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STUDY ON THE FEASIBILITY OF ERADICATING *Aedes aegypti*

With the deterioration of the dengue situation and the notable increase in dengue hemorrhagic fever (DHF) in the Region, PAHO convened a group of experts in 1991 to develop guidelines for the establishment of effective programs to control dengue and DHF. These guidelines were widely disseminated and are being applied in the Region. The situation continued to deteriorate, and in 1995 the XXVIII Meeting of the Directing Council considered the response to new, emerging, and re-emerging infectious diseases and resolved "to establish immediately a technical task force to study the feasibility, timeliness, and appropriateness of drawing up a hemispheric plan for the eradication of *Aedes aegypti* as an effective means of controlling dengue and urban yellow fever in the Americas." A task force was established and met in April 1996. Its members agreed, in view of the epidemiological situation, that it was timely and appropriate to consider developing a hemispheric plan. A majority of members also believed that was feasible to do so.

The Executive Committee is requested to review this report and make recommendations to the Directing Council on how the Secretariat might proceed.

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EXECUTIVE SUMMARY

With the deterioration of the dengue situation and the notable increase in dengue hemorrhagic fever (DHF) in the Region, PAHO convened a group of experts in 1991 in order to develop guidelines for the establishment of effective programs to control dengue and DHF. These guidelines were widely disseminated and are being applied in several countries of the Americas. As the situation continued to deteriorate, in September 1995 the PAHO Directing Council asked the Director "to establish immediately a technical task force to study the feasibility, timeliness, and appropriateness of drawing up a hemispheric plan for the eradication of *Aedes aegypti* as an effective means of controlling dengue and urban yellow fever in the Americas." A task force was established and, after preparation of background material by the Secretariat, the Task Force met at the Fundação Oswaldo Cruz, in Rio de Janeiro, Brazil, on 16-18 April 1996.

The Task Force recognized and congratulated the Government of Brazil for the bold initiative it had taken to propose eradication of *A. aegypti* in that country in order to eliminate dengue and DHF.

The members of the Task Force agreed that, while it is timely and appropriate to consider designing a hemispheric eradication plan, there are key challenges to be considered regarding the feasibility of drafting such a plan. The majority of the members agreed that these challenges could now be met and that it was feasible to design a hemispheric eradication plan. Some dissenting members thought that certain critical factors were not present, namely: a proven eradication strategy or model, the possibility of universal coverage, and international commitment.

1. Introduction

In recent years considerable attention has been given to the serious threat posed by new, emerging, and re-emerging infectious diseases. The magnitude of the problem is illustrated by the appearance of several new pathogens which cause disease of marked severity, as well as old pathogens that have re-emerged and are having a considerable impact in the Americas. One of those is dengue virus, which is widely dispersed and has become an important problem in the Western Hemisphere.

The fundamental framework for species eradication in the Americas emerged in 1947, when the I Meeting of the Directing Council of the Pan American Sanitary Organization (an earlier name for PAHO) adopted a resolution that established a policy to eradicate *Aedes aegypti* in the Region and requested that the Pan American Sanitary Bureau (PASB) develop an eradication program under its auspices. After notable successes in the 1950s and 1960s, the program went into decline and now all countries, with the exception of Bermuda, Canada, Chile, and Uruguay, are infested. Since the early 1980s there has been a notable increase of dengue and dengue hemorrhagic fever (DHF) in the Region. Because the mosquito vector is the same, there is the additional potential threat of urban transmission of yellow fever.

2. Historical Background

The issue of the eradication of *A. aegypti* in the Americas had been debated since at least the 1920s. In 1934 approval was given in Brazil, albeit unofficially, to a proposal for the eradication of *A. aegypti*. In 1942 the Government of Brazil officially approved the eradication of *A. aegypti*. The I Meeting of the Directing Council of the Pan American Sanitary Organization, held in Buenos Aires in October 1947, analyzed a joint report of Argentina, Bolivia, Brazil, and Paraguay on the plan for hemispheric eradication of *A. aegypti* proposed by Brazil. The Directing Council endorsed the proposal and resolved to entrust to PASB the solution of the hemispheric problem through the development of a program under its auspices. Hemispheric eradication thereby became official policy.

The hemispheric campaign was organized by PASB, and its success was reflected in the fact that, by 1962, 18 continental countries and several Caribbean island countries had achieved eradication (Figure 1).

The reasons for the success of the eradication efforts were:

- Adequate national and external funding for well-trained personnel, equipment, and insecticides;

- Country priorities that were translated into political will;
- Total coverage of infested areas in time-limited programs;
- Use of DDT for perifocal spraying in and around all breeding sites;
- Streamlined, semiautonomous programs, separate from national health programs;
- Centralized, vertically structured programs with a military-type organization and clear lines of command, strict supervision, and a high level of discipline. Community participation occurred, but was limited and not systematic.

Unfortunately, after 1962 only three additional countries or territories eliminated the vector. Even more serious, however, was that the countries which had achieved eradication were becoming reinfested in the 1960s. Not all countries in the Hemisphere had been willing to eradicate *A. aegypti*. Countries that were still infested (Cuba, United States of America, Venezuela, and several Caribbean countries) became sources of reinfestation for those that had eradicated the vector.

From 1947-1985, the Directing Council passed numerous resolutions concerning the eradication of *A. aegypti*.

Over time, in most of the countries that achieved eradication, the programs against *A. aegypti* lost political importance, and surveillance for reinfestation gradually declined so that small reinfestations could no longer be detected. In addition, once a reinfestation was discovered, because of the centralized structure of the program the response usually came too late, and the resources to eliminate it before it could spread tended to be insufficient, although control was still possible (Figure 2). In 1985 the XXXI Meeting of the Directing Council adopted a resolution on control or eradication of *A. aegypti*, which is interpreted as the end of the policy for species eradication in the Region.

The campaigns against *A. aegypti* undertaken in the Hemisphere also eradicated urban yellow fever from the Americas several decades ago. However, the progressively wider dissemination of this vector observed in the Americas since the 1970s, including urban centers located in enzootic and epizootic areas of jungle yellow fever, has created again the possibility of re-emergence of urban yellow fever in the Americas (Figure 3).

3. Present Situation

3.1 *Epidemiological Status*

Tables 1 and 2 show the countries infested with *A. aegypti*, the size of the infested area, the population at risk, and the incidence of dengue and DHF.

The severe outbreak of jungle yellow fever (YF) that affected Peru in 1995 near urban centers infested with *A. aegypti* illustrates that the urbanization of the disease is a real threat. The risk is potentially greater due to the presence of *Aedes albopictus* in Bolivia, Dominican Republic, Guatemala, Mexico, and the United States of America. This is an exotic species which invaded the Americas in the mid 1980s. Laboratory studies show that *A. albopictus* can transmit yellow fever virus. As this species can breed in domestic and in forest environment, it could potentially serve as a bridge between the jungle and urban cycles of yellow fever. There is a real possibility that *A. albopictus* will infest enzootic areas of yellow fever in the near future, thus increasing the risk of urbanization of YF. Although an effective vaccine against YF is available, its coverage is low in most enzootic areas and virtually absent in non-enzootic areas infested by *A. aegypti* and by *A. albopictus*.

3.2 *Prevention and Control Activities*

A program to control dengue and *A. aegypti* should be integrated in its implementation and include the following components: epidemiological surveillance; education of the medical community; entomological surveillance; and integrated vector control, which is the logical combination of all the available methods of control in the most effective, economic, and safe manner, in order to limit the *A. aegypti* population to acceptable levels. Vector control methods include environmental management, chemical control, and biological control. A control program such as this, in order to be successful, needs to be sustained indefinitely.

3.3 *Current Aedes aegypti Programs*

In preparation for the meeting of the Task Force, an international working group prepared a questionnaire to obtain information from all of the countries of the Americas on subjects dealing with the feasibility, timeliness, and appropriateness of eradication campaigns. Eradication was considered as the total elimination of all stages of the mosquito (adults, pupae, larvae, and eggs) from every container on all premises in every infested area. There must be total coverage of all infested and potentially infested areas, both for the eradication of the mosquito and for the verification of eradication. Once eradication is achieved in each area, adequate surveillance against reinfestation must continue indefinitely.

The data presented below are from the 28 countries that responded. Questionnaires from Belize, Brazil, Guatemala, and Haiti have not been received. The answers on the questionnaires were not always the same as official government reports, but are presented here without modification.

3.3.1 Entomological Aspects

With the exceptions of Bermuda, Canada, Chile, and Uruguay, all the countries of the Americas are reinfested with *A. aegypti*. This mosquito has been found in natural breeding sites (tree holes, leaf axils) in 19 countries, and has been found up to 500 meters away from human habitation and up to 1800 meters above sea level. In eight countries there is infestation in areas where there is no access via roads or waterways. In 12 countries there is infestation where access is difficult or dangerous because of social problems (e.g., armed conflict, slums). Refusal of entry of health workers into houses is low in most countries (0% - 3%), but in some areas it is as high as 30% (Ecuador).

Aedes albopictus is now found in Bolivia, Brazil, Dominican Republic, Guatemala, Mexico, and United States of America. In 19 countries there is a surveillance system for *A. albopictus*, and in 16 countries container larvae are identified with a bacteriological microscope.

3.3.2 Epidemiological Aspects

During the past five years there has been an increase in the total number of dengue and DHF cases and deaths. In 1995, a total of 274,422 dengue cases, 7,715 DHF cases, and 104 deaths were reported. A total of 522 sylvatic yellow fever cases were reported from Bolivia (15 cases), Brazil (4), Colombia (3), Ecuador (1), and Peru (499).

3.3.3 Economic Aspects

Per capita expenses for *Aedes* programs are highest in the Caribbean (average of US\$ 2.03 per capita, maximum of \$4.70), less in Central America and Mexico (average \$0.57, maximum of \$1.94), and lowest in South America (average \$0.29, maximum of \$0.65). Table 3 shows the spending by different countries in 1995.

3.3.4 Operational Aspects

In 21 countries there is an active *A. aegypti* program: in 19 countries it is a control program, and in two countries (Cuba and Trinidad and Tobago) it is an eradication program. Six countries have a vertically structured program, nine countries

a decentralized program, and six countries are in the process of decentralization. Resistance to several insecticides used in *Aedes* control (temephos, malathion, lambda-cyhalothrine) is appearing in the Caribbean area.

3.3.5 Legal Aspects

In 13 countries there is legislation for the establishment of an *Aedes* program. In 15 countries there are laws to permit the entrance of field personnel into houses. Eight countries levy fines on people or businesses that have potential or actual breeding sites on their premises. In four countries there are laws prohibiting the importation of used tires. Six countries require the treatment of used tires at the point of origin. Disinsection of aircraft arriving from infested areas is done in 14 countries. Notification of dengue cases is obligatory in 21 countries.

3.3.6 Political Aspects

In 21 countries the fight against dengue is said to be a high priority in the national health policy. In 15 countries, eradication is reported to be compatible with the national health policies and plans. Twelve countries consider that an eradication program is feasible, timely, and appropriate for them. They think that the structure of such a program should be decentralized (15 countries), vertical (four countries), or "other" (two countries). Only two countries (Argentina and Trinidad and Tobago) said that they foresaw the conversion of their program to an eradication program, and only one country (Cuba) said that it had sufficient resources for eradication. Possible types of external financing mentioned were donations (seven countries) and a combination of donations and loans (eight countries).

In recent meetings, certain countries have made declarations concerning their future programs. In the Central American Seminar-Workshop on Strategies for the Prevention and Control of Dengue and Dengue Hemorrhagic Fever in Guatemala (May 1995), the seven countries of Central America chose the strategy of control over the strategy of eradication. In the meeting of the Southern Cone countries in Paraguay in April 1996, the representatives of Argentina, Bolivia, and Paraguay stated that their countries would embark on eradication programs, and the representatives of Peru said that their country would continue with its control program.

4. Recommendations of the Task Force

It was the consensus of the Task Force members that it is timely and appropriate to consider drafting a hemispheric plan for the eradication of *A. aegypti*, because this mosquito continues to spread to new areas and the incidence of dengue and dengue hemorrhagic fever continues to increase throughout the Americas (Figure 4). As Brazil

has drafted a national plan, now is an appropriate time for other countries to consider joining in a coordinated hemispheric effort.

The members of the Task Force agreed that the following key challenges needed to be considered in order to determine the feasibility of drafting a hemispheric plan for the eradication of *A. aegypti*:

(a) *Magnitude of the problem*: The geographical extension of the infested areas, the size of the urban population affected, the penetration of infestation into rural areas, and the numbers of containers per premises are all greater than during the first eradication campaigns of the 1950s and 1960s. The magnitude of the problem must be clearly defined.

(b) *Eradication strategy*: Eradication requires universal coverage of every municipality, every building and dwelling, and every container in the infested areas. The original eradication campaigns that succeeded in eliminating *A. aegypti* from 21 countries were vertically structured and rigorously supervised. Most of the countries in the Americas consider that future eradication programs should be decentralized. However, *A. aegypti* has never been eradicated from any country with a decentralized program. The efficacy of any new eradication strategy needs to be demonstrated in pilot projects.

(c) *Cost*: The cost of future eradication efforts will probably be much greater than previous campaigns and much greater than present control programs. Realistic estimates of costs required to achieve the goal and identification of national and international sources of funds are needed. It should be noted that programs which have large environmental sanitation components will bring health and quality of life benefits in addition to eradication or control of *A. aegypti*.

(d) *Political will*: As governments and government officials change, health priorities change. In order for eradication to be maintained, subsequent surveillance against reinfestation must continue uninterrupted indefinitely.

(e) *International coordination*: For hemispheric eradication to be completed, all of the countries of the Americas, as well as European authorities responsible for territories in the Americas, must agree to eradicate. Not all of the countries eradicated *A. aegypti* during the early campaigns, and many of these same countries may not decide to launch an eradication program in the future. Also, *A. aegypti* is present in great numbers in Asia, posing the risk of reinfestation from that region.

The majority of the Task Force members agreed that the above listed key challenges have been met or can be met in the near future, and that it is feasible to draft an eradication plan. The dissenting members thought that certain of the key challenges

had not been met, namely: a proven eradication strategy or model, the possibility of universal coverage, and international commitment.

The Task Force also recommended that PAHO review the list of key challenges and provide an update and report on their status to Member States.

Finally, the Task Force recognized and congratulated the Government of Brazil for the bold initiative it has taken to propose eradication of *A. aegypti* in order to eliminate dengue and DHF in that country. The plan is decentralized and does include a large environmental sanitation component. The Government of Brazil is encouraged to continue with its effort, to document its progress, and to keep other countries informed.

Table 1: *Aedes aegypti* Infestation in the Americas, 1995

Country or Territory	Km ²		Population		Number of Houses	
	Country	Infested Area*	Country	Infested Area*	Country	Infested Area*
Central and North America						
Costa Rica	50,900	40,720	3,392,075	996,700	678,415	28,156
El Salvador	21,041	782	5,405,013	1,767,565	1,236,188	333,503
Honduras	112,492	67,495	5,547,658	3,605,978	906,698	90,670
Mexico	1,967,183	320,560	91,852,474	19,988,371	18,297,306	3,188,856
Nicaragua	121,428	98	4,139,486	-	722,280	-
Panama	75,517	33,084	2,400,000	1,922,673	597,058	452,880
United States	2,000,021	-	76,467,421	-	-	-
Caribbean						
Bermuda	21	-	60,000	-	26,000	-
Cuba	110,992	4,237	11,000,000	419,887	3,302,557	552,373
Dominica	771	-	71,994	64,795	20,000	3,600
Dominican Republic	48,000	-	-	2,096,640	5,600	181
Grenada	344	344	95,600	-	35,554	-
Montserrat	104	69	10,639	-	6,300	6,300
Nevis	93	-	9,004	10,639	2,891	278
Puerto Rico	8,960	5,376	3,500,000	-	700,000	-
Saint Kitts	176	3	34,000	-	33,500	-
Saint Vincent and the Grenadines	388	388	110,000	12,605	271,871	-
Trinidad and Tobago	5,128	-	1,234,388	-	-	-
South America						
Argentina	2,780,40	35,000	32,608,687	15,000,000	10,096,875	-
Brazil	8,511,965	865,000	161,790,000	56,000,000	32,200,000	11,200,000
Bolivia	1,098,581	358,987	6,420,792	1,470,740	1,701,142	1,660
Colombia	1,141,748	689,339	35,886,280	15,245,071	-	-
Ecuador	272,045	18,150	10,990,000	6,205,691	715,802	-
Paraguay	406,752	406,752	4,152,588	4,152,588	855,547	-
Peru	1,285,216	273,081	23,029,603	1,726,270	4,605,920	345,254
Venezuela	912,050	911,930	21,644,121	1,515,905	4,328,824	303,181

* Estimated

Table 2: Population at Risk and Incidence of Dengue and Dengue Hemorrhagic Fever (DHF) in the Americas, 1995

Country or Territory	Total Population	Population at Risk	Dengue+ DHF Cases	Serotypes	Rate/ 100,000	Cases of DHF (Deaths)	Ratio DHF/ Dengue
Mexico	91,852,474	19,988,371	11,604	1,2,4	58.1	355 (29)	1:33
Costa Rica	3,392,075	996,700	5,134	1,3	515.1	1	1:5,134
El Salvador	5,405,013	1,767,565	9,658	1,2,3,4	546.4	129 (5)	1:75
Guatemala	9,744,627	9,744,627	3,644	1,2,4	37.4	1	1:3,644
Honduras	5,547,658	3,605,978	27,560	1,2,3,4	764.3	35	1:787
Nicaragua	7,139,486	4,139,486	19,260	1,2,3	456.3	806	1:24
Panama	2,400,000	1,992,672	3,083	1,3	154.7	3 (1)	1:1,028
Puerto Rico	3,500,000	2,096,640	6,765	1,2,4	322.6	24 (2)	1:282
Antigua and Barbuda	59,355	n.a.	56	1	94.3	0	-
Barbados	260,491	n.a.	674	1	258.7	2 (1)	1:337
Belize	44,039	n.a.	107	n.a.	243.0	0	-
Dominica	71,994	64,795	293	1,2	452.2	11	1:27
Dominican Republic	7,600,000	n.a.	1,787	n.a.	23.5	33 (2)	1:54
Grenada	95,600	95,600	83	1	86.8	1	1:83
Jamaica	2,366,067	n.a.	1,588	2	67.1	88 (3)	1:18
Montserrat	10,639	10,639	75	n.a.	704.9	0	-
Saint Kitts and Nevis	43,004	23,244	27	n.a.	116.2	0	-
French Guiana	115,000	n.a.	896	1,4	779.1	1	1:896
Brazil	161,790,000	56,000,000	124,887	1,2	223.0	105 (2)	1:1189
Bolivia	6,420,792	1,470,740	n.a.	n.a.	-	n.a.	-
Colombia	35,886,280	15,245,071	18,398	n.a.	120.7	733 (10)	1:25
Ecuador	10,990,000	6,205,691	2,899	1	46.7	0	-
Peru	23,029,603	1,726,270	2,732	1,2	158.3	0	-
Venezuela	21,644,121	1,515,905	32,280	1,2,4	2129.4	5380 (43)	1:6
Argentina	32,608,687	15,000,000	n.a.	n.a.	-	n.a.	-
Paraguay	4,152,588	4,152,588	n.a.	n.a.	-	n.a.	-

* Rates estimated over population at risk when information is available

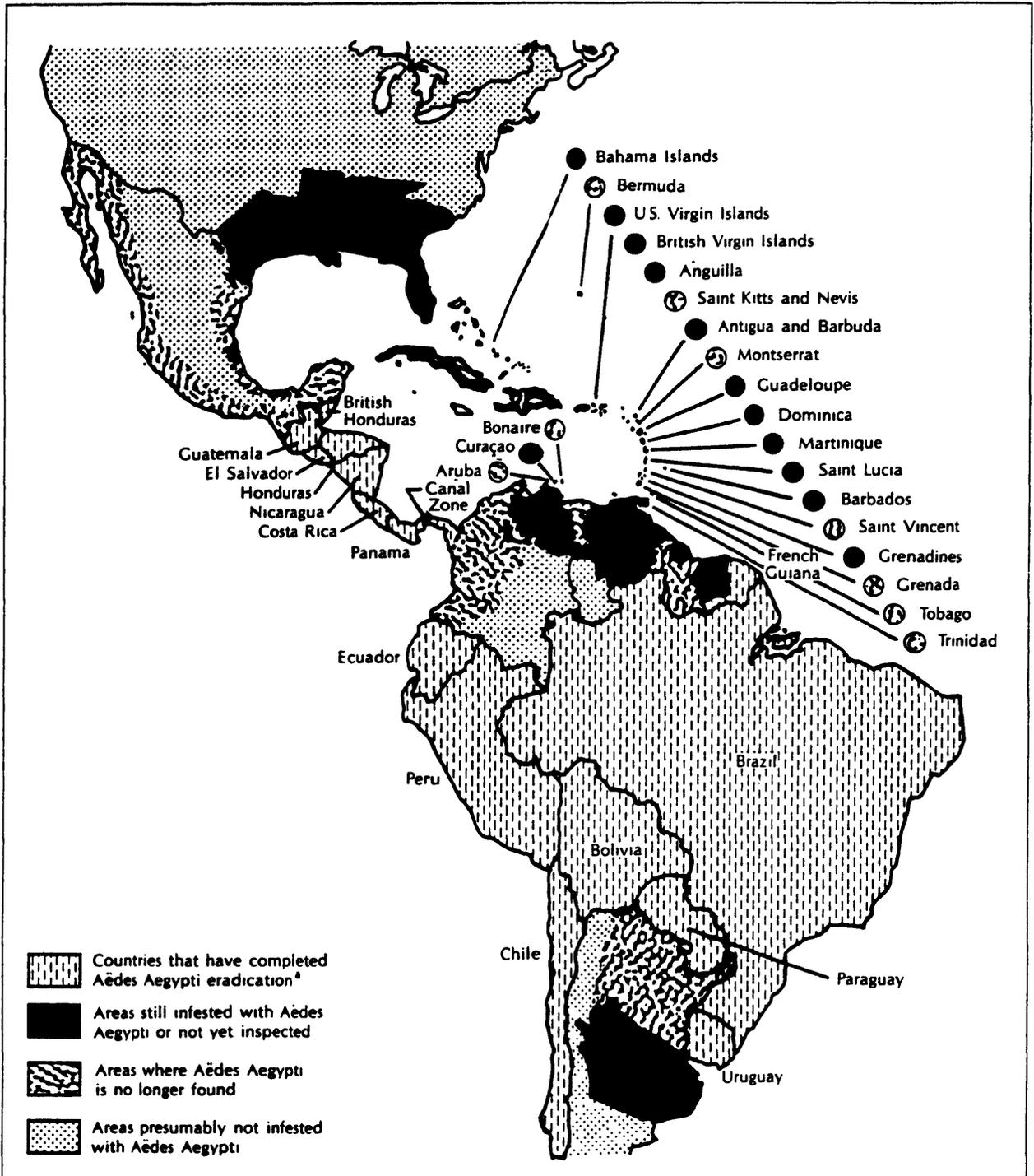
n.a.: Not available

**Table 3: Spending on Dengue Control Activities
in the Countries of the Americas, 1995**

Countries and Territories		US\$
Mexico	(1)	3,000,000
Belize	(2)	90,000
Costa Rica	(2)	1,500,000
El Salvador	(2)	1,000,000
Guatemala	(2)	2,100,000
Honduras	(2)	1,000,000
Nicaragua	(2)	500,000
Panama	(2)	1,294,000
Cuba	(1)	20,884,658
Dominica	(1)	41,000
Dominican Republic	(2)	231,000
Puerto Rico	(1)	1,159,342
Montserrat	(1)	50,000
Saint Vincent and the Grenadines	(1)	132,080
Argentina	(3)	5,950,000
Bolivia	(3)	250,000
Brazil	(3)	58,591,825
Chile	(3)	12,000
Colombia	(3)	3,610,490
Ecuador	(1)	1,034,483
Paraguay	(3)	185,000
Peru	(3)	1,200,000
Uruguay	(3)	10,000
Total		103,825,798

- (1) Data obtained from survey done by PAHO
(2) Up to 30 August 1995
(3) Data obtained from Doc. OPS/HPC/HCT/96.066

Figure 1. STATUS OF THE Aedes Aegypti ERADICATION CAMPAIGN, APRIL 1962



^aEradication carried out according to the standards established by the Pan American Health Organization

Figure 2. DISTRIBUTION OF AEDES AEGYPTI IN THE AMERICAS

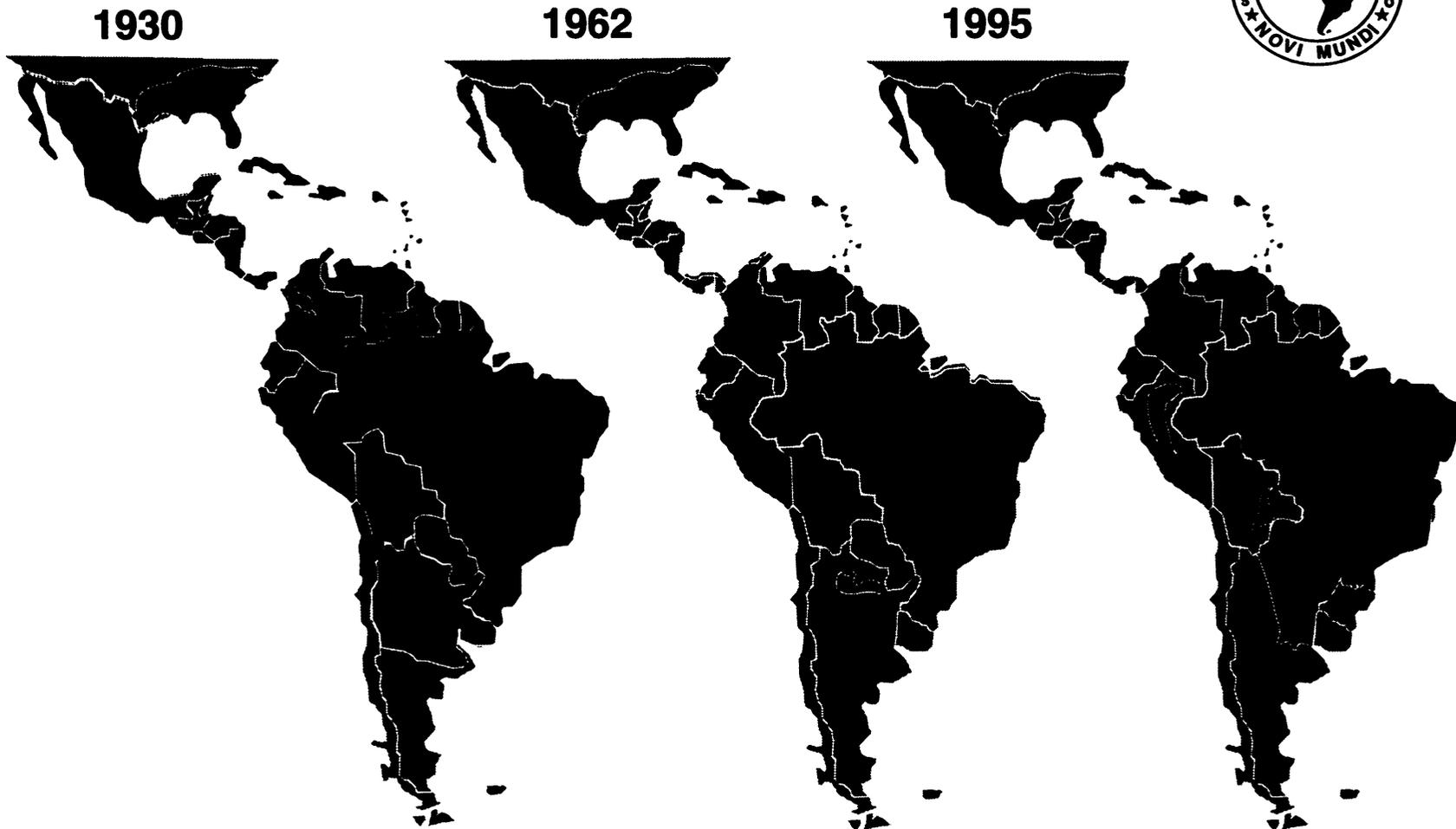


Figure 3. MAP OF SOUTH AMERICA SHOWING ENZOOTIC AND EPIZOOTIC AREAS OF YELLOW FEVER, AND INFESTED WITH AEDES AEGYPTI



Figure 4. DENGUE HEMORRHAGIC FEVER IN THE AMERICAS 1995*

1968 - 1980
5 ** countries: 60 CASES

1981 - 1995
24 countries: 37.030 CASES



* Provisional figures through March 1996

** Four of these countries also reported DHF cases during 1981-95