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 reinfestes 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 Tirirical - 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 reinfection, and investigations carried out showed that further reinfection 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 reinfections, 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 reinfections. Since then, the problem of Aedes aegypti in Mexico has been limited to the reinfections which have occurred in the area bordering the United States of America.

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

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<tr>
<th>State</th>
<th>Locality</th>
<th>Date</th>
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<tr>
<td>Tamaulipas</td>
<td>Nuevo Laredo</td>
<td>June 1965</td>
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<td>Nuevo Laredo</td>
<td>February 1967</td>
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<td>Coahuila</td>
<td>Allende</td>
<td>June 1967</td>
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<tr>
<td>Tamaulipas</td>
<td>Nuevo Laredo</td>
<td>June 1968</td>
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<td>Piedras Negras</td>
<td>September 1968</td>
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<td>Coahuila</td>
<td>Sabinas</td>
<td>October 1968</td>
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<td>Coahuila</td>
<td>Agujita</td>
<td>May 1969</td>
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<tr>
<td>Coahuila</td>
<td>Nueva Rosita</td>
<td>July 1969</td>
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With the exception of that in Nueva Rosita, all these reinfections 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 Colón, 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 Colón, 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 introducing 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 reinfestated. A survey made by the Government in 1964 showed that the reinfection 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.
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:

"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.

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

Washington, D. C.

9-14 February 1970
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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.
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.
FIGURE 2

JUNGLE YELLOW FEVER IN THE AMERICAS

AREAS SUBJECT TO PERIODIC OUTBREAKS OF JUNGLE YELLOW FEVER.

JUNGLE YELLOW FEVER AREAS 1964-1969:

- ★ 1964
- □ 1965
- ● 1966
- ■ 1967
- ▲ 1968
- ○ 1969
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

<table>
<thead>
<tr>
<th>Country</th>
<th>Eradication Confirmed</th>
<th>Reinfested</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bermuda</td>
<td>September 1953</td>
<td>-</td>
</tr>
<tr>
<td>Bolivia</td>
<td>September 1958</td>
<td>-</td>
</tr>
<tr>
<td>Brazil</td>
<td>September 1958</td>
<td>July 1967</td>
</tr>
<tr>
<td>British Honduras</td>
<td>September 1958</td>
<td>-</td>
</tr>
<tr>
<td>Ecuador</td>
<td>September 1958</td>
<td>-</td>
</tr>
<tr>
<td>Nicaragua</td>
<td>September 1958</td>
<td>-</td>
</tr>
<tr>
<td>Panama</td>
<td>September 1958</td>
<td>March 1969</td>
</tr>
<tr>
<td>Paraguay</td>
<td>September 1958</td>
<td>-</td>
</tr>
<tr>
<td>Peru</td>
<td>September 1958</td>
<td>-</td>
</tr>
<tr>
<td>Uruguay</td>
<td>September 1958</td>
<td>-</td>
</tr>
<tr>
<td>Canal Zone</td>
<td>September 1958</td>
<td>-</td>
</tr>
<tr>
<td>Guatemala</td>
<td>September 1959</td>
<td>-</td>
</tr>
<tr>
<td>Honduras</td>
<td>September 1959</td>
<td>March 1968</td>
</tr>
<tr>
<td>El Salvador</td>
<td>September 1960</td>
<td>June 1965</td>
</tr>
<tr>
<td>Chile</td>
<td>October 1961</td>
<td>-</td>
</tr>
<tr>
<td>Costa Rica</td>
<td>October 1961</td>
<td>-</td>
</tr>
<tr>
<td>Mexico</td>
<td>September 1963</td>
<td>Nine reinfestations since 1965, latest in October 1969</td>
</tr>
<tr>
<td>Argentina</td>
<td>October 1965</td>
<td>-</td>
</tr>
</tbody>
</table>
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 $-20^\circ$C, and under refrigeration ($+4^\circ$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 re-introduction 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"

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 reinfections, 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 reinfection 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 disinfected 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 re-infestation 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

<table>
<thead>
<tr>
<th>Country or Other Political Unit</th>
<th>Area (in Kms²)</th>
<th>Present Status</th>
<th>Activity in Progress</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Area Assumed Initially Infested</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Percentage of Total</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Argentina</strong></td>
<td>4,024,458</td>
<td>1,000,000</td>
<td>24.8</td>
</tr>
<tr>
<td><strong>Barbados</strong></td>
<td>450</td>
<td>171</td>
<td>39.8</td>
</tr>
<tr>
<td><strong>Bolivia</strong></td>
<td>1,098,581</td>
<td>100,000</td>
<td>9.1</td>
</tr>
<tr>
<td><strong>Brazil</strong></td>
<td>6,511,965</td>
<td>5,358,822</td>
<td>63.0</td>
</tr>
<tr>
<td><strong>Colombia</strong></td>
<td>1,136,358</td>
<td>280,000</td>
<td>24.6</td>
</tr>
<tr>
<td><strong>Costa Rica</strong></td>
<td>20,000</td>
<td>20,000</td>
<td>100.0</td>
</tr>
<tr>
<td><strong>Cuba</strong></td>
<td>114,524</td>
<td>100,000</td>
<td>87.3</td>
</tr>
<tr>
<td><strong>El Salvador</strong></td>
<td>756,945</td>
<td>100,000</td>
<td>13.2</td>
</tr>
<tr>
<td><strong>Guatemala</strong></td>
<td>100,909</td>
<td>36,423</td>
<td>35.7</td>
</tr>
<tr>
<td><strong>Suriname</strong></td>
<td>114,969</td>
<td>4,662</td>
<td>2.2</td>
</tr>
<tr>
<td><strong>Haiti</strong></td>
<td>27,750</td>
<td>27,750</td>
<td>100.0</td>
</tr>
<tr>
<td><strong>Honduras</strong></td>
<td>11,424</td>
<td>69,929</td>
<td>62.4</td>
</tr>
<tr>
<td><strong>Jamaica</strong></td>
<td>11,424</td>
<td>11,424</td>
<td>100.0</td>
</tr>
<tr>
<td><strong>Mexico</strong></td>
<td>1,972,546</td>
<td>1,000,000</td>
<td>50.7</td>
</tr>
<tr>
<td><strong>Nicaragua</strong></td>
<td>130,000</td>
<td>65,263</td>
<td>50.2</td>
</tr>
<tr>
<td><strong>Paraguay</strong></td>
<td>75,850</td>
<td>56,246</td>
<td>74.3</td>
</tr>
<tr>
<td><strong>Peru</strong></td>
<td>404,752</td>
<td>200,000</td>
<td>49.2</td>
</tr>
<tr>
<td><strong>Dominican Republic</strong></td>
<td>1,285,215</td>
<td>638,000</td>
<td>49.6</td>
</tr>
<tr>
<td><strong>Trinidad &amp; Tobago</strong></td>
<td>404,752</td>
<td>200,000</td>
<td>49.2</td>
</tr>
<tr>
<td><strong>Uruguay</strong></td>
<td>710,000</td>
<td>710,000</td>
<td>100.0</td>
</tr>
<tr>
<td><strong>Venezuela</strong></td>
<td>914,050</td>
<td>710,000</td>
<td>77.8</td>
</tr>
</tbody>
</table>

**Cont.**
<table>
<thead>
<tr>
<th>COUNTRY OR OTHER POLITICAL UNIT</th>
<th>AREA (IN KMS²)</th>
<th>AREA ASSUMED INITIALLY INFESTED</th>
<th>PERCENTAGE OF TOTAL</th>
<th>PRESENT STATUS</th>
<th>ACTIVITY IN PROGRESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antigua (Barbuda y Adolanda)</td>
<td>442</td>
<td>442</td>
<td>100.0</td>
<td>Infested</td>
<td>Program in preliminary of operation</td>
</tr>
<tr>
<td>Aruba</td>
<td>190</td>
<td>174</td>
<td>91.6</td>
<td>Infested</td>
<td>Program in preliminary of operation</td>
</tr>
<tr>
<td>Bahamas</td>
<td>11,405</td>
<td>11,405</td>
<td>100.0</td>
<td>Infested</td>
<td>Limited program</td>
</tr>
<tr>
<td>Bermuda</td>
<td>53</td>
<td>53</td>
<td>100.0</td>
<td>Eradication completed</td>
<td></td>
</tr>
<tr>
<td>Bonaire</td>
<td>281</td>
<td>266</td>
<td>94.0</td>
<td>Infested</td>
<td>Program in preliminaries of operation</td>
</tr>
<tr>
<td>British Honduras</td>
<td>22,965</td>
<td>22,965</td>
<td>100.0</td>
<td>Eradication completed</td>
<td>Surveillance</td>
</tr>
<tr>
<td>Cara. Zone</td>
<td>1,432</td>
<td>1,432</td>
<td>100.0</td>
<td>Eradication completed</td>
<td>Surveillance</td>
</tr>
<tr>
<td>Carieu Islands</td>
<td>259</td>
<td>259</td>
<td>100.0</td>
<td>Infested</td>
<td>Program in operation</td>
</tr>
<tr>
<td>Curasac</td>
<td>472</td>
<td>448</td>
<td>94.9</td>
<td>Infested</td>
<td>Program in operation</td>
</tr>
<tr>
<td>Dominica</td>
<td>789</td>
<td>789</td>
<td>100.0</td>
<td>Infested</td>
<td>No activities</td>
</tr>
<tr>
<td>French Guiana</td>
<td>91,000</td>
<td>91,000</td>
<td>100.0</td>
<td>Infested</td>
<td>Program in operation</td>
</tr>
<tr>
<td>Grenada-Grenadines (Carriacou, Little Martinique &amp; Union)</td>
<td>344</td>
<td>344</td>
<td>100.0</td>
<td>Infested</td>
<td>Program in preliminary of operation</td>
</tr>
<tr>
<td>Guadeloupe (part of St. Maarten)</td>
<td>1,779</td>
<td>1,619</td>
<td>91.0</td>
<td>Infested</td>
<td>Program in operation</td>
</tr>
<tr>
<td>Martinique</td>
<td>1,102</td>
<td>1,000</td>
<td>90.7</td>
<td>Infested</td>
<td>Program in operation</td>
</tr>
<tr>
<td>Montserrat</td>
<td>98</td>
<td>83</td>
<td>84.7</td>
<td>Infested</td>
<td>Program in operation</td>
</tr>
<tr>
<td>Puerto Rico</td>
<td>8,897</td>
<td>8,897</td>
<td>100.0</td>
<td>Infested</td>
<td>Program suspended</td>
</tr>
<tr>
<td>Saba, St. Eustatius (part of St. Maarten)</td>
<td>67</td>
<td>67</td>
<td>100.0</td>
<td>Infested</td>
<td>Program in preliminary of operation</td>
</tr>
<tr>
<td>St. Kitts-Nevis &amp; Anguilla</td>
<td>357</td>
<td>357</td>
<td>100.0</td>
<td>Infested</td>
<td>No activities</td>
</tr>
<tr>
<td>St. Lucia</td>
<td>616</td>
<td>259</td>
<td>42.0</td>
<td>Infested</td>
<td>Program in operation</td>
</tr>
<tr>
<td>St. Vincent</td>
<td>388</td>
<td>332</td>
<td>85.6</td>
<td>Infested</td>
<td>Program in organizational phase</td>
</tr>
<tr>
<td>Surinam</td>
<td>142,822</td>
<td>48,000</td>
<td>33.6</td>
<td>Infested</td>
<td>Program in operation</td>
</tr>
<tr>
<td>Turks &amp; Caicos Islands</td>
<td>430</td>
<td>430</td>
<td>100.0</td>
<td>Infested</td>
<td>No activities</td>
</tr>
<tr>
<td>Virgin Islands (UK)</td>
<td>153</td>
<td>153</td>
<td>100.0</td>
<td>Infested</td>
<td>No activities</td>
</tr>
<tr>
<td>Virgin Islands (US)</td>
<td>344</td>
<td>344</td>
<td>100.0</td>
<td>Infested</td>
<td>Program suspended</td>
</tr>
</tbody>
</table>
DATA ON THE COST OF THE VIGILANCE ACTIVITIES FOR *Aedes Aegypti* IN SOME COUNTRIES FREE OF THE VECTOR IN THE AMERICAS

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

Source: Data presented by each country at the Conference on *Aedes Aegypti* Eradication in the Americas, 1967, or received by cable in February 1970.
DATA BASED ON THE TOTAL COST OF THE Aedes aegypti ERADICATION IN SOME COUNTRIES OF THE AMERICAS

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

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

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

1Source: Data received by cable from each country or territory.
### APPENDIX F

#### ESTIMATED COST OF THE AEGEDES AEGYPTI ERADICATION CAMPAIGN IN THE COUNTRIES AND TERRITORIES STILL INFESTED OR REINFESTED IN THE AMERICAS

*February 1970*

<table>
<thead>
<tr>
<th>Country or Territory</th>
<th>Estimated number of houses</th>
<th>Probable duration of the campaign</th>
<th>Cost in US$ estimated by Working Group in 1967</th>
<th>Updated estimate in 1970, in US$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antigua</td>
<td>14,000</td>
<td>3 years</td>
<td>176,000</td>
<td>1,760,000</td>
</tr>
<tr>
<td>Netherlands Antilles</td>
<td>52,000</td>
<td>3 &quot;</td>
<td>542,000</td>
<td>542,000</td>
</tr>
<tr>
<td>Bahamas</td>
<td>29,000</td>
<td>3 &quot;</td>
<td>358,000</td>
<td>358,000</td>
</tr>
<tr>
<td>Barbados</td>
<td>52,000</td>
<td>3 &quot;</td>
<td>499,000</td>
<td>499,000</td>
</tr>
<tr>
<td>Brazil</td>
<td>180,000</td>
<td>2 &quot;</td>
<td>-</td>
<td>2,500,000</td>
</tr>
<tr>
<td>Colombia</td>
<td>41,000</td>
<td>2 &quot;</td>
<td>39,000</td>
<td>200,000</td>
</tr>
<tr>
<td>Cuba</td>
<td>2,330,000</td>
<td>4 &quot;</td>
<td>27,400,000</td>
<td>27,400,000</td>
</tr>
<tr>
<td>Dominica</td>
<td>14,000</td>
<td>3 &quot;</td>
<td>176,000</td>
<td>176,000</td>
</tr>
<tr>
<td>El Salvador</td>
<td>220,000</td>
<td>4 &quot;</td>
<td>2,100,000</td>
<td>2,100,000</td>
</tr>
<tr>
<td>United States of America (2)</td>
<td>14,496,100</td>
<td>5 &quot;</td>
<td>-</td>
<td>250,000,000</td>
</tr>
<tr>
<td>Grenada</td>
<td>22,000</td>
<td>3 &quot;</td>
<td>290,000</td>
<td>290,000</td>
</tr>
<tr>
<td>Guadalupe</td>
<td>66,000</td>
<td>3 &quot;</td>
<td>764,000</td>
<td>764,000</td>
</tr>
<tr>
<td>French Guiana</td>
<td>8,000</td>
<td>3 &quot;</td>
<td>117,000</td>
<td>117,000</td>
</tr>
<tr>
<td>Guyana</td>
<td>135,000</td>
<td>4 &quot;</td>
<td>1,220,000</td>
<td>1,220,000</td>
</tr>
<tr>
<td>Haiti</td>
<td>689,000</td>
<td>4 &quot;</td>
<td>1,682,000</td>
<td>6,000,000</td>
</tr>
<tr>
<td>Honduras</td>
<td>60,000</td>
<td>2 &quot;</td>
<td>-</td>
<td>600,000</td>
</tr>
<tr>
<td>Cayman Islands</td>
<td>500</td>
<td>2 &quot;</td>
<td>-</td>
<td>10,000</td>
</tr>
<tr>
<td>British Virgin Islands</td>
<td>3,000</td>
<td>3 &quot;</td>
<td>46,000</td>
<td>46,000</td>
</tr>
<tr>
<td>Jamaica</td>
<td>512,000</td>
<td>4 &quot;</td>
<td>3,899,000</td>
<td>4,800,000</td>
</tr>
<tr>
<td>Martinique</td>
<td>67,000</td>
<td>3 &quot;</td>
<td>764,000</td>
<td>764,000</td>
</tr>
<tr>
<td>Mexico</td>
<td>(3)</td>
<td>2 &quot;</td>
<td>-</td>
<td>500,000</td>
</tr>
<tr>
<td>Montserrat</td>
<td>3,000</td>
<td>3 &quot;</td>
<td>46,000</td>
<td>46,000</td>
</tr>
<tr>
<td>Panama</td>
<td>16,000</td>
<td>2 &quot;</td>
<td>-</td>
<td>600,000</td>
</tr>
<tr>
<td>Dominican Republic</td>
<td>740,000</td>
<td>4 &quot;</td>
<td>5,886,000</td>
<td>8,000,000</td>
</tr>
<tr>
<td>St. Kitts, Nieves</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>and Anguilla</td>
<td>13,000</td>
<td>3 &quot;</td>
<td>176,000</td>
<td>176,000</td>
</tr>
<tr>
<td>St. Vincent</td>
<td>19,000</td>
<td>3 &quot;</td>
<td>261,000</td>
<td>261,000</td>
</tr>
<tr>
<td>St. Lucia</td>
<td>21,000</td>
<td>3 &quot;</td>
<td>285,000</td>
<td>285,000</td>
</tr>
<tr>
<td>Suriname</td>
<td>70,000</td>
<td>3 &quot;</td>
<td>859,000</td>
<td>859,000</td>
</tr>
<tr>
<td>Trinidad</td>
<td>50,000</td>
<td>2 &quot;</td>
<td>161,000</td>
<td>400,000</td>
</tr>
<tr>
<td>Turks and Caicos</td>
<td>3,000</td>
<td>3 &quot;</td>
<td>46,000</td>
<td>46,000</td>
</tr>
<tr>
<td>Venezuela</td>
<td>1,768,000</td>
<td>6 &quot;</td>
<td>31,496,000</td>
<td>17,000,000 (4)</td>
</tr>
</tbody>
</table>

**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.
Provisional Agenda Item 7

CE64/4 (Eng.)
ADDENDUM II
18 June 1970
ORIGINAL: SPANISH

AEDES AEGYPTI

Cost-benefit Study

Resolution XXIII of the XIX Meeting of the Directing Council of the Pan American Health Organization requested the Director to convene a multi-disciplinary study group to review the present strategy for the prevention of Aedes aegypti-borne diseases and define the objectives and guidelines of a study that would examine all possible alternative systems, the relevancy of which should be based on a cost-benefit analysis.

Chapter IV of the report of the study group summarizes their general considerations on the cost-benefit study and groups the various elements which could or should be taken into consideration in this connection.

In accordance with the Resolution of the Directing Council, the cost-benefit study could be made by an independent agency. The Director of the Bureau, after investigating various specialized undertakings with experience in this field, selected the firm of Robert R. Nathan Associates, Inc., whose headquarters are in this city, to carry out the above-mentioned study.

Robert R. Nathan Associates, Inc., after being informed of the background and specific recommendations and bearing in mind the complexity of the study, signed an agreement with the Bureau whereby it undertook to make a preliminary study to identify the components of a thorough cost-benefit study. This project may possibly be submitted to the consideration of the XVIII Pan American Sanitary Conference.