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DEVELOPMENT OF THE SMALLPOX ERADICATION PROGRAMME

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## INTRODUCTION

A global programme for smallpox eradication was first launched by the Eleventh World Health Assembly in 1958<sup>1</sup> and programmes in a number of countries developed soon after. Although some progress was made, many countries in which the disease is endemic lacked the necessary resources, particularly transport and vaccine, to implement an effective programme.

Recognizing the need for additional resources and the importance of a co-ordinated global attack on the problem, the Nineteenth World Health Assembly<sup>2</sup> decided that the "participation of the Organization in the smallpox eradication programme should be financed from the regular budget" and "urged countries which plan to strengthen or initiate smallpox eradication programmes to take the necessary steps to begin the work as soon as possible". In view of the importance of the threat of smallpox to countries in which the disease is not endemic, additional support from bilateral and other multilateral sources was requested. A total of \$ 2 674 403 has been allocated in the WHO regular budget for the 1967 programme and \$ 2 820 439 is proposed to continue and intensify the programme in 1968.

In compliance with the resolution, the requisite detailed programme planning and other preparatory work has been initiated in consultation with the governments concerned to permit the Organization to utilize the funds approved in the best possible manner.

This report, requested in resolution WHA19.16, presents the current status of programme plans for 1967 and 1968 in the context of the present smallpox problem.

### I. THE STATUS OF SMALLPOX AND PROGRAMME DEVELOPMENT

The reported incidence of smallpox in 1966, according to provisional figures was approximately that observed in 1965. During 1966, 63 946 cases were reported compared with 62 685 cases for 1965 and 49 956 for 1964. The numbers of cases by continent are shown in Table 1 and by WHO region in Table 2.

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<sup>1</sup> Resolution WHA11.54, Handbook of Resolutions and Decisions, 8th ed., p. 48.

<sup>2</sup> Resolution WHA19.16, Off. Rec. Wld Hlth Org., 151, 8-9.

Endemic regions persist in South-East Asia, Africa south of the Sahara and several countries in South America. Europe, North and Central America and the Western Pacific Region continue to be non-endemic areas.

In 1966 and early 1967, a number of countries reported cases and outbreaks resulting from imported infection. Reported episodes include, during 1966, the occurrence of seven cases in Sarawak, after almost four decades of freedom from the disease, and 71 cases in the United Kingdom of Great Britain and Northern Ireland. During the first three months of 1967, there were three separate importations of smallpox into Europe and one into the Trucial States. The infected individuals in each instance came from India. Two of the three cases in Europe occurred in the Federal Republic of Germany; following these introductions, almost 50 000 persons were vaccinated and over 100 contacts isolated. The third case occurred in Czechoslovakia, the first case of smallpox in that country since 1925. No secondary cases resulted.

## 1. African Region

### 1.1 Smallpox incidence and status of activity

Smallpox continues to be a problem in most countries of Africa south of the Sahara (Tables 3 and 4) although, as in other parts of the world, reporting is often incomplete, making it difficult to obtain a precise assessment of the problem. Three general areas, two in West Africa and one in East Africa, account for the majority of cases. Countries included in these three foci are, respectively: (a) Nigeria, Niger, Dahomey and Togo; (b) Sierra Leone, Mali and Guinea; (c) United Republic of Tanzania, Democratic Republic of the Congo, Uganda, Burundi and Malawi.

In all African countries, vaccination programmes of a greater or lesser degree of intensity have been carried out for many years by mobile teams and through other health services. Rarely, however, have the programmes involved systematic geographical coverage of the population; frequently, glycerinated-type vaccine of low potency has been used. Despite these deficiencies, smallpox incidence has been reduced in several countries to the point where only occasional outbreaks resulting from imported cases now occur.

## 1.2 Programme development

Two WHO inter-country advisers, one for West Africa and one for East Africa, began work in 1965. They have visited most of the countries in their respective areas to review the current smallpox situation and to assist governments in the development of operational plans, including particularly those aspects dealing with surveillance and assessment mechanisms. During the coming years, they will continue to assist in the development and institution of programmes and will serve to provide co-ordination between campaigns in the various countries.

It is expected that, in 1967, 24 African countries will be actively participating in the smallpox eradication programme with WHO and/or bilateral assistance (Tables 3 and 4). The United States of America has offered material and technical assistance to 19 West and Central African countries for smallpox eradication and measles control. Over 40 technical staff from the United States of America will be involved in these programmes; in most countries, vaccinations will be performed with jet injectors. This programme is being closely co-ordinated with WHO efforts in these and other African countries. A WHO medical officer assigned to Mali to assist in smallpox eradication activities will continue in this assignment, working closely with those concerned with the bilateral programme. A plan of operations concerning WHO technical and material support for pilot programmes of smallpox eradication and BCG vaccination in the Democratic Republic of the Congo has been approved. Recruitment and procurement have commenced. The programme will be initiated in three provinces in 1967 and expanded to a full-scale three-year effort beginning in 1968. Plans for WHO-assisted eradication programmes are also being developed in Kenya, the United Republic of Tanzania and Zambia. Additional assistance in the form of vaccine supplies is being provided to Zambia during 1967 by the USSR and to Uganda by UNICEF.

## 2. South-East Asia Region

### 2.1 Smallpox incidence and status of activity

Of the cases reported during 1966 throughout the world, over 75 per cent. were reported by countries in the South-East Asia Region. Afghanistan, India, Indonesia and Nepal continue to be principal endemic areas (Table 5). Burma, which initiated

an eradication programme in 1962, has effected a remarkable reduction in cases and, during 1966, reported only one case. Vaccine for this programme was provided partly by USSR bilateral donations and partly by vaccine donations through WHO. Neither Thailand nor Ceylon has recorded indigenous cases for over three years.

In Afghanistan, where a WHO medical officer is assisting in an eradication programme, almost 4.0 million vaccinations have been carried out since October 1965. Vaccine for this programme has been provided mainly by the USSR. More than a quarter of the provinces, mainly located in the south-west and eastern part of the country, are reported to have been covered by the programme. Seventy-two cases were reported during 1966, in contrast to 71 cases in 1965 and 157 cases in the preceding year. Reporting mechanisms, however, are not yet well developed so that, in fact, the actual numbers of cases are undoubtedly greater than those recorded.

India, which started a national smallpox eradication programme in 1962, reported that about 500 million vaccinations had been carried out up to the end of 1966. Until mid-1966, there was a progressive decline in the number of smallpox cases. During the autumn and winter, however, the incidence of smallpox rose progressively and, during the early months of 1967, sharp increases have been noted in several provinces. The number of cases recorded during 1966 was actually higher than that recorded in 1965. Present trends suggest a further increase during 1967.

From the results of field assessment, it is apparent that vaccination coverage is generally inadequate in the younger age-groups; satisfactory coverage of migrant and "floating" populations has been achieved in comparatively few areas. Most cases are occurring among unvaccinated children and among those vaccinated many years previously. Floating and migrant populations account for a large proportion of the cases.

The programme has so far been carried out by 150 mobile eradication units, each consisting of 70 field personnel, but the integration of programme activities into the structure of the basic health services is now being considered. An extensive reassessment and reappraisal of the present programme is required. Over 500 million doses of freeze-dried smallpox vaccine have been provided to the programme by the USSR.

Indonesia is conducting vaccination activities in conjunction with existing health programmes and as a containment measure during outbreaks, but has not yet instituted a systematic programme. A highly successful pilot project encompassing a population of 500 000 persons was conducted in West Java. This will serve as a model for future eradication efforts. Plans for a systematic programme are now under study and may be initiated during 1968. During 1966, 10 113 cases were reported, compared with 13 326 cases in 1965 and 1874 in 1964. This increase in cases in 1965 and 1966 may partly reflect an improved reporting system.

In Nepal, a pilot eradication project was started in 1962. Vaccination activities were originally limited to the Katmandu Valley, but recently the programme has been expanded by incorporating panchayat workers throughout the country. Since 1962, over 800 000 vaccinations have been carried out, mainly in the Katmandu Valley and in the eastern part of the country. The necessary vaccine was provided by donation through WHO. During 1966, 385 cases were reported from Nepal, as compared with somewhat less than 100 cases during each of the preceding two years. As in the instance of Afghanistan, reporting of cases, although improving, is still incomplete.

## 2.2 Programme development

During December 1966, representatives from each of the countries met in Delhi at a meeting sponsored by the WHO Regional Office, to discuss the status and development of eradication efforts throughout the Region. Special WHO consultants visited Afghanistan, India and Nepal to appraise present smallpox eradication activities and to discuss methods for strengthening the respective programmes.

An inter-country smallpox eradication and epidemiological team has been formed to assist the countries in the planning of smallpox programmes and the development of surveillance activities, as well as to participate in allied communicable disease activities.

In Afghanistan and Nepal, it is expected that programmes will be accelerated beginning in 1967 with additional support provided by WHO (Table 5). Emphasis will be placed on health education efforts as well as on the strengthening of surveillance and assessment activities. Additional support will be required for the Indian programme. Supplies and equipment will be provided to Burma to strengthen the maintenance programme there.



### 3. Eastern Mediterranean Region

#### 3.1 Smallpox incidence and status of activity

In this Region, cases are being reported principally from Ethiopia and Pakistan, both of which represent significant endemic foci of disease (Table 6). Periodic reintroduction of smallpox occurs in the neighbouring countries, Sudan, Saudi Arabia, Somalia and Yemen. Because of their large nomadic populations, all these countries, as well as Iran, are considered to be at a particular and continuing risk of reimporting the disease.

In Pakistan, intensified vaccination programmes have been carried out in recent years in both West and East Pakistan. Although the numbers of cases declined substantially up to the end of 1964, smallpox incidence rose during 1965 and increased sharply during 1966. In East Pakistan, only 43 cases were recorded in 1964; however, the number of cases increased to 304 in 1965 and 3119 in 1966. West Pakistan reported 738 cases in 1964, 1285 in 1965 and 2551 in 1966. As in India, the present programme is not succeeding in providing adequate vaccination coverage to the more inaccessible younger children and the floating populations who now account for a large proportion of cases.

In Sudan, a WHO-assisted vaccination programme was carried out during the period 1962-1964, when 8 840 000 vaccinations were performed. A satisfactory maintenance programme was not, however, established. The disease was last introduced in 1965, resulting in 69 recorded cases before the outbreak was brought under control.

Iran, which has successfully completed a systematic vaccination programme, has reported no smallpox cases since 1964. Maintenance vaccination activities are being continued. The immunity status of the populations in Saudi Arabia, Somalia, French Somaliland and Yemen is uncertain although, except for French Somaliland, few cases have been reported in recent years. All these countries are subject to the periodic reintroduction of smallpox.

### 3.2 Programme development

A smallpox inter-country adviser has been appointed for the Region.

WHO staff and consultants visited Pakistan and Sudan during 1966 and early 1967 to discuss the status and development of programmes in these two countries. It is expected that intensified systematic vaccination programmes will be developed with WHO assistance in Pakistan and Sudan, and intensified programmes in Ethiopia, Saudi Arabia, Somalia and Yemen during 1968. Vaccine will be required from outside sources, except for Pakistan, where national vaccine production is expected to be able to meet local requirements.

## 4. Region of the Americas

### 4.1 Smallpox incidence and status of activity

In the Americas, Brazil represents the principal endemic focus of smallpox although some cases are also reported from nearby areas in Argentina, Colombia, Peru and Paraguay (Table 7). Other neighbouring countries, where extensive vaccination programmes have been carried out, with a resultant cessation of endemic smallpox transmission, are exposed to the reintroduction of smallpox. Vaccination programmes at varying levels of intensity are in progress in most countries.

### 4.2 Programme development

Early in 1966, the Pan American Sanitary Bureau/WHO Regional Office for the Americas, with assistance from consultants, carried out a detailed appraisal of the smallpox situation in all countries of the Americas to determine the amount and type of collaboration that countries required from international sources. On the basis of this appraisal, a comprehensive five-year eradication plan was developed. Priority will be given to countries where smallpox is now endemic: Argentina, Brazil, Colombia, Paraguay and Peru, as well as Uruguay, which is situated between two such countries. Maintenance vaccination and surveillance programmes will be strengthened in those countries bordering endemic areas, i.e. Bolivia, Chile, Ecuador and Venezuela. Other countries in the Americas will be encouraged to increase their vaccination activities, apply the International Sanitary Regulations more strictly, and improve their surveillance mechanisms.

Freeze-dried vaccine is now being produced in 11 laboratories in the Americas. Most of these laboratories originally received equipment and technical assistance from WHO to permit them to become established. An agreement was signed with the University of Toronto to provide continuing consultation and guidance to these vaccine production centres.

A smallpox regional adviser has been appointed for the Region. Agreements for the implementation of the programme have been signed with Bolivia, Brazil and Chile. Recruitment of personnel for the programme is well advanced. Eighty jet injectors and 40 vehicles were provided to Brazil in 1966 to permit the early implementation of its eradication programme. During 1966, two courses in smallpox laboratory diagnosis were held in São Paulo, Brazil, to assist in the development of necessary supporting laboratory services, and two additional courses are planned for 1967.

## II. GENERAL PROGRAMME DEVELOPMENT

### 1. WHO headquarters

During 1966, the Smallpox Eradication unit was reinforced by three medical officers with supporting technical and administrative staff. Preparations were begun for the recruitment of additional WHO personnel by the regions to take responsibility for assisting governments early in 1967. By April 1967, over half of the positions projected for the programme had been filled. A number of technical papers were prepared by headquarters staff to assist regions in planning for the programme. Subsequently, a comprehensive manual setting forth the principles and technical considerations of the eradication programme was prepared. A draft of this manual is presently under review by WHO staff and consultants and will be available for general use in June 1967. Technical assistance was provided by headquarters staff to countries in Africa and Asia to assist them in the formulation of plans of operations.

Planning sessions were initiated between relevant headquarters and regional office units, particularly those concerned with basic health services, health education, statistical methodology, surveillance and health laboratory services.

## 2. Vaccine supplies

One of the most immediate critical problems in the programme is the adequate supply of high-quality, fully stable freeze-dried smallpox vaccine. As emphasized in previous documents, liquid vaccine, although effective if properly stored and transported, is commonly rendered impotent in the course of normal field operations, particularly in tropical areas. Its use has been specifically and emphatically discouraged for the countries where smallpox is endemic.

The development of vaccine production facilities in these has been actively promoted over the past few years. UNICEF, with WHO technical advice, has provided substantial assistance to a number of countries in different parts of the world; WHO has frequently provided consultants and fellowship training to those concerned with vaccine manufacture. Unfortunately, a number of laboratories are still producing vaccines which fail to meet WHO standards. The deficit between vaccine needs and vaccine production is substantial in many areas of the world.

Priority is being given to technical and material support to the development of vaccine production facilities in the African countries, the expansion of vaccine production facilities and the provision of all possible assistance to improve the standards of vaccine produced by existing laboratories in countries of South America, Africa and Asia where smallpox is endemic.

As noted in previous documents, emphasis is being placed on the development of production facilities capable of producing large quantities of smallpox vaccine rather than on the development of many minor production units which, because of their small size and limited personnel cannot maintain consistently high standards.

To provide necessary consultation and assistance required by the various production laboratories, WHO entered into a formal agreement with the University of Toronto, which will provide continuing consultation and assistance to vaccine producers in South America and help to train laboratory staff, test sample vaccine lots, etc. The development of similar arrangements with respect to assistance to vaccine producers in other endemic countries is presently being explored.

In the meantime, requirements for freeze-dried vaccine are barely being met by donations. A comprehensive study of vaccine needs and production capabilities, recently completed, indicates that, unless donations of vaccine are immediately increased, shortages may be expected towards the end of 1967 and in 1968. Since January 1966, vaccine has been offered to the Organization by Cambodia, France, the Netherlands, Pakistan, the Philippines, Sweden, Switzerland, Thailand and the United Arab Republic (Table 8). The USSR has contributed 75 million doses of vaccine to be used for the programme over the next three years and has provided, under bilateral assistance, large amounts of vaccine to programmes in Burma, India, Afghanistan and Zambia. The United States of America is providing large amounts of vaccine, similarly under bilateral assistance, to programmes in West and Central Africa.

The problem of vaccine supply may be further complicated in countries where jet injectors are used. Although only a tenth as much vaccine is needed with jet injectors, it is believed that the vaccines used for jet injection administration should be free or essentially free of bacterial contaminants. Few production laboratories appear to be able to produce vaccine of this quality at present. Moreover, there is still doubt about the consistency with which they can produce batches of vaccine of animal origin of the requisite high quality. Vaccine production on egg membrane and tissue culture are being considered, and WHO is co-operating in appropriate studies.

### 3. Consultant services

Since the provision of adequate supplies of freeze-dried vaccine of high quality is essential to the global programme, and since this has been a special problem, priority has been given to the provision of the necessary consultant services to production facilities in the countries where smallpox is endemic. Consultants will also be employed to assist in the continuing assessment of eradication programmes in progress in order to detect weaknesses and to determine the precise causes of any failures. Additional consultative services regarding the development of virus diagnostic facilities, assessment methods, surveillance procedures and operational methodology are also required.

4. Emergency vaccine reserve and technical assistance

Early in 1967, a small emergency vaccine reserve was established in Geneva to permit the rapid dispatch of vaccine in case of emergencies. Three requests of this type were received within a two-month period after the establishment of the reserve supply. In March, for example, the Trucial States experienced several simultaneous introductions of smallpox from India. Because of the largely unvaccinated status of the population, an urgent request for assistance was sent to WHO. Less than 36 hours after the dispatch of their cabled request, a WHO medical officer with 100 000 doses of vaccine arrived in the principal city, Dubai. Ways and means of providing immediate assistance of this type in the future are under study.

5. Training courses

It is proposed to hold training courses for national and international programme staff regarding methods of operation, assessment, surveillance and laboratory procedures. Seminars are being planned in the Americas and Asia during 1967 and in Africa early in 1968.

6. Fellowships

The principal training in operational and surveillance procedures will be provided by WHO staff and consultants at the regional and country levels. Several fellowships, however, will be required for the training of national personnel in vaccine production and virus diagnostic work.

7. Scientific groups

In order to establish the methodology of smallpox eradication on a sound technical basis, meetings of scientific groups are planned both in 1967 and 1968. These groups will be asked to study and advise on technical policy and standards for eradication, to appraise the status of research activities and to advise on appropriate steps to be taken with respect to a future course of action.

## 8. Research

A number of important areas demand intensive, special study, the results of which will serve to guide the programme in the immediate years ahead. Particular attention will be focused on the question of the comparative levels of susceptibility required to permit endemic propagation of the disease under differing circumstances. Other studies will include the choice of strains for vaccine production; the nature of viruses of the monkey-pox group: the possible use of attenuated or killed vaccines for immunization especially in countries where smallpox is not endemic; appraisals of the safety, efficacy and stability of smallpox vaccines propagated by tissue culture; comparative studies of variola strains from different regions; assessment of the relative efficacy of vaccination over varying time periods and under circumstances of natural challenge; operational studies, including studies of the jet injector, to determine the most efficient and economical means of conducting vaccination programmes..

Chemoprophylactic and chemotherapeutic agents, including particularly 6-azauracil-ribosid, will be tested and evaluated.

In conjunction with the responsible WHO reference centres, attention will be focused on the development of the most practical methods of laboratory diagnosis, the production of standard reference sera and antigens, and the preparation of appropriate teaching manuals.

It is expected that total or partial financial support for many of these projects would be provided to responsible investigators from national funds.

## 9. League of Red Cross Societies

During the Nineteenth World Health Assembly, the League of Red Cross Societies expressed a desire to participate in the global programme. The modalities of its participation were discussed at the Eleventh Session of the Health and Social Service Advisory Committee of the League of Red Cross Societies held in September. The contribution of the League, in collaboration with national Red Cross societies, may include health education, the training of field personnel, and the actual participation of voluntary workers in programme activities at the country level.

## 10. World Food Programme

The World Food Programme has expressed an interest in collaborating with the smallpox eradication programme. As the smallpox programme, in countries where the disease is endemic, is sometimes hampered by the shortage of field personnel and particularly by the cost of their travel, it would be of great advantage if countries could provide food subsidies to supplement their salaries. The possibility of obtaining such assistance in the smallpox eradication programme is being explored.

### III. ERADICATION METHODOLOGY

#### 1. General consideration

Technical policies and eradication methodology have been and will continue to be reviewed in order to develop the programme on a sound basis. The basic concepts involved in smallpox eradication have been discussed<sup>1</sup> in the past with full acceptance that smallpox eradication is technically feasible. These concepts continue to be valid.

On the other hand, it is well recognized from past experience that, if eradication is to be achieved, the difficulties must not be underestimated. These difficulties include financial, logistic and administrative problems, incompletely developed health administrations in many of the countries where smallpox is endemic, unfavourable attitudes towards vaccination on the part of the population in some endemic areas, the shortage of vaccine of good potency, and the difficulties inherent in establishing suitable maintenance programmes and effective surveillance activities.

Although eradication may be achieved by a comparatively straightforward approach of extensive vaccination, the programme in each country will require much thought and imagination in respect of an adequate operational approach, epidemiological surveillance, continuous assessment of vaccination coverage and the quality of the vaccine used, health education, and effective maintenance programmes. Finally, the eradication programmes of many different countries must be co-ordinated over large areas owing to the extensive movements of populations.

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<sup>1</sup> Off. Rec. Wld Hlth Org., 143, Annex 19  
Wld Hlth Org. techn. Rep. Ser., No. 283  
Off. Rec. Wld Hlth Org., 151, Annex 15



A discussion of the salient points of eradication methodology, as conceived at present, are presented in the following chapters.

## 2. Timing and extent of vaccination coverage

It is believed that, in general, country-wide campaigns, in the attack phase, should last no longer than three years. If prolonged beyond three years, population migration may complicate obtaining adequate coverage, impetus and morale may wane and efficiency decline. Further, the country programmes must be closely co-ordinated on a regional basis to decrease the probability of reintroduced infection.

Although the objective of the programme is to vaccinate the entire population of an endemic country during this initial vaccination phase, it must be appreciated that, however assiduously the vaccination programme is carried out, some people will not be reached.

What proportion of the population must be rendered immune in order to interrupt transmission is not clear. It is evident in this man-to-man transmitted disease that the proportion of susceptible persons necessary to ensure the continued propagation of the disease is a function of the number of contacts that the infected individual may have with susceptible persons. In densely crowded areas, the frequency and number of contacts is apt to be greater and the likelihood of smallpox transmission is increased; on the other hand, the more dispersed and isolated the population, the less likely is smallpox transmission to persist. Evaluation must be carried out in the course of the programme to provide a more precise estimate of the level of immunity needed to interrupt transmission under differing circumstances. At this time, it would seem probable that, if at least 80 per cent. of the different population subsegments are successfully vaccinated, transmission of smallpox should cease. However, in densely populated areas, a higher proportion may need to be vaccinated in order to interrupt transmission.

It has been the common experience, throughout the world, that the lower socio-economic groups living in densely crowded areas generally respond poorly to vaccination programmes and it is just in this group that transmission is most readily accomplished.

Intensive vaccination efforts must, therefore, be applied to these, to young children, and to other subsegments of the population in which transmission of the disease is most likely to occur. It is conceivable that intensive systematic vaccination efforts as often as every two years may be required in at least some segments of heavily populated areas to ensure adequate maintenance of immunity.

Acceptance of vaccination by the lower socio-economic groups as well as by the population as a whole requires, of course, an intensive health education effort. In some programmes, however, acceptance of vaccination has been consistently hampered simply because of the use of the painful and traumatic vaccination procedure utilizing the rotary lancet. As stated clearly by the WHO Expert Committee on Smallpox, less traumatic vaccination techniques should be substituted.

### 3. Assessment scheme of the programme

The assessment of the smallpox eradication programme must encompass several factors, including epidemiological findings developed in the course of surveillance (4.), continuing evaluation of the potency of vaccine used, vaccination coverage of the population, etc. Specific methods and criteria are being developed.

#### 3.1 Assessment of the potency of vaccine, and take-rate

Assessment of the potency of vaccine should be determined first at the central level before distribution to the field. Since the vaccine is administered under varying field conditions, further appraisals of potency during the operation is of the utmost importance and can be carried out best by routine verification of the take-rates obtained in a sample of vaccinated or revaccinated persons.

Under most circumstances, continuing assessment of perhaps 10 per cent. of vaccinations should be sufficient to assure that potent vaccine is being employed and that vaccination techniques are adequate. Experience has shown that consistently low take-rates are most likely to be caused by vaccine of low potency, either as originally delivered or resulting from improper storage. Great variation in take-rates may suggest inconsistency in the vaccination technique.

### 3.2 Assessment of vaccination coverage

The total absence of reported cases in the context of an effective surveillance system represents, of course, the ultimate assessment of the programme. Measurements of vaccination coverage provide interim information on the progress of the programme.

Where population figures exist, the simplest form of assessment of vaccination coverage may be based on a comparison between the total number of vaccinations performed and the estimated total population in the country or given area. However, the proportion derived represents only a rough approximation of the success of the programme. Population data are frequently inaccurate owing to original errors in enumeration or because of population migration; little information is provided about coverage of sub-segments of the population, e.g., young children, particular religious sects, etc. Assessment of a programme in this manner provides no information on the proportion of persons successfully vaccinated.

In some programmes, where detailed vaccination records (for example, family registers) are available, it is possible to determine the coverage, mainly based on such records, by area and age. If the records are reasonably complete, the results can give reasonably reliable information on the vaccination status of the population. However, it is difficult to maintain records such as family registers, and the requisite clerical work is frequently overwhelming.

Challenge vaccination has been proposed as an alternative method of assessing the immunity level of a population. However, recent experience shows that, with potent vaccine, reasonably high take-rates, sometimes over 80 per cent., can be obtained even in persons vaccinated recently. A measurement of the frequency of primary vaccination reactions among very young children or, more simply, an assessment of the frequency of primary scars in young children can be most useful in determining the efficacy and extent of coverage of vaccination programmes in this vulnerable age-group.

A more elaborate but probably the most reliable method of assessing vaccination coverage consists in simple cluster sampling by independent teams. This might be carried out in given areas shortly after vaccination is complete. Normally, only a small proportion of the population would need to be sampled in order to provide a broad

estimate of vaccination coverage in a given area. The response to vaccination could be obtained by questioning and the examination of vaccination reactions. An area for sampling should be defined mainly from an operational viewpoint so that, if the results imply an unsatisfactory coverage in that area, the team could return there for additional vaccination activities.

#### 4. Surveillance

Since the ultimate objective of the programme is the occurrence of "0" cases of smallpox, quite clearly a surveillance mechanism for the detection, reporting and investigation of suspect cases must be established in every area and every country. This is particularly important not only for countries where the disease is endemic but also for those bordering them. Since the establishment of an effective surveillance programme takes time, attention must be focused on this activity from the inception of every programme.

Each case of smallpox occurring after a systematic vaccination programme represents a possible flaw in the programme. If the case has occurred in a person ostensibly recently vaccinated, it suggests that the vaccine used may have been impotent or vaccination techniques inadequate. If a number of cases occurs among unvaccinated persons in one age-group or segment of the population, such as nomads, male field-workers, etc., this suggests that the operational aspects of the programme may need revision to ensure that such groups are better vaccinated. An effective surveillance system consists in several interrelated measures:

- (a) routine, systematic reporting of cases from "detection posts" throughout the country. Special field investigations, surveys, etc. will serve to clarify the data obtained by routine reporting;
- (b) prompt analysis and interpretation of routinely reported data and other studies;
- (c) the initiation of appropriate action including on-the-spot epidemiological investigations, control measures, and, as required, modification of operational procedures, etc.;
- (d) distribution of the interpreted information to reporting units and to others concerned with communicable disease activities.

#### 4.1 Routine case reporting

Virtually all countries have some form of disease notification system from basic health services and other medical and preventive care units and facilities. Prompt, regular reporting of suspect clinical cases observed at all such units generally should provide a reasonably complete detection network in most countries. In some instances, this network may require extension through carefully selected and trained "village reporters", and through school teachers, itinerant health workers, mobile teams concerned with specific disease control, etc. Since the persistence of smallpox depends on its continuing transmission from man to man, even limited outbreaks should soon be recognized even with a simple detection and reporting network. With field investigation of reported cases, the source can generally be identified, the problem appraised, and definitive containment measures initiated.

Past experience indicates that the local reporting "units" will perform best if they fully understand the need for reporting, if specific actions such as field investigations follow the reporting of cases, and if the units are required to report regularly whether or not cases have been seen.

#### 4.2 Analysis and interpretation of data

The pattern of smallpox occurrence must be constantly under study to permit prompt action to be taken where required. Smallpox cases should be reported promptly to those responsible for the eradication programme.

#### 4.3 Initiation of appropriate action

Rapid investigation of cases and outbreaks and their effective containment becomes increasingly important as disease incidence declines. The sooner they can be investigated, the sooner the problem can be defined and the more quickly corrective measures can be taken. Since the follow-up of reported cases and outbreaks is one of the best ways of motivating reporting units, consideration should be given from the beginning of programmes to the development of special mobile emergency units at the area or country level, whose principal responsibility would be the investigation and control of local outbreaks and eventually of individual cases.

#### 4.4 Continuing distribution of information pertaining to smallpox and the progress of the campaign

The regular publication of data on the occurrence of smallpox, the progress of the campaign, problems of concern, etc. can have a material educational value for all direct participants in the programme, basic health service personnel and others. Such a publication can serve to motivate and inform and will constitute a continuing link with all participants.

#### 4.5 Definition of a case of smallpox

In developing the detection network for cases, the constant aim should be to develop the most sensitive system possible. As a maxim, it is better to err on the side of over-reporting than under-reporting. Reporting units should be encouraged to report all suspect clinical cases. As the eradication programme progresses, epidemiological and laboratory confirmation of cases may be increasingly employed and many "suspect" cases may later be discarded as other illnesses.

Although in some countries cases of supposed "alastrim" (variola minor) are reported as such and are not considered to be "true" smallpox, this practice is to be deplored. Both forms of smallpox are caused by the variola virus and, in most instances, they cannot be clinically differentiated.

#### 5. Maintenance programmes

The development of effective tactical approaches for conducting the maintenance phase of the programme requires considerable skill and imagination. The strategy, needs and costs for the maintenance phase need to be considered preferably before the attack phase of the programme.

The maintenance phase of the programme includes two important components:  
(1) surveillance and (2) continuing vaccination.

A sensitive case detection system for introduced cases, coupled with an active field investigation and containment activity is of vital importance if the re-establishment of endemic foci is to be prevented. Particular attention should be paid to "high-risk" areas, i.e. densely populated areas and areas where migrants are particularly prevalent.

The importance of vaccination during the maintenance phase is emphasized by the fact that, each year, the newborn will account for an increase of two to four per cent. in the population and all will be susceptible to smallpox; large numbers of persons may be expected to migrate to urban centres from rural areas, many of whom may have resided in comparatively inaccessible places with inadequate vaccination coverage; normal waning of immunity will occur in those previously vaccinated. In a comparatively short time a large susceptible population group will accumulate.

Of chief concern are the newborn and migrant populations. To reach recently born children early in life for routine vaccination is a continuing and difficult problem which has only been partially solved in areas with complete birth registration and adequate numbers of health centres. Children born in hospitals or under the supervision of staff from maternity centres are accessible for vaccination at birth. In only few areas of the world, however, are very substantial proportions of children born under the supervision of maternity centre staff.

Full reliance on routine vaccination at health centres, while excellent in concept, poses difficulties in execution. Health centres in most endemic countries are few and sparsely distributed; refrigeration in these centres is often inadequate, and the response of the local population is frequently limited.

The establishment of mandatory vaccination or revaccination at school entry serves to ensure immunity within the school, a likely place for disease transmission. In many areas, of course, comparatively few attend schools.

Migrants pose an even more difficult problem since there is no ready method for identifying migrant persons. Although in some areas vaccination cards or certificates have been issued and it has been "required" that they be carried, the complexities of enforcing such a ruling, together with the loss or falsification of certificates, etc., has frequently led to abandonment of this system.

For many if not most endemic countries, effective maintenance vaccination programmes will probably have to rely principally on systematic community-wide vaccination programmes at regular intervals. A general scheme might be proposed as follows:

- (a) routine vaccination of the newborn cared for by health services or other medical or auxiliary health personnel;
- (b) routine vaccination of children at health clinics and at school entry;
- (c) periodic systematic community-wide vaccination programmes at regular intervals. In urban centres and other vulnerable areas and population concentrations, community-wide programmes probably should be conducted at least every two to three years so as to ensure adequate immunity. In sparsely populated rural areas, less frequent intervals of vaccination, perhaps every four to five years, may serve to maintain adequate immunity levels.

#### 6. Health education

The development of well-planned health education activities is a basic requirement since the success of the programme depends on the population's acceptance of vaccination as well as its active participation in surveillance and assessment work. The educational component should be of such a nature and scope that it can serve to motivate people's immediate readiness for vaccination and also generate their lasting interest in the prevention of smallpox as well as other priority health problems in accordance with local needs and available resources and health services. Many other-wise well-planned programmes have not achieved satisfactory population coverage owing to lack of awareness, or apathy, or the unfavourable attitudes of the population towards vaccination.

The health educational aspect should be included as one of the important aspects in the training of field personnel, in the preparatory phase as well as during operations. Close co-operative planning and organizational work by officials and specialist staff responsible for the smallpox programme and those responsible for health education services is of vital importance to develop essential educational activities in country programmes at the central and peripheral levels.

The motivation of voluntary co-operation of the people in the vaccination programme and in related health measures should be an integral and specific role of every health worker who comes into contact with the public. For example, with the proper approach



and explanations appropriate to various local circumstances, all vaccinators should be capable of persuading people to accept vaccination. Collaboration should be sought with recognized authorities and with various influential local persons, school officials and teachers, interested workers of voluntary associations, religious leaders, and any other respected persons and groups in the areas concerned. Early contact and participation of the appropriate and influential elements of any given population group in helping to work out plans for the promotion of public participation can be an important step towards enlisting more effective and widespread co-operation of the people in the programme.

Low vaccination coverage rates usually are due either to lack of co-operation on the part of the population or lack of adequate supervision of the vaccination teams. Whenever a team finds a very low coverage rate in a particular area, it would be useful to determine the reason by a study on the spot. A proper scheme for implementing such a study should be prepared and appropriate action taken to improve the situation on the basis of the results.

A proportion of the funds made available for the smallpox eradication programme should be allocated to health education activities to assist health ministries to develop the activities most urgently needed for health education programmes including: (a) training of health personnel (e.g. vaccinators, supervisory personnel, etc.) in health education techniques; (b) co-operative teaching projects with schools and teacher-training institutions; (c) joint education projects with existing professional and voluntary organizations such as the Red Cross, agricultural groups, religious institutions, and others; (d) preparation and production of visual aids and other communication media suited to local requirements and available resources and services.

#### 7. Role of basic health services in the smallpox eradication programme

The importance of the full participation of the basic health services in the smallpox eradication programme is well recognized. The Eighteenth World Health Assembly made a comprehensive review of the position of global smallpox eradication, as well as the requirements for its effective development, and in its resolution WHA18.38<sup>1</sup> requested "governments to take early steps to establish basic health services for the maintenance phase . . .".

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<sup>1</sup> Handbook of Resolutions and Decisions, 8th ed., p. 51.

It is expected that in some countries the existing general public health services will be able to undertake a significant portion of the smallpox eradication activities and that they may, to a great extent, be capable of integrating smallpox eradication activities. This will serve two main purposes, namely, the desirable promotion of the basic health service structure, and the achievement of the important task of smallpox eradication.

The relative degree and type of participation of the basic health services in smallpox eradication will vary from country to country depending on the resources available and on the pattern and coverage by community health services of any particular country or part of a country. Detailed planning can be done effectively only on the spot and must involve all concerned sections in the national health administration to see how best existing health services can be mobilized to assist the smallpox eradication programme and how the smallpox programme, in turn, can strengthen the existing health structure. It is essential for those responsible for basic health services at all levels, central, intermediate and local, to be involved as from the planning stage of the smallpox eradication programme to ensure their full collaboration in all phases of its implementation.

Many countries have already had considerable experience with mass campaigns for the control or eradication of some diseases, e.g., yaws, malaria and tuberculosis. It is important that the lessons learned should be taken into consideration in planning for smallpox eradication. Specialized mobile teams, either provided by the basic health services, or newly recruited, will generally be needed for total population coverage, at least in the initial phases. If, in any local areas, existing health services are strong enough to provide coverage of the community with a house-to-house family service, specialized vaccination teams may not be necessary. Even so, in such situations, a special effort will be needed to stimulate and train health personnel with a view to the organization of effective immunization coverage. As soon as a particular community has been covered in the first round of vaccination, plans should be developed where possible for local community health services to assume the maximum possible responsibility for the continued vaccination of the newborn, of immigrants, of persons "missed" during the mass vaccination period, and of the population at large at regular intervals.

This approach presupposes that the planning of smallpox vaccination programmes will provide for the training of basic health service staff as well as specialized vaccinators. It may often be desirable as the programme advances to detach trained vaccinators and to leave them as permanent additions to the strength of the local health unit. In any case training of existing personnel in various health units in smallpox eradication requirements is the sine qua non of a successful campaign.

In areas where mobile teams represent the only possible approach in the vaccination programme, consideration should be given to enlisting the services of a local "leader" to maintain records and to prepare the community for each visit of a mobile team. This approach may develop the participation of the local authorities in the programme.

In many countries there may be communicable disease programmes in progress, for example, BCG vaccination, yaws eradication, malaria eradication or pre-eradication, trachoma control, etc. The combination of smallpox eradication activities with these programmes can be envisaged, especially in maintenance and surveillance activities.

In most countries an effort could be made to train midwives in vaccination of the newborn; maternal and child health and school health services wherever they exist obviously should participate.

In addition to these activities, the health units of the country should at all stages of the programme participate actively in the reporting of smallpox cases. Where possible, they should be trained in procedures of simple field investigation of cases and outbreaks, and appropriate containment measures to be taken. In other words, they should play a major and continuing role in the surveillance structure.

All such considerations lead to the conclusion that a successful smallpox eradication programme must closely involve all levels of the general health services. A pre-planning activity in any country should include:

- (a) a study of how and where existing general and specialized health activities can play an effective part, and a definition of the responsibilities of medical officers and auxiliary health workers at the district and community levels;

- (b) the delineation of areas where no general health services exist and where mobile health teams must play a more comprehensive role;
- (c) a study of the health facilities required to provide adequate maintenance of vaccination status in the population;
- (d) a study of the role and participation of the facilities in the essential surveillance activities of the programme.

TABLE 1. SMALLPOX CASES REPORTED BY CONTINENT 1959-1966

	1959	1960	1961	1962	1963	1964	1965	1966
Africa	15 781	16 127	24 182	24 837	16 723	12 362	16 670	13 882
America	4 899	5 531	8 168	7 860	7 126	3 051	3 095	2 941
Asia	60 749	39 251	53 217	49 579	75 621	34 543	44 555	48 618
Europe	15	47	27	137	129	-	1	71
World total	81 444	60 956	85 594	82 413	99 599	49 956	64 321	65 512

TABLE 2. SMALLPOX CASES REPORTED BY WHO REGION 1964-1966

	1964	1965	1966
Africa	12 259	16 543	13 608
West	5 676	9 910	9 284
East	6 583	6 633	4 324
The Americas	3 051	3 095	2 941
Eastern Mediterranean	901	1 716	5 945
South-East Asia	33 745	42 966	42 942
Europe	-	1	71
Western Pacific	-	-	5
World total	49 956	64 321	65 512

TABLE 3. AFRICAN REGION (WEST AND CENTRAL)  
STATUS OF SMALLPOX ERADICATION ACTIVITIES IN SMALLPOX ENDEMIC AND NEIGHBOURING COUNTRIES

Country	Estimated* population (in millions)	Smallpox cases reported			Vaccinations <sup>(A)</sup> performed (in 1000)			Eradication activities <sup>(B)</sup> anticipated	
		1964	1965	1966	1964	1965	1966	1967	1968
Cameroon	5.2	31	-	3	1 035	664	+	x	x
Chad	2.9	5	73	-	559	1 022	+	x	x
Central African Republic	1.4	-	-	-	182	372	+	x	x
Congo (Republic of)	0.8	196	89	2	+	+	+	x	x
Congo (Democratic Republic of)	15.8	2 302	3 683	1 913	+	+	+	x	x
Dahomey	2.4	703	167	493	475	+	+	x	x
Equatorial Guinea	0.3	-	-	-	+	+	+	xx	xx
Gabon	0.5	49	1	1	13	+	+	x	x
Gambia	0.3	6	6	3	60	52	+	x	x
Ghana	7.8	9	7	13	+	+	+	x	x
Guinea	3.6	300	69	55	1 050 <sup>b</sup>	712 <sup>a</sup>	+	x	x
Ivory Coast	4.0	11	8	-	3 629 <sup>b</sup>	+	+	x	x
Liberia	1.0	128	40	-	728 <sup>b</sup>	+	+	x	x
Mali	4.8	321	659	284	732	608	+	x	x
Mauritania	0.9	-	-	-	147	120	+	x	x
Niger	3.4	29	455	1 023	586	298	+	x	x
Nigeria	58.4	1 416	4 566	4 925	+	+	+	x	x
Portuguese Guinea	0.5	-	-	-	+	+	+	xx	xx
Senegal	3.5	2	-	-	+	+	+	x	x
Sierra Leone	2.2	89	60	293	245	+	+	x	x
Togo	1.6	21	13	201	+	1 112 <sup>c</sup>	+	x	x
Upper Volta	4.9	8	14	75	1 516	1 121 <sup>a</sup>	+	x	x
Total	126.2	5 676	9 910	9 284					

\* 1966 (est.)

(A) + Complete data not available

<sup>a</sup> Through September<sup>b</sup> 1962-1964<sup>c</sup> 1962-June 1966

(B) x Systematic programmes to be initiated or intensified with bilateral assistance from the United States of America or assistance from WHO (Congo Democratic Republic)

xx Continuation of present programme of vaccination

TABLE 4. AFRICAN REGION (EAST AND SOUTH)  
STATUS OF SMALLPOX ERADICATION ACTIVITIES IN SMALLPOX ENDEMIC AND NEIGHBOURING COUNTRIES

Country	Estimated* population (in millions)	Smallpox cases reported			Vaccinations <sup>(A)</sup> performed (in 1000)			Eradication activities <sup>(B)</sup> anticipated	
		1964	1965	1966	1964	1965	1966	1967	1968
Angola	5.3	1	-	3	+	+	+	xx	xx
Botswana	0.6	174	-	-	+	+	+	xx	xx
Burundi	2.9	-	1 213	340	7	+	+	xx	xx
Kenya	9.5	266	271	159	500-1000	500-1000	+	x	x
Lesotho	0.8	-	-	-	+	+	+	xx	xx
Malawi	3.9	704	228	88	1 569	751	540	xx	xx
Mozambique	7.0	250	111	19	+	+	+	xx	xx
Rwanda	3.1	-	5	-	+	+	+	xx	xx
South Africa	18.1	320	67	-	+	+	+	xx	xx
Southern Rhodesia	4.3	200	40	33	+	+	+	xx	xx
Swaziland	0.3	517	89	31	+	+	+	xx	xx
Uganda	7.6	523	1 338	552	+	7 500 <sup>a</sup>	+	x	x
United Republic of Tanzania	10.6	1 405	2 743	3 027	+	3 000 <sup>b</sup>	+	x	x
Zambia	3.8	2 214	528	63	1 657	1 500	+	x	x
Total	77.8	6 583	6 633	4 324					

\* 1966 (est.)

(A) + Complete data not available

<sup>a</sup> 1965-June 1966<sup>b</sup> 1964-1965

(B) x Systematic programmes expected to be initiated or intensified with WHO assistance

xx Continuation of present programme of vaccination

TABLE 5. SOUTH-EAST ASIA REGION  
STATUS OF SMALLPOX ERADICATION ACTIVITIES IN SMALLPOX ENDEMIC AND NEIGHBOURING COUNTRIES

Country	Estimated* population (in millions)	Smallpox cases reported			Vaccinations <sup>(A)</sup> performed (in 1000)			Eradication activities <sup>(B)</sup> anticipated	
		1964	1965	1966	1964	1965	1966	1967	1968
Afghanistan	15.9	157	71	72	+	+	3 757 <sup>a</sup>	x	x
Burma	25.1	28	8	1	5 500	+	3 766 <sup>b</sup>	x	x
Ceylon	11.4	-	1	-	+	+	313 <sup>b</sup>	xx	xx
India	488.0	31 587	29 476	32 371		457 781 <sup>c</sup>	64 094	xx	xx
Indonesia	106.4	1 874	13 326	10 113	30 000	27 000	+	xx	x
Nepal	10.1	09	84	385	+	547 <sup>b</sup>	257	x	x
Thailand	31.1	-	-	-	+	+	2 819	xx	xx
Total	688.0	33 745	42 066	42 942					

\* 1966 (est.)

(A) + Complete data not available  
<sup>a</sup> October 1965 - February 1967  
<sup>b</sup> Through September  
<sup>c</sup> 1962-June 1966

(B) x Systematic programmes expected to be initiated  
or intensified with WHO assistance  
xx Continuation of present programme of  
vaccination

TABLE 6. EASTERN MEDITERRANEAN REGION  
STATUS OF SMALLPOX ERADICATION ACTIVITIES IN SMALLPOX ENDEMIC AND NEIGHBOURING COUNTRIES

Country	Estimated* population (in millions)	Smallpox cases reported			Vaccinations <sup>(A)</sup> performed (in 1000)			Eradication activities <sup>(B)</sup> anticipated	
		1964	1965	1966	1964	1965	1966	1967	1968
Ethiopia	22.8	103	58	222	+	209 <sup>a</sup>	1 300	xx	x
French Somaliland	0.08	-	-	52	+	+	+	xx	xx
Iran	23.7	12	-	-	4 000	4 000	12 397	xx	xx
Pakistan	103.9	781	1 589	5 670	32 519	34 107	+	x	x
East Pakistan	55.3	43	304	3 119	19 840	19 229	+		
West Pakistan	48.6	738	1 285	2 551	12 679	14 878	18 700		
Saudi Arabia	6.6	-	-	-	+	112 <sup>a</sup>	+	xx	x
Somalia	2.5	-	-	-	+	+	110	xx	x
Yemen	13.7	-	69	-	8 840 <sup>b</sup>	+	90 <sup>c</sup>	x	x
Yemen	5.0	5	-	1	+	+	+	xx	xx
Total	282.18	901	1 716	5 945					

\* 1966 (est.)

(A) + Complete data not available  
<sup>a</sup> Through June  
<sup>b</sup> 1962-1964  
<sup>c</sup> Year ending 30 June

(B) x Systematic programmes expected to be initiated  
or intensified with WHO assistance  
xx Continuation of present programme of vaccination

TABLE 7. REGION OF THE AMERICAS  
STATUS OF SMALLPOX ERADICATION ACTIVITIES IN SMALLPOX ENDEMIC AND NEIGHBOURING COUNTRIES

Country	Estimated* population (in millions)	Smallpox cases reported			Vaccinations <sup>(A)</sup> performed (in 1000)			Eradication activities <sup>(B)</sup> anticipated	
		1964	1965	1966	1964	1965	1966	1967	1968
Argentina	22.6	12	15	21	284	3 686	853	x	x
Bolivia	4.4	4	-	-	+	417	933	x	x
Brazil	82.5	2 505	2 962	2 896	8 016	22 120	2 073 <sup>a</sup>	x	x
Chile	8.8	-	-	-	1 481	829	1 040	x	x
Colombia	17.9	24	68	8	1 702	4 093	+	x	x
Ecuador	5.1	42	-	-	652	919	716 <sup>b</sup>	x	x
French Guiana	0.24	-	-	-	1	+	+	xx	xx
Guyana	0.7	-	-	-	7	+	+	xx	xx
Paraguay	2.1	7	32	5	135	929	92	x	x
Peru	11.7	454	18	11	3 165 <sup>b</sup>	+	210	x	x
Surinam	0.3	-	-	-	6	+	+	xx	xx
Uruguay	2.8	3	-	-	188	196	184 <sup>a</sup>	x	x
Venezuela	8.9	-	-	-	953	1 295	1 081	x	x
Total	167.84	3 051	3 095	2 941					

\* 1966 (est.)

(A) + Complete data not available

<sup>a</sup> Through November

<sup>b</sup> Through September

(B) x Systematic programmes expected to be initiated or intensified with WHO assistance

xx Continuation of present programme of vaccination

TABLE 8. CONTRIBUTIONS TO THE SPECIAL ACCOUNT FOR SMALLPOX ERADICATION  
January 1966 - March 1967

A. Contributions in kind

Freeze-dried smallpox vaccine\*

Cambodia	100 000 doses
France	200 000 doses
Netherlands	600 000 doses
Pakistan	100 000 doses
Philippines	120 000 doses
Sweden	1 000 000 doses
Switzerland	2 325 000 doses
Thailand	200 000 doses
United Arab Republic	1 000 000 doses
USSR	75 000 000 doses

Other items

Japan - private manufacturers	120 motorcycles
Poland	2 vehicles
USA - University of Colorado	Laboratory equipment

B. Contributions in cash

	US\$
Democratic Republic of Congo	2 000
Greece	2 000
Kenya	840
Monaco	306
Nepal	2 564
Uganda	840

\* For various technical reasons, certain of these donations have not yet been officially accepted by the Organization