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Annex 19

SMALLPOX ERADICATION PROGRAMME ¹

[A18/P&B/10 — 12 April 1965]

REPORT BY THE DIRECTOR-GENERAL

In conformity with the request made by the Seventeenth World Health Assembly in its resolution WHA17.43, paragraph 3 (1) and (3), the Director-General has the honour to present to the Eighteenth World Health Assembly a further report on the progress of the smallpox eradication programme.

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1. Introduction

In accordance with resolution WHA12.54 adopted by the Twelfth World Health Assembly, the World Health Organization, in concert with many Member States, has, since 1959, actively engaged in a worldwide programme of smallpox eradication. Since that time, substantial progress has been made in the control of the disease. In some areas, in fact, eradication has been achieved. However, full international participation in the eradication effort has not yet been attained. A number of countries whose smallpox programmes have been or are being successfully completed are in jeopardy of having the disease reintroduced. In a number of instances, the reintroduction or the threat of reintroduction of smallpox has already forced individual countries to repeat mass national vaccination campaigns.

This report summarizes the present status of smallpox and the eradication effort. Information is also

included pertaining to the supply and production of freeze-dried vaccine and the status of special research projects of concern to WHO and the programme as a whole. In addition, a summary² is included of the observations made by two consultants who were appointed to appraise the eradication efforts in four endemic countries, each of which was facing different problems in its eradication campaign. From their observations and experience, they have also given their views on the problems and difficulties besetting the general WHO smallpox eradication programme and on how these might be overcome.

Based on the views of the consultants and on the experience of the Secretariat gained over the past six years since the programme was established, it is clear that substantially increased effort and support are required if the programme is to achieve success within the foreseeable future.

¹ See resolution WHA18.38.

² Not reproduced in this volume.

2. Smallpox Incidence

World Incidence

Since the inception of the world-wide smallpox eradication programme in 1959, the reported annual incidence of the disease has varied between about 47 000 and 98 000 cases (Table 1). In 1964 the frequency of cases reached a record low level, according to provisional figures. These figures must, however, be interpreted cautiously since, in many countries, the reporting of cases and deaths is far from complete. The decrease in incidence may reflect the successful application of control measures but may also correspond in part with cyclical declines in incidence in endemic areas.

Bearing in mind the difficulties of making exact appraisals, it seems reasonable to conclude that since 1959 about twelve countries have succeeded in eradicating the disease either through national control programmes or as a result of definite eradication programmes. In 1963 however Peru, which had successfully eradicated the disease, again experienced extensive outbreaks which are still continuing.

Cases and deaths reported from 1959 to 1964 are shown by continent in Table 1. Most cases occurred in Asia and Africa. In Asia the annual number of cases has varied from about 34 000 to 75 000 during the past five years. In Africa the number has varied from about 12 000 to 25 000, and in the Americas from about 700 to 8000. Europe has recorded relatively little smallpox, none of an epidemic character; no cases occurred during 1964.

The percentage distribution of smallpox cases during 1959 to 1964 is shown in Table 2. Annually 60 to 78 per cent. of the world total is reported from Asia and 16 to 30 per cent. from Africa.

Smallpox Incidence in Individual Countries

In Table 3 are shown smallpox cases reported by individual countries for the years 1959 to 1964.

In Africa, most countries in East, West and South Africa have annually recorded substantial numbers of cases. Since 1959, nineteen countries have reported 500 or more cases during one or more years. They are Cameroon, Chad, Congo (Brazzaville), Dahomey, the Democratic Republic of the Congo, Ethiopia, Guinea, Ivory Coast, Liberia, Malawi, Mali, Niger, Nigeria, Swaziland, Togo, Uganda, the United Republic of Tanzania, Upper Volta, and Zambia. Trends in the disease incidence from country to country are not readily interpretable. In some, such as the Ivory Coast, a sharp decline followed an intensive mass vaccination programme. In others, however, declining frequencies may reflect recognized cyclical trends in the disease or, perhaps, variations in the adequacy

of disease reporting from year to year. In recent years, no endemic cases of smallpox have been reported from the North African countries—Algeria, Libya, Morocco, Tunisia or the United Arab Republic.

TABLE 1. SMALLPOX CASES AND DEATHS REPORTED, BY CONTINENT, 1959-1964

Continent		1959	1960	1961*	1962*	1963*	1964*
Africa . . .	C	15 671	16 127	24 182	24 837	16 723	12 362
	D	1 071	1 017	1 798	2 423	1 685	818
Americas . . .	C	4 899	5 531	8 168	7 860	6 430	716
	D	—	—	—	—	28	36
Asia	C	60 749	39 250	53 217	49 579	75 437	34 414
	D	15 781	9 639	13 081	12 287	23 660	9 008
Europe	C	15	47	27	137	129	—
	D	1	—	4	27	11	—
TOTALS:	C	81 334	60 955	85 594	82 413	98 719	47 492
	D	16 853	10 656	14 883	14 737	25 384	9 862

C = Cases; D = Deaths.

* Figures are provisional. Figures for 1964 are those available on 22 January 1965.

In the Americas, mass vaccination campaigns have served to eliminate endemic smallpox from most countries. In 1964, only Brazil, Colombia and Peru recorded significant disease foci. Brazil continues to report the great majority of cases and, although a vaccination programme was begun in 1962, the disease remains widely prevalent. Peru, having eradicated the disease in 1954, experienced a resurgence in 1963 in areas bordering Brazil. Uruguay and Argentina experienced three and twelve cases respectively in 1964, most of which were recorded as importations or secondary cases from neighbouring Brazil.

TABLE 2. PERCENTAGE GEOGRAPHICAL DISTRIBUTION OF SMALLPOX CASES, 1959-1964

	1959	1960	1961	1962	1963	1964
World Total . . .	100	100	100	100	100	100
Africa	19	27	28	30	16	26
Americas	6	9	10	10	6	2
Asia	75	64	62	60	78	72
Europe	0	0	0	0	0	—

— no case.
0 negligible number of cases.

In Asia, India, Indonesia and Pakistan together account for 90 per cent. of all cases reported, and over 60 per cent. of the world's total. In each of these countries the incidence declined during 1964. In India, the number of cases declined from 61 000 to 32 000; in Pakistan, from 5200 to 800; and in

TABLE 3. SMALLPOX CASES REPORTED BY INDIVIDUAL COUNTRIES, 1959-1964

	1959	1960	1961 *	1962 *	1963 *	1964 *
Africa						
Algeria	11	7	8	1	—	—
Angola	7	—	—	23 (3)	38(10)	1 (1)
Basutoland	1	—	83	52	—	—
Bechuanaland	5	22	16	4	—	174
Burundi	—	—	—	26	3	—
Cameroon	17	—	1 345	792	133	81
Central African Republic	—	1	—	57 (2)	3 (3)	—
Chad	34	4	273	1 157	10	5
Congo (Brazzaville)	—	—	22	1 313	1 515	196 (1)
Dahomey	1 708	768	119	124	228	703
Democratic Republic of the Congo	3 036	605	2 251+	3 785+	5 496+	2 302
Ethiopia	362+	293	761	360	232	103
Gabon	—	—	—	1 (1)	111 (§)	49
Gambia	3	7	12	4	52	6
Ghana	105	139	75	135 (5)	23	9
Guinea	441	176	96	2 948	224	300
Ivory Coast	784	1 634	4 656	2 066	219	11
Kenya	572	347	289 (1)	96	254	266
Liberia	591	...	1 119	323	57	128
Malawi	559	795	1 465	634	455	704
Mali	772	1 212	1 706	1 668	1 096	321
Mauritania	32	123	12	40	1	—
Mozambique	37	81	51	67	85	250
Niger	1 149	2 408	1 740	1 038	445	29
Nigeria	1 599	4 140	3 538	3 863	1 774	1 416
Portuguese Guinea	24	1	7	2	—	—
Ruanda Urundi ¹	77	17	18	—	—	—
Rwanda	—	—	—	30	—	—
Senegal	487	6	201	231	87	2
Sierra Leone	96	12	6	78	14	89
Somalia	94	2	—	—	—	—
South Africa	—	65	8	112	163	329 (6)
Southern Rhodesia	133	12	3	15	44	200
Spanish Equatorial Region	—	1	—	—	—	—
Sudan	517	135	104	70 (1)	26 (3)	—
Swaziland	—	—	—	—	182	517 (1)
Togo	66	347	281	572	274	21
Uganda	334	709	398	628	419	523
United Arab Republic	30	7 (7)	1 (1)	4 (4)	2 (2)	—
United Republic of Tanzania: Tanganyika	1 442	1 575	925	973	837	1 405
Upper Volta	368	126	2 360	1 335	339	8
Zambia	178	350	233	210	1 882	2 214
TOTALS	15 671	16 127	24 182	24 837	16 723	12 362
Americas						
Argentina	36	65	4	2 (1)	—	12 (10)
Bolivia	7	1	—	—	—	—
Brazil	2 804	3 017+	7 656+	7 589+	5 516+	306+
Canada	—	—	—	1 (1)	—	—
Chile	1 (1)	—	—	—	—	—
Colombia	867	209	16	41	4	21
Ecuador	1 184	2 185	491	205	45	—
Paraguay	—	35	—	—	—	—
Peru	—	—	—	—	865+	374
Uruguay	—	19	1 (1)	11 (2)	—	3 (3)
Venezuela	—	—	—	11	—	—
TOTALS	4 899	5 531	8 168	7 860	6 430	716

SMALLPOX CASES REPORTED BY INDIVIDUAL COUNTRIES, 1959-1964 (continued)

	1959	1960	1961*	1962*	1963*	1964*
Asia						
Aden: Colony	8 (6)	8	1 (1)	—	—	—
Protectorate	62 (10)	5	—	—	—	—
Afghanistan	441	111	174	303	571	157
Burma	1 533	392	88	21	10 (1)	28
Cambodia	4	—	1	—	—	—
Ceylon	—	—	34	12	**	—
India	45 939	31 058*	45 195	42 231	60 901	31 587
Indonesia	1 129	5 196	4 677	3 340	7 966	1 745
Iran	311	378	123	29 (5)	6 (2)	12 (6)
Iraq	23	—	—	—	—	—
Kuwait	10	—	—	1 (1)	—	—
Malaysia:						
Malaya	38	15	—	—	—	—
Singapore	10	—	—	—	—	—
Muscat and Oman	8	—	—	8 (1)	—	—
Nepal . . . . .	...	...	5	...	779	99+
Pakistan:						
East Pakistan	6 292*	1 086*	421 (1)	523	3 724	43
West Pakistan	3 261*	912*	2 321 (7)	3 091	1 475	738
Portuguese India	3	12	124	—	—	—
Qatar	1	—	1 (1)	—	—	—
Republic of Korea	—	13	1	—	—	—
Saudi Arabia	115	32	17	1 (1)	—	—
Thailand	1 548	32	33	2 (1)	—	—
Trucial Oman	—	—	—	17 (1)	—	—
Union of Soviet Socialist Republics (Asian region)	1	—	1	—	—	—
Viet-Nam	12	—	—	—	—	—
Yemen . . . . .	...	...	...	...	5+	5+
TOTALS	60 749	39 250	53 217	49 579	75 437	34 414
Europe						
Belgium	—	—	1 (1)	—	—	—
Eastern Germany	1 (1)	—	—	—	1 (1)	—
Federal Republic of Germany	13	—	5 (1)	38 (2)	—	—
Hungary	—	—	—	—	1	—
Poland	—	—	—	32 (29)	99 (1)	—
Spain	—	—	17 (1)	—	—	—
Sweden	—	—	—	—	27 (1)	—
Switzerland	—	—	—	1 (1)	1 (1)	—
Union of Soviet Socialist Republics (Moscow)	—	46 (1)	1 (1)	—	—	—
United Kingdom of Great Britain and Northern Ireland	1	1 (1)	3 (3)	66 (4)	—	—
TOTALS	15	47	27	137	129	—
WORLD TOTALS	81 334	60 955	85 594	82 413	98 719	47 492

Figures in brackets show the number of imported cases (e.g. 8 (6) means 8 cases, 6 of which were imported); (§) means several imported cases.

* Provisional figures. For 1964, situation according to reports received by WHO up to 22 January 1965.

— Nil.

** One suspected case; a suspected case was also reported from Niue in 1960.

+ Figures not complete.

... Data not available.

¹ Since July 1962 the independent States of Burundi and Rwanda.

TABLE 4. IMPORTED CASES OF SMALLPOX NOTIFIED TO WHO, 1 JANUARY-20 NOVEMBER 1964

	Imported cases	Secondary cases	Imported from	Other information
Africa				
Angola	1	—	Democratic Republic of the Congo	By land
Congo (Brazzaville)	1	?	Democratic Republic of the Congo	By river route
South Africa	6	16	Malawi	By land, probably
Swaziland	1	?	South Africa	By land
Americas				
Argentina	3	—	?	By land
	7	1	Brazil	By land
Uruguay	3	—	Brazil	By land
Asia				
Iran	5	—	an eastern neighbouring country	By land
	1	6	an eastern neighbouring country	By land

Indonesia, from 8000 to 1700. Although normal epidemic cycles and factors of reporting may partially underlie these decreases, it should be noted that in India about 70 per cent. of the entire population has recently been covered in a systematic vaccination programme. In East Pakistan, a mass campaign has been completed; over 3700 cases were reported in 1963 and only 43 cases in 1964.

In Afghanistan and Nepal, the number of cases recorded each year continues to vary between one and several hundred. In Burma, where a systematic vaccination programme is in progress, less than thirty cases have been recorded during each of the past three years. Yemen reported five cases in 1963 and in 1964. No cases were recorded in 1964 in Cambodia, Ceylon, Malaysia and Thailand which are in the maintenance phase of eradication.

No other Asian countries report endemic smallpox at present; cases in Iran during the past two years all originated directly from imported cases.

No countries in Europe report endemic smallpox.

Imported Cases

Table 4 shows the imported cases reported to WHO between 1 January and 20 November 1964. No cases were imported into Europe or Oceania; none of the importations into the other three continents was by air.

3. Research

Four research projects which WHO is supporting or in which it has a special interest deserve comment in this report:

A. *Studies of simultaneous and sequential vaccinations in persons being revaccinated*

With regard to the amendment proposed by the Committee on International Quarantine in its twelfth report,¹ studies were carried out to determine how frequently a repeat revaccination would be successful if carried out one week after an unsuccessful first attempt at revaccination, and whether two simultaneous revaccinations would give a better success rate than one. Studies have been or are being made in India and the United States of America, and by the medical service of the United Nations, in Geneva.

The preliminary results suggest that there is a slight but variable advantage when two insertions are made either simultaneously or a week apart. This is less evident when high potency vaccines are used.

B. *Vaccination by jet injector*

Studies of the effectiveness of jet injectors have been conducted in the United States of America and other countries. The United States studies show that the intradermal injection of 0.10 cc of 1:10 and 1:50

¹ See *Off. Rec. Wld Hlth Org.* 135, 46, and resolution WHA17.42.

dilutions of potent reconstituted freeze-dried vaccine produces results comparable to those obtained by the multiple pressure method in both primary vaccination and revaccination. Evaluation by United States teams working with local personnel under field conditions in Brazil and Tonga revealed success rates exceeding 95 per cent. for primary vaccination. Successful revaccination was as frequently accomplished with the jet injector as with the multiple pressure method. Similar success rates were achieved by both the United States teams and the local personnel.

Estimates of the cost and efficacy of mass campaigns employing jet injectors as compared with the door-to-door type of campaign using the multiple pressure method were carried out in Brazil in towns with populations varying from 1000 to 35 000. Though a higher proportion of the population was vaccinated by the door-to-door campaign employing multiple pressure, the proportion of successful vaccinations was lower and the final number of effective vaccinations was similar in both groups. In the door-to-door campaign using the multiple pressure method five times as many man-hours and vehicles were required; 75 vaccinations per man day were accomplished at a cost of US \$0.067 per vaccination. In the mass campaign using jet injectors, 304 vaccinations per man day were performed at a cost of US \$0.017 per vaccination.

There exists a pedal (foot-operated) jet injector (weight 12 pounds; cost US \$600) which is particularly suited to field campaigns. There also exist hand models, less expensive than the foot-operated models but slower in use, which are available and are suitable for small groups. Electrically driven models have been found to be cumbersome and more subject to mechanical failures.

The jet injectors are most efficiently employed when large groups can be assembled and vaccinated rapidly. In sparsely populated rural areas in which most of the vaccinators' time is spent in travelling, vaccine application by multiple pressure or scratch or by a hand-operated injector is more practical. Mechanical and manual means of vaccination both have a place in the eradication programmes. Studies in individual countries are required to define clearly how each method can be most effectively and economically employed under the local conditions.

C. *Variations in variola strains*

Although outbreaks of smallpox can usually be identified as variola major or variola minor by epidemiological and clinical observations, laboratory methods have now been developed which can differentiate between the two types of virus. In contrast

to variola minor strains, the strains of variola major have a high virulence for the chick embryo and produce lesions in the chorio-allantoic membrane or in tissue cultures at 38.5°C.

Strains isolated in Africa have shown intermediate laboratory characteristics. Although it has been assumed in the past that the lower case-fatality rate observed in Africa, as compared with Asia, is due to the presence of both variola major and variola minor strains, it is now thought possible that there may also be strains of intermediate virulence. Variola strains isolated in Africa are therefore being studied in the laboratory using temperature "markers" and other "markers" to differentiate them. If laboratory methods for clearly distinguishing strains can be established, combined field and laboratory studies will be set up to obtain further information on their distribution and importance.

D. *Chemoprophylaxis*

The activity of isatin- β -thiosemicarbazone ("Marboran") against vaccinia and variola infections in tissue cultures and laboratory animals has been known for a decade. Because of its low toxicity for animals and man and its high level of activity against vaccinia and variola viruses in the laboratory, a derivative—N-methyl-isatin- β -thiosemicarbazone—was used in prophylactic trials carried out against smallpox in Madras in 1963. Close contacts of established smallpox cases were selected and divided into two groups. Both groups were vaccinated but only one group received the prophylactic drug. In over 1100 household contacts given the drug by mouth, three mild cases of smallpox occurred. In the comparative group of contacts who did not receive the drug, there were seventy-eight cases of smallpox and twelve deaths. As treatment was begun on the day after the removal of the index case to the hospital it can be assumed that the drug was given about the middle of the incubation period, about six days after contact.

Untoward side-effects observed consisted principally of nausea and vomiting. These symptoms were occasionally severe.

Many chemical compounds showing sufficient antiviral activity to merit field trials have become available recently. In the first instance WHO was closely associated with these studies, but it was later decided that competent national authorities should be responsible for deciding which of the new agents were of sufficient promise for inclusion in trials. The role of the Organization is to co-ordinate the studies and to give expert advice to the national technical committees conducting the studies.

4. Eradication and Control Programmes — Country Reports

AFRICAN REGION

Eradication and control programmes in the smallpox endemic areas of Africa have as yet been few in number and have generally met with irregular success. Surveillance is limited, vaccine supplies are inadequate, and co-ordination as well as the development of effective, systematic programmes are needed. Principal emphasis is being given by WHO to the problem of increased production of freeze-dried vaccine and to the initiation and co-ordination of control and eradication efforts in the different countries. A full-time WHO medical officer has been appointed as adviser and co-ordinator for smallpox activities in West Africa, and a similar post has been created for an adviser for East Africa. To facilitate the development and expansion of vaccine production centres, consultant visits to Kenya and Nigeria have been arranged; plans are being made for regional production centres in West and East Africa; additional assistance is being provided in individual country programmes.

In Liberia a WHO-assisted smallpox eradication project has been in progress since 1962. A WHO medical officer was technical adviser until 1964, when he was transferred to other duties. The campaign was started in the capital and is being expanded to the surrounding areas. There are thirty field-workers, including vaccinators, recorders and supervisors. House-to-house visits are being carried out by mobile teams. So far only 100 000 vaccinations have been performed. Eighty-five per cent. coverage of the population was achieved in the areas visited by the teams. Primary vaccination success rates were over 95 per cent. Progress is slow due to the shortage of transport and field personnel. It is planned to combine this project with the yaws project which is also being assisted by WHO.

A similar project is in progress in Mali, where 800 000 vaccinations have been carried out during the past two years by mobile teams under the Division des Grandes Endémies. The campaign was conducted in the provinces adjoining Guinea and Upper Volta. There is a shortage of transport and refrigerators, but these deficiencies are now being met.

In Nigeria, Sierra Leone and Togo, smallpox control is being combined with yaws control projects. The areas covered and age-groups vaccinated in these joint programmes are, however, limited to those of the yaws programme. In Nigeria, where combined work with the WHO-assisted yaws project was started in 1961, 2 400 000 vaccinations were carried out in 1964. In Togo, a new plan of operation for the integration of yaws, leprosy and smallpox projects was set up with

the assistance of UNICEF and WHO in 1964. In Sierra Leone the yaws project, assisted by WHO, started to include smallpox vaccination in 1964.

In the Ivory Coast the attack phase of the national eradication programme has been completed and the maintenance phase has been started.

In Upper Volta the Government is preparing to launch a control campaign and a WHO medical officer assigned to the inter-country project will visit the country to discuss the proper plan of operations. Though vaccination is carried out in the other endemic countries many of them do not have systematic programmes.

REGION OF THE AMERICAS

Eradication and control programmes have been in progress over the past decade in many countries of the Americas. Most countries are now in the maintenance phase of the programme although Peru and other countries have been obliged again to institute systematic mass programmes because of actual or threatened reintroduction of the disease from residual endemic foci in neighbouring countries and elsewhere. Active surveillance machinery is urgently needed in a number of the countries.

In the principal endemic area, Brazil, a national campaign commenced in 1962 with the objective of vaccination of the total population within five years. In 1963 seven million were vaccinated in the states of Sergipe and Guanabara, and in Brasilia. Although the programme is continuing, additional support in the form of personnel and equipment will be needed if the original goal is to be met.

Satisfactory progress has been made in recent vaccination programmes in El Salvador, Guatemala, Haiti, and Honduras. These campaigns were carried out as part of the routine activities of their health services or as special campaigns.

In Argentina, financial difficulties have hampered the vigorous eradication campaign begun in 1960. Seventeen provinces were included in the vaccination programme, and up to the end of 1963 80 per cent. or more of the population had been vaccinated in eight of these provinces. The activities are now continuing in the other nine provinces.

In Bolivia, the national smallpox vaccination programme approved in 1962 was initiated in 1963 with the assistance of PAHO and WHO and the Expanded Programme of Technical Assistance, and is now under way. A health inspector appointed by PAHO and WHO to organize and conduct field activities assumed his post in mid-1963.

In Ecuador, the campaign which was begun in 1951 was interrupted temporarily on two occasions for

administrative and financial reasons. It was renewed in 1958 and was planned to end in 1964. Between 1958 and mid-1964, 3 600 000 persons (80 per cent. of the population) were vaccinated. Violent opposition to vaccination on the part of the Indian population was finally overcome thanks to the prudence and consideration shown by the vaccinators.

SOUTH-EAST ASIA REGION

At its sixteenth session the WHO Regional Committee for South-East Asia recommended that the attention of the World Health Assembly be drawn to the urgent need for supplies of freeze-dried smallpox vaccine and emphasized the necessity of promoting the synchronization of smallpox eradication activities in adjoining areas of countries where smallpox is endemic. At its seventeenth session, in 1964, governments expressed their determination to undertake intensive vaccination campaigns, utilizing freeze-dried vaccine whenever possible, with the objective of ultimately eliminating the disease from the Region.

Of the five countries in which endemic smallpox persists, four (Afghanistan, Burma, India and Nepal) are actively engaged in the development or conduct of systematic programmes, and two (Burma and India) have made substantial progress. Indonesia has undertaken emergency vaccination programmes. WHO has provided personnel, vaccine and equipment for the various projects; continued assistance will be required.

The WHO-assisted smallpox control pilot project in Afghanistan, which was started at the end of 1962 in Kabul City, has been completed with more than 80 per cent. of the city's population vaccinated. A plan of operation has been drawn up for a national eradication programme but has not yet been implemented. A WHO medical officer has been assigned to this project, and supplies of freeze-dried vaccine are being provided by WHO and the Union of Soviet Socialist Republics.

In Burma, preparatory to planning a country-wide eradication programme, pilot projects were started in Rangoon City and seven districts in 1963. The Government launched a national programme early in 1964, using existing basic health services and vaccination teams for mass campaigns in large cities and very remote areas. Freeze-dried smallpox vaccine is being supplied by the USSR and WHO. By the end of 1964 8 million of the total population of 24 million had been covered systematically, and it is expected that the whole population will be covered within the next two years.

In India, where a national smallpox eradication programme was started at the end of 1962, a total of 304 million vaccinations (about 70 per cent. of the

population) had been performed by the end of 1964; 35 million were primary vaccinations, and 269 million revaccinations. Work has been completed in 157 of the 313 districts. At the end of the year there were 150 eradication units in the field, each consisting of seventy-two vaccinators, twelve supervisors, two health educators, one paramedical officer (senior health inspector) and one medical officer. A total of 450 million doses of freeze-dried vaccine has been donated by the USSR following a bilateral agreement, and much of this has already been received. The requirements of the programme during 1964 exceeded the amount which could be delivered. As a result of an appeal by the Director-General of WHO, additional supplies of freeze-dried vaccine were obtained early in 1964 from the Netherlands, Switzerland and the United Kingdom.

Following the independent assessment of the programme in the Union Territory of Delhi, reported last year, the Indian National Institute of Communicable Diseases was entrusted with the assessment and evaluation of the programme at the end of the attack phase in several districts. They found that in none of the assessment areas had 80 per cent. or more of every sector of the population by age, sex and place of residence been covered in the campaign, and hence none of the districts qualified to enter the maintenance phase. They also noted considerable deficiencies in the primary vaccination coverage.

The attack phase of the national programme has now been extended up to the end of the third Five-Year Plan period, i.e. until March 1966, with the intention of vaccinating by then over 90 per cent. of all sections of the population.

In Indonesia emergency vaccination programmes were undertaken to control outbreaks of smallpox as they occurred during the year, mostly in West Java. A WHO consultant recommended additional equipment necessary for production of more freeze-dried vaccine.

In Nepal a pilot project, assisted by a WHO smallpox control officer, has been in progress since 1962. There is, however, both a shortage of transport and personnel and resistance of the population to vaccination. The project has been limited to the valley of Kathmandu, where 250 000 vaccinations were carried out from 1961 to 1964. The proportion vaccinated was low; of 820 000 persons checked only 30 per cent. had been vaccinated. In 1964 a WHO medical officer recommended that the efforts toward systematic coverage be intensified and that a greater effort be made in health education.

In Ceylon a satisfactory vaccination status is being maintained through the general health services.

In Thailand the country-wide vaccination campaign is being maintained by mobilizing various types of health personnel from basic health services, hospitals, and from yaws, leprosy, and maternal and child health programmes. No cases of smallpox were recorded in 1963 or 1964.

EASTERN MEDITERRANEAN REGION

For the principal endemic areas in Pakistan, an eradication programme has been under way since 1961 in East Pakistan and one will begin in 1965 in West Pakistan. A substantial programme is being completed in Sudan and a pilot project in Yemen.

In East Pakistan the programme was launched in November 1961 and by the end of November 1963 70 per cent. of a population of 51 million had been vaccinated. The whole population was covered by mid-1964. In West Pakistan an eradication campaign will begin this year. In Karachi smallpox is well under control.

In Sudan, the third phase of the smallpox eradication campaign started in late 1963 in the Northern Province, the northern part of Kassala Province (Red Sea) and the northern part of the Blue Nile Province. In the southern part of Kassala the campaign began in June 1964. By the middle of 1964 the eradication campaign had covered a total of seven million persons. A consultant visited Sudan in March and April 1964 to evaluate smallpox eradication activities in the country. Although vaccination of the nomad population was difficult, he stressed that the campaign should continue. Shortage of personnel is affecting the maintenance phase.

In Yemen mass vaccination, preceded by intensive efforts at health education, was carried out in a pilot campaign in Hodeida where stationary and mobile teams were organized and about 15 000 persons had been vaccinated by the end of 1963. A systematic vaccination programme has not yet developed.

In Saudi Arabia the Government is preparing the smallpox eradication programme. A law was promulgated making smallpox vaccination compulsory and the allocation covering the commitments of the Government for the implementation of the eradication project has been approved.

In Somalia a consultant is being provided by WHO to visit the country to organize a smallpox eradication scheme.

WHO has assisted the programmes by providing technical advice, transport, refrigerators, vaccine and training. Additional assistance in these areas and in the development of surveillance programmes is needed.

Other programmes are in various stages of development.

WESTERN PACIFIC REGION

Though countries in the Region have remained free of smallpox during the past year, governments recognize the possible danger of introduction of the infection from areas still infected and are continuing their efforts to maintain an effective degree of immunization. Cambodia has continued its combined yaws and smallpox campaign effectively and the Philippines has embarked on an intensified vaccination campaign, importing a quantity of freeze-dried vaccine to supplement the locally produced vaccine.

5. Vaccine Supply

Substantial amounts of vaccine are required during the attack phase of the eradication programmes. The routine requirements of the maintenance phase are less. In general WHO policy has been to assist endemic countries in developing sufficient production capacity to meet the routine requirements of their maintenance programmes but, where necessary, to obtain from outside sources the additional amounts needed for the initial mass campaigns.

Considerable assistance has already been given by WHO and PAHO to develop vaccine production facilities in many countries in the Americas. In this Region, production capacity is sufficient to meet anticipated requirements of attack and maintenance phases.

In Asia substantial aid has been provided by UNICEF and WHO. Currently, assistance is being provided to Burma, India, Indonesia and Thailand in obtaining equipment for freeze-dried vaccine production and in training personnel. Similar assistance has been requested by China (Taiwan), Guinea, Kenya, Nigeria, the Philippines and others. Good progress has been made in Burma, India, Indonesia and Thailand, where modern equipment has now been supplied and staff have been or are being trained. Numerous visits have been made by consultants to advise in the setting up and operation of equipment and the production of vaccine. It is probable that these countries will shortly be able to meet their routine maintenance phase requirements.

The situation is less far advanced in Africa and (as already mentioned in section 4 above) negotiations are proceeding for the establishment of two centres capable of producing vaccine for distribution to countries on a regional basis, one in West Africa, possibly in Nigeria, and one in East Africa, possibly in Kenya.

The Organization has arranged for the vaccines from newly established laboratories to be tested by independent biological control laboratories and up to

the present the quality of the vaccines has, on the whole, been satisfactory. It is recognized, however, that it will be necessary to continue to have the vaccines tested routinely if their high quality is to be maintained.

Vaccine Donations

The amounts of freeze-dried vaccine supplied through WHO in 1961, 1962 and 1963 were as follows:

	Doses
1961	1 740 000
1962	3 140 000
1963	7 300 000

The amounts had been increasing rapidly, reflecting the activities of the projects under way. Late in 1963 the stock of donated vaccine was almost exhausted, but following the urgent appeals at the end of 1963 for 30 000 000 doses of vaccine to continue programmes, as mentioned in the report on the smallpox eradication programme made to the Seventeenth World Health Assembly,¹ 9 875 000 doses were received—1 000 000 doses from the Netherlands, 250 000 doses from Madagascar and 4 625 000 doses from Switzerland, as well as the 4 000 000 doses from the United Kingdom already mentioned in that report. During 1964 also, 3 500 000 doses were received from the USSR as a final instalment of their donation of 25 000 000 doses. Other offers have been made by Bulgaria, Cambodia, Chile, Colombia, France, Japan, Pakistan, Peru, Tunisia, the United Arab Republic and Yugoslavia. The position about these is shown below:

	Donations	Doses
Results of tests unsatisfactory	5	4 300 000
Samples still being tested	2	3 300 000
Samples requested but not received	1	1 000 000
Correspondence in progress on various points	3	700 000
Total	11	9 300 000

It is to be noted that no vaccine has yet been distributed from these recent offers and that about half is already known not to reach the sterility, potency or stability standards recommended by the WHO Study Group on Requirements for Smallpox Vaccine.²

The total amounts of vaccine distributed by the Organization in 1964 and up to March in 1965 were as follows:

1964

	Doses
<i>Africa</i>	
Congo (Brazzaville)	10 000
Liberia	100 000
Senegal	50 000
Sierra Leone	50 000
Togo	200 000
Upper Volta	450 000
<i>South-East Asia</i>	
Afghanistan	1 020 000
Burma	1 500 000
India	7 225 000
Nepal	200 000
<i>Eastern Mediterranean</i>	
Sudan	1 350 000
Yemen	250 000
	<hr/>
	12 405 000

1965 (January to March)

<i>Africa</i>	
Mali	250 000
<i>South-East Asia</i>	
India	600 000
	<hr/>
	850 000
	<hr/>
Total	13 255 000

Apart from these donations, the USSR has supplied about 400 000 000 doses to Afghanistan, Burma and India on a bilateral basis in the past three years.

6. The WHO Smallpox Eradication Programme

A WHO Expert Committee on Smallpox met in Geneva in January 1964 and its report which has since been published³ was summarized in the Director-General's report on the smallpox eradication programme to the Seventeenth World Health Assembly.⁴

The Committee stressed that the eradication of smallpox should be a matter of concern to all countries and that those now free from infection were at constant risk of the disease being introduced from the endemic areas. As a result of its review of the WHO eradication programme it concluded that the non-endemic countries could best aid the endemic countries to carry out effective programmes by providing adequate amounts of stable freeze-dried vaccine which could be distributed and stored in tropical countries without loss of potency. It recommended that programmes should be planned and carried out in three distinct phases—preparatory, attack and maintenance.

¹ *Off. Rec. Wld Hlth Org.*, 135, Annex 11.

² *Wld Hlth Org. techn. Rep. Ser.*, 1959, 180.

³ *Wld Hlth Org. techn. Rep. Ser.*, 1964, 283.

⁴ *Off. Rec. Wld Hlth Org.* 135, Annex 11, section 4.

The target in the attack phase should be the vaccination of the whole population of the country. Experience had shown that even when 80 per cent. of the total population had been vaccinated there were often groups, e.g. infants under one year of age, and men working at a distance from home, where the coverage was as low as 30 per cent.

Though the Committee was confident that the programme of the Organization would result in the ultimate eradication of the disease, it stated that sustained effort over a period of years would be required before success was achieved. It drew attention to the importance of the maintenance phase and the need for adequate measures for the notification of cases and deaths, especially in the maintenance phase, since without this there could be no assurance that the disease had been eradicated.

To assist the Organization in evaluating the current status of the eradication programme two consultants were appointed late in 1964 to obtain first-hand information on eradication and control programmes in four countries, considered to be representative of conditions in Africa and Asia. The consultants, with a medical officer of the Secretariat, visited these countries and made detailed reports on each. Summaries of the reports, in which the countries are identified as A, B, C and D, are attached.¹ It is clear that in all four countries the programmes were unsatisfactory in a number of respects, and that in three of them the programmes are unlikely to succeed unless considerably changed.

From their observations in the four countries, their experience in administration and epidemiology, and their special knowledge of smallpox they have made the following observations applicable to the WHO smallpox eradication programme as a whole:

1. In many of the endemic countries, though not in all, health problems other than smallpox are considered of greater immediate importance and the claims for funds for smallpox eradication programmes have to compete with claims for programmes for other diseases. In many of the endemic countries the health services are short of staff and lack facilities for preventive and curative medicine. They often have inadequate epidemiological surveillance and this leads to the widespread dissemination of infection before smallpox outbreaks are recognized and before such control measures as may be available can be applied.
2. Of fundamental importance in national eradication programmes is the need for, and frequent lack of, an adequate administrative and supervisory structure

covering all levels from the central health authority to the periphery. The absence of this has been responsible for much wasted labour and expenditure and at times for the failure of campaigns. Many of the defects and deficiencies observed could be traced to the lack of effective administration and supervision. They included storage of vaccine for long periods at room temperature, the use of time-expired vaccine, the employment of poor vaccination techniques, failure of team supervisors to check success rates, absence of simple but effective recording systems, and absence of facilities to analyse at regional or central level the information obtained by the teams.

3. Even if increased national resources are allocated to smallpox programmes the endemic countries will not be able to carry out effective programmes without help—on a scale far greater than has hitherto been provided—from the countries which are no longer endemic. Supplies of freeze-dried vaccine in very large amounts are needed, also transport for vaccinators, refrigerators, equipment for the production of freeze-dried vaccine on a national or regional basis, and short- and long-term consultant services to endemic countries for help in planning and execution of the campaigns. The speed at which initial control and ultimate eradication will be accomplished will depend on how much practical help is given by the countries already free from the disease.

4. To achieve eradication, the maintenance phase (i.e. the routine vaccination and revaccination of the population and the surveillance of possible cases) is as important as the attack phase. It must be taken into account in the plan and diligently carried out for many years. Failure to do so will mean that smallpox will again occur in areas which have remained free after completing a well-planned attack. This is shown by experience in Peru, where no cases were reported for eight years after an intensive campaign completed in 1954, but where 860 cases were reported in 1963 and 370 cases in 1964.

5. In all endemic countries pilot projects should be set up and the experience gained in the pilot projects should be used in the planning of the main campaign. Flexibility is important and should take into account the stage of development of the health services, since this will to a large extent determine whether the campaign will have to be carried out by special teams or by supplementing already existing health services.

6. The proportion of the population covered and the success rates must be carefully checked and the campaign currently evaluated by an independent team directly responsible to the senior medical officer in charge of the campaign.

¹ Not reproduced in this volume.

7. A heat-stable freeze-dried vaccine that can be stored for at least one month at ambient temperatures without any loss of potency is essential for campaigns in the tropics.

8. It is highly desirable that contiguous endemic countries should start mass vaccination campaigns simultaneously, particularly when there is free population movement over the borders. Such co-ordinated effort gives a greater degree of success over a shorter period of time than can otherwise be obtained and could lead to a substantial reduction in the duration of the maintenance phase. However, the absence of synchronization should not deter individual countries from launching national eradication campaigns, because adequate vaccination and revaccination of the population will remove the risk of epidemics even though single cases or small outbreaks may occasionally occur.

7. Needs of the Programmes

With smallpox eradication and control activities at different stages of development in the different regions and in different countries, consideration of the present status and needs of the programme by regions, and by countries within regions, is most appropriate.

Africa

Smallpox is currently endemic throughout most countries of East, West, Central and South Africa. Eradication and control programmes have been few and incomplete.

In virtually all countries programmes for the systematic vaccination and maintenance operations must yet be evolved.

In the Ivory Coast the attack phase is reported to have been completed but very active maintenance phase operations will have to be conducted, since smallpox is endemic in the surrounding countries. A limited systematic vaccination programme has been started in Liberia and a similar plan has been developed for Mali. However, both will demand substantial continued assistance of all types if they are to be successful. Vaccination programmes in conjunction with yaws projects in Nigeria, Sierra Leone and Togo, although serving as control measures, cannot be expected to effect eradication. Vaccination programmes in other African countries need systematic development and must be expanded substantially to be fully effective.

Most vaccine for the attack and maintenance phases will have to be provided from sources outside Africa; regional vaccine production laboratories must be developed or expanded to meet maintenance needs.

Since basic health services throughout Africa are limited, substantially greater assistance in the form of technical personnel, transport and equipment will have to be provided in Africa than in the other continents, not only for the attack phase, but also for the maintenance aspects of the programme. Pilot projects to explore the most effective means of conducting systematic vaccination programmes and surveillance are needed. The possible use of jet injectors in these programmes should be considered.

The problems in achieving smallpox eradication in Africa are formidable. Intensive study of possible approaches should be promptly initiated. Eradication programmes, when initiated, must take into consideration the mobility of the population and thus should be developed on a multi-country co-ordinated basis wherever possible. With substantial assistance from outside the countries and an active interest on the part of the countries themselves, eradication of the disease by the end of 1974 is a conceivable target.

Americas

With eradication programmes completed or in progress in all countries in the Americas, the prospects for hemisphere-wide eradication are excellent.

Endemic smallpox is currently prevalent only in Brazil (population 80 million) and in limited areas of Peru and Colombia. For completion of the attack phase of the programme, it is necessary to complete the vaccination programme in Brazil and to vaccinate systematically portions of the population of Peru and Colombia. More adequate continuing vaccination schemes must be evolved in a number of additional non-endemic areas and adequate continuing surveillance programmes established throughout the Americas.

Vaccine supplies from established national facilities are adequate for both attack and maintenance aspects of the programme; consultative assistance and testing of the vaccines produced are required since some do not presently meet minimum standards of potency, safety and stability. Substantial additional transport and equipment are necessary for the Brazilian programme to ensure its early completion; more limited quantities of transport and supplies are needed for programmes in several other South American countries for completion of the attack phase and adequate coverage of the population during the maintenance programme. It is also necessary to assign to Brazil for three to four years expert personnel in addition to the personnel at present in the country, and to arrange for the other countries to obtain expert advice on the establishment of adequate maintenance phase programmes and effective surveillance.

With immediate forceful action on the part of WHO and the individual countries, endemic smallpox could be eliminated from the hemisphere before the end of 1968.

South-East Asia and Eastern Mediterranean

In five of the seven remaining endemic countries in South-East Asia and the Eastern Mediterranean (Afghanistan, Burma, India, Nepal and Pakistan), eradication programmes are in progress or are being developed. In Burma, India and East Pakistan, considerable progress has been made. In most other countries in these regions maintenance operations of some type are in progress. In Burma, India and Pakistan the prospects for eradication of smallpox are good. In Afghanistan, Nepal and Yemen successful eradication poses more of a problem, but is reasonably attainable. In Indonesia, where mainly emergency programmes are being conducted, eradication in the immediate future is not probable.

In India 70 per cent. of a population of 438 million has been vaccinated since 1962. The major part of the vaccine has been supplied by the USSR; adequate vaccine for maintenance vaccination should be available from national production facilities within two years. Personnel and transport are thought to be adequate to complete the attack phase by 1966.

In Burma 8 million of the population of 24 million have been vaccinated; completion of the programme by 1966 is intended. The vaccine has been supplied principally by the USSR; production facilities are being developed. Transport and personnel are being provided through the routine basic health services.

In East Pakistan a mass vaccination programme has been completed among a population of 51 million. Plans are being developed for a similar mass campaign in West Pakistan among a population of 43 million. Vaccine supplies for both the attack and maintenance phases are available from national production laboratories.

In Nepal (population 9 million), Afghanistan (population 15 million) and Yemen (population 5 million), pilot programmes have been conducted but the development of a systematic vaccination effort awaits additional personnel, transport and equipment. Vaccine for these areas must be supplied from outside the respective countries for both the attack and maintenance phases. Although vaccine supplies for the attack phase of the programme in Indonesia are adequate, such a programme has not yet been implemented.

In summary, vaccine has to be supplied to all countries except Pakistan for the attack phase of the programme, and to Yemen, Nepal and Afghanistan

for maintenance vaccination. It is understood that the needs for the attack phases in India, Burma and Afghanistan will probably be met by direct bilateral arrangements between these countries and the USSR. Moderately substantial quantities of transport and equipment will be required for all programmes except those in India and Burma. Supplementary technical personnel are required from outside the country in Nepal, Yemen, Afghanistan, and possibly Pakistan, if effective programmes are to be conducted. Consultative assistance is required by all countries in this area to assure continuation of effective maintenance programmes and surveillance.

If substantial support is provided promptly to assist the programmes in these regions, smallpox could conceivably be eliminated from all areas from which we have information about the existence of the disease by 1970.

General Cost Estimates

In the Director-General's report to the Twelfth World Health Assembly, in 1959,¹ it was stated that the estimated average cost per vaccination was US \$0.08 in Colombia, \$0.07 in Ecuador, \$0.08 in Iran, \$0.10 in Peru, \$0.10 in the Philippines, \$0.08 in the Republic of Korea, \$0.075 in Thailand, and \$0.11 in Venezuela.

In India, where an intensive systematic vaccination programme is now under way, it is estimated that vaccination costs roughly US \$0.084 per person. This cost includes the salaries, subsistence and travel expenses of field personnel, and the cost of vaccine, gasoline and maintenance of vehicles. It is roughly made up as follows—70 per cent. for personnel and travel, 15 per cent. for vaccine, 10 per cent. for transport, and 5 per cent. for miscellaneous expenses.

The translation of the estimate of about US \$0.1 per vaccination into realistic costs of a global eradication programme is difficult, but an attempt has been made to give a general approximation for each of the three main endemic regions. If the programme in the Americas and Asia were to be intensified sufficiently to complete the attack phase within five years it may be estimated that about half of the total population of endemic areas in South America and Asia would have to be vaccinated or revaccinated. The total to be vaccinated would be about 50 million in South America and 350 million in Asia. The cost would be in the region of US \$40 million. It would probably be reasonable to calculate that 80 to 90 per cent. of the costs of the attack phases in the Americas and 70 to 80 per cent. of those costs in Asia could be met from national sources. The amounts required from abroad

¹ *Off. Rec. Wld Hlth Org.* 95, Annex 18.

would therefore be in the range of US \$7.5 million to US \$11 million.

There is every reason to suppose that the costs of the maintenance phase could in large part be met by the countries themselves except for a few small countries in which health services are not yet adequately developed.

The problem of costing in Africa is much more complicated because fewer programmes have yet been developed. The state of development of the health services in many of the African countries limits the speed with which the attack phase can be mounted and will necessitate greater expenditure for the maintenance phase after the attack phase has been completed.

In the present state of knowledge it would be unrealistic to forecast the eradication of smallpox from the whole of Africa before the end of 1974, and unless large synchronized regional programmes can be developed it is probable that vaccination of total national populations may have to be repeated more than once in the course of the general campaign.

Taking into account the fact that the whole of the present population in endemic areas (approximately 200 million) may have to be vaccinated twice in systematic campaigns, the total estimated cost would be US \$40 million. Of this sum, perhaps 40 to 50 per cent. (approximately US \$16 million to US \$20 million) might have to come from outside sources.

8. Conclusions

The smallpox eradication programme will not achieve its objective in the foreseeable future unless it is given a very much greater measure of support than it has received in the past from the governments of the endemic countries, from the smallpox-free countries, and from the international agencies.

It is considered that the following steps are necessary to assure the success of the programme:

1. Additional technical personnel will have to be provided at national and international levels to improve the necessary consultative services for planning and development of national programmes; to ensure the effective functioning of vaccine production laboratories; to advise on the establishment of independent evaluation teams; and to organize adequate surveillance methods.

2. An adequate administrative and supervisory structure must be established for the execution of eradication campaigns as these are set up in the endemic countries.

3. Greater quantities of potent, heat-stable freeze-dried vaccine must be donated by the non-endemic countries to meet the needs of the attack phases of the eradication programmes. (The annual requirements will depend on the speed of development of individual programmes, but may be expected to range from 20 to 50 million doses.)

4. The development of freeze-dried vaccine production in the endemic countries must be accelerated with immediate regard to the needs for Africa.

5. Stronger emphasis will have to be placed on the necessity for all production laboratories to conform to the WHO requirements for the safety and potency of vaccines. This can be facilitated by the provision of means for the independent examination of batches of vaccine from laboratories in countries where national biological control examination is not available.

6. Suitable transport, refrigeration and other equipment must be provided to the endemic countries in adequate quantities and adequately serviced.

7. Training of field and laboratory personnel at the national level must be further promoted.

8. In countries which have recently completed the attack phase there must be established an effective system for the routine vaccination and revaccination of the population, for case findings and diagnosis and for the investigation and control of outbreaks.

9. Research must be carried out on the use of jet injectors of different types and in different environments. Studies of the epidemiology and the immunology of smallpox are also required.

For the coming year, it is proposed that particular emphasis be placed on:

- (1) The acceleration of the development of adequate vaccine production facilities in Asia and the development and expansion of production in Africa.

- (2) Acceleration of the eradication programme in the Americas and Asia, where substantial progress has already been made.

- (3) Intensification of the programmes in African countries which have already set up eradication schemes, and the establishment of pilot projects to explore the most effective methods to accomplish eradication in the countries which do not yet have programmes.

It is essential that the endemic countries should pay attention to the development of sound schemes of smallpox eradication based on a knowledge of the epidemiological situation and the structure of health

services. The schemes should be properly costed and phased in accordance with the medical and other resources which can be made available. The non-endemic countries must provide either in kind or in cash the very large quantities of vaccine, equipment, transport, and other support necessary for the pro-

grammes. Such provision will be of direct value to those countries since vaccination and revaccination of the population, the application of quarantine services, and the control of outbreaks when they occur will continue indefinitely so long as smallpox occurs in any part of the world.