SMALLPOX ERADICATION IN THE AMERICAS[1]

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Smallpox having been endemic throughout the world for many centuries, its eradication in the Americas has been a victory of great consequence for millions of people. This article presents a detailed and documented account of the measures taken to achieve that extraordinary triumph.

Historical Background

Smallpox, which from remotest antiquity claimed victims throughout the world, ran its course for many centuries without encountering any effective means of control. It appeared in China 200 years before Christ, and it smote Rome in the second century A.D. Our first accurate written description dates from the tenth century, when the Persian physician Abu Bekr Ar-Razi (Mohammed ibn Zakariya) produced a treatise whose Latin version bears the title *De Pestilentia.*

Dr. Edward Jenner

The Moslems carried smallpox with them into Europe, where it is estimated to have caused more than 60 million deaths in the seventeenth century. Later, in the year 1707, it is believed to have slain 14,000 people in the City of Paris alone, among them King Louis XV. In a similar manner, havoc wrought by smallpox has continued up to very recent times; in Russia, for example, there were 256,242 cases between 1919 and 1922.

Smallpox was introduced into the Americas by a slave in the army of Hernán Cortés. In a short time it killed over 300,000 Mexican Indians, and in this way probably facilitated the Spanish Conquest. Similar effects were felt farther north, where it reduced Massachusetts and Narragansett Indian populations estimated at 40,000 in 1633 to a mere few hundred souls.

Yet all through these centuries, the long search for means of protection against this implacable foe was causing a certain amount of knowledge to be gained. Thus it was observed that survivors of an initial attack were protected against later infections, and that the appearance presented by the pustules was one of varying severity.

Variolation

From these observations sprang the idea of inducing a benign infection in healthy persons, so as to protect them against more serious attacks. To do this the Chinese and the Hindus developed their own methods, which were used for many centuries in the Far East and which came to be known as "variolation." This practice was introduced into England by Lady Mary Wortley Montagu, the wife of the British ambassador to Turkey, at the beginning of the eighteenth century.

The First Vaccination

Later on Edward Jenner, an English country doctor who practiced variolation, began to test a belief held by some of his patients—the belief that a case of the cowpox, a disease often contracted by milkers of cattle, conferred

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protection against smallpox. On 14 May 1796, Jenner inoculated a boy, James Phipps, with cowpox material from a pustule on a dairymaid's hand and an immune response was produced. A month and a half later, on 1 July, he again inoculated James Phipps, this time with smallpox material, and the boy did not become ill. That success paved the way for smallpox vaccination, the means for neutralizing this major scourge of mankind.

The Persistent Threat

Despite the availability of this protective measure discovered nearly 200 years ago, smallpox remained active on every continent. Cases imported from endemic smallpox areas caused panics—such as that which occurred in New York in 1947 when an infection brought from Mexico was transmitted to 12 persons and caused two deaths. The consequent mass vaccination of the city's 6,350,000 inhabitants in a single week involved considerable turmoil and expense.

To provide a more recent illustration, it is sufficient to note that 710,775 known smallpox cases occurred in the world between 1963 and 1970, 36,135 of them in the Americas.

The Recent Smallpox Situation in the Americas, up to the World Eradication Campaign

The three countries of Northern America have been free of smallpox in recent years. Mexico has had no cases since 1952. The United States reported two imported cases in 1955 and another in 1957. Canada's only recent case, imported from Brazil, was notified in 1962.

Regarding Central America and the Caribbean area, one case occurred in Guatemala in 1953, and sporadic cases were reported in Panama in 1947 and 1958, Belize in 1948, Trinidad and Tobago in 1948, and Martinique and the Netherlands Antilles in 1951. The other countries of this area have been free of the disease in recent years.

In South America, Bolivia eradicated smallpox in 1961, but the disease was reintroduced in 1964. Likewise, Paraguay and Peru conducted successful eradication campaigns, but the disease was later reintroduced. However, no cases were reported in Chile after 1954, except for a single indigenous case contracted from an imported case in 1959. Ecuador reported no cases after 1964. Venezuela, which had achieved eradication in 1957, experienced an outbreak near the Brazilian border in 1962, but this was promptly contained. Uruguay became free of smallpox in 1957, and only sporadic cases derived from imported infections were reported after that time. As of 1965, endemic smallpox persisted only in Argentina, Brazil, Colombia, Paraguay, and Peru. (Tables 1 and 2 show the reported cases of smallpox in the Americas between 1955 and 1972.)

The Case of Brazil

Smallpox existed in Brazil from colonial times onward, epidemic outbreaks being reported in 1563, 1834, 1836, 1844, 1848, 1850, and 1865. Several outbreaks also occurred around the turn of the century, the most prominent being one in 1908 that involved about 10,000 cases.

As Table 3 shows, until recently smallpox was present in all of Brazil's geographic regions. The absence of reported cases in some territories over the years 1957-1966 merely reflected the need for an adequate network of epidemiologic surveillance units, since the subsequent eradication campaign demonstrated that smallpox still existed in those areas.

In 1962 Brazil's Ministry of Health launched the country's National Campaign Against Smallpox. However, budgetary limitations restricted the campaign's initial activities to a vaccination drive in the State of Sergipe. This effort succeeded in interrupting smallpox transmission in Sergipe, even though the disease was endemic in all neighboring states.

In addition, the Government of Brazil, the United States Center for Disease Control in Atlanta, Georgia, and the Pan American Health

TABLE 1--Reported cases of smallpox in the Americas, 1955-1965.[a]

Country	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965
Argentina	55	86	335	27	36	65	6	2[b]	-	13[b]	15[b]
Bolivia	372	499	1,310	183	7	1	-	-	-	5	-
Brazil	2,580[c]	4,464[d]	2,413[d]	2,190[d]	3,911[d]	6,018[d]	8,546	9,583	6,433	3,076	3,269
Canada	-	-	-	-	-	-	-	1[c]	-	-	-
Chile	-	-	-	-	1[e]	-	-	-	-	-	-
Colombia	3,404	2,572	2,145	2,009	950	209	16	41	4	21	149
Ecuador	1,831	669	913	863	1,140	2,185	496	204	45	42	-
French Guiana	-	-	-	-	-	-	-	-	-	-	-
Panama	-	-	-	8[b]	-	-	-	-	-	-	-
Paraguay	57	132	103	21	-	35	-	-	-	7	32
Peru	-	-	-	-	-	-	-	-	865	454	18
United States of America	2	-	1	-	-	-	-	-	-	-	-
Uruguay	45	42	2	-	-	19[b]	1[e]	10[b]	1[e]	3[e]	1[e]
Venezuela	2	4	-	-	-	-	-	11	-	-	-
Total	8,343	8,468	7,222	5,301	6,045	8,532	9,055	9,852	7,348	3,621	3,484

- None.
[a]Based on official reports from the countries involved.
[b]Includes imported cases.
[c]Data for state capitals.
[d]Incomplete data.
[e]Imported cases.
[f]These cases did not conform to generally accepted standards for diagnosis of smallpox.

TABLE 2--Reported cases of smallpox in the Americas, 1966-1972.

Country or other political unit	1966	1967	1968	1969	1970	1971	1972	Total
Argentina	21	23[a]	-	-	24[a]	-	-	68[a]
Brazil	3,518	4,514	4,372	7,407	1,771	19	-	21,582
Colombia	8	-	-	-	-	-	-	8
French Guiana	-	-	1[b]	-	-	-	-	1[b]
Paraguay	5	-	-	-	-	-	-	5
Peru	13	-	-	-	-	-	-	13
Uruguay	-	-	2[a]	3[a]	-	-	-	5[a]
Total	3,565	4,537	4,375	7,410	1,795	19	-	21,682

- None.
[a]Includes imported cases.
[b]Imported.
Source: Annual PAHO/WHO questionnaires or official reports from the countries.

Organization undertook a joint preliminary study in the Territory of Amapá to determine the effectiveness of jet injectors in mass vaccination campaigns. Use of the "Ped-O-Jet" was approved, on grounds that the injector's speed permitted rapid vaccination of large groups of people (up to 2,000 vaccinations per man/day), that the general public accepted it, and that its operating costs were low.

On the basis of this study and pertinent PAHO/WHO resolutions, on 31 August 1966 the Government issued Decree No. 59,153 launching the Smallpox Eradication Campaign in Brazil.

The Eradication Campaign in the Americas

Early Resolutions by International Agencies

In 1949 PAHO's Executive Committee, considering both the epidemiologic situation in the Americas and the availability of a highly effective prophylactic procedure, approved a proposal by the Director calling for initiation of smallpox eradication in the Hemisphere;[3] that

[3]Pan American Health Organization, Document OSP.CE7.W-15, In: *Documents of the Seventh Meeting of the Executive Committee*, Washington, D.C., 1949.

TABLE 3--Notification of smallpox cases in Brazil, by states and territories, from 1957 to 1966 (including reports received up to 12 August 1967).

States and territories	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
North										
Rondônia	...	...	...	...	...	...	-	-	-	-
Acre	...	...	...	...	...	...	-	1	-	-
Amazonas	5[a]	2[a]	68[a,b]	377[a]	196	48	38	5	2	7
Roraima	...	...	...	...	...	...	-	-	-	2
Pará	45[a]	11[a]	-[a,b]	14[a]	129	44	30	26	2	25
Amapá	...	...	...	...	...	...	-	-	56[c]	23[c]
Northeast										
Maranhão	66[a]	180[a]	2[a,b]	1[a]	380	349	747	40	55	7[a]
Piauí	7[a]	13[a]	7[a,b]	12[a]	5	9	34	22	328	563
Ceará	44[a]	38[a]	43[a,b]	205[a]	62	195	77	102	382	291
Rio Grande do Norte	...	-	7[a,b]	4[a]	94	364	122	20	15	-
Paraíba	6[a]	22[a]	8[a,b]	...	4	11	5	15	56	20
Pernambuco	17[a]	48[a]	23[a,b]	57[a]	208	236	104	114	31	8
Alagoas	323	56	104	103	116	193	188	19	13	8
Fernando de Noronha	...	...	...	...	...	...	-	-	-	-
Southeast										
Sergipe	2[a]	8[a]	-[a,b]	...	1	15	-	-	24[a]	2
Bahia	17[a]	133[a]	128[a,b]	747	1,965	1,866	1,322	113	24	-
Minas Gerais	6[a]	30[a]	661[a,c]	...	517	506	747	487	208[d]	143
Espírito Santo	5	8	9	15	34	29	25	21	11	12
Rio de Janeiro	...	...	...	195	484	853	127	66	76	44
Guanabara	353	247	199[b]	732	1,080	1,198	125	75	168	45
South										
São Paulo	562	468	1,626	1,808	1,452	1,036	916	804	947	1,286
Paraná	246[a]	69[a]	83[a,b]	285[a]	726	358	443	133	85	42
Santa Catarina	63[a]	109[a]	...	7	...	90	28	38	8	9
Rio Grande do Sul	456	517	388	919	889	1,988	720	633	515	229
Center-West										
Mato Grosso	4[a]	6[a]	...	22[a]	...	...	68	56	11	32
Goiás	12[a]	41[a]	...	5[a]	204	187	491	203	243	261
Distrito Federal					...	...	4	-	-	1
All states and territories										
North	50	13	68	391	325	92	68	32	79	57
Northeast	463	357	194	382	869	1,357	1,277	332	880	897
Southeast	383	426	997	1,689	4,081	4,467	2,326	762	511	246
South	1,327	1,163	2,097	3,019	3,067	3,472	2,107	1,608	1,555	1,566
Center-West	16	47	...	27	204	187	563	259	254	294
Total	2,239	2,006	3,356	5,508	8,546	9,575	6,341	2,993	3,279	3,060

... Data not available.
- None.
[a] Notifications from capitals only.
[b] Data covering only six months.
[c] Tentative data.
[d] Notified as of August.
Source: Annual PAHO/WHO questionnaires or official reports from the countries.

proposal was later endorsed by the XIII Pan American Sanitary Conference, which met in Santo Domingo in 1950.[4] From then on, the decision to seek eradication was supported repeatedly in a series of resolutions by the Governing Bodies of both PAHO and WHO.

In 1958 the Soviet Union proposed that a worldwide smallpox eradication campaign be implemented under auspices of WHO.[5] In 1965 the United States enlarged on that proposal by calling for a special WHO effort to achieve smallpox eradication within the next decade.[6]

Organization of American States

The Ten-Year Public Health Plan outlined in the Charter of Punta del Este in 1961 listed a number of immediate action measures whose adoption was recommended to the Governments of the Americas. One of these was preparation of programs "To eradicate malaria

[4]Pan American Health Organization, Document CSP/13/PAT 10, In: *Documents of the XIII Pan American Sanitary Conference,* Washington, D.C., 1950.

[5]World Health Organization, *Eleventh World Health Assembly,* Geneva, 1958, pp. 508-512 (WHO Official Records, No. 87).

[6]World Health Organization, *Eighteenth World Health Assembly, Part II,* Geneva, 1965, pp. 312-314 (WHO Official Records, No. 144).

and smallpox from the Hemisphere and to intensify the control of other common infectious diseases, such as enteric ailments and tuberculosis."[7]

In 1967 the Presidents of the Americas met at Punta del Este and recommended specifically that "measures be taken to eradicate those [communicable diseases] that can be completely eliminated by existing techniques."[8] This declaration reinforced an earlier recommendation made by the Ministers of Health of the Americas in 1963, which read as follows:

The Governments of the countries where foci still exist should intensify and accelerate their national programs of smallpox eradication, give them a high priority within national health plans, and seek such additional funds and resources as are needed from national and international sources.

The Governments that have already eradicated smallpox should establish procedures within their health services which will guarantee the maintenance of adequate levels of immunity, as well as continued vigilance to avoid possible recurrence of the disease. This can be accomplished through the annual vaccination of one-fifth of the population.

The Governments should coordinate their efforts and assist each other in developing programs of smallpox vaccination aimed at eradicating smallpox in the Americas in the shortest possible time. Collaboration among countries is of special importance in border areas.[9]

Program and Budget

In accord with these instructions and recommendations from the Member Governments and Governing Bodies of PAHO/WHO, the Organization directed maximum attention to smallpox eradication, which came to be considered one of PAHO's leading activities. Funds were allocated and (in accord with Resolution 12 of the Twenty-second Meeting of the WHO Executive Board) a special smallpox account was set up.[10] In May 1966 the Nineteenth World Health Assembly approved a program and budget for global smallpox eradication and allocated part of this to the eradication program in the Americas which was to begin in 1967.[11]

Evaluation Survey

In 1966 PAHO undertook a survey to evaluate the smallpox situation in the countries of the Region. The results of this survey, presented in a report to the XVII Pan American Sanitary Conference,[12] laid the groundwork for defining the nature and extent of international assistance needed by the countries to organize, carry out, and evaluate their national eradication programs.

Activities Planned

An action plan was set up that reflected the status of smallpox in the various countries of the Region. Specifically, it divided the countries into three groups, according to the phases of eradication activity appropriate to each:

1) *Attack phase*–for countries with five cases of smallpox or more per 100,000 inhabitants, and where less than 80 per cent of the population showed a vaccination mark.

2) *Consolidation phase*–for countries experiencing less than five cases of smallpox per

[7]Pan American Union, *Alliance for Progress,* Washington, D.C., 1961 (OAS Official Documents, Ser. H/XII.1).

[8]Pan American Union, *Meeting of American Chiefs of State, Punta del Este, Uruguay, April 12-14, 1967,* Washington, D.C., 1967 (OAS Official Records, OEA/Ser. C/IX.1).

[9]Pan American Health Organization, *Task Force on Health at the Ministerial Level, Washington, D.C., 15-20 April 1963.* Washington, D.C., 1964, p. 33 (PAHO Official Document No. 51).

[10]World Health Organization, *Executive Board, Twenty-Second Session,* Geneva 1958, p. 7 (WHO Official Records, No. 88).

[11]World Health Organization, *Nineteenth World Health Assembly,* Geneva, 1966, pp. 8-9 and 106-121 (WHO Official Records, No. 151).

[12]Pan American Health Organization, *Status of Smallpox Eradication in the Americas and Estimated Requirements for the Eradication of Smallpox in the Americas,* Washington, D.C., 1966 (PAHO Document CSP17/20, Rev. 1, English).

100,000 inhabitants, and where more than 80 per cent of the population showed a vaccination mark.

3) *Surveillance and maintenance phase in the absence of disease*—for countries that had been free of smallpox for over two years.

Identification of Problems

The previously mentioned report to the XVII Pan American Sanitary Conference pinpointed various obstacles faced by the countries of the Americas in their smallpox eradication efforts. These could be grouped into three general categories:

(a) *Budgetary difficulties.* The countries involved had not budgeted sufficient funds to purchase the vehicles, jet injectors, laboratory equipment, and other material required for their eradication campaigns.

(b) *Lack of adequate plans.* This had been an important cause of failure in certain campaigns. For example, lack of continuity (essential in maintenance programs to ensure a minimum satisfactory level of protection for the population) had been responsible for reintroduction of smallpox into two South American countries.

Another common shortcoming had been lack of the supervision and evaluation needed to ascertain levels of coverage and successful vaccination. Moreover, the health infrastructure of most countries had been deficient and was in a weak position for undertaking large-scale activities of this kind.

(c) *Vaccine shortages.* Besides the financial problems, technical difficulties had made it hard for some countries to produce enough stable, pure, high-potency freeze-dried vaccine to meet their own needs. At the same time, donations from other countries had been insufficient to supply their programs in a continuous and efficient manner.

Furthermore, production and use of contaminated or low-potency vaccines, resulting from inadequately trained production personnel—as well as lack of adequate equipment—had frustrated the efforts of several countries, which then had to undertake revaccination campaigns in zones already covered more than once before.

Activities Undertaken

Government Agreements

Based on knowledge of the problem and of the difficulties the countries had experienced trying to solve it, PAHO signed agreements with Argentina, Bolivia, Brazil, Colombia, Paraguay, Peru, Uruguay, and Venezuela, and collaborated directly with the countries in drawing up their plans of operation.

Technical Advisory Structure

To provide advisory services for the campaign supplementing those of the WHO Smallpox Unit in Geneva, PAHO appointed a Regional Adviser to coordinate Hemisphere-wide activities, assigned three epidemiologic advisers to Zone V (i.e., Brazil, the only country where smallpox was endemic), stationed an adviser in Zone IV, and placed another in Zone VI.[13] Also, specialized statistical advisers were assigned to PAHO Headquarters in Washington, D.C., and to Zones IV, V, and VI; and a technical officer was assigned to Zone IV.

Strategy and Methodology

Special attention was devoted to planning strategy and methods for the smallpox eradication program, which in essence entailed the following activities:

(a) Holding of seminars, which besides establishing field-work standards and procedures were devoted to study of vaccination methods and analysis of past outbreaks in order to evaluate factors underlying persistence of the endemic disease.

[13]These PAHO field activities were administered from six Zone Offices. Zone IV encompasses Bolivia, Colombia, Ecuador, and Peru. Zone VI includes Argentina, Chile, Paraguay, and Uruguay.

(b) Supervision and evaluation of vaccination activities, in order to accurately assess the effectiveness and results of the work done.

(c) Preparation of operations manuals for the countries concerned, particularly those signing smallpox eradication agreements with PAHO. In the case of Brazil, manuals were prepared especially for vaccinators, supervisors, and evaluators.

(d) Training of personnel responsible for project activities in the various areas of operation.

(e) Holding of three courses designed to improve the efficiency of laboratory diagnosis. These courses, sponsored by the Government of Brazil and PAHO with the collaboration of the U.S. Center for Disease Control in Atlanta, Georgia, were held in São Paulo, Brazil, and were attended by 18 fellows from 13 countries. (As Figure 1 shows, there are 18 laboratories engaged in diagnosis of smallpox in the Region, the Atlanta facility serving as a reference center.)

FIGURE 1—Laboratories for diagnosis of smallpox in the Americas.

(f) Provision of advice concerning organization and outfitting of national laboratories for the purpose of producing smallpox vaccine that would meet the requirements for potency, stability, and purity established by WHO.

Production of Freeze-dried Vaccine

The year before the PAHO/WHO-supported eradication program began in 1967, laboratories in seven countries were producing only 17,557,600 doses of freeze-dried vaccine. Apart from the fact that this was not enough to satisfy the needs of the Region, the vaccine produced was frequently contaminated and incapable of meeting potency and stability requirements.

With the assistance of the Connaught Laboratories of the University of Toronto, Canada, permanent technical advisory services, financial resources, and modern equipment for production of freeze-dried vaccine were provided to Argentina, Brazil, Chile, Colombia, Cuba, Ecuador, Mexico, Peru, Uruguay, and Venezuela. Professionals responsible for the production of freeze-dried smallpox vaccine in several countries (Argentina, Brazil, Chile, Colombia, Mexico, and Peru) visited the Connaught Laboratories in order to familiarize themselves directly with the techniques used there. Arrangements were also made for exchange visits between professionals from Argentina, Brazil Colombia, Ecuador, and Uruguay.

Table 4 shows the number of doses of freeze-dried vaccine produced in 1966-1972. Because WHO does not recommend using liquid vaccine, production figures for such vaccine are not included—although some countries have continued to use it despite the problems that its administration entails.

Not only has production of freeze-dried vaccine increased rapidly since 1966, but the stability and the potency of the product are now satisfactory. Moreover, vaccine prepared in chick embryos has also been effective, as the field results obtained in Brazil show.

TABLE 4--Production of freeze-dried smallpox vaccine in the Americas, 1966-1972.

Country	Years						
	1966	1967	1968	1969	1970	1971	1972
Argentina	-	560,000	14,944,800	21,427,850	44,350,325	12,218,600	17,456,000
Bolivia	1,800,000	400,000	-	230,000	235,250	-	-
Brazil	9,386,200	31,331,900	49,482,650	61,000,000	72,298,050	44,726,975	29,386,650
Chile	36,500	693,000	1,962,000	3,950,000	721,000	500,000	2,583,000
Colombia	2,535,000	4,504,502	7,992,200	7,586,500	10,800,000	4,000,000	4,008,000
Cuba	...	20,000	...	...	...	...	1,834,800
Ecuador	2,019,800	1,559,740	-	-	1,800,000	2,400,000	1,016,900
Guatemala	-	-	263,300	-	-	-	-
Peru	1,033,100	2,220,000	5,848,750	6,527,200	6,227,800	5,227,950	5,850,000
Venezuela	747,000	624,000	-	-	-	-	301,025
Total	17,557,600	41,913,142	80,493,700	100,721,550	136,432,425	69,073,525	62,436,375

- None.
... Data not available.
Source: Annual PAHO/WHO questionnaires or official reports from the countries.

Eradication Measures

Besides the assistance of a purely technical nature given to diagnostic and vaccine production laboratories, the advisory services provided in planning strategy and methodology, the preparation of procedural manuals, the promotion of special studies, and the distribution of publications,[14] PAHO/WHO assistance was essential for coping with numerous technical and administrative problems. That is, to help secure the eradication of smallpox, activities were undertaken for purposes of achieving the following specific objectives:

- Efficient prosecution of the attack phase in order to reduce the incidence of the disease to levels facilitating more productive surveillance and containment efforts.
- Activation of surveillance and containment services through organization of active reporting units covering the whole territory of all the countries.
- Establishment of an order of priority for the vaccination programs, so as to give preference to persons under age 15, to assign primovaccinations greater epidemiologic value than revaccinations, and to achieve vaccination of all newborn infants.
- Establishment of mandatory vaccination for health personnel, especially hospital workers, as well as systematic vaccination of hospital patients.
- Support for administration of maintenance vaccinations by local health services.
- Installation of a freeze-dried vaccine bank at Zone V Headquarters in order to meet emergency requests from any country in the Hemisphere, and maintenance of chick-embryo vaccine stocks to meet emergency situations in Middle American countries free of foot-and-mouth disease.[15]

Surveillance Programs

As indicated in Table 2, only Brazil and Argentina had indigenous cases of smallpox in 1967, and some of those notified by Argentina were imported.

Five countries entered the maintenance phase in 1969. These were Bolivia (no reported cases after 1964), Ecuador (no reported cases after 1965), and Colombia, Paraguay, and Peru (no reported cases after 1966). Once transmis-

[14]Including the following: *Epidemiologic Surveillance Bulletin, Manual for Eradication Programs,* and *Manual for Surveillance, Control, and Maintenance* (Ministry of Health of Brazil); and *Guide to the Laboratory Diagnosis of Smallpox for Eradication Programmes; Requirements for Biological Substances,* Technical Report Series, Nos. 180 and 323; *Requirements for Production of Freeze-dried Vaccine; Smallpox--A Pictorial Guide to Diagnosis; Smallpox Eradication,* Technical Report Series, No. 393; *Studies on the Bifurcated Needle;* and *WHO Expert Committee on Smallpox,* Technical Report Series, Nos. 283 and 493 (World Health Organization).

[15]Calf vaccine, prepared from calf lymph, is prohibited in countries free of foot-and-mouth disease.

sion was interrupted in Bolivia, Colombia, Ecuador, and Peru, these four countries incorporated other vaccinations (such as BCG, DPT, and in the case of Ecuador poliomyelitis) into their smallpox vaccination programs. Budgetary outlays were accordingly increased and personnel working in other programs, such as Colombia's malaria eradication program, were brought into the vaccination campaigns.

Smallpox foci in Argentina, from 1965 on, were limited to the provinces of Corrientes, Formosa, Jujuy, Misiones, and Santa Fe. No cases were reported in 1968 and 1969; but in 1970 there was an outbreak of 23 local cases in Misiones Province resulting from an imported case.

In Brazil, the real endemic center implicated in spread of the disease to neighboring countries, far fewer cases were reported in 1970 than in 1969, even though surveillance and case-finding activities had been stepped up considerably. The reduction was even more evident the next year, when only 19 cases were reported, all of them in the City of Rio de Janeiro, the last of them on 19 April 1971. (A total of 1,211 cases had been reported for this portion of 1970.) Since that date no smallpox cases have been reported in Brazil.

However, the success of the Hemispheric campaign begun in 1967, which led to detection of the last case in 1971, made it all the more necessary to step up epidemiologic surveillance programs and to submit any suspected case found to laboratory examination.

In Argentina, suspected cases were reported via telephone or by radio communication systems. Diagnosis was based on inoculation of material onto chick chorioallantoic membranes, immunodiffusion in agar, and electron microscopy.

Bolivia (which had an inadequate reporting system) used special surveillance teams to investigate suspected cases. Also, it stopped using the U.S. Center for Disease Control (CDC) for laboratory diagnosis, depending instead on diagnostic facilities in Argentina and Brazil.

Colombia and Ecuador organized reporting networks and made provision for epidemiologic investigation of suspected cases. Laboratory diagnoses were made in the countries themselves, using the technical procedure recommended by PAHO/WHO; results were periodically checked by the CDC.

Beginning in 1971, Peru entrusted its national smallpox reporting system to its regional health offices and hospital institutions. In cases where special epidemiologic investigations were needed, assistance was provided by members of the PAHO/WHO technical staff.

Evaluation

To confirm the success of these activities, culminated by interruption of smallpox transmission and by epidemiologic silence throughout South America, an investigation was made of problem regions—i.e., areas where the last known cases had existed and where residual unreported cases might remain. These regions, including all parts of South America recently experiencing indigenous or imported cases, were precisely those where surveillance and maintenance activities had been very inefficient or had simply not been carried out.

The investigators assigned to each area made use of surveys and other sources of data and criteria, including the following: maps defining the places to be visited; population estimates of the area under study; and descriptions of the places to be covered.

In each locality interviews were conducted with local officials (town managers, mayors, etc.), and visits were made to all local health services (including health centers, government and private hospitals, dispensaries, malaria outposts, etc.). Photographs of smallpox cases were shown at all schools, and those present were asked whether any cases had been seen in the past 12 months; if there was an affirmative response, the place and time of the occurrence was requested. The general procedure was to interview the headmaster or the teaching staff plus at least five classes; if a school operated in shifts, the students interviewed were those present at the time of the visit.

Recommendations of the Director

In view of these developments, the Director of the Pan American Sanitary Bureau officially notified the Ministers of Health of the Americas of the eradication program's success in the Hemisphere, and requested their support and further assistance in consolidating the results achieved. This message from the Director also contained a number of recommendations, which in essence urged:

1) That local health agencies be instructed to remain alert and take the measures needed (including laboratory examinations) to identify suspected cases of smallpox and to investigate the chain of transmission of the disease.

2) That the cooperation of personnel in the malaria eradication program be enlisted for activities aimed at fulfilling the foregoing recommendation.

3) That special surveys be made in those areas of each country where the last smallpox cases were reported or where surveillance may have been relatively ineffective.

In addition, the Director offered all PAHO/WHO collaboration that might be needed to implement plans for special investigations of this kind.

Confirmation of Success in Zones I and IV

The complete absence of smallpox cases in South America was verified by special investigations made during 1971 and 1972 in the countries adjoining Brazil, and by more extensive and detailed investigations in Brazil itself.

Surveys by special PAHO/WHO consultants in Zone I—Venezuela, Guyana, Surinam, and French Guiana—confirmed that smallpox had been eradicated there. However, with the exception of Venezuela, it was found that maintenance vaccination activities were inadequate in all these countries and territories.

Smallpox eradication in Venezuela dates back to 1947, but the nation did experience a later outbreak in 1962, when nine cases at Santa Elena, a locality on the Brazilian border, were caused by infection imported from Brazil. A 1971 sample survey of vaccination marks showed that the 91.6 per cent of the general population was protected, while the level of protection at Santa Elena was 82 per cent.

In Zone IV, periodic investigations made in Bolivia, Colombia, Ecuador, and Peru confirmed the epidemiologic silence that had been registered for several years. Furthermore, in 1971 and 1972 special investigations were made in all the Zone IV countries to confirm the absence of smallpox cases; in Bolivia they were carried out in Larecaja Province, a subdivision of La Paz Department; in Colombia, in the jungle areas of the Amazon Basin and the Comissary of Vaupés as well as in the Alta Guajira; in Ecuador, in the localities of General Morales and Suscal in Cañar Province, where the last cases of smallpox occurred; and in Peru, along the banks of the Amazon from the Brazilian border to Iquitos. All these investigations produced negative results as far as small-

TABLE 5--Sample survey evaluation of protection levels, by age groups, in the countries of Zone IV, 1972 and January-June 1973.

Countries	Under 5 years			5 - 14 years			15 years and over		
	Examined	No. Positive	% Positive	Examined	No. Positive	% Positive	Examined	No. Positive	% Positive
Colombia	-	-	-	-	-	-	-	-	-
Ecuador	2,420	998	41.2	3,844	3,282	85.4	2,094	1,853	88.5
Peru[a]	5,615	5,051	90.0	6,835	6,587	96.4	12,883	11,465	89.0
Bolivia	1,106	797	72.1	1,708	1,625	95.1	1,823	1,793	98.3
Total	9,141	6,846	74.9	12,387	11,494	92.8	16,800	15,111	89.9

- Not conducted.

[a] 1972 only.

Source: Annual PAHO/WHO questionnaires and official reports from the countries.

TABLE 6--Epidemiologic surveillance units and reporting stations in Brazil, showing the average number of regularly reporting stations in 1971.

Surveillance units by major political division[a]	No. of municipalities	No. of reporting posts	No. of municipalities with reporting posts	% coverage	Average No. of posts providing punctual reports	% providing punctual reports[b]
Brazil (total)	3,953	3,243	2,895	73.5	680	
North						
Rondônia	2	1	1	50.0	1	...
Acre	7	1	1	14.3	1	...
Amazonas	44	1	1	2.3	1	...
Roraima	2	1	1	50.0	1	...
Pará	83	1	1	1.2	1	...
Amapá	5	1	1	20.0	1	...
Northeast						
Maranhão	129	142	122	94.6	67	47
Piauí	114	140	114	100.0	66	47
Ceará	142	150	118	83.1	46	31
Rio Grande do Norte	150	130	101	67.3	33	25
Paraíba	171	100	83	48.5	40	40
Pernambuco	164	135	108	65.8	61	45
Alagoas	94	96	94	100.0	53	55
Fernando de Noronha	1	1	1	100.0	1	100
Sergipe	76	80	76	100.0	70	88
Bahia	336	214	180	53.6	86	40
Southeast						
Minas Gerais	722	288	283	39.2	147	51
Espírito Santo	53	83	53	100.0	77	93
Rio de Janeiro	63	71	63	100.0	22	31
Guanabara	1	23	1	100.0	23	100
São Paulo	571	584	571	100.0	489	84
South						
Paraná	288	318	287	99.6	267	84
Santa Catarina	197	188	173	87.8	148	79
Rio Grande do Sul	232	227	219	94.4	211	93
Center-West						
Mato Grosso	84	34	25	29.8	34	100
Goiás	221	222	216	97.7	82	37
Distrito Federal	1	11	1	100.0	11	100

... Data not available.

[a] In the Federal District and in each state or territory there is an epidemiologic surveillance unit installed in the capital (in the Department of Health), as well as a network of reporting stations; the latter are situated at the center of local government of each municipality possessing such a center.

[b] Weekly average.

Source: Annual PAHO/WHO questionnaires or official reports from the countries.

pox was concerned. Table 5 shows the smallpox protection levels found in the course of these special investigations.

Confirmation of Eradication in Brazil

Brazil progressively extended its network of reporting units (see Table 6) and promoted epidemiologic investigation of suspected cases in all its political subdivisions. Table 7 provides data on laboratory examinations conducted in 1971-1973.

From 7 July to 21 November 1972, a further special epidemiologic investigation was carried out in Brazil which covered 451 localities throughout the country. A total of 317,292 persons were interviewed, including 1,309 political officials, 2,535 health authorities, 15,579 people attending health services, 5,378 persons attending private medical services, and 561 people at civil registry offices—as well as 45,605 tradespeople and factory personnel, 125,920 schoolteachers and students, and 120,405 members of the general public. As a result of these interviews, 96 suspected cases of smallpox were reported; but although these reports were carefully investigated, not a single case was confirmed.

Brazil's Surveillance Network

To conduct epidemiologic surveillance activities, 21 epidemiologic surveillance units had been established in Brazil. These covered 22

TABLE 7--Notifications, investigations, and final diagnoses of cases in Brazil, by regions and major political divisions, 1971-1973.

Major political divisions	1971			1972			1973[a]		
	Suspect cases reported	Investigations	Laboratory examinations	Suspect cases reported	Investigations	Laboratory examinations	Suspect cases reported	Investigations	Laboratory examinations
Brazil (total)	450	444	320	718	718	375	131	131	97
North									
Rondônia	-	-	-	-	-	-	-	-	-
Acre	-	-	-	-	-	-	-	-	-
Amazonas	-	-	-	4	4	4	-	-	-
Roraima	-	-	-	-	-	-	-	-	1
Pará	-	-	-	5	5	5	-	-	-
Amapá	-	-	-	-	-	-	-	-	-
Northeast									
Maranhão	10	10	4	8	8	5	-	-	-
Piauí	2	2	2	30	30	7	5	5	-
Ceará	20	20	15	5	5	4	7	7	6
R. G. do Norte	-	-	-	-	-	1	3	3	-
Paraíba	1	1	-	5	5	3	-	-	-
Pernambuco	18	18	9	76	76	34	16	16	12
Alagoas	-	-	-	3	3	4	2	2	1
Fernando de Noronha	-	-	-	-	-	-	-	-	-
Sergipe	5	5	5	11	11	2	6	6	2
Bahia	22	16	18	59	59	26	11	11	8
Southeast									
Minais Gerais	32	32	24	39	39	50	14	14	10
Espírito Santo	31	31	27	19	19	33	4	4	4
Rio de Janeiro	26	26	18	48	48	26	9	9	4
Guanabara	35[b]	35[b]	25[b]	181	181	29	9	9	-
São Paulo	118	118	80	124	124	64	16	16	18
South									
Paraná	42	42	35	37	37	38	1	1	2
Sta. Catarina	9	9	6	13	13	7	11	11	8
R. G. do Sul	63	63	40	40	40	24	15	15	18
Center-West									
Mato Grosso	-	-	-	7	7	3	2	2	3
Goiás	11	11	10	4	4	6	-	-	-
D. Federal	5	5	2	-	-	-	-	-	-

- None.

[a] Provisional data through 30 June.

[b] Including 19 confirmed smallpox cases.

Source: Annual PAHO/WHO questionnaire of official reports from the countries.

states, four federal territories, and the District of Brasília; in addition, supporting subunits were set up where required. Also, a network of notification posts was established that by the end of 1973 included 6,362 posts in 3,542 of Brazil's 3,951 municipalities.

Brazil's Drive against Smallpox

The extraordinary effort made by the Government of Brazil to interrupt smallpox transmission in its territory deserves special attention. Each year it was necessary to invest an average of US$1.2 million in a campaign designed to vaccinate a population estimated in 1967 at 90 million inhabitants, distributed over an area of 8,500,000 km^2. In view of the negative results obtained previously by an identical campaign in Asia, many people doubted that Brazil would be able to attain the goal it has now achieved.

In particular, the ability and dedication of those reponsible for the smallpox eradication campaign in Brazil should be emphasized. The careful preparation of operations manuals, the meticulous logistics planning, and the activities carried out in the field—including vaccination, case detection, supervision of campaign activities, evaluation of the coverage achieved in

each area by the vaccinators, and confirmation of successful vaccination—represented a gigantic effort. This teamwork, with the single goal of eradicating smallpox in Brazil—flowed from the collaboration of everyone, from the directors and technical specialists to the auxiliary personnel of the Federal Government, states, and municipalities. It was not the product of any particular person, nor would it be just to consider it so. There is thus good reason for the Pan American Health Organization and the World Health Organization to be proud of having contributed with their technical staff and resources to accomplishing the goal finally attained on 19 April 1971.

Investigations in Zone VI

With the exception of Chile, which had been free of smallpox since 1959, special investigations were also undertaken in the countries of Zone VI (Argentina, Paraguay, and Uruguay).

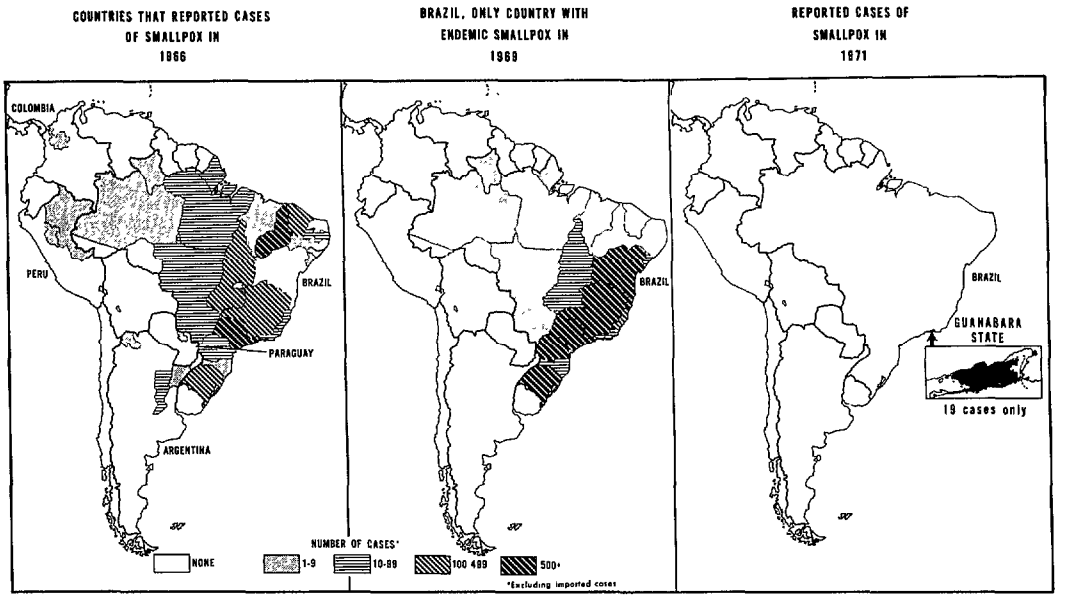
As previously noted, Argentina experienced an outbreak of 24 cases during 1970 in Misiones Province. This outbreak, caused by an imported case, constituted reintroduction of the disease after it had been absent for several years. In the wake of this outbreak, mass vaccination efforts succeeded in providing coverage for approximately 84.18 per cent of the area's 443,020 inhabitants. Since the vertical program of vaccination was not carried out on schedule, a special consultant was sent to Argentina in 1971 to evaluate the epidemiologic status of smallpox. This consultant and a national expert visited 14 localities and interviewed 86 persons among them the staff members of schools and health services in the cities of Buenos Aires, Corrientes, Posadas, and Santa Fe. Sixteen cases of chickenpox were detected by the survey, but not a single case of smallpox was found. Regular epidemiologic surveillance is currently performed by capable personnel of the Ministry of Health, who visit reported cases to determine whether or not the disease is present.

In Chile, thanks to the high level of collective immunity maintained by the regular health services' vaccination programs, smallpox has been eradicated for the last 20 years—with the sole exception of the single imported case reported in 1959. Between 1964 and 1970 an average of 1,300,000 persons per year were vaccinated in areas covered by health services.

In Paraguay, where the last five confirmed cases occurred in 1965, a PAHO/WHO technical expert working with nationals of the country conducted a special survey in 1971 of zones considered high-risk areas. These investigators covered 88 localities in six health regions, travelling a total of about 5,000 km. During this investigation, interviews were conducted with 39 physicians, 37 midwives, 4 health educators, 13 health inspectors, 13 statisticians, 19 nurses, and 19 local officials. In addition, 68 primary and secondary schools with a total of 9,253 students were visited, and 63 headmasters and 371 teachers were interviewed. Fifteen suspected cases were reported and 50 persons were examined, but the results were all negative for smallpox. In addition, another investigation was carried out at randomly selected schools and health centers throughout the country. Data were obtained from 206 schools with a total of 35,898 students and from 102 health units, but again all the suspected cases proved negative. Aside from these special investigations, maintenance vaccination and epidemiologic surveillance activities are currently conducted by the regular health services in each region.

In Uruguay there were only sporadic cases after 1963, all involving infection imported from Brazil. Uruguay has continued to use liquid vaccine for its vaccination program, despite provision by PAHO/WHO of freeze-drying equipment. However, as shown by the absence of indigenous cases, the level of protection conferred has been satisfactory. A sample survey carried out in nine departments found vaccination marks on 75.7 per cent of the 3,208 persons examined (the findings ranged from 55.5 per cent positive in the Department

FIGURE 2–Progress of the smallpox eradication program in the Americas 1966-1971.



of Artigas to 92.3 per cent positive in the Department of Treinta y Tres). Current epidemiologic surveillance is also considered satisfactory. Suspected cases are reported by telephone to help expedite diagnostic investigations and other health measures.

Conclusions

The foregoing account of activities begun in 1967, within the framework of the smallpox eradication program and with the assistance of PAHO/WHO, demonstrates that the proposed goal has been achieved and provides full justification for the investment of effort and resources in bolstering vertical and regular health service vaccination programs that are supported by epidemiologic surveillance (see Figure 2).

Now epidemiologic surveillance activity must be strengthened, provided with a dynamic structure, and staffed with appropriately trained personnel capable of remaining continually alert in order to detect any case that may reach the Americas from regions that are still infected. Only in this way will it be possible to preserve the success achieved at such great effort and expense.

The insufficient levels of maintenance vaccination currently observed in almost all the countries (Table 8) impose a heavy burden on surveillance services. The United States has been able to discontinue maintenance vaccination because it has an efficient and active health service with extensive technical and material resources. But countries that do not have such services and resources must continue to depend on maintenance vaccination of their susceptible populations, particularly those population groups directly exposed to infected regions of other continents, until eradication is complete in Africa and Asia–an event forecast for 1975. It is worth remembering that *variola major,* well-known for its great lethality, prevails in some countries of those regions.

When the goal of worldwide eradication is

TABLE 8--Vaccination against smallpox in the Americas, 1967-1972.

Countries	1967	1968	1969	1970	1971	1972[a]
Signatories of eradication agreements						
Argentina	1,808,302	323,952	2,141,000	11,008,850	1,544,943	843,668
Bolivia	1,141,991[a]	319,688	442,213	490,096	412,011	211,313
Brazil	17,983,660	21,405,830	25,850,711	37,325,209	18,010,098	13,882,924
Chile	1,556,506	1,520,315	1,304,379	1,150,194	941,529	747,252
Colombia	2,307,324	5,236,389	4,520,971	3,582,457	1,243,210	1,825,307
Cuba	113,489	90,745	114,995	119,507	101,302	17,964
Ecuador	508,247	1,113,741	931,492	945,831	755,649	277,402
Paraguay	167,358	183,098	214,053	337,764	328,761	357,278
Peru	2,222,055	1,676,853	2,195,052	2,630,726	2,118,210	2,419,276
Uruguay	299,269	502,937	442,531	545,696	361,234	173,554
Venezuela	1,502,099	1,592,740	1,378,671	1,119,235	869,078	786,023
Other countries and areas						
Antigua	...	...	...	618	...	1,073
Bahamas	4,141	2,223	2,530	3,029	4,984	5,522
Barbados	10,865	10,626	13,115	17,000	19,683	18,197
Belize	5,951	7,390	8,609	6,903	8,827	6,667
Bermuda	2,589	2,797	2,952	3,305	3,128	...
Canada	...	1,709,823	116,759[a]	...	883,214	...
Costa Rica	673,364	14,589	23,929	83,925	33,953	33,470
Dominica	2,412	2,490	3,797	3,177	2,861	...
Dominican Republic	108,642	8,716	8,728	14,789	11,698	1,274
El Salvador	274,207	78,932	248,957	285,143	283,028	291,886
Falkland Islands	...	155	...	...	...	...
French Guiana	...	...	...	5,181	5,243	...
Guadaloupe	5,457	...	...	...	18,039	15,909
Guatemala	437,576	226,803	...	...	...	134,416
Guyana	5,398	11,823	16,558	536,028	12,126	5,763
Haiti	338,024	446,506	458,868	...	175,729	274,608
Honduras	186,105	156,869	88,552	52,362	126,305	70,702
Jamaica	92,587	39,004	...	...	30,132	45,818
Martinique	7,084	8,536	...	...	18,668	...
Mexico	3,244,116	3,674,081	2,423,472	2,531,064	3,160,369	3,934,918
Netherlands Antilles	3,000	...	...	...	...	...
Nicaragua	93,503	52,233	82,488	...	...	77,390
Panama	42,153	44,935	7,610	70,813	59,493	56,995
Canal Zone	9,705	9,452	8,081	8,332	8,279	7,307
Puerto Rico	56,140	333,296	83,937	83,317	64,507	23,579
St. Kitts, Nevis, Anguilla	7,378	...	3,136	2,421	3,323	3,128
St. Lucia	...	96	...	...	...	462
St. Vincent	...	...	1,215	908	...	...
Surinam	...	...	...	...	12,676	24,667
United States of America	14,770,000	13,555,000	...	12,327,000	12,329,000	8,906,000
Virgin Islands (UK)	278	264	264	338	...	...

... Data not available.

[a] Provisional data.

Source: Annual PAHO/WHO questionnaires or official reports from the countries; in the case of the United States the figures were obtained from the United States Immunization Survey (1967-1972), Center for Disease Control, Atlanta, Georgia.

achieved, maintenance vaccination and even smallpox vaccine production may be discontinued, and the chapter on smallpox in the *International Health Regulations*, with all the obligations it entails, can be closed forever.

With this idea in mind, a number of countries in the Americas have forged the epidemiologic surveillance services originally designed for smallpox eradication into an infrastructure for control of other diseases—especially diseases preventable by vaccination, such as poliomyelitis and measles.

In this vein, possible cholera invasion of the Americas must also be considered, especially since this contingency requires sufficient preparation well in advance. For if "integration" is the watchword for the general field of public health, it should be even more so for those

working against communicable diseases, and especially those concerned with epidemiologic surveillance.

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In reviewing the success of the smallpox eradication program in the Americas, special mention should be made of the active and continuing participation by national authorities of Brazil, where the problem was extremely serious, and of the other countries that signed the agreement with PAHO/WHO. A great debt of gratitude is also owed to the participating professionals, technical personnel, and administrative employees at all levels. In addition, valuable services were provided by PAHO/WHO consultants working at the Smallpox Unit in Geneva, at PAHO Headquarters in Washington, D.C., and in the PAHO Zone Offices, who strove to provide the fullest possible support and assistance to the nations engaged in the eradication campaign.