research aimed at eventually controlling the disease, with or without eradication of Aëdes aegypti

The task would be approached along several lines: through the assignment of two full-time PAHO epidemiologists to oversee the areas at risk, through the extension of laboratory facilities for the diagnosis of dengue, through the development of an effective system of information exchange, through definition and encouragement of field and laboratory research on dengue, and through the establishment of a permanent subcommittee for coordination of epidemiologic investigation.

The two epidemiologists would carry out continuous and vigorous case detection efforts, working from laboratories located in key positions, such as Trinidad, Miami, or Puerto Rico. Each could be responsible for a given geographic

area--for example, the TRVL epidemiologist might cover Guyana, Surinam, French Guiana, the Lesser Antilles, the Netherlands Antilles, Jamaica, Venezuela, and Colombia, while the other could oversee surveillance activities in the Dominican Republic, Haiti, Cuba, Puerto Rico, the Bahamas, and Central America. Specifically, the surveillance epidemiologists would undertake to do the following:

- Establish "sentinel" units in their respective areas of influence. The units would include hospitals, medical officers, and private practitioners. Personal and frequent contact between the epidemiologists and the units should be maintained.

- Select sample populations of children under five in specific areas for periodic determination of current group B virus activity on a serological basis.

- Encourage "dengue-risk" countries not now reporting suspected cases of the disease to do so, and provide them with the assistance as required.

- Make available to health officials and physicians the new information and laboratory diagnostic support necessary to permit early detection of dengue, including possibly the hemorrhagic fever/shock syndrome.

- Investigate outbreaks and immediately contact the Epidemic Subcommittee of the PAHO Scientific Advisory Committee on Dengue (see below) to determine jointly the additional steps to be taken; initiate requests to implement the measures agreed on.

- Coordinate their activities with other concerned persons, such as other PAHO epidemiologists, laboratory workers, and Aëdes aegypti control personnel assigned to the zones involved.

The extension of laboratory facilities should permit the establishment of a functional system to cover the areas at risk in the Americas. It should include provision for the collection, transportation, and testing of specimens, as well as the reporting of results back to physicians.

An effective system of information exchange on dengue should be established. This could be done through a quarterly newsletter, supplemented as necessary by special editions, prepared by one of the surveillance epidemiologists. Information on Aëdes aegypti control would be included when pertinent. These newsletters would be distributed by PAHO to the laboratories directly concerned, to Chief Medical Officers in the area, and to the sentinel units, as well

as to the members of the PAHO Scientific Advisory Committee on Dengue and all the persons on the Organization's regular mailing list for the Weekly Epidemiological Reports.

Within certain areas of the Caribbean, such as Cuba, Santo Domingo, and the smaller islands, and in Colombia and Central America, periodic serological surveys should be conducted. In localities that are considered relatively or absolutely free of Aëdes aegypti, such surveys would provide information on unrecognized foci of transmission; of particular interest are projects such as the studies at MARU of serum samples collected by INCAP for the recent nutrition surveys in Central America and Panama. Laboratory investigations which may produce results of most relevance in the present epidemiological situation are those directed toward biologic and antigenic characterization of dengue viruses, the ultimate objective being to clearly differentiate subtypes and relate the differences to epidemiologic and clinical observations. Efforts to increase the sensitivity and efficiency of virus isolation procedures should be encouraged. An efficient serologic method for detecting type-specific anti-dengue antibody in large numbers of sera is critically needed. An effort should be made to further develop and adapt the micro plaque-reduction neutralization test for use with dengue viruses.

Finally, to permit prompt coordination of epidemiologic investigations and control measures, a Permanent Epidemic Subcommittee of the PAHO Scientific Advisory Committee on Dengue should be constituted.

CONCLUSIONS AND RECOMMENDATIONS

The Committee recommended that the program, as described above, be established, and that two full-time epidemiologists be provided for its implementation. Coordination with all existing dengue activities in the Americas was stressed.

Priorities for designation of areas of investigation were considered to be important because of the magnitude of the problem and the limited resources available. The heavily populated areas where Aëdes aegypti is prevalent and where dengue has occurred in the past should, the Committee felt, receive first attention. In particular, Venezuela was cited as a critical area because of its size, population, geographical location, and history of epidemic,

and possibly endemic, dengue. The situation would appear to call for short-term epidemiologic and long-term laboratory support, and it was suggested that a virologist-epidemiologist be assigned to work there locally. Haiti, Jamaica, and Puerto Rico were also considered important areas. The initial evidence for endemicity in Jamaica and Haiti should be further explored and serial studies carried out to prove or disprove the question of continued endemicity. The Committee recommended, therefore, that the capability be developed to sustain epidemiological studies in these areas.

The Committee then recommended formation of a Permanent Epidemic Subcommittee, with its initial membership to consist of Drs. Russell (Chairman), Downs, Henderson, and Scherer.* The two surveillance epidemiologists would serve ex officio.

Finally, it was agreed that the PAHO Scientific Advisory Committee on Dengue should meet at least annually.

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*Members were selected from the United States to facilitate quick and easy assembly and communication; persons from involved regions would be added to the Subcommittee on an ad hoc basis.

SPECIAL RECOMMENDATION OF THE MEETING

During the past few years, epidemics of Venezuelan encephalitis (VE) have occurred in many countries of northern South America and Central America. In 1969 alone, epidemic VE was reported in Ecuador, Venezuela, Guatemala, El Salvador, Honduras, and Nicaragua. These epidemics have resulted in significant illness and death in human and equine populations in the affected areas. A considerable body of epidemiological and virological data has been collected by investigative groups, but this information is fragmentary. Because the geographical regions involved and the investigative resources available are similar to those applicable to dengue, it is considered to be within the province of this Advisory Committee to express concern about future VE activities. It is therefore highly recommended that PAHO utilize this unique opportunity to develop and coordinate a continuing research program on Venezuelan encephalitis, to promote efforts for the collection of available information, and to indicate the priorities of investigative activities in the future by creating a PAHO Advisory Committee on Venezuelan Encephalitis similar to this Advisory Committee on Dengue. The Advisory Committee on Dengue requests its Secretary to study the feasibility of implementing this recommendation and organizing within the next year a Symposium on Venezuelan Encephalitis, with publication of its proceedings.

TABLES AND FIGURES

Table 1

THE REPORTING OF DENGUE: CURRENT STATUS

A. Countries that include dengue in their weekly reports of communicable diseases sent to PAHO

1. Countries that use the PAHO reporting form, which includes dengue

a. Dengue notifiable

Mexico
Panama
Bahamas
Canal Zone
St. Kitts, Nevis, Anguilla

b. Dengue not notifiable

Barbados
Colombia (symbol used in the reports)
Costa Rica
Guatemala
Haiti
Trinidad and Tobago
Guadeloupe

2. Countries that use their own reporting form, which includes dengue (notifiable)

Antigua (no reports received in 1969)
Dominican Republic
El Salvador
Jamaica
Venezuela (outbreaks only)
Grenada
Puerto Rico

B. Countries that do not include dengue in their reports or do not report regularly

1. Countries for which dengue is not listed in the weekly reports (not notifiable)

Cuba
Honduras
Nicaragua
United States (optional reports of cases in 1963 and 1964)
British Honduras (monthly)
Dominica (reported dengue in 1963, 1964, and 1968)
Martinique
St. Lucia

2. Countries for which dengue has not been stated to be notifiable, and for which no reports were received in 1968 or 1969

Cayman Islands
Montserrat
Netherlands Antilles
St. Vincent
Turks and Caicos Islands (since June 1968)
Virgin Islands (UK)
Virgin Islands (US)

Table 2

REPORTED CASES OF DENGUE IN THE CARIBBEAN AREA, 1960-1969*

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Barbados	...	...	...	...	...	...	...	...	(p)	+ -
Dominican Republic	494	821	822	350	407	527	...	...	-	1
Jamaica	-	-	-	1 578	156	36	6	6	367	+ 5
Venezuela	56	-	-	-	18 306	4 040	7 750	1 330	-	+4 09
Antigua	-	-	-	-	264	8	-	-	+179	...
Dominica	...	...	-	2	43	-	...	-	42	+ -
Grenada	...	-	...	...	...	...	...	...	...	+ 4
Martinique	...	-	...	(p)	...	...	...	...	...	...
Montserrat	-	-	...	...	-	-	-	...	(p)	...
Netherlands Antilles	...	...	...	(p)	...	...	...	...	...	...
Puerto Rico	-	-	-	25 737	2 440	93	2	1	-	16 66
St. Kitts-Nevis and Anguilla	-	-	-	-	721	-	-	-	(p)	-
St. Lucia	-	-	...	...	...	...	...	-	(p)	...
St. Vincent	-	-	-	-	-	-	-	...	(p)	...

... Data not available

\+ Incomplete data

(p) Outbreak reported

*Colombia, Panama, and the countries of Central America have been basically free of Aëdes aegypti during the period and have not reported any cases of dengue since 1960; they are therefore not included in the table.

Figure 1

OCCURRENCE OF DENGUE IN THE CARIBBEAN, 1963-1965

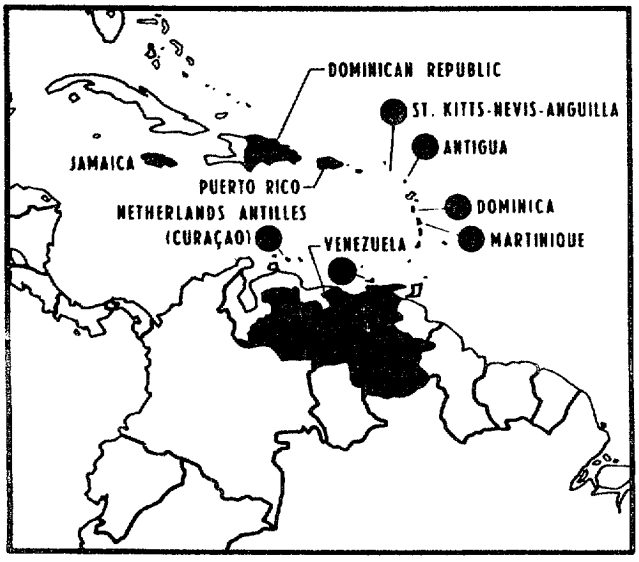


Figure 2

OCCURRENCE OF DENGUE IN THE CARIBBEAN, 1966-1967

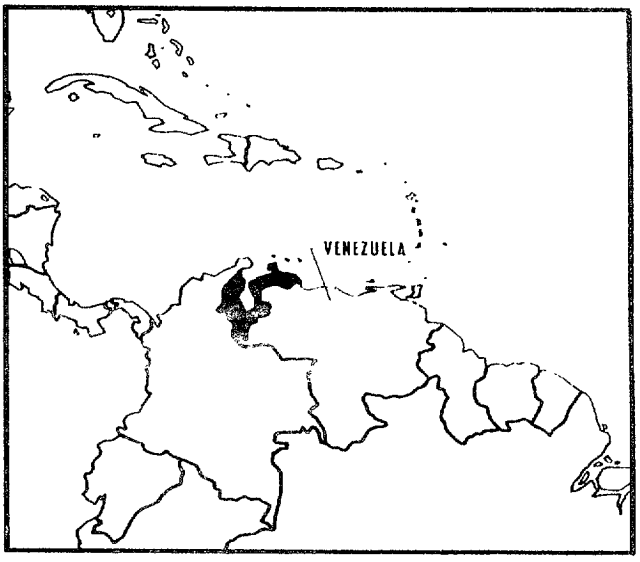


Figure 3

OCCURRENCE OF DENGUE IN THE CARIBBEAN, 1968-1969

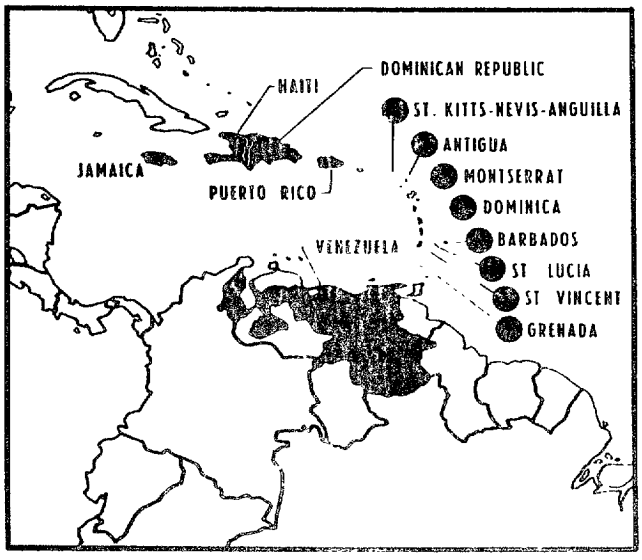
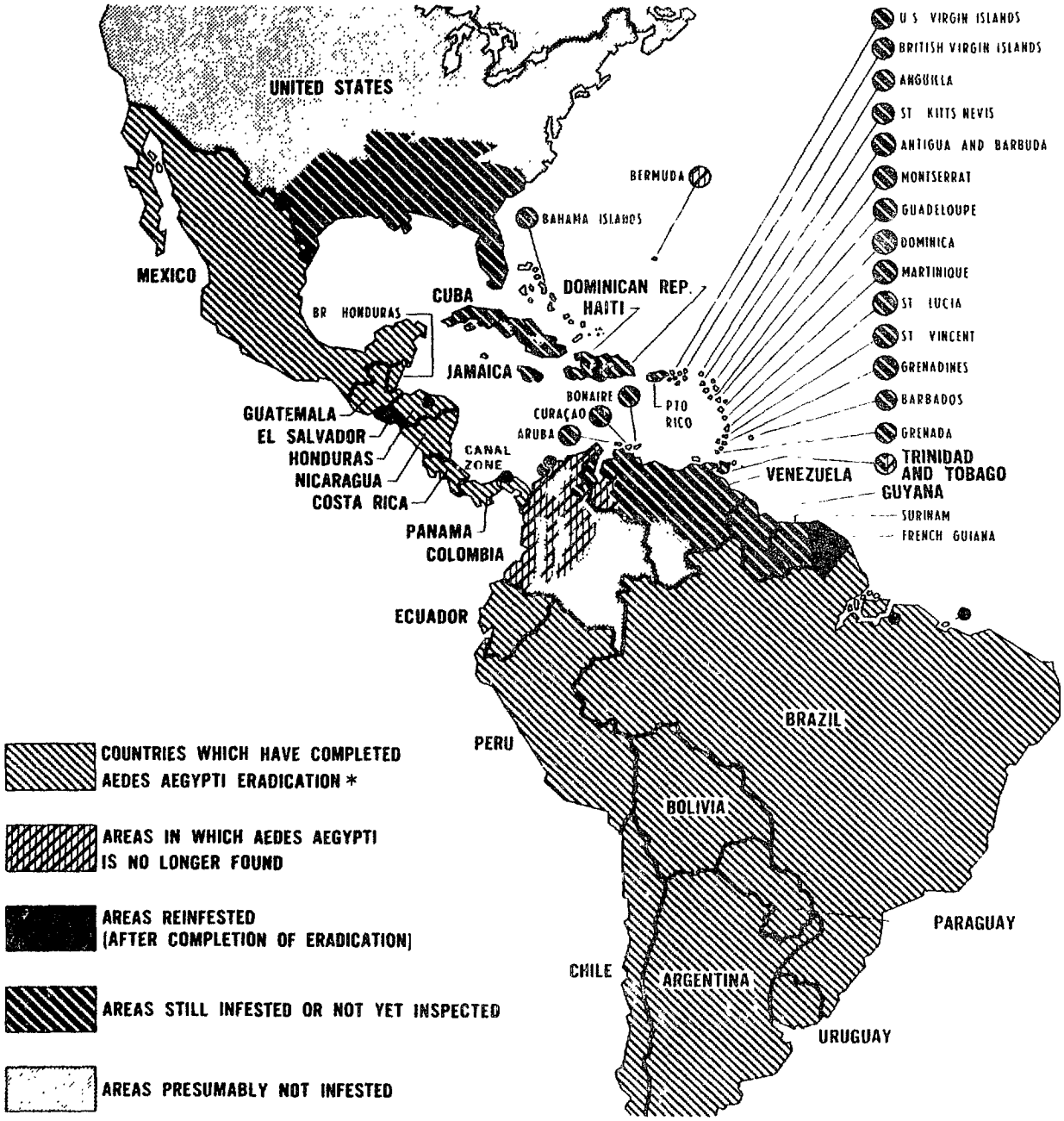


Figure 4

STATUS OF THE AEDES AEGYPTI ERADICATION CAMPAIGN IN THE AMERICAS, DECEMBER 1969



* ERADICATION CARRIED OUT ACCORDING TO THE STANDARDS ESTABLISHED BY THE PAN AMERICAN HEALTH ORGANIZATION

PANAMERICAN HEALTH ORGANIZATION

WORLD HEALTH ORGANIZATION

XVIII PAN AMERICAN SANITARY CONFERENCE

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COST-BENEFIT ASPECTS OF PREVENTING AEDES AEGYPTI-BORNE DISEASES IN THE WESTERN HEMISPHERE

CSP18/13 (Eng.)
ADDENDUM I

COST-BENEFIT ASPECTS OF PREVENTING AEDES AEGYPTI-BORNE DISEASES IN THE WESTERN HEMISPHERE

A Study for

The Pan American Health Organization
Pan American Sanitary Bureau
Regional Office of the
World Health Organization

Robert R. Nathan Associates, Inc.
Washington, DC

September 28, 1970

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FOREWORD

This study was commissioned on June 3, 1970, and work commenced on June 10, 1970.

In order to observe at first hand the problems of control and eradication of the Aedes aegypti mosquito, an RRNA team visited those areas of the United States and Latin America most affected by the problem. From July 16 through August 6, Mr. Morris Solomon and Dr. John Geary of RRNA, accompanied by Dr. Solon de Camargo, a member of the Ministry of Health in Brazil on loan to PAHO, visited the Center for Communicable Diseases in Atlanta, Georgia; Airport Quarantine officials in Miami, Florida; and PAHO officials and local health officers in Kingston, Jamaica; San Juan, Puerto Rico; Port of Spain, Trinidad; Belem and Rio de Janeiro, Brazil; Caracas, Venezuela; and Mexico City, Mexico.

Officials of PAHO provided timely and effective assistance to our study. We are indeed grateful to the PAHO staff.

SUMMARY

In 1961, the Directing Council recommended that PAHO coordinate a hemispheric effort to eradicate Aedes aegypti, the carrier of both urban yellow fever and dengue. Similar resolutions had been passed in 1942 and 1947; however, the 1961 resolution differed in suggesting that hemispheric eradication be achieved within 5 years. After some initial successes, a number of reverses occurred which threaten the viability of the concept of eradication. The vaccine for yellow fever is effective, but the total elimination of yellow fever by this method presents many problems and requires substantial expense. Dengue fever remains a problem resolvable only by the eradication of Aedes aegypti or through the continuing expense of control operations. Epidemics of dengue have been occurring with some frequency, and new knowledge reveals the possibility of the more serious hemorraghic dengue becoming prevalent in the Western Hemisphere. While epidemics of urban yellow fever are rare, they are an ever-present threat. Jungle yellow fever continues to be a problem in the hemisphere, and with the scheduled opening of new jungle areas, this problem can become more serious.

Eradication of the vector in the hemisphere has been difficult to achieve. The problem becomes increasingly complex because of the growing mobility of goods (particularly open containers) and persons which in their movement can convey Aedes aegypti, and because of other changes taking place in the hemisphere. Programs to eliminate the vector are proving to be expensive. Sums spent on these programs, and their effectiveness, vary considerably from country to country; however, for those countries that have not achieved eradication, contemplated expenditures are far below present estimated requirements for control or eradication. Surveillance programs appear inadequate to prevent reinfestation in some countries that have currently achieved eradication.

Visits to the various countries of the hemisphere fully confirmed the findings of the various study groups set up by PAHO in late 1969 and early 1970 to study the various aspects of the problem. Financial restrictions, administrative rigidity, unsatisfactory labor relationships, sociocultural factors, and insecticide resistance in the vector are the main factors that have prevented the completion of national eradication programs. In addition, it was found that, on the basis of their experience, countries are seeking to improve the effectiveness of their eradication, control and surveillance programs. In doing so, these countries are using procedures that often differ from those preferred by PAHO. Unfortunately, the experience on which such procedures are based is often of an ad hoc nature, and in any case is not the result of carefully controlled experiments which provide a firm basis for innovative action. Furthermore, historical costs furnish a very inadequate basis for determining methods for reducing costs and increasing effectiveness. In seeking programs of greater effectiveness and lower cost, it is imperative that systematic methods of evaluation be used so that dependable results are produced. Systematic methods require the use of design of experiments, quality control procedures and modern sampling techniques, in conjunction with inputs from various disciplines. Such methods should produce procedures that are more cost effective than present procedures.

More systematic investigation can also yield solid data on which to judge least-cost programs, to achieve specified levels of risk and effectiveness. Associated economic benefits, such as decreased absenteeism, tourism receipts gained (or not lost), doctor and hospital bills not incurred, and other benefits are measured against these levels. The choice among alternative programs can then be made in the light of cost-benefit analyses. For given levels of effectiveness and risk, programs are compared on the basis of the rates of return they show, using the technique of discounting. The value of a flow of future benefits over costs for a stated period of time is expressed in terms of its internal rate of return, a value which, when realized, represents an increment to the country's growth and wealth. Through the use of this discounting technique, comparisons can be made between various programs to prevent yellow fever and dengue, and between such programs and other programs in the health field.

A potentially important outcome of systematic cost-benefit investigations is the ability to obtain financing

for shorter, more concentrated campaigns for the eradication of Aedes aegypti, if it can be demonstrated that such programs are optimum. If financing is coupled with favorable administrative conditions, the combination may be especially attractive.

Cost-benefit analyses are only as good as the data and the concepts of "costs" and "benefits" used. Hence, the critical tasks for analysts are to define meaningful and operational concepts, to derive relevant data that are reliable, and to know what to do with this data. PAHO can play an important part in assembling a team of experts that has the ability to:

- Design programs to obtain valid statistical results on costs and effectiveness of various types of anti-Aedes aegypti and other programs under varying circumstances of the hemisphere.

- Investigate means to overcome restraints that limit the effectiveness of programs: budget limitations that stretch programs over too-lengthy periods; boredom that afflicts workers in surveillance programs; lack of inspection and control over international movements, particularly of vessels, goods, and vehicles that are carriers of Aedes aegypti.

The team needs to be interdisciplinary: entomologist, economist, mathematical statistician, medical doctor, sociocultural expert, labor and training expert, and perhaps others. It should do its work in the field, both conducting controlled experiments and aiding others to do so. It should be able to draw on consultants in each of the countries of the hemisphere as needed.

To benefit from the experience of persons working in the field and in turn to make its influence felt, such a team should work closely with existing institutions and local personnel concerned with the problem.

The entire problem requires a long-term research effort. Long-term research success on Aedes aegypti eradication will be almost irrelevant, however, if countries like Brazil, Trinidad and Mexico fail to deal with reinfestation

on an economical basis in the next few years. Such failure, if followed by complete reinfestation, will be virtually irreversible, even with later favorable research results. Therefore, the first priority for the team should be to find more effective procedures for stamping out a reinfestation and for carrying on surveillance of areas that have achieved eradication.

As data of general applicability are improved in quality, the cost-benefit exercise will also improve. Costs that reflect effective operations and associated risks will be more precisely estimated; economic benefits will be more accurately measured. More comprehensive and complicated calculations will be involved, but more valid cost-benefit ratios will be developed. As matters now stand, such calculations yield only doubtful results, because data vary so in their quality, importance, and meaning both within and between countries. It is by remedying these deficiencies that PAHO can do most in the battle against Aedes aegypti, thereby providing a basis for meaningful cost-benefit calculations to aid those whose decisions will shape the campaign against yellow fever and dengue in the coming years.

I. BACKGROUND AND PURPOSE OF THE STUDY

In epidemic form, yellow fever has existed in the Western Hemisphere since Aedes aegypti mosquitoes were carried from Africa by slave ships. During the long voyages, the open caskets of water on the sailing ships provided breeding places for generations of Aedes aegypti. Ports of call were often infested during the summer, and serious epidemics occurred from colonial times into the 20th century. The last serious epidemic in the United States occurred in New Orleans in 1905. Elsewhere in this hemisphere, the most recent large epidemic was in Rio de Janeiro in 1928; in 1954 a jungle yellow fever outbreak occurred in Trinidad, with 18 diagnosed cases, of which two were urban (in Port of Spain).

Yellow fever is a virus disease that attacks the liver and the digestive tract. In the sudden onset the patient has headache, high fever and low pulse. Later he develops nausea and pains in the head, limbs and back. In later stages the skin turns yellow, and the patient may vomit black blood or black vomitus. Mortality generally is approximately 5 percent of cases in endemic areas, with a higher rate in nonendemic areas.

At the beginning of the 20th century, Aedes aegypti was identified as the carrier of yellow fever. In 1915, the Rockefeller Foundation, in collaboration with a number of South American countries, began work on a program to combat Aedes aegypti and consequently yellow fever. Based on considerable information accumulated over several decades, the idea of the eradication of Aedes aegypti gained support, first on a national basis and then on a hemispheric basis, as the most promising approach to the prevention of yellow fever. Eradication gained support for two major reasons:

. A number of important hemispheric cities, and later, countries, achieved eradication, using procedures that were based on an

increased knowledge of the peculiarly man-oriented breeding habits of Aedes aegypti.

. Because yellow fever epidemics are related to the jungle source of the virus, there seemed to be a choice either of maintaining costly permanent programs of Aedes aegypti control in all cities and towns, or of achieving complete eradication within the region.

Reduction of the Aedes aegypti population was regarded as an alternative to eradication, because it had been observed that if less than 5 percent of the premises of a city was infested with the Aedes aegypti, yellow fever did not spread. Eradication rather than control was seen as the most economical way to rid the hemisphere of yellow fever. It was realized, of course, that continuing surveillance would be necessary to prevent reinfestation from Africa or Asia. In the meantime, a vaccine against yellow fever was developed in the thirties, and over the years it has become highly effective and inexpensive.

The early history of dengue fever is more obscure. However, it is known that epidemics of dengue and dengue-like diseases have occurred at frequent intervals in the Western Hemisphere. Major outbreaks took place in 1904, 1915, 1922, 1934, 1941, 1949-50, 1963 and 1968-69. While attack rates are believed high, reliable estimates of incidence are not available. Many cases are never brought to a doctor's notice, and diagnosis and reporting by doctors is loose in most countries because the symptoms are very much like those of flu. Table 1 gives the reported cases of dengue in the Caribbean in the period 1960-69. The reported cases are generally regarded as only a small fraction of the actual cases. One health official estimated the proportion of reported cases in his country to be one-tenth of the total.

Mortality from dengue is low, but the disease typically is disabling to the patient for some days, with a convalescence period that stretches into weeks, thus leading to absenteeism and impaired efficiency at work. At present there is no satisfactory vaccine to prevent dengue. While hemorraghic dengue (a more serious form of the disease) has not yet occurred in the Western Hemisphere, knowledge of the subject points to its probable occurrence. Hemorraghic dengue is believed to occur when a person is attacked by more than one

Table 1. Reported Cases of Dengue in the Caribbean Area, 1960-1969[a/]

Country	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Barbados	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	c/	b/
Dominican Republic	494	821	822	350	407	527	n.a.	n.a.	-	13
Jamaica	-	-	-	1,578	156	36	6	6	367	530[b/]
Venezuela	56	-	-	-	18,306	4,040	7,750	1,330	-	4,097[b/]
Antigua	-	-	-	-	264	8	-	-	179[b/]	n.a.
Dominica	n.a.	n.a.	-	2	43	-	n.a.	-	42	b/
Grenada	n.a.	-	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	46[b/]
Martinique	n.a.	-	n.a.	c/	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Montserrat	-	-	n.a.	n.a.	-	-	-	n.a.	c/	n.a.
Netherlands Antilles	n.a.	n.a.	n.a.	c/	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Puerto Rico	-	-	-	25,737	2,440	93	2	1	-	16,665
St. Kitts-Nevis and Anguilla	-	-	-	-	721	-	-	-	c/	-
St. Lucia	-	-	n.a.	n.a.	n.a.	n.a.	n.a.	-	c/	n.a.
St. Vincent	-	-	-	-	-	-	-	n.a.	c/	n.a.

n.a. = not available

a/ Colombia, Panama, and the countries of Central America have been basically free of Aedes aegypti during this period, and have not reported any cases of dengue since 1960; they are therefore not included in the table.

b/ Incomplete data.

c/ Outbreak reported.

Source: Pan American Health Organization, Scientific Advisory Committee on Dengue, "Surveillance of Dengue in the Americas: A Report to the Director," Ref. RD 49/10.2, 16 January 1970, Table 2.

type of dengue virus, and various types of the virus have been identified in the Western Hemisphere.

In this hemisphere, 44 countries or territories have had an Aedes aegypti problem.1/ The cost of achieving eradication of Aedes aegypti has differed considerably among these countries, depending upon the extent to which there has been a parallel malaria campaign and upon the area of the country subject to Aedes aegypti infestation. The fact that Aedes aegypti does not breed at high altitudes has meant that certain centers of population have had no problem.

Brazil has spent many millions of dollars over the years to achieve eradication. The amounts spent for eradication vary widely from country to country in the Americas. Table 2 shows figures ranging from $1,000 to $765,000 spent in 13 countries in 1969, and from $30,000 to $743,000 budgeted for 1970.

The estimated cost of anti-Aedes aegypti work in 13 countries was about $2 million in 1969, and the amount budgeted for 1970 was about $2.6 million (table 2). These figures are quite small in relation to the estimated cost -- $27 million -- of carrying out eradication campaigns in the same countries (see table 3). The total estimated cost to carry out eradication programs in the hemisphere is given as $326 million, of which $250 million is to be spent in the United States alone.

Information available on expenditures for surveillance activities against Aedes aegypti indicates modest levels of expenditure (table 4).

PAHO Activities

The Pan American Health Organization (PAHO) has been coordinating hemispheric action and providing technical assistance on Aedes aegypti eradication and vaccine production and distribution since 1947. An important activity has been the testing of Aedes aegypti for resistance to various insecticides. PAHO expenditures in the area of prevention of

1/ See table 2.

Table 2. Data Based on the Amount Expended by The Aedes Aegypti Eradication Campaign in 1969, and Figures for the 1970 Budget of Some Countries and Territories in the Americas

Country	Expended in 1969 (US$)	Budget for 1970 (US$)
Brazil	345,000	644,000
Colombia	53,521	72,394
El Salvador	61,291	62,160
Grenada	1,000	30,000
Guyana	100,000	120,000
Honduras	54,291	83,080
Martinique	3,000	261,000
Mexico	179,813	72,000
Panama	65,133	100,602
Santa Lucia	36,000	47,000
Surinam	202,503	236,096
Trinidad	119,000	123,000
Venezuela	765,618	742,824
Total	1,986,170	2,594,156

Source: Data received by cable from each country or territory; appeared as Appendix E of "Report of the PAHO Study Group on the Prevention of Aedes Aegypti-Borne Diseases," Washington, DC, February 9-14, 1970.

Table 3. Estimated Cost of the *Aedes Aegypti* Eradication Campaign in the Countries and Territories Still Infested or Reinfested in the Americas (February 1970)[a/]

Country or territory	Estimated number of houses	Probable duration of the campaign	Cost in US$ estimated by *Aedes aegypti* Working Group in 1967	Updated estimate in 1970 in US$
Antigua	14,000	3 years	176,000	176,000
Netherlands Antilles	52,000	3 "	542,000	542,000
Bahamas	29,000	3 "	358,000	358,000
Barbados	52,000	3 "	499,000	499,000
Brazil	180,000	2 "	-	2,500,000
Colombia	41,000	2 "	39,000	200,000
Cuba	2,330,000	4 "	27,400,000	27,400,000
Dominica	14,000	3 "	176,000	176,000
El Salvador	220,000	4 "	2,100,000	2,100,000
United States of America [b/]	14,496,100	5 "	-	250,000,000
Grenada	22,000	3 "	290,000	290,000
Guadalupe	66,000	3 "	764,000	764,000
French Guiana	8,000	3 "	117,000	117,000
Guyana	135,000	4 "	1,220,000	1,220,000
Haiti	689,000	4 "	1,682,000	6,000,000
Honduras	60,000	2 "	-	600,000
Cayman Islands	500	2 "	-	10,000
British Virgin Islands	3,000	3 "	46,000	46,000
Jamaica	512,000	4 "	3,849,000	4,800,000
Martinique	67,000	3 "	764,000	764,000
Mexico	[c/]	2 "	-	500,000
Montserrat	3,000	3 "	46,000	46,000
Panama	16,000	2 "	-	600,000
Dominican Republic	740,000	4 "	5,886,000	8,000,000
St. Kitts-Nevis and Anguilla	13,000	3 "	176,000	176,000
St. Vincent	19,000	3 "	261,000	261,000
St. Lucia	21,000	3 "	285,000	285,000
Surinam	70,000	3 "	859,000	859,000
Trinidad	50,000	2 "	161,000	400,000
Turks and Caicos Islands	3,000	3 "	46,000	46,000
Venezuela	1,768,000	6 "	31,496,000	17,000,000[d/]
		Total	79,218,000	326,735,000

cont.

Table 3. Estimated Cost of the Aedes Aegypti Eradication Campaign in the Countries and Territories Still Infested or Reinfested in the Americas (February 1970) Continued--a/

Observations:

a/ Total cost, including cost of equipment, vehicles, materials, insecticides, etc. Not including PASB/WHO budgetary allocations, amounting to US$491,637 in 1970 for this hemisphere.

b/ Including Puerto Rico and US Virgin Islands.

c/ Not possible to estimate.

d/ Information received from one of the Study Group members.

Source: Appendix F of "Report of the PAHO Study Group on the Prevention of Aedes Aegypti-Borne Diseases," Washington, DC, February 9-14, 1970.

Table 4. Data on the Cost of the Vigilance Activities for *Aedes Aegypti* in Some Countries Free of the Vector in the Americas

Country	Year	National currency	Cost	Equivalent US$
Argentina	1964 - 1966	Argentinian Peso	18,185,579	90,027
Bolivia	1 year	Bolivian Peso	38,000	3,193
Brazil	1959 - 1965	New Cruzeiro	365,390	167,918
Mexico	1964 - 1966	Mexican Peso	2,962,000	236,960
Nicaragua	1969	Cordoba	72,247	10,321
Paraguay	1958 - 1966	Guarani	1,104,000	8,761
Peru	1954 - 1964	Sol	1,000,000	37,313
Uruguay	1969	Uruguayan Peso	6,325,000	25,500

Source: Data presented by each country at the Conference on *Aedes Aegypti* Eradication in the Americas, 1967, or received by cable in February 1970; apeared as Appendix C of "Report of the PAHO Study Group on the Prevention of *Aedes Aegypti*-Borne Diseases," Washington, DC, February 9-14, 1970.

yellow fever and dengue were $334,040 in 1968 and $411,013 in 1969, and are scheduled to be $491,637 in 1970 and $596,582 in 1971.

As of August 1970, PAHO had a staff of 13 professionals working in the area of prevention of yellow fever and dengue. This staff was composed of two medical officers, one entomologist and 10 sanitarians. Practically all personnel were deployed in countries carrying on Aedes aegypti eradication campaigns. The typical role of a PAHO staff member was that of advisor to the country official concerned with the problem. In many cases a staff member was responsible for more than one country. The first line of supervision and coordination was the zone representative of PAHO, who was responsible to PAHO headquarters in Washington for all PAHO health activities in the countries of the zone.

After some earlier recommendations at PAHO meetings to obtain coordinated hemispheric eradication of Aedes aegypti, the Directing Council of the Pan American Health Organization resolved in 1961 that all nations in the Western Hemisphere should initiate and complete eradication of Aedes aegypti within 5 years. In 1962 the Surgeon General of the United States, speaking at the Pan American Sanitary Conference, declared that the United States intended to conduct an eradication program in the continental United States and its territories. In 1963, at the specific request of the President, the 87th Congress appropriated funds to begin limited eradication operations.

New Problems in Eradication

Since 1962, a number of developments has raised serious doubts about the attainability of the goal of hemispheric eradication of Aedes aegypti and/or the prevention of yellow fever and dengue fever in the hemisphere.

Specific discouraging developments have been:

. After the $54 million expenditure for the eradication of Aedes aegypti in the continental United States and overseas territories, the United States suspended anti-Aedes aegypti work in 1969, except for very limited work in Puerto Rico. This suspension resulted from a recognition that the cost of Aedes aegypti

eradication would be substantially greater than the original estimate, and from pressures for a reduction in government expenditures. While the continental United States has not had a serious problem with either disease since the 1905 New Orleans epidemic, the cessation of operations meant that the 10 Southern States infested with Aedes aegypti would remain as an active focus for reinfestation of other countries in the Western Hemisphere.

. There have been sizable outbreaks of dengue in 1963 and 1968-69 in a number of countries of the hemisphere, including the Dominican Republic, Jamaica, Venezuela and Puerto Rico, despite considerable expenditures on anti-Aedes aegypti campaigns.

. Countries that had previously achieved eradication have experienced reinfestation in varying degrees, namely El Salvador, Brazil, Mexico, Honduras, and Panama. Table 5 summarizes the status of eradication in the Western Hemisphere.

A number of other factors have raised doubts about the need for and the possibility of succeeding in hemispheric Aedes aegypti eradication.

. It has been argued that the availability of 17D, an inexpensive and effective vaccine against yellow fever which provides at least a 10-year immunity period, has introduced an important means of preventing yellow fever that was not previously available, and thus seems to reduce the need for costly eradication.

. A proliferation of man-made containers in the countries of the hemisphere has provided breeding places for Aedes aegypti and has made eradication more difficult.

. In the United States, there is an increasing opposition to the use of insecticides. This opposition is bound to increase in other countries too.

Table 5. Status of Aedes Aegypti Eradication by Country and Other Political Units in the Americas
(December 1969)

Country or other political unit	Area in km.^{2}			Present status	Activity in progress
	Total	Area assumed initially infested	Percentage of total		
Argentina	4,024,458	1,000,000	24.8	Eradication completed	Surveillance
Barbados	430	171	39.8	Infested	Program in operation
Bolivia	1,098,581	100,000	9.1	Eradication completed	Surveillance
Brazil	8,511,965	5,358,822	63.0	Reinfested	Program in operation
Colombia	1,138,338	280,000	24.6	Infested	Program in operation
Costa Rica	50,700	20,000	39.4	Eradication completed	Surveillance
Cuba	114,524	100,000	87.3	Infested	Program in operation
Chile	756,945	100,000	13.2	Eradication completed	Surveillance
Ecuador	283,561	69,454	24.5	Eradication completed	Surveillance
El Salvador	21,393	18,675	87.3	Reinfested	Limited program
United States of America	9,359,781	1,536,819	16.4	Infested	Program suspended
Guatemala	108,889	36,423	33.4	Eradication completed	Surveillance
Guyana	214,969	4,662	2.2	Infested	Program in operation
Haiti	27,750	27,750	100.0	Infested	Program suspended
Honduras	112,088	69,929	62.4	Reinfested	Limited program
Jamaica	11,424	11,424	100.0	Infested	Program in organizational phase
Mexico	1,972,546	1,000,000	50.7	Reinfested	Program in operation

cont.

Table 5. Status of Aedes Aegypti Eradication by Country and Other Political Units in the Americas (December 1969) Continued--

Country or other political unit	Area in km.^{2}			Present status	Activity in progress
	Total	Area assumed initially infested	Percentage of total		
Nicaragua	130,000	65,263	50.2	Eradication completed	Surveillance
Panama	75,650	56,246	74.3	Reinfested	Program in operation
Paraguay	406,752	200,000	49.2	Eradication completed	Surveillance
Peru	1,285,215	638,000	49.6	Eradication completed	Surveillance
Dominican Republic	48,734	42,020	86.2	Infested	Program suspended
Trinidad and Tobago	5,128	3,108	60.6	Infested	Program in operation
Uruguay	186,926	186,926	100.0	Eradication completed	Surveillance
Venezuela	912,050	710,000	77.8	Infested	Limited programs
Antigua (Barbuda y Redonda)	442	442	100.0	Infested	Program in preliminaries of operation
Aruba	190	174	91.6	Infested	Program in preliminaries of operation
Bahamas	11,405	11,405	100.0	Infested	Limited program
Bermuda	53	53	100.0	Eradication completed	No information
Bonaire	281	246	87.5	Infested	Program in preliminaries of operation
British Honduras	22,965	22,965	100.0	Eradication completed	Surveillance
Canal Zone	1,432	1,432	100.0	Eradication completed	Surveillance
Cayman Islands	259	259	100.0	Infested	Program in operation at Cayman Brac cont.

Table 5. Status of Aedes Aegypti Eradication by Country and Other Political Units in the Americas (December 1969) Continued--

Country or other political unit	Area in km.^{2}			Present status	Activity in progress
	Total	Area assumed initially infested	Percentage of total		
Curacao	472	448	94.9	Infested	Program in preliminaries of operation
Dominica	789	789	100.0	Infested	No activities
French Guiana	91,000	91,000	100.0	Infested	Program in operation
Grenada - Grenadines (Carriacou, Little Martinique and Union)	344	344	100.0	Infested	Program in preliminaries of operation
Guadeloupe (part of St. Maarten)	1,779	1,619	91.0	Infested	Program in operation
Martinique	1,102	1,000	90.7	Infested	Program in operation
Montserrat	98	83	84.7	Infested	Program in preliminaries of operation
Puerto Rico	8,897	8,897	100.0	Infested	Program suspended
Saba, St. Eustatius (part of St. Maarten)	67	67	100.0	Infested	Program in preliminaries of operation
St. Kitts-Nevis and Anguilla	357	357	100.0	Infested	No activities
St. Lucia	616	259	42.0	Infested	Program in operation
St. Vincent	388	332	85.6	Infested	Program in organizational phase
Surinam	142,822	48,000	33.6	Infested	Program in operation
Turks and Caicos Islands	430	430	100.0	Infested	No activities
Virgin Islands (UK)	153	153	100.0	Infested	No activities
Virgin Islands (US)	344	344	100.0	Infested	Program suspended

Source: Appeared as Appendix B of "Report of the PAHO Study Group on the Prevention of Aedes Aegypti-Borne Diseases," Washington, DC, February 9-14, 1970.

. Except in a few countries, Aedes aegypti have been found to be resistant to DDT, requiring a shift to more expensive and shorter-lasting insecticides. This problem is partially offset by the excellent long-lasting properties of abate as a larvicide.

. The increasing mobility of people within countries has made eradication more difficult, and has at least put a premium on shorter campaigns, since mobility increases the likelihood of reinfestation of cleared areas.

. The increased mobility both between and within countries has increased the likelihood of the spread of epidemics. Two examples of this mobility which come to mind are the opening up of large jungle areas by the trans-Amazon road in Brazil, and the substantial growth of tourism to the Caribbean and Mexico.

By 1969 not only had the goal of hemispheric eradication adopted by PAHO in 1961 not been realized, but the possibility of retaining Aedes aegypti-free conditions even in those countries that had achieved eradication was in question. In response to the above developments, a series of meetings was held in Washington under the sponsorship of PAHO in the latter part of 1969 and the early part of 1970. Out of these meetings came a report entitled "Report of the PAHO Group on the Prevention of Aedes Aegypti-Borne Diseases," written by a high-level group of specialists that met in Washington, DC, from February 9 to February 14, 1970.

A key statement in the above report (page 19) follows:

The present Study Group did not include persons with expert knowledge of the technical approaches to a study of cost-benefit analysis. This is a highly specialized field, and the development of a detailed plan of cost-benefit analysis would require the collaboration of such persons with counterpart experts in the scientific fields concerned with the epidemiology of Aedes aegypti-borne diseases and control of the vector.

Robert R. Nathan Associates, Inc., was chosen to make a study of a cost-benefit approach to programs for the prevention and control of Aedes aegypti-borne diseases to answer the question: Can procedures be developed for relating the costs of the control and eradication programs on one hand to the reduction of risks and the generation of economic and other benefits on the other? It was recognized that the preliminary study could only indicate promising cost-benefit approaches, and methods for exploring these approaches.

The report of the PAHO Study Group laid great stress on collecting comparative costs of programs in different countries, on the cost of combating epidemics of diseases, and on the economic impact that such epidemics have in terms of medical care, quarantine embargoes and decreased tourism.

The matters which the Study Group were interested in exploring were:

- The control of epidemics
- Preventive programs
- Surveillance after Aedes aegypti eradication
- The advantages of preventing Aedes aegypti-borne diseases and the penalties of inaction
- The establishment and maintenance of a research program over the next 10 years

Under each of the above headings, the Study Group enumerated specific problems and possibilities, with a final notation that the list was not all inclusive.

II. ELEMENTS OF COST-BENEFIT ANALYSIS

Cost-benefit analysis has developed as a logic and a set of procedures for:

- Formulating criteria in a quantitative form to be applied to suggested courses of action
- Identifying, formulating and quantifying promising alternatives in their least-cost form
- Comparing the promising alternatives with respect to the criteria to facilitate decision-making
- Recycling the process as required by findings.

Each of these steps is important in itself and in relation to the whole process of decision-making. Each will be discussed first in general, and then with respect to the problem of Aedes aegypti-borne diseases.

Formulating Criteria

Criteria are the yardsticks that the decision-maker uses to choose a course of action. Criteria take two basic forms, constraints and indexes.

A constraint is a limitation on the objectives, the goals or the instruments that can be used. A constraint may be physical or institutional, fixed or subject to change. A key element in the analysis of a particular problem is the judging of whether a particular constraint is subject to change.

The second type of criterion is the index, which is a quantitative measure of the desirability of a particular

solution. An important index in our problem is the measure of the economic benefits in relation to economic costs. Costs are clear; they are the outlays for control, eradication, and surveillance programs. Economic benefits are both the added income generated as well as the income not lost by absenteeism or by medical outlays.

Characteristically, a complex problem has a number of relevant indexes, and this makes decision-making more difficult than if there were only one relevant index. The cost-benefit analyst can help the decision-maker in this regard by defining meaningful indexes that summarize what would otherwise be many individual indexes. This can generally be done with success in economic considerations by aggregating the estimated stream of benefits and costs in the common dimension of money, and by allowing for time by some form of discounting. The cost-benefit analyst also can quantify in a systematic way the dimensions that might otherwise be vague and troublesome elements in decision-making.

In the hemispheric problem under discussion, the relevant constraints have been summarized by the Study Group in the following way:

> The main factors that have prevented the completion of national eradication programs appear to be financial restrictions, administrative rigidity, unsatisfactory labor relationships, sociocultural factors, insecticide resistance in the vector and reinfestations (page 10).

It should be recognized that in each country, at any point in time, there is a budget limit for all health activities. Money spent on the prevention of yellow fever and dengue must not merely be exceeded by the value of prospective benefits, but these benefits must also be more promising than those derivable from other possible uses of the limited health funds available. In other words, it is not sufficient that a given course of action on yellow fever and dengue has benefits that exceed costs by a wide margin. The margin must be at least as great as that achieved from efforts in other health problems (malnutrition, intestinal diseases, etc.). The relevance of payoff of other uses of the health dollar stems from the constraint of a limited health budget. The competition for the health dollar explains why the priority given to the prevention of yellow fever and dengue varies greatly from country to country, according to the urgency of

the problem of yellow fever and dengue in relation to other health problems and the total available budget. Even in the same country the priority given to the problem can change substantially over a period of time.

In each country at any point in time, there is a maximum amount that will be budgeted for preventing Aedes aegypti diseases, and there is a maximum hazard that will be tolerated.

These constraints aside, the cost-benefit configuration for any alternative program should be determined by using the following:

I. Estimated costs of the proposed program on a planned basis
   A. Cost of campaign itself
   B. Cost of continuing surveillance
   C. Cost of an immunization program (if any)

II. Estimated probabilities and the cost of hazards associated with the proposed program
   A. Medical care for patients
   B. Value of lost income
      1. Absence from work
      2. Lower productivity
      3. Through death
      4. Commercial losses
      5. Other causes
   C. Cost of emergency programs
   D. Loss of tourism
   E. Cost of combating reinfestation (if any)

Cost of Campaign Itself

As will become apparent from the discussion of formulation of alternatives, the cost of any campaign can vary within very wide limits.

Cost of Combating Reinfestation

The probability of reinfestation is very closely related to the effectiveness of the surveillance process. The cost of dealing with a given infestation depends on the degree of reinfestation, the rapidity with which it is attacked, and the cost effectiveness of what in effect are the last stages of an eradication effort.

Cost of Continuing Surveillance

Surveillance is a necessary consequence of eradication and has a continuing cost.

Cost of Immunization Program

An alternative that includes immunization will generally have a first cost and an annual maintenance cost.

Medical Care of Patients

Given an outbreak of yellow fever or dengue, there is a cost of medical care of patients.

Value of Lost Income

Depending on the number of cases; the distribution of days absence from work; the distribution among occupations, age groups and sex; the days and percent of lowered productivity while on the job; the loss through death; and description of loss of economic activity, one can estimate the value of lost income that corresponds to each stated occurrence.

Cost of Emergency Programs

When an outbreak of yellow fever or dengue occurs, emergency measures are taken which tend to be costly, because the emphasis is on speed with little regard for cost. Airplane spraying, flying in equipment and supplies, and frequent and widespread fogging make such efforts costly. Unless special efforts are made to record such costs at the time they occur, it is difficult to determine them at a later point.

Loss of Tourism

Tourism expenditures in the Caribbean, including Puerto Rico, were in excess of $350 million in 1968 and are expected to double by 1978. Tourist expenditures in Mexico were in excess of $1 billion in 1968, with a 70 percent increase expected by 1978. For areas such as the Caribbean, it has been estimated that each dollar of tourism generates

$2.30 of income; for a country like Mexico which is more self-sufficient, it is estimated that each tourist dollar generates about $3.20 of income.1/ In the case of Mexico, the main impact on tourism could be expected to be outside of Mexico City, but there could be spillover effects.

The Caribbean area, particularly Jamaica and Puerto Rico, has a large number of tourists each year. There is little evidence, however, that the outbreaks of dengue so far experienced have had the effect of reducing tourism. Health authorities in various countries made it clear that, while such outbreaks can potentially be damaging to tourism, conscious attempts are made to avoid publicizing such outbreaks. In Puerto Rico, the figures released to the newspapers at the time of an outbreak were described as flu and flu-like cases rather than specifically as dengue.

While health authorities in Florida are concerned with cases of dengue which United States' visitors to the Caribbean may contract, to date this has not been a serious problem. According to Dr. N. Joel Ehrenkranz, of the Department of Epidemiology and Public Health, School of Medicine of the University of Miami:

> We have previously identified individuals with dengue acquired outside the United States who became ill in the South Florida area. By keeping these people under close surveillance we have not had any major difficulty. The same could be true of an imported identified case of yellow fever. By contrast, failure to detect such persons could permit them to serve as sources for a major epidemic here with disastrous consequnces. The

1/ The Future of Tourism in the Eastern Caribbean, H. Zinder & Associates, Inc., Washington, DC, May 1969, page 40. While the multiplier effect of lost tourism is of interest, it is recommended that the cost of lost tourism (primary effects) be computed as the total value of tourist expenditures less those expenditures that are made to buy goods and services from abroad. These would be the primary effects, comparable to the other costs. Any use of more refined figures which take into account succeeding rounds of expenditures would require an extremely complex analysis for all costs and is not considered worthwhile.

detection of either locally acquired dengue or yellow fever would clearly imply that an outbreak was likely to follow. Such an outbreak would undoubtedly have tragic health and economic consequences.1/

Should hemorrhagic dengue fever occur in the Americas, there is little question that the effects on tourism would be very great. The probability of such an event occurring is not known, but it is not negligible.

The one recent outbreak of urban yellow fever was in Port of Spain in 1954. Of 18 fully diagnosed yellow fever cases in Trinidad, two were diagnosed as urban. It is believed by some authorities that the total cases in Trinidad may have been as high as 150. The port was closed. There was no apparent loss in tourism, but the losses from closing the port were estimated by the Junior Chamber of Commerce to be $25 million. It has not been possible to obtain documentation for this estimate.2/

Measuring the Costs and Benefits of Alternatives

Cost-benefit methodology arose originally in the evaluation of water-resource projects which typically involved the investment of large amounts of inputs in the early years, with benefits arising in later years. Use was made of a ratio consisting of the discounted benefits divided by the discounted costs over the life of the project. Discounting was used to reflect the greater worth of resources available at the present time than the same amount of resources some years hence. As evaluation was extended to other nonmarket activities, other indexes were found more suitable. It was found useful to express the inputs and outputs of alternatives over time, with the index being the internal rate of return of the flow. The internal-rate-of-return criterion is a measure of growth of resources, and is especially useful for developing countries where growth of income is crucial for their development.

To obtain the present value of a flow of resources (money), one multiplies the quantity of each year by a

1/ Letter to Robert R. Nathan Associates dated July 29, 1970.
2/ Letter to PAHO dated August 17, 1970.

discount factor corresponding to a given rate of growth. The specified rate of growth is that which represents the prevailing average rate earned by capital in the country in productive enterprises. It is not uncommon these days for the rates to be set at 10 percent and higher, for borrowed capital may cost nearly that much. If some surplus is to be created to add to economic growth, something above the borrowing cost must be earned by the capital.

Subject to further consideration, it is suggested that the criterion of rate of return be applied to a flow expressing the value of inputs and outputs of alternatives for preventing yellow fever and dengue over 30 years. To do so, it is helpful to use as a reference alternative a hypothetical state where there is no yellow fever, no dengue and no campaign costs of any kind. The costs and benefits would be derived for each year on the basis indicated in table 6. The figures provided are merely illustrative. Items can be negative with reference to the no-cost alternative, if that is the most convenient way of expressing the effect. It should be noted that the value associated with a hazard is the expected (average) cost, i.e., it is the value of each event (hazard) multiplied by its respective probability, summed over all possible events.

Having obtained the estimated flow of the promising alternatives in their most cost-effective form, one is in a good position to ask, concerning any two alternatives, what the return is on the additional resources required. But before this is done, it must be ascertained that the hazards associated with the alternative are tolerable. For example, it may be estimated that a given alternative bears the probability of admitting a very bad epidemic once in 50 years. If such an event occurred, it could be catastrophic and therefore might not be considered tolerable. It might be considered intolerable despite the fact that, when expressed as an average cost per year, the catastrophe's low probability makes the economic rate of return of the alternative attractive.[1/]

1/ Estimates of probabilities of rare events will be required. These cannot be derived in the usual way by inference from historical experience or theoretical probabilities based on a priori considerations. This suggests the need to resort to subjective probability estimates, an approach that makes use of the best available information (objective and subjective) to arrive at probability estimates for decision-making.

Table 6. Hypothetical Illustration of Items Contributing to Flow of Each Alternative (in Least-Cost Form) for Any Particular Year

Item	Probabilities	Zero cost alternative no yellow fever, no dengue, no program	Alternative A^1	Alternative A^2
Cost of campaign	1.0	0	a/	a/
Cost of continuing surveillance	1.0	0	a/	a/
Cost of immunization	1.0	0	a/	a/
Medical care for patients	Associated with alternative	0	b/	b/
Lost income reflecting absenteeism, lower production and death	Associated with alternative	0	-5000 b/	-10,000 b/
Cost of emergency program	Associated with alternative	0	b/	b/
Tourist proceeds reflecting outbreaks	Associated with alternative	50,000	45,000 b/	35,000 b/
Cost of combating reinfestation	Associated with alternative	0	b/	b/
TOTAL FOR YEAR				

a/ Quantity derived on a planned basis (probability = 1.0).
b/ Quantity is expected value, that is, the value of each event (hazard) multiplied by its respective probability summed over all possible events.

Once it has been ascertained that the hazards of an alternative are tolerable, the alternative can be compared with other alternatives on an internal-rate-of-return basis.

Identifying, Formulating and Quantifying Promising Alternatives in Their Least-Cost Form

Unless a course of action is identified and given specific form, it is lost to the decision-making process. Because one can suggest an almost infinite number of alternatives in many problems, the identification and formulation of promising alternatives calls for a screening process which requires a mixture of technical knowledge, discrimination and judgment. Formulation of alternatives is the most demanding part of cost-benefit analysis.

In most complex problems the determination of cost, and indeed the practicality of an alternative, may require giving the alternative very specific form, and may also require a series of limited and controlled tests. The process of formulating the alternatives and the tests to determine their effects can be costly in time and money.

While certain technical problems may pertain to one field of specialty and may be the key elements in a formulation, the identification and formulation of promising alternatives frequently require close interaction and coordination of different specialities. Interaction among different disciplines is especially important with regard to binding constraints that specialists tend to take as absolute, even though there may be ways of breaking or removing such constraints. In formulating alternatives, one should be alert to ways of overcoming particularly severe constraints. In the case of anti-*Aedes aegypti* work, this would apply with particular force to budgetary restrictions and administrative and bureaucratic rigidity.

An additional characteristic of complex problems is that cost is often a critical factor, and, unless the alternative in question is given its least-cost form, its apparent cost rules it out as a practical solution. It is not unusual for the same basic alternative to have a wide range of possible cost, depending on the specific way its execution is carried out. Thus, cost minimization of promising

alternatives is an absolutely vital part of cost-benefit analysis.

The process of obtaining the least-cost alternatives is part of a larger process known as cost effectiveness. Under pressure of rising costs and discouraging progress, personnel in various countries are seeking better ways of achieving Aedes aegypti eradication. They are instituting changes in procedure which depart from PAHO recommendations, basing their initiative on "experience" which does not necessarily give a reliable basis for such action. For example, of the three main treatments encountered, perifocal, interdomiciliary and larval treatment combined with fogging, only the first is preferred by PAHO on grounds of economy and efficiency. Variations in practices among countries point to the need for more systematic investigations on how reliable least-cost procedures can be devised.

Some Alternatives

The problem of yellow fever and dengue fever is particularly complex and exhibits all of the characteristics enumerated in the foregoing section. A wide variety of alternatives, as well as the costs, risks, and benefits of each, need consideration. Some major types of alternatives which appear worth exploring are:

- Greater use of 17D, and the problems connected with such use
- Economic ways of achieving low enough Aedes-aegypti indexes to rule out epidemics
- Ways of breaking or bypassing existing constraints, such as budgetary constraint and administrative inflexibility
- Reduction in cost and increase in effectiveness of carrying out anti-Aedes aegypti activity in eradication and surveillance, and in case of reinfestation.

Specific alternatives that seem especially promising will be discussed later in the report.

Choosing Among Promising Alternatives

Decisions on many alternatives can often be made with very little time and effort, because many possibilities which immediately present themselves are clearly defective. Those alternatives that survive a rough screening are reduced to their most cost-effective form, that is, for a given level of effectiveness, their least-cost configuration. As was pointed out in the previous section, this reduction often requires imagination tempered by analytical experiments and appropriate testing. The inputs and outputs (in their most cost-effective form) are then specified for the most promising alternatives on a comparative basis.

Until alternatives are formulated on a reliable basis in their least-cost form, one can hardly compare them in a meaningful way, inasmuch as cost itself is an important basis for comparison. In general, historical information on costs is of very limited usefulness for comparison of alternatives, since they reflect different wage levels, varying degrees of effectiveness, varying practices and conditions. Therefore, least-cost figures that provide a sound basis for planning as well as evaluation require engineering and other systematic approaches, buttressed by pilot operations to arrive at validated figures.

Once the alternatives in the prevention of yellow fever and dengue have been expressed in their least-cost form, one can then determine which alternative gives the highest rate of return.

The rate of return of the flow of the best alternative way of dealing with yellow fever and dengue can readily be compared with the rate of return on solutions of other health problems, and money can be allocated with due regard for the return in various problems.

Recycling

While the steps outlined above generally occur in the specified order, in actual practice there is overlap in time. One engages in repeated cycles and feedbacks as required by the problem, until one arrives at the most promising alternative. Thus, after formulating initial criteria, through the attempt to identify and formulate promising alternatives,

one may conceive of additional criteria which are relevant but which were not thought of previously. Similarly, a comparison of promising alternatives may suggest a somewhat different formulation for some of these alternatives.

III. PROMISING LINES OF RESEARCH ACTIVITY

Unless a major technical breakthrough changes the dimensions of the problem, the prevention of yellow fever and dengue will require a long-term research effort.

But in any research program it must be recognized that several aspects of the problem have an immediate urgency. Failure of countries like Brazil, Trinidad and Mexico to deal with reinfestation on an economical basis in the next few years would seriously jeopardize the concept of eradication of Aedes aegypti, perhaps irreversibly so. This would be so even if the results of long-term research are very favorable to such eradication. Therefore the first priority of a research effort must be to concentrate on finding the most cost-effective procedures for stamping out a reinfestation[1/] and carrying on surveillance of areas that have achieved eradication.

Redesign of Anti-Aedes Aegypti Campaigns

As was previously pointed out, unless an alternative is put in its least-cost form, the decision-maker is in a poor position to make a choice. In combating Aedes aegypti, one must determine the least-cost way to carry out the following procedures:

- Reduction of the Aedes aegypti population to a sufficiently low level, and maintenance

1/ The most cost-effective procedures for stamping out a reinfestation will in general correspond to those appropriate for the last stages of an eradication campaign. These tasks can be best discussed as part of the redesign of anti-Aedes aegypti campaigns.

of a level low enough to prevent the spread of yellow fever or dengue

- Eradication at a national level
- Surveillance to prevent and detect reinfestation
- Elimination of reinfestation
- Eradication at an hemispheric level.

Redesign of these procedures would involve the derivation of suitable planning factors, administrative procedures, training, and phasing, as well as numerous technical matters.

There are three statistical approaches that can be extremely useful in redesigning anti-Aedes aegypti campaigns. These are:

- Design of experiments
- Statistical quality control
- Modern sampling

Design of Experiments

In discussing procedures and problems with officials of various countries, it became clear that anti-Aedes aegypti work is carried out in many different variations under many different conditions. The kind of personnel, the training given to personnel, the form of supervision, the types of treatment and the methods for handling trash are some of the variables that influence cost and effectiveness. There are many interactions between variables that are very difficult to perceive by ad hoc procedures. Chance effects of such variables as the quality of personnel or weather can obscure the true relationships. A similar situation is encountered in research on agricultural yields. Modern design of experiments was first developed to pinpoint the relationships between such variables as genetic variety, water, application of fertilizer, cultivation procedures and insecticide treatment.

Those who are responsible for anti-Aedes aegypti work are faced with problems of comparable complexity. The statistical design of experiments is a practical way of deriving

reliable estimates of effectiveness and cost of alternative procedures under complex conditions. To apply the design of experiments fruitfully, it will be necessary for the entomologist, the medical doctor, the sanitary engineer, the economist and other specialists to help the mathematical statistician set up experiments under the range of conditions that are relevant to large-scale application. Working with other specialists, the mathematical statistician can stratify the universe, provide careful measurement of results and achieve sufficient replication to give reliable estimates of the effects, costs and risks of different procedures that can be applied on a large scale with a stated range of statistical confidence levels.

Some examples of the potential use of the statistical design of experiments are:

- Determination of the effectiveness of various forms of treatment of premises under various levels and kinds of infestation (indoor-outdoor), and relation of each to their potential large-scale costs. Through the use of statistical controls, it should be possible to determine reliably the circumstances under which each should be used. Present practice in the field varies considerably, often determined by ad hoc judgments.

- Determination of the effectiveness (and potential large-scale cost) of the use of ovitraps to detect various levels and kinds of infestation (indoor-outdoor), as compared to regular inspection. Determination of the optimum distribution of ovitraps (how many per block, outdoor-indoor), given the level of infestation and the cost.

Statistical Quality Control

Successful eradication and surveillance activities depend upon disciplined and reliable performance by personnel over long periods of time. Breeding sources that remain undiscovered and untreated often serve as foci for additional breeding, extending the length of the campaign and adding to the cost in the case of eradication, and delaying measures to eliminate an infestation in the case of surveillance.

In either case -- eradication or surveillance -- one must rely on individuals who will be making thousands of inspections and treatments. Primary reliance must be placed

on the supervisor of the inspector. Techniques of statistical quality control are able to give greater assurance that both supervisors and inspectors are carrying out their activities in accordance with instructions. These techniques generally sample the work of a man or a group of men and provide a basis for further action on an economical basis.

Using random selection, routines for checking quality might involve:

I. Sampling procedures for checking inspectors on probation

II. Sampling regular inspectors
   A. Number of "perfect inspections" that permit stopping of additional sampling
   B. Schedule of errors to continue sampling
   C. Schedule of errors to retrain or discipline inspector

III. Sampling to check the quality of a given round as it proceeds.

Sample Survey Theory

A campaign is basically an activity in which a sample of premises (sometimes a 100-percent sample) is inspected, and on the basis of findings, action is taken. This is essentially the sample-survey problem, for which modern sample-survey theory was developed. The theory makes use of stratification of the universe, cluster sampling, cost functions and risk analysis, all of which are directly applicable to all types of campaigns. The theory is completely general, since it also gives guidance even when 100-percent inspection is appropriate.

In discussing present surveillance procedures with personnel of several countries, it became clear that some of the principles of modern sampling theory have influenced the surveillance plans being used. Stratification is being used on a common-sense basis. Cluster sampling is employed to keep traveling costs down. However, an expert in modern sampling could put surveillance plans on a substantially more efficient basis, after making some critical measurements and defining the risk considerations more carefully.

The types of questions that would be asked and answered by appropriate measurements are:

. Can premises be stratified in a way that would permit sampling until the last stage of eradication (e.g., premises that have not had breeding receptacles in two successive inspections, to cut down on inspection in the interim)?

. Based on an analysis of infestation patterns, what size cluster and what sampling pattern should be used to estimate the infestation rate for quick intelligence?

In the later stages of both an eradication campaign and a surveillance effort, the problem of boredom of personnel arising from the "needle in the haystack" nature of the operation makes it imperative that human-factor considerations be taken into account in the design of the effort. A combination of interpenetrating samples, the use of ovitraps and manual inspection appears to be a promising approach.

In any large country, certain parts of a surveillance effort will be thin, that is, there will be a definite but small set of activities spread over a wide geographic area. It may be that part of the surveillance process can be performed most economically by persons stationed in the area on a full-time basis. Otherwise, personnel must be in almost continuous travel status to cover the wide range of territory. The development of patterns to use existing health personnel for surveillance under carefully controlled conditions may be desirable. This would make it possible to achieve lower costs for surveillance than would otherwise be possible.

Routinized Training

Training of personnel is an important activity, because it affects the quality of the effort. The turnover experienced in some countries makes it necessary to train a large number of personnel, as does the need to shorten the duration of the eradication effort. A common core curriculum for use in training personnel could facilitate training by the individual country. Such a curriculum could be readily adapted by each country. The curriculum could include a suggested sequence of lectures (which could be taped for use by instructors); audiovisual material such as slides; quizzes;

and a pattern for supervised field work. Before adoption by PAHO, any suggested training material should be tested in the field and revised on the basis of the results that are achieved.

As research findings become available, they could be incorporated in the training material.

Study of Suitable International Action

As long as some countries are infested with Aedes aegypti, an important part of surveillance is the inspection of boats and ships, their treatment when required, and the elimination of potential breeding places. At present, boats and ships that travel from country to country and are found to be infested are not reported to international agencies. Besides alerting future destinations of an infested ship, such reporting could give captains of boats and ships a strong incentive to eliminate practices that allow Aedes aegypti to breed on their vessels. This incentive would be especially strong for a troublesome category of vessels, those engaged in smuggling, since such ships would obviously prefer to remain inconspicuous.

As recognized by International Sanitary Regulations, it is very desirable that international airports be kept free of Aedes aegypti. This requires some minimum action that is clearly more stringent than existing practices in international airports. More effective international agreement or adherence by the countries of the hemisphere to specific procedures for maintaining international airports free of Aedes aegypti appears to be an item with priority for action. A related question is that of the specific measures that can be taken to prevent infestation of adjacent land areas. These questions may lend themselves to systematic research.

Study of Constraints

Eradication work requires a conscientious and disciplined effort that culminates in a sharp cutback in personnel. This fact poses serious problems in recruitment and retention of personnel. The increasing mobility of societies has accentuated this problem by putting a premium on a shorter campaign, and by making it desirable to hire and retain more personnel for a shorter period of time. The requirements of effective Aedes aegypti work and governmental administrative practices have to be reconciled. The creation

of practical incentive structures that will be effective for anti-Aedes aegypti work will require ingenuity and practical liaison work with various governments.

It is generally conceded that a short, concentrated campaign is more efficient than a longer, more drawn-out campaign. The factor of budgetary limitations is regarded as a major obstacle to what is generally regarded as the optimum shorter campaign. If this obstacle could be confirmed by research, combined with a demonstrated small-scale capability in the country concerned, it might be possible for countries to obtain loans from international finance agencies to achieve eradication. This is particularly true for countries that have a large stake in tourism. An important by-product of a suitably conducted research program would be the providing of an information base for applications for loans. The prospect of loans in turn could provide a strong incentive for the countries to discard administrative constraints that seriously hinder eradication. Careful liaison work with lending agencies, followed by research oriented toward loan requirements, could radically change the constraints presently restricting progress.

Emerging Possibilities

Considerable research is taking place on mosquito control in general and Aedes aegypti control in particular. It is likely that, from time to time, developments will be sufficiently promising to warrant initiating applied testing on a limited scale. An example of this, which requires further study, is the use of sterilized males in the last stage of an eradication campaign or in the early stage of reinfestation. It is precisely where the mosquito population is small that the use of sterilized males becomes more economical, due to the fact that one has to inundate the wild population to achieve good results.

Problems of Use of 17D Vaccine

There are problems in the use of 17D vaccine for jungle yellow fever that require further investigation. How can greater coverage of the population at risk be achieved on an economical basis? The encouragement of more systematic investigation appears to be in order.

The expandability of the production of the vaccine, the question of reserves and the size of ampule are problems that may profit from investigation. The two sizes of ampules presently in use (100 doses and 200 doses) involve an unknown amount of wastage. More serious than wastage is the fact that such large ampules may possibly reduce the coverage of persons exposed to jungle yellow fever through the introduction of inflexibility in the field.

Emergency Plans for Hemisphere

While the main thrust of the research effort should be aimed at making an emergency less likely at any point in time, emergency plans should be in readiness so that action can be taken readily and with a minimum of expense. It appears that the preparation of such plans could best be handled as a regular professional activity by PAHO personnel, probably as part of a wider emergency plan for the hemisphere. Such plans would have to be related to research findings.

Study of Hemispheric Strategy

The items discussed above are tactical means that can have important effects on the ways in which the countries of the hemisphere prevent or control yellow fever and dengue. As research findings become available, they must be fitted into an updated hemispheric strategy that reflects new possibilities. This calls for a continuing effort that is both analytical and comprehensive.

Liaison with Existing Institutions

A considerable amount of research is now being carried out by a large number of institutions that have important outputs to provide for the solution of the problem. In discussing research with a number of institutions that have an interest in the problem, it became apparent that such institutions could benefit from greater interchange with each other, interaction with different disciplines and greater contact with operations in the field. This fact suggests that an interdisciplinary team concerned with applied problems of the field could perform a very useful liaison and coordination function with specialized institutions in various countries.

Making institutions aware of important gaps in information relevant to the problem is an important function that needs to be performed. An example of such a gap is the extremely poor information on the incidence, income, occupation, age, and sex of dengue victims, and the distribution of effects. Only a survey specifically designed before an outbreak can fill this gap. This is a specialized task which a number of institutions might undertake if they were encouraged to do so.

IV. SUBJECTS SUGGESTED BY THE STUDY GROUP

In describing the scope of the present study, the "Report of the PAHO Study Group on the Prevention of Aedes Aegypti-Borne Diseases" outlined the work under five headings. Since the promising lines of research activity have been discussed under somewhat different terms,1/ it is useful to relate these to the headings suggested by the Study Group.

The Control of Epidemics

In the event of an epidemic of yellow fever or dengue in a country, there is a tendency to adopt plausible available measures. While it is sometimes possible to reconstruct the cost of such measures, the effectiveness of such emergency measures under the given conditions is very difficult to evaluate after the fact. A review of all that is known about the effectiveness and cost of such measures would be extremely useful. Such a review may, by itself, furnish a basis for decisions on how to organize a future emergency plan and, at the very least, on what measurements need to be arranged for.

It would appear that the review of measures available could very well be done by university personnel with some guidance from a PAHO research group.

Preventive Program

This study has concentrated on preventive programs. It is clear that preventive programs can benefit substantially

1/ See chapter III.

from systematic interdisciplinary research as outlined in chapter III of this report.

Surveillance After Aedes Aegypti Eradication

As has been discussed in the body of this report, the surveillance process tends to deteriorate unless safeguards are built into it. There is reason to believe that, through the use of design of experiments, quality control, sampling and human resources psychology, it is possible to design very low-cost surveillance procedures. The costly part of surveillance is the surveillance designed to prevent reinfestation from ships, from planes, and particularly from land vehicles. The cost of reinfestation can be kept low by:

- Prompt detection
- Prompt treatment.

With regard to the latter, it is important to find ways of quickly delimiting the infested areas, and of devising treatments that are rapid, yet effective.

The Advantage of Preventing Aedes Aegypti-Borne Diseases and the Penalties of Inaction

The advantage of preventing Aedes aegypti-borne diseases has been obscured in recent years by several factors.

The hemisphere has tended to take for granted the benefits accruing to it that have arisen from Aedes aegypti eradication in Brazil and other countries constituting reservoirs of yellow fever virus. However, unless the present reinfestation in the Belem area is promptly destroyed on an economical basis, there is real danger that Brazil will become fully infested, thus requiring either an expensive control program on a continuing basis or a mass innoculation program. Either result in Brazil would have very substantial repercussions on the rest of the hemisphere, affecting anti-Aedes aegypti campaigns and creating risks of epidemics of yellow fever and especially dengue, since there is no vaccine for dengue. Fortunately for the hemisphere, it is very much in Brazil's interest to eliminate

the reinfestation. This fact can be seen from a comparison of present costs of fighting the reinfestation (roughly about $644,000) with the cost of mass innoculation (estimated by the US Health Service to be $26 million, with an annual maintenance cost of $5.5 million) or the cost of an Aedes aegypti control program that would probably require millions of dollars per year.

The cost of dengue epidemics in the Caribbean and Venezuela is not known because of poor reporting and lack of information on who is affected. The risks inherent in the present situation are quite substantial, however, and at the very least more should be known about these risks and the cost of avoiding them.

Without some action to put anti-Aedes aegypti work on firmer ground, a likely possibility exists that the hemisphere will be forced to adopt mass innoculation programs for yellow fever -- at a cost (outside the United States) estimated by the US Health Service to be about $81.5 million, with an annual maintenance cost of $15.8 million -- and will thereby leave the problem of dengue completely unresolved. In such an event, anti-Aedes aegypti campaigns could easily become a stop-and-go control activity punctuated by costly epidemics of dengue.

The Establishment and Maintenance of a Research Program Over the Next Ten Years

The research program over the next 10 years should evolve out of studies that are made over the next 3 years. The suggested research program for the next 3 years is discussed in the next chapter.

V. FUNCTIONAL REQUIREMENTS FOR SUGGESTED COST-BENEFIT STUDIES

The Need for an Interdisciplinary Team

The problems of yellow fever and dengue are sufficiently similar in the various countries to make one central effort appropriate. Cost-benefit studies will require the integration of factors that are economic, entomological, statistical, medical, psychological, institutional and administrative. The need for some of these specialties, particularly with regard to the amount and specificity, can only become evident as intensive work on the problems proceeds. The complexity and the nature of the problems, however, clearly indicate a need for a core group of specialists consisting of an economist, an entomologist, a mathematical statistician and a medical doctor with experience in field operations.

The plan of operations of such a group should recognize that this group's prime function is to serve as a catalyst for the much larger resources that are being devoted to the problem of yellow fever and dengue by PAHO staff, universities, institutions and government agencies of the various countries of the hemisphere. One of the efforts of the group should be to interest qualified organizations in the hemisphere to undertake crucial experiments, to provide statistical guidance on experiments that countries can carry out, and to disseminate the results of such experiments.

The team should not undertake any function that other personnel or organizations will assume. This will require special emphasis on the quality assurance of the effort.

Because cost-benefit studies relate closely to field operations, the team should be located in a country that is currently carrying on anti-Aedes aegypti work, with provisions for travel to other countries.

Objectives of the Interdisciplinary Team

As its objectives, the team should undertake to:

. Find economical ways to arrest reinfestation of eradicated areas and to carry out effective surveillance of such areas.

. Redesign anti-Aedes aegypti campaigns, including:

-- Exploring the potential cost and effectiveness of control programs where the population of Aedes aegypti is held to some predetermined level to rule out epidemics

-- Redesigning eradication campaigns to achieve less costly and more effective procedures

-- Finding ways to bypass present impediments to effective anti-Aedes aegypti work.

. Explore the potential of 17D vaccine to give greater protection against yellow fever, particularly jungle yellow fever.

. Define specific international action that appears desirable.

. Explore emerging possibilities that appear promising.

. Maintain liaison with existing institutions.

. Review hemispheric strategy in the light of research findings.

. Make recommendations for future research work.

Work Plan for Team

The team leader should be responsible for achieving the preceding objectives.

To provide ease of communication and geographical closeness to at least one operation, the headquarters of the team should be located in a country that has an on-going operation.

It should be the policy of the team to work in close collaboration with PAHO and with personnel working in various countries.

- Because so many of the key personnel in the various countries are medical, the liaison member of the team should be a medical officer, preferably one who has worked with PAHO in the field of yellow fever and dengue.

- To assure that efforts will reflect the experience and ideas of persons working in the field, the team leader and his specialists should consult periodically with an Advisory Council of field personnel set up for this purpose.

- Experiments should be designed in close consultation with those in charge of the effort in individual countries. It is particularly important that the experiments span the conditions that are prevalent in the countries of the hemisphere. Otherwise, results will not be applicable.

- It should be the policy of the team to publish significant results, with authorship to be joint with country personnel at least.

- It can be anticipated that some of the experiments will require duplicative efforts to yield necessary parameters, e.g., use of ovitrap and ordinary inspection to compare the effectiveness of both methods. Such experiments may require additional costs, and it may sometimes be necessary for PAHO to compensate a country for some of these costs.

The program has been divided into three major phases, which are listed below in the order of their probable performance. It should be recognized, however, that in actual practice the time boundaries of the different phases are not distinct. Activities taking place during Phase I are preparatory to the activities of the other phases. Indeed, subject to the needs of the earlier phase, every attempt should be made to begin the work of the subsequent phase.

Phase		Calendar time in months	Target completion date (months from initiation)
I.	Preliminary Organization of Effort	6	6
II.	First Priority Efforts on Improvement of Methods For Eliminating Reinfestation and Organizing Surveillance	18	24
III.	Other Efforts, Including Strategic Studies	12	36

Phase I. Preliminary Organization of Effort
(Because the team leader will be responsible for achieving the objectives, it is desirable to give him the option of recruiting team members and drafting a more final work plan.)

		Beginning and ending months
1.	Appoint team leader and appoint PAHO liaison officer	0 - 1
2.	Study by team leader and visit to countries	1 - 3
3.	Appoint other team members	2 - 3
4.	Organize field advisory council	2 - 3

	Beginning and ending months
5. Brief and orient team	3 - 4
6. Draft work plan of team, based on this report, consultations and deliberations of team	3 - 5
a. First priority efforts	
(1) Develop surveillance procedures suggested by theory of sampling and human factors	
(2) Devise tests which lead to validation or modification of such procedures	
(3) Using design of experiments, quality control and sampling, devise procedures that can deal adequately with reinfestation	
b. Establish liaison with international financing agencies and other organizations	
c. Define data needed for cost-benefit calculations and make arrangements to obtain such data if the occasion arises	
(1) Data on incidence and characteristics of patients if an epidemic occurs	
(2) Cost and measures of effectiveness of different emergency measures used in case of outbreak	
d. Draw up specific plans for pursuing team objectives (excluding the first objective) listed above	
7. Council and PAHO review	5 - 6

Phase II. First Priority Efforts on Improvement of Methods for Eliminating Reinfestation and Organizing Surveillance

8. Initiate experiments on alternative procedures for achieving first priority goals	5 - 22
a. Test ovitraps under varying conditions that are encountered in countries	
b. Test plan for surveillance with particular reference to clustering effects (time and space)	

	Beginning and ending months
c. Test potential uses of stratification d. Test final configuration of surveillance procedures	
9. Obtain adoption of methods indicated by results of experiments	12 - 22
a. Prepare publications describing results b. Sponsor seminars to disseminate findings	
10. Prepare report on progress	22 - 24
Phase III. Other Efforts	
11. Conduct studies of costs and benefits	10 - 32
a. Determine the costs and benefits of different alternatives from national viewpoint b. Determine the costs and benefits of different alternatives from hemispheric viewpoint	
12. Conduct experiments for control and eradication redesign	12 - 30
a. Effects of stratification and clustering b. Effects of shorter phasing c. Effects of sanitation practices d. Interaction of quality of personnel and type of treatment used e. Quality control requirements for effective supervision and control f. Costs and effectivensss of alternative control procedures	
13. Prepare report on costs and benefits	33 - 34
14. Prepare report on hemispheric strategy	34 - 35
15. Prepare progress report and recommendations for future program	35 - 36

Project Controls

The project work should be subdivided into clearly definable and measurable tasks and milestones as outlined in the preceding work program.

The entire project and its principal tasks should be budgeted and scheduled on a tentative basis at the outset of the work. The team leader should compare planned manpower and other expenditures against actual allocation, and should note the progress of the tasks currently undertaken. The team leader should be in full control and should direct the team's efforts to best accomplish the scheduled work.

The team should be in frequent contact and in close collaboration with countries that are actively engaged in anti-*Aedes aegypti* activities and other relevant efforts. Because of the large numbers of countries involved, the effort will have to be highly selective (in accordance with the research requirements). Nevertheless, it is thought that members of the team will have to travel a considerable amount in pursuing the team objectives.

Liaison Plan

Because of the complexity of the problem, the number of countries involved, and the various types of organizations that can affect results, the quality and nature of liaison efforts will be quite crucial to the success of the effort.

It is proposed that PAHO appoint a medical officer with experience in the area of yellow fever and dengue to serve as a member of the team and as liaison officer to PAHO staff in Washington, PAHO zone officers, and personnel in various countries. Such a person would be invaluable because of his experience and the assistance he could give in obtaining the cooperation of various officials of countries involved in the prevention of yellow fever and dengue.

To provide a systematic channel for persons working in countries, it is proposed that an Advisory Council be formed consisting of representatives from key countries who will meet periodically with the team to formulate specific plans and to review progress.

The team leader may find it useful to sponsor seminars for representatives from institutions concerned with particular problems connected with the prevention of yellow fever and dengue.

To maintain close contact with the various countries, it is necessary to provide for an adequate travel budget.

To stimulate interest in the Aedes aegypti problem, it may be useful for team members to address country student-faculty groups during visits to the country for other purposes.

Composition, Caliber and Qualifications of Team Members

It is important that each team member be a well-qualified professional, but, in addition, he must be problem-oriented rather than technique-oriented.

The team leader should be an economist with a sufficiently broad background to enable him to work with and coordinate inputs from various disciplines. In addition to providing leadership for the effort, the team leader will undertake intensive consultation with specialists as needed in whatever countries of the hemisphere seem most promising. Whenever practical, he will carry out this consultation with a minimum of travel using short-term consultants. This procedure will require that he have the capacity to brief the short-term consultants effectively.

The statistician member of the team should be a highly qualified mathematical statistician, preferably with experience in census-type planning and operations, since Aedes aegypti campaigns resemble census operations, including sample surveys. The rich experience accumulated in this area over the last 30 years is readily applicable to Aedes aegypti campaigns.

The entomologist, in addition to being well qualified in his field, should have the capacity to work well with other disciplines.

The medical doctor should have experience with the epidemiology of yellow fever and dengue, familiarity with problems of Aedes aegypti work, and the capability to carry on liaison work with PAHO, government agencies, and other relevant personnel in the hemisphere.

Organization of the Effort

Some Questions Concerning the Organization of the Research Effort

The Pan American Health Organization has unparalleled experience in the problem of yellow fever and dengue. How can it organize a research effort to be most effective?

It would appear that the major choices open to PAHO are the following:

- An interdisciplinary team can be recruited and managed by PAHO as part of the PAHO organization.

- A consultant group can be contracted by PAHO to recruit and manage such a team, without direct representation by PAHO on the team.

- Personnel who are most closely related to PAHO past experience can be supplied to the team by PAHO, and a consultant group can be contracted to recruit other team members and short-term consultants as required and to manage the effort.

Considerations that have a bearing on the decision as to how the research effort should be organized follow:

- Certain consultant groups have great experience in coordinating interdisciplinary groups.

- Consultant groups can be easily held to account for results.

- Consultant groups can exercise great flexibility in obtaining the services of specialists on a short-term consulting basis.

. PAHO personnel can make crucial contributions in liaison work and in knowledge of the problem.

. In general, consultant services cost more than PAHO direct hire, but if one allocates to the team the overhead PAHO would charge its support, the difference may not be large.

. Use of a consultant group gives great long-term program flexibility to PAHO.

. The participation of an independent consultant group may be advantageous in dealing with international financing organizations. In fact, in the absence of such participation, a study by a consultant may be called for before financing can take place.

It may well be that a mixed approach such as is described above in the third alternative would be very attractive. PAHO could contract with a consulting firm to supply the team leader (economist) and the mathematical statistician, and could itself supply the entomologist and the medical doctor. The consulting firm would be responsible for managing the effort and for recruiting short-term specialists as needed. Although the team leader and the firm would be responsible for results, cooperation and coordination with PAHO would be close, since the contributions of PAHO personnel would be vital and highly complementary to the rest of the team.

Required Budget

It is estimated that, if the full team were recruited and managed by a consulting firm, the cost would roughly be about $350,000 per year. This figure would include the costs of travel, of housing allowances, of movement of household goods, of short-term consultant services and of grants paid to countries to cover additional expenses incurred in experiments generated by the team. While it is difficult to estimate the amount required for this last purpose, it would appear that $75,000 per year would be a minimal amount.

If PAHO were to supply two team members, the cost would be approximately 70 percent of $350,000, or about $245,000.

PERSONS CONSULTED

Washington, DC

Dr. Fred L. Soper
Mr. Donald J. Schliessman, PAHO, former Head of Eradication Effort, US
Dr. J. Austin Kerr
Dr. Eugene Gerberg, Entomologist
Officials of the US Department of Agriculture

Atlanta, Georgia, Center for Disease Control, Department of Health, Education and Welfare, US Government

Dr. David Sencer, Director
Dr. James Smith, Special Assistant to Director
Dr. Harry Pratt, Training Officer

Miami, Florida, Miami International Airport

Dr. James Porter, Chief, Quarantine Service, US Public Health, Department of Health, Education and Welfare, US Government

Kingston, Jamaica

Dr. Phillipe Cavalié, PAHO Country Representative, Jamaica
Dr. Milton Tinker, PAHO Entomologist
Dr. S.P.W. Street, Chief Medical Officer, Ministry of Health, Jamaica
University of the West Indies, Kingston, School of Medicine: Dr. E.A. Belle, Dr. Bissessar, Mr. B.B. Griffiths, Dr. Brown, Health Officer, St. Catherine Parish, Jamaica

San Juan, Puerto Rico

Dr. Henry Negrón, Department of Preventive Medicine, Puerto Rico
Mr. Harry Romney and Mr. Barreira, Vector Control Division
Dr. Irving Fox, Head, Medical Entomology, School of Tropical Medicine, University of Puerto Rico
Personnel from Office of Tourism

Port of Spain, Trinidad

Dr. Maxwell P. Avon, Minister of Health
Dr. R.M.A. Doubdeen, Insect Vector Control Division
Mr. Estrich, Chief of Aedes aegypti program
Dr. Alfonso Ramirez, Acting Representative, PAHO
Dr. T. Omardeen, Regional Advisor for Caribbean Aedes aegypti Eradication, PAHO

Belem, Brazil

Dr. Pedro Freire Fausto, Chief, Aedes aegypti Eradication Campaign
Dr. Humberto Trindade, Assistant Chief, Aedes aegypti Eradication Campaign
Dr. Moacyr Pinto da Costa, Port Health Officer
Dr. Miguel Cordeiro de Azevedo, Director, Instituto "Evandro Chagas"
Dr. Pinheiro, Virologist, Instituto "Evandro Chagas"
Dr. Boshell, Instituto "Evandro Chagas"

Rio de Janeiro, Brazil

Dr. V.P. Musa, Advisor, National Eradication Campaign
Dr. Henrique Pena, Instituto "Oswaldo Cruz"
Dr. Alberto Romeu Nicolau, Instituto "Oswaldo Cruz," Yellow Fever Vaccine Production
Dr. Zamir de Oliveira, Departamento Nacional de Endemias Rurais
Dr. Francisco Porto, in charge of inspection of Rio Airport

Caracas, Venezuela

Dr. Daniel Orellan, Director, International Health, Ministry of Health
Dr. Rumento Isaac Diaz, Yellow Fever Service
Dr. Freddy Gonzalez Valdiviseso, Aedes aegypti Service

Caracas, Venezuela (con't)

Dr. Ramón Hernandez, Director of Epidemiology
Dr. A. Gerald, Chief, Zone I, PAHO
Dr. A. Sotello, PAHO/WHO Representative

Mexico City, Mexico

Dr. Pedro Daniel Martinez, Subsecretary of Health
Dr. Luis David Marcial, Technical Department, Subsecretary of Health
Dr. Jorge Vilhis Villaseñnor, Director of Epidemiology, Campanas Sanitarias
Dr. A. Torres Muñoz, Aedes aegypti Service